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(54) **CASCADED HEAT PUMP SYSTEM WITH LOW GWP REFRIGERANT**

(57) The invention relates to a system (1) for heating or cooling a space and for providing hot water, with a first refrigerant circuit (2) for heating or cooling a space using a first heat transfer fluid, comprising a compressor device (C1), a first heat exchanger device (H1), a second heat exchanger device (H2), and an expansion device, where the first heat exchanger device (H1) is configured for transferring heat to or from the space which is to be heated or cooled, respectively, via the first heat transfer fluid, and the second heat exchanger device (H2) is configured for transferring heat from the first heat transfer fluid to a second heat transfer fluid; and with a second refrigerant circuit (5) for providing hot water using the second heat transfer fluid, comprising a compressor device (C2), the second heat exchanger device (H2), a third heat exchanger device (H3), and an expansion device, where the third heat exchanger device (H3) is configured for transferring heat from the second heat transfer fluid to water which is to be provided as hot water; wherein at least the first heat transfer fluid has a net global warming potential for 100 years, GWP₁₀₀, which is below 500, and first and second heat transfer fluid are chosen such that respective values of at least one characteristic of first and second heat transfer fluid make the second heat transfer fluid more suitable for higher working tempera-

tures than the first heat transfer fluid so as to maximize the coefficient of performance, COP.

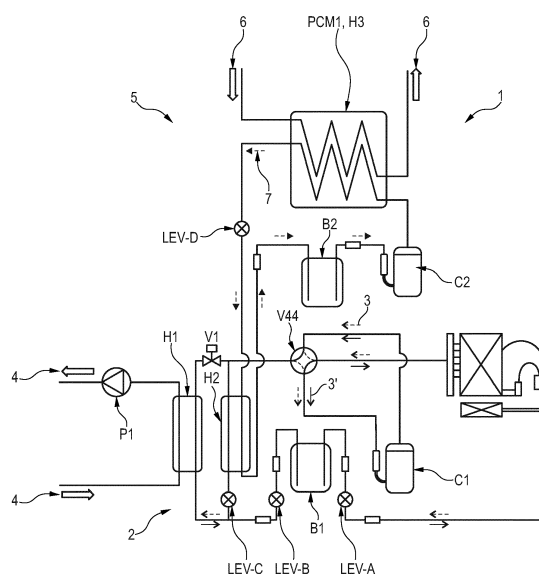


Fig. 1

Description

[0001] The invention relates to a system for heating and/or cooling a space and for providing hot water, comprising a first refrigerant circuit for heating and/or cooling a space using a first heat transfer fluid and a second refrigerant circuit for providing hot water using a second heat transfer fluid, which is different from the first heat transfer fluid.

[0002] There is a need for heat pump systems which can provide heating/cooling of a space as well as (domestic) hot water that are environment friendly and have a high coefficient of performance.

[0003] In this context, the WO 2015/147338 A1 provides a two-stage cascade refrigeration device that uses a refrigerant composition that is earth friendly, and can achieve low temperatures of -80°C . The two-stage cascade refrigeration device uses, as a low temperature side refrigerant, a refrigerant composition that is formed by mixing R-1132a with R-508a or R-508b that achieves a evaporation temperature that is lower than the boiling point of R-1132a or R-508a, and 508b. The two-stage cascade refrigeration device uses, as a high temperature side refrigerant, a refrigerant composition that is formed by adding HFO-1234ze to a zeotropic mixture comprising the refrigerant group of R-32, R-105, R-134a, and R-143a, and that has a global warming potential, GWP, of no more than 1,500.

[0004] US 2016/138 837 A1 describes a heat pump arrangement including a first heat pump through which a first fluid flows, a second heat pump through which a second fluid flows, and a heat exchanger to transfer heat from the first fluid to the second fluid. The heat is transferred from the first fluid to the second fluid at a fluid temperature of at least 120°C for the second fluid. The first fluid and the second fluid each have a volumetric heating capacity of at least 500 kJ per m^3 when the heat is transferred from the first fluid to the second fluid.

[0005] US 2011/094 259 A1 discloses a multi-stage refrigerant system operating with the lower stage compressor of a first type and a higher stage compressor of a second type. Therein, the lower stage compressor type may be selected to have the most beneficial characteristics at lower pressure operation, while the higher pressure stage compressor may be selected to have the most beneficial characteristics at higher pressure operation.

[0006] Further, multi-stage low GWP conditioning systems are disclosed in JP 2019 504 985 A, US 2011/289 953 A1, and US 2016/363 354 A1.

[0007] The current heat pump systems can only operate either in a space heating mode or a hot water mode, that is may also be referred to as domestic hot water mode. As a consequence, in the middle season, the coefficient of performance, COP, is low due to the low space heating demand and the system operating in a low partial load range.

[0008] It is thus an objective of the invention at hand to provide a system for heating and/or cooling a space

and for providing domestic hot water which is environment-friendly, that is, working with a low net global warming potential, GWP, and provides an increased COP as compared with the known solutions. Said objective is achieved by the subject-matter of the independent claim. Advantageous features and embodiments are apparent from the dependent claims, the description, and the figures.

[0009] One aspect relates to a system for heating and/or cooling a space and for providing (domestic) hot water, which can also be referred to as a heat pump system, comprising a first and a second refrigerant circuit.

[0010] Therein, the first refrigerant circuit is configured for heating and/or cooling a space using a first heat transfer fluid, and comprises a compressor device, a first heat exchanger device, a second heat exchanger device, and an expansion device. In operation, it also comprises the first heat transfer fluid. The first heat exchanger device is configured for transferring heat to and/or from the space which is to be heated and/or cooled, respectively, via the first heat transfer fluid, and the second heat exchanger device is configured for transferring heat from the first heat transfer fluid to a second heat transfer fluid of the second refrigerant circuit.

