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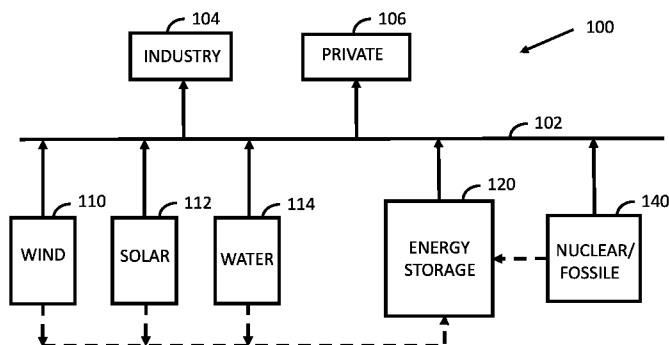
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US 2012301801 A1, US 2013108931 A1, WO 2015058165 A1, US 1501756 A, EP 3033443 B1, EP 0998595 B1

(57) Tiivistelmä - Sammandrag - Abstract

Kohteena on energianhallintamenetelmä, käsittäen askeleet: johdetaan (304) sähköenergiaa energiantuotantolaitoksesta (110, 112, 114, 140) energian varastointilaitokseen (120), käytetään vastaanotettua sähköenergiaa energian varastointilaitoksessa (120, 220) kemialliseen yhdisteeseen sen erottamiseksi ensimmäiseen komponenttiin (224) ja toiseen komponenttiin (226), ja varastoidaan ensimmäinen komponentti (224) ja toinen komponentti (226) erillään energian varastointilaitoksessa (120, 220).

There is provided an energy management method, comprising steps of conducting (304) electric energy from an energy production plant (110, 112, 114, 140) to an energy storage facility (120, 220), applying, in the energy storage facility (120, 220), the received electric energy on a chemical compound (222) to separate the chemical compound to a first component (224) and a second component (226), and storing (306), in the energy storage facility (120, 220), the first component and the second component separately.



ENERGY MANAGEMENT METHOD AND ARRANGEMENT

FIELD

The present invention relates to a method and arrangement for storing and recovering energy.

BACKGROUND

Employment of renewable energy is increasing rapidly in modern power systems. Also there is a continuous need for energy storage solutions as the production of energy does not always match the level of consumption of the consumers.

Several alternative ways have been proposed for storing excess energy, such as by using hydroelectric, compressed air or thermal energy storages or by using flywheels to name a few examples.

However, there still exists a need for a new alternative having high efficiency and low environmental impact.

SUMMARY

The object of the invention is to provide an improved solution for energy management including energy storage and/or recovery upon need.

The object is achieved with an invention defined in the independent claims. Some advantageous embodiments have been disclosed in the dependent claims.

DRAWINGS

The invention and some advantageous embodiments have been illustrated in the accompanying drawings, where

Figure 1 shows a high level architecture of the embodiments;

Figure 2 shows a more detailed view of an energy storage;

Figure 3 shows one embodiment of a method; and

Figure 4 shows one embodiment of a control system.

DESCRIPTION OF SOME EMBODIMENTS

The embodiments relate to energy management. In the embodiments, there is provided an energy management method and energy management system for providing energy to users. Specifically, the embodiments relate to usage of an

energy storage, that is, to storing and/or recovering energy to/from the energy storage.

Figure 1 illustrates the architecture of an energy management system 100 of the invention on a high level.

There is provided a power grid/network 102 for distributing energy produced by the energy providers to the consumers connected to the power network. As one example of the consumers connected to the power network, Figure 1 shows industrial consumers 104 including factories, other industrial facilities or traffic users, for instance. As another major group of consumers, Figure 1 shows private users 106 including households, for instance.

To satisfy the energy needs and requirements of the consumers 104, 106, the energy management system comprises energy providers or energy production plants also connected to the power network 102. As examples of the energy providers, Figure 1 shows a wind farm 110, a solar farm 112 and a hydro energy plant 114. Each of these renewable energy sources 110, 112, 114 can be directly connected to the power network for provision of energy to the network and subsequently to the consumers 104, 106. There may also be a backbone energy provider 140, which may include a nuclear power plant, for instance, for providing most of the energy needed in the grid. Some quick adjustment power provided by a fossile power source, such as coal, may also be connected to the power network 102.

