A water production plant (10) having an atmospheric water generator (36) and a power source powered by gas and comprising a combustion engine (12) and/or a fuel cell (38), wherein the atmospheric water generator (36) is powered by the power source (12, 38) and wherein water in the exhaust gas of the combustion engine (12) and/or from the fuel cell (38) and water generated by the atmospheric water generator (36) is captured.
FIELD

The present invention relates to an apparatus for generating drinking water from gas fields and oil fields, which flare gas. The invention has particular utility when dealing with fields of "stranded" gas. The term "stranded" is used to refer to hydrocarbon deposits, and in particular gas deposits, where the transport costs make it uneconomic to invest in infrastructure to deliver the gas to consumers (be that domestic or industrial) at locations geographically remote from the gas deposit.

BACKGROUND

Every year, billions of dollars worth of natural gas is flared (burnt off) during oil and/or gas production. Flaring of gas is particularly common at gas production sites in locations that make it uneconomic to invest in infrastructure to deliver the gas to consumers at locations geographically remote from the gas deposit. In remote locations, a supply of gas in excess of 20mmscfd (million standard cubic feet per day) may be large enough to justify some liquefaction technology or the cost of installing a pipeline to the market. Many gas sources do not fall into these categories. Other gas resources, such as gas fields, rather than oil fields producing associated gas, are too small to develop and again fall into the problem of not being big enough to justify the liquefaction technology or a pipeline to market.

The amount of natural gas being flared and vented annually is equivalent to 30 per cent of the European Union's annual gas consumption as of 2012. In Africa alone, the annual amount of gas flared is equivalent to half the continent's power consumption.

Gas flaring has a global impact on climate change by producing about 400 million tons of greenhouse gas emissions annually. In addition, residents in nearby communities have experienced chronic health problems, including bronchial, thoracic, rheumatic, and eye problems. Other problems include acid rain. Venting, rather than flaring is even worse for the environment as methane has 21 times the Global Warming Potential (GWP) of carbon dioxide.
SUMMARY

According to a first aspect of the invention, there is provided a water production plant having an atmospheric water generator and a power source powered by gas and comprising a combustion engine and/or a fuel cell, wherein the atmospheric water generator is powered by the power source and water generated by the atmospheric water generator is captured, and energy in the exhaust of the combustion engine and/or an outlet of the fuel cell is recovered.

Captured water may be used in the production of drinking water, used to irrigate crops or in the production of bio-fuel.

Advantageously moisture in the exhaust gas of the combustion engine is condensed to make more water. Similarly moisture in the output of the fuel cell may be condensed to make more water. Advantageously heat in the exhaust gas may be used to generate electricity, for example by driving a heat engine such as an organic Rankine cycle engine. Similarly heat from the fuel cell may be used to generate electricity.

Advantageously, where a combustion engine is provided it may be used to drive a generator. Advantageously the water production plant may further comprise at least one turbo expander. Turbo expanders are used to reduce gas pressure by gas expansion, and in doing so they provide rotational motion and torque. The water production plant may comprise one or more generators which may be driven by a turbo expander.

Advantageously, the water production plant comprises means for producing drinking (potable) water. It may further comprise a bottling plant for bottling the drinking water. Additionally or alternatively, the water production plant may comprise a soft drinks plant for production of soft drinks from the drinking water.

Advantageously, the water production plant includes an absorption chiller and/or an adsorption chiller in combination with the combustion engine and/or the fuel cell. The absorption chiller may be operable to condense atmospheric moisture. The moisture may be supplied to a bottling plant. The absorption or adsorption chiller may absorb heat from the combustion engine and/or the fuel cell.
The combustion engine may be diesel or bio-fuel powered instead of or in addition to being powered by a fuel gas. As used herein "fuel gas" refers to a gas that can be combusted with air. An example is "natural gas".

