

AIR HANDLING UNIT WITH A CARBON DIOXIDE REFRIGERANT CIRCUIT, ELECTRONIC CONTROL UNIT, HVAC-SYSTEM AND METHOD

5 Technical field

[0001] The present invention relates to an Air Handling Unit (AHU) for heating, ventilation, and air conditioning (HVAC) systems. More specifically, it pertains to an Air Handling Unit that utilizes carbon dioxide (CO₂) as a refrigerant in with an integrated cooling/heating function, specifically applied for usage in HVAC systems for buildings and vehicles.

10 Background

[0002] A prior invention WO2018199835A1, Air handling system with partially indirect heat pump and method to reduce the drop of the supply air temperature in defrost mode; implemented a cooling system for buildings with recovery of cold air.

[0003] Propane and butane-based refrigerant are highly flammable. Hence, usage of CO₂ also known as R744, is a safer alternative.

[0004] CO₂ also known as R744, is environmentally preferably for AHU and HVAC system, compared to HFC and HFO refrigerants. HVAC systems may include one or more AHU blocks, each comprising one or more CO₂ refrigerant circuits for circulating CO₂ for cooling and heating purposes. An AHU or HVAC system may include one or more heat exchangers/gas coolers placed outside of the building to be cooled, as is known from outdoor mounted Air Conditioning (AC)-systems.

[0005] HVAC systems and Air Handling Units (AHU) using CO₂ have been found to be suboptimal and challenging in hot environments, especially during hot summer days. Using CO₂ as refrigerant makes the control over the cooling process more sensitive than when using earlier less sustainable refrigerants. Systems using, CO₂ are more demanding as its gas cooler coil requires a lower max temperature for optimal cooling operation, than when operating with HFC, HFO, butane- or propane as refrigerant.

[0006] Hence, there is a need for a better method and configuration for CO₂ based Air handling units, suited for building in hot environments.

30 Summary of the invention

[0007] To increase efficiency of an Air Handling Unit (AHU) using a CO₂ (R744) refrigerant circuit, an integrated cooling and heating block without (700) or with CO₂ pressure optimization (750); the inventors have realized that usage of an outdoor air stream for cooling a gas-cooler of the heating block reduces the possibility to get an optimal transcritical and sub-critical CO₂ refrigeration process, especially with hot outdoor temperatures, or when the outdoor air intake to the gas-cooler coil is placed outdoors. Fluctuations in temperature and high temperature of

the outdoor air, as well as sun-radiation and microclimate make the control process challenging and makes it difficult to reach an optimal cooling process.

[0008] A better and more stable cooling air flow temperature control is needed, as realized by the inventors. Experimentation and studies, shows that indoor temperatures of most
5 conditioned buildings and rooms rarely reach as high temperature as outdoor air, received by the AHU, during warm and/or sunny days.

[0009] Hence, an AHU configuration can be optimized, where the AHU 50, 100, 150, ... 650 is commissioned and installed operational in a building 900 as a complete HVAC system 20; using indoor extract air stream as inlet air to a gas cooler, a First coil 703 of a an integrated
10 cooling and heating block without 700, or with CO₂ pressure optimization 750.

[0010] When the AHU installed in a building 900 or at least partly outside 900' the Frist coil 703 is commissioned/installed in an air flow/channel that passes from the inside of the building or room, to receive air at room temperature, into the extract air flow 23 with extract air channel 23, thru an extract air temperature sensor 803 if present, thru a heat exchanging function 102,
15 302, 502; and finally thru the First coil 703 acting as a gas cooler; to further exchange heat with a Second coil 702, configured to cool supply air 22 entering the building 900 or room.

[0011] In mentioned system configuration for the AHU 50, 200, 250, 400, 450, 600, 650 the HVAC system 20, and building 900; the AHU may further be equipped with a function to control the heat exchanging function's 102, 302, 502 efficiencies to further control and adjust the air-
20 temperature at the First coil air intake temperature sensor T 801. A method for optimizing the efficiency with respect to maintain an optimal First coil air intake temperature at sensor T 801, is provided. A method that can be implemented as electronics, hardware, mechanical, and/or as an ECU software (ECU SE).

[0012] The invention presented includes an Air Handling Unit (AHU), an HVAC system
25 comprising the AHU; and an Electronic Control Unit (ECU) 800 with methods for control and optimization of the AHU operation. The AHU 50 may be provided according to three embodiments, or as variation of the first embodiment:

an AHU with cross/counterflow heat exchanger (PHE) 100, 150, 200, 250;
an AHU with rotary heat exchanger (RHE) 300, 350 ,400, 450; and
30 an AHU with run-around-coil heat (RAC) exchanging function 500, 550, 600, 650.

[0013] A preferred embodiment is recognized as the rotary heat exchanger (RHE) according to Figure 8, the AHU (450) with pressure optimized cooling system, which is expected to be very efficient. Optimization of the cooling system can be implemented for all AHU:s 200, 250, 400, 450, 600, 650 with the heat recovery function located between the first coil 703 and
35 second coil 702. These alternatives offers optimization of CO₂ (R744) refrigerant circuit by controlled cooling recovery using an airstream from inside a building or room.

[0014] The AHU may comprise an ECU 800, or similar control system for sensors, control logic functions, and actuator control, implemented as ECU hardware (ECU HW) 810 as electronics, or with ECU software (ECU SW) 811, possibly with a System configuration data file (812) or interface to set optimal target ranges for sensor T (802), a First coil air inlet temperature sensor T (801), and an Extract air room/building temperature sensor (803).

[0015] The AHU further comprises an ECU 800; a heat exchanger function, a First coil (703) gas cooler placed in extract air channel, to receive air from a building, a CO₂ (R744) refrigerant circuit, an integrated cooling and heating block without (700) or with CO₂ pressure optimization (750); for exchanging heat with a First coil (703) a gas-cooler, and a Second coil (702) placed in the AHU's air supply channel to the building (900). Placement of the First coil (703) after the heat exchanger in an extract air flow/channel (23), lets the ECU (800) control/adjust of the air temperature at the First coil by regulating the efficiency of heat exchange by regulating: damper for a by-pass channel of cross/counterflow heat exchanger; rotation speed of rotary heat exchanger; and/or liquid flow in RAC/run around coil system, which maximizes the CO₂ refrigerant cycle efficiency.

[0016] The present invention relates to heating, ventilation, and air conditioning (HVAC) systems. More specifically, it pertains to HVAC systems that utilize carbon dioxide (CO₂) as a refrigerant in an integrated cooling/heating Air Handling Unit (AHU) block 50; 100, 150, ... 650.

[0017] The HVAC system includes one or more AHU blocks, each comprising one or more CO₂ refrigerant circuits for circulating CO₂ for cooling and heating purposes. The system also includes one or more heat exchangers/gas coolers placed in the extract air stream of the AHU for exchanging heat, thereby maximizing cycle efficiency.

[0018] The CO₂ refrigerant circuit can operate as a simple circuit design utilizing CO₂ as a refrigerant with main components or as an advanced circuit design utilizing CO₂ as a refrigerant with main components and pressure optimization.

[0019] The HVAC system may also include heat recovery system like a rotary heat exchanger (RHE) or cross/counter flow plate heat exchanger (PHE) or Run Around Coils (RAC) controlled by an electronic control unit (ECU) to maintain air temperature before the gas cooler between 40 Celsius and 15 Celsius. The system may also use a trans critical or subcritical carbon-dioxide refrigeration process, here denoted as CO₂ or R744, refrigerant circuit using extract air from the building or room at the inlet of the gas cooler.

[0020] The HVAC system may also include temperature sensors T 801, 803 to measure the temperature of the air before it enters the gas cooler, the First coil 703, and in the extract air stream 23, that is the extract air channel configured to receive air at indoor temperature from a building or room.

[0021] The ECU may be configured to control heat exchange efficiency of its PHE, RHE, or RAC as maximum usage of heat exchanger functions are more energy efficient, than using a

CO₂ (R744) refrigerant circuit, an integrated cooling and heating block without (700) or with CO₂ pressure optimization (750). If a maximum heat exchange is in use in the PHE, RHE, or RAC; there is a risk that the air temperature at the First coil 703, indicated by the First coil air intake temperature at sensor T 801; reaches a temperature that is sub-optimal for the CO₂ refrigerant process.

[0022] Hence, the need for an optimization method that maintains the temperature at First coil air intake temperature at sensor T 801, within a desired optimal temperature target range for sensor T 802; while controlling the heat exchange efficiency by adjusting: a bypass damper for any cross/counter flow plate heat exchanger (PHE); the revolution speed of any rotary heat exchanger (RHE), or the liquid flow in any run around coil (RAC) system.

[0023] As the ECU 800 may control one AHU (50, 100, 150, ... 650), it may control and optimize multiple AHU:s located in different building, and even over the internet as a cloud service, and/or with a central control software for a surveillance, control, and optimization. Therefore, a single ECU may serve multiple AHU:s, buildings with HVAC systems other HVAC systems, not limited to installations in buildings and vehicles. The ECU may execute its functions in a cloud computing environment, or locally in the ECU HW, or implemented in the electrical design circuitry.

[0024] The HVAC 20 system including its AHU(s) may also include a heat exchanger/evaporator in cooling mode located in the supply air channel that provides air to the inside of the building or room. The supply air channel provides air to the inside of the building or room. The HVAC system may also include expansion valves for control of evaporator suction gas superheat. The HVAC system may include expansion valves used for pressure optimization in the gas cooler/condenser and pressure optimization in a flash receiver.

[0025] To maintain an efficient cooling and heat transfer process using CO₂ it is essential to have control over pressure, temperature, and fluid flow. The invention provides a technical solution on how to maintain an effective or optimized cooling process using CO₂ R744 refrigerant for HVAC/AHU-applications. By configuring the AHU for usage of extract air stream, that is the extract air channel, for gas cooling of the First coil 703, during cooling season, the system can reach higher efficiency during the cooling season, that are usually during hot weather. During cold weather, the function will operate as usual with maximum heat recovery through the PHE, RHE and RAC heat exchanging process.

[0026] During cold winter season, using an AHU with a usual configuration where the CO₂ (R744) refrigerant circuit, the integrated cooling and heating block without (700), or with CO₂ pressure optimization (750); is configured reverse the heat transfer process; that is to let the First coil 703, and Second coil 702, work in opposite mode where heat is transferred from the First coil to the Second coil, to heat supply air entering the building or room.

[0027] During hot summer days, the inventors have identified and concluded that by placing the gas cooler/condenser, in the extract air channel of the HVAC system and AHU, it is possible

to maintain the temperature range required for an optimal CO₂ cooling system. This is a preferred configuration in hot climate zones, in the middle of the day, and during high-season summer, as the indoor temperature of a building is much lower than outdoor temperature in hot environments, during summer, and during sunny days. Hence, the new AHU configurations
5 make it possible to control the conditions required for optimal HVAC CO₂ based cooling of a building, while saving energy.

Technical problem

[0028] The main technical problem solved by the invention is how to provide a sustainable CO₂ based optimized HVAC system with efficient cooling in hot environments. This is a
10 challenge since the CO₂ refrigeration process could work in trans-critical mode where past technical solutions using less environmentally preferable green-house gases works in sub critical mode. The high-pressure CO₂ refrigeration process is recognized as more sensitive for high temperature at the gas-cooler side, than with earlier less sustainable refrigerants.

[0029] As the heat exchangers included in the AHU, and corresponding HVAC systems;
15 provide a more energy efficient way to transfer and recover heat and cooling in a heat exchanging function such as a PHE, RHE, and RAC system; an energy efficient system should make maximum usage of such heat exchanging capacity.

Such a heat exchange may unfortunately interfere with a integrated cooling and heating block without 700, or with CO₂ pressure optimization 750; as the First coil 703 may reach non-
20 optimally high temperatures ranges due to an efficient PHE, RHE or RAC heat exchange, leading to preheating of the airflow at the intake to the First coil 703, attempting to operate as a gas cooler.

[0030] Environmental and sustainability directives force a quick phase out of damaging refrigerants such as HFC and HFO refrigerants, in favor of the introduction of natural
25 refrigerants such as CO₂, which requires significant higher pressure and a better control of the cooling process, especially when using a trans-critical process.

Solution to problem

[0031] HVAC systems using a reversible heat pump to maximize energy recovery and provide both heating and cooling by efficient transfer of energy between supply and exhaust air
30 streams are known as prior art. Such installations have been using mainly HFC or HFO-blends as refrigerant/heat transfer medium. From an environmental perspective the HFC/HFO refrigerants need to be replaced due to their Greenhouse warming potential (high GWP-value) and chemicals with long life and unknown risks being released in the atmosphere. Then CO₂ (R744) has been identified as a preferable alternative.

