

Title: Dynamic PtX plant

The present invention is directed to a method for controlling a dynamic operation in a chemical or fuel plant, preferably a Power-to-X (PtX) plant via a computerized control system. Said plant comprises one or more electrolyzers for converting water into hydrogen and said plant can produce one or more of ammonia, synthetic alcohols such as methanol or ethanol, or dimethyl ether (DME) or synthetic hydrocarbon(s) such as synthetic fuels (e.g. jet fuel and/or kerosene) or such as substitute natural gas (SNG) (e.g. methane).

Background of the Invention

Currently, no Power-to-X (PtX) plants are operating dynamically, directly connected to the grid. A battery is often used in PtX plants as a mean to storage excess energy for a long period of time and thereby ensuring that the plant can operate at a high capacity when there is a low production of renewable power. This requires however a very large battery with a capacity corresponding to several hours of consumption in the plant.

Green ammonia, also known as renewable or sustainable ammonia, is produced using a process that reduces or eliminates the carbon emissions associated with traditional ammonia production methods. The production of green ammonia typically involves the following steps:

- **Renewable Energy Generation:** Green ammonia production relies on renewable energy sources, such as solar or wind power, to generate the necessary electricity for

the process. This renewable energy ensures that the production process is carbon-free or has significantly reduced emissions compared to conventional methods.

- 5 • **Electrolysis of Water:** The first step in green ammonia production involves the electrolysis of water, also known as water splitting. Electricity generated from renewable sources is used to split water (H_2O) into hydrogen (H_2) and oxygen (O_2) gases.
- 10 • **Hydrogen Production:** The hydrogen gas (H_2) generated from the water splitting process is collected and separated from the oxygen. The hydrogen is then purified to remove any impurities or traces of remaining water.
- 15 • **Nitrogen Capture:** The next step involves typically capturing nitrogen (N_2) from the air. This can be done using air separation technologies, such as pressure swing adsorption (PSA) or membrane separation, to concentrate nitrogen for further processing.
- 20 • **Synthesis Process:** In the final step, the captured nitrogen gas (N_2) is combined with the purified hydrogen gas (H_2), typically using the Haber-Bosch process, which
- 25 is the traditional method for ammonia production. This process involves typically high temperature and pressure conditions and the use of catalysts to convert the hydrogen and nitrogen into ammonia (NH_3).
- 30 By using renewable energy for the electrolysis step and capturing nitrogen from the air, the overall process of green

ammonia production reduces or eliminates the carbon emissions associated with traditional ammonia production, making it a more environmentally friendly alternative. Green ammonia has potential applications as a clean energy carrier, as
5 a source of hydrogen, and in the production of fertilizers and other chemical products.

Green alcohols, such as methanol and ethanol, can be produced through various methods, including biomass conversion and
10 carbon capture and utilization.

Biomass Conversion

- a. Biomass Feedstock: Biomass, such as agricultural waste, wood chips, or dedicated energy crops, is used as
15 the feedstock for alcohol production.
- b. Pretreatment: The biomass feedstock undergoes pretreatment processes, which may include drying, grinding, and chemical treatment, to make it more suitable for further processing.
- 20 c. Fermentation: Enzymes or microorganisms, such as yeast or bacteria, are used to convert the carbohydrates present in the biomass into sugars. This step is known as fermentation.
- d. Distillation: The fermentation mixture is then subjected to distillation to separate and concentrate the
25 alcohol from the other components, such as water and impurities.
- e. Purification: Further purification steps, such as dehydration or rectification, may be employed to obtain
30 high-purity methanol or ethanol.
- f. Co-Products: In some cases, the biomass conversion process can also produce other valuable co-products, such

as bio-oil or biogas, which can be used for energy generation or other purposes.