[0011] The second refrigerant circuit is configured for providing hot water using the second heat transfer fluid, and comprises a compressor device, the second heat exchanger device, a third heat exchanger device, and an expansion device. In operation, the second refrigerant circuit also comprises the second heat transfer fluid. The second heat transfer fluid is separated and different from the first heat transfer fluid. The third heat exchanger device is configured for transferring heat from the second heat transfer fluid to water which is to be provided as hot water. Said heat may be transferred directly from the second heat transfer fluid to the water or via a heat buffer, which may be realized by a (phase change) storage material such as water or a dedicated phase change material, as described in more detail below. The second refrigerant circuit may be configured for providing (domestic) hot water only, that is, preferably it is not configured for heating and/or cooling a space. Correspondingly, the second refrigerant circuit preferably is configured to have a higher working temperature than the first refrigerant circuit. Correspondingly, the control device advantageous embodiments of which are specified in more detail below can be adapted for the system comprising first and second heat transfer fluids with different working temperatures. Preferably the working temperature of the second heat transfer fluid has a higher working temperature than the first heat transfer fluid.

[0012] Therein, at least the first heat transfer fluid has a net global warming potential for 100 years, GWP₁₀₀, which is below 500. The GWP₁₀₀ may be determined according to the Fifth Assessment Report (AR-5) of the United Nations Intergovernmental Panel on Climate Change (IPCC), or the Sixth Assessment Report (AR-6), respectively. Furthermore, first and second heat transfer

fluid are chosen such that respective values of at least one characteristic of first and second heat transfer fluid make the second heat transfer fluid more suitable for higher working temperatures than the first heat transfer fluid, so as to maximize the coefficient of performance, COP, in particular for low space heating demand. In other words, the second refrigerant circuit is optimized for higher temperatures than the first refrigerant circuit.

[0013] As a consequence, the cascaded system described above uses different refrigerants for different applications, that is, the first heat transfer fluid for space heating/cooling and (indirect) providing hot water, and the second heat transfer fluid for providing domestic hot water only. Consequently, it can supply heat to space and to water which is to be provided as hot water at the same time. This differentiation allows the individual optimization of the different heat transfer fluids while selecting eco-friendly heat transfer fluids and achieving an increased coefficient of performance even when the system operates with a low space heating demand, for example in the middle season.

[0014] In an advantageous embodiment, also the second heat transfer fluid has a GWP 100 which is below 500. The first heat transfer fluid and/or the second heat transfer fluid may have a GWP100 which is below 400, or below 300, or below 200, or below 150, or below 100, or below 50, or below 30, or below 10. Most preferably, the first heat transfer fluid and/or the second heat transfer fluid have a GWP100 which is below 20 % of the GWP100 of difluoromethane, or R-32. This results in a particularly eco-friendly system, which still realizes an increased COP.

[0015] According to another advantageous embodiment, the at least one characteristic of the first and second heat transfer fluid is or comprises a volumetric capacity. In particular, the first heat transfer fluid has a higher volumetric capacity value than the second heat transfer fluid. Preferably, the volumetric capacity is determined for both heat transfer fluids at a working temperature of the first circuit. The first heat transfer fluid may have a volumetric capacity which is at least 80 % larger than the volumetric capacity of difluoromethane, preferably its volumetric capacity is at least 12,824 MegaJoule per m³ at 24°C. This gives the advantage that the respective heat transfer fluids are individually adapted so as to maximize the overall COP and arrive at a particularly efficient eco-friendly system.

[0016] In another advantageous embodiment, said characteristic of first and second heat transfer fluid is or comprises a critical temperature. In particular, the first heat transfer fluid has a lower critical temperature than the second heat transfer fluid. The second heat transfer fluid may have a critical temperature which is higher than the critical temperature of difluoromethane, in particular higher than 78°C. This gives the advantage of an increased performance of the eco-friendly system with an increased coefficient of performance as compared to the available systems.

[0017] In another advantageous embodiment, the first heat transfer fluid is R-41, or a mixture of R-32 and R41, or a mixture of R-32 and R-290. The second heat transfer fluid may be R-290. This gives the advantage of achieving the above described advantages with known components.

[0018] In a particularly advantageous embodiment, the third heat exchanger device is or comprises a heat storage device, in particular a phase change material heat storage device, which is configured for transferring heat from the second heat transfer fluid and/or from the respective storage material, in particular from a phase change material of the phase change material heat storage device, to the water which is to be provided as (domestic) hot water. This gives the advantage that the efficiency of the system can be further increased as heat from the first refrigerant circuit can be used more efficiently for providing the hot water.

[0019] In a further advantageous embodiment, the system comprises another phase change material storage device, which is part of the first refrigerant circuit, and which is configured for transferring heat from the first heat transfer fluid and/or from its phase change material to the water which is provided as hot water. This gives the advantage that the efficiency of heat transferral from the first refrigerant circuit to the water which is to be provided as hot water is further increased.

[0020] It is particularly advantageous if a phase change temperature of the phase change material of the another phase change material storage device of the first refrigerant circuit is lower than a phase change temperature of the phase change material of the phase change material storage device of the second refrigerant circuit. This gives the advantage of a particularly efficient usage of the different heat sources of the system.

[0021] In another advantageous embodiment, the phase change material storage devices are configured, that is, arranged and connected such that the water which is to be provided as hot water can receive heat from the (another) phase change material storage device of the first refrigerant circuit prior to receiving heat from the third heat exchanger device, in particular the phase change material storage device of the second refrigerant circuit. Again, this gives the advantage of an even more efficient usage of the heat.

[0022] In a particularly advantageous embodiment, the another phase change material storage device of the first refrigerant circuit is connected in parallel to the first heat exchanger device as well as to the second heat exchanger device, and the first refrigerant circuit comprises a pump, which is configured for transferring heat from the another phase change material storage device to the first heat exchanger device by pumping the first heat transfer fluid through the another phase change material storage device and the first heat exchanger device. This gives the advantage that the efficiency of the system is further increased as the stored heat can be used both for providing hot water and space heating, which is particularly

advantageous in the middle season or other times of low space heating demand, in particular occasional space heating demand.

