

APPARATUS FOR ENERGY CONVERSION

[001] The present disclosure relates to energy conversion, and more particularly, to a low-grade heat powered apparatus having dual-functionality of a generator and a
5 chiller, and methods of operations thereof.

[002] Electricity is an essential requirement of present civilisation. However, electricity is generally generated from mechanical power which is mostly obtained by burning of fossil fuels for conversion to mechanical power. The use of fossil fuels is not sustainable as it non-renewable, contributes to environmental pollution, and emits
10 greenhouse gases which triggers climate change. Various efforts have been made to generate electricity using renewable sources, such as sunlight and wind using photovoltaic and wind turbine technologies, respectively. However, these solutions may not be available at all the locations and all the time for effective harvesting.

[003] Therefore, an effective solution for electricity generation is desired that is
15 available in abundance and overcomes the challenges otherwise posed by the use of fossil fuels.

[004] This summary is provided to introduce a selection of concepts, in a simplified format, that are further described in the detailed description of the invention. This summary is neither intended to identify key or essential inventive concepts of the
20 invention and nor is it intended for determining the scope of the invention.

[005] In an implementation of the present disclosure, an apparatus for energy conversion optionally with dual-functionalities of a generator and a chiller is disclosed. The apparatus may include a storage container configured to store a working medium fluid, wherein the working medium fluid is stored in the storage container at a first
25 predefined temperature and a first predefined pressure and a pressure release valve

coupled with the storage container. The pressure release valve may be configured to release the working medium fluid to a second pressure. The temperature of the working medium fluid drops to a second temperature as a result of release. The second pressure is lower than the first predefined pressure, and the second temperature is lower than the first predefined temperature of the working medium fluid. The apparatus further includes a vane motor configured to receive the working medium fluid at a third pressure, the third pressure being greater than the second pressure. The apparatus further includes an embedded heat exchanger encased within the vane motor configured to create an interface between the working medium fluid within the vane motor and an energy carrier fluid, for heat exchange to occur between the working medium fluid and the energy carrier fluid. Upon the heat exchange, the temperature and pressure of the working medium increases and the temperature of the energy carrier fluid decreases. The embedded heat exchanger contained in a ring module configured to be removably encased within the vane motor. The vane motor may be rotated under combined effect of the working medium fluid entering the vane motor at the third pressure and the pressure of the working medium increasing upon the heat exchange.

[006] The apparatus may further include a pressure regulator fluidically coupled with the pressure release valve. The pressure regulator may be configured to regulate the pressure drop to the second pressure. When the pressure release valve is opened, a high-pressure working medium fluid may discharge into the pressure regulator, to the second pressure.

[007] The apparatus may further include a high-pressure pump positioned between the pressure release valve and the vane motor. The high-pressure pump may be configured to receive the cold working medium fluid from the pressure release valve

and pump the cold working medium fluid into the vane motor at the third pressure. The high-pressure pump may be configured to receive the cold working medium fluid from the pressure release valve and pump the working medium fluid into the vane motor at the third pressure.

55 **[008]** The apparatus may further include an electricity generator mechanically coupled within the vane motor and configured to generate electrical power using the rotation of the vane motor. The electricity generator may be mechanically coupled within the vane motor, via a plurality of vanes of the vane motor configured to engage with a plurality of slots on an outer side of the electricity generator. The electricity
60 generator encased within the vane motor acts as the rotor, to provide a compact assembly of the electricity generator and the vane motor.

[009] In some embodiments, the working medium fluid may be Carbon dioxide (CO₂). CO₂ becomes very cold because of its thermodynamic property. As such, once the working medium fluid (CO₂) is released via the pressure release valve, the
65 temperature of the working medium fluid falls to the second temperature which is lower than the first predefined temperature.

[010] In some embodiments, the energy carrier fluid may be water.

[011] The embedded heat exchanger contained in the ring module may include a peripheral enclosure along a periphery of the ring module defining: a closed space
70 and an inner wall. The peripheral enclosure may be configured to receive the energy carrier fluid in the closed space. Further, the inner wall may act as an inner surface of the vane motor whilst creating the interface between the working medium fluid within the vane motor and the energy carrier fluid within the closed space. The embedded heat exchanger contained in the ring module may further include an inlet orifice
75 configured to allow passage of the working medium fluid into the vane motor, across

the peripheral enclosure and an outlet orifice configured to allow passage of the working medium fluid out of the vane motor, across the peripheral enclosure. The embedded heat exchanger contained in the ring module may further include at least one inlet port configured to allow passage of the energy carrier fluid into the peripheral enclosure and at least one outlet port configured to allow passage of the energy carrier fluid out of the peripheral enclosure. The embedded heat exchanger, contained in the ring module, may be removably encased within the vane motor. In particular, the ring module may constitute an inner surface of the vane motor. As such, the ring module may sit between an inner wall of a housing of the vane motor and the encased electricity generator. The embedded heat exchanger contained in the ring module may be encased in the vane motor at a section where the working medium fluid enters the vane motor.

