MICROSCALE DISTRIBUTED ENERGY COGENERATION METHOD AND SYSTEM

CROSS-REFERENCE TO PRIORITY APPLICATION

[0001] This application is a Continuation-In-Part, which claims priority to United States Non-Provisional Utility Patent Application Serial No. 14/075,607 filed on November 08, 2013.

FIELD OF THE INVENTION

[0002] The present invention relates generally to energy generating systems. More specifically, the present invention relates to a microscale energy cogeneration system that can be used in a residential setting to supplement or substitute for a conventional utility electrical supply system and, further, can be used as part of an energy supply network. Even more particularly, the present invention is referred to as a distributed energy cogeneration method with which it is possible to generate electricity and heat water and air.

DESCRIPTION OF RELATED ART

[0003] Cogeneration is a highly efficient means of generating heat and electric power at the same time from the same energy source. Displacing fossil fuel combustion with heat that would normally be wasted in the process of power generation reaches efficiencies that can triple, or even quadruple, conventional power generation. In general, cogeneration systems are adapted to generate both electricity and heat from a single energy source. Such a cogeneration system can recover exhaust gas heat or waste heat of cooling water generated from an engine or turbine during an electricity generation operation, so that the cogeneration system can achieve an increase in energy efficiency of 70 to 80% over other systems.

US2007084205A1 discloses a power plant with a CHP system having a distillation apparatus to yield a high thermally efficient electrical power plant for reduced fuel usage and subsequent lower CO_2 emission specie.

US20070137215A1 discloses a cogeneration system which is capable of reliably switching a bypass damper even if a supply of electric power is shut off in an abnormal state etc. and which is unlikely to leak exhaust gas and is cost-effective even if it is increased in size.

US20040020206A1 discloses a power generation system including a prime mover subsystem and a Rankine-cycle heat energy utilization subsystem. The waste heat stream from the prime mover subsystem provides sufficient thermal content to power the heat energy utilization subsystem.

BRIEF SUMMARY OF THE INVENTION

[0013] This invention is directed to a microscale energy cogeneration system that can be used independently of a conventional utility electrical supply system or can be integrated into a conventional electrical supply system to supplement the system or contribute to the energy supply as part of a network.

[0014] In one form of the invention, a microscale energy cogeneration method includes steps of converting the energy produced by the combustion chamber into mechanical energy and converting the mechanical energy produced by the turbine into electrical energy.

[0015] An important aspect of the present invention is a microscale energy cogeneration system designed to produce between 1 to 5 kWh, more particularly 1 to 3 kWh, and more specifically 3 kWh using a portable and modular unit.

[0016] It is an object of the present invention to provide a microscale energy cogeneration system that is capable of heating tap water and heating air at the same time with high efficiency.

[0017] In another aspect of the invention, the generator may be an electric generator producing alternating electric current during the operation of the microscale energy cogeneration

system. The fuel for the microscale energy cogeneration system may be natural gas, diesel, gasoline, and liquefied petroleum gas (LPG), among others.

[0018] According to another aspect of the invention, the microscale energy cogeneration system further includes an exhaust passage downstream from the micro/nano-turbine delivering high temperature exhaust air from the micro/nano-turbine and a heat exchanger receiving the high temperature exhaust air for heat transfer. A water heating system for converting tap water into hot water is coupled to a heat exchange exhaust for releasing lower temperature exhaust air. The system is modular and portable and is able to generate electricity, hot water and hot air at the same time with efficiency higher than 85%.

[0019] In yet another aspect of the invention, the microscale energy cogeneration system may include another heat exchanger for coupling the present system to the heating system of a house.

[0020] In yet another aspect of the invention, the microscale energy cogeneration system may be scaled up to form a set of interconnected micro/nano-turbines that can be used to provide the same user with more energy or to balance out the energy demand of a group of houses in a residential area.

