CLAIMS

1. Energy generation and storage plant, comprising:

a working fluid other than atmospheric air;

a casing (5) configured to store the working fluid in a gaseous phase and in equilibrium of pressure with the atmosphere;

a tank (9) configured to store said working fluid in liquid or supercritical phase with a temperature close to the critical temperature; wherein said critical temperature is between 0°C and 100°C;

wherein the plant is configured to perform a closed cyclic thermodynamic transformation (CTT), first in one direction in a charge configuration and then in an opposite direction in a discharge configuration, between said casing (5) and said tank (9); wherein in the charge configuration the plant stores heat and pressure and in the discharge configuration the plant generates energy;

wherein the plant comprises:

- a compressor (3) and a motor mechanically connected to each other;
- a turbine (2) and a generator (4b) and/or a driven machine (300) mechanically connected to each other;
- said casing (5) externally in contact with the atmosphere and delimiting, at the interior thereof, a volume configured to contain the working fluid at atmospheric pressure or substantially atmospheric pressure, wherein said volume is selectively in fluid communication with an inlet (3a) of the compressor (3) or with an outlet (2b) of the turbine (2);
- a primary heat exchanger (7) selectively in fluid communication with an outlet (3b) of the compressor (3) or with an inlet (2a) of the turbine (2);
- said tank (9) in fluid communication with the primary heat exchanger (7) to accumulate the working fluid;
- a secondary heat exchanger (10) operationally active between the primary heat exchanger (7) and the tank (9) or in said tank (9);
- an additional heat exchanger (13) operatively interposed between the casing (5) and the compressor (3) and/or between the casing (5) and the turbine (2);
- a further heat exchanger (220) operatively interposed between the turbine (2) and the primary heat exchanger (7);

wherein, in the charge configuration, the casing (5) is in fluid communication with the inlet (3a) of the compressor (3) and the primary heat exchanger (7) is in fluid communication with the outlet (3b) of the compressor (3), the turbine (2) is at rest, the motor (4a) is operating and drives the compressor (3) to compress the working fluid coming from the casing (5), the primary heat exchanger (7) works as a cooler to remove heat from the compressed

working fluid, cool it and store thermal energy, the secondary heat exchanger (10) works as a cooler to remove further heat from the compressed working fluid and store further thermal energy, the tank (9) receives and stores the compressed and cooled working fluid, wherein the working fluid stored in the tank (9) has a temperature close to its own critical temperature;

wherein, in the discharge configuration, the casing (5) is in fluid communication with the outlet (2b) of the turbine (2) and the primary heat exchanger (7) is in fluid communication with the inlet (2a) of the turbine (2), the compressor (3) is at rest, the secondary heat exchanger (10) works as a heater to release heat to the working fluid coming from the tank (9), the primary heat exchanger (7) works as a heater to release further heat to the working fluid and heat it, the turbine (2) is rotated by the heated working fluid and drives the generator (4b) and/or the driven machine (300), generating energy, the working fluid returns in the casing (5) to atmospheric or substantially atmospheric pressure;

wherein the plant is further configured to define a closed circuit and to perform a closed thermodynamic cycle (TC) in said closed circuit with at least part of said working fluid;

wherein, in said closed circuit, the outlet (3b) of the compressor (3) is in fluid communication with the further heat exchanger (220), the outlet (2b) of the turbine (2) is in fluid communication with the inlet (3a) of the compressor (3) and said additional heat exchanger (13) is operatively interposed between the outlet (2b) of the turbine (2) and the inlet (3a) of the compressor (3);

wherein the plant further comprises:

a first bypass conduit (310) comprising a respective first valve (311), wherein the first bypass conduit (310) is configured to connect the outlet (3b) of the compressor (3) with the further heat exchanger (220) and to bypass the primary heat exchanger (7) and the tank (9); a second bypass conduit (320) comprising a respective second valve (321), wherein the second bypass conduit (320) is configured to connect the outlet (2b) of the turbine (2) with the inlet (3a) of the compressor (3) and to bypass the casing (5).

2. Plant according to claim 1, wherein the working fluid has the following chemical-physical properties: critical temperature between 0°C and 200°C, density at 25°C between 0.5 kg/m^3 and 10 kg/m^3.

3. Plant according to claim 1 or 2, wherein the working fluid is chosen in the group comprising: CO_2, SF_6, N_2O.

4. Plant according to claim 1 or 2 or 3, wherein the casing (5) is a pressure-balloon.

5. Plant according to one of claims 1 to 4, wherein the first valve (311) and the second valve (321) can be throttled to adjust a flow of working fluid in the closed thermodynamic cycle (TC).

6. Plant according to one of claims 1 to 5, comprising a recuperator (400) operatively active between the primary heat exchanger (7) and the further heat exchanger (220) and between the outlet (2b) of the turbine (2) and the additional heat exchanger (13).

7. Plant according to one of claims 1 to 6, wherein the compressor (3) is multi-stage and inter-cooled.

8. Plant according to one of claims 1 to 7, wherein the further heat exchanger (220) is in fluid connection with at least one stage of the turbine (2) in order to inter-heat said turbine (2).

9. Plant according to one of claims 1 to 8, wherein a pump (25) is placed between the secondary heat exchanger (10) and the primary heat exchanger (7) and is configured for increasing the pressure in the discharge configuration.