[0023] In another advantageous embodiment, the system comprises a control device configured for controlling, according to at least four pre-set control schemes, one or more of the following elements: At least one pump of the system, at least one valve of the system, which may also be a throttling valve, in particular a linear expansion valve, at least one compressor of the system; in dependence of one or more of: At least one temperature sensor signal, at least one pressure sensor signal. Therein, the control schemes comprise a single-circuit defrosting mode for defrosting the first refrigerant circuit, a single-circuit space heating/cooling mode for heating and/or cooling the space without providing heat for the hot water, a two-circuit hot water mode for providing heat for the hot water without heating and/or cooling the space, and a two-circuit space heating/cooling hot water mode for heating and/or cooling the space and providing heat for the hot water. As described later with the reference to the figures, in particular the control device can be configured for controlling said elements according to, for instance, four or eight control schemes. Therein, each control scheme represents a specific combination of states of the elements controlled by the control device.

[0024] The control device may be configured to control one or more of the elements of the system in the first refrigerant circuit in dependence upon a predefined defrosting condition and/or in dependence upon a space heating/cooling demand provided by an input of a user or another device and a state of charge of the phase change material storage device of the first and/or second refrigerant circuit and/or to control one or more of the elements of the system in the second refrigerant circuit in dependence upon the state of charge of the phase change material storage device of the first and/or second refrigerant circuit.

[0025] This results in the advantage of a simple yet flexible control of the system which allows an efficient operation of the system in various conditions.

[0026] The features and combinations of features described above, including the general part of the description, as well as the features and combinations of features disclosed in the figure description or the figures alone may not only be used alone or in the described combination, but also with other features or without some of the disclosed features without leaving the scope of the invention. Consequently, embodiments that are not explicitly shown and described by the figures but that can be generated by separately combining the individual features disclosed in the figures are also part of the invention. Therefore, embodiments and combinations of features that do not comprise all features of an originally formulated independent claim are to be regarded as disclosed. Furthermore, embodiments and combinations of features that differ from or extend beyond the combinations of features described by the dependencies of the

claims are to be regarded as disclosed.

[0027] Exemplary embodiments are further described in the following by means of schematic drawings. Therein:

- 5 Fig. 1 shows an exemplary embodiment of a cascaded system for heating and/or cooling a space for providing hot water;
- 10 Fig. 2 shows an exemplary control flow chart for the embodiment of Fig. 1;
- Fig. 3 shows an overview of exemplary control schemes for the control flow chart of Fig. 2, and the exemplary elements of the system of Fig. 1;
- 15 Fig. 4 shows another exemplary embodiment of a system for heating and/or cooling a space and for providing hot water;
- 20 Fig. 5 shows an exemplary control flow chart for the embodiment of Fig. 4; and
- 25 Fig. 6 shows an overview of exemplary control schemes for the embodiment of Fig. 4 and the control flow chart of Fig. 5.

[0028] In the figures, identical or functionally identical elements have the same reference signs.

- 30 **[0029]** Fig. 1 shows a system diagram of an exemplary system 1 for heating/cooling a space and for providing domestic hot water. The system 1 comprises a first refrigerant circuit 2 for heating/cooling a space using a first heat transfer fluid, comprising a compressor device C1,
- 35 a first heat exchanger device H1, a second heat exchanger device H2, and an expansion device. The first heat exchanger H1 is configured for transferring heat to or from the space which is to be heated or cooled, respectively, via the first heat transfer fluid, and the second heat exchanger device H2 is configured for transferring heat from the first heat transfer fluid to a second heat transfer fluid.
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- 45 **[0030]** The first refrigerant circuit 2 also comprises a reversible four-way valve V44 which allows to switch between a heating and a cooling mode. The dashed arrows 3 indicate the refrigerant flow in the cooling mode, and the solid arrows 3' the refrigerant flow in the heating mode. In said first refrigerant circuit 2, first and second heat exchanger device H1, H2 are coupled in parallel,
- 50 with a first valve V1 regulating the flow of the first heat transfer fluid through the first heat exchanger device H1 and another valve LEV-C, in the present case a linear expansion valve as an exemplary specific implementation of a throttling valve, is provided to regulate the flow of the first heat transfer fluid through the second heat exchanger device H2. Furthermore, in the present example, in the first refrigerant circuit 2, two additional valves LEV-D, LEV-B, are provided before and after a buffer
- 55

tank B1 for the first heat transfer fluid. Arrows 4 indicate the space heating or cooling flow through the first heat exchanger H1, which is supported, in the present example, by a pump P1.

[0031] The system 1 also comprises a second refrigerant circuit 5 for providing hot water using said second heat transfer fluid, the second refrigerant circuit 5 comprising a compressor device C2, said second heat exchanger device H2, a third heat exchanger device H3, and an expansion device. Therein, the third heat exchanger H3 is configured for transferring heat from the second heat transfer fluid to water which is to be provided as hot water/domestic hot water. The arrows 6 indicate the flow of the water which is to be provided as hot water/domestic hot water through the third heat exchanger device H3. In this particular example, the third heat exchanger device H3 is a phase change material heat storage device PCM1, which is configured for transferring heat from the second heat transfer fluid or from a phase change material of the phase change material heat storage device PCM1 to the water which is to be provided as hot water. Also, in this particular example, the second refrigerant circuit 5 comprises a buffer tank B2 for the second heat transfer fluid. The refrigerant flow through the second refrigerant circuit 5 is indicated by the dash-dot arrow 7 and throttled by another valve LEV-D, which is, in the present example, as the other valves LEV-A to LEV-C, a linear expansion valve as example for a throttling valve.