Carbon Capture and Utilization (CCU)

- 5 a. Carbon Dioxide (CO₂) Capture: Carbon dioxide is captured from industrial emissions, such as power plants or other industrial processes, or directly from the atmosphere.
- 10 b. Hydrogen Production: Hydrogen gas (H₂) is produced through water electrolysis, steam reforming of natural gas, or other renewable methods.
- 15 c. Syngas Generation: The captured CO₂ is combined with the produced hydrogen gas to form a synthesis gas (syngas). Alternatively, the CO₂ is partly converted into CO and combined with the produced hydrogen gas to form a synthesis gas (syngas) mixture containing carbon dioxide, carbon monoxide (CO) and hydrogen (H₂).
- 20 d. Catalytic Conversion: The syngas mixture is then subjected to catalytic conversion processes, such as methanol synthesis, or ethanol synthesis, to produce the desired alcohol product.
- 25 e. Purification: The alcohol product is purified through distillation and other separation techniques to obtain the desired purity level.

Both biomass conversion and carbon capture and utilization methods offer pathways to produce green alcohols by utilizing renewable resources and reducing carbon emissions compared to traditional fossil fuel-based processes. These green alcohols have various applications, including as transportation fuels, fuel additives, solvents, and chemical feedstocks.

Green Dimethyl Ether (DME) is another example of a green
5 fuel. DME is a colorless gas that can be used as a clean-
burning fuel and as a substitute for diesel fuel. It is
produced through the following process:

Biomass or Carbon Capture: Similar to the production of green
10 methanol and ethanol, DME can be produced using biomass
feedstock or carbon capture and utilization methods.

- Biomass Conversion: If biomass is used, the biomass
feedstock undergoes pretreatment, fermentation, and
distillation processes to produce methanol.
- 15 • Carbon Capture and Utilization: If carbon capture and
utilization methods are employed, CO₂ is captured from
industrial emissions or directly from the atmosphere,
and hydrogen gas is produced through electrolysis or
other methods.

20 Methanol Synthesis: The next step involves methanol synthe-
sis, where methanol (CH₃OH) is produced using a catalyst by
combining carbon monoxide (CO) or CO₂ with hydrogen gas (H₂).
This can be done through various processes, such as the
25 catalytic hydrogenation of CO or the hydrogenation of CO₂.

Dehydration: After methanol is produced, it undergoes a de-
hydration process to remove water and convert it into DME.
This involves removing a molecule of water (H₂O) from two
30 molecules of methanol (2CH₃OH), resulting in the formation
of one molecule of DME (CH₃OCH₃).

Purification: The DME produced is then purified through processes such as distillation and other separation techniques to obtain the desired purity level.

5 Green DME, like other green fuels, offers several benefits such as reduced greenhouse gas emissions, improved air quality due to lower emissions of pollutants, and potential use as a renewable and clean fuel. It can be used in transportation applications, power generation, and as a chemical
10 feedstock in various industries.

Methane can be produced from renewable sources of energy through a process called methanation or power-to-gas. Methanation involves the conversion of carbon dioxide (CO₂)
15 and hydrogen (H₂) produced from renewable sources into methane (CH₄), which can be used as a renewable natural gas or a versatile energy carrier. The process typically involves the following steps:

- 20 a. *Carbon Dioxide Capture*: Carbon dioxide can be captured from various sources, including industrial emissions, biogas plants, or directly from the atmosphere. Technologies such as absorption, adsorption, or membrane separation can be used for CO₂ capture.
- 25 b. *Hydrogen Generation*: Hydrogen gas is produced using renewable energy sources such as solar, wind, or hydroelectric power through processes like water electrolysis or steam reforming of biomass-derived gases.
- 30 Electrolysis splits water (H₂O) into hydrogen (H₂) and oxygen (O₂) using electricity.