The produced amount of energy from the renewable energy sources cannot be fully predicted beforehand but that depends on environmental weather conditions such as wind, sunshine and rain. If the share of the renewable energy is large in the power network, and the environmental conditions for producing the energy are good, there may be excess energy exceeding the consuming capability of the users connected to the power network. In such situations there is need for capacity of storing energy received from the renewable sources to be used later.

In terms of storing energy, the system comprises an energy storage 120. As shown in Figure 1, all the renewable energy sources 110, 112 and 114 may be connected to the energy storage. Even the backbone energy source may be connected to the energy storage. For instance, in the case of nuclear energy, adjustment of the energy production is difficult or impossible, whereas such energy not being consumed by the consumers can be advantageously stored in the energy storage facility 120.

The energy storage 120 functions as a further energy source when additional energy is needed to fulfil the needs of the industrial and household users.

Figure 2 shows a more detailed illustration of the energy storage 220. The energy storage comprises a compound storage 222 for storing a compound. In one embodiment, the compound comprises salt, that is, sodium chloride (NaCl). The dashed line leading to the compound storage 222 denotes energy received from renewable energy sources, for instance. The energy, such as electric energy can be applied in the compound storage in a so called Downs' process. Even though reference is made in the following to Downs' process, the embodiments are not limited to use of that process but any corresponding process to separate a chemical compound to components may be applied. Furthermore, the embodiments are not limited to whether the received electric energy is applied directly or indirectly on the compound. Indirect application refers here to conversion of the energy to another form of energy, such as thermal energy.

In the Downs' process there is provided a carbon anode and an iron cathode, where molten sodium chloride is applied as an electrolyte. Melting of sodium chloride needs a temperature approximately 800 Celsius but when melted can be kept liquid at temperature approximately 600 Celsius depending on the composition of the compound. In an embodiment calcium chloride CaCl_2 is applied in the compound so that the share by weight of calcium chloride is 2/3 of the mixture and sodium chloride 1/3. In the embodiments of the present invention, the energy received from the energy sources can be used also the heat and melt the electrolyte.

In the Downs' process, as an outcome of the process sodium metal and chlorine gas are obtained as results. Both are less dense than the electrolyte and float to the surface and can be separated into separate storages 224 and 226.

In the inverse process when energy is wished to be recovered from the system, the compound components sodium and chloride are recovered from their respective storages 224, 226 and brought together in the chamber 228. When the sodium and chloride are brought together, sodium chloride is formed and energy is released.

As a result of the chemical process, the energy is output in the form of thermal energy, which may be converted in a generator 230 to electric energy.

Even though above reference has been made to sodium chloride or a mixture containing sodium chloride, also other alkaline metals can be used instead of sodium in combination with chloride or other halogens. Most advantageously

the compound is or at least comprises, however, sodium chloride, being a substance being readily available in large quantities thereby providing a cost efficient alternative.

Figure 3 illustrates one embodiment of the invention. The embodiment is applicable in a power system, comprising a power network to which consumers of electric energy are connected to. In the embodiment, there are also one or more producers of energy also coupled to the power network. Mainly the embodiment shows the method from the point of view of an operator or service provider of the electric network and the method specifically focuses on how it is possible to balance and optimize usage of electric energy in the network.

In step 302, the service provider has a storage or reservoir of a compound. In a preferred embodiment the compound is or at least comprises salt, that is, sodium chloride. The compound may be arranged into a container or chamber.

In step 304, there may occur a situation when the energy producers are capable of producing more energy than the consumers are consuming for the moment, and/or in the close future. The future consumption may be estimated based on past experience of the consumption as a function of time of the day, and weather conditions, for instance. The situation of over production may take place in a network where a substantial share of the energy production takes place by renewable energy being wind, solar and hydro energy.