[0021] In another aspect of the invention, the microscale energy cogeneration system is portable or may be compatible for integration with a plurality of energy systems to provide the electrical distribution system with power and further may be configured for integration into a heating system, a cooling system and/or a water heating system.

[0022] Another aspect of the present invention provides a microscale energy cogeneration system that creates an energy source that produces efficient and clean electric energy, produces heat for heating, produces hot water, does not create pollution or vibrations, and does not need any maintenance over the years.

[0023] Also another aspect of this invention comprises a microscale energy cogeneration system that is smart, modular and portable, which can be managed remotely through Internet.

[0024] Also another aspect of this invention comprises a microscale energy cogeneration system that has a 3 kWh, 110/220 V AC, 12/24 VDC output, using different fuels including natural gas, diesel, gasoline and LPG.

[0025] Also another aspect of this invention consists of a microscale energy cogeneration system that generates electricity, 100 liters of hot water per hour, and hot air for heating a building.

[0026] In summary, the present invention is related to a microscale energy cogeneration method according to claim 11.

[0027] Also, the present invention is related to a microscale energy cogeneration system according to claim 1.

[0028] Also the present invention is related to a microscale distributed energy cogeneration method comprising the steps of:

(a) Connecting a fuel provider to a micro/nano-turbine,

(b) Connecting the micro/nano-turbine to a micro electric generator;

(c) Connecting the micro electric generator to the electrical grid of a facility.

(d) Connecting a heat exchanger apparatus to an exhaust passage downstream from the micro/nano-turbine, and

(e) Connecting the heating system of the house to the heat exchanger apparatus.

[0029] These and other aspects, features, and advantages of the present invention will become more readily apparent from the attached drawings and the detailed description of the preferred embodiments, which follow.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0030] The preferred embodiments of the invention will hereinafter be described in conjunction with the appended drawings provided to illustrate and not to limit the invention, where like designations denote like elements, and in which:

[0031] FIG. 1 presents front, side perspective view of an exemplary micro/nano-turbine driven energy generating system in accordance with the present invention;

[0032] FIG. 2 presents a side elevation view of the micro/nano-turbine driven energy generating system, originally introduced in FIG. 1;

[0033] FIG. 3 presents a rear elevation view of the micro/nano-turbine driven energy generating system, originally introduced in FIG. 1;

[0034] FIG. 4 presents a top plan view of the micro/nano-turbine driven energy generating system, originally introduced in FIG. 1;

[0035] FIG. 5 presents a front elevation view of the micro/nano-turbine driven energy generating system, originally introduced in FIG. 1;

[0036] FIG. 6 presents an isometric view of the micro/nano-turbine driven energy generating system in combination with a water processing system and an air heating system installed within a household application through which tap water and/or air is heated using exhaust gases of the micro/nano-turbine;

[0037] FIG. 7 presents an isometric view of the micro/nano-turbine driven energy generating system, originally introduced in FIG. 1, the illustration introducing functional components of the micro/nano-turbine;

[0038] FIG. 8 presents an isometric view of the water processing system, originally introduced in FIG. 6, the illustration introducing functional components of the water processing system;

[0039] FIG. 9 presents an isometric view of the air heating system, originally introduced in FIG. 6, the illustration introducing functional components of the air heating system;

[0040] FIG. 10 presents an operational schematic diagram, representative of the micro/nano-turbine energy generating system in combination with the water processing system and the air heating system in accordance with the arrangement of the energy generating system originally introduced in FIG. 6; and

[0041] FIG. 11 presents a schematic view of an energy generating system connected to the power grid with which the different energy generating systems may interact with the grid by taking energy if the particular application requires so, or may provide the grid with energy if the application is not requiring energy.