- c. *Syngas Generation*: The captured CO₂ is combined with the produced hydrogen gas to form a synthesis gas (syngas) mixture. This can be achieved through processes like the Sabatier reaction or catalytic methanation. The Sabatier reaction involves the reaction of CO₂ with hydrogen at elevated temperatures and pressures to produce methane and water.
- d. *Methane Synthesis*: The syngas mixture is subjected to further catalytic reactions, such as the methanation process, to convert the carbon dioxide and hydrogen into methane. Catalysts are used to facilitate the chemical reactions and promote the formation of methane.
- e. *Purification*: The produced methane is then purified to remove any remaining impurities, such as water or other trace gases, to obtain high-purity methane suitable for various applications.
- The resulting methane can be used in a similar way as natural gas. It can be injected into natural gas pipelines, stored, or utilized for heat generation, electricity production, or as a fuel for vehicles. The production of methane from renewable sources contributes to reducing carbon emissions and increasing the share of renewable energy in the overall energy mix.
- The production of fuels like **kerosene** and **jet fuel** from renewable sources of energy can be achieved through advanced biofuel technologies or synthetic fuel production methods. Here are two common approaches:

Advanced Biofuels

- 5 a. Biomass Feedstock: Renewable feedstocks, such as non-food biomass or algae, are used as the starting material for biofuel production. These feedstocks can be grown on non-arable land, minimizing competition with food crops.
- 10 b. Biomass Conversion: Various conversion processes, including thermochemical or biochemical methods, are employed to convert the biomass into liquid hydrocarbon fuels.
- c. Thermochemical Conversion: Thermochemical processes like pyrolysis or gasification are used to convert biomass into a synthesis gas (syngas) composed of carbon monoxide (CO) and hydrogen (H₂).
- 15 d. Fischer-Tropsch Synthesis: The syngas generated in the previous step is then subjected to the Fischer-Tropsch process, which involves catalytic reactions that convert the syngas into liquid hydrocarbon fuels, including kerosene and jet fuel.
- 20 e. Upgrading and Refining: The produced biofuels undergo further refining processes to improve their properties and remove impurities, resulting in high-quality kerosene or jet fuel that meets the necessary specifications.

25 ***Synthetic Fuels***

- a. Carbon Capture and Utilization: Carbon dioxide (CO₂) is captured from industrial emissions or directly from the atmosphere using various technologies.
- 30 b. Hydrogen Production: Renewable hydrogen gas (H₂) is produced using electrolysis powered by renewable energy sources like solar or wind power.

c. Syngas Generation: The captured CO₂ is combined with the produced hydrogen gas to form a syngas mixture composed of carbon monoxide (CO) and hydrogen (H₂).

5 d. Fischer-Tropsch Synthesis: The syngas mixture is subjected to the Fischer-Tropsch process, which converts the syngas into liquid hydrocarbon fuels, including kerosene and jet fuel, through catalytic reactions. The process involves several steps: (i) *Syngas Generation*: Carbon monoxide (CO) and hydrogen (H₂) are generated through different methods,
10 such as the gasification of coal, biomass, or the reforming of natural gas. In the context of renewable sources, syngas can be produced from captured carbon dioxide (CO₂) combined with renewable hydrogen (H₂) generated through electrolysis. (ii) *Syngas Conditioning*: The generated syngas is typically
15 impure and contains impurities such as sulfur compounds and traces of other gases. Therefore, it needs to undergo conditioning processes to remove these impurities. (iii) *Catalyst Preparation*: A suitable catalyst is selected for the Fischer-Tropsch process. Traditionally, iron or cobalt-based
20 catalysts are used. These catalysts help facilitate the reaction and control the selectivity and activity of the process. (iv) *Fischer-Tropsch Reaction*: The conditioned syngas is then introduced into a reactor containing the selected catalyst. The reaction takes place at elevated temperatures
25 (typically between 150-300°C) and moderate to high pressures (typically between 10-50 bar). The CO and H₂ gases react on the surface of the catalyst to form a range of hydrocarbon products. (v) *Hydrocarbon Product Formation*: The Fischer-Tropsch reaction results in the formation of a wide range of
30 hydrocarbon products, ranging from methane (CH₄) to longer chain hydrocarbons such as waxes. The distribution of the

hydrocarbon products can be influenced by adjusting the reaction conditions and catalyst properties. (vi) Product Separation and Refining: After the reaction, the resulting mixture is cooled and passed through a series of separation and refining steps. These steps involve distillation, hydrocracking, and other processes to separate and refine the desired liquid hydrocarbon products, removing any impurities and adjusting their properties.