[012] In some embodiments, the at least one inlet port may include a first inlet port positioned in proximity to the inlet orifice and a second inlet port positioned in proximity to the outlet orifice. The energy carrier fluid flow entering the embedded heat exchanger via the first inlet port may be controlled, such that the working medium fluid is at ambient room temperature, i.e., about 20 °C or higher when the working medium fluid exits the vane motor. Furthermore, the temperature and the pressure of the working medium fluid may continue to increase as it gets in contact with the energy carrier fluid streaming in via the second inlet port within the vane motor.

[013] The at least one outlet port may include a first outlet port positioned substantially mid-way of the first inlet port and the second inlet port and a second outlet port positioned substantially mid-way of the first inlet port and the second inlet port. The energy carrier fluid, upon entering into the embedded heat exchanger via each of

100 the first inlet port and the second inlet port, may move towards each other and exit midway via the first outlet port and the second outlet port.

[014] In some embodiments, a heat exchange area may be defined on a portion of the peripheral enclosure, such that the heat exchange occurs along the heat exchange area.

105 **[015]** In some embodiments, each pair of vanes of the plurality of vanes of the vane motor along with the inner wall may define a vane chamber therebetween. A volume of the vane chamber defined throughout along the heat exchange area may be the same.

[016] In some embodiments, the second temperature of the working medium fluid is less than or equal to -40°C . Further, upon the heat exchange, the temperature of the working medium fluid may increase to a fourth temperature, wherein the fourth temperature is within a temperature range of 20°C to 32°C . Furthermore, upon the heat exchange, the temperature of the energy carrier fluid decreases to a third temperature, wherein the third temperature may be close to 1°C .

115 **[017]** The apparatus may further include at least one flow-regulating valve fluidically coupled with the at least one outlet port. The flow-regulating valve may be configured to regulate the flow of the energy carrier fluid from the embedded heat exchanger, such that the temperature of the energy carrier fluid may drop to around 1°C (as chilled water).

120 **[018]** The working medium fluid, upon exiting from the vane motor, may be directed into the storage cylinder. At the time of entering the storage cylinder, the pressure of the working medium fluid may be lower than the first predefined pressure.

[019] The apparatus may further include a chiller heat exchanger configured to receive the energy carrier fluid from the embedded heat exchanger, via a secondary

125 pump. The chiller heat exchanger may be further configured to raise the temperature
of the energy carrier fluid up from the third temperature. The apparatus, which can
therefore be a combination of the electricity generator and a chiller, may provide for a
compact and portable solution which is also scalable to power residential/commercial
buildings of any size, ships, motor vehicles, trains, and airplanes. Further, the
130 apparatus may provide for energy saving in air-conditioning by the use of the chilled
energy carrier fluid.

[020] The apparatus may further include a first check valve positioned between the
high-pressure pump and the vane motor, to prevent a backflow of the working medium
fluid therebetween. The apparatus may further include a second check valve
135 positioned between the vane motor and the storage container, to prevent a backflow
of the working medium fluid therebetween. The apparatus may further include a third
check valve positioned between the vane motor and the chiller heat exchanger, to
prevent a backflow of the energy carrier fluid therebetween.

[021] In another implementation of the present disclosure, a method of energy
140 conversion is disclosed. The method may include releasing a working medium fluid
stored in a storage container via a pressure release valve coupled with the storage
container. The working medium fluid may be stored in the storage container at a first
predefined temperature and a first predefined pressure. The pressure release valve
may be configured to release the working medium fluid to a second pressure. The
145 temperature of the working medium fluid may drop to a second temperature as a result
of release. The second pressure may be less than the first predefined pressure, and
the second temperature may be less than the first predefined temperature of the
working medium fluid. The method may further include inputting the working medium
fluid to a vane motor at a third pressure, the third pressure being greater than the

150 second pressure. The method may further include interfacing the working medium fluid within the vane motor with an energy carrier fluid, via an embedded heat exchanger encased within the vane motor, for heat exchange to occur between the working medium fluid and the energy carrier fluid. Upon the heat exchange, the temperature and pressure of the working medium increases and the temperature of the energy
155 carrier fluid decreases. The embedded heat exchanger contained in a ring module configured to be removably encased within the vane motor. The vane motor may be rotated under combined effect of the working medium fluid entering the vane motor at the third pressure and the pressure of the working medium increasing upon the heat exchange.

160 **[022]** To further clarify the advantages and features of the present invention, a more particular description of the invention will be rendered by reference to specific implementations thereof, which is illustrated in the appended drawings. It is appreciated that these drawings depict only typical implementations of the invention and are therefore not to be considered limiting of its scope. The invention will be
165 described and explained with additional specificity and detail with the accompanying drawings.

[023] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts
170 throughout the drawings, wherein:

[024] FIG. 1 illustrates a block diagram depicting an apparatus for energy conversion, according to an implementation of the present disclosure;

[025] **FIG. 2** illustrates a schematic perspective view of an embedded heat exchanger of the apparatus of FIG. 1, in accordance with an implementation of the present disclosure;

[026] **FIG. 3** illustrates a schematic front view of an electricity generator of the apparatus of FIG. 1, in accordance with an implementation of the present disclosure;

[027] **FIG. 4** illustrates a schematic front view of a vane motor of the apparatus of **FIG. 1** along with the embedded heat generator and the electricity generator encased in the vane motor, in accordance with an implementation of the present disclosure; and

[028] **FIG. 5** is flowchart of a method of energy conversion, in accordance with an implementation of the present disclosure.