DETAILED DESCRIPTION OF THE INVENTION

[0042] The following detailed description is merely exemplary in nature and is not intended to limit the described embodiments or the application and uses of the described embodiments. As used herein, the word “exemplary” or “illustrative” means “serving as an example, instance, or illustration.” Any implementation described herein as “exemplary” or “illustrative” is not necessarily to be construed as preferred or advantageous over other implementations. All of the implementations described below are exemplary implementations provided to enable persons skilled in the art to make or use the embodiments of the disclosure and are not intended to limit the scope of the disclosure, which is defined by the claims.

[0043] Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field, background, brief summary or the following detailed description. It is also to be understood that the specific devices illustrated in the attached drawings, and described in the following specification, are simply exemplary embodiments of the inventive concepts defined in the appended claim. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

[0044] The present invention is referred to an exemplary microscale energy cogeneration system 100, as illustrated in FIGS. 1 through 5 and 7.

[0045] The microscale energy cogeneration system 100 is of a size and design enabling portability, being easily transportable between locations. Its general compact size, its light weight and can include a handle 170, which is especially useful for that purpose. The micro/nano-turbine 122 is preferably dimensioned such that it may be portable and has an output in a range to 1 to 5 kilowatts per hour and more preferably in a range of 2 to 4 kWh. In addition, the micro/nano-turbine 122 may be configured to have an efficiency of at least 70%, more preferably at least 80%, and more typically, in a range of 80% to 86%.

[0046] The present microscale energy cogeneration system 100 is compatible for integration with other energy systems and systems requiring energy, as explained below.

[0047] Gaseous heat energy is provided from the combustor chamber 150 to the micro/nano-turbine 122, which converts the provided gaseous heat energy into mechanical energy. The turbine 122 rotates an micro electric generator 124. The rotational motion of the micro electric generator 124 converts this mechanical energy into a generated electrical power output 132. The generated electrical power output 132 created can be supplied to an electrical grid of a home or house, an electrical grid of a group of houses, a building, a business, a group of business, a hybridizing car, a boat, an outdoor application, or any other electric power consuming entity.

[0048] The microscale energy cogeneration system 100 includes an energy generating system housing 102. The energy generating system housing 102 is preferably fabricated of a section of an extruded, hollow stock of material, such as aluminum. Various features are machined into the section of extruded stock. This can include a series of features to receive component mounting hardware 103, such as bolts, screws, rivets, brackets, and the like to assembly operational components to the energy generating system housing 102. Another feature can include a series of features for assembly of a series of energy generating system feet 109. Each energy generating system foot 109 is preferably fabricated of a pliant material, such as rubber, wherein the pliancy is provided to absorb vibrations generated during operation of the microscale energy cogeneration system 100. The series of energy generating system feet 109 can be individually assembled to the energy generating system housing 102 or assembled to a supporting bracket, wherein the supporting bracket is then assembled to the energy generating system housing 102. It is preferred that the series of energy generating system feet 109 be

assembled directly or indirectly to a lower or bottom panel of the energy generating system housing 102, a lower or bottom portion of the frontal end cap 104, and/or a lower or bottom portion of the rear end cap 106. Alternatively, the feet 109 can be integrally formed in the frontal end cap 104 and the rear end cap 106.

[0049] A frontal end cap 104, preferably comprising a ventilation grill 105, is secured to a front end of the energy generating system housing 102. A frontal end cap 104 is secured to a front end of the energy generating system housing 102. Each of the frontal end cap 104 and the rear end cap 106 are preferably slideably assembled to an exterior surface of the energy generating system housing 102. The frontal end cap 104 and the rear end cap 106 can then be secured to the energy generating system housing 102 by any suitable method, such as an adhesive, one or more mechanical fasteners, a mechanical interference, and the like. It is preferred that at least one of the frontal end cap 104 and the rear end cap 106 is removably assembled to the energy generating system housing 102. The removability of the at least one of the frontal end cap 104 and the rear end cap 106 from the energy generating system housing 102 enables access to the operational components for servicing and/or repairs.

[0050] A handle 170 or a handle assembly 170 is assembled to the energy generating system housing 102 (as shown), the frontal end cap 104 and/or the rear end cap 106. It is preferred that the handle 170 be removable from the energy generating system housing 102. This eases access to the heated air exhaust port 107.

