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(54) **Title:** SHIPPING CARBON DIOXIDE EMISSIONS FOR PROCESSING AND GREEN AMMONIA FOR IMPORT/EXPORT

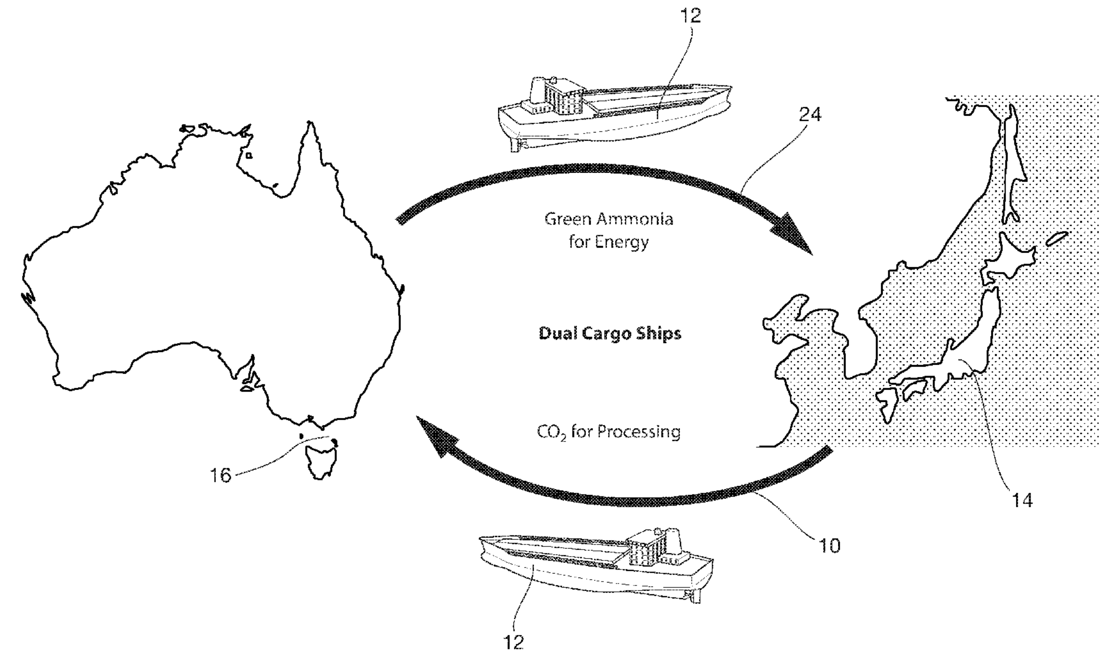

Figure 1

(57) **Abstract:** The present invention is broadly directed to a method of shipping carbon dioxide (CO_2) emissions for processing and green ammonia (NH_3) for import/export. The preferred method of one aspect of the invention broadly comprises the steps of: (a) shipping CO_2 emissions atvia a dual-cargo carrier ship (12) from an emissions region at (14) to a production region at (16); (b) processing the CO_2 emissions at the production region (16); (c) producing green ammonia at (22) at the production region (16); (d) shipping the green ammonia depicted at (24) from the production region (16) to the emissions region (14) via the dual-cargo carrier ship (12).

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SHIPPING CARBON DIOXIDE EMISSIONS FOR PROCESSING AND GREEN AMMONIA FOR IMPORT/EXPORT

Technical Field

[0001] The present invention is broadly directed to a method of shipping carbon dioxide emissions for processing and green ammonia for import/export. The invention is also generally directed to a dual-cargo transportation and associated infrastructure system.

Summary of Invention

[0002] According to a first aspect of the present invention there is provided a method of shipping carbon dioxide (CO_2) emissions for processing and green ammonia (NH_3) for import, said method comprising:

(a) shipping CO_2 emissions via a dual-cargo carrier ship from an emissions region to a production region being remote from the emissions region, said CO_2 emissions captured from a CO_2-emitting plant located at the emissions region;

(b) processing the CO_2 emissions at the production region;

(c) producing green ammonia at the production region;

(d) shipping the green ammonia from the production region to the emissions region via the dual-cargo carrier ship.

[0003] Preferably the method comprises repeating steps (a) to (d) for multiple shipping roundtrips between the emissions and the production regions.

[0004] According to a second aspect of the invention there is provided a method of shipping carbon dioxide (CO_2) emissions for processing and green ammonia (NH_3) for import, said method comprising:

(A) shipping CO_2 emissions via a dual-cargo carrier ship from an emissions region to a production region being remote from the emissions region, said CO_2 emissions being (i) captured from a CO_2-emitting plant located at the emissions region, and (ii) processed at the production region;

(B) importing green NH_3 to the emissions region via the dual-cargo carrier ship, said green NH_3 produced at the production region.

[0005] According to a third aspect of the invention there is provided a method of shipping green ammonia (NH_3) for export and carbon dioxide (CO_2) emissions for processing, said method comprising:

(a) producing green ammonia at a production region;
(b) shipping the green ammonia via a dual-cargo carrier ship from the production region to an emissions region being remote from the production region;
(c) shipping CO_2 emissions via the dual-cargo carrier ship from the emissions region to the production region, said emissions captured from a CO_2-emitting plant located at the emissions region;
(d) processing the CO_2 emissions at the production region.

[0006] Preferably the method comprises repeating steps (a) to (d) for multiple shipping roundtrips between the production and emissions regions.

[0007] According to a fourth aspect of the invention there is provided a method of shipping green ammonia (NH_3) for export and carbon dioxide (CO_2) emissions for processing, said method comprising:

(1) producing green NH_3 at a production region;
(2) exporting the green NH_3 via a dual-cargo carrier to an emissions region remote from the production region;
(3) importing CO_2 emissions to the production region via the dual-cargo carrier ship, said CO_2 emissions being captured from a CO_2-emitting plant located at the emissions region;
(4) processing the CO_2 emissions at the production region.

[0008] Preferably the method also comprises unloading of the CO_2 emissions from storage vessels of the carrier ship at the production region prior to processing of said emissions. More preferably the method further comprises loading of the green ammonia into the storage vessels of the carrier ship docked at a port or terminal at the production region.

[0009] Preferably the method additionally comprises purging of the storage vessels of the carrier ship at the production region of residual CO_2 emissions following unloading of the CO_2 emissions and prior to loading of the green ammonia at the production region. Likewise, the method comprises purging of the storage vessels at the emissions region of residual green ammonia following unloading of the green ammonia and prior to loading of further CO_2 emissions at the emissions region.

[0010] Preferably the step of processing the CO_2 emissions includes but is not limited to any one of geosequestration, urea production, synthetic methane production, synthetic methanol production, synthetic polymer or plastics production. More preferably the geosequestration of the CO_2 emissions involves docking the carrier ship at a port or terminal associated with an onshore receiving facility at the production region, and piping the CO_2 emissions offshore from said receiving facility for injection into a subsea well at the production region. Alternatively, the carrier ship is anchored at or in close proximity to an offshore CO_2 receiving facility at the production region, and the CO_2 emissions are injected from said receiving facility into a subsea well.

[0011] Preferably the step of producing green ammonia at the production region involves a catalytic reaction between nitrogen (N_2) and hydrogen (H_2) via the Haber-Bosch (HB) process. More preferably the N_2 is directly separated from air in an air separation unit, and the H_2 is split from water in an electrolyser. Still more preferably the air separation unit and the electrolyser are powered via green electricity derived from wind turbines, solar power, or hydro power located at the production region.