[029] Further, skilled artisans will appreciate that elements in the drawings are illustrated for simplicity and may not have necessarily been drawn to scale. For example, the flow charts illustrate the method in terms of the most prominent steps involved to help to improve understanding of aspects of the present invention. Furthermore, in terms of the construction of the device, one or more components of the device may have been represented in the drawings by conventional symbols, and the drawings may show only those specific details that are pertinent to understanding the implementations of the present invention so as not to obscure the drawings with details that will be readily apparent to those of ordinary skill in the art having benefit of the description herein.

[030] For the purpose of promoting an understanding of the principles of the invention, reference will now be made to the implementation illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such

alterations and further modifications in the illustrated apparatus, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates. Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skilled in the art to which this invention belongs. The apparatus, methods, and examples provided herein are illustrative only and not intended to be limiting.

[031] Whether or not a certain feature or element was limited to being used only once, it may still be referred to as “one or more features” or “one or more elements” or “at least one feature” or “at least one element.” Furthermore, the use of the terms “one or more” or “at least one” feature or element do not preclude there being none of that feature or element, unless otherwise specified by limiting language including, but not limited to, “there needs to be one or more...” or “one or more element is required.”

[032] Unless otherwise defined, all terms and especially any technical and/or scientific terms, used herein may be taken to have the same meaning as commonly understood by a person ordinarily skilled in the art.

[033] Reference is made herein to some “implementations.” It should be understood that an implementation is an example of a possible implementation of any features and/or elements of the present disclosure. Some implementations have been described for the purpose of explaining one or more of the potential ways in which the specific features and/or elements of the proposed disclosure fulfil the requirements of uniqueness, utility, and non-obviousness.

[034] Use of the phrases and/or terms including, but not limited to, “a first implementation,” “a further implementation,” “an alternate implementation,” “one implementation,” “an implementation,” “multiple implementations,” “some

implementations,” “other implementations,” “further implementation”, “furthermore
implementation”, “additional implementation” or other variants thereof do not
225 necessarily refer to the same implementations. Unless otherwise specified, one or
more particular features and/or elements described in connection with one or more
implementations may be found in one implementation, or may be found in more than
one implementation, or may be found in all implementations, or may be found in no
implementations. Although one or more features and/or elements may be described
230 herein in the context of only a single implementation, or in the context of more than
one implementation, or in the context of all implementations, the features and/or
elements may instead be provided separately or in any appropriate combination or not
at all. Conversely, any features and/or elements described in the context of separate
implementations may alternatively be realized as existing together in the context of a
235 single implementation.

[035] Any particular and all details set forth herein are used in the context of some
implementations and therefore should not necessarily be taken as limiting factors to
the proposed disclosure.

[036] Implementations of the present invention will now be described below in detail
240 with reference to the accompanying drawings.

[037] The present disclosure provides for utilizing a renewable energy source of
energy in form of low-grade heat of 20 degrees Celsius (°C) and above. This low-
grade heat is abundantly available in the ambient atmosphere or as waste heat from
industrial operations. Further, in absence of this low-grade heat, burning of renewable
245 non pollutive fuel like magnesium or hydrogen can be used as well. This low-grade
heat requires an apparatus for energy conversion that can convert the low-grade heat

into useful mechanical motion that can be used to further drive a generator to generate electricity.

[038] To this end, a cold hydraulic powered generator with combined delivery function of a chiller is disclosed, in which a cold working medium fluid (for example, carbon dioxide (CO₂)) at a temperature of about -40°C or lower is generated *in situ*. The

working medium fluid operates in a closed loop cycle. An energy carrier fluid (for example, water) harvests ambient heat or waste heat from machine or industrial operations and is pumped into an embedded heat exchanger encased in a vane motor.

Further, a generator may also be encased within the vane motor. The cold working medium is pumped into the vane motor. The cold working medium flows by and absorbs energy from the warm energy carrier fluid in the heat exchanger without mixing together. The cold working medium becomes warmer and its pressure increase, to drive the generator. The warm energy carrier fluid becomes chilled by the time it exists the vane motor. An electricity output and a chilled fluid are obtained. The chilled energy carrier may collect more heat to reach temperature 20 °C and above before it returns back to power the generator. The apparatus, therefore, provides dual function of the generator and the chiller combined.

[039] The electricity generated is clean and renewable as it does away with the requirement of burning of fossil fuels. The heat source is ambient heat, or waste heat from industrial operations, or natural heat from deep in the earth or other sources, or even heat from burning of renewable resources like magnesium or hydrogen. The chilled energy carrier fluid can be used for air-conditioning where it is warmed.

[040] The above apparatus which is combination of an electricity generator and a chiller provides for a compact and portable solution which is also scalable to power residential/commercial buildings of any size, ships, motor vehicles, trains, and

airplanes. Further, the above apparatus provides for energy saving in air-conditioning by the use of the chilled energy carrier fluid. Moreover, the above apparatus provides a solution for decarbonization, mitigating climate change, and providing low-cost clean energy security and independence for all societies.

