

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
5 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
close to the ambient temperature, preferably between 0°C and 100°C;
wherein the plant is configured to perform a closed cyclic thermodynamic
10 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 is further configured to define a closed circuit and to perform a
15 closed thermodynamic cycle (TC) in said closed circuit with at least part of said
working fluid, optionally while said plant (1) is in the charge configuration or in the
discharge configuration.
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
20 at 25°C between 0.5 kg/m³ and 10 kg/m³; and/or is preferably chosen in the group
comprising: CO₂, SF₆, N₂O.
3. Plant according to claim 1 or 2, comprising:
- a compressor (3) and a motor mechanically connected to each other;
 - a turbine (2) and a generator (4b) and/or a driven machine (300)
25 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
30 compressor (3) or with an outlet (2b) of the turbine (2), wherein
optionally the casing (5) is a pressure-balloon;
 - 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);
 - 5 - 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);
- 10 said plant (1) being configured to operate in the charge configuration or in the discharge configuration;
- 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
- 15 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
- 20 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
- 25 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
- 30 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;

said plant (1) being configured to define the closed circuit and to perform the closed thermodynamic cycle (TC); 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).

4. Plant according to claim 3, comprising: 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).

5. Plant according to claim 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 claim 3, 4 or 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 3 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 3 to 7 or according to claim 8 when it depends on claim 3, 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, optionally implemented with the plant according to at least one of the previous claims, wherein the process comprises:

carrying out a closed cyclic thermodynamic transformation (CTT), first in one direction in a charge configuration/phase and then in an opposite direction in a discharge configuration/phase, between a casing (5) for the storage of a working fluid different from atmospheric air, in a gaseous phase and in pressure equilibrium with the atmosphere, and a tank (9) for the storage of said working fluid in a liquid or supercritical phase with a temperature close to the critical temperature; wherein said critical temperature is close to the ambient temperature, preferably between 0°C and 100°C; wherein, in the charge phase, the process accumulates heat and pressure and in the discharge phase generates energy;

10 carrying out, with at least a part of said working fluid, a closed thermodynamic cycle (TC), optionally simultaneously with the charge phase or the discharge phase.

11. Process according to claim 10, wherein the charge phase comprises:
- compressing in a 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 a primary heat exchanger (7) and a 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 optionally 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:

- 5 - 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;
- 10 - passing the heated working fluid through a 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);
- 15 - 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 11 or 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 a further heat
20 exchanger (220) operatively associated with an additional heat source (230);
- expanding said at least a part of said heated working fluid through a turbine (2), wherein the turbine (2) is rotated by the heated working fluid and drives a generator (4b) and/or a driven machine (300), generating energy, wherein
25 the working fluid expands and cools in the turbine (2);
- cooling said at least a part of said working fluid in an additional heat exchanger (13) and re-introducing said at least a part of said working fluid into the compressor (3).

14. Process according to claim 11, 12 or 13, wherein the compression of the
30 working fluid in the compressor is inter-cooled; wherein, optionally, the closed thermodynamic cycle (TC) is recuperative.

15. Process according to one of claims 10 to 14, in which 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 configuration/phase; wherein the lower pressure is equal to or higher than the minimum pressure of the cyclic thermodynamic transformation (CTT) in the discharge configuration/phase.

- 5 16. Process according to one of the 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, optionally between 20% and 30%; wherein the remaining part of the working fluid accumulated in the tank (9) or in
10 the casing (5) is between 100% and 50% of said working fluid, optionally between 80% and 70%.

17. Process according to any 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/m³ and 10 kg/m³; and/or it is preferably chosen in the group including: CO₂, SF₆, N₂O.

- 15 18. Process according to claim 12, wherein an expansion of the working fluid in the turbine (2) is inter-heated.

19. Process according to claim 12, 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).