[0012] According to a fifth aspect of the invention there is provided a dual-cargo transportation and associated infrastructure system comprising:

a dual-cargo carrier ship adapted to transport CO_2 emissions captured from a CO_2-emitting plant located at an emissions region to a production region remote from the emissions region;

a processing facility located at the production region, said facility adapted for processing of the CO_2 emissions;

a green ammonia production plant located at the production region, said ammonia plant adapted to produce green ammonia to be transported via the dual-cargo carrier ship to the emissions region.

[0013] According to a sixth aspect of the invention there is provided a dual-cargo transportation and associated infrastructure system comprising:

a green ammonia NH_3 production plant located at a production region, said ammonia plant adapted to produce green ammonia;

a dual-cargo carrier ship adapted to transport the green NH_3 from the production region to an emissions region remote from the production region;

a CO_2 processing facility located at the production region, said facility adapted for processing of CO_2 emissions (i) captured from a CO_2-emitting plant located at the emissions region, (ii) transported to the production region via the dual-cargo carrier ship.

[0014] According to a seventh aspect of the invention there is provided a method of shipping carbon dioxide (CO_2) emissions for geosequestration and green ammonia (NH_3) for import, said method comprising:

(a) shipping CO_2 emissions via a dual-cargo carrier ship from an emissions region to a production region being remote from the emissions region, said CO_2 emissions captured from a CO_2-emitting plant located at the emissions region;
(b) geosequestrating the CO_2 emissions at the production region;
(c)producing green ammonia at the production region;
(d) shipping the green ammonia from the production region to the emissions region via the dual-cargo carrier ship.

[0015] According to an eighth aspect of the invention there is provided a method of shipping carbon dioxide (CO_2) emissions for geosequestration and green ammonia (NH_3) for import, said method comprising:

(A) shipping CO_2 emissions via a dual-cargo carrier ship from an emissions region to a production region being remote from the emissions region, said

CO_2 emissions being (i) captured from a CO_2-emitting plant located at the emissions region, and (ii) geosequestrated at the production region;

(B) importing green NH_3 to the emissions region via the dual-cargo carrier ship, said green NH_3 produced at the production region.

[0016] According to an ninth aspect of the invention there is provided a method of shipping green ammonia (NH_3) for export and carbon dioxide (CO_2) emissions for geosequestration, said method comprising:

(a) producing green ammonia at a production region;

(b) shipping the green ammonia via a dual-cargo carrier ship from the production region to an emissions region being remote from the production region;

(c) shipping CO_2 emissions via the dual-cargo carrier ship from the emissions region to the production region, said emissions captured from a CO_2-emitting plant located at the emissions region;

(d) geosequestrating the CO_2 emissions at the production region.

[0017] According to an tenth aspect of the invention there is provided a method of shipping green ammonia (NH_3) for export and carbon dioxide (CO_2) emissions for geosequestration, said method comprising:

(1) producing green NH_3 at a production region;

(2) exporting the green NH_3 via a dual-cargo carrier to an emissions region remote from the production region;

(3) importing CO_2 emissions to the production region via the dual-cargo carrier ship, said CO_2 emissions being captured from a CO_2-emitting plant located at the emissions region;

(4) geosequestrating the CO_2 emissions at the production region.

[0018] According to an eleventh aspect of the invention there is provided a dual-cargo transportation and associated infrastructure system comprising:

a dual-cargo carrier ship adapted to transport CO_2 emissions captured from a CO_2-emitting plant located at an emissions region to a production region remote from the emissions region;

a CO_2 geosequestration facility located at the production region, said facility adapted for geosequestration of the CO_2 emissions;

a green ammonia production plant located at the production region, said ammonia plant adapted to produce green ammonia to be transported via the dual-cargo carrier ship to the emissions region.

[0019] According to a twelfth aspect of the invention there is provided a dual-cargo transportation and associated infrastructure system comprising:

a green ammonia NH_3 production plant located at a production region, said ammonia plant adapted to produce green ammonia;

a dual-cargo carrier ship adapted to transport the green NH_3 from the production region to an emissions region remote from the production region;

a CO_2 geosequestration facility located at the production region, said facility adapted for geosequestration of CO_2 emissions (i) captured from a CO_2-emitting plant located at the emissions region, (ii) transported to the production region via the dual-cargo carrier ship

Brief Description of Drawings

[0020] In order to achieve a better understanding of the nature of the present invention a preferred embodiment of a method of shipping carbon dioxide (CO_2) emissions for processing and green ammonia (NH_3) for import/export together with other aspects of the technology will now be described, by way of example only, with reference to the accompanying illustrations in which:

Figure 1 is a schematic illustration of a method of shipping carbon dioxide (CO_2) emissions for processing and green ammonia (NH_3) for import according to a preferred embodiment of the first to fourth aspects of the invention;

Figure 2 is a schematic illustration of processing of CO_2 emissions at the production region according to the preferred embodiment of figure 1;

Figures 3A and 3B illustrate alternative embodiments depicting production of green ammonia at the production region and shipping of this green ammonia to the emissions region according to the preferred embodiment of figure 1;

Figure 4 is a map broadly depicting the production region for both processing of the CO_2 emissions and production of the green ammonia according to the preferred embodiment of figure 1;

Figure 5 illustrates sectional views of a liquid CO_2 cargo carrier of a known design suitable for modification to a dual-cargo carrier ship appropriate for transportation of both CO_2 emissions and green ammonia in implementation of the preferred embodiment of figure 1 according to both the broadly defined method and system aspects of the technology.

Detailed Description

[0021] Figures 1 to 3 schematically depict a preferred embodiment of a method of shipping carbon dioxide (CO_2) emissions for processing and green ammonia (NH_3) for import/export according to the first to fourth aspects of the technology. The method of this example in the context of the first aspect of the invention broadly comprises the steps of:

(a) shipping CO_2 emissions at 10 via a dual-cargo carrier ship 12 from an emissions region at 14 to a production region at 16 (see figure 1);
(b) processing the CO_2 emissions at the production region 16 (see figure 2);
(c) producing green ammonia at 22 at the production region 16 (see figure 3A);
(d) shipping the green ammonia depicted at 24 from the production region 16 to the emissions region 14 via the dual-cargo carrier ship 12 (returning to figure 1).

[0022] As seen in figure 3A, the production of green ammonia at 22 at the production region 16 typically involves a catalytic reaction between nitrogen (N_2) and hydrogen (H_2) via the Haber-Bosch (HB) process. In this embodiment the N_2 is directly separated from air in an air separation unit (not shown) and the H_2 is split from water in an electrolyser (not shown). Importantly, the air separation unit and the electrolyser are powered via green electricity derived in this instance from wind turbines 26 located at the production region 16. Alternatively, the green electricity may be derived from solar or hydro energy sources. It is to be understood that the production of green ammonia may extend to or include emerging technologies including but not limited to solid oxide electrolysis where N_2 and H_2 are extracted from air and water using the same electrolyser cell.

[0023] Figure 5 shows a liquid CO_2 cargo carrier 13 of a known design suitable for modification to a dual-cargo carrier ship for application in the preferred methodology of the various aspects of the technology. The conventional carrier 13 includes a series of liquid CO_2 vessels 30a to 30d. In the context of the first aspect of the invention it is to be understood that the dual-cargo carrier ship performs multiple shipping roundtrips between the emissions and the production regions 14 and 16, in this instance Japan and Australia. Importantly the dual-cargo carrier ship includes storage tanks in the form of relatively low pressure storage tanks such as 30a to 30d. The storage tanks such as 30a are designed and rated to handle the storage requirements of both (i) liquid CO_2 emissions at between -40° to -57°C and between 5 to 7 bar, and (ii) liquid ammonia at between -30°C to -35°C and atmospheric pressure. It should be noted that the pressure storage requirement for liquid CO_2 is many times more than the pressure requirement for liquid NH_3.