10 e. Refining and Upgrading: The produced synthetic fuels undergo refining and upgrading processes to meet the required specifications and ensure high quality.

Both advanced biofuels and synthetic fuels from renewable sources provide alternatives to conventional fossil fuels, with reduced carbon emissions and a lower environmental impact. These renewable fuels can be used as drop-in replacements for traditional kerosene and jet fuel, contributing to the decarbonization of the aviation industry and reducing reliance on fossil fuels.

Production of hydrocarbon fuels from renewable hydrogen and captured carbon dioxide (CO₂), can also be used to produce renewable **gasoline**. These synthetic fuels involve the conversion of CO₂ and hydrogen through processes like the Fischer-Tropsch synthesis, resulting in the production of liquid hydrocarbon fuels that can be blended with gasoline. Gasoline is mostly used in the automobile industry.

Summary of the Invention

The present invention is directed to a method and system for controlling dynamic operation in a chemical or fuel plant, preferably a Power-to-X (PtX) plant via a DCS (distributed control system), to address the problem of fluctuation in the supply of renewable power in case said power is periodically curtailed from the grid, where no power is exported to the grid. This curtailed operation may also be due to a safety issue, such as a fire or a malfunction. Said plant comprises one or more electrolyzers for converting water into hydrogen and can produce one or more of ammonia, synthetic alcohols such as methanol or ethanol, or dimethyl ether (DME) or synthetic hydrocarbon(s) such as synthetic fuels (e.g. jet fuel and/or kerosene) or such as substitute natural gas (SNG) (e.g. methane) .

Electrolyzers use about 80-90% of total power and balance power consumers (chemical or fuel plant (e.g. Ptx), nitrogen generation, utility systems, etc.) take the remaining approximately 10-20%.

The present invention provides for improvement in reliability, reduction in installation costs, as well as remote monitoring.

Description of the Invention

The present invention is a method, system and computer-implemented method for controlling dynamic operation of chemical plant, preferably a PTX plant.

A distributed control system or **DCS** is a computerized control system for a process or plant usually with many control loops, in which autonomous controllers are distributed throughout the system, but there is no central operator supervisory control. This contrasts with systems that use centralized controllers; either discrete controllers located at a central control room or within a central computer. The DCS concept increases reliability and reduces installation costs by localizing control functions near the process plant, with remote monitoring and supervision. Distributed control systems first emerged in large, high value, safety critical process industries, and are attractive because the DCS manufacturer supply both the local control level and central supervisory equipment as an integrated package, thus reducing design integration risk. Today the functionality of Supervisory control and data acquisition (SCADA) and DCS systems are very similar, but DCS tends to be used on large continuous process plants where high reliability and security is important, and the control room is not geographically remote. In the present invention, a DCS computerized control system, or similar, controls the level of noise of rectifiers via harmonic filters.

Definitions

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Chemicals in the present invention mean ammonia, synthetic alcohols such as methanol or ethanol, or dimethyl ether (DME) or such as substitute natural gas (SNG) (e.g. methane).

A **chemical-rich stream** can contain approximately between 10 to 50 vol% of chemical after the converter and approximately 90-100 vol% after separation of the chemical from the unconverted synthesis gas.

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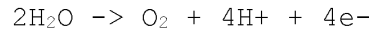
Electrical power and **electricity** refer to the flow of electric energy or the rate at which electric energy is transferred or used. Electricity is a form of energy resulting from the movement of electric charges. It is the general term used to describe the presence and flow of electric charge, typically in the form of electrons, through conductive materials like wires. Electricity can be generated from various sources such as fossil fuels, nuclear energy, renewable sources like solar or wind, or even through chemical reactions in batteries. Electrical power, on the other hand, specifically refers to the rate at which electrical energy is transferred, used, or consumed. It is the amount of electrical energy per unit of time. Power is measured in units such as watts (W), kilowatts (kW), or megawatts (MW). One watt represents the transfer of one joule of energy per second.