[041] FIG. 1 illustrates a schematic diagram depicting an apparatus for energy conversion 100, according to an implementation of the present disclosure. In an implementation of the present disclosure, the apparatus for energy conversion 100 may include a storage container 102 configured to store a working medium fluid. The working medium fluid may be stored in the storage container 102 at a first predefined temperature and a first predefined pressure. By way of an example, the working medium fluid may be Carbon Dioxide (CO₂), and in particular, liquid CO₂. In some embodiments, the first predefined temperature at which the working medium (liquid CO₂) may be stored in the storage container 102 may be room temperature, i.e. above 20 degrees Celsius (°C). The first predefined pressure at which the working medium (liquid CO₂) may be stored in the storage container 102 may be around 70 bars, when not in operation. The storage container, for example, may be a metal cylinder capable of storing a high-pressure fluid.

[042] The apparatus 100 may further include a pressure release valve 104 coupled with the storage container 102. For example, the pressure release valve 104 may be a start/stop valve. The pressure release valve 104 may be configured to release the working medium fluid to a second pressure. As a result of release, the temperature of the working medium fluid drops to a lower temperature (second temperature), becoming a cold working medium. The second pressure may be lower than the first predefined pressure, and the second temperature may be lower than the first predefined temperature of the working medium fluid. When the pressure release valve

104 is opened, the high-pressure liquid CO₂ may discharge into a pressure regulator 106, to the second pressure. The second pressure may be about 10 bars. A pressure gauge 108 may be provided in proximity to the pressure regulator 106 to constantly monitor the pressure of the working medium fluid as it is released. The working medium fluid (liquid CO₂) becomes very cold because of the thermodynamic property of the working medium fluid (CO₂). As such, once the working medium fluid is released via the pressure release valve 104, the temperature of the working medium fluid falls to the second temperature which is lower than the first predefined temperature.

[043] The apparatus 100 may further include a vane motor 110 configured to receive the working medium fluid at a third pressure. The third pressure may be greater than the second pressure, i.e. greater than 10 bars. To this end, the apparatus 100 may include a high-pressure pump 112 which may be positioned between the pressure release valve 104 and the vane motor 110 (as shown in **FIG. 4**). The high-pressure pump may be configured to receive the cold working medium fluid from the pressure release valve 104 and pump the working medium fluid into the vane motor 110 at the third pressure. As shown in **FIG. 1**, the cold working medium at an inlet of the high-pressure pump 112 may be pumped into the vane motor 110. A first check valve 130A may be positioned between the high-pressure pump 112 and the vane motor 110, to prevent a backflow of the working medium fluid.

[044] The apparatus 100 may further include an embedded heat exchanger 114. In some embodiments, the embedded heat exchanger 114 may be encased within the vane motor 110 (as shown in **FIG. 4**). In some embodiments, the embedded heat exchanger 114 contained in a ring module 210, a ring-shaped structure, configured to be removably encased within the vane motor 110. In particular, the ring module 210 may constitute an inner surface of the vane motor 110. The embedded heat exchanger

114 contained in the ring module 210 which may be encased in the vane motor 110 at a section where the working medium fluid enters the vane motor 110. However, the working medium fluid does not enter the embedded heat exchanger 114 while entering the vane motor 110. The embedded heat exchanger 114 may be configured to carry an energy carrier fluid therewithin. By way of an example, the energy carrier fluid may be water that may be circulated through the embedded heat exchanger 114 at a temperature of about 20 °C or higher. The embedded heat exchanger 114 is further explained in detail, in conjunction with **FIG. 2**.

[045] Referring now to **FIG. 2**, a schematic perspective view 200 of the embedded heat exchanger 114 is illustrated, in accordance with an implementation of the present disclosure. The embedded heat exchanger 114 is contained in the ring module 210, a ring-shaped structure (as shown in **FIG. 4**), configured to be removably encased within the vane motor 110. The embedded heat exchanger 114 may define a peripheral enclosure along a periphery of the ring module 210 defining a closed space. The peripheral enclosure may be configured to receive the energy carrier fluid in the closed space. The embedded heat exchanger 114 contained in the ring module 210 may further include an inner wall 208 acting as an inner surface of the vane motor 110. The inner wall 208 may create an interface between the working medium fluid within the vane motor 110 and the energy carrier fluid within the closed space of the embedded heat exchanger 114.

[046] In some embodiments, as shown in **FIG. 2** the ring module 210 where it contains the embedded heat exchanger 114, may include an inlet orifice 202A configured to allow passage of the working medium fluid into the vane motor 110, across the peripheral enclosure. The ring module 210 may further include an outlet orifice 202B configured to allow passage of the working medium fluid out of the vane

motor 110, across the peripheral enclosure. As such, the working medium fluid may flow into vane motor 110 via the inlet orifice 202A and may flow out of the vane motor 110 via the outlet orifice 202B. The flow of working medium fluid between the inlet orifice 202A and outlet orifice 202B can be reversible.