[0024] The liquid CO_2 and liquid NH_3 storage tanks must also be constructed of a material compatible with both liquids. The compatible material selected for construction of the relatively low pressure storage tanks must also extend to fittings, piping and other infrastructure associated with the storage tanks. It is to be understood that cast iron, cast steel, nickel steel, aluminium, carbon steel, stainless steel and mild steel are appropriate materials insofar as they are suited to both liquid CO_2 and liquid NH_3. On the other hand, it is to be understood that copper, zinc or their alloys, such as bronze and brass, are to be avoided together with galvanised materials as they are not compatible with ammonia.

[0025] Figures 3A and 3B illustrate alternative embodiments of the methodology where the CO_2 emissions are unloaded or offloaded from the storage vessels such as 30a of the dual-cargo carrier ship 12 at the production region 16 prior to their processing. In the embodiment of figure 3A, the production region 16 is in the form of a manmade or reclaimed island named the “Bass Strait Energy Island” 32. In this example the CO_2 emissions are processed at 34 from onshore the island 32. In the other embodiment of figure 3B, the production region 16 is in the form of a naturally occurring island within the Bass Strait, in this example Prime Seal Island 36. In this instance the CO_2 emissions are piped offshore of the island 36 via CO_2 emissions pipe 38 and processed offshore within the Bass Strait itself. In this embodiment the CO_2 emissions are in both scenarios processed by geosequestration for carbon capture and storage (CCS). It is to be understood that processing of the CO_2 emissions may also extend to industrial processes including but not limited to urea production, synthetic methane or methanol production, or synthetic polymer or plastics production.

[0026] In either of the alternative geosequestration embodiments, the dual-cargo carrier ship 12 is docked at a port or terminal 39 or 40 associated with an onshore receiving facility at the island 32 or 36. In both cases, the liquid CO_2 emissions are reconfigured or otherwise treated at an onshore CO_2 receiving facility or handling system (not shown) prior to geosequestration or injection via an injection well head into a well, typically a subsea well at 18 (see figure 2). In a departure from these approaches, the dual-cargo carrier ship 12 may anchor at, or in close proximity to, an offshore CO_2 receiving facility or platform at the production region in the Bass Strait. In this instance the CO_2 emissions are decanted from the storage vessels such as 30a of the carrier ship 12 to the receiving facility or platform and reconfigured for injection into a subsea well associated with the platform (not shown).

[0027] It is to be understood that the renewable energy source to be harnessed in the production of green ammonia may be accessible from or in close proximity to the production region. The renewable energy source is not limited to wind energy and includes solar, hydro, wave, ocean current, and geothermal energy. These renewable energy sources may also be used in powering unit operations associated with processing activities. The processing activities may also be powered by other energy sources which are considered zero carbon emitting, such as nuclear power.

[0028] In this embodiment the production region at 16 is shown in figure 4 as extending across the Bass Strait or more generally the ocean passage separating Tasmania from the Australian mainland. It is to be understood that the production region 16 of the Bass Strait lends itself to the preferred embodiment of the first to fourth aspects of the invention insofar as the Bass Strait:

1. provides significant storage potential for geosequestration of CO_2 which is understood to exceed 31G tonnes;
2. provides an enormous renewable energy source in the form of wind capable of generating hundreds of GW in electricity from wind turbines 26.

[0029] It would ordinarily be understood to be counterintuitive to use the same carrier ship or more particularly storage vessels in the transportation of both liquid CO_2 and liquid ammonia. At least the following two reasons contribute to this conventional understanding:

1. storage and typical transportation absolute pressures for liquid CO_2 are around 5 to 7 times that of liquid ammonia and thus shipping liquid NH_3 in tanks dedicated to liquid CO_2 would be considered overkill;
2. ammonia and CO_2 combine to form white powders in the form of ammonium bicarbonate and ammonium carbamate which must be avoided in materials handling where such solids/powders coagulate and block pipes and associated infrastructure and therefore it would not ordinarily be considered logical to ship/store NH_3 and CO_2 interchangeably in the same tank.

[0030] In addressing problems associated with formation of white powders caused by ammonia contamination of a CO_2 storage vessel such as 30a (and *vice versa*), the preceding embodiment additionally comprises the step of purging of the dual-cargo carrier ship 12 or associated storage vessels such as 30a. It will be understood that purging of residual CO_2 emissions is undertaken at the production region 16 following unloading of the CO_2 emissions and prior to loading of the green ammonia. Likewise, purging of the storage vessels such as 30a is undertaken at the emissions region 14 in order to remove residual green ammonia following unloading of the green ammonia and prior to loading of further CO_2 emissions at the emissions region.

[0031] It is to be understood that the CO_2 emissions for processing at the production region 16 are captured from a CO_2-emitting plant (not shown) located at the emissions region 14. It is expected that CO_2 emitting plants will extend, although not be limited, to fossil-fuelled power plants, cement plants, steel making plants, chemicals production plants, and other point source emitting plants. Alternatively, the CO_2 emissions may be sourced from direct air capture technology rather than from a point source emitting plant. The emissions region may vary and extend to countries other than Japan with relatively high CO_2 emissions levels from CO_2-emitting plants, such as Korea or other countries in Asia. Although the production region of the Bass Strait is particularly suited to the invention, other regions of Australia having the required processing capabilities and an abundance of offshore wind for harnessing in the generation of wind turbine derived electricity may be appropriate. For example, the production region may be located at coastal Western Australia and more particularly offshore and/or on the coast of the Kimberley, Pilbara and Gascoyne regions. It is to be understood that the production and/or emission regions may extend across geographical areas, oceanic areas, and combined geographic and oceanic areas.

[0032] In the preferred embodiment it is to be understood that the first and second aspects of the invention are to be interpreted in the context of activity originating from the emissions region or in this case Japan. On the other hand, the third and fourth aspects of the technology are to be understood in the context of activity originating from the production region or in this example the Bass Strait of Australia.

[0033] The fifth and sixth aspects of the invention are directed to a dual-cargo transportation and associated infrastructure system. In the context of the preferred embodiment of the earlier aspects of the technology, it is to be understood that the system of the fifth and sixth aspects broadly comprises:

1. a dual-cargo carrier ship 12 adapted to transport CO_2 emissions at 10 captured from a CO_2-emitting plant (not shown) at an emissions region 14 to a production region 16 remote from the emissions region 14;
2. a CO_2 processing facility such as 34 located at the production region 16 and adapted for processing of the CO_2 emissions;

3. a green ammonia production plant such as 22 located at the production region 16 and adapted to produce green ammonia to be transported at 24 via the dual-cargo carrier ship 12 to the emissions region 14.

[0034] In a similar manner to the preceding aspects of the invention, the sixth aspect of the technology is broadly directed to a dual-cargo transportation and associated infrastructure system corresponding to the fifth aspect but drafted in the context of unit operations residing at the production region or in this case Australia. The fifth aspect is on the other hand drafted in the context of the unit operations originating at the emissions region, such as Japan.