Further in step 304, the received energy is utilized to separate the compound to components. In an embodiment, if the compound is salt, the process may be a so called Downs' process for separating the sodium and chloride. In the first stage of the Down process, the compound is heated to a melted status. The energy received from the power network may be applied also for this stage. That is, the electric energy may be led to a resistor associated with the chamber housing the compound to heat it up. When the compound has been melt, the Downs' process can be initiated, and the sodium and chloride obtained can be led to respective containers or chambers according to step 306.

By the method illustrated by steps 302 to 306 significant advantages can be achieved in that the overproduction of electricity can be recovered and stored instead of the network operator being obliged to sell the overproduction for consumers that are prepared to consume or waste the received excess energy.

Steps 308 to 312 show a second phase of the method. In 308, there is detected that the consumption in the power network exceeds the production and energy could be recovered from the energy stored in steps 302 to 306.

In step 310, the sodium and chloride from their respective chambers are brought together in a reaction chamber, whereby salt and thermal energy are produced as the outcome. The thermal energy may then be further processed in the electric plant to produce electric energy. In step 312, the produced electric energy is released to the power network to satisfy the increased need of energy by the consumers.

Figure 4 shows an example of the total energy management system according to the invention.

Correspondingly as was shown in connection with Figure 1, there are provided energy consumers 404, 406 connected to a power grid 402. To the power grid are also connected multiple energy producing plants 410, 412, 414 and 440. The energy producing plants provide mainly energy to the power grid 402 but in circumstances when there is excess energy over the consumption of the consumers, the energy may be conducted to the energy storage 420.

Figure 4 shows a control system 450 for controlling different operations in the energy management system 400. There may be provided a production level monitoring system 452, 454, 456 and 458 for each of the energy production plant. For example, the monitoring system 452 monitors the current production capacity of the wind power plant 410. The solar monitoring system 454 monitors the actual production of the solar power plant 412, and similarly the monitoring systems 456 and 458 monitor the production of the hydro 414 and nuclear 440 power plants.

The monitoring system 450 may also comprise a grid consumption measuring unit 470 for measuring and/or estimating the grid consumption. The consumption may, for instance, be estimated based on weather prognoses and usual consumption patterns of the users depending on the time of the day, for instance.

The energy storage control unit 460 may control one or more energy storages 420 by monitoring the energy storage capability, for instance. In this controlling it may be monitored how much of the capacity of the energy storage has been used and how much is still available.

In the overall controlling, the controlling unit 450 may perform decisions whether to store energy from one or more energy producing plants to the energy storage or whether to release energy from the energy storage for consumers in the power grid.

The embodiments disclosed above provide the significant advantage in that the working material or compound is fully recyclable. When the working material has been applied the full operation cycle, that is, been split into components and then combined again into the compound, the original material is again fully usable for storage of energy. Compared to use of fossile fuels, for instance, whose circulation time is calculated in millions of years, the embodiments provide an extremely rapid and environmentally sustainable use of resources.

It is evident that when the technology develops, the invention can be implemented in other ways. The invention and the embodiments are thus not limited to the preceding embodiments but can vary in the scope of the attached claims.

CLAIMS

1. An energy management method, comprising:
conducting (304) electric energy produced by an energy production plant (110, 112, 114, 140) to an energy storage facility (120, 220), **characterized** by the method comprising:

applying, in the energy storage facility (120, 220), the received electric energy on a chemical compound (222) to separate the chemical compound to a first component (224) and a second component (226), wherein the first component comprises an alkaline metal and the second component comprises a halogen gas;

storing (306), in the energy storage facility (120, 220), the first component and the second component separately; and

bringing (310) the first component and second component together to return the original chemical compound and to produce energy to the power grid when needed.

2. The energy management method according to claim 1, **characterized** by:

detecting an over production situation in a power grid where all the energy available is not consumed by consumers connected to the power grid; and

initiating the conducting of electric energy from the energy production plant to the energy storage facility upon detection an over production situation in the power grid.