[047] The embedded heat exchanger 114 may include at least one inlet port configured to allow passage of the energy carrier fluid into the peripheral enclosure of the embedded heat exchanger 114. In particular, in some embodiments, as shown in **FIG. 2**, the embedded heat exchanger 114 may include two inlet ports - a first inlet port 204A positioned in proximity to the inlet orifice 202A and a second inlet port 204B positioned in proximity to the outlet orifice 202B. Further, the embedded heat exchanger 114 may include at least one outlet port configured to allow passage of the energy carrier fluid out of the peripheral enclosure. In particular, in some embodiments, as shown in **FIG.2**, the embedded heat exchanger 114 may include two outlet ports - a first outlet port 206A positioned substantially mid-way of the first inlet port 204A and the second inlet port 204B, and a second outlet port 206B positioned substantially mid-way of the first inlet port 204A and the second inlet port 204B. As such, the energy carrier fluid may enter into the embedded heat exchanger 114 via each of the first inlet port 204A and the second inlet port 204B, and move towards each other and exit midway via the first outlet port 206A and the second outlet port 206B.

[048] The embedded heat exchanger 114 may be configured to create an interface between the working medium fluid within the vane motor 110 and the energy carrier fluid flowing through the peripheral enclosure along the periphery of the ring module 210, a ring-shaped structure of the embedded heat exchanger 114. In some embodiments, a heat exchange area may be defined on a portion of the peripheral

enclosure of the ring module 210, a ring-shaped structure. The heat exchange occurs along the heat exchange area.

[049] As a result of the interfacing, heat exchange occurs between the working medium fluid and the energy carrier fluid. Upon the heat exchange, the temperature and pressure of the working medium may increase and the temperature of the energy carrier fluid may decrease. In example scenarios, the temperature of the energy carrier fluid may decrease to a third temperature. For example, the third temperature may be close to 1 °C.

[050] Referring back to **FIG. 1**, as mentioned above, the working medium fluid (very cold liquid CO₂) may be pumped into the vane motor 110 using the high-pressure pump 112. The high pressure working medium fluid flowing into the vane motor 110 (via the inlet orifice 202A) may push a plurality of vanes 116 of the vane motor 110, to thereby move toward the outlet orifice 202B. As the working medium fluid (i.e. the very cold liquid CO₂) flows and into the vane motor 110 and contacts the surface of the embedded heat exchanger 114, the energy carrier fluid (i.e. the warm water) heats up the working medium fluid, thereby raising the temperature of the working medium fluid. Further, the pressure of the working medium fluid also increases in the closed space formed between two adjacent vanes of the plurality of vanes 116. As a result, energy is transferred from the energy carrier fluid (warm water) to the working medium fluid (cold liquid CO₂) to cause the vane motor 110 to rotate. The vane motor 110 may be rotated under combined effect of the working medium fluid entering the vane motor at the third pressure and the pressure of the working medium increasing upon the heat exchange.

[051] In some embodiments, the apparatus 100 may further include an electricity generator 118 which may be mechanically coupled with the vane motor 110. The

electricity generator 118 may be configured to generate electrical power using the rotation of the vane motor 110. To this end, the electricity generator 118 may be mechanically coupled with the vane motor 110, via the plurality of vanes 116 of the vane motor 110. This is further explained in conjunction with **FIGs. 3-4**.

[052] **FIG. 3** illustrates a schematic front view 300 of the electricity generator 118, in accordance with an implementation of the present disclosure. **FIG. 4** illustrates a schematic front view of a vane motor of the apparatus of **FIG. 1** along with the embedded heat generator and the electricity generator encased in the vane motor, in accordance with an implementation of the present disclosure. As shown in **FIG. 4**, the embedded heat generator 114 and the electricity generator 118 are encased within the vane motor 110. As shown in **FIG. 3**, the electricity generator 118 may include an outer side 302, over which a plurality of slots 304 may be defined. Further, as shown in **FIG. 4**, the plurality of slots 304 defined on the outer side 302 may be configured to engage with the plurality of vanes 116 of the vane motor 110. The electricity generator 118, therefore, may be encased in the vane motor 110, where the rotation of the plurality of vanes 116 of the vane motor 110 may drive the electricity generator 118.

[053] The vane motor 110 may include the embedded heat exchanger 114 (the terms embedded heat exchanger 114 and ring module 210, a ring-shaped structure may have been used interchangeably in this disclosure). which may include the peripheral enclosure along a periphery of the ring-shaped structure defining a closed space. The peripheral enclosure may be configured to receive the energy carrier fluid in the closed space. The ring module 210 may sit between an inner wall of a housing of the vane motor 110 and the encased electricity generator 118.

[054] The inner wall 208 of the ring module 210 may be configured to define vane chambers of the vane motor 110 between the adjacent vanes to the plurality of vanes

116. In particular, each pair of vanes of the plurality of vanes 116 along with the inner wall may define a vane chamber therebetween. In some embodiments, a volume of the vane chamber defined throughout along the heat exchange area may be the same.

425 In other words, the vane chambers may have the same volume throughout the section of the embedded heat exchanger 114. The volume of the vane chamber reduces (eventually to zero volume) by way of forcing the plurality of vanes 116 to retract to their respective slots at the same level of the inner wall of the removable ring module 210. The vane chamber space between the plurality of vanes 116 is created initially
430 by gravity and subsequently by centrifugal force when the electricity generator 118 is rotating. The electricity generator 118 includes the plurality of slots 304 (defined on the outer side 302) for holding the plurality of vanes 116. With the plurality of vanes 116 sitting on the surface of the outer side 302 of the electricity generator 118, the electricity generator 118 acts as the rotating shaft of the vane motor 110. The electricity
435 generated 118 may be further connected to an inverter (not shown in FIG. 4) for generating electricity at the required frequency and voltage.