35 [0032] Other types of refrigerants in class A2L (mildly flammable) and A3 (highly flammable) have been found not to be suitable. For these refrigerants, the challenge has been to avoid fire, as mentioned in patent application prior invention WO2018199835A1.

[0033] A consequence of using CO₂, resulting in a technical problem is that the R744 refrigerant operates at much higher pressure and reaches its transcritical mode. This could make the cooling process less energy efficient and the process is sensitive to high air temperature at the gas cooler inlet. In prior art AC systems, the gas cooler is placed outdoors
5 and directly influenced by outdoor air temperature. As a result, such systems often operate in transcritical mode with reduced efficiency and control stability as a result.

[0034] The inventors have recognized that the inlet temperature to the gas cooler in the extract air flow channel should stay within 15 to 40 °C, preferably 20 to 32 °C; in order to get an efficient cooling process.

10 [0035] A more efficient technical solution was requested to increase efficiency and reduce energy usage for such a HVAC system, especially during hot summers, warm climate and hot seasons.

[0036] The inventors have solved the technical challenge by placing the gas cooler in the in-door-air extract channel. During summer and sunny days, the indoor temperature is normally
15 lower than the outdoor temperature and provides for a lower and more stable temperature range in the extract air channel.

[0037] Hence, the technical solution of the HVAC system using a CO₂ refrigeration process will be more controllable and have lower air temperature at the gas cooler inlet compared to an outdoor placed gas cooler, and therefore being more energy efficient.

20 [0038] The inventors propose a few alternative combinations solutions with CO₂ refrigerant circuits in combination with PHE, RHE and RAC (counter/cross flow-plate heat exchanger(s), rotary heat exchanger and run around coil systems).

[0039] By introducing new ways of configuring AHU in HVAC system comprising heat recovery systems in combination with refrigerant circuits, the inventors have identified
25 preferable configurations where heat exchangers have been combined with CO₂ based refrigeration processes.

[0040] The inventors have also identified a need and a solution to control the extract air temperature to an optimal temperature for the CO₂ refrigeration process. This regulation can be made by:

- 30 a) using different heat recovery systems/heat exchangers, PHE, RHE or RAC;
b) by configuring heat exchangers in series with the CO₂ based refrigeration processes, such as the gas cooler will maintain its optimal temperature, or at least stay within an optimal temperature range for continued operation;
c) by opening a by-pass channel for outdoor air and supply air flow it is possible to control the
35 air temperature at the gas cooler inlet; and
d) by with a rotary heat exchanger, vary and optimize the revolution speed RPM of the rotary heat exchanger.

e) for a run-around-coil system for heat-recovery, the efficiency of the heat-recovery process can be controlled using:

- i. a variable speed drive (VSD), on pump, and/or fans if any.
- ii. an electrical circuit for RPM control of the electrical motor driving a pump, or fan if any.
- iii. Actuated dampers to modulate the airflow around the RAC coils, or a regulated bypass duct.

[0041] The mentioned regulation techniques, makes it possible to control and optimize the air temperature at the gas cooler inlet within preferred range.

10 Advantageous effects of invention

[0042] The invention provides an Air Handling Unit with or without ECU 50 with embodiments for PHE, RHE and RAC; and an HVAC system 20 using an environmentally friendly CO₂ based solution R744 with optimized function for cooling indoor climate of buildings using extract air from the building at the gas cooler inlet, resulting in stable and favorable conditions even when outdoor climate and sun-radiation changes during a day, hour, or over a longer time, especially during hot summer days when outdoor air reaches temperatures not feasible for an outdoor placed gas cooler.

[0043] The efficiency of the First coil 703 acting as condenser (subcritical) or gas cooler (transcritical), emitting heat to the air flow, depends on the extract air temperature, as sensed by the First coil air inlet temperature sensor T 801, entering the First coil, reversible heat exchanger extract air 703. The desired temperature range 802 is much more sensitive in a high-pressure CO₂ condenser (subcritical) or gas cooler (transcritical), than in a conventional cooling system for example using HFC/HFO refrigerants. Hence, the usage of extract air flow 23 for cooling the First coil, reversible heat exchanger extract air 703, and adjustable control of the PHE 102, RHE 302 and RAC 502 heat exchanging properties ensures temperature stability resulting in an improved cooling process stability, precision, energy efficiency and cooling performance.

[0044] Yet another advantage of the invention is the same ECU 800 control function, which not need to be implemented as a single HW ECU 810, a compute, a PID regulator, or even a Convolutional Neural Network (CNN), or Field Programmable Gate Array (FPGA), but may also be configured as a technical solution made from hardware connections, thus eliminating the need for an ECU HW 810.

[0045] As the ECU 800 is configured to receive an optional System configuration 812 file, defining, and representing configuration data for the different mechanical and electrical embodiments represented by the heat exchanger mechanism; PHE, RHE, and RAC; and the first aspect of the configuration equipped with either:

- a) an integrated cooling and heating block with CO₂ 700, or
- b) the advanced integrated cooling and heating block with CO₂ pressure optimization 750.

A second aspect of the configuration is the location of the First coil air inlet temperature sensor T 801 sensing the extract air stream 23 temperature collocated with First coil, reversible heat exchanger extract air 703 in relation to the Extract Air stream 23, and heat exchanger function PHE, RHE, or RAC.

- 5 c) the AHU is configured connect the extract air stream 23 channel, with the First coil air inlet temperature sensor T 801, and the First coil 703, followed by the heat exchanger function PHE 100, 150; RHE 300, 350; or RAC 500, 550; or
- d) the AHU is configured connect the extract air stream 23 channel, with the heat exchanger function PHE 200, 250; RHE 400, 450; or RAC 600, 650; followed by
- 10 the First coil air inlet temperature sensor T 801, and the First coil 703.

This configuration enables optimization and heating or cooling of the extract air stream 23 temperature passing an efficiency-controlled heat exchanger function, to maintain a preferred or set optimal target range for temperature sensor T. The efficiency control of the heat exchanger may be adjusted using: a bypass damper and channel for the PHE 200, 250; by RPM control of

15 the rotary RHE 400, 450; and by fluid flow control at a RAC 600, 650.

[0046] A third aspect of the invention is if a separate Extract air room/building temperature sensor 803, is present and in use in the configuration, typically an AHU 200, 250, 400, 450, 600, 650 with a configuration enabling optimization using an adjustable heat exchanger as mentioned above. With the Extract air room/building temperature sensor 803, present and First

20 coil air inlet temperature sensor T 801; the ECU and method determines the temperature difference achieved when while adjusting the heat exchanger efficiency, for usage in optimization and air temperature control of air reaching First coil air inlet temperature sensor T 801, before reaching the First coil 703.

[0047] A fourth aspect is the settings for optimal target range for sensor T 802 is available

25 in the configuration. If the setting of optimal target range for sensor T 802 is available, then it may override an earlier set desired air temperature range at First coil 703, as sensed by the First coil air inlet temperature sensor T 801.

[0048] A fifth aspect, is if the learning function 805 should be activated. When the learning function is activated with method step S4000, it (usually the ECU 800) will use collected

30 historical sensor data, and actuator outputs, to determine and optimize for an improved regulation control loop at step S2000.

[0049] Optimization can be achieved using Extended Kalman Filter (EKF), Kalman filter, a control equation, a look-up table, adjustment of a PID regulator, and even using convolutional neural networks (CNN).

35 [0050] A typical learning situation occurs when previous regulation of a heat exchanger function efficiency for a PHF, RHE, or RAC did not result in a sufficient regulation to maintain a desired temperature range at First coil air inlet temperature sensor T 801. The learning function 805 may then adjust the control algorithm or mechanism such that future similar fault situations can be avoided. Likewise, an optimization towards optimal energy efficiency is also possible.

[0051] As the System configuration 812 file, depicted in Fig. 17, provides configuration data, it is possible to use the same ECU to control all embodiments and all aspects of the "Air Handling Unit (AHU) with or without an ECU 50". The system configuration file may define how to adjust an AHU with PHE as one embodiment 100, 150, 200, 250; with a first aspect defining the location of the First coil 703 with temperature sensor 801, in relation to the heat exchanger function and extract air stream 23 channel. A second aspect is the usage of: an integrated cooling and heating block with CO₂ 700; or an advanced integrated cooling and heating block with CO₂ pressure optimization 750.

[0052] Also, variations in hardware and configurations of AHU may require minor pre-adjustments of the determination function, also possibly when regulating heat exchanger control parameters, to fit the actual mechanical configuration, as well as efficiency of circulation fluid at a RAC.

[0053] It has been mentioned that a too high temperature at the gas cooler could interfere with the integrated cooling and heating block with CO₂ 700; or an advanced integrated cooling and heating block with CO₂ pressure optimization 750

Brief description of the drawings

[0054] The invention is described, by way of example, with reference to the accompanying figures as follows.

Air handling unit (AHU) with cross/counter flow plate heat exchanger (PHE)

[0055] Fig. 1: Illustrates, an Air handling unit (AHU) with ECU 100, controlled by an ECU 800 with temperature sensor 801, with an Air handling unit (AHU) 101 mechanical unit designed to receive extract air 23 via a First coil air inlet temperature sensor T 801, to a First coil 703, a reversible heat exchanger for extract air, of an integrated cooling and heating block with CO₂ 700, and then a cross/counter flow plate heat exchanger PHE 102.

[0056] Fig. 2: Illustrates, an Air handling unit (AHU) 150, controlled by an ECU 800 with temperature sensor 801, with an Air handling unit (AHU) 151 designed to receive extract air 23 via a First coil air inlet temperature sensor T 801, to a First coil, reversible heat exchanger extract air 703 of an advanced integrated cooling and heating block with CO₂ pressure optimization 750, and then a cross/counter flow plate heat exchanger PHE 102.

[0057] Fig. 3: Illustrates, an Air handling unit (AHU) 200, controlled by an ECU 800 with temperature sensor 801, with and Air handling unit (AHU) 201 designed to receive extract air 23 to an extract air room/building temperature sensor T_i 803, further to a cross/counter flow plate heat exchanger PHE 102, then to

a First coil air inlet temperature sensor T 801, and then to
 a First coil, reversible heat exchanger extract air 703 of
 an integrated cooling and heating block with CO₂ 700.

[0058] Fig. 4: Illustrates, an Air handling unit (AHU) 250,
 5 controlled by an ECU 800 with temperature sensor 801, with
 and Air handling system (AHU) 251 designed to receive extract air 23 to,
 an extract air room/building temperature sensor T_i 803, further to
 a cross/counter flow plate heat exchanger PHE 102, then to
 a First coil air inlet temperature sensor T 801, and then to
 10 a First coil, reversible heat exchanger extract air 703 of
 an advanced integrated cooling and heating block with CO₂ pressure optimization 750.

HVAC, and AHU with rotary heat exchanger (RHE)

[0059] Fig. 5: Illustrates, an Air handling unit (AHU) 300,
 15 controlled by an ECU 800 with temperature sensor 801, with
 an Air handling system (AHU) 301 designed to receive extract air 23 via
 a First coil air inlet temperature sensor T 801, to
 a First coil, reversible heat exchanger extract air 703 of
 an integrated cooling and heating block with CO₂ 700, and then
 20 a Rotary heat exchanger (RHE) 302.

[0060] Fig. 6: Illustrates, an Air handling unit (AHU) 350,
 controlled by an ECU 800 with temperature sensor 801, with
 an Air handling system (AHU) 351 designed to receive extract air 23 via
 a First coil air inlet temperature sensor T 801, to
 25 a First coil, reversible heat exchanger extract air 703 of
 an advanced integrated cooling and heating block with CO₂ pressure optimization 750, and then
 a Rotary heat exchanger (RHE) 302.

[0061] Fig. 7: Illustrates, an Air handling unit (AHU) 400,
 controlled by an ECU 800 with temperature sensor 801, with
 30 and Air handling system (AHU) 401 designed to receive extract air 23 to
 an extract air room/building temperature sensor T_i 803, further to
 a Rotary heat exchanger (RHE) 302, then to
 a First coil air inlet temperature sensor T 801, and then to
 a First coil, reversible heat exchanger extract air 703 of
 35 an integrated cooling and heating block with CO₂ 700.

[0062] Fig. 8: Illustrates, an Air handling unit (AHU) 450,
 controlled by an ECU 800 with temperature sensor 801, with
 and Air handling system (AHU) 451 designed to receive extract air 23 to
 an extract air room/building temperature sensor T_i 803, further to

a Rotary heat exchanger (RHE) 302, then to
 a First coil air inlet temperature sensor T 801, and then to
 a First coil, reversible heat exchanger extract air 703 of
 an advanced integrated cooling and heating block with CO₂ pressure optimization 750.