3. An energy management method according to any preceding claim, **characterized** by:

the chemical compound comprises sodium chloride, whereby the first component is sodium and the second component is chloride.

4. An energy management method according to any preceding claim, **characterized** by:

heating the solid chemical compound to liquid form;

applying Downs' process to separate the first component and second component from each other.

5. The energy management method according to claim 1, **characterized** by:

bringing (310) the first component and second component together to produce thermal energy; and

converting the thermal energy to electric energy to be released to the power grid.

6. An energy management arrangement, comprising:

an energy storage facility (120, 220) for storing energy, comprising:

means for receiving electric energy from an energy production plant (110, 112, 114), **characterized** in that the energy storage facility further comprises:

means for applying the received electric energy on a chemical compound to separate the chemical compound (222) to a first component (224) and a second component (226), wherein the first component comprises an alkaline metal and the second component comprises a halogen gas;

means for storing the first component and the second component separately; and

means for bringing (310) the first component and second component together to return the original chemical compound and to produce energy to the power grid when needed.

7. The energy management arrangement according to claim 6, **characterized** in that the energy storage facility comprises sodium chloride as the chemical compound, whereby the first component is sodium and the second component is chloride.

8. The energy management arrangement according to claim 7, **characterized** by the energy storage facility comprising:

means for bringing (228) the first component and second component together to produce thermal energy; and

means for converting (230) the thermal energy to electric energy to be released to the power grid.

PATENTTIVAATIMUKSET

1. Energian hallintamenetelmä, käsittäen:

johdetaan (304) energian tuotantolaitoksen (110, 112, 114, 140) tuottamaa sähköenergiaa energian varastointilaitokseen (120, 220), **tunnettu** siitä, että menetelmä käsittää:

käytetään energian varastointilaitoksessa (120, 220) vastaanotettua sähköenergiaa kemialliseen yhdisteeseen (222) kemiallisen yhdisteen erottamiseksi ensimmäiseen komponenttiin (224) ja toiseen komponenttiin (226), jolloin ensimmäinen komponentti käsittää alkalimetallin ja toinen komponentti käsittää halogeenikaasun;

varastoidaan (306) energian varastointilaitoksessa (120, 220) ensimmäinen komponentti ja toinen komponentti erillään; ja

saatetaan (310) ensimmäinen komponentti ja toinen komponentti yhteen alkuperäisen kemiallisen yhdisteen palauttamiseksi ja energian tuottamiseksi sähköverkkoon tarpeen mukaan.

2. Patenttivaatimuksen 1 mukainen energian hallintamenetelmä, **tunnettu** siitä, että:

havaitaan sähköverkossa ylituotantotilanne, jolloin sähköverkkoon yhteydessä olevat kuluttajat eivät kuluta kaikkea saatavilla oleva energiaa; ja

aloitetaan sähköenergian johtaminen energian tuotantolaitokselta energian varastointilaitokseen sähköverkossa havaitun ylituotantotilanteen seurauksena.

3. Jonkin edellisen patenttivaatimuksen mukainen energian hallintamenetelmä, **tunnettu** siitä, että kemiallinen yhdiste käsittää natriumkloridia, jolloin ensimmäinen komponentti on natrium ja toinen komponentti on kloridi.

4. Jonkin edellisen patenttivaatimuksen mukainen energian hallintamenetelmä, **tunnettu** siitä, että:

lämmitetään kiinteä kemiallinen yhdiste nestemäiseen muotoon;

käytetään Downin prosessia ensimmäisen komponentin ja toisen komponentin erottamiseksi toisistaan.