[0051] The energy generating system housing 102 introduces a heated air exhaust port 107. The heated air exhaust port 107 is preferably formed through an upper panel of the energy generating system housing 102, as the heated air exhaust port 107 is designed to transfer heat, and the optimal location would be along an upper panel of the energy generating system housing 102, as heat naturally rises. An exhaust transfer element 108 can be assembled to the upper panel of the energy generating system housing 102 providing a conduit for the heated gases passing through the exhaust transfer element 108 to another unit. The exhaust transfer element 108 can be removable to accommodate the handle 170.

[0052] Operational components of the microscale energy cogeneration system 100 are illustrated in an isometric schematic illustration presented in FIG. 7 and a schematic diagram illustrated in FIG. 10. Operational components include a compressor 120, a micro/nano-turbine 122, an micro electric generator 124, a heat exchanger 140, and a combustor chamber 150. An inverter central processing unit (CPU) 130 and a Wired or wireless communication circuit 131 can be included to providing electrical management of generated power and, separately of interest, a communication link to provide information to a support system, service personal, a third party, or any other desired recipient.

[0053] The micro/nano-turbine 122 drives the system. The micro/nano-turbine 122 is rotationally coupled to a compressor 120 by a turbine shaft 126. The micro electric generator 124 is rotationally coupled to either the compressor 120 and/or the micro/nano-turbine 122 by a generator shaft 127. The turbine shaft 126 and the generator shaft 127 can be a continuous shaft, separate shafts, separate shaft segments coupled by a universal joint, and the like. Gears, transmission or any other rotational conversion element (not shown) can be integrated between any two or each of the three rotating elements 120, 122, 124 to modify a rotational speed, a torque, or to suit any other design element. Support of each of these elements would be provided in accordance with any known suitable operational component support design, including brackets, bearings, bushings, mechanical fasteners, adjustable features, and the like. Specific details of compressor 120, the micro/nano-turbine 122, and the micro electric generator 124 are not provided as they do not form part of the present invention. Any suitable compressor 120, any suitable micro/nano-turbine 122, and any suitable micro electric generator 124 that are available in the market can be used in the microscale energy cogeneration system 100.

[0054] A fuel supply 129 is provided to a combustor chamber 150, where the fuel is used to generate a rotational force causing a rotational motion of the micro/nano-turbine 122. The fuel 129 can be natural gas, diesel, gasoline, liquefied petroleum gas (LPG), and the like. The rotational motion of the micro/nano-turbine 122 drives a rotation of the compressor 120. The rotational motion of the micro/nano-turbine 122 also drives a rotation of the micro electric generator 124. Compressed air provided by the compressor 120 is then exposed to a heat exchanger (cold side) 142 of a heat exchanger 140, cooling the compressed air. The chilled

compressed air is transferred to the combustor chamber 150. The use of chilled compressed air in combination with the fuel 129 improves the efficiency of the combustion process used to drive the micro/nano-turbine 122. The heated air discharged from the turbine is directed towards a heat exchanger (hot side) 144 of the heat exchanger 140.

[0055] The arrangement between the compressor 120, the micro/nano-turbine 122 and the micro electric generator 124 can be modified to suit the engineer and/or designer of the system.

[0056] The micro electric generator 124 as usual may include a rotating rotor and a stator. The rotor may be a permanent magnet positioned rotatably within the stator and rotates relative to the stator during the operation of micro/nano-turbine 122. Mechanical energy can be transferred to the generator shaft 127 from micro/nano-turbine 122 to the rotor, so that the generator shaft 127, the micro/nano-turbine 122 and the rotor of the micro electric generator 124 rotate in unison at speeds, for example, of up to 100,000 RPM's or more.

[0057] The rotational motion of the micro electric generator 124 generates an electric power output. The electric power output