One or more heat exchangers may be provided in the water production plant and be operable to distribute heat between elements of the plant. For example, a heat exchanger may be provided downstream of the turbo expander or a pressure reduction part of the water production plant. A second heat exchanger may be provided in communication with the combustion engine. As such, cold from the turbo expander may be provided to the atmospheric water generator. Additionally or alternatively, cold from the turbo expander may be used to cool the bottling plant and/or the combustion engine. Similarly heat from the combustion engine and/or other heat sources may be used to inhibit component of the gas freezing in gas pipes downstream of a turbo expander.

Water from an exhaust of the combustion engine and/or from the outlet of the fuel cell may be used as a cooling medium within the water production plant.

Captured water may be treated in an ultraviolet and/or ozone treatment plant operable to subject the captured water to ultraviolet and/or ozone.

Carbon dioxide produced by the combustion engine and/or the fuel cell may be used to carbonate the captured water. Where the water production plant includes a soft drinks plant, the carbon dioxide may be used to carbonate soft drinks.

In embodiments comprising a fuel cell, the fuel cell may be powered by the fuel gas and may be operable to generate electricity and/or concentrate carbon dioxide produced by the combustion engine. Carbon dioxide, either concentrated or un-concentrated, may then be used to carbonate the captured water. The fuel cell is preferably a molten carbonate fuel cell. However other fuel cell technologies may also be used or become available. The carbon dioxide may be concentrated by injection into the fuel cell alongside a slipstream of fuel gas. Thus, carbon dioxide can be separated from the fuel cell outlet more easily because its dilution with air is reduced.
According to a second aspect of the invention, there is provided a method of producing water from stranded gas, comprising generating electricity by combusting the stranded gas in an engine to drive a generator and/or oxidising the stranded gas in a fuel cell; condensing water from the atmosphere using the generated electricity; and collecting the condensed water. The method may further comprise at least one of: recovering energy from the exhaust gas of the combustion engine and/or the output of the fuel cell to enhance the capture of water from the atmosphere; and collecting the water from combustion or oxidation of the gas.

Embodiments of the invention thus provide a method of and an apparatus for converting gas, for example stranded gas, into water, thereby reducing gas venting, as well as reducing particulates in the air, and reducing acid rain. Such a system also reduces the strain on ground water and its exploitation and therefore the risk of geological damage. It also reduces light and noise pollution that can result from flaring, thereby reducing disruption to the lives of residents of the area surrounding the stranded gas field. For the owner of a stranded gas field, embodiments of the disclosure provide an extra source of revenue, and may create a source of carbon dioxide which can be used for carbonating water or soft drinks, or may be re-injected into gas and oil wells or injected into a greenhouse or bio-fuel production facility while carbon dioxide emissions from the gas field are reduced.

Embodiments of the present invention also allow for commercialisation of gas, which would otherwise have been lost to the atmosphere by flaring or otherwise. Using stranded gas that would normally be wasted or undeveloped.

The inventor realised that embodiments of the disclosure improve the commercial viability of the individual technologies by combining them together.

The inventor further realised that, looking at the power budget for a water production facility as a whole, that electricity and other infrastructure utilities may require the plant to be connected to a local area power network or distribution centre. The overall dependency on infrastructure of a water production and bottling plant could be significantly reduced or eliminated by placing it in proximity or conjunction with a
stranded gas source. Excess power from the water production plant may be used for other purposes.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the disclosure will now be described, by way of non-limiting example only, with reference to the accompanying Figures, in which:

Figure 1 is a diagram of an apparatus for collecting and flaring gas in a stranded gas field;

Figure 2 is a schematic diagram of a water production centre; and

Figure 3 is a schematic diagram of a further water production centre.

DESCRIPTION OF SOME EMBODIMENTS

The inventor has realised that gas, such as stranded gas, could be used to produce water by capturing water from combustion of the gas in a combustion engine and/or use of the gas in a fuel cell and utilising electricity and heat generated from the combustion engine and/or the fuel cell to condense atmospheric moisture. Further, by utilising turbo-expansion technology more electricity can be generated and cooling can be provided for condensing atmospheric water. Embodiments described herein have particularly application at wells producing gas volumes in the region of between 0.5mmcf/day (half a million standard cubic feet per day which is equal to 14,158m³ per day) and 20mmcf/day (twenty million standard cubic feet per day which is equal to 566,367m³ per day).