Electrolysis of water is a chemical process that uses an electric current to decompose water molecules (H_2O) into their constituent elements, hydrogen (H_2) and oxygen (O_2). It involves the application of an electric current through a water-based solution, typically using electrodes immersed in the water.

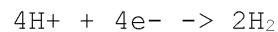
During electrolysis of water, two half-reactions occur at the electrodes:

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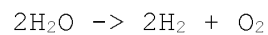
At the anode (positive electrode): Oxygen is produced through the oxidation reaction.



5 At the cathode (negative electrode): Hydrogen is produced through the reduction reaction.



10 In the overall reaction, two molecules of water are split into one molecule of oxygen gas and two molecules of hydrogen gas:



15 The electrolysis process requires an external source of electrical energy to drive the reaction. The electrodes are typically made of conductive materials like platinum or graphite. The cathode attracts positively charged ions (H^+ ions) and reduces them to form hydrogen gas, while the anode attracts negatively charged ions (OH^- ions) and oxidizes them to form oxygen gas.

25 Electrolysis of water is a way to produce hydrogen gas, which can be used as a clean fuel or for various industrial applications. Additionally, this process can be used for energy storage and as a means to balance intermittent renewable energy sources by converting excess electricity into hydrogen fuel. The hydrogen is classified as green when the conversion is achieved using renewable energy.

30 Large-scale electrolysis of water for hydrogen production at a power plant mainly aims for improved efficiency and cost-

effectiveness. Some key differences in the context of a power plant electrolysis system include:

- 5 • **Electrolyzer design:** Electrolyzers used in industrial-scale applications are optimized for high production rates and durability. They may incorporate advanced materials and designs to enhance efficiency and minimize degradation.
- 10 • **Power supply:** Power plants often have their own dedicated sources of electricity, which can provide a stable and continuous supply of power for the electrolysis process. In the present application the power supply
15 may be provided by one or more sources comprising the power grid and renewable sources of electricity.
- 20 • **Integration with the power plant:** Large-scale electrolysis systems can be integrated with power plants to utilize excess electricity generated during low-demand periods. This allows for efficient utilization of renewable or excess electricity, enabling the production of hydrogen as a form of energy storage.
- 25 • **Downstream applications:** Hydrogen produced through large-scale electrolysis can be used for a variety of applications, such as fueling hydrogen fuel cells, industrial processes, or even injected into the natural gas grid.

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Electrolyzers within the context of the present invention means any kind of electrolyser, such as PEM, alkaline, SOEC

or other. Electrolyzers utilize a rectifier for converting alternating current (AC), to direct current (DC).

Fuels in the present invention mean synthetic hydrocarbon(s) such as synthetic fuels (e.g. jet fuel and/or kerosene or gasoline).

A **fuel-rich stream** can contain approximately between 10 and 50 vol% of fuels after the converter or approximately 90 to 100 vol% after separation of the fuel.

Harmonic filters can be active or passive and are used to control the level of noise from electrical consumers such as transformers, rectifiers, VSD, motors, etc. to ensure the plant compliance with regulation. Even when no power is being exported to the grid, there is still noise to be handled.

MVAR stands for **megavolt-amp reactive**, and it is a unit of electrical reactive power. It is equal to one million volt-amp reactive (VAR). The prefix "mega" denotes a multiplication factor of one million. MVAR is commonly used to express large values of reactive power in power systems, especially in high-voltage transmission and distribution networks.

A **PtX plant** operates conversion of electricity into hydrogen or PtX products based on hydrogen, such as ammonia by adding nitrogen, or methanol, DME, diesel, methane, gasoline, by adding carbon. The first part of the PtX process is to use electricity to power electrolysis plants where hydrogen is split from water.