5 HVAC, and AHU with run-around-coil (RAC), heat exchange function

[0063] Fig. 9: Illustrates, an Air handling unit (AHU) 500,
 controlled by an ECU 800 with temperature sensor 801, with
 an Air handling system (AHU) 501 designed to receive extract air 23 via
 10 a First coil air inlet temperature sensor T 801, to
 a First coil, reversible heat exchanger extract air 703 of
 an integrated cooling and heating block with CO₂ 700, and then a Run-around-coil (RAC)
 system 502.

[0064] Fig. 10: Illustrates, an Air handling unit (AHU) 550,
 15 controlled by an ECU 800 with temperature sensor 801, with
 an Air handling system (AHU) 551 designed to receive extract air 23 via
 a First coil air inlet temperature sensor T 801, to
 a First coil, reversible heat exchanger extract air 703 of
 an advanced integrated cooling and heating block with CO₂ pressure optimization 750, and then
 20 a Run-around-coil (RAC) system 502.

[0065] Fig. 11: Illustrates, an Air handling unit (AHU) 600,
 controlled by an ECU 800 with temperature sensor 801, with
 and Air handling system (AHU) 601 designed to receive extract air 23 to
 an extract air room/building temperature sensor T_i 803, further to
 25 a Run-around-coil (RAC) system 502, then to
 a First coil air inlet temperature sensor T 801, and then to
 a First coil, reversible heat exchanger extract air 703 of
 an integrated cooling and heating block with CO₂ 700.

[0066] Fig. 12: Illustrates, an Air handling unit (AHU) 650,
 30 controlled by an ECU 800 with temperature sensor 801, with
 and Air handling system (AHU) 651 designed to receive extract air 23 to
 an extract air room/building temperature sensor T_i 803, further to
 a Run-around-coil (RAC) system 502, then to
 a First coil air inlet temperature sensor T 801, and then to
 35 a First coil, reversible heat exchanger extract air 703 of
 an advanced integrated cooling and heating block with CO₂ pressure optimization 750.

Heating cooling and block with CO₂

[0067] Fig. 13a: Illustrates, an integrated cooling and heating block with CO₂ 700.

[0068] Fig. 13b: Illustrates, an advanced integrated cooling and heating block with CO₂ pressure optimization 750.

Building with HVAC System including Air handling unit

[0069] Fig. 14a: Illustrates, a Building 900 with Air handling unit mounted inside building.

- 5 [0070] Fig. 14b: Illustrates, a Building 900' with Air handling unit mounted at least partly outside a building.

Electronic Control Unit (ECU) and methods for AHU control:

- [0071] Fig. 15: Illustrates, the components of the Electronic Control Unit (ECU) 800, that executes the optimization of the extract airflow temperature adjustment needed, using a
10 Determination Function 804, that calculates adjustment needs, of the plate heat exchanger, rotary heat exchanger or RAC performance, as a Control signal for heat exchange efficiency 806.

[0072] Fig. 16: Illustrates, method steps for optimization of the extract airflow temperature adjustment.

- 15 System hierarchy and AHU embodiments with AHU configuration aspects

[0073] Fig. 17: Illustrates, the hierarchy of systems and sub-systems, starting with the Building with HVAC System 900, which includes at least one HVAC System 20. The HVAC System 20 comprises at least one Air Handling Unit (AHU) 50 with or without any ECU 800.

20 **Description of embodiments**

System hierarchy

[0074] Figure 17 visualizes the system hierarchy including:

- a Building with HVAC system;
- an HVAC System comprising an AHU;
- 25 - an Air Handling Unit (AHU) comprising a CO₂ Refrigerant circuit, and an ECU and;
- a CO₂ Refrigerant circuit, and
- the Electronic Control Unit (ECU) configured for controlling one or several AHU:s.

- [0075] As mentioned, Fig. 17: Illustrates, the hierarchy of systems and sub-systems, starting with the Building with HVAC System 900, which includes at least one HVAC System 20.
30 The HVAC System 20 comprises at least one Air Handling Unit (AHU) 50 with or without any ECU 800. The AHU exists as three different embodiments based on their heat exchange function PHE 100, 150, 200, 250; RHE 300, 350, 400, 450; and RAC 500, 550, 600, 650.

- [0076] A first aspect of the AHU is the selection of configuration defining how the extract air stream 23, with channel, flows and connects with the First coil 703 and the heat exchanger
35 function. According to the first aspect the First coil 703 may be placed between extract air 23 and the heat exchanger function: a PHE as in 100, and 150; a RHE as in 300 and 350; or a

RAC as in 500 and 550. Alternatively, that the heat exchanger function: a PHE as in 200, and 250; a RHE as in 400 and 450; or a RAC as in 600 and 650 is placed in between extract air stream 23, with channel and the First coil 703.

- The later typically makes use of an ECU for optimization of the heat recovery function in the
- 5 PHE 200, 250 by opening/closing and adjusting a by-pass channel; or regulating the RPM of an RHE 400, 450; alternatively regulating the fluid circulation of a RAC 600, 650.

- According to a second aspect, the AHU may be provided with an integrated cooling and heating block with CO₂ 700; or with an advanced integrated cooling and heating block with CO₂
- 10 pressure optimization 750.

Three AHU embodiments differentiated by type of heat exchange function

- [0077] All HVAC systems use extract air flow 23 to cool the First coil, reversible heat exchanger extract air 703, either before or after the air flow passes the heat exchanger
- 15 mechanism PHE, RHE, and RAC. The HVAC system's ECU 800, equipped with at least the extract air temperature sensor T 801, and optionally the Extract air room/building temperature sensor Ti 803, and an input/definition of desired reference temperature range 802, if provided. The ECU 800 controls the heat exchange mechanism efficiency to reach a desired temperature range 802, at the extract air temperature sensor T 801, to optimize the efficiency of the CO₂
- 20 Refrigeration circuit, in use. The Control signal for heat exchange efficiency 806 can be implemented without an ECU, while some control logics will be needed, implemented as: electrical, mechanical, and/or fluid mechanical implemented; to steer the optimization control of actuators.

- [0078] Referring to Fig. 17, the 12 different HVAC systems configurations can be
- 25 summarized as the following variants and embodiments:

PHE = 100, 150, 200, 250;
RHE = 300, 350, 400, 450;
RAC = 500, 550, 600, 650.

- [0079] Another aspect of each of the mentioned AHU embodiments PHE, RHE, and RAC,
- 30 may be provided with the following two major alternative mechanical configurations:

- a) Extract air 23 flows first to the Extract Air Temperature Sensor T 801, and then to the First coil, 703 then to the Heat Exchanger 102, 302, 502
- b) Extract air 23 flows first to the Heat Exchanger 102, 302, 502 and then to
- 35 the First coil, 703; with the Extract Air Temperature Sensor T 801.

[0080] Another aspect is that each of the mentioned AHU embodiments PHE, RHE, and RAC, may further be equipped with:

- x) an integrated cooling and heating block with CO₂ with reference sign 700, or

y) an advanced integrated cooling and heating block with CO₂ pressure optimization with reference sign 750.

[0081] Figure 17, presents a table of all three Air handling unit (AHU) embodiments: PHE, RHE, and RAC; with aspects of the invention indicated by reference sign 51.

- 5
- Some aspects of the inventions are visualized such as:
- i)
- the selection of location for the First Coil 703 in relation to the heat exchanger function, and
- extract air stream channel 23;
- ii)
- the selection of CO₂ Refrigeration circuit, such as with or without pressure
- 10 optimization.

Extract air flows first to...	Type of CO ₂ Refrigeration circuit	PHE	RHE	RAC
First coil 703, and then to, Heat exchanging function (PHE 102, RHE 302, RAC 502)	<u>Integrated</u> cooling and heating block with CO ₂ 700	100	300	500
	<u>Advanced integrated</u> cooling and heating block with CO ₂ pressure optimization 750	150	350	550
Heat exchanging function (PHE 102, RHE 302, RAC 502) and then to First coil 703	<u>Integrated</u> cooling and heating block with CO ₂ 700	200	400	600
	<u>Advanced integrated</u> cooling and heating block with CO ₂ pressure optimization 750	250	450	650

AHU with cross/counter flow plate heat exchanger (PHE)

15

[0082] Fig. 1. Illustrates an Air Handling Unit (AHU) 50, more specifically AHU 100; which is feasible as an element in a HVAC system 20. The Air handling unit comprises an integrated cooling/heating Air Handling Unit (AHU) (101). Each AHU includes a CO₂ (R744) refrigerant circuits 700, for circulating CO₂ (R744) for cooling and heating purposes, with heat exchangers/gas cooler, denoted First Coil 703, and Second Coil 702.

The ECU 800 defines the control function and logic for the optimization method for ensuring an optimal temperature range as Extract Air Temperature sensor T 801, at the air inlet to the First

20 coil 703 of the CO₂ (R744) refrigerant circuits 700. HVAC system 20, is usually placed inside a building 900, or at least partly outside of a building 900', as described in Fig 14a and 14b.

[0083] The Air Handling Unit (50; 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650) can be described as comprising a mechanical design comprising

an outdoor air stream channel 21

25 a supply air stream channel 22;

an extract air stream channel 23;

an exhaust air stream channel 24; and

an heat exchanger function 52 of type:

a cross/counter flow plate heat exchanger PHE 102,

30 a rotary heat exchanger RHE 302, or

a run-around-coil RAC 502;

an CO₂ (R744) refrigerant circuit 760 without 700, or with pressure optimization 750.

The CO₂ (R744) refrigerant circuit is comprising

a first coil 703 placed between:

5 the extract air stream channel 23 and the exhaust air stream channel 24; and

a second coil 702 placed between a second side of the heat exchanger function 52

and the supply air stream channel 22.

The CO₂ (R744) refrigerant circuit 760, 700, 750 is

10 configured for heat transferring between the a first coil 703 the second coil 702; and may operation in both directions, but for the challenging problem for cooling the building, the second coil 702 located at the supply air stream channel 22, transfers heat to the first coil 703 located in the extract air stream channel 23, or down-streams at the exhaust air stream channel 24.

Hence, the first coil 703 is configured for heat exchange with an airstream from

15 the extract air stream channel 23, such as air received, via the extract air stream 23, from the inside a building 900.

[0084] Air handling unit (AHU) 100,

controlled by an ECU 800 with temperature sensor 801, with

an Air handling unit (AHU) 101 designed to receive extract air 23 via

a First coil air inlet temperature sensor T 801, to

20 a First coil, reversible heat exchanger extract air 703 of

an integrated cooling and heating block with CO₂ 700, and then a cross/counter flow plate heat exchanger PHE 102.

[0085] The Air handling unit (AHU) designed to receive extract air 23 is usually configured with a First coil air inlet temperature sensor T 801 actually being a part of the ECU 800 sub-system. The First coil 703, is a reversible heat exchanger for extract air from the extract air stream channel 23.

25 The First coil 703 is also a part of the integrated cooling and heating block with CO₂ 700, or pressure optimized version 750.

[0086] Furthermore, in Fig. 1 the AHU is equipped with a cross/counter flow plate heat

30 exchanger PHE 102. The AHU is preferably provided with a first fan 112, to propel the supply air stream 22; and a second fan 114, to propel the extract air stream 23; though the propelling mechanism can be different but with similar function.

[0087] To be able to adjust the heat transfer efficiency of the PHE, the AHU 100-250 may be provided with an actuated bypass damper 53 that can open at least partly to let air pass

35 beside the PHE thru a separate channel, or a Cross/Counter flow plate heat exchanger damper control 103, that can be used to adjust the efficiency of the PHE heat exchange function.

[0088] Air handling unit (AHU) 150,

controlled by an ECU 800 with temperature sensor 801, with

an Air handling unit (AHU) 151 designed to receive extract air 23 via

a First coil air inlet temperature sensor T 801, to
a First coil, reversible heat exchanger extract air 703 of
an advanced integrated cooling and heating block with CO₂ pressure optimization 750, and then
a cross/counter flow plate heat exchanger PHE 102.

- 5 [0089] Air handling unit (AHU) 200,
controlled by an ECU 800 with temperature sensor 801, with
and Air handling unit (AHU) 201 designed to receive extract air 23 to
an extract air room/building temperature sensor T_i 803, further to
a cross/counter flow plate heat exchanger PHE 102, then to
10 a First coil air inlet temperature sensor T 801, and then to
a First coil, reversible heat exchanger extract air 703 of
an integrated cooling and heating block with CO₂ 700.