Figure 1 shows a typical prior art apparatus for flaring gas at a gas field. The apparatus is situated near to a gas well or an oil and gas well 1 and comprises a compressor 2, a hydrocarbon liquid separator 3 and one or more burners 4. The compressor 2 may be provided to condense out intermediate products from the gas stream that may be commercially viable to collect and distribute. Gas is then separated from liquid in the stream by the hydrocarbon liquid separator 3 before being provided to the burner 4 where it is burnt in air. Parts of the apparatus may be owned by a single organisation or
may be owned by multiple organisations. For example, a single party may own the stranded gas field, and different steps in the oil and gas extraction contracted out to multiple parties.

The inventor realised that by situating a water production plant near or at a stranded gas field, electricity generated from the stranded gas could meet some or all of the power requirements of the plant.

Figure 2 is a schematic diagram of a water production plant 10 constituting an embodiment of this disclosure. The water production plant 10 may be installed at or close to a stranded gas field, or situated close to or at a well 1 which may be used primarily for the extraction of oil but from which gas may also be extracted. Fossil fuels other than oil and gas may also be extracted from the well 1. These other products or fuels may be more commercially valuable than the gas and hence may not be stranded. Alternatively, the well 1 may be a gas well which would not be commercially exploited due to its size. Another possibility is that the gas well is economically viable for the provision of a gas distribution infrastructure, but the gas is produced by 'fracking' the gas bearing rocks beneath the well, but water is scarce. Thus the water production plant may produce water for use in the fracking process.

The water production plant 10 may comprise one or more of a combustion engine 12 and a fuel cell 38. The combustion engine 12 may be provided in combination with and drivingly connected to at least one generator 14 for generating electricity. Electricity output from the fuel cell 38 and/or the generator 14 may be used to power some or all of the water production plant 10. Preferably the entirety of the power requirements for the plant can be generated at the plant 10.

A gas extractor 20 receives gas from the well 1 and/or is used to extract gas from the well 1 using known techniques, such as those described with reference to Figure 1. The gas extractor 20 may be part of the water production plant 10 or may be separate from it. The gas extractor 20 may comprise a let down station for reducing the pressure of the gas exiting the well 1. Additionally or alternatively, the plant 10 may further comprises at least one turbo-expander 22 coupled to the gas extractor 20 and operable
to receive high pressure gas which may then expand in a turbo-expander 22 creating torque. Thus the turbo expander can function as a let down station so as to reduce the gas pressure. The torque from the turbo expander may be used to drive the generator 14 or a second generator (not shown) providing additional electricity to the water production plant 10. In some embodiments, the turbo-expander 22 may be incorporated into the gas extractor 20.

The generator 14 and optional further generator may provide enough electricity to power the entire water production plant 10. Accordingly, by situating the water production plant 10 in the proximity of a well, for example a stranded well 1, the production plant 10 can be provided with its energy source thus obviating the need for a connection to locally distributed power and/or a power distribution infrastructure such as a regional or national electricity grid.

In some embodiments, where the combustion engine 12 is present, gas is received at the combustion engine 12 either directly from the gas extractor 20 or from the turbo expander 22, and it is burnt in air producing heat, water and carbon dioxide in accordance with the equation below.

\[ CH_4(g) + 2O_2(g) \rightarrow CO_2 + 2H_2O(g) \]

Thus the exhaust gas contains useful amount of water vapour which can be collected and used in the production of water.

In embodiments having the fuel cell 38, gas extracted from the well 1 may be injected into a fuel cell 38, and the fuel cell 38 may be operable to convert fuel gas into water, heat and carbon dioxide and to generate electricity. The fuel cell may, for example, be a molten carbonate fuel cell. Electricity generated by the fuel cell may be used to power the water production plant 10. The water from the fuel cell may be captured and purified at the water production plant 10.