[0032] Therein, the first heat transfer fluid has a net global warming potential GWP100 which is below 500, and first and second heat transfer fluids are chosen such at respective values of at least one characteristic of first and second heat transfer fluid make the second heat transfer fluid more suitable for higher working temperatures than the first heat transfer fluid so as to maximize the coefficient of performance.

[0033] Fig. 2 illustrates an exemplary embodiment of a control of the system of Fig. 1. There, in a first step S20, it is checked whether frost is detected or not. If yes, a single-circuit defrosting mode for defrosting the first refrigerant circuit is enabled. If no frost is detected, it is checked whether the state of charge of the phase change material storage device PCM1 fulfils a specific requirements, for instance if it is not charged fully. If it is charged fully, in a step S22 it is checked whether space heating is required or not. If not, no further steps are taken. If space heating is required, a single-circuit space-heating mode for heating the space without providing heat for the hot water is enabled. If it is determined, in step 21, that the phase change material storage device is not fully charged, it is determined whether space heating is required or not in an alternative step S22'. Then, if it is decided that space heating is not required, a two-circuit hot-water mode for providing heat for the hot water without heating or cooling the space is enabled. If space heating is required, a two-circuit space heating-hot-water mode for heating the space and providing heat for the

hot water is enabled in this example.

[0034] Fig. 3 discloses a concrete example of how the respective elements of the system 1 may be switched in order to enable said specific modes or control schemes.

[0035] Fig. 4 shows an alternative exemplary embodiment of a system for heating and/or cooling a space and for providing hot water. The alternative system 1 comprises the elements of the embodiments of Fig. 1, which are therefore not explained here in more detail.

[0036] In addition to said features of Fig. 1, the system 1 comprises another phase change material storage device PCM2, which is part of the first refrigerant circuit 2 and which is configured for transferring heat from the first heat transfer fluid or from its phase change material to the water which is to be provided as hot water. Therein, the another phase change material storage device PCM2 is connected in parallel to the first heat exchanger device H1 and the second heat exchanger device H2. Corresponding to the valves V1 and LEV-C in the embodiment of Fig. 1, valve V2 is added to decouple the first heat exchanger H1 from the phase change material storage device PCM2 and the second heat exchanger device H2, and a (here: throttling) valve in form of a linear expansion valve LEV-E is used to adjust the flow through the phase change material storage device PCM2. Correspondingly, valve V1 now is suited to decouple both first heat exchanger device H1 and phase change material device PCM2 from the second heat exchanger device H2.

[0037] The branch of the first refrigerant circuit 2 connecting the phase change material storage device PCM2 to the rest of the first refrigerant circuit 2 further comprises a second pump P2 and a three-way valve V33-A that allows transferring stored heat from the phase change material storage device PCM2 to space heating by pumping the first heat transfer fluid through said branch.

[0038] The first phase change material storage device PCM1 and the second phase change material storage device PCM2 are configured such that the water which is to be provided as hot water can receive heat from the second phase change material storage device PCM2 prior to receiving heat from the first phase change material storage device PCM1. In the present example, several three-way valves V33-B, V33-C, V33-D allow the use of both phase change material storage devices PCM1, PCM2, or only one respective phase change material storage device, that is, phase change material storage device PCM1 or phase change material storage device PCM2 for transferring heat to the water which is to be provided as hot water. Advantageously, a phase change temperature of the phase change material of the phase change material storage device PCM2 is lower than the phase change temperature of the phase change material of the phase change material storage device PCM1.

[0039] In Fig. 5, an exemplary control flow chart for the system of Fig. 4 is shown. There, in a first method step S50, corresponding to the step S20, it is checked whether frost is detected. If yes, a single-circuit defrosting mode for defrosting the first refrigerant circuit is enabled. If not,

in a step S51, it is checked whether a domestic hot water priority demand is present or not. If yes, in a step S52 it is, in the present example, checked whether the state of charge of the first phase change material storage device PCM1, the high temperature phase change material storage device, or a state of charge of the second phase change material storage device, PCM2, the low temperature phase change material storage device, meets a preset criteria, for instance if one or both of the phase change material storage devices are not fully charged. If at least one of the devices is not fully charged, depending of the individual combination of the state of charge SOC_LT of the low temperature phase change material storage device PCM2 and/or the state of charge SOC_HT of the high temperature phase change material storage device PCM1, a respective operation mode or control scheme is chosen.

[0040] So, in the present example, if neither of the phase change material storage devices PCM1, PCM2 is charged fully, a two-circuit hot-water mode for charging both phase change material storages is enabled. If only the low temperature phase change material storage device PCM2 is not fully charged, a single-circuit hot-water mode for charging the low temperature phase change material storage device PCM2 is enabled. If only the high temperature phase change material storage device PCM1 is not fully charged, a two-circuit hot-water mode for charging the high temperature phase change material storage device PCM1 is enabled.

[0041] If in step S52 it is determined that the respective requirement is not met, for example if both phase change materials storage devices PCM1, PCM2 are fully charged, it is evaluated whether space heating is required or not in step S53. If space heating is not required, no further steps are taken. If space heating is required, it is determined whether the state of charge SOC_LT of the low temperature phase change material storage device PCM2 is zero, that is, if the phase change material storage device PCM2 is empty. If not, a phase-change-material space-heating mode is enabled, where heat is transferred from the phase change material storage device PCM2 to the space heating. If in step S54 it is determined that the low temperature phase change material storage device PCM2 is empty, in a step S55 it is determined whether a predefined partial load ratio is below a pre-set threshold. If no, a single-circuit space-heating mode is enabled, where space heating is provided, but not charging of the phase change material storage devices.