- [0090] Both the previous AHU 200 and the following AHU 250, includes cooling-recovery
and temperature optimization and control for the First coil 703, using an actuator to control a
15 bypass damper and channel for the PHE 102.

- [0091] Air handling unit (AHU) 250,
controlled by an ECU 800 with temperature sensor 801, with
and Air handling unit (AHU) 251 designed to receive extract air 23 to,
an extract air room/building temperature sensor T_i 803, further to
20 a cross/counter flow plate heat exchanger PHE 102, then to
a First coil air inlet temperature sensor T 801, and then to
a First coil, reversible heat exchanger extract air 703 of
an advanced integrated cooling and heating block with CO₂ pressure optimization 750.

AHU with rotary heat exchanger (RHE)

- 25 [0092] Air handling unit (AHU) 300,
controlled by an ECU 800 with temperature sensor 801, with
an Air handling unit (AHU) 301 designed to receive extract air 23 via
a First coil air inlet temperature sensor T 801, to
a First coil, reversible heat exchanger extract air 703 of
30 an integrated cooling and heating block with CO₂ 700, and then
a Rotary heat exchanger (RHE) 302.

- [0093] To be able to adjust the heat transfer efficiency of the AHU 300-450, the RHE may
be provided with a rotary heat exchanger (RHE) revolution per minute (RPM) control 303.
The AHU 300-450 may also be combined with a damper function actuator 53 to control the air
35 flow via the RHE or to pass beside the RHE, to further regulate the efficiency of the heat
exchange function.

- [0094] Air handling unit (AHU) 350,
controlled by an ECU 800 with temperature sensor 801, with

an Air handling unit (AHU) 351 designed to receive extract air 23 via
a First coil air inlet temperature sensor T 801, to
a First coil, reversible heat exchanger extract air 703 of
an advanced integrated cooling and heating block with CO₂ pressure optimization 750, and then
5 a Rotary heat exchanger (RHE) 302.

[0095] Air handling unit (AHU) 400,
controlled by an ECU 800 with temperature sensor 801, with
and Air handling unit (AHU) 401 designed to receive extract air 23 to
an extract air room/building temperature sensor T_i 803, further to
10 a Rotary heat exchanger (RHE) 302, then to
a First coil air inlet temperature sensor T 801, and then to
a First coil, reversible heat exchanger extract air 703 of
an integrated cooling and heating block with CO₂ 700.

[0096] Both the previous AHU 400 and the following AHU 450, includes cooling-recovery
15 and temperature optimization and control for the First coil 703; using adjustment of the RPM of
the RHE.

[0097] Air handling unit (AHU) 450,
controlled by an ECU 800 with temperature sensor 801, with
and Air handling unit (AHU) 451 designed to receive extract air 23 to
20 an extract air room/building temperature sensor T_i 803, further to
a Rotary heat exchanger (RHE) 302, then to
a First coil air inlet temperature sensor T 801, and then to
a First coil, reversible heat exchanger extract air 703 of
an advanced integrated cooling and heating block with CO₂ pressure optimization 750.

25 AHU with run-around-coil (RAC), heat exchange function

[0098] Air handling unit (AHU) 500,
controlled by an ECU 800 with temperature sensor 801, with
an Air handling unit (AHU) 501 designed to receive extract air 23 via
30 a First coil air inlet temperature sensor T 801, to
a First coil, reversible heat exchanger extract air 703 of
an integrated cooling and heating block with CO₂ 700, and then
a Run-around-coil (RAC) system 502.

[0099] To be able to adjust the heat transfer efficiency in the AHU 500-650 for the RAC
35 heat transfer function, a Run-around-coil (RAC) system fluid flow control actuator 503, can
adjust the efficiency of the RAC heat transfer exchange function by changing its fluid circulation
speed at its circulation pump, or using a circulation control valve. A bypass damper 53 may also
be used to control the air flow around or thru the RAC coils.

[00100] Air handling unit (AHU) 550,
controlled by an ECU 800 with temperature sensor 801, with
an Air handling unit (AHU) 551 designed to receive extract air 23 via
a First coil air inlet temperature sensor T 801, to
5 a First coil, reversible heat exchanger extract air 703 of
an advanced integrated cooling and heating block with CO₂ pressure optimization 750, and then
a Run-around-coil (RAC) system 502.

[00101] Air handling unit (AHU) 600,
controlled by an ECU 800 with temperature sensor 801, with
10 and Air handling unit (AHU) 601 designed to receive extract air 23 to
an extract air room/building temperature sensor T_i 803, further to
a Run-around-coil (RAC) system 502, then to
a First coil air inlet temperature sensor T 801, and then to
a First coil, reversible heat exchanger extract air 703 of
15 an integrated cooling and heating block with CO₂ 700.

[00102] Both the previous AHU 600 and the following AHU 650, includes cooling-recovery
and temperature optimization and control for the First coil 703, using adjustment of circulation
flow regulation of the RAC system 502.

[00103] Air handling unit (AHU) 650,
20 controlled by an ECU 800 with temperature sensor 801, with
and Air handling unit (AHU) 651 designed to receive extract air 23 to
an extract air room/building temperature sensor T_i 803, further to
a Run-around-coil (RAC) system 502, then to
a First coil air inlet temperature sensor T 801, and then to
25 a First coil, reversible heat exchanger extract air 703 of
an advanced integrated cooling and heating block with CO₂ pressure optimization 750.

Air handling unit with new features

[00104] The Air Handling Units (50; 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600,
650) are all proving the feature that a First coil 703 is placed in the air flow from an extract air
30 stream channel 23 for connection with the inside of a building, a room, or similar space
providing a less varying and less hot temperature than outdoor air, during hot days. In some
configuration the extract air is let to pass thru a heat exchanger function: a PHE, a RHE, or a
RAC system; to the First coil 703, and further into the exhaust air stream channel 24.

[00105] The Heating Mode, (HM) is not described here as its operation and should be
35 familiar to an HVAC system engineer. Likewise, the Electronic Control Unit (ECU) as described
later, may implement a method to switch between:
Cooling Mode(CM) according to the invention described, and Heating Mode (HM).

[00106] When the AHU includes cooling recovery and the system is in Cooling Mode, the optimization and control methods provided by the invention can be used to optimize how the Air Handling Unit's CO₂ (R744) refrigerant circuit 760, 700, 750 is coordinated with an adjustable heat exchange function 52. Examples of adjustable heat exchanged functions 52 are as follows:

- 5 - a cross/counter flow plate heat exchanger PHE 102 with adjustable actuated bypass-damper;
 - a rotary heat exchanger RHE 302 with RPM control.
 - a Run-around-coil (RAC) system 502, with coolant flow control.

[00107] A typical trigger for entering an optimized Cooling Mode is when the temperature of the air stream entering the first coil 703 is above an optimal value, a temperature that may be
 10 detected by an extract air stream channel temperature sensor 803, or a first coil inlet temperature sensor T 801.

[00108] The Air Handling Unit (AHU) 50; 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650 is typical comprising:

- 15 an outdoor air stream channel 21, as an air intake from outside of building;
 a supply air stream channel 22, for provisioning of an air stream into building or room;
 an extract air stream channel 23, for evacuation of used air from inside building or room;
 an exhaust air stream channel 24, for ejection of air from the AHU to outside of building;
 an heat exchanger function 52, for heat transfer between air streams into the building via channels 21, 22 and air streaming out of the building via channels 23, 34.

20 [00109] The Air Handling Unit (AHU) is usually provided with a fan to propel the air stream from outdoor to indoor thru channels 21, 22, and another fan, or same mechanism for propelling an air stream indoor to outdoor thru channels 23, 24; and heat exchanger function 52.

As the AHU may also be propelled by an external air stream generating mechanism, it is possible that the AHU does not have to include its own fans, or fan system.

25 Still, the Air Handling Unit (AHU) 50; 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650 may be provided with a fan, or fans to propel air thru its air flow channels 21, 22, 23, 24. Likewise, motors for circulation pumps, actuators, and drive motor for any RHE, are assumed to be present when needed.

[00110] The Heat exchanger function 52 comprises at least one of:

- 30 a cross/counter flow plate heat exchanger PHE 102,
 a rotary heat exchanger RHE 302, or
 a run-around-coil RAC 502;

which configurations' can be considered express different embodiments (PHE, RHE, RAC).

[00111] As such the heat exchanger function 52 provides a heat transfer mechanism with
 35 low energy consumption.

[00112] The AHU also provides an CO₂ (R744) refrigerant circuit 760, 700, 750 comprising a first coil 703 placed between:

the extract air stream channel 23 and the exhaust air stream channel 24;

a second coil 702 placed between the heat exchanger function 52
and the supply air stream channel 22; and
a first coil air inlet temperature sensor T 801;
wherein the CO₂ (R744) refrigerant circuit 760, 700, 750 is
5 configured for heat transferring between
the first coil 703 and the second coil 702.

[00113] The CO₂ (R744) refrigerant circuit consumes power and transfers heat between its
first coil 703 and second coil 702, operating on the principles of thermodynamics, like traditional
CO₂ (R744) refrigeration systems. The first coil 703 and second coil 702 may operate in reverse
10 mode, thus offering both heating and cooling in different system modes.

[00114] The Air Handling Unit (AHU) 50; 100, 150, 200, 250; 300, 350, 400, 450; 500, 550,
600, 650 is specifically designed with
the first coil 703 configured for heat exchange with an airstream originating from
the extract air stream channel 23, such as air received from inside of a building 900; with the
15 purpose to use indoor air as air stream for the first coil 703.
This configuration has been found superior to placing the first coil in an air stream providing air
from the outside of the building, and also a better alternative to the traditional Air Conditioning
system configuration where the First coil 703 a gas cooler is placed outside the building with or
without a fan, to act as a heat sink.

[00115] A first aspect of the invention is that the AHU may be provided with two alternative
configurations of integrated cooling and heating block with CO₂, where the:
a) Air handling unit 100, 200, 300, 400, 500, 600 as specified in claim 2 may comprise
a CO₂ (R744) refrigerant circuit 760, being an integrated cooling and heating block
with CO₂ 700; alternatively
25 b) Air handling unit 150, 250; 350, 450; 550, 650 as specified in claim 3,
the CO₂ (R744) refrigerant circuit 760, being an advanced integrated cooling and
heating block with CO₂ pressure optimization 750.

[00116] A second aspect of the invention is where the First coil 703 is placed in the AHU in
relation to the heat exchanger functions 52. The following alternatives exists:

30 a) An Air handling unit 100, 150; 300, 350; 500, 550 as described in claim 4, where
the first coil 703 is placed between:
the extract air stream channel 23 and the heat exchanger function 52.

This can be alternatively expressed as, an Air handling unit 100, 150, 300, 350, 500,
35 550 as specified in claim 5, designed to:
receive extract air via the extract air stream channel 23 via
the First coil air inlet temperature sensor T 801, to
the First coil 703, and then to
a heat exchanger function 52 such as:

a cross/counter flow plate heat exchanger PHE 102,
a rotary heat exchanger RHE 302, or
a run-around-coil RAC 502.

Or alternatively:

- 5 b) An Air handling unit 200, 250, 400, 450, 600, 650 as described by claim 6, where
the first coil 703 is placed between:
the heat exchanger function 52 and the exhaust air stream channel 24.

10 This can be alternatively expressed as, an Air handling unit 200, 250; 400, 450; 600,
650 for cooling recovery, as specified in claim 7; designed to:
receive extract air via extract air stream channel (23), to
an extract air room/building temperature sensor T_i 803, further to
the heat exchanger function 52, such as:
a cross/counter flow plate heat exchanger PHE 102,
15 a rotary heat exchanger RHE 302, or
a run-around-coil RAC 502;
and then to
the First coil air inlet temperature sensor T 801; and
further to
20 the First coil 703.

[00117] As mentioned, the Air handling unit can be expressed as three different
embodiments, which could also be seen as aspects being variants or configurations supported.
For example, the ECU 800 and methods according to claims 18-22 may support all types of Air
handling unit configurations mentioned for the (AHU) 50; 100, 150, 200, 250; 300, 350, 400,
25 450; 500, 550, 600, 650.

[00118] According to a first embodiment, the Air handling unit 100, 150, 200, 250 as
described in claim 8, comprises a heat exchanger function 52 being:
a cross/counter flow plate heat exchanger (PHE) 102.

[00119] The mentioned embodiment an air handling unit 100, 150, 200, 250 as described in
30 claim 11 may further comprise an actuated bypass damper 53, designed to:
when open let at least a fraction or the complete air flow bypass the heat exchanger function 52;
and when closed let the air flow pass the heat exchanger function, a PHE 102, offering an
adjustable heat transfer efficiency.