The water production plant 10 further comprises an atmospheric water generator 36 operable to extract water from the atmosphere. The atmospheric water generator 36
operates to extract water from the atmosphere. Such devices are known in the art and need not be discussed in detail. The atmospheric water generator 36 may receive electricity from one or more of the fuel cell 38 (where present) and the generators 14 (where present). The water generator 36 may further comprise a compressor and/or condenser powered by electricity generated at the plant 10 by the fuel cell or the combustion engine or turbo expander driven generator 14.

Water produced by the atmospheric water generator and optionally one or more of the combustion engine 12 and the fuel cell 30 is captured.

The captured water may then be collected and provided to the water treatment facility 16. The water treatment facility 16 may comprise a treatment plant 24 and a storage and bottling plant 26. At the treatment plant 24, water received from any one or more of the combustion engine 12, fuel cell 38, atmospheric water generator and any other source may be processed and stored. For example the water may be screened/filtered and/or chlorinated to minimize growth of fouling organisms. The water may then be treated using ozone disinfection to oxidise toxic waterborne organisms and/or ultraviolet disinfection. Additionally or alternatively, the treatment plant 24 may use other known potable water purification techniques to render the extracted water suitable for human consumption. Treated water from the treatment plant 24 may then be passed to the storage and bottling plant 26 where it may be stored for local distribution or bottled for local or regional distribution or export from the stranded gas field. "Bottled" in this context includes placing the water into bulk storage vessels for transport and/or later use on site.

Additionally or alternatively, the storage and bottling plant 26 may incorporate a soft drinks manufacturing plant (not shown) operable to manufacture soft drinks from the water received from the treatment plant 24.

The storage and bottling plant 26 may also be operable to carbonate the drinking water before or during bottling. In order to do so, the bottling plant 26 may use carbon dioxide captured from the exhaust gases of the combustion engine. Additionally or alternatively, the bottling plant 26 may use carbon dioxide produced by the fuel cell 38.
The water production plant 10 may comprise a carbon dioxide capture and treatment plant 25 operable to remove carbon dioxide from the exhaust gas received from the combustion engine 12 or from an outlet of the fuel cell 38, purify the carbon dioxide and convert it into a suitable form for carbonating water and/or soft drinks. Suitable carbon dioxide separation technologies include membrane separation and pressure swing adsorption. This list is not intended to be limiting. When used in combination with the combustion engine 12, the fuel cell 28 may intake carbon dioxide exhaust gas from the combustion engine 12 to concentrate the emitted carbon dioxide before being provided to the carbon dioxide capture and treatment plant 25.

The treated carbon dioxide may then be compressed and stored in a carbon dioxide store 27 coupled to the storage and bottling plant 26. By capturing carbon dioxide produced by the combustion of the fuel gas or created in the fuel cell 38, emissions at the stranded gas field may be significantly reduced while providing a source of carbon dioxide suitable for carbonation of fluids for human consumption.

In addition or as an alternative to using the carbon dioxide for carbonation, waste carbon dioxide from the combustion engine 12 and/or the fuel cell 38 may be ducted towards greenhouses to enrich their environment thereby enhancing the rate of growth of plants situated therein.

Additionally or alternatively, captured water and carbon dioxide may be used in the production of bio-fuels. For example, carbon dioxide and water may be used to cultivate algae by photosynthesis so as to produce fats, oils and other bio-fuels, as is known in the art. Accordingly, embodiments of the invention provide for conversion of stranded gas into bio fuels.

It will be appreciated that some elements of the water production plant 10, such as the combustion engine 12 and fuel cell 38, emit heat whereas other elements, such as at the turbo expander 22, absorb heat. Accordingly, the water production plant 10 preferably further comprises a network of pipes connected to heat exchangers to distribute heat throughout the plant 10. For example, in embodiments where the turbo-expander 22 is present, a first heat exchanger 28 may be provided downstream of the turbo-expander
22, in gas flow terms. A further heat exchanger (not shown) may also be provided upstream of the turbo-expander 22 so as to warm the high pressure gas prior to it arriving at the turbo-expander 22.