[0042] If in step S55 it is determined that the partial load ratio is above a certain threshold ε , three different operation modes can be chosen, depending on states of charge SOC_LT, SOC_HT, i.e. on whether the low temperature phase change material storage device PCM2 is empty or not, and the high temperature phase change material storage device is not fully charged. If both applies, a single-circuit space-heating-hot-water-low-temperature-charging mode for heating the space and pro-

viding heat for the hot water while charging the low temperature phase change material storage device PCM2 is enabled. If the low temperature phase change material storage device PCM2 is empty and the high temperature phase change material storage device is full, the same mode is chosen. If the low temperature phase change material storage device PCM2 is not empty and the high temperature phase change material storage device is not full, a two-circuit space-heating-hot-water-high-temperature-charging mode for heating the space and providing heat for the hot water while charging the high temperature phase change material storage device PCM1 is enabled is chosen.

[0043] The state of charge may be given, in this or the other examples, by an indicator function indication the respective phase change material storage device being fully depleted, SOC=0, the phase change material storage device being partial charged/depleted, SOC=0,5, and the phase change material storage device being fully charged, SOC=1. This may, for instance, be determined by determining whether an actual temperature of the phase change material of the phase change material storage device lies within a preset band around the respective characteristic phase change temperature of said phase change material (SOC=0,5), below said band (SOC=0) or above said band (SOC=1).

[0044] Fig. 6 shows the respective control states of the respective elements in the different parts of the system 1 in dependence on the chosen operation mode.

Claims

1. A system (1) for heating or cooling a space and for providing hot water, comprising:

- a first refrigerant circuit (2) for heating or cooling a space using a first heat transfer fluid, comprising a compressor device (C1), a first heat exchanger device (H1), a second heat exchanger device (H2), and an expansion device, where

the first heat exchanger device (H1) is configured for transferring heat to or from the space which is to be heated or cooled, respectively, via the first heat transfer fluid, and

the second heat exchanger device (H2) is configured for transferring heat from the first heat transfer fluid to a second heat transfer fluid;

- a second refrigerant circuit (5) for providing hot water using the second heat transfer fluid, comprising a compressor device (C2), the second heat exchanger device (H2), a third heat exchanger device (H3), and an expansion device, where

- the third heat exchanger device (H3) is configured for transferring heat from the second heat transfer fluid to water which is to be provided as hot water;
wherein
- at least the first heat transfer fluid has a net global warming potential for 100 years, GWP100, which is below 500, and
 - first and second heat transfer fluid are chosen such that respective values of at least one characteristic of first and second heat transfer fluid make the second heat transfer fluid more suitable for higher working temperatures than the first heat transfer fluid so as to maximize the coefficient of performance, COP.
2. The system (1) of the preceding claim, **characterized in that** the second heat transfer fluid has a GWP100 which is below 500 in particular below 150, most preferably below 20% of the GWP100 of difluoromethane.
 3. The system (1) of any of the preceding claims, **characterized in that** the first heat transfer fluid has a GWP100 which is below 150, most preferably below 20% of the GWP100 of difluoromethane.
 4. The system (1) of any of the preceding claims, **characterized in that** the characteristic is or comprises a volumetric capacity, where in particular the first heat transfer fluid has a higher volumetric capacity than the second heat transfer fluid.
 5. The system (1) of any of the preceding claims, **characterized in that** the first heat transfer fluid has a volumetric capacity which is at least 80% larger than the volumetric capacity of difluoromethane.
 6. The system (1) of any of the preceding claims, **characterized in that** the characteristic is or comprises a critical temperature, where in particular the first heat transfer fluid has a lower critical temperature than the second heat transfer fluid.
 7. The system (1) of any of the preceding claims, **characterized in that** the second heat transfer fluid has a critical temperature which is higher than the critical temperature of difluoromethane.
 8. The system (1) of any of the preceding claims, **characterized in that** the first heat transfer fluid is R-41, or a mixture of R-32 and R-41, or a mixture of R-32 and R-290, and/or the second heat transfer fluid is R-290.
 9. The system (1) of any of the preceding claims, **characterized in that** the third heat exchanger device (H3) is or comprises a heat storage device, in particular a phase change material heat storage device (PCM1), which is configured for transferring heat from the second heat transfer fluid or from its storage material, in particular from its phase change material, to the water which is to be provided as hot water;
 10. The system (1) of any of the preceding claims, **characterized by** another phase change material heat storage device (PCM2), which is part of the first refrigerant circuit (2), and which is configured for transferring heat from the first heat transfer fluid or from its phase change material to the water which is to be provided as hot water.
 11. The system (1) of claims 8 and 9, **characterized in that** a phase change temperature of the phase change material of the another phase change material heat storage device (PCM2) of the first refrigerant circuit (2) is lower than a phase change temperature of the phase change material of the phase change material heat storage device (PCM1) of the second refrigerant circuit (5).
 12. The system (1) of the preceding claim, **characterized in that** the phase change material heat storage devices (PCM1, PCM2) are configured such that the water which to be provided as hot water can receive heat from the phase change material heat storage device (PCM2) of the first refrigerant circuit (2) prior to receiving heat from the phase change material heat storage device (PCM1) of the second refrigerant circuit (5).
 13. The system (1) of any of the three preceding claims, **characterized in that** the another phase change material heat storage device (PCM2) of the first refrigerant circuit (2) is connected in parallel to the first heat exchanger device (H1), and in parallel to the second heat exchanger device (H2), and the first refrigerant circuit (2) comprises a pump (P2) which is configured for transferring heat from the another phase change material heat storage device (PCM2) to the first heat exchanger device (H1) by pumping the first heat transfer fluid through the another phase change material heat storage device (PCM2) and the first heat exchanger device (H1).