5. Patenttivaatimuksen 1 mukainen energian hallintamenetelmä, **tunnettu** siitä, että:

 saatetaan (310) ensimmäinen komponentti ja toinen komponentti yhteen lämpöenergian tuottamiseksi; ja
 muutetaan lämpöenergia sähköenergiaksi vapautettavaksi sähköverkkoon

6. Energian hallintajärjestely, käsittäen:
 energian varastointilaitoksen (120, 220) energian varastoimiseksi, käsittäen:

 välineet sähköenergian vastaanottamiseksi energian tuotantolaitokselta (110, 112, 114), **tunnettu** siitä, että energian varastointilaitos edelleen käsittää:

 välineet vastaanotetun sähköenergian käyttämiseksi kemialliseen yhdisteeseen kemiallisen yhdisteen (222) erottamiseksi ensimmäiseen komponenttiin (224) ja toiseen komponenttiin (226), jolloin ensimmäinen komponentti käsittää alkalimetallin ja toinen komponentti käsittää halogeenikaasun;

 välineet ensimmäisen ja toisen komponentin varastoimiseksi erillään; ja
 välineet ensimmäisen komponentin ja toisen komponentin saattamiseksi (310) yhteen alkuperäisen kemiallisen yhdisteen palauttamiseksi ja energian tuottamiseksi sähköverkkoon tarpeen mukaan.

7. Patenttivaatimuksen 6 mukainen energian hallintajärjestely, **tunnettu** siitä, että energian varastointilaitos käsittää kemiallisena yhdisteenä natriumkloridia, jolloin ensimmäinen komponentti on natrium ja toinen komponentti on kloridi.

8. Patenttivaatimuksen 7 mukainen energian hallintajärjestely, **tunnettu** siitä, että energian varastointijärjestely käsittää:

 välineet (228) ensimmäisen ja toisen komponentin saattamiseksi yhteen lämpöenergian tuottamiseksi; ja

 välineet lämpöenergian muuttamiseksi (230) sähköenergiaksi sähköverkkoon vapauttamiseksi.