A second heat exchanger 30 may also be provided at the site of the combustion engine 12 and/or the fuel cell 38, and may be operably coupled to the combustion engine 12, generator 14 and/or the fuel cell 38.

A heat exchange medium, such as a gas or water, may be circulated between the heat exchangers via a heat exchange bus (not shown). The flow of the heat exchange medium between any of the heat exchangers may be controlled by a system of valves, which may incorporate electrically operated valves. The valves may be controlled using a computerised control module 32.

Heat generated by the combustion engine 12 and/or the fuel cell 38 may also be used in low temperature desalination plants where the stranded gas field is situated in the proximity of a source of salt water. Similarly the heat may be used in waste water concentration plants.

In some embodiments, one or more water condensing capture plates 34 may be provided in fluid connection with the heat exchange medium via the heat exchange bus. The capture plates 34 may be operable to capture atmospheric water and provide it to the water treatment facility 16 where it may be treated in a similar manner to the water produced by the atmospheric water generator 36.

Heat and/or cold may also be delivered via the heat exchange bus to the atmospheric water generator 36 to enhance atmospheric water extraction.

In addition to combusting gas released from the well 1, the combustion engine 12 may also combust other fuels extracted from the gas field and/or diesel or bio-fuel.

The water production plant 10 may comprise an absorption and/or adsorption chiller (not shown) for regeneration purposes and which can further cool the heat exchange fluid via a further heat exchanger. The absorption chiller may operate to condition the
air in the bottling plant or may also be used to produce water. The absorption chiller may use desiccants to extract water from the air. Heat from the heat transfer network may be provided to the absorption chiller to aid water extraction from the air.

Figure 3 shows a further embodiment of a water production plant 10 in accordance with the present invention. Gas from a gas extractor 120 may be provided to a water separator 122 where water in the gas may be extracted by cooling it, or by cooling of the gas during expansion. Gas exiting the water separator 122 is provided to an internal combustion engine, or bank of combustion engines 124. The or each engine 124 provides motive power to one or more generators 126. The generators 126 provide electricity to be distributed throughout the water generator production plant 10 by way of a switchboard and control module 130. During operation the engine generates waste heat, which can be ducted by a suitable cooling system to one or more heat exchangers 140, 142 and 144. In this example heat exchanger 140 is in heat flow communication with a further heat exchanger 146 by way of an airflow path. Exhaust gas from the engine follows a route through an exhaust system 150 which includes a nitrous oxide control element 152 and one or more heat exchangers, of which only one is shown for simplicity, and designated 154. Thus the heat exchangers 140, 142, 144, 146 and 154 allow heat to be recovered from the cooling system of the engine 124 and from the exhaust gas of the engine 124. This recovered heat can be delivered, by way of a suitable fluid delivery network to an absorption chiller 170. The absorption chiller 170 operates, in a known way, to provide a chilled liquid flow to an air to water generator 180 which may, for example, receive a flow of forced atmospheric air through condensers 182 and 184 provided therein such that water from the air is condensed and caught in a collection reservoir 186. Condenser 184 may be an electrically powered atmospheric water generator. Furthermore electricity from the generator 126 may be distributed to an electrically powered atmospheric water generator 200 which may also receive a flow of air from the atmosphere, and condense water out of it which is collected into a reservoir 210. A carbon dioxide capture unit may also be operative to collect carbon dioxide from the exhaust of the internal combustion engine if so desired. Provision of this unit depends on whether carbon dioxide will be a useful product, for example if the intention is make carbonated water. Water collected from the various sources may be distributed to a water cleaning unit 220 before going to a water storage
facility 230. The water cleaning unit 220 may be provided if the water is intended for consumption. However, if the water is being produced for some industrial use, for example within a manufacturing plant or as water to be used by a fracking process to extract more gas, then the water cleaning unit 220 may be dispensed with.