[055] Referring back to **FIG. 1**, it should be noted that the temperature of the working medium fluid at the time of entering the vane motor 110 may be less than or equal to -40 °C. As a result of the interfacing between the working medium fluid and the energy
440 carrier fluid, the temperature of the energy carrier fluid may drop, as it flows out of the embedded heat exchanger 114. The flow of the energy carrier fluid from the embedded heat exchanger 114 may controlled by at least one flow-regulating valve fluidically coupled with the at least one outlet port. For example, as shown in **FIG. 1**, the apparatus 100 may include two flow-regulating valves 120A, 120B fluidically coupled
445 with the first and second outlet ports 206A, 206B, respectively. The flow-regulating valves 120A, 120B may be configured to regulate the flow of the energy carrier fluid

from the embedded heat exchanger 114. The flow-regulating valves 120A, 120B may regulate the flow of the energy carrier fluid from the embedded heat exchanger 114, such that the temperature of the energy carrier fluid is dropped to around 1 °C (as
450 chilled water).

[056] Further, as a result of the heat exchange, the temperature of the working medium fluid rises, but may still remain below 0 °C as the working medium fluid continues to flow towards the outlet orifice 202B. The temperature and the pressure of the working medium fluid continues to increase as it gets in contact with the energy
455 carrier fluid streaming in via the second inlet port 204B (from the direction of the outlet orifice 202B) within the vane motor 110. The cold liquid CO₂ may exit the vane motor 110, i.e. via the outlet orifice 202B at high temperature and high pressure. The energy carrier fluid flow entering the embedded heat exchanger 114 via the first inlet port 204A (in proximity to the inlet orifice 202A) may be controlled, such that the working medium
460 fluid is at ambient room temperature, i.e.. about 20 °C or higher when the working medium fluid exits the vane motor 110. The energy carrier fluid may exit at a lower temperature via the first and second outlet ports 206A, 206B positioned midway of the embedded heat exchanger 114, where the resultant temperature of the energy carrier fluid is at around 1 °C.

[057] Upon the heat exchange, the temperature of the working medium fluid may increase to a fourth temperature. The fourth temperature is within a temperature range of 20 °C to 32 °C. As such, the working medium fluid may exit the vane motor 110 at the fourth temperature of about 20 °C. Upon exiting the vane motor 110, the working medium fluid may be directed to flow into the storage container 102 (alternatively
470 known as storage cylinder) where the pressure is slightly lower than the initial pressure (i.e. the first predefined pressure) when it just started operation. A second check valve

130B may be positioned between the vane motor 110 and the storage container 102, to prevent a backflow of the working medium fluid. The first and the second check valves 130A, 130B may prevent back flow of the working medium fluid, especially
475 when the apparatus 100 is not in operation. The working medium fluid is recycled continuously and flows through all the intermediary devices via a first piping network 122, until the pressure release valve 104 of the storage container 102 (alternatively known as storage cylinder) is closed.

[058] The energy carrier fluid may be directed to flow through a second piping
480 network 124. When the chilled energy carrier fluid exits the embedded heat exchanger 114, via the first and second outlet ports 206A, 206B, the chilled energy carrier fluid may be directed to a secondary pump 126. The secondary pump 126 may pump the chilled energy carrier fluid to a chiller heat exchanger 128. The chiller heat exchanger 128 may be configured to receive the energy carrier fluid from the embedded heat
485 exchanger 114, via the secondary pump 126. The chiller heat exchanger 128 may be further configured to raise the temperature of the energy carrier fluid up from the third temperature. The chilled energy carrier fluid gets warmer and may have to harvest more heat before flowing back to the embedded heat exchanger 114, to deliver energy to the vane motor 110 and the electricity generator 118. A third check valve 130C may
490 be positioned between the vane motor 110 and the chiller heat exchanger 128, to prevent a backflow of the energy carrier fluid.

[059] In some embodiments, the flow-regulating valves 120A, 120B may control the flow rate of the energy carrier fluid, such that the energy carrier fluid exits at a temperature just above 0 °C via the first and second outlet ports 206A, 206B. The
495 working medium fluid exits to the storage container 102 (alternatively known as

storage cylinder) at the fourth temperature which may be above 20 °C and above but below 32 °C.

[060] It may be noted that an initial filling of the working medium fluid in the storage container 102 from external source may be done via an inlet 132 by opening a corresponding first valve 134 and closing a second valve 136 and closing the pressure release valve 104. It should be noted that second valve 136 may be opened for initial purging of residual air in the apparatus piping and devices. The second valve 136 may be closed after a few seconds to allow filling of the working medium to about 70 bars as indicated by the pressure gauge 138, before closing the first valve 134. A pressure relief valve 140 is a safety valve provided to prevent over pressure. For example, the pressure relief valve 140 may prevent the pressure from going above 150 bars, especially when the apparatus 100 is not in operation and is left in a hot environment. The pressure in the apparatus 100 can be released by opening the second valve 136, and the working medium fluid can be collected at an outlet 142.