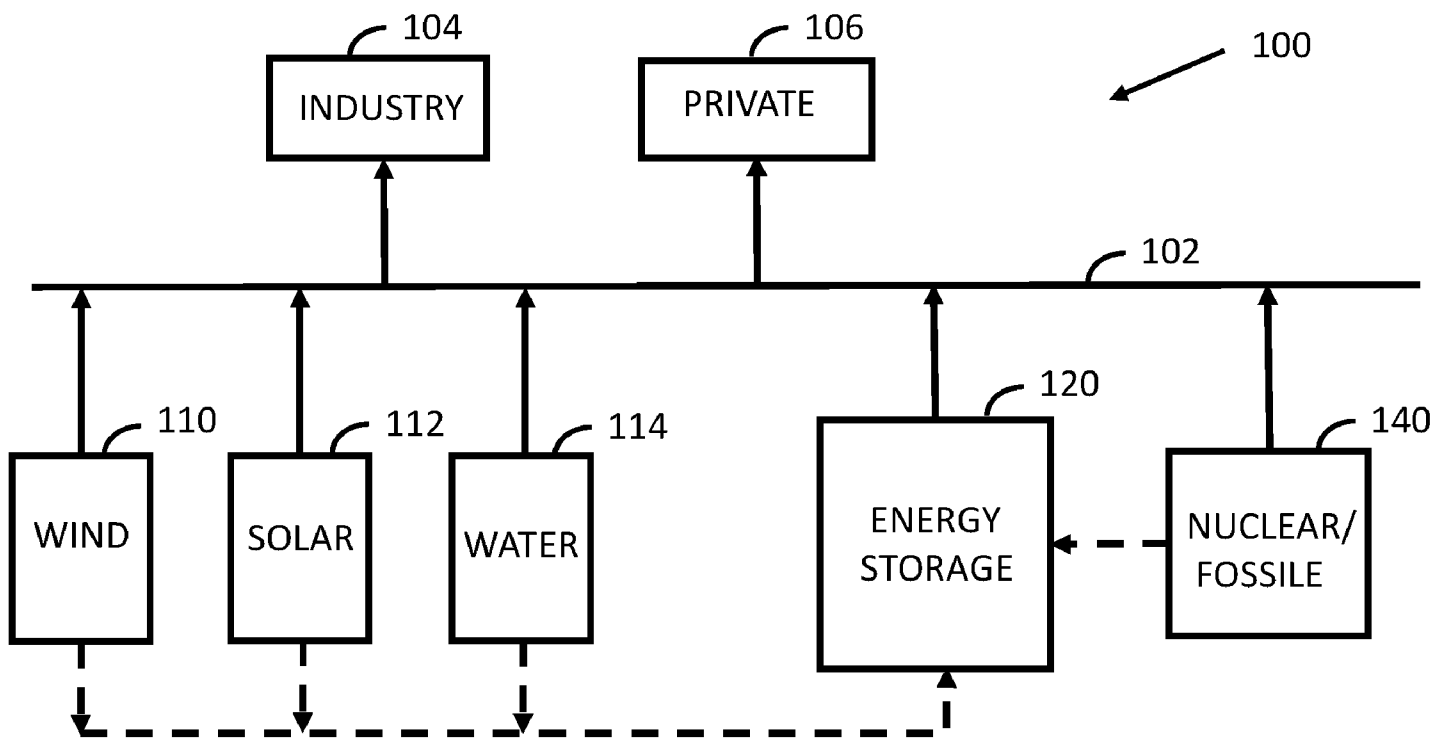


Fig. 1