Water from the water storage facility 230 may be provided to a water treatment plant 235 which may treat the water to render it biologically and mineralogically safe by known means. Water from the water treatment plant may then go to a water bottling or water packing facility 240 and 242. All of these features may be unnecessary if the water is going to be used industrially.

In an exemplary embodiment, the engine may receive a gas fuel input in the region of, say, 28 megawatts. Such an arrangement would allow the engine to drive a generator to produce approximately 14 megawatts. The remaining energy appears as heat which requires the engine to be cooled and which is lost by way of the exhaust gas which typically may have a temperature of around 270°C when exiting the internal combustion engine. The provision of the heat exchangers 140, 142, 144, 146 and 154 in combination with the absorption chiller allows approximately another 9 megawatts of energy to be recovered and used by the atmospheric water generator 180.

In use, the electrically driven atmospheric water generator comprising condenser 184 can produce approximately 25000 to 28000 kg of water per hour. The atmospheric water generators powered by the absorption chiller using heat that would otherwise have been lost to the environment can provide around another 4200 to 7400kg/hour of water production, depending on the air temperature and relative humidity. It can be seen that, in this non-limiting example, the rate of water production has been increased by a further 25% or so by the addition of the heat exchangers and absorption chiller. This is less capital intensive than providing a bigger engine and more generators.

It is thus possible to reduce the environmental impact of flaring gas by converting it to a usable commodity.
CLAIMS

1. A water production plant having an atmospheric water generator and a power source powered by gas and comprising a combustion engine and/or a fuel cell, wherein the atmospheric water generator is powered by the power source and wherein water generated by the atmospheric water generator is captured, and energy in the exhaust of the combustion engine and/or in the outlet of the fuel cell is recovered.

2. A water production plant as claimed in claim 1 wherein water in the exhaust gas of the combustion engine and/or from the outlet of the fuel cell is captured.

3. A water production plant as claimed in any preceding claim, wherein the water production plant further comprises one or more generators driven by a turbo expander powered by the expansion of the gas and/or the combustion engine where a combustion engine is included.

4. A water production plant as claimed in any preceding claim, wherein the captured water is used for the production of drinking water.

5. A water production plant as claimed in claim 4, further comprising a bottling plant for bottling the drinking water.

6. A water production plant as claimed in any preceding claim further comprising an absorption chiller and/or an adsorption chiller in combination with the combustion engine and/or the fuel cell.

7. A water production plant as claimed in claim 6 in which heat from the engine or fuel cell is transferred by a heat exchanger to the adsorption chiller and/or the absorption chiller to capture more atmospheric water.

8. A water production plant as claimed in any preceding claim in which heat from the engine and/or the fuel cell is used to generate electricity to drive the atmospheric water generator.
9. A water production plant as claimed in any preceding claim wherein the water production plant includes the combustion engine and the combustion engine is operable to combust diesel or bio-fuel.

10. A water production plant as claimed in claim 3 or any claim dependant on claim 4, further comprising one or more heat exchangers operable to distribute heat between one or more of the atmospheric water generator and, where included, the combustion engine, the fuel cell, the turbo-expander, the bottling plant and other elements of the plant as appropriate.

11. A water production plant as claimed in any preceding claim, wherein water from an exhaust of the combustion engine or from the outlet of the fuel cell is used as a cooling medium within the water production plant.

12. A water production plant as claimed in any preceding claim, further comprising an ultraviolet and/or ozone treatment plant for subjecting the captured water to ultraviolet and/or ozone treatment.

13. A water production plant as claimed in any of the preceding claims, wherein carbon dioxide produced by the combustion engine and/or the fuel cell is injected in to a hydrocarbon well to increase gas or oil production or is used in the production of bio-fuel or is used to carbonate the captured water.