[00120] According to a second embodiment, the An Air handling unit 300, 350, 400, 450 as
35 described in claim 9 comprises a heat exchanger function 52 being:
a Rotary Heat exchanger (RHE) 302. The RHE may be provide with a revolutions per minute
RPM control offering adjustable rotation speed, and heat transfer efficiency.

[00121] According to a third embodiment, the Air handling unit (500, 550, 600, 650) as described in claim 10, comprises a heat exchanger function (52) being:
a Run-around-coil (RAC) system 502. Furthermore, the RAC system may be provided with a flow regulator for its fluid, typically a valve, or circulation motor control, offering adjustable heat transfer efficiency.

[00122] In a configuration of the Air handling unit 200; 250; 400, 450; 600, 650 as specified in claim 12, the AHU is further comprising:
an extract air room/building temperature sensor 803, configured to receive the extract air room/building temperature sensor 803 value.

[00123] Mentioned configuration, lets methods and the ECU estimate the difference at the temperature of extract air, compared to temperature at the First coil 703, sensed with the first coil air inlet temperature sensors 801. The information is then used by the determination function 804, to determine an adjustment of control signal 806, for adjustment of the heat transfer efficiency at the PHE 102, RHE 302, and RAC system 502.

[00124] As mentioned earlier, the heat transfer efficiency at the heat exchanger can be regulated or adjusted using:
a) an actuator for a bypass damper at a PHE 102,
b) an RPM control at a RHE 302, and/or
c) a circulation flow control, an actuated circulation valve or circulation motor control, at a RAC system 502.

Electronic Control Unit (ECU) and methods for AHU control:

[00125] Fig. 15: Illustrates, the components of the Electronic Control Unit (ECU) 800, that executes the optimization of the extract airflow temperature adjustment needed, using a Determination Function 804, that calculates adjustment needs, of the heat exchanger or RAC performance, as a Control signal for heat exchange efficiency 806. The Control signal for heat exchange efficiency 806, controls the heat exchanger performance using one of the following devices depending on the system configuration:
a) Actuator for damper of bypass channel for PHE;
b) Regulator for rotation speed of RHE; and
c) Regulator for liquid flow of RAC,

[00126] Fig. 16: Illustrates, method steps for optimization of the extract airflow temperature adjustment, by first S2000 Determining adjustment need for AHU heat exchanger efficiency to reach optimal air temperature before gas cooler/condenser. By in S3000 Regulating heat exchanger efficiency control parameters, by different sub-steps such as:
a) S3100 Regulating rotation speed of RHE,
b) S3200 Regulating damper of bypass channel for PHE, or
c) S3300 Regulating liquid flow of RAC.

[00127] Step S4000, Learning, and adjusting regulation loop in step S2000 based on regulation history; provides optimization of the regulation and control function in step S2000. This allows the system to adapt its control function to increase precision, speed of regulation, robustness against deviations from desired temperature rangers; and to adjust and calibrate regulation methods in step S3000.

[00128] The Electronic Control Unit (ECU) 800, is designed to control an Air handling unit (AHU) 50; 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650, as defined according to claim 1-12, and 17 where in the ECU is integrated with the AHU.

The ECU 800 is as a physical object comprising

10 an Electronic Control Unit hardware (ECU HW) 810,
for sensor data processing and optimization of AHU operation;
an interface to the First coil air inlet temperature sensor T 801 designed to
sense the temperature at the air inlet of the first coil 703;
an interface to the Extract air stream temperature sensor T_i 803 designed to
15 sense the temperature at the extract air stream 23 or
a temperature inside building 900, or room 900, or alternative building/room 900'.

[00129] The ECU 800 further comprises

a Determination function 804, implementing a regulation control function, designed:
to determine a Control signal for heat exchange efficiency 806
20 with at least input signal from:
the First coil air inlet temperature sensor T 801, and
the Extract air stream temperature sensor T_i 803, if present depending on AHU and ECU
configuration.

[00130] The determination function 804 is implemented

25 to control, and adjust, the AHU heat exchanger function efficiency,
to maintain, and reach, optimal air temperature at First coil 703,
that is within an optimal target range for sensor T 802 at
the First coil air inlet temperature sensor T 801.

[00131] The determination function 804 determines a control signal for heat exchange efficiency 806. This Control Signal 806 is then used as input to adjust the efficiency of the heat exchanger function (52), which is controlled, or adjusted, according to the Control signal for heat exchange efficiency (806), which is to regulate:

an actuator for damper of bypass channel for PHE (821),
a regulator for rotation speed of RHE (822), or
35 a regulator for liquid flow of RAC (823).

[00132] The ECU (800), as further described in claim 14, further comprises:
a Learning function (805) for feedback adjustment of the regulation function based on regulation history, in the Determination function (804). This learning function optimizes the control and optimization function of the ECU to optimize the air temperature reaching the first coil 703 inside

an AHU with adjustable heat exchange efficiency (806), able to regulate:

- an actuator for damper of bypass channel for PHE (821),
- a regulator for rotation speed of RHE (822), or
- a regulator for liquid flow of RAC (823).

5 [00133] In order to optimize the operation at First coil 703 at the AHU, the AHU needs to be of a configuration where the heat exchanger function separates the First coil 703 for placement between the heat exchanger function PHE 102, RHE 302, and/or 502, and the exhaust air stream channel 24 (AHU 200, 250, 400, 450, 600,650) . By adjusting the efficiency of the heat exchange function, it is made possible to control the actual temperature at First coil air inlet
10 temperature sensor T 801.

[00134] By using the indoor, see Fig 14a and 14b, extract air stream channel 23 temperature sensor 803, together with the First coil air inlet temperature sensor T 801, the determination function 804 is able to determine the actual temperature difference over the heat exchanger, as input for the optimization and regulation of the heat exchanger efficiency 806,
15 821, 822, and 823.

[00135] The ECU 800 may as further be described in claim 15, comprise:
a Setting for optimal target range for sensor T (802), and/or
a System configuration file (812), defining at least
one optimal temperature target range (802); for setting the default values, and to adjust
20 target temperature ranges at the First coil 703.

[00136] The First coil 703 is connected with the Second coil 702, for heat exchange. The Integrated cooling and heating block with CO₂ 700, or the Advanced integrated cooling and heating block with CO₂ pressure optimization 750; transfer heat to the First coil 703 from the Second coil 702 during cooling of the building and in the opposite direction when heating the
25 building and rooms.

[00137] Depending on weather, temperature sensors 801, 803, and/or setting of temperature range 802, as well as other sensor data such as pressure, cloud information such as weather data and weather predictions may be used for adjusting the behaviour and optimization of the Determination function 804, also implemented as method step S3000.

30 Integrated heating and cooling block with CO₂

[00138] Fig. 13a: Illustrates, an integrated cooling and heating block with CO₂ 700, a self-contained autonomous regulation process, typically integrated as provided from a manufacturer.

[00139] Fig. 13b: Illustrates, an advanced integrated cooling and heating block with CO₂ pressure optimization 750. The CO₂ pressure optimization is a self-contained autonomous regulation process, typically integrated as provided from a manufacturer. As pressure
35 optimization is provided, the determination method for regulating the efficiency of a heat exchanger function may have slightly different characteristics than for the non-pressure

optimized variant 700 found in Fig 13a. If the system is provided with a system configuration file, then this file may specify that the system ECU 800 and/or AHU 50, 100 ... 650 should optimize for usage with an advanced integrated cooling and heating block with CO₂ pressure optimization 750; or a more basic integrated cooling and heating block with CO₂ 700.

5 Air handling unit comprising an ECU

[00140] The Air handling unit (AHU) 50, 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650 is an AHU, integrated with an Electronic Control Unit (ECU) 800 as further specified in claim 17. The AHU then includes an ECU, locally or remotely such as a SaaS as described in claim 16. The AHU with ECU integrates:

- 10 an Electronic Control Unit (ECU) 800 according to claim 12-16 which is configured to control the Air handling unit 50, 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650.

The ECU is then configured to sense temperatures 801, 803 and desired temperature range 802, to determine a control signal 806 to adjust and control the AHU, equipped with cooling
15 recovery 50, 200, 250; 400, 450; 600, 650. By actuating a bypass damper for an AHU with PHE 200, 250, adjusting the RPM of an AHU with RHE 400, 450, and/or adjusting the circulation flow of an AHU with RAC 600, 650. As a result, the ECU senses, determines control signal 806 and adjusts/controls the heat exchange function's efficiency; to maintain and ensure an optimal temperature at First coil air inlet temperature sensor T 801.

- 20 Both temperature sensors 801, 803 may be used when determining 804 the adjustment needs, the control signal 806.

HVAC system integrated with building

[00141] The HVAC system 20 comprising an AHU 50 with or without an ECU 800 may be integrated with a building 900, either inside or at least partly outside the building 900'. AC
25 systems are usually equipped with a similar function as the First coil 703, the gas cooler located outside the building. In the invention, it has been recognized that a preferable place for the gas-cooler is in connection with the building's or room's extract air stream channel 23.

[00142] An HVAC system 20 according to claim 23, is comprising at least one Air handling unit (AHU) (50; 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650) according to claim
30 1-12 or 17, wherein the extract air stream channel (23) is connected to the inside of a building (900), vehicle, train, or ship.

[00143] Fig. 14a illustrates the AHU placed completely inside a building 900, meanwhile Fig. 14b shows an AHU that is at least partly placed outside a building 900', a common placement for Air Conditioning (AC) systems. The invention presented, contradicts the usage of using
35 outdoor air for the gas cooler, which is the First coil 703, by placing the First coil 703 in direct communication with indoor air passing thru the extract air stream channel 23.

[00144] Sun 904 radiation 905 and outdoor air 902 with high temperature possesses a challenge when cooling air using any of the cooling and heating block 760 with CO₂ aspects 700 and 750, as the first coil 703 is temperature sensitive for optimal operation when cooling the

building. Hence, the methods for the ECU, AHU and HVAC system are needed to ensure and maintain temperature 801 within the desirable temperature range 802.

Cooling and heating block with CO₂

[00145] In one aspect of the AHU, the cooling and heating block with CO₂ is:

- 5 a) an integrated cooling and heating block with CO₂ 700;
- b) advanced integrated cooling and heating block with CO₂ pressure optimization 750.

[00146] Fig. 13a: Illustrates, an integrated cooling and heating block with CO₂ 700.

[00147] Fig. 13b: Illustrates, an advanced integrated cooling and heating block with CO₂ pressure optimization 750.

- 10 [00148] Fig. 14a: Illustrates, a Building 900 with Air handling unit mounted inside building.

[00149] Fig. 14b: Illustrates, a Building 900' with Air handling unit mounted at least partly outside a building.

- 15 [00150] Fig. 15: Illustrates, the components of the Electronic Control Unit (ECU) 800, that executes the optimization of the extract airflow temperature adjustment needed, using a Determination Function 804, that calculates adjustment needs, of the heat exchanger or RAC performance, as a Control signal for heat exchange efficiency 806. The Control signal for heat exchange efficiency 806, controls the heat exchanger performance using one of the following devices depending on the system configuration:

- 20 a) Actuator for damper of bypass channel for PHE;
- b) Regulator for rotation speed of RHE; and
- c) Regulator for liquid flow of RAC, using RPM control of RAC circulation pump, or a flow regulation valve.

- 25 [00151] The ECU may be a computer with memory, an electronic circuit, an adaptive electronic circuit, a PID regulator, a Kalman filter or optionally any other adaptable control function that may be put in a feedback learning loop.

- [00152] Fig. 16: Illustrates, method steps for optimization of the extract airflow temperature adjustment, by first S2000 Determining adjustment need for AHU heat exchanger efficiency to reach optimal air temperature before gas cooler/condenser. By in S3000 Regulating heat exchanger efficiency control parameters, by different sub-steps such as:

- 30 a) S3100 Regulating rotation speed of RHE,
- b) S3200 Regulating damper of bypass channel for PHE;
- c) S3300 Regulating liquid flow of RAC.

- [00153] As historical data develops, step S4000 Learning, and adjusting regulation loop (in step S2000) based on regulation history; will update the optimization parameters used in the Determination step S2000.
- 35

[00154] In another embodiment, Step S4000 may be implemented in a cloud computing context, where multiple installed AHU:s is analyzed as a statistical material, before determining optimization parameters for each AHU in step S2000. Such a cloud service can make use of extrinsic parameters such as changed and expected weather conditions. Central execution of

5 Step S4000 allows for coordinated or uncoordinated pre-adjustment of multiple AHU:s and HVAC systems. As a central cloud or server-side processing function, the processing of Step S4000 can consider changes in weather and environmental, for example to get prepared for humid and cold weather conditions, as well as variations in heat, air pollution, and barometer pressure changes. Also, method steps, S2000, S3000 with sub-steps S3100, S3200, and

10 S3300, as well as step S1100 may all be executed and processed at a server-side or in a cloud computing environment.

[00155] Step S2000 Determining adjustment need, receives information from step S1000 Receiving temperature sensor data T; and optional information from step S1100 Setting optimal target range for sensor T; and optional information from step S1200 Receiving extract air

15 temperature for room/building.