14. The system (1) of any of the preceding claims,

characterized by

a control device configured for controlling, according to at least four control schemes, one or more of the following elements: at least one pump of the system (P1, P2), at least one valve of the system (V1, V2, V44, V33-A-D, LEV-A-E), at least one compressor of the system (C1, C2); in dependence of one or more of: at least one temperature sensor signal, at least one pressure sensor signal; wherein the control schemes comprise a single-circuit defrosting mode for defrosting the first refrigerant circuit, a single-circuit space-heating/cooling mode for heating or cooling the space without providing heat for the hot water, a two-circuit hot-water mode for providing heat for the hot water without heating or cooling the space, and a two-circuit space-heating/cooling-hot-water mode for heating or cooling the space and providing heat for the hot water.

15. The system (1) of the preceding claim,

characterized in that

the control device is configured to control one or more of the elements of the system in the first refrigerant circuit in dependence upon a predefined defrosting condition and/or in dependence upon a space heating/cooling demand provided by an input and a state of charge of the phase change material heat storage device of the first and/or second refrigerant circuit, and/or to control one or more of the elements of the system in the second refrigerant circuit in dependence upon the state of charge of the phase change material heat storage device of the first and/or second refrigerant circuit.

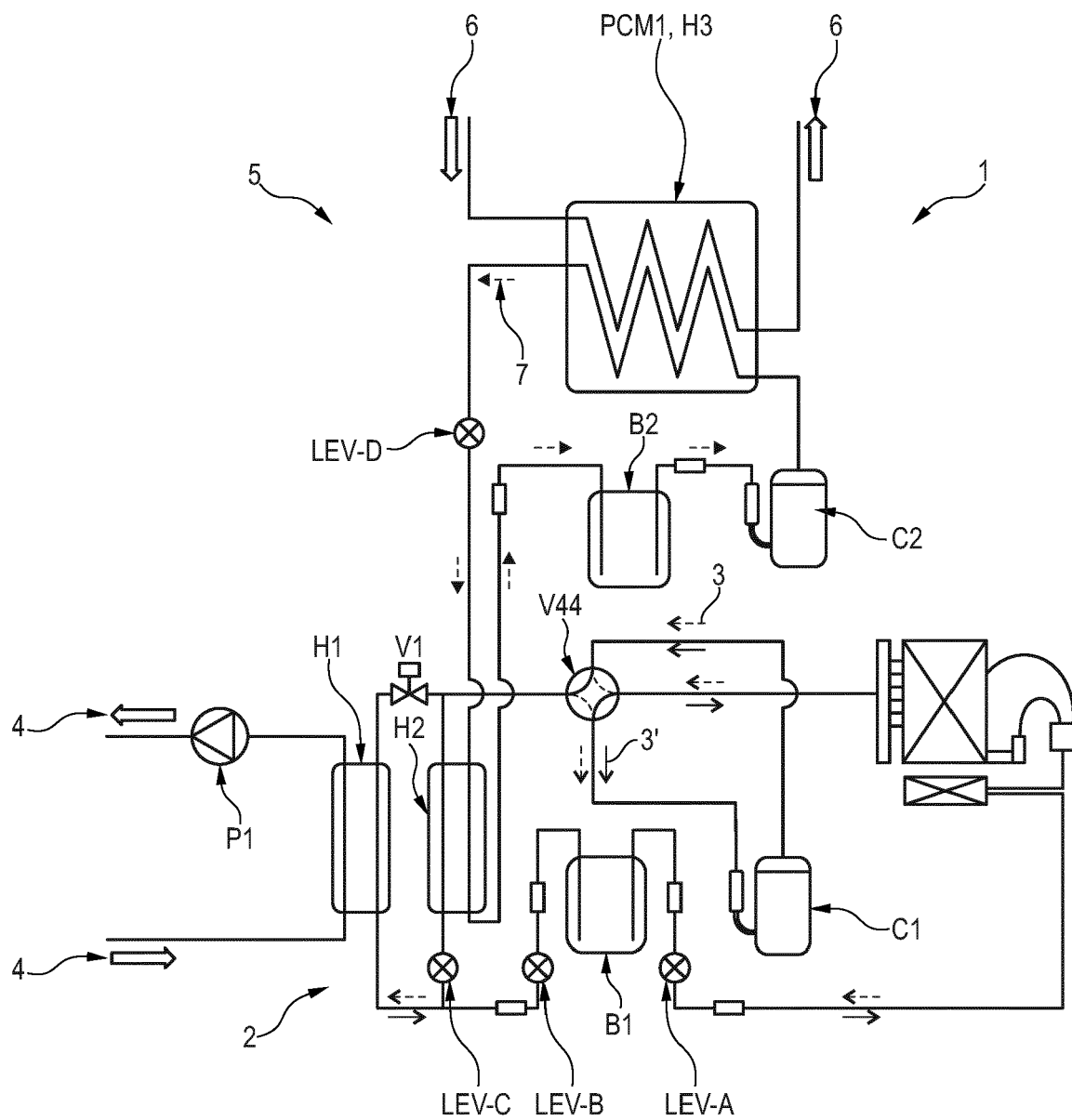


Fig. 1

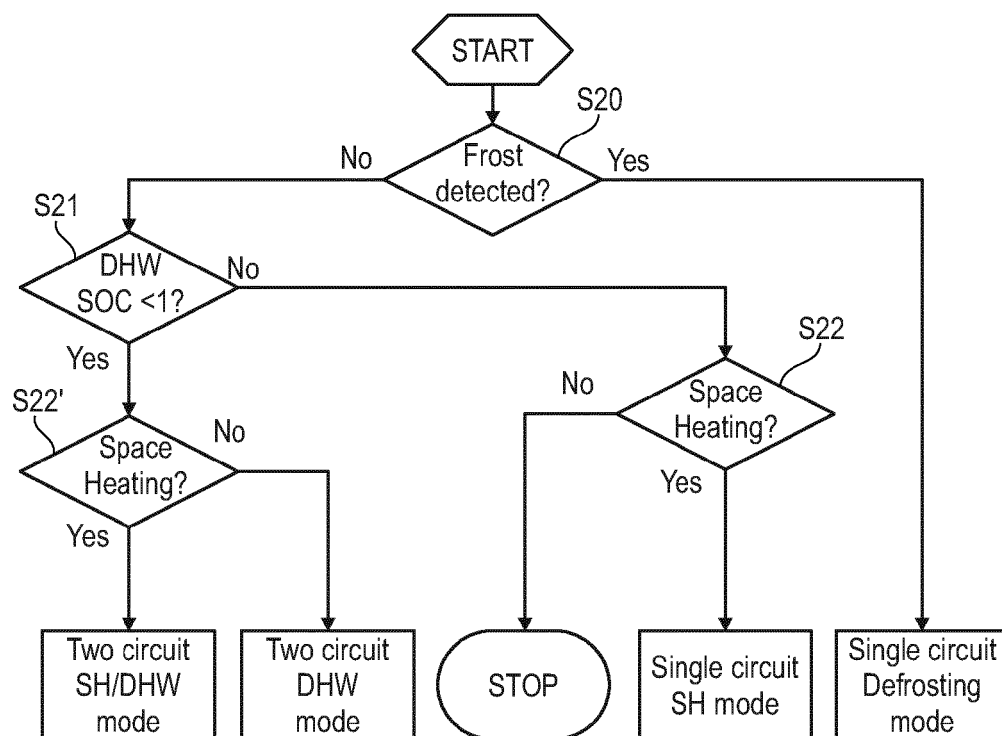


Fig. 2

No.	Mode	V44	C1	C2	LEV-A	LEV-B	LEV-C	LEV-D	V1	P1
1	Two circuit SH/DHW mode	OFF	ON	ON	OPEN	OPEN	OPEN	OPEN	OPEN	ON
2	Two circuit DHW mode	OFF	ON	ON	OPEN	OPEN	OPEN	OPEN	CLOSED	OFF
3	Single circuit SH mode	OFF	ON	OFF	OPEN	OPEN	CLOSED	CLOSED	OPEN	ON
4	Single circuit Defrosting mode	ON	ON	OFF	OPEN	OPEN	CLOSED	CLOSED	OPEN	OFF