14. A water production plant as claimed in any preceding claim, wherein the water production plant includes the fuel cell and the fuel cell is operable to concentrate carbon dioxide produced by the combustion engine.

15. A method of producing water from gas, comprising: generating electricity by combusting the gas so as to drive a generator and/or oxidising the gas in a fuel cell; condensing water from the atmosphere using an atmospheric water generator powered by the generated electricity; and
collecting condensed water and further recurring heat energy from the combustion engine and/or fuel cell and using that to recover more water from the atmosphere.

16. A method of producing water as claimed in claim 15, further comprising producing drinking water from the collected water.

17. A method of producing water as claimed in claim 16, further comprising carbonating the drinking water using carbon dioxide produced during combustion or oxidation of the gas.

18. A method of producing water as claimed in claims 16 or 17, further comprising bottling the drinking water.

19. A method of producing water as claimed in any of claims 15 to 18, further comprising:
   extracting the gas from a gas well;
   generating electricity by reducing the pressure of the extracted gas using a turbo expander to drive a generator; and
   condensing water from the atmosphere using electricity generated from the pressure reduction.

20. A method of producing water as claimed in any of claims 15 to 19, further comprising inputting carbon dioxide produced by combustion of the gas into the fuel cell.

21. A method of producing water as claimed in any of claims 15 to 20, further comprising producing bio-fuel using water and carbon dioxide produced during combustion or oxidation of the gas.

22. A method as claimed in any of claims 15 to 21, in which the gas is "stranded" gas.
23. A method of providing water for use in the extraction of oil or gas by hydraulic fracking, comprising recovering a supply of hydrocarbon fuel from a well, using the fuel in a combustion engine and/or a fuel cell to generate electricity and heat, using the electricity to drive an atmospheric water generator, and using the water for hydraulic fracking.

24. A method as claimed in claim 23 further comprising using heat to drive a recovery process to extract water from the atmosphere.
INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2014/053094

A. CLASSIFICATION OF SUBJECT MATTER
INV. E03B3/28
ADD.

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)
E03B

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)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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Further documents are listed in the continuation of Box C.

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
- "E" earlier application or patent but published on or after the international filing date
- "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)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "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
- "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
- "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
- "Z" document member of the same patent family

Date of the actual completion of the international search
18 December 2014

Date of mailing of the international search report
27/03/2015

Name and mailing address of the ISA/
European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016

Authorized officer
Horst Werner
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Form PCT/ISA/210 (continuation of second sheet) (April 2005)
### Box No. II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. [x] Claims Nos.: 14, 21
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
   see FURTHER INFORMATION sheet PCT/ISA/21Q

3. [ ] Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

   see additional sheet

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
   1-12, 15-18, 22-24

**Remark on Protest**

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.
Continuation of Box 11.2

Claims Nos.: 14, 21

Claim 14 is not clear, because a fuel cell by definition serves to convert the chemical energy from a fuel into electricity through a chemical reaction; hence the skilled person would be at a loss when trying to determine how such a fuel cell should be operable to concentrate carbon dioxide. From the description it appears that it is not the fuel cell itself but a secondary element that should perform this concentration.

The method of claim 21 stipulates that biofuel be produced using the water and the carbon dioxide stemming from the plant. This wording of the claim allows for any known or unknown process which uses inter alia the two elements. The claimed subject-matter thus is so broad that no comprehensive search could be performed for the claim.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.
This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-12, 15-18, 22-24
   a water production plant, having means to capture water contained in the exhaust of the combustion engine

1.1. claims: 5, 18
   a water production plant having a bottling plant

1.2. claim: 8
   a water production plant having means to generate electricity from the heat from the engine

1.3. claims: 11, 23, 24
   a water production plant including means to use the water produced

1.4. claims: 12, 17
   a water production plant having a treatment plant for the captured water

2. claims: 13, 20
   a water production plant having means to further use the carbon dioxide produced by the combustion engine

3. claim: 19
   a method of producing water including the use of a turbo expander as power source
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