Improvements to the cooling method

[00156] The control process is improved by introducing the following features.

[00157] To maximize cycle efficiency, the heat exchanger/gas cooler is placed in the extract air stream of the AHU. This design gives a considerable advantage in efficiency compared to

20 when in the past heat exchanger/gas coolers have been placed outdoors, which is problematic when reaching high outdoor temperatures.

[00158] As a first design step, as pictured in Fig 1, the CO₂ cycle can be used as simple refrigerant circuit without pressure optimization.

[00159] The inventors have recognized the opportunity to make use of the fact that buildings

25 during summer temperatures, are always lower indoors than at least warm outdoor temperatures.

[00160] The extract air temperature from the buildings can vary between 15-30°C when outdoor temperatures vary in the range of 20-40°C.

[00161] In heating mode low inlet temperature on the gas cooler/condenser is very beneficial

30 for system efficiency.

[00162] Placement of the extract air temperature sensor T_i (803) and air temperature sensor T (801) at the inlet to the gas cooler, provides for air temperature for extract air and air temperature at the inlet to the gas cooler. The air temperature T (801) is then used for optimization of maximum air temperature at the inlet to the gas cooler, feasible for partial, or

35 complete cooling recovery with PHE, RHE or RAC system during warm and hot summer conditions.

[00163] To regulate an optimal cooling process when temperature is reaching a maximum temperature setting; then the dampers in the PHE are controlled to hold and maintain air temperature at the inlet to the gas cooler on optimal values with high cycle efficiency.

[00164] To regulate an optimal cooling process when temperature is reaching a maximum temperature setting; then the RHE, rotary heat exchanger is controlled to ramping down, that is reducing its RPM, to hold and maintain air temperature at the inlet to the gas cooler on optimal values with high cycle efficiency.

[00165] To regulate an optimal cooling process when temperature is reaching a maximum temperature setting; then the liquid flow in the RAC system is controlled to hold and maintain air temperature at the inlet to the gas cooler on optimal values with high cycle efficiency.

[00166] If an AHU block with advanced CO₂ refrigerant circuit is used for the invention, then optimization can control and regulate, using extra expansion valves and flash receiver. It is recognized that such an embodiment can give higher circuit efficiency compared with simple CO₂ refrigerant circuits.

15 Methods for optimization of system efficiency and cycle

[00167] The following methods describes how to optimize and improve the cooling process, and indirectly the system efficiency of an AHU when configured for usage in a building, with access to indoor air, as cooling air for extraction thru the extract air stream channel 23.

20 [00168] The methods may be implemented and executed hardwired electronics in the AHU 50, 100, ... or preferably executed by the ECU 800, likely implemented as ECU software 811 for execution of control electronics, a computer, FPGA, micro-controller, an ECU HW 810.

[00169] Also, an ECU may be implemented as Software as a Service (SaaS) in a cloud or centrals server computer model. Such an EXCU may execute methods in the central computer or as a SaaS, while controlling one or multiple AHU:s from a remote location. Such a software execution would be equivalent to a local execution, while offering additional coordination opportunities. For example, changes in weather condition, temperature, pressure, rain/snow, clouds, can be used to improve the Learning functions as described further on in the document, as well as to provide input to an improved coordinated determination function (804).

30 [00170] The main method, is responsible for optimization of the cooling efficiency for an Air Handlings Unit (AHU) 200, 250; 400, 450; 600, 650 as further detailed in and described in claim 18,

The 1st method executes the following steps (S1000 to S3300)

35 (S1000)

Receiving first coil air inlet temperature from sensor T 801;

(S1100)

Receiving Extract air room/building temperature sensor Ti 803;

(S2000)

Determining adjustment needs 804 for the heat exchanger efficiency control parameters,

- 5 to reach and maintain an optimal transcritical or sub-critical refrigerant cycle,
 to ensure that First coil air inlet temperature sensor T 801, is regulated towards
 an optimal temperature range 802 for temperature sensor T,
 for the gas cooler of a transcritical or sub-critical carbon dioxide CO₂ cycle;

(S3000)

- 10 Regulating heat exchanger efficiency control parameters,
 using the Control signal for heat exchange efficiency (806) to adjust the performance of
 the at least one heat exchange functions by:
 (S3100) Regulating rotation speed (303) of rotary heat exchanger (302);
 (S3200) Regulating damper of bypass channel for cross/counter flow heat exchanger (102); or
 (S3300) Regulating liquid flow of run around coil system (RAC) (502), to reach efficient
 cooling recovery and maximal system efficiency.

A maximal system efficiency during cooling, is reached when the first coil air inlet temperature from sensor T 801 is maintained in the optimal temperature range 802.

- [00171] A 2nd method, as further detailed in claim 19, adds step (S1100) which precedes
 step (S2000). Step (S1100) is described as follows.

(S1100)

Setting optimal target temperature range (OTTR) 802 for temperature sensors T,
 such that step (S2000) is using the optimal target temperature range when determining
 adjustment need for heat exchanger efficiency.

- 25 [00172] A 3rd method as further detailed in claim 20, specifying a sub-step (S1200) which
 precedes step (S2000), wherein step (S1200) is comprising
 (S1200) Receiving extract air temperature from room/building Ti 803, such that step
 (S2000) is using the extract air temperature from room/building when determining 804
 adjustment need, that is Control signal for heat exchange efficiency 806 adjusting the heat
 exchanger efficiency.

- [00173] A 4th method as further defined in claim 21, uses an optimal temperature target
 range for temperature sensor T (802), set to between 15 Celsius and 40 Celsius, preferably
 between 20 to 32 Celsius. This temperature range has been found to be optimal for the cooling
 of First coil 703, while making optimal use of the heat exchanger function such as PHE 102,
 RHE 302, or RAC 502, in use for the actual AHU 50, 100, ... 650.

[00174] A 5th method as further defined in claim 22, describes how the learning step, for
 optimization of the determination step is processed. During the learning step (S4000), which
 follows step (S3000). Step (S4000) analyses and optimized parameters used the Determination
 step (S3000) such as, identifying a more preferred range for the optimal temperature target

- range for temperature sensor T 802. For example, if the determination function was found by analysing the history of input and outputs for the control, and have been found to not be able to sufficiently maintain the first coil air inlet temperature sensor T 801 within the optimal temperature range; then the responsiveness of the Determination regulation function can be re-
- 5 calibrated and adjusted to ensure future regulation stability to maintain the desired temperature. A person working with control systems would be familiar with a variety of technical solutions for this optimization, or Learning function. More sophisticated methods are possible, including Convolutional Neural Network (CNN) techniques, Kalman filtering with learning parameters, Tuneable PID regulators.
- 10 [00175] The step (S4000), Learning, is further comprising:
(S4000)
Learning, or feedback adjusting the regulation loop, to optimize control parameters for:
Step (S2000) Determining adjustment need for heat exchanger efficiency.

Reference Signs List

- [00176] Description of reference numbers used in drawings are defined as follows. First a figure reference number is specified, and then a short name of the item, arrow, flow of information or method step is presented, and in some cases also briefly described.
- 5 [00177] The complete system described here, is the "CO₂ refrigeration HVAC system", that is the: INTEGRATED COOLING/HEATING AIR HANDLING UNIT WITH OPTIMIZED CARBON DIOXIDE REFRIGERANT CIRCUIT USING RETURN AIR FROM THE BUILDING, with reference number 20.
- [00178] To avoid risks of mixing figure numbers with reference sign numbers, numbers 1-19
- 10 are omitted. Method steps are numbered as S1000, S2000, and on.
- 20= An HVAC system,
The HVAC system is typically installed in a building 900, the integrated cooling/heating air handling unit with carbon dioxide refrigerant circuit using return air from the building 900, is an HVAC system that optimizes cooling efficiency of its refrigerant circuit by first
- 15 using the indoor air as cooling media for the refrigerant circuit, as especially during hot seasons, the indoor air rarely reaches the high temperature as outdoor air does under sun 904 radiation 905. The HVAC system 20 also makes use of a control mechanism that asserts a feasible temperature range for the refrigerant circuit to operate with optimal efficiency. The HVAC system 20 also may be equipped with AHU:s with Plate
- 20 Heat Exchanger (PHE), Rotary Heat Exchanger (RHE), or Run-Around-Coil (RAC); in combination with simple refrigerant circuits 700, or advanced refrigerant circuits with pressure optimization 750; and may also be combined with a refrigerant circuit configuration that is located with its First coil, Reversible heat exchanger extract air 703
- 25 directly receiving the building's exhaust air 23, as in Air-Handling Units (AHU) and system variants 100, 150, 300, 350, 500, and 550; or alternatively configured such that the exhaust air passes through the heat exchanger PHE, RHE, RAC, before entering the refrigerant circuit's First coil, Reversible heat exchanger extract air 703; Which are exemplified in 200, 250, 400, 450, 600, and 650.
- 20'= Same as 20 but with AHU mounted placed at least partly outside of building 900'.
- 30 21= Outdoor air stream channel, at the AHU. Outdoor may also mean exterior to the AHU for example when placed on a ship, other vessel or structure having an inside and outside space, typically referring to outdoor air providing fresh air to the building.
- 22= Supply air stream channel, designed to supply air to the building, or room.
- 23= Extract air stream channel, connecting with the room or building for extraction of air
- 35 from the inside of the building.
- 24= Exhaust air stream channel, connects with the outside of a building to remove used air.
- 50= An Air handling unit according to the three Air handling unit embodiments with configuration aspects:
PHE: 100, 150, 200, 250;
- 40 RHE: 300, 350, 400, 450; and

- RAC: 500, 550, 600, 650.
- 50'= Any Air handling unit 50 mounted inside building, as an installation example for any Air handling unit:
PHE: 100, 150, 200, 250; RHE: 300, 350, 400, 450; and RAC: 500, 550, 600, 650.
- 5 50''= Any Air handling unit 50 mounted at least partly outside building, as an example installation for any other Air handling unit.
- 51= Table illustrating all the air handling unit embodiments PHE, RHE, and RAC; with:
a first aspect where the AHU is mechanically configured for:
a) extract airflow to First coil, and then the heat exchanging function; alternatively,
10 b) extract airflow to the heat exchanging function, and then to the First coil.
a second aspect where the AHU's Type of CO₂ Refrigeration circuit are:
c) Integrated cooling and heating block with CO₂ 700; and
d) Advanced integrated cooling and heating block with CO₂ pressure optimization 750
- 52= A heat exchanger function such as:
15 a Cross/Counter flow Plate Heat Exchanger PHE 102,
a Rotary Heat Exchanger RHE 302, or
a Run-Around-Coil RAC 502.
- 53= Bypass damper. If open, then air will flow around the heat exchanger function (52), typically a PHE 102. If closed, then the air will flow through the heat exchanger function
20 (52).
- 100= Air handling unit (AHU) controlled by an ECU 800 with First coil air inlet temperature sensor T 801.
The Air handling unit (AHU) comprises an Air handling unit mechanics 101, as follows.
The Air handling unit (AHU) 100 is designed to receive extract air 23 via
25 a First coil air inlet temperature sensor T 801, to
a First coil 703 of
an integrated cooling and heating block with CO₂ 700, and then a cross/counter flow plate heat exchanger PHE 102.
- 101= Air handling unit (AHU) mechanics comprises the following elements and is designed to
30 receive extract air 23 via
a First coil air inlet temperature sensor T 801, to
a First coil 703 of
an integrated cooling and heating block with CO₂ 700, and
then a cross/counter flow plate heat exchanger PHE 102.
- 35 102= Cross/Counter flow plate heat exchanger (PHE)
103= Cross/Counter flow plate heat exchanger damper control, that can be used to adjust the efficiency of the PHE heat exchange function. Same as 53.
- 112= First fan, for supply air stream.
114= Second fan, for the extract air stream.
- 40 150= Air handling unit (AHU), controlled by an ECU 800 with First coil air inlet temperature sensor T 801.
The Air handling unit (AHU) comprises an Air handling unit mechanics 151, as follows.