The hydrogen can then either be used directly as a fuel or as an element in making hydrogen-based chemicals and/ or

fuels in a synthesis plant. PtX products are produced by adding either nitrogen or carbon. The carbon may be classified as fossil based or sustainable depending on its origin. when Sustainable carbon may be obtained from via for example
5 gasification, fermentation or combustion of biogenic resources. The carbon may be obtained directly or obtained via carbon capture, and then used for the production of carbon containing PtX products (carbon capture and utilization, CCU). Alternatively, the captured carbon may be stored (carbon
10 capture and storage, CCS) -to reduce carbon emissions. CCS is ideally suited to large fossil fuel point sources, where sustainable alternatives are difficult to find, such as in cement production. Direct Air Capture, where CO₂ is captured from the air rather than a concentrated carbon
15 source is also being industrialized.

In the context of a plant, e.g. a PtX plant, a "**trip**" refers to an unexpected shutdown or interruption in the normal operation of the plant. It occurs when there is a sudden and
20 automatic disconnection of the plant from the electrical grid (or alternative sources of energy) or a failure in one or more components of the plant. A **plant trip** can happen due to various reasons, including equipment failures, safety concerns, grid instability, or abnormal operating conditions. Some common causes of a plant trip include

- (i) equipment failure: Trips can occur when critical equipment such as generators, turbines, boilers, or control systems experience malfunctions or breakdowns. These failures may be caused by mechanical issues, electrical faults, or other technical problems.

- (ii) Grid disturbances: Plants can be designed to disconnect from the electrical grid automatically in response to grid disturbances or abnormalities, such as voltage or frequency fluctuations. This protective measure ensures the safety and stability of both the plant and the grid.
- (iii) Safety considerations: Plants may be equipped with safety systems and sensors that can detect hazardous conditions. If abnormal conditions are detected, such as high temperatures, excessive pressures, or gas leaks, the plant may initiate a trip to prevent any potential accidents or damage.
- (iv) Human error: Operational mistakes or errors in the control room can also lead to plant trips. Improper settings, incorrect procedures, or operator negligence can cause the plant's safety systems to trigger a shutdown.

When a plant trip occurs, the plant's control systems and protective mechanisms act to isolate and protect the plant and its equipment. Once the cause of the trip is identified and addressed, the plant can be restarted and brought back online for normal operation.

Plant trips are undesirable events which in the context of the present invention may result in interrupted production of chemicals and/or fuels.

A **rectifier** converts AC power into DC power and generates noise. A conventional thyristor rectifier has a low input power factor practically requiring passive or active compensation to avoid a reduction of the power quality of the grid.

Other types of rectifiers may reduce the need for passive or/and active power compensation.

5 **Renewable energy or power** can be produced from sources such as sun wind, and hydro that are naturally replenished and do not run out. Renewable energy can be used for electricity generation, space and water heating and cooling, and transportation.

10 Non-renewable energy, in contrast, comes from finite sources that could get used up, such as fossil based fuels like coal and oil.

15 The switchgear connected to the DCS system may be connected to a separate secondary consumer which is not associated with the PtX plant trip system. This means that when the PtX synthesis plant trips stop consuming electricity instantaneously, the secondary consumer is ready to consume the energy produced before the renewable energy source (e.g. wind turbines or photovoltaic panels) can be stopped.

20 Photovoltaic panels can shut down production in seconds whereas wind turbines require minutes, at least. In case of a trip, the PtX synthesis plant stops consuming electricity
25 instantaneously which means that a separate secondary consumer must be ready to consume the energy produced before the renewable energy can be stopped.

30 The **secondary consumer** may be a battery, electric heater or similar. The capacity of the battery corresponds to maximum 5, 10, or 30 min of the nominal electrical consumption of the PtX plant in case of wind turbines being a part of the

renewable power and maximum 1, 3, or 10 min in case of only PV. The secondary consumer may be controlled by the plant's DCS system, or a power plant controller connected to the renewable energy.

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Preferred embodiments

1. Power-to-X plant for producing chemicals and fuels, said plant comprising:
 - 10 a) A first feed stream and an optional second feed stream;
 - b) A connection to one or more sources of electrical power or electricity;
 - 15 c) An electrical section, arranged to receive at least a portion of said electrical power, said electrical section comprising a transformer, a switch gear and one or more power factor correction - and harmonic filter systems.
 - d) A feed processing and/or synthesis section; and
 - 20 e) A DCS computerized control system, arranged so that one or more of said feed stream(s) are converted into chemical- or fuel-rich stream(s), in said feed processing and/or synthesis section.
- 25 2. Plant according to embodiment 1, arranged so that a first feed stream is converted into chemical or fuel-rich stream(s), in the feed processing and/or synthesis section.