Fig. 3

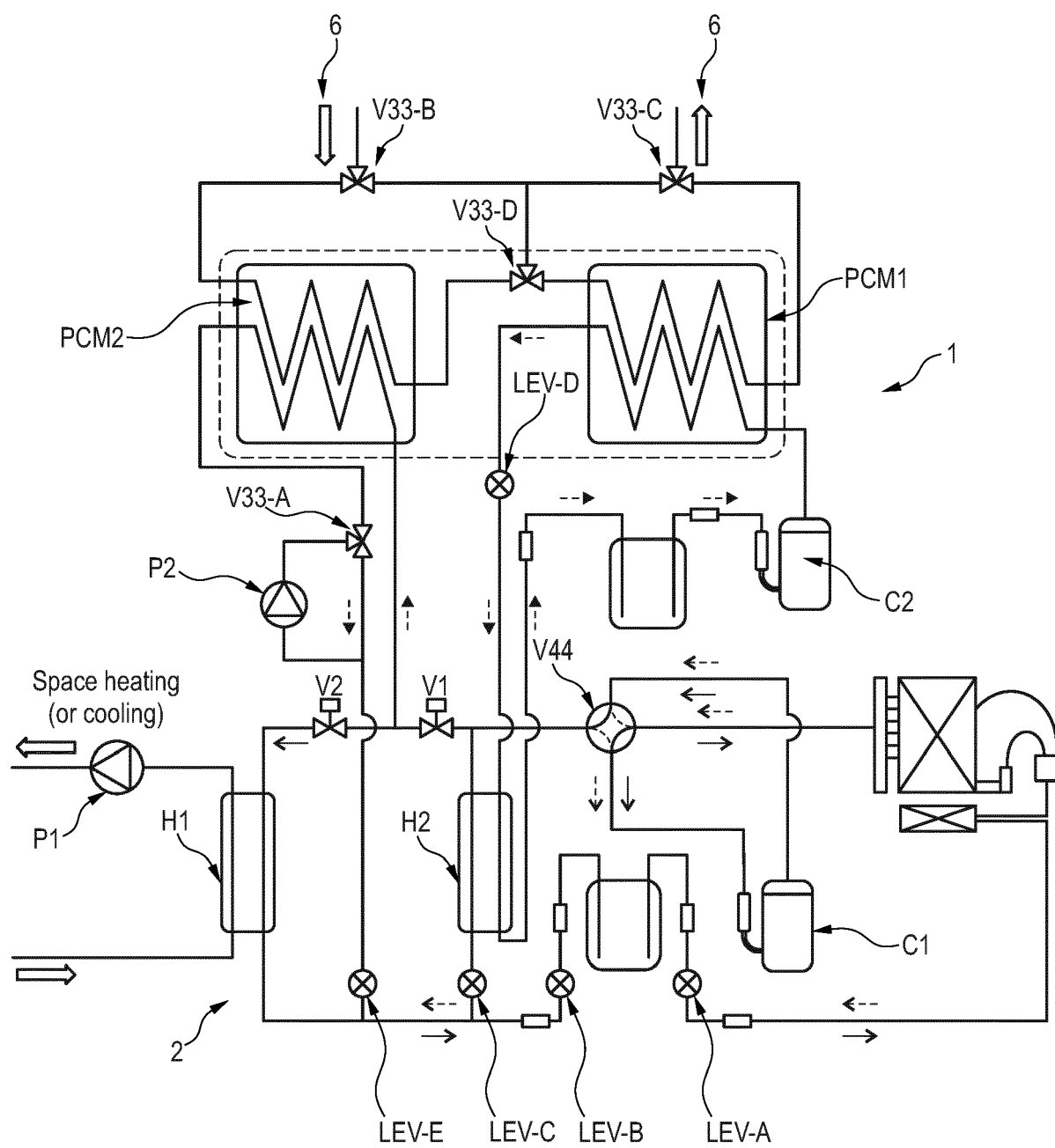


Fig. 4

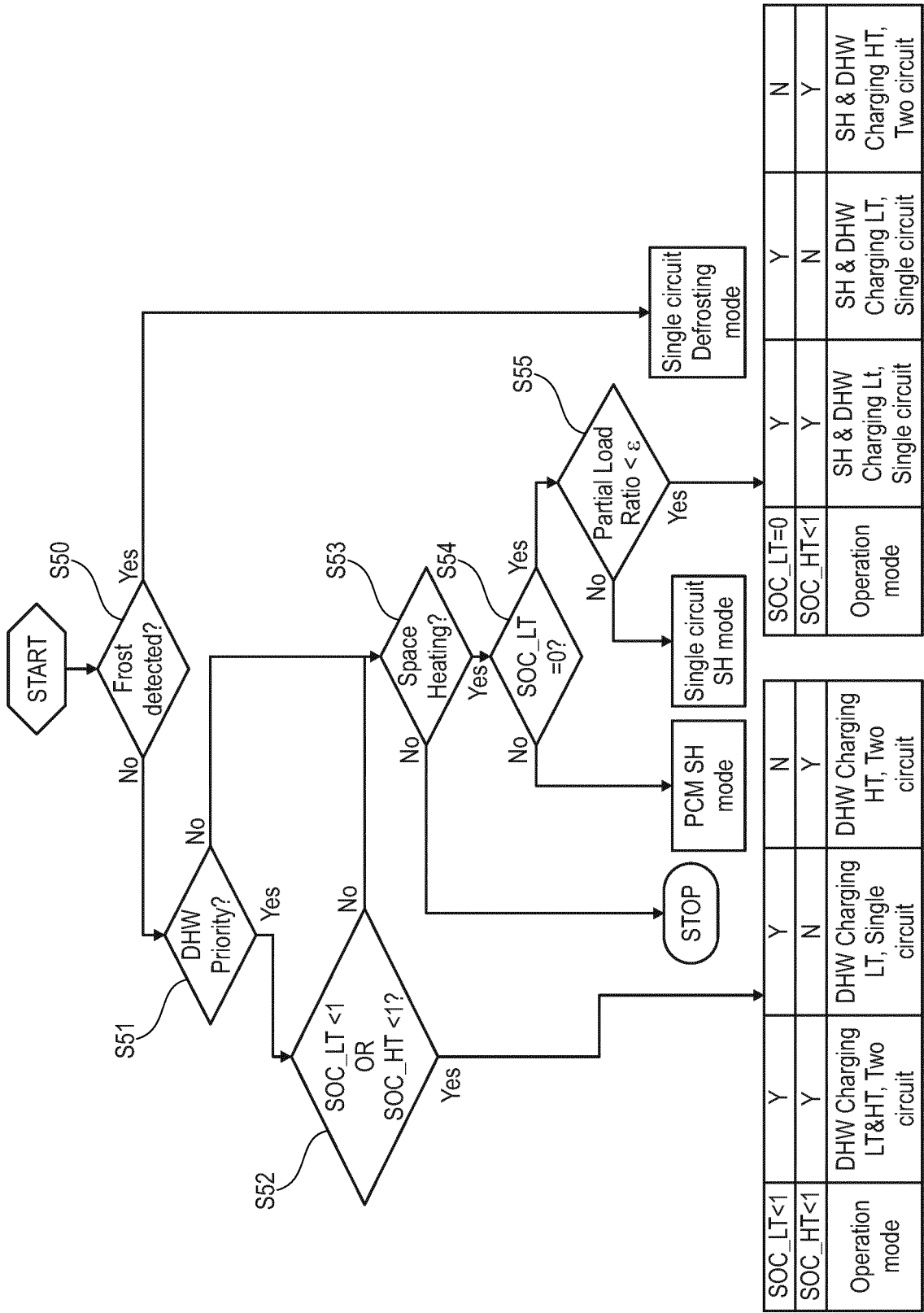


Fig. 5

No.	Mode	V44	C1	C2	LEV-A	LEV-B	LEV-C	LEV-D	LEV-E	V1	V2	P1	P2
1	DHW Charging LT&HT, Two circuit	OFF	ON	ON	OPEN	OPEN	OPEN	OPEN	OPEN	OPEN	CLOSED	OFF	OFF
2	DHW Charging LT, Single circuit	OFF	ON	OFF	OPEN	OPEN	CLOSED	CLOSED	OPEN	OPEN	OPEN	OFF	OFF
3	DHW Charging HT, Two circuit	OFF	ON	ON	OPEN	OPEN	OPEN	OPEN	CLOSED	CLOSED	CLOSED	OFF	OFF
4	PCM SH mode	OFF	OFF	OFF	CLOSED	CLOSED	CLOSED	CLOSED	OPEN	CLOSED	OPEN	ON	ON
5	Single circuit SH mode	OFF	ON	OFF	OPEN	OPEN	CLOSED	CLOSED	CLOSED	OPEN	OPEN	ON	OFF
6	SH&DHW Charging LT, Single circuit	OFF	ON	OFF	OPEN	OPEN	CLOSED	CLOSED	OPEN	OPEN	OPEN	ON	OFF
7	SH&DHW Charging HT, Two circuit	OFF	ON	ON	OPEN	OPEN	OPEN	OPEN	CLOSED	OPEN	OPEN	ON	OFF
8	Defrosting mode Single circuit	ON	ON	OFF	OPEN	OPEN	CLOSED	CLOSED	CLOSED	OPEN	OPEN	OFF	OFF

Fig. 6



EUROPEAN SEARCH REPORT

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Place of search Munich		Date of completion of the search 26 August 2021	Examiner Weisser, Meinrad
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26-08-2021

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