- The Air handling unit (AHU) 150 is designed to receive extract air 23 via
 a First coil air inlet temperature sensor T 801, to
 a First coil 703 of
 an advanced integrated cooling and heating block with CO₂ pressure optimization 750,
 and then a cross/counter flow plate heat exchanger PHE 102.
- 5 151= Air handling unit (AHU) mechanics comprises the following elements and is designed to
 receive extract air 23 via
 a First coil air inlet temperature sensor T 801, to
 a First coil 703 of
 10 an advanced integrated cooling and heating block with CO₂ pressure optimization 750,
 and then a cross/counter flow plate heat exchanger PHE 102.
- 200= Air handling unit (AHU), controlled by an ECU 800 with First coil air inlet temperature
 sensor T 801.
 The Air handling unit (AHU) comprises Air handling unit mechanics 201, as follows. The
 15 Air handling unit (AHU) 200 is designed to receive extract air 23 to
 an extract air room/building temperature sensor T_i 803, further to
 a cross/counter flow plate heat exchanger PHE 102, then to
 a First coil air inlet temperature sensor T 801, and then to
 a First coil 703 of
 20 an integrated cooling and heating block with CO₂ 700.
- 201= Air handling unit (AHU) mechanics comprises the following elements and is designed to
 receive extract air 23 to
 an extract air room/building temperature sensor T_i 803, further to
 a cross/counter flow plate heat exchanger PHE 102, then to
 25 a First coil air inlet temperature sensor T 801, and then to
 a First coil 703 of
 an integrated cooling and heating block with CO₂ 700.
- 250= Air handling unit (AHU), controlled by an ECU 800 with First coil air inlet temperature
 sensor T 801.
 The Air handling unit (AHU) comprises an Air handling unit mechanics 251, as follows.
 The Air handling unit (AHU) 250 is designed to receive extract air 23 to,
 an extract air room/building temperature sensor T_i 803, further to
 a cross/counter flow plate heat exchanger PHE 102, then to
 a First coil air inlet temperature sensor T 801, and then to
 35 a First coil 703 of
 an advanced integrated cooling and heating block with CO₂ pressure optimization 750.
- 251= Air handling unit (AHU) mechanics comprises the following elements and is designed to
 receive extract air 23 to
 an extract air room/building temperature sensor T_i 803, further to
 40 a cross/counter flow plate heat exchanger PHE 102, then to
 a First coil air inlet temperature sensor T 801, and then to
 a First coil 703 of

- an advanced integrated cooling and heating block with CO₂ pressure optimization 750.
- 300= Air handling unit (AHU), controlled by an ECU 800 with First coil air inlet temperature sensor T 801.
- The Air handling unit (AHU) comprises an Air handling unit mechanics 301, as follows.
- 5 The Air handling unit (AHU) 300 is designed to receive extract air 23 via
a First coil air inlet temperature sensor T 801, to a First coil 703 of
an integrated cooling and heating block with CO₂ 700, and then
a Rotary heat exchanger (RHE) 302.
- 301= Air handling unit (AHU) mechanics comprises the following elements and is designed to
10 receive extract air 23 via
a First coil air inlet temperature sensor T 801, to
a First coil 703 of
an integrated cooling and heating block with CO₂ 700, and then
a Rotary heat exchanger (RHE) 302.
- 15 302= Rotary heat exchanger (RHE).
- 303= Rotary heat exchanger (RHE) revolution per minute (RPM) control, that can be used to
adjust the efficiency of the RHE heat exchange function.
- 350= Air handling unit (AHU), controlled by an ECU 800 with First coil air inlet temperature
sensor T 801.
- 20 The Air handling unit (AHU) comprises an Air handling unit mechanics 351, as follows.
The Air handling system (AHU) 351 is designed to receive extract air 23 via
a First coil air inlet temperature sensor T 801, to
a First coil 703 of
an advanced integrated cooling and heating block with CO₂ pressure optimization 750,
25 and then a Rotary heat exchanger (RHE) 302.
- 351= Air handling unit (AHU) mechanics comprises the following elements and is designed to
receive extract air 23 via
a First coil air inlet temperature sensor T 801, to
a First coil 703 of
30 an advanced integrated cooling and heating block with CO₂ pressure optimization 750,
and then a Rotary heat exchanger (RHE) 302.
- 400= Air handling unit (AHU), controlled by an ECU 800 with First coil air inlet temperature
sensor T 801.
- The Air handling unit (AHU) comprises an Air handling unit mechanics 401, as follows.
- 35 The Air handling unit (AHU) 400 is designed to receive extract air 23 to
an extract air room/building temperature sensor T_i 803, further to
a Rotary heat exchanger (RHE) 302, then to
a First coil air inlet temperature sensor T 801, and then to
a First coil 703 of
40 an integrated cooling and heating block with CO₂ 700.
- 401= Air handling unit (AHU) mechanics comprises the following elements and is designed to
receive extract air 23 via

- an extract air room/building temperature sensor T_i 803, further to
 a Rotary heat exchanger (RHE) 302, then to
 a First coil air inlet temperature sensor T 801, and then to
 a First coil 703 of
- 5 an integrated cooling and heating block with CO₂ 700.
- 450= Air handling unit (AHU), controlled by an ECU 800 with First coil air inlet temperature sensor T 801.
- The Air handling unit (AHU) comprises an Air handling unit mechanics 451, as follows.
 The Air handling unit (AHU) 450 is designed to receive extract air 23 via
- 10 an extract air room/building temperature sensor T_i 803, further to
 a Rotary heat exchanger (RHE) 302, then to
 a First coil air inlet temperature sensor T 801, and then to
 a First coil 703 of
- an advanced integrated cooling and heating block with CO₂ pressure optimization 750.
- 15 451= Air handling unit (AHU) mechanics comprises the following elements and is designed to receive extract air 23 via
 an extract air room/building temperature sensor T_i 803, further to
 a Rotary heat exchanger (RHE) 302, then to
 a First coil air inlet temperature sensor T 801, and then to
- 20 a First coil 703 of
 an advanced integrated cooling and heating block with CO₂ pressure optimization 750.
- 500= Air handling unit (AHU), controlled by an ECU 800 with First coil air inlet temperature sensor T 801.
- The Air handling unit (AHU) comprises an Air handling unit mechanics 501, as follows.
- 25 The Air handling unit (AHU) 500 is designed to receive extract air 23 via
 a First coil air inlet temperature sensor T 801, to
 a First coil 703 of
 an integrated cooling and heating block with CO₂ 700, and then a Run-around-coil (RAC) system 502.
- 30 501= Air handling system (AHU) mechanics comprises the following elements and is designed to receive extract air 23 via
 a First coil air inlet temperature sensor T 801, to
 a First coil 703 of
 an integrated cooling and heating block with CO₂ 700, and then a Run-around-coil (RAC) system 502.
- 35 502= Run-around-coil (RAC) system.
- 503= Run-around-coil (RAC) system fluid flow control actuator, that can be used to adjust the efficiency of the RAC heat exchange function.
- 550= Air handling unit (AHU), controlled by an ECU 800 with First coil air inlet temperature sensor T 801.
- 40 The Air handling unit (AHU) comprises an Air handling unit mechanics 551, as follows.
 The Air handling unit (AHU) 550 is designed to receive extract air 23 via

- a First coil air inlet temperature sensor T 801, to
 a First coil 703 of
 an advanced integrated cooling and heating block with CO₂ pressure optimization 750,
 and then a Run-around-coil (RAC) system 502.
- 5 551= Air handling unit (AHU) mechanics comprises the following elements and is designed to receive extract air 23 via
 a First coil air inlet temperature sensor T 801, to
 a First coil 703 of
 an advanced integrated cooling and heating block with CO₂ pressure optimization 750,
 10 and then a Run-around-coil (RAC) system 502.
- 600= Air handling unit (AHU), controlled by an ECU 800 with First coil air inlet temperature sensor T 801.
 The Air handling unit (AHU) comprises an Air handling unit mechanics 601, as follows.
 The Air handling unit (AHU) 600 is designed to receive extract air 23 to
 15 an extract air room/building temperature sensor T_i 803, further to
 a Run-around-coil (RAC) system 502, then to
 a First coil air inlet temperature sensor T 801, and then to
 a First coil 703 of
 an integrated cooling and heating block with CO₂ 700.
- 20 601= Air handling unit (AHU) mechanics comprises the following elements and is designed to receive extract air 23 to
 an extract air room/building temperature sensor T_i 803, further to
 a Run-around-coil (RAC) system 502, then to
 a First coil air inlet temperature sensor T 801, and then to
 25 a First coil 703 of
 an integrated cooling and heating block with CO₂ 700.
- 650= Air handling unit (AHU), controlled by an ECU 800 with First coil air inlet temperature sensor T 801.
 The Air handling unit (AHU) comprises Air handling unit mechanics 651, as follows. The
 30 Air handling unit (AHU) 650 is designed to receive extract air 23 to
 an extract air room/building temperature sensor T_i 803, further to
 a Run-around-coil (RAC) system 502, then to
 a First coil air inlet temperature sensor T 801, and then to
 a First coil 703 of
 35 an advanced integrated cooling and heating block with CO₂ pressure optimization 750.
- 651= Air handling unit (AHU) mechanics comprises the following elements and is designed to receive extract air 23 to
 an extract air room/building temperature sensor T_i 803, further to
 a Run-around-coil (RAC) system 502, then to
 40 a First coil air inlet temperature sensor T 801, and then to
 a First coil 703 of
 an advanced integrated cooling and heating block with CO₂ pressure optimization 750.

- 700= Integrated cooling and heating block with CO₂ 700.
- 701= AHU block with simple CO₂ integrated cooling and heating block with CO₂ 700.
- 702= Second coil. Reversible heat exchanger supply air.
Reversible means :
- 5 When operating in in cooling mode, the coil function as evaporator, and when in heating mode, the coil works as condenser (subcritical) or gas cooler (transcritical).
- 703= First coil. Reversible heat exchanger extract air. See Second coil 702, above.
- 704= Variable speed or ON/OFF compressor.
- 705= Expansion valve.
- 10 707= Expansion valve (flash receiver pressure control).
- 708= Expansion valve (gas cooler pressure control).
- 709= Flash receiver tank.
- 710= Expansion valve (suction superheat control)
- 720= CO₂ refrigerant of type R744.
- 15 721= CO₂ refrigerant, of type R744, for advanced CO₂ refrigerant circuit.
- 750= Advanced CO₂ refrigerant circuit with pressure optimization.
- 751= AHU block with advanced CO₂ refrigerant circuit.
- 760= CO₂ (R744) refrigerant circuit, such as:
an integrated cooling and heating block with CO₂ (700); or
- 20 an advanced integrated cooling and heating block with CO₂ pressure optimization (750).
- 800= Electronic control unit (ECU), controlling the regulation and optimization of the refrigeration process for the CO₂ transcritical or subcritical refrigerant circuit.
The ECU receives extract air flow temperature T before the airflow passes through the First coil, Reversible heat exchanger extract air.
- 25 ECU determines optimal regulation needed for the heat exchanger efficiency parameters, to ensure an optimal CO₂ transcritical or subcritical refrigerant circuit process. The ECU may then control bypass-damper for a cross/counter flow plate heat exchanger if any, or RPM for a rotary heat exchanger, or liquid flow in RAC-system.
- 801= First coil air inlet temperature sensor T. Located at the inlet to the First coil 703, to
- 30 sense temperature of air flow entering the First coil 703.
- 802= Optimal target range for temperature sensor T; that is the First coil air inlet temperature sensor T (801). The range can be preconfigured or provided via an interface defining actual optimal target range for temperature sensor T, or manual setting for optimal target range for the First coil air inlet temperature sensor T 801.
- 35 803= Extract air room/building temperature sensor T_i. This sensor measures the temperature of the room, and/or the air flow temperature of extract air entering the AHU mechanics, typically via an extract air channel, to mentioned sensor 803, towards a heat exchanger function PHE, RHE or RAC; before reaching the First coil air inlet temperature sensor T 801. Temperature difference between the two sensors will tell the temperature
- 40 difference over a controlled heat exchange function, controlled by a PHE bypass damper, RPM of RHE, or circulation flow adjustment on a RAC sub-system.
- 804= Determination function for adjustment needs, to control AHU heat exchanger function