3. Plant according to embodiment 1, arranged so that a first feed stream and a second feed stream are converted into chemical or fuel-rich stream(s), in the feed processing and/or synthesis section.
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4. Plant according to any one of embodiments 1 to 3, wherein the switch gear has a power quality meter providing input to the one or more power factor correction - and harmonic filter systems.
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5. Plant according to any one of embodiments 1 to 4, wherein at least one of the sources of electrical power or electricity is the power grid.
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6. Plant according to any one of embodiments 1 to 5 wherein at least one of the sources of electrical power or electricity is a renewable power facility with at least one wind turbine and the electrical power used in said plant is at least in part wind
- 20
- power.
7. Plant according to any one of embodiments 1 to 6 wherein at least one of the sources of electrical power or electricity is a renewable power facility
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- with at least one photo-voltaic module and the electrical power is at least in part solar power.
8. Plant according to any of embodiments 6 or 7, wherein the single source of electrical power or electricity
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- is a renewable power facility, said plant drawing power completely from said facility and operating in an island mode.

9. Plant according to any one of embodiments 1-8, wherein said plant comprises a power dissipation unit and/or an energy storage system.

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10. Plant according to embodiment 9 wherein the power dissipation unit is connected to the switch gear of the plant, or to an additional transformer section in the renewable power facility.

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11. Plant according to any one of embodiments 9- 10 wherein the energy storage system is connected to the switch gear of the plant, or to an additional transformer section in the renewable power facility.

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12. Plant according to embodiment 11 wherein the capacity of the energy storage system corresponds to up to 30 minutes of power consumption of said plant, preferably up to 10 minutes.

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13. Plant according to any one of the previous embodiments 1-12, wherein the first feed comprises carbon dioxide, the electrical section additionally comprises an SCR power controller and the feed processing and/or synthesis section is an electrical reverse water gas shift section, said section being arranged to convert said first feed into a first carbon monoxide-rich stream.

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14. Plant according to any one of the previous embodiments 1-12, wherein the first feed comprises biogas and/or methane, the electrical section additionally

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comprises an SCR power controller and the feed processing and/or synthesis section is an electrical reforming section, said reforming section being arranged to convert the first feed into a first hydrogen-rich stream.

15. Plant according to any one of the previous embodiments 1-12, wherein the first feed comprises water, a second feed comprises nitrogen, carbon dioxide and/or carbon monoxide, the electrical section additionally comprises a rectifier and the feed processing and/or synthesis section is an electrolysis section comprising one or more electrolyzers, said electrolysis section being arranged to electrolyze the first feed into a first hydrogen-rich stream.

16. Plant according to embodiment 15 wherein the power factor (ratio of active power (MW) and apparent power (MVA)) of the electrolysis unit downstream the power factor correction - and harmonic filter system is between 0.7 and 1, preferably 0.8 to 0.95.

17. Plant according to any one of embodiments 15 or 16 wherein said first hydrogen rich stream is reacted to a gaseous stream of nitrogen.

18. Plant according to any one of embodiments 15 or 16 wherein said first hydrogen rich stream is reacted to a gaseous stream of carbon dioxide and/or carbon monoxide.

19. Method for operating a plant for production of chemicals and fuels, according to embodiments 1 to 18 wherein at least a first feed is converted into a chemical- or fuel-rich stream, in said feed processing and/or synthesis section using electricity generated at least partially from renewable power and wherein a DCS computerized system controls power factor correction - and harmonic filter system and/or equipment for active and/or passive power factor compensation.
20. Method according to embodiment 20 wherein in the event of the operation being interrupted or shut down, the plant stops consuming electricity instantaneously and a secondary consumer starts consuming the energy produced before the renewable energy source ceases operation.
21. Computer-implemented method for operating a plant according to embodiments 1 to 18, monitoring a method according to embodiment 19 and optimizing operation by comparing collected data with target data.