[0035] It is to be understood that the component parts or unit operations for each of the emissions and production activities may not be co-located within the respective emissions region and production region. At the emissions region, the unloading or offloading of green NH_3 may be distant or separated from the capturing or collecting of the CO_2 emissions from the CO_2 emitting plant. At the production region, the processing of CO_2 emissions or the associated receiving facility may be distant or separated from the green ammonia production plant. For example, the processing activities may be performed at or in the vicinity of the Tasmanian Coast whereas the production of green NH_3 and associated activities may be performed on an island in the Bass Strait. In this scenario the dual-cargo carrier ship navigates or sails between these separate locations within the production region.

[0036] Now that a preferred embodiment of the various aspects of the technology have been described it will be apparent to those skilled in the art that the method of shipping carbon dioxide emissions for processing and green ammonia for import/export has at least the following advantages:

1. the method provides a dual-carrier supply chain where backloaded freight in the form of liquid ammonia improves the commercial viability of the transport system;
2. the production region provides two coincident resources in the form of (a) renewables or geological storage or other resources which assist in industrial processing of the CO_2 emissions, and (b) wind to facilitate the production of green ammonia;

3. the method and system are effective in providing a decarbonisation loop where CO_2 emissions are processed at the production region, for example geosequestrated for storage;
4. the coincident wind energy and CO_2 storage capacity provide the capability to extend the technology to multiple of the dual-cargo carrier ships operating in a fleet thereby scaling storage and production capabilities.

[0037] Those skilled in the art will appreciate that the invention as described herein is susceptible to variations and modifications other than those specifically described. For example, the specific construction of the dual-cargo carrier ship may vary from that described provided the methodology as broadly defined is effectively enabled. The specific nature and steps for both the production of ammonia and processing of the CO_2 emissions may depart from that described and remain within the scope of the invention. For example, the production of ammonia may involve the production of blue ammonia in the sense that the hydrogen for the ammonia has been produced from a fossil fuel, such as methane or coal gasification, with the resulting carbon dioxide emissions being stored by geosequestration. With either the production of green or blue ammonia, the process need not be limited to the HB process described. Furthermore, the NH_3 production plant may be of either a fixed (land-based or offshore) or floating configuration.

[0038] All such variations and modifications are to be considered within the ambit of the present invention the nature of which is to be determined from the foregoing description.

Claims

1. A method of shipping carbon dioxide (CO_2) emissions for processing and green ammonia (NH_3) for import, said method comprising:

   (e) shipping CO_2 emissions via a dual-cargo carrier ship from an emissions region to a production region being remote from the emissions region, said CO_2 emissions captured from a CO_2-emitting plant located at the emissions region;

   (f) processing the CO_2 emissions at the production region;

   (g) producing green ammonia at the production region;

   (h) shipping the green ammonia from the production region to the emissions region via the dual-cargo carrier ship.

2. A method as claimed in claim 1 involving repeating steps (a) to (d) for multiple shipping roundtrips between the emissions and the production regions.

3. A method of shipping carbon dioxide (CO_2) emissions for processing and green ammonia (NH_3) for import, said method comprising:

(A) shipping CO_2 emissions via a dual-cargo carrier ship from an emissions region to a production region being remote from the emissions region, said CO_2 emissions being (i) captured from a CO_2-emitting plant located at the emissions region, and (ii) processed at the production region;

(B) importing green NH_3 to the emissions region via the dual-cargo carrier ship, said green NH_3 produced at the production region.

4. A method of shipping green ammonia (NH_3) for export and carbon dioxide (CO_2) emissions for processing, said method comprising:

(a) producing green ammonia at a production region;

(b) shipping the green ammonia via a dual-cargo carrier ship from the production region to an emissions region being remote from the production region;

(c) shipping CO_2 emissions via the dual-cargo carrier ship from the emissions region to the production region, said emissions captured from a CO_2-emitting plant located at the emissions region;

(d) processing the CO_2 emissions at the production region.

5. A method as claimed in claim 4 involving repeating steps (a) to (d) for multiple shipping roundtrips between the production and emissions regions.

6. A method of shipping green ammonia (NH_3) for export and carbon dioxide (CO_2) emissions for processing, said method comprising:

(1) producing green NH_3 at a production region;
(2) exporting the green NH_3 via a dual-cargo carrier to an emissions region remote from the production region;
(3) importing CO_2 emissions to the production region via the dual-cargo carrier ship, said CO_2 emissions being captured from a CO_2-emitting plant located at the emissions region;
(4) processing the CO_2 emissions at the production region.

7. A method as claimed in any one of the preceding claims also comprising unloading of the CO_2 emissions from storage vessels of the carrier ship at the production region prior to processing of said emissions.

8. A method as claimed in claim 7 further comprising loading of the green ammonia into the storage vessels of the carrier ship docked at a port or terminal at the production region.

9. A method as claimed in either of claims 7 or 8 additionally comprising purging of the storage vessels of the carrier ship at the production region of residual CO_2 emissions following unloading of the CO_2 emissions and prior to loading of the green ammonia at the production region.

10. A method as claimed in either of claims 7 or 8 also comprising purging of the storage vessels at the emissions region of residual green ammonia following unloading of the green ammonia and prior to loading of further CO_2 emissions at the emissions region.

11. A method as claimed in any one of the preceding claims wherein the processing the CO_2 emissions includes but is not limited to any one of

geosequestration, urea production, synthetic methane production, synthetic methanol production, synthetic polymer or plastics production.

12. A method as claimed in claim 11 wherein the geosequestration of the CO_2 emissions involves docking the carrier ship at a port or terminal associated with an onshore receiving facility at the production region, and piping the CO_2 emissions offshore from said receiving facility for injection into a subsea well at the production region.

13. A method as claimed in claim 11 wherein the geosequestration involves anchoring of the carrier ship at or in close proximity to an offshore CO_2 receiving facility at the production region, and injecting the CO_2 emissions from said receiving facility into a subsea well.

14. A method as claimed in any one of the preceding claims wherein the production of green ammonia at the production region involves a catalytic reaction between nitrogen (N_2) and hydrogen (H_2) via the Haber-Bosch (HB) process.

15. A method as claimed in claim 14 wherein the N_2 is directly separated from air in an air separation unit, and the H_2 is split from water in an electrolyser.

16. A method as claimed in claim 15 wherein the air separation unit and the electrolyser are powered via green electricity derived from wind turbines, solar power, or hydro power located at the production region.

17. A dual-cargo transportation and associated infrastructure system comprising:

a dual-cargo carrier ship adapted to transport CO_2 emissions captured from a CO_2-emitting plant located at an emissions region to a production region remote from the emissions region;

a processing facility located at the production region, said facility adapted for processing of the CO_2 emissions;

a green ammonia production plant located at the production region, said ammonia plant adapted to produce green ammonia to be transported via the dual-cargo carrier ship to the emissions region.

18. A dual-cargo transportation and associated infrastructure system comprising:

a green ammonia NH_3 production plant located at a production region, said ammonia plant adapted to produce green ammonia;

a dual-cargo carrier ship adapted to transport the green NH_3 from the production region to an emissions region remote from the production region;

a CO_2 processing facility located at the production region, said facility adapted for processing of CO_2 emissions (i) captured from a CO_2-emitting plant located at the emissions region, (ii) transported to the production region via the dual-cargo carrier ship.