10. Process for energy generation and storage comprising:

carrying out a closed cyclic thermodynamic transformation (CTT) through a working fluid different from atmospheric air;

the closed thermodynamic cyclic transformation being carried out first in one direction in a charge phase and then in an opposite direction in a discharge phase;

the closed thermodynamic cyclic transformation being carried out between a casing (5) and a tank (9);

wherein, in the charge phase, the working fluid stored in the casing (5) in a gaseous phase and in pressure equilibrium with the atmosphere is compressed in a compressor (3), cooled in a primary heat exchanger (7) and in a secondary heat exchanger (10) and stored in the tank (9) in a liquid or supercritical phase with a temperature close to the critical temperature; wherein said critical temperature is between 0°C and 100°C; wherein, in the charge phase, the process accumulates heat and pressure and the primary heat exchanger (7) and secondary heat exchanger (10) store thermal energy;

wherein, in the discharge phase, the working fluid stored in the tank (9) in the liquid or supercritical phase is heated through the primary heat exchanger (7) and the secondary heat exchanger (10), expanded in a turbine (2) and returned to the casing (5) in the gaseous

phase and in pressure equilibrium with the atmosphere; wherein, in the discharge phase, the process generates energy through a rotation of the turbine (2);

wherein the process further comprises: carrying out, with at least a part of said working fluid, a closed thermodynamic cycle (TC) in a closed circuit;

wherein the closed circuit for actuation of the closed thermodynamic cycle passes through: the compressor (3), a further heat exchanger (220), the turbine (2) and an additional heat exchanger (13);

wherein the closed circuit comprises: a first bypass conduit (310) connecting an outlet of the compressor (3) with the further heat exchanger (220) and bypassing the primary heat exchanger (7) and the tank (9); a second bypass conduit (320) connecting an outlet of the turbine (3) with an inlet of the compressor (2) and bypassing the casing (5).

11. Process according to claim 10, wherein the charge phase comprises:

compressing in the compressor (3) said working fluid, coming from said casing (5) externally in contact with the atmosphere and delimiting at the interior thereof a volume configured to contain the working fluid at atmospheric pressure or substantially atmospheric, absorbing energy;

introducing the compressed working fluid through the primary heat exchanger (7) and the secondary heat exchanger (10) placed in series to bring a temperature of the working fluid close to its own critical temperature; wherein the primary heat exchanger (7) works as a cooler to remove heat from the compressed working fluid, cool it and store thermal energy, wherein the secondary heat exchanger (10) works as a cooler to remove further heat from the compressed working fluid and store further thermal energy;

accumulating the cooled working fluid in said tank (9); wherein the secondary heat exchanger (10) and the primary heat exchanger (7) carry out a super-critical transformation of the working fluid so that said working fluid is accumulated in the tank (9) in super-critical phase or wherein the secondary heat exchanger (10) and the primary heat exchanger (7) carry out a sub-critical transformation of the working fluid so that said working fluid is accumulated in the tank (9) in liquid phase; wherein a temperature of the working fluid accumulated in the tank (9) is between 0 °C and 100 °C and wherein a pressure of the working fluid accumulated in the tank (9) is between 10 bar and 150 bar.

12. Process according to claim 11, wherein the discharge comprises:

passing the working fluid, coming from the tank (9), through the secondary heat exchanger (10) and the primary heat exchanger (7); wherein the secondary heat exchanger (10) works as a heater to transfer heat to the working fluid coming from the tank (9), wherein

the primary heat exchanger (7) works as a heater to transfer further heat to the working fluid and heat it;

passing the heated working fluid through the turbine (2), wherein the turbine (2) is rotated by the heated working fluid and drives a generator (4a) and/or a driven machine (300), generating energy, wherein the working fluid expands and cools down in the turbine (2);

re-introducing the working fluid coming from the turbine (2) into the casing (5) at atmospheric or substantially atmospheric pressure.

13. Process according to claim 12, wherein the closed thermodynamic cycle (TC) comprises:

- compressing at least a part of said working fluid into the compressor (3);
- passing said at least a part of said working fluid through the further heat exchanger (220) operatively associated with an additional heat source (230);
- expanding said at least a part of said heated working fluid through the turbine (2), wherein the turbine (2) is rotated by the heated working fluid and drives the generator (4b) and/or the driven machine (300), generating energy, wherein the working fluid expands and cools in the turbine (2);
- cooling said at least a part of said working fluid in the additional heat exchanger (13) and re-introducing said at least a part of said working fluid into the compressor (3).

14. Process according to one of claims 10 to 13, wherein the compression of the working fluid in the compressor (3) is inter-cooled.

15. Process according to one of claims 10 to 14, wherein the closed thermodynamic cycle (TC) has a higher pressure and a lower pressure; wherein the higher pressure is equal to or lower than the maximum pressure of the cyclic thermodynamic transformation (CTT) in the charge phase; wherein the lower pressure is equal to or higher than the minimum pressure of the cyclic thermodynamic transformation (CTT) in the discharge phase.

16. Process according to one of claims from 10 to 15, wherein said part of the working fluid operating according to the closed thermodynamic cycle (TC) is between 0% and 50% of said working fluid; wherein the remaining part of the working fluid accumulated in the tank (9) or in the casing (5) is between 100% and 50% of said working fluid.

17. Process according to one of claims 10 to 16, wherein said working fluid has the following physical-chemical properties: critical temperature between 0 °C and 200 °C,

density at 25 °C between 0.5 kg/m^3 and 10 kg/m^3; or it is chosen in the group including: CO_2, SF_6, N_2O.

18. Process according to one of claims 10 to 17, wherein an expansion of the working fluid in the turbine (2) is inter-heated.

19. Process according to one of claims 10 to 18, comprising: increasing the pressure in the discharge phase by means of a pump (25) placed between the secondary heat exchanger (10) and the primary heat exchanger (7).

20. Process according to one of claims 10 to 19, wherein the closed thermodynamic cycle (TC) is carried out simultaneously with the charge phase or the discharge phase.