compressor 14 during the compression process is not used in the air expansion process, but may be used beneficially for other purposes..

**[0053]** In a diabatic system configuration, the system 10 may include a combustor 18c to heat the air used in the HP and LP turbines 18a and 18b. As illustrated in the example of Figure 3, when the system 10 is a diabatic system, the stored energy in the compressed air may be released from the storage vessel 16. The compressed air is heated by the combustor 18c through combustion, for example by natural gas or fuel. The heated air may be expanded in HP and/or LP turbines 18a and 18b to generate electricity, as previously described.

**[0054]** In an embodiment, the temperature of the air decreases as the air expanded in the turbines 18a and 18b. In some examples, the air discharged from the HP turbine 18a may have a flow rate of 0.302 kg/s, a volume flow rate of 0.005 $m^3$/s, a pressure of 15 MPa and a temperature of 100 $^oC$. In this case, the air expander 18 may generate electricity up to 5.5 MWh if the fuel flow rate supply to the combustor 18c to reheat the air in the turbines 18a and 18b is 0.03 kg/s. Therefore, the round trip efficiency of air expander 18 in the diabatic system illustrated in Figure 3 is about 55%, which is the ratio of the energy generated from the air expander 18 over the energy stored in the storage vessel 16, for example 10 MWh.

**[0055]** If the diabatic system has a 55% round-trip efficiency, the table below shows exemplary parameters of the diabatic system illustrated in Figure 3 in different pressurization scenarios:

| Initial Pressure of the Vessel (PSI) | Final Pressure of the Vessel (PSI) | Discharge Time (hours) | Total Produced Energy (kWh) | Round-trip Efficiency |
|---|---|---|---|---|
| 7250 | 14 | 24 | 5500 | 55% |
| 7250 | 3000 | 14 | 3400 | 34% |
| 7250 | 4350 | 9.5 | 2300 | 23% |

**Claims:**

1. A storage vessel for storing compressed gas, comprising:
   a wellbore provided in a subsurface;
   a casing placed within the wellbore and cemented to surrounding rock layers for providing in situ confinement from the surrounding rock layers due to stiffness of the rock mass, the cased wellbore defining a volumetric space for storing the compressed gas generated from a renewable energy source; and
   at least one gas flow regulator sealed at a top end of the casing for selectively injecting the compressed gas into the space or discharging the compressed gas from the volumetric space for generating electrical energy, wherein the storage vessel is configured to store at least a portion of heat in a charging process, for heating the compressed gas in a subsequent expansion process for generation of the electrical energy, the portion of heat being generated during a compression process of the compressed gas, and wherein the compressed gas stored in the storage vessel has said pressure up to 100 MPa and said temperature up to 250$^{o}$ C.

2. The storage vessel of claim 1, wherein an effective volume capacity of the well is 1-8 $m^3$/100 meter of well length.

3. The storage vessel of claim 2, wherein a total volume of the well is 50-100 $m^3$.

4. The storage vessel of claim 1, wherein the stored compressed gas has a pressure of 5 MPa to 100 MPa, and a temperature of 50 $^{o}$C to 250 $^{o}$C.

5. The storage vessel of claim 1, wherein the casing further comprises multitude sections comprising progressively smaller diameter casing as the wellbore length is extended.

6. The storage vessel of claim 1, wherein the compressed gas is compressed air.

7. The storage vessel of claim 1, wherein the compressed gas has a pressure of 50 MPa.

8. The storage vessel of claim 1, wherein the cased wellbore has a volumetric capacity of $7m^3$/100m of length, a depth of 1000 meters, and a total volume of $70m^3$.

9. A system for storing energy in a form of compressed gas for generation of electrical energy, comprising:

one or more energy storage vessels for storing compressed gas, said energy storage vessels each provided in a subsurface, comprising:

a wellbore provided in a subsurface;

a casing placed within each of the one or more energy storage vessels and cemented to surrounding rock layers for providing in situ confinement from the surrounding rock layers due to stiffness of the rock mass , the casing defining a volumetric space for storing the compressed gas; and

at least one gas flow regulator sealed at a top end of the casing for selectively injecting the compressed gas into the space or discharging the compressed gas from the volumetric space,

at least one surface gas compressor in sealed, fluid communication with the one or more energy storage vessels for compressing the gas and for injecting the compressed gas therein; and

at least one surface gas expander system in sealed, fluid communication with the one or more energy storage vessels for generating electricity from the compressed gas discharged from the one or more energy storage vessels;

wherein the one or more storage vessels store in a charging process at least a portion of heat being generated during a compression process of the gas, the portion of the heat to be used for heating the compressed gas in said subsequent expansion process for generation of the electrical energy,

wherein the compressed gas stored in the one or more storage vessels has a pressure up to 100 MPa and a temperature up to 250$^{o}$ C per energy storage vessel.

10. The system of claim 9, wherein the one or more energy storage vessels comprise a plurality of energy storage vessels and wherein adjacent energy storage vessels are in fluid communication with each other.

11. The system of claim 9, wherein the compressed gas is compressed air.

12. The system of claim 9, wherein an effective volume capacity of the storage vessel is 1-8 $m^3$/100 meter of cased wellbore length.

13. The system of claim 12, wherein a total volume of the well is 50-100 $m^3$.

14. The system of claim 9, wherein the system is configured to provide a maximum pressure in the one or more energy storage vessels of 100 MPa per energy storage vessel.

15. The system of claim 10, where the plurality of energy storage vessels form an array that is in fluid connection to collectively provide a cumulative storage capacity for energy storage.

16. The system of claim 9, wherein said thermal storage medium includes the surrounding rock formations for heat storage.

17. A method for energy storage for generation of electrical energy, comprising:
forming at least one storage vessel by cementing a casing in a wellbore in the subsurface; providing, from surrounding rock layers of the subsurface, in situ confinement to the at least one storage vessel,
compressing gas on the surface using a renewable energy source;
and
storing at least a portion of heat generated from compression of the gas in the at least one storage vessel,

wherein the compressed gas stored in the storage vessel has a pressure up to 100 MPa and a temperature up to 250$^{o}$ C.

18. The storage vessel of claim 1, wherein the storage vessel stores the compressed air that stores on an order of 5 MWh or more of energy for electricity generation.

19. The system of claim 14, wherein overall round-trip efficiencies of the system is greater than 23 %.

20. The storage vessel of claim 1, wherein the storage vessel is used in an adiabatic system for storing energy in the compressed gas for generation of electrical energy.