19. A method of shipping carbon dioxide (CO_2) emissions for geosequestration and green ammonia (NH_3) for import, said method comprising:

(a) shipping CO_2 emissions via a dual-cargo carrier ship from an emissions region to a production region being remote from the emissions region, said CO_2 emissions captured from a CO_2-emitting plant located at the emissions region;

(b) geosequestrating the CO_2 emissions at the production region;

(c) producing green ammonia at the production region;

(d) shipping the green ammonia from the production region to the emissions region via the dual-cargo carrier ship.

20. A method of shipping carbon dioxide (CO_2) emissions for geosequestration and green ammonia (NH_3) for import, said method comprising:

(A) shipping CO_2 emissions via a dual-cargo carrier ship from an emissions region to a production region being remote from the emissions region, said CO_2 emissions being (i) captured from a CO_2-emitting plant located at the emissions region, and (ii) geosequestrated at the production region;

(B) importing green NH_3 to the emissions region via the dual-cargo carrier ship, said green NH_3 produced at the production region.

21. A method of shipping green ammonia (NH_3) for export and carbon dioxide (CO_2) emissions for geosequestration, said method comprising:

(a) producing green ammonia at a production region;

(b) shipping the green ammonia via a dual-cargo carrier ship from the production region to an emissions region being remote from the production region;

(c) shipping CO_2 emissions via the dual-cargo carrier ship from the emissions region to the production region, said emissions captured from a CO_2-emitting plant located at the emissions region;

(d) geosequestrating the CO_2 emissions at the production region.

22. A method of shipping green ammonia (NH_3) for export and carbon dioxide (CO_2) emissions for geosequestration, said method comprising:

(1) producing green NH_3 at a production region;

(2) exporting the green NH_3 via a dual-cargo carrier to an emissions region remote from the production region;

(3) importing CO_2 emissions to the production region via the dual-cargo carrier ship, said CO_2 emissions being captured from a CO_2-emitting plant located at the emissions region;

(4) geosequestrating the CO_2 emissions at the production region.

23. A dual-cargo transportation and associated infrastructure system comprising:

a dual-cargo carrier ship adapted to transport CO_2 emissions captured from a CO_2-emitting plant located at an emissions region to a production region remote from the emissions region;

a CO_2 geosequestration facility located at the production region, said facility adapted for geosequestration of the CO_2 emissions;

a green ammonia production plant located at the production region, said ammonia plant adapted to produce green ammonia to be transported via the dual-cargo carrier ship to the emissions region.

24. A dual-cargo transportation and associated infrastructure system comprising:

a green ammonia NH_3 production plant located at a production region, said ammonia plant adapted to produce green ammonia;

a dual-cargo carrier ship adapted to transport the green NH_3 from the production region to an emissions region remote from the production region;

a CO_2 geosequestration facility located at the production region, said facility adapted for geosequestration of CO_2 emissions (i) captured from a CO_2-emitting plant located at the emissions region, (ii) transported to the production region via the dual-cargo carrier ship.

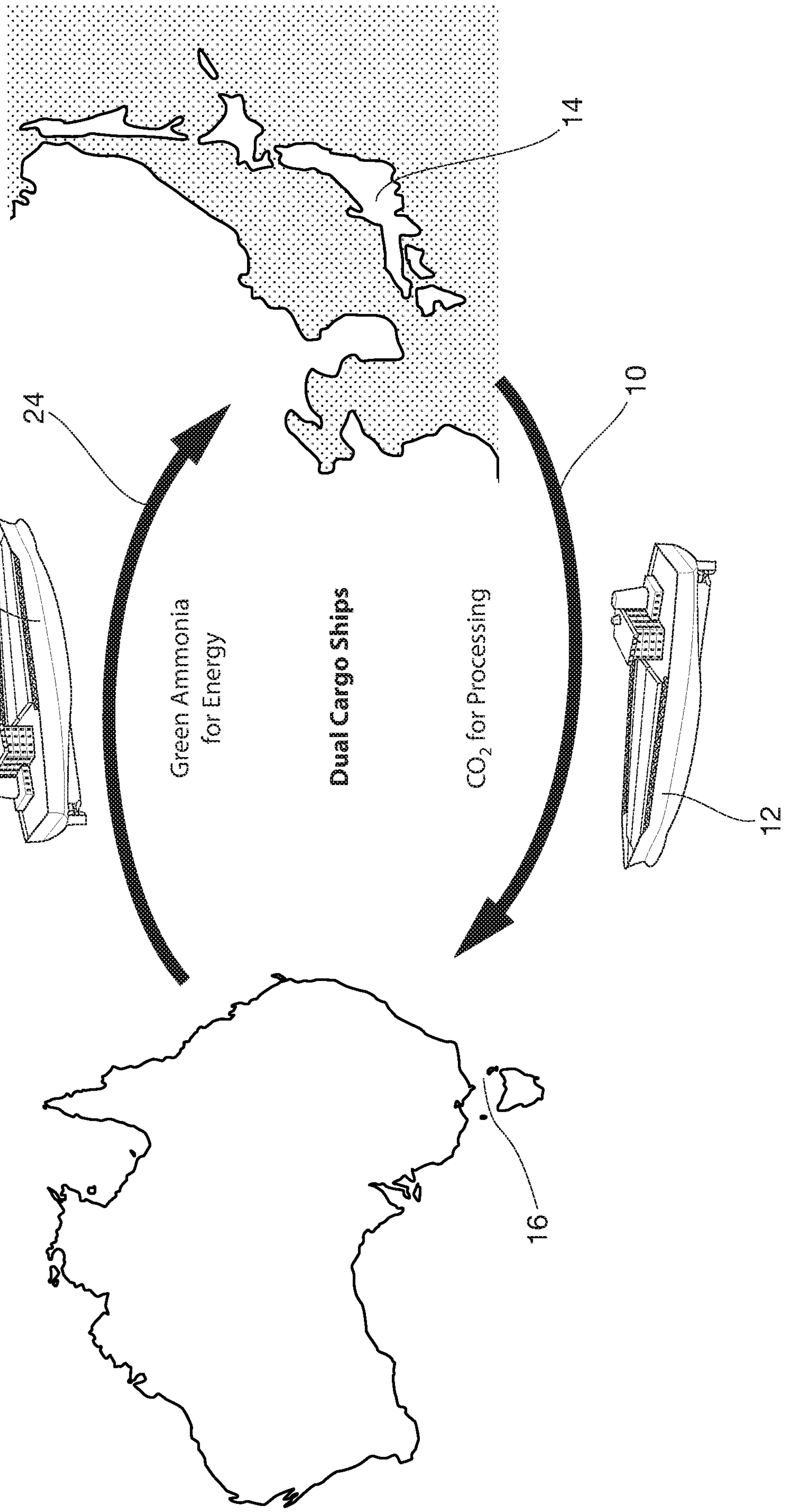
14
24
10
12
Green Ammonia
for Energy
Dual Cargo Ships
CO_2 for Processing
12
16