[061] Referring now to **FIG. 5**, a flowchart of a method 500 of energy conversion to dual-functionality is illustrated, in accordance with an implementation of the present disclosure. The flowchart of a method 500 is explained in conjunction with **FIGs. 1-4**.

[062] At step 502, a working medium fluid stored in the storage container 102 may be released via the pressure release valve 104 which may be coupled with the storage container. The working medium fluid may be stored in the storage container at the first predefined temperature and the first predefined pressure. The pressure release valve 104 may be configured to release the working medium fluid to the second pressure. Further. The temperature of the working medium fluid may drop to the second temperature as a result of the release. The second pressure is less than the first predefined pressure, wherein the second temperature is less than the first predefined

temperature of the working medium fluid. For example, the second temperature of the working medium fluid may be less than or equal to -40 °C.

[063] At step 504, the working medium fluid now cold may be input to the vane motor 110 at the third pressure. The third pressure may be greater than the second pressure.

525 **[064]** At step 506, the cold working medium fluid within the vane motor 110 may be interfaced with the energy carrier fluid, via the embedded heat exchanger 114 encased within the vane motor 110, for heat exchange to occur between the cold working medium fluid and the energy carrier fluid. Upon the heat exchange, the temperature and pressure of the working medium increases and the temperature of the energy carrier fluid decreases. For example, upon the heat exchange, the temperature of the working medium fluid may increase to the fourth temperature within the temperature range of 20 °C to 32 °C. Further, upon the heat exchange, the temperature of the energy carrier fluid may decrease to a third temperature which may be close to 1 °C, the first conversion function. The embedded heat exchanger 114 may be contained in 535 the removable ring module 210, a ring-shaped structure, configured to be removably encased within the vane motor 110. The vane motor 110 may be rotated under combined effect of the working medium fluid entering the vane motor 110 at the third pressure and the pressure of the working medium increasing upon the heat exchange.

[065] Additionally, in some embodiments, at step 508, the electricity generator 118 540 may be mechanically coupled within the vane motor 110 to generate electrical power using the rotation of the vane motor 110. The electricity generator 118 may be mechanically coupled with the vane motor 110, via the plurality of vanes 116 of the vane motor 110 configured to engage with the plurality of slots 304 on the outer side 302 of the electricity generator 118. Hence, the electric generator within the vane 545 motor acts as the rotor, the second conversion function.

[066] Further, in some embodiments, at step 510 (change to 510, instead of 512), the temperature of the energy carrier fluid may be raised, via the chiller heat exchanger 128, upon receiving the energy carrier fluid from the embedded heat exchanger 114. Further, in some embodiments, freshwater may be produced via condensation of water vapour in the atmosphere at the chiller heat exchanger 128.

[067] While specific language has been used to describe the present subject matter, any limitations arising on account thereto, are not intended. As would be apparent to a person in the art, various working modifications may be made to the method in order to implement the inventive concept as taught herein. The drawings and the foregoing description give examples of implementations. Those skilled in the art will appreciate that one or more of the described elements may well be combined into a single functional element. Alternatively, certain elements may be split into multiple functional elements. Elements from one implementation may be added to another implementation.

Reference Numerals

100	apparatus for energy conversion
102	storage container
104	pressure release valve
106	pressure regulator
108	pressure gauge
110	vane motor
112	high-pressure pump
114	embedded heat exchanger
116	plurality of vanes
118	electricity generator
120A, 120B	flow-regulating valves
122	first piping network
124	second piping network
126	secondary pump
128	chiller heat exchanger
130A	first check valve
130B	second check valve
130C	third check valve
132	inlet
134	First Valve
136	Second Valve
138	pressure gauge
140	pressure relief valve
142	outlet
200	a schematic perspective view
202A	Inlet orifice
202B	outlet orifice
204A	first inlet port
204B	second inlet port
206A	first outlet port
206B	second outlet port
208	inner wall
210	ring module
300	a schematic front view
302	outer side
304	plurality of slots
400	Can't find in the description
500	flowchart of a method
502	Release a working medium fluid stored in a storage container via a pressure release valve coupled with the storage container
504	Input cold working medium fluid to a vane motor at a third pressure

506	Interface the working medium fluid within the vane motor with an energy carrier fluid, via an embedded heat exchanger encased within the vane motor, for heat exchange to occur between the working medium fluid and the energy carrier fluid
508	Mechanically couple an electricity generator within the vane motor to generate electrical power using the rotation of the vane motor
510 – can't find in description, it shown as 512	Raise the temperature, via a chiller heat exchanger, of the energy carrier fluid upon receiving the energy carrier fluid form the embedded heat exchanger. – can't find in the description

CLAIMS

565 1. An apparatus for energy conversion, the apparatus comprising:

a storage container configured to store a working medium fluid, wherein the working medium fluid is configured to be stored in the storage container at a first predefined temperature and a first predefined pressure;

570 a pressure relief valve coupled with the storage container, the pressure release valve configured to release the working medium fluid to a second pressure, wherein the temperature of the working medium fluid is to drop to a second temperature as a result of release the working medium fluid from the storage container, the second pressure is lower than the first predefined pressure, and the second temperature is lower than the first predefined temperature of the working medium fluid;

575 a vane motor further connected to the pressure relief valve and configured to receive the working medium fluid at a third pressure, the third pressure being greater than the second pressure; and

an embedded heat exchanger encased within the vane motor configured to create an interface between the working medium fluid within the vane motor and an
580 energy carrier fluid, for heat exchange to occur between the working medium fluid and the energy carrier fluid, wherein upon heat exchange between the working fluid and the energy carrier fluid, the temperature and pressure of the working medium are to increase whilst the temperature of the energy carrier fluid is to decrease;

wherein the embedded heat exchanger is contained in a ring module
585 configured to be removably encased within the vane motor, and

wherein the vane motor is rotated under combined effect of the working medium fluid entering the vane motor at the third pressure and the pressure of the working medium increasing upon the heat exchange.