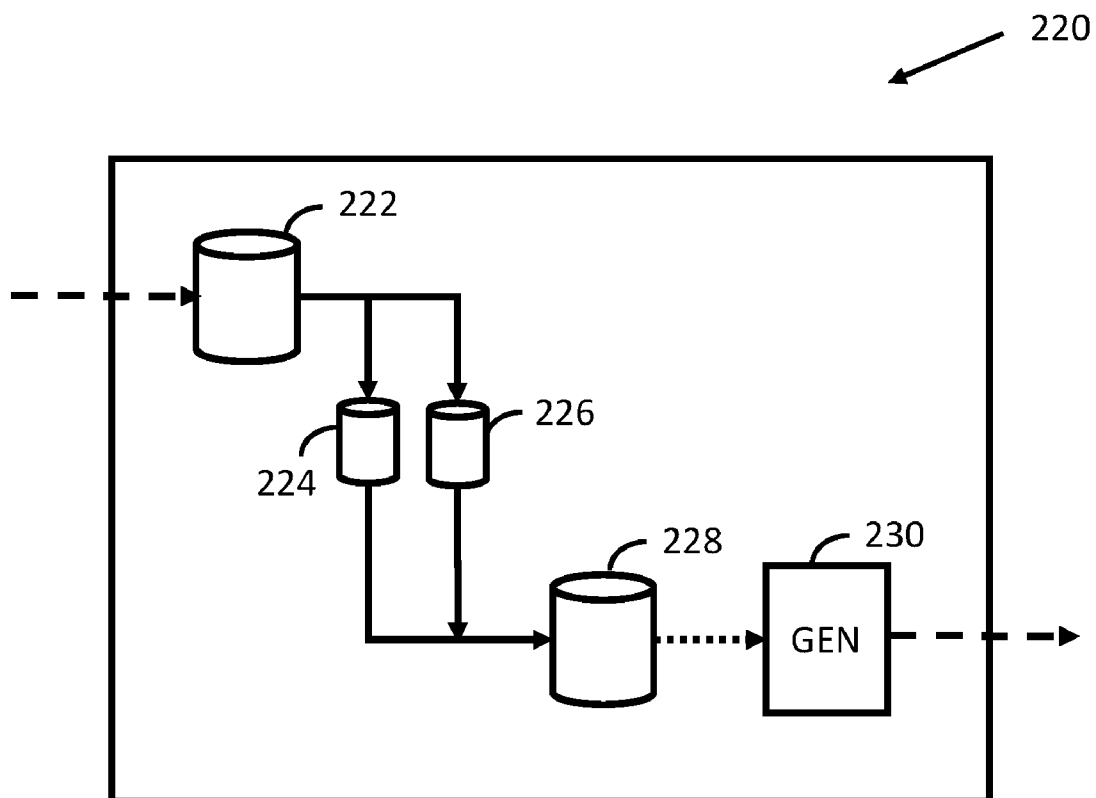


Fig. 2

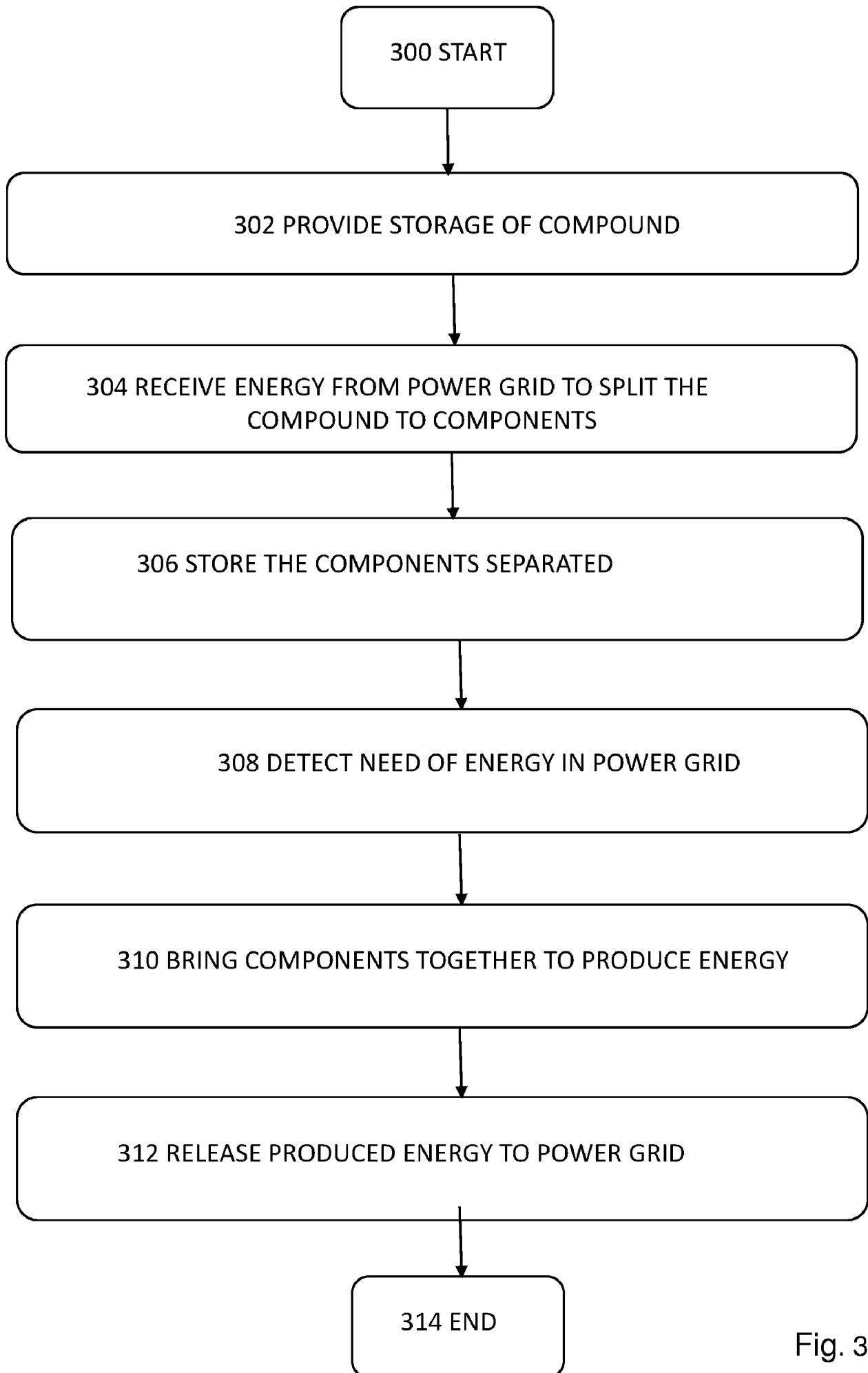