Figure 1

2/6

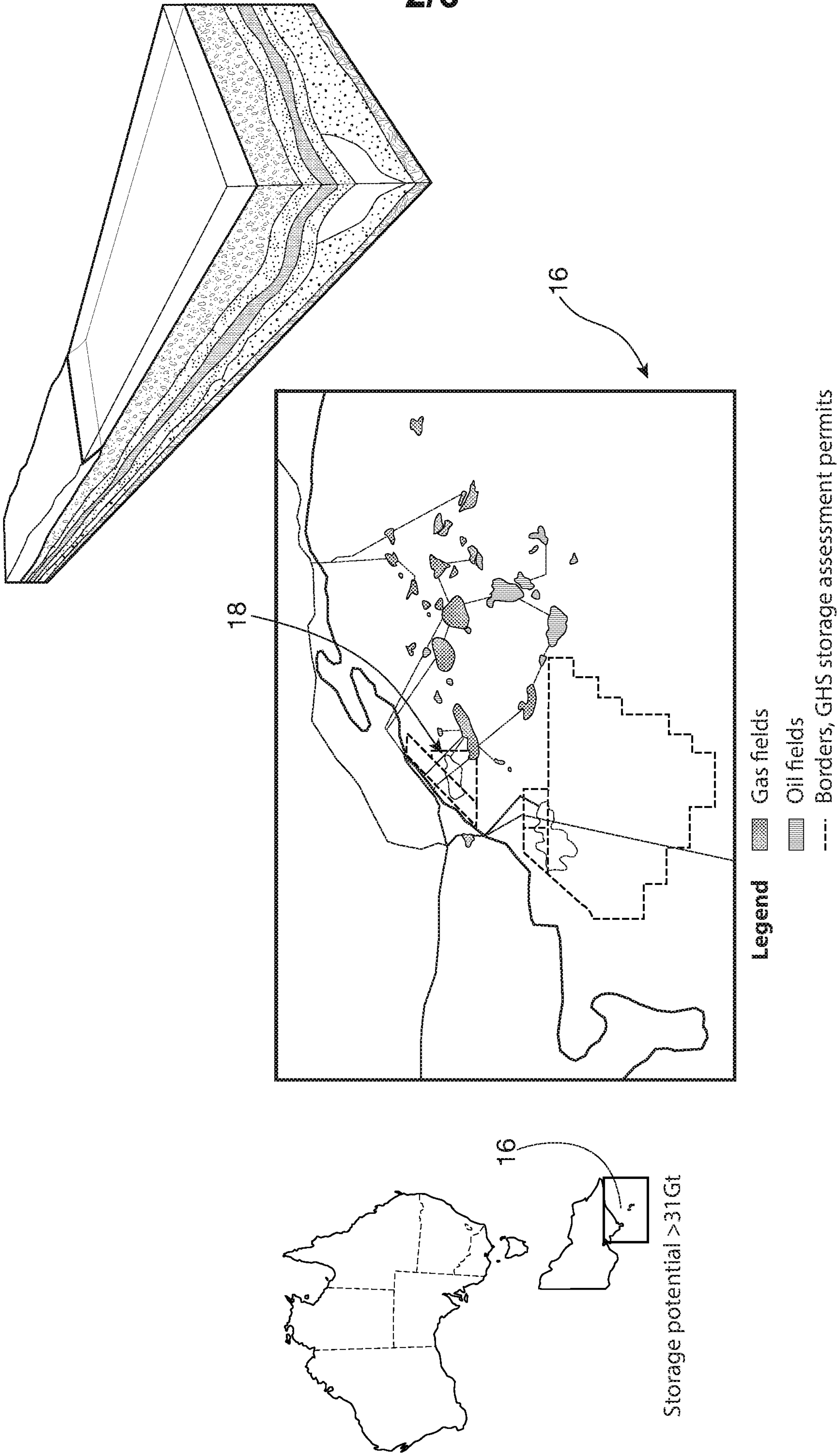
16
18
Legend
Gas fields
Oil fields
Borders, GHS storage assessment permits
16
Storage potential >31Gt

Figure 2

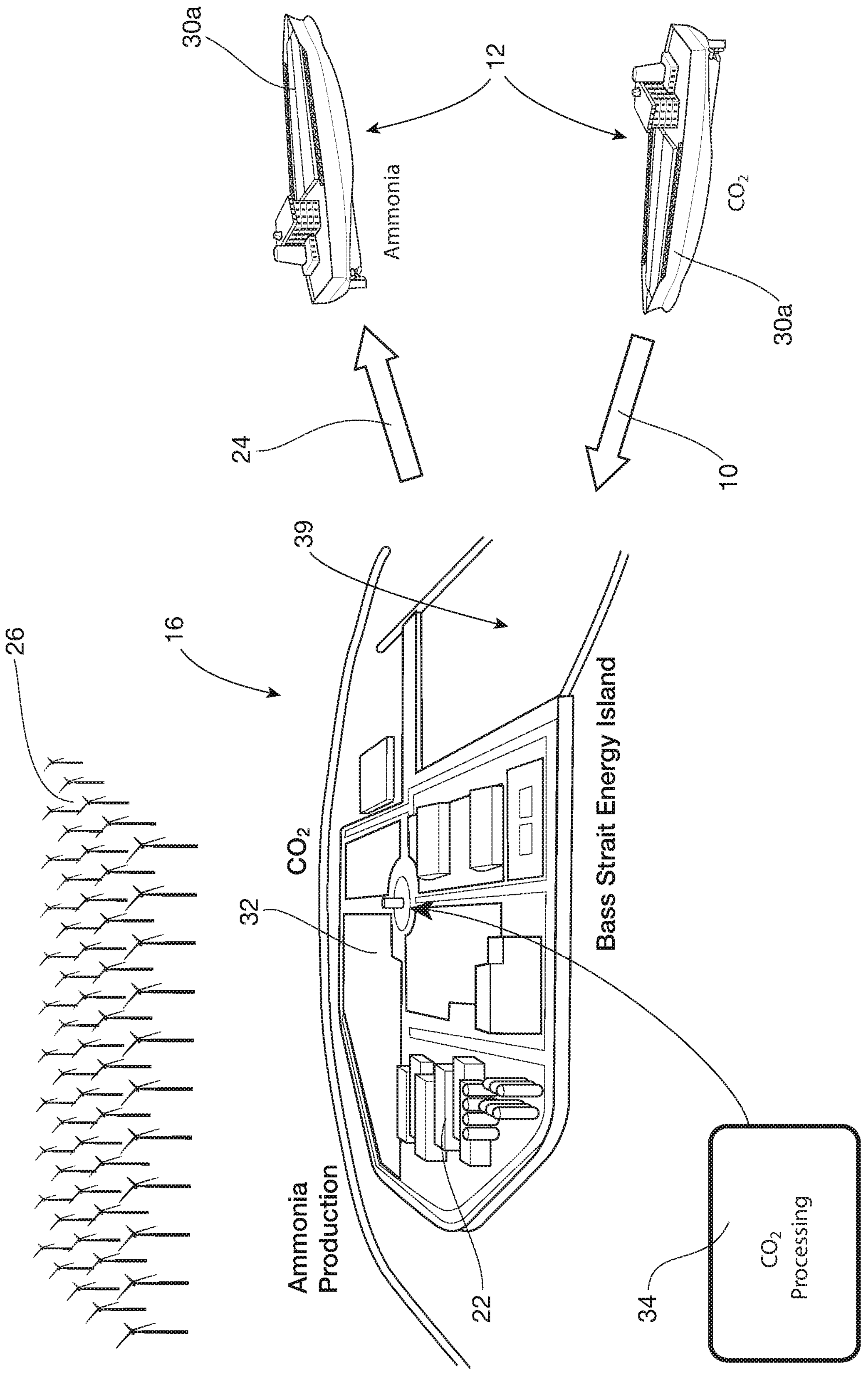
30a
12
Ammonia
CO_2
30a
24
10
39
26
16
CO_2
32
Bass Strait Energy Island
Ammonia Production
22
34
CO_2 Processing