590 2. The apparatus as claimed in claim 1 further comprising:

a pressure regulator fluidically coupled with the pressure release valve, the pressure regulator being configured to regulate the pressure drop to the second pressure.

595 3. The apparatus as claimed in claim 1 further comprising:

a high-pressure pump positioned between the pressure release valve and the vane motor, the high-pressure pump configured to receive the cold working medium fluid from the pressure release valve and pump the cold working medium fluid into the vane motor at the third pressure.

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4. The apparatus as claimed in claim 1 further comprising:

an electricity generator mechanically coupled within the vane motor and configured to generate electrical power using the rotation of the vane motor, wherein the electricity generator is mechanically coupled with the vane motor, via a plurality of
605 vanes of the vane motor configured to engage with a plurality of slots on an outer side of the electricity generator.

5. The apparatus as claimed in claim 1, wherein the working medium fluid is Carbon dioxide.

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6. The apparatus as claimed in claim 1, wherein the energy carrier fluid is water.

7. The apparatus as claimed in claim 6, wherein the embedded heat exchanger comprises:

- 615 a peripheral enclosure along a periphery of the ring module defining:
- a closed space, wherein the peripheral enclosure is configured to receive
the energy carrier fluid in the closed space; and
- an inner wall acting as an inner surface of the vane motor, the inner wall
creating the interface between the working medium fluid within the vane motor
- 620 and the energy carrier fluid within the closed space;
- an inlet orifice configured to allow passage of the working medium fluid into the
vane motor, across the peripheral enclosure;
- an outlet orifice configured to allow passage of the working medium fluid out of
the vane motor, across the peripheral enclosure;
- 625 at least one inlet port configured to allow passage of the energy carrier fluid into
the peripheral enclosure; and
- at least one outlet port configured to allow passage of the energy carrier fluid
out of the peripheral enclosure.

630 8. The apparatus as claimed in claim 7, wherein the at least one inlet port comprises:

- a first inlet port positioned in proximity to the inlet orifice; and
- a second inlet port positioned in proximity to the outlet orifice.

9. The apparatus as claimed in claim 8, wherein the at least one outlet port comprises:

635 a first outlet port positioned substantially mid-way of the first inlet port and the
second inlet port; and

 a second outlet port positioned substantially mid-way of the first inlet port and
the second inlet port.

640 10. The apparatus as claimed in claim 9, wherein each of the at least one inlet port
and the at least one outlet port is placed on the same flank side of the ring module.

11. The apparatus as claimed in claim 7, wherein a heat exchange area is defined on
a portion of the peripheral enclosure, wherein the heat exchange occurs along the
645 heat exchange area.

12. The apparatus as claimed in claim 11, wherein each pair of vanes of the plurality
of vanes of the vane motor along with the inner wall defining a vane chamber
therebetween,

650 wherein a volume of the vane chamber defined throughout along the heat
exchange area is the same.

13. The apparatus as claimed in claim 1,

 wherein the second temperature of the working medium fluid is less than or
655 equal to -40°C ,

 wherein, upon the heat exchange, the temperature of the working medium fluid
increases to a fourth temperature, wherein the fourth temperature is within a
temperature range of 20°C to 32°C , and

wherein, upon the heat exchange, the temperature of the energy carrier fluid
660 decreases to a third temperature, wherein the third temperature is close to 1 °C.

14. The apparatus as claimed in claim 1, further comprising:

at least one flow-regulating valve fluidically coupled with the at least one outlet
port, the flow-regulating valve configured to regulate the flow of the energy carrier fluid
665 from the embedded heat exchanger.

15. The apparatus as claimed in claim 1, wherein the working medium fluid, upon
exiting from the vane motor, is directed into the storage cylinder, wherein at the time
of entering the storage cylinder, the pressure of the working medium fluid is lower than
670 the first predefined pressure.

16. The apparatus as claimed in claim 1 further comprising:

a chiller heat exchanger configured to receive the energy carrier fluid from the
embedded heat exchanger, via a secondary pump, the chiller heat exchanger further
675 configured to raise the temperature of the energy carrier fluid up from the third
temperature.

17. The apparatus as claimed in claim 1 further comprising at least one of:

a first check valve positioned between the high-pressure pump and the vane
680 motor, to prevent a backflow of the working medium fluid;

a second check valve positioned between the vane motor and the storage
container, to prevent a backflow of the working medium fluid; and

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a third check valve positioned between the vane motor and the chiller heat exchanger, to prevent a backflow of the energy carrier fluid.

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