- efficiency, to maintain optimal air temperature at First coil 703. The control function is implemented as a method to optimize the temperature of extract air flowing into the First coil 703 reversible heat exchanger extract air.
- 805= Learning function for feedback adjustment of regulation function based on regulation history and deviations.
- 806= Control signal for heat exchange efficiency. The control signal 806 is configured to adjust the performance of a PHE, RHE, or RAC heat exchange performance, at an AHU with CO₂ refrigerant circuit, where the signal is adapted to the type of AHU to be controlled depending on the presence of a PHE (102), RHE (302), or RAC (502), as indicated by System configuration 812 if present.
- 810= Electronic Control Unit (ECU) hardware (HW) electronics, control, and computing functions such as a micro controller, or CPU, MPU, with memory to store and execute software 811, or implemented as hardware configured methods to execute at least the Determination function 804, and preferably the Learning function 805.
- 811= ECU SW software or control logic implementation to optimize the integrated cooling and heating block with CO₂ 700, or advanced integrated cooling and heating block 750 with pressure control.
- 812= A system configuration, that provides information about the type of Air handling unit or AHU such that the Electronic control unit (ECU) 800 may determine 804 and control: the Actuator 821 of a bypass channel regulating PHE 100, 150, 200, or 250; regulate the rotation speed of the RHE 822 regulating RHE 300, 350, 400, or 450; or regulator for liquid flow of RAC 823, regulating RAC 500, 550, 600, or 650.
- 820= AHU with CO₂ refrigerant circuit control, using the Control signal for heat exchange efficiency 806 for optimization of temperatures for the:
- a) integrated cooling and heating block with CO₂ 700, or
- b) advanced integrated cooling and heating block with CO₂ pressure optimization 750.
- 821= Actuator for damper of bypass channel for PHE, regulating PHE 100, 150, 200, or 250.
- 822= Regulator for rotation speed of RHE, regulating RHE 300, 350, 400, or 450.
- 823= Regulator for liquid flow of RAC, regulating RAC 500, 550, 600, or 650.
- 900= Building with Air handling unit mounted inside building.
- 900'= Building with Air handling unit mounted at least partly outside a building.
- 901= Building walls and roof.
- 902= Air temperature outside building, with temperature T_o.
- 903= Air inside the building, with temperature T_i.
- 904= Sun and environment with heat radiation 905.
- 905= Heat radiation from sun 904 and environment.

S1000-S4000 represents method steps. In Fig. 16 dotted lines represent optional method steps.

- S1000= Receiving temperature sensor data T.
- S1100= Setting optimal target range for sensor T.
- S1200= Receiving extract air temperature for room/building.

- S2000= Determining adjustment need for AHU heat exchanger efficiency, to reach optimal air temperature before gas cooler/condenser.
- S3000= Regulating heat exchanger efficiency control parameters.
- S3100= Regulating rotation speed of rotary heat exchanger.
- 5 S3200= Regulating damper of bypass channel for a cross/counter flow plate heat exchanger (PHE) 102. The bypass channel allows some of the fluid in the system to bypass the heat exchanger, using a pathway that diverts a portion of the fluid around the heat exchanger.
- S3300= Regulating liquid flow in RAC system, to control the heat recovery process in a Run-Around Coil (RAC) system, hence regulating the temperature at sensor T, where air enters the First coil (703) reversible heat exchanger extract air in the AHU equipped with a RAC 500, 550, 600, and 650.
- 10
- S4000= The learning, and adjusting regulation loop, is used in step S4000, based on regulation history, adjust parameters the Determining adjustment S2000, regulation step. At step S4000, historical deviations from desired temperature range defined by the setting for optimal target range for sensor T 802, are analyzed; to adjust the regulation parameters for the Determination function for adjustment needs 804, used in step S2000.
- 15

CLAIMS

1. An Air Handling Unit (50; 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650) comprising:
 - 5 an outdoor air stream channel (21);
 - a supply air stream channel (22);
 - an extract air stream channel (23);
 - an exhaust air stream channel (24);
 - an heat exchanger function (52) such as:
 - 10 a cross/counter flow plate heat exchanger PHE (102),
 - a rotary heat exchanger RHE (302), or
 - a run-around-coil RAC (502); and
 - a CO₂ (R744) refrigerant circuit (760, 700, 750) comprising:
 - a first coil (703) placed between:
 - 15 the extract air stream channel (23) and the exhaust air stream channel (24);
 - a second coil (702) placed between the heat exchanger function (52)
 - and the supply air stream channel (22); and
 - a first coil air inlet temperature sensor T (801);
 - wherein the CO₂ (R744) refrigerant circuit (760, 700, 750) is
 - 20 configured for heat transferring between
 - the first coil (703) and the second coil (702),

characterized in that

 - the first coil (703) is configured for heat exchange with an airstream originating from the extract air stream channel (23), such as air received from inside of a building (900).
- 25 2. An Air handling unit (100, 200, 300, 400, 500, 600) according to claim 1, wherein the CO₂ (R744) refrigerant circuit (760), is an integrated cooling and heating block with CO₂ (700).
- 30 3. An Air handling unit (150, 250; 350, 450; 550, 650) according to claim 1, wherein the CO₂ (R744) refrigerant circuit (760), is an advanced integrated cooling and heating block with CO₂ pressure optimization (750).
- 35 4. An Air handling unit (100, 150; 300, 350; 500, 550) according to claim 1-3, wherein the first coil (703) is placed between:
 - the extract air stream channel (23) and the heat exchanger function (52).
5. An Air handling unit (100, 150, 300, 350, 500, 550) according to claim 1-4, **characterized that it** is configured to:
 - 40 receive extract air via the extract air stream channel (23) via
 - the First coil air inlet temperature sensor T (801), to
 - the First coil (703), and then to

a heat exchanger function (52) such as:

a cross/counter flow plate heat exchanger PHE (102),

a rotary heat exchanger RHE (302), or

a run-around-coil RAC (502).

5

6. An Air handling unit (200, 250, 400, 450, 600, 650) according to claim 1-3, wherein:
the first coil (703) is placed between:

the heat exchanger function (52) and the exhaust air stream channel (24).

- 10 7. An Air handling unit (200, 250; 400, 450; 600, 650) for cooling recovery,
according to claim 1-3, 6; configured to:

receive extract air via extract air stream channel (23), to

an extract air room/building temperature sensor T_i 803, further to

the heat exchanger function (52), such as:

- 15 a cross/counter flow plate heat exchanger PHE (102),

a rotary heat exchanger RHE (302), or

a run-around-coil RAC (502);

and then to

the First coil air inlet temperature sensor T (801); and

- 20 further to

the First coil (703).

8. An Air handling unit (100, 150, 200, 250) according to claim 1-7, wherein:
the heat exchanger function (52) is a cross/counter flow plate heat exchanger (PHE) (102).

25

9. An Air handling unit (300, 350, 400, 450) according to claim 1-7, wherein:
the heat exchanger function (52) is a Rotary Heat exchanger (RHE) (302).

10. An Air handling unit (500, 550, 600, 650) according to claim 1-7, wherein:
30 the heat exchanger function (52) is a Run-around-coil (RAC) (502).

11. An Air handling unit (100, 150, 200, 250) according to claim 8-10, wherein
the Air handling unit further comprises a bypass damper (53), configured to
when open, let at least a percentage of air flow bypass the heat exchanger function (52).

35

12. An Air handling unit (300, 350, 400, 450) according to claim 9, wherein
the Air handling unit further comprises a Rotary heat exchanger (RHE) revolution per
minute (RPM) control, that can be used to adjust the efficiency of the RHE heat exchange.

- 40 13. An Air handling unit (500, 550, 600, 650) according to claim 10, wherein
the Air handling unit further comprises a Run-around-coil (RAC) system fluid flow control
actuator, that can be used to adjust the efficiency of the RAC heat exchange function.

14. An Air handling unit (200; 250; 400, 450; 600, 650) according to claim 1-13,
further comprising:
an extract air room/building temperature sensor (803), configured to receive
the extract air room/building temperature sensor (803) value.
15. An Electronic Control Unit (ECU) (800), configured to control an Air handling unit (AHU)
(50; 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650) according to claim 1-14,
comprising:
an Electronic Control Unit hardware (ECU HW) (810),
for sensor data processing and optimization of AHU operation;
an interface to the First coil air inlet temperature sensor T (801) configured to
sense the temperature at the air inlet of the first coil (703);
an interface to the Extract air stream temperature sensor T_i (803) configured to
sense the temperature at the extract air stream (23) or
a temperature inside building, or room (900);
a Determination function (804) configured:
to determine a Control signal for heat exchange efficiency (806)
with input from:
the First coil air inlet temperature sensor T (801), and
the Extract air stream temperature sensor T_i (803) if any;
to control the AHU heat exchanger function efficiency,
to maintain optimal air temperature at First coil (703),
that is within an optimal target range for sensor T (802) at
the First coil air inlet temperature sensor T (801); and
to adjust the efficiency of the heat exchanger function (52) according to
the Control signal for heat exchange efficiency (806) to regulate:
an actuator for damper of bypass channel for PHE (821),
a regulator for rotation speed of RHE (822), or
a regulator for liquid flow of RAC (823).
16. An ECU (800), according to claim 15, further comprising:
a Learning function (805) for feedback adjustment of the regulation function based on
regulation history, in the Determination function (804).
17. An ECU (800) according to claim 15-16, further comprising:
a Setting for optimal target range for sensor T (802), and/or
a System configuration file (812), defining at least
one optimal temperature target range (802).
18. An ECU (800), according to claim 15-17,
characterized in that

the ECU is configured as a software-based cloud service, for interfacing and control of at least one Air Handling Unit (AHU)
(50; 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650) according to claims 1-13.

- 5 19. An Air handling unit (50, 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650) according to claim 1-14, further comprising:
 an ECU (800) according to claim 14-18, configured to
 control the Air handling unit
 (50, 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650), and/or
 10 for the AHU with cooling recovery (50, 200, 250; 400, 450; 600, 650)
 to maintain an optimal temperature at First coil air inlet temperature sensor T (801).
20. Method, for cooling recovery efficiency and system efficiency for
 an Air Handlings Unit (AHU) (50, 200, 250; 400, 450; 600, 650) according to
 15 claim 1-14 and 19; and
 an ECU (800) according to claim 15-18,
 comprising the steps:
 (S1000)
 Receiving first coil air inlet temperature from sensor T (801);
 20 (S1200)
 Receiving Extract air room/building temperature sensor Ti (803);
 (S2000)
 Determining adjustment needs (804), as
 a Control signal for heat exchange efficiency (806);
 25 to reach and maintain an optimal transcritical or sub-critical refrigerant cycle, and
 to ensure that First coil (703) air inlet temperature at sensor T (801), is maintained at
 an optimal temperature range (802),
 for the gas cooler of a transcritical or sub-critical carbon dioxide CO₂ cycle;
 (S3000)
 30 Regulating heat exchanger efficiency control parameters,
 using the Control signal for heat exchange efficiency (806) to adjust
 the performance of the at least one heat exchange functions, by:
 (S3100) Regulating rotation speed (303) of rotary heat exchanger (302);
 (S3200) Regulating damper of bypass channel for
 35 cross/counter flow heat exchanger (102); or
 (S3300) Regulating liquid flow of run around coil system (RAC) (502),
 to reach efficient cooling recovery and maximal system efficiency.
21. Method according to claim 20, further
 40 **characterized in that**
 that step (S1100) precedes step (S2000), wherein step (S1100) is comprising:
 (S1100)

Setting optimal target temperature range (OTTR) (802) for temperature sensor T, such that step (S2000) is using the optimal target temperature range when determining adjustment need for heat exchanger efficiency.

- 5 22. Method according to claim 20-21, further
 characterized in that
 the step (S1200) precedes step (S2000), wherein step (S1200) is comprising:
 (S1200)
 Receiving extract air temperature from room/building (TTR) (801), such that step (S2000) is
10 using the extract air temperature from room/building when determining (804) adjustment
 need, that is Control signal for heat exchange efficiency (806) adjusting the heat exchanger
 efficiency.
23. Method according to claim 20-22, further
15 **characterized in that**
 the optimal temperature target range for temperature sensor T (802) is set to
 between 15 Celsius and 40 Celsius, preferably between 20 to 32 Celsius.
24. Method according to claim 20-23, further
20 **characterized in that**
 a step (S4000) follows step (S3000), wherein step (S4000) is comprising
 (S4000)
 Learning, or feedback adjusting the regulation loop, to optimize control
 parameters for:
25 Step (S2000) Determining adjustment need for heat exchanger efficiency.
25. An HVAC system (20) comprising at least one Air handling unit (AHU)
 (50; 100, 150, 200, 250; 300, 350, 400, 450; 500, 550, 600, 650) according to claim 1-14 or
 19, wherein the extract air stream channel (23) is connected to the inside of a building
30 (900), vehicle, train, or ship.
26. A building or vehicle comprising an HVAC system (20), according to claim 25, or an Air
 handling unit (50, 100, ... 650) according to claim 1-14 or 19.