Figure 3A

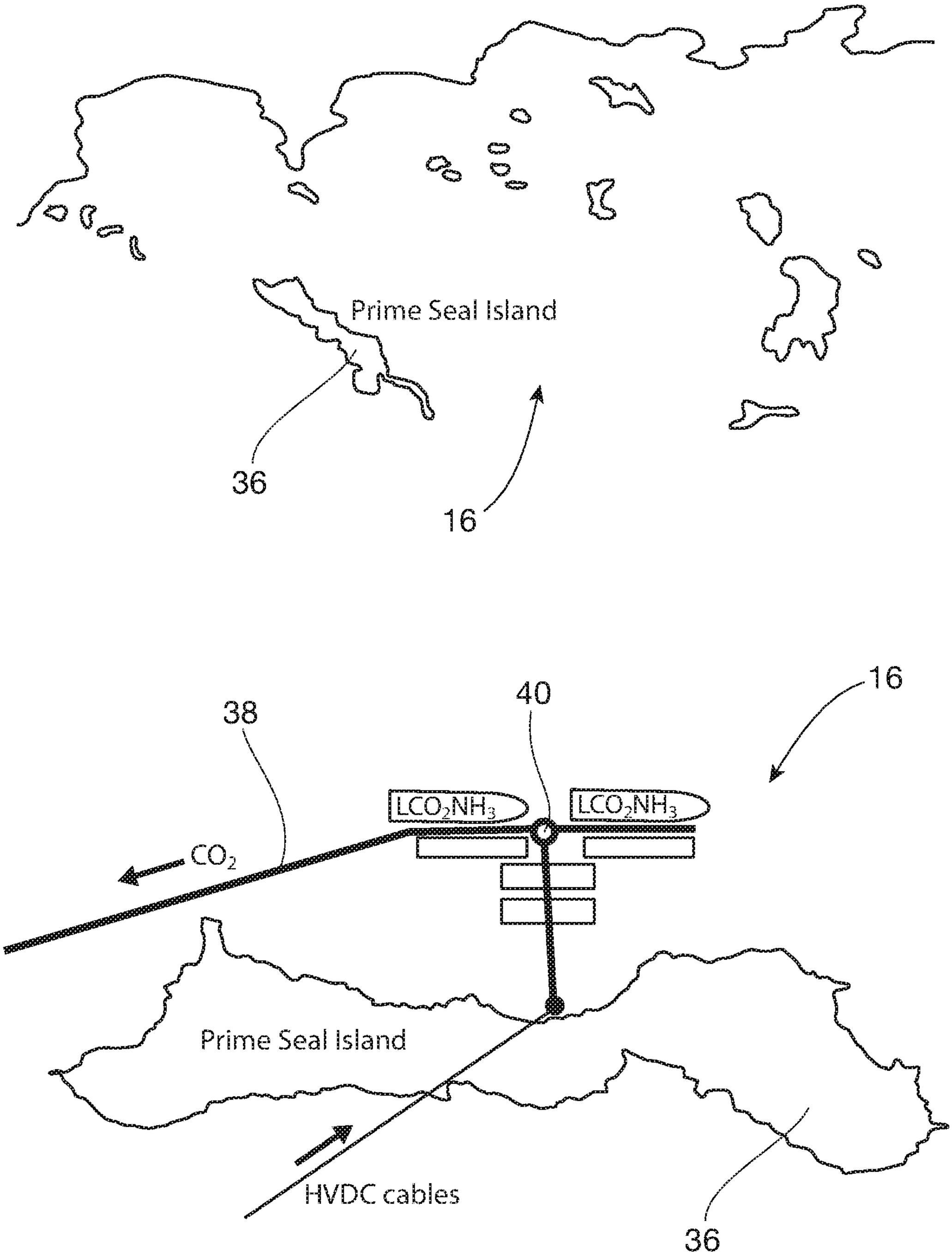
Prime Seal Island
36
16
38
40
16
LCO2NH3
LCO2NH3
CO2
Prime Seal Island
HVDC cables
36

Figure 3B

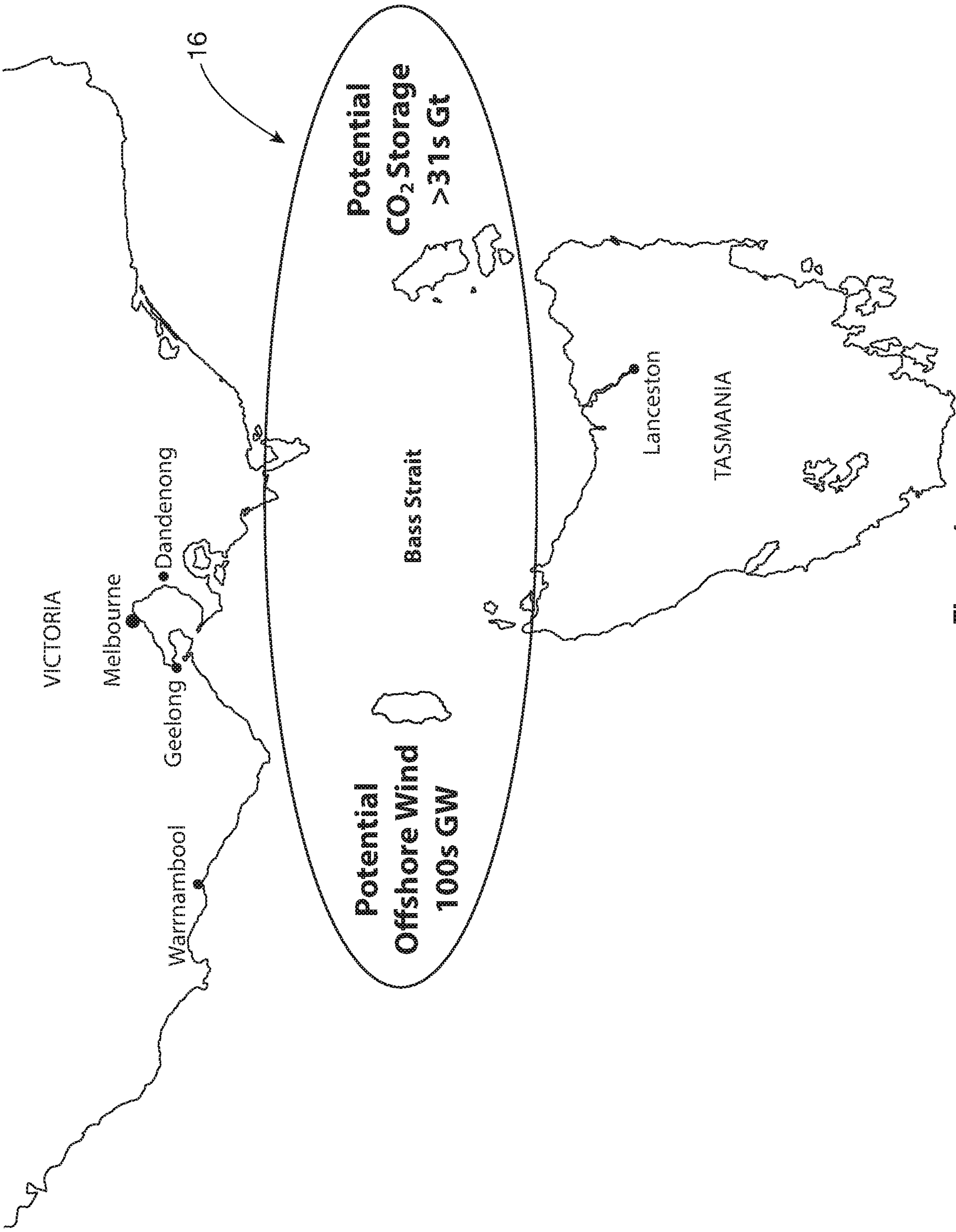
16
Potential
CO_2 Storage
>31s Gt
VICTORIA
Melbourne
Dandenong
Geelong
Warrnambool
Bass Strait
Lanceston
TASMANIA
Potential
Offshore Wind
100s GW