Fig. 3

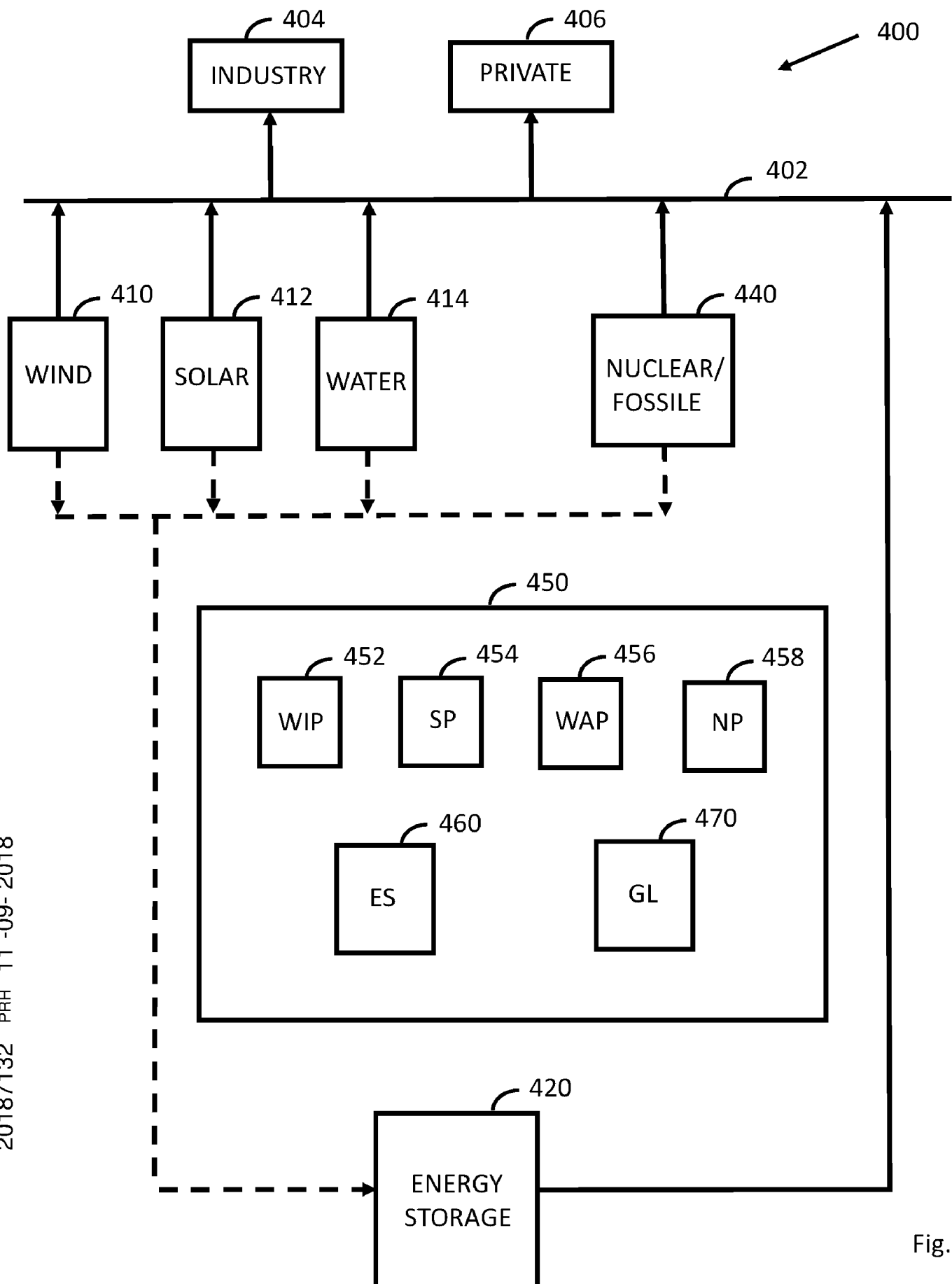


Fig. 4