Claims

1. Power-to-X plant for producing chemicals and fuels,
said plant comprising:
- 5 f) A first feed stream and an optional second feed
stream;
- g) A connection to one or more sources of electrical
power;
- 10 h) An electrical section, arranged to receive at least a
portion of said electrical power, said electrical sec-
tion comprising a transformer, a switch gear and one
or more power factor correction - and harmonic filter
systems.
- i) A feed processing and/or synthesis section; and
- 15 j) A DCS computerized control system,
arranged so that one or more of said feed stream(s) are
converted into chemical- or fuel-rich stream(s), in said
feed processing and/or synthesis section.
- 20 2. Plant according to claim 1, arranged so that a first
feed stream is converted into chemical or fuel-rich
stream(s), in the feed processing and/or synthesis
section.
- 25 3. Plant according to claim 1, arranged so that a first
feed stream and a second feed stream are converted
into chemical or fuel-rich stream(s), in the feed pro-
cessing and/or synthesis section.
- 30 4. Plant according to any one of claims 1, 2 or 3,
wherein at least one of the sources of electrical
power is the power grid.

5. Plant according to any one of claims 1 to 4 wherein at least one of the sources of electrical power is a renewable power facility with at least one wind turbine and the electrical power used in said plant is at least in part wind power.
6. Plant according to claim 5, wherein the single source of electrical power is a renewable power facility, said plant drawing power completely from said facility and operating in an island mode.
7. Plant according to any one of claims 1-6, wherein said plant comprises a power dissipation unit and/or an energy storage system.
8. Plant according to any one of the previous claims 1-7, wherein the first feed comprises carbon dioxide, the electrical section additionally comprises an SCR power controller and the feed processing and/or synthesis section is an electrical reverse water gas shift section, said section being arranged to convert said first feed into a first carbon monoxide-rich stream.
9. Plant according to any one of the previous claims 1-7, wherein the first feed comprises biogas and/or methane, the electrical section additionally comprises an SCR power controller and the feed processing and/or synthesis section is an electrical reforming section, said reforming section being arranged to convert the first feed into a first hydrogen-rich stream.

10. Plant according to any one of the previous claims 1-7, wherein the first feed comprises water, a second feed comprises nitrogen, carbon dioxide and/or carbon monoxide, the electrical section additionally comprises a rectifier and the feed processing and/or synthesis section is an electrolysis section comprising one or more electrolyzers, said electrolysis section being arranged to electrolyze the first feed into a first hydrogen-rich stream.
11. Plant according to claim 10 wherein the power factor (ratio of active power (MW) and apparent power (MVA)) of the electrolysis unit downstream the power factor correction - and harmonic filter system is between 0.7 and 1, preferably 0.8 to 0.95.
12. Plant according to any one of claims 10 or 11 wherein said first hydrogen rich stream is reacted to a gaseous stream of nitrogen.
13. Plant according to any one of claims 10 or 11 wherein said first hydrogen rich stream is reacted to a gaseous stream of carbon dioxide and/or carbon monoxide.
14. Method for operating a plant for production of chemicals and fuels, according to claims 1 to 13 wherein at least a first feed is converted into a chemical- or fuel-rich stream, in said feed processing and/or synthesis section using electricity generated at least partially from renewable power and wherein a DCS computerized system controls power factor correction - and

harmonic filter system and/or equipment for active and/or passive power factor compensation.

5 15. Method according to claim 14 wherein in the event
of the operation being interrupted or shut down, the
plant stops consuming electricity instantaneously and
a secondary consumer starts consuming the energy pro-
duced before the renewable energy source ceases opera-
tion.

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16. Computer-implemented method for operating a plant
according to claims 1 to 13, monitoring a method ac-
cording to claims 14 and 15 and optimizing operation by
comparing collected data with target data.

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