Figure 4

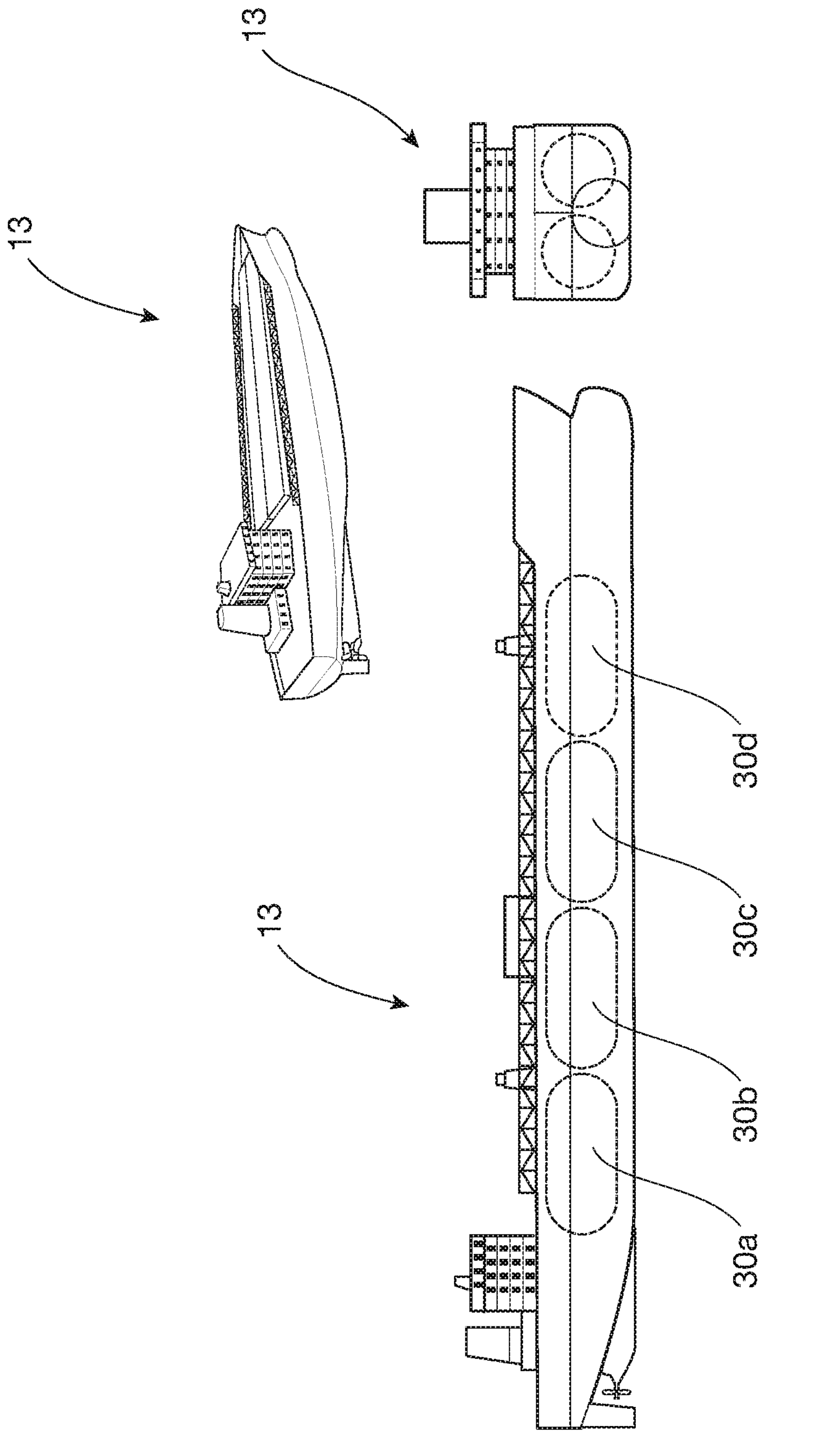

Figure 5

A. CLASSIFICATION OF SUBJECT MATTER

B63B 25/14 (2006.01) B63B 25/02 (2006.01) B63B 25/08 (2006.01) B63B 27/24 (2006.01) B63B 27/34 (2006.01) B63B 35/44 (2006.01) B63B 57/02 (2006.01) C01C 1/00 (2006.01) C01C 1/04 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PATENW: IPC, CPC: B63B25/14, F17C2227/044, F17C2270/0105 and keywords and keywords :AMMONIA, NH3, CARBON DIOXIDE, CO2, PRODUCTION PLANT, TRANSPORT, DELIVER, SHIP, CARRIER, IMPORT and like terms

Applicant and Inventor name search in Google Patents Search and Auspat: Tasrex Pty Ltd or Mott, John

Google Patents Search, Escpacenet Searcch with similar IPC/CPCs and keywords.

Google Search : horisont energi, TOKYO-Mitsui O.S.K. Lines, dual cargo carrier, NH3 and CO2 carrier, Blue ammonia, Green ammonia, CO2 storage and similar keywords

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

*	Special categories of cited documents:		
"A"	document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"D"	document cited by the applicant in the international application		
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
12 May 2023	12 May 2023

Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	CheeWei Tan AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61 2 6225 6105

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Anders Torheim, Design of a gas carrier for transportation of NH3 and CO2 , Bachelor's thesis in Ship Design, December 2021 [online], [retrieved from internet on 02 May 2023] URL:<https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/2976425/no.ntnu:inspera:98456680:37533598.pdf?sequence=1> Section 1.2, 1.3	1-13, 17-24
Y	Horisont Energi AS Information Document, [retrieved from internet on 02 May 2023] URL: <https://horisontenergi.no/wp-content/uploads/2023/02/Horisont-Energi-AS-FINAL-Information-Document-Euronext-Growth-22.01.21_-1.pdf> Pages 5, 17-18, 20, 21	1-24
Y	WO 2021124621 A1 (MITSUBISHI SHIPBUILDING CO., LTD.) 24 June 2021 Para.0004-0005	1-24
A	WO 2021124622 A1 (MITSUBISHI SHIPBUILDING CO., LTD.) 24 June 2021	
A	WO 2011063962 A2 (TGE MARINE GAS ENGINEERING GMBH et al.) 03 June 2011	
P,A	WO 2022096264 A1 (HORISONT ENERGI AS) 12 May 2022	

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2023/050112**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
WO 2021124621 A1	24 June 2021	WO 2021124621 A1	24 Jun 2021
		AU 2020408428 A1	30 Jun 2022
		CN 114787550 A	22 Jul 2022
		EP 4056886 A1	14 Sep 2022
		JP 2021095092 A	24 Jun 2021
		KR 20220092600 A	01 Jul 2022
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		EP 4079622 A1	26 Oct 2022
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WO 2011063962 A2	03 June 2011	WO 2011063962 A2	03 Jun 2011
		DE 102009047140 A1	26 May 2011
WO 2022096264 A1	12 May 2022	WO 2022096264 A1	12 May 2022
		EP 3995667 A1	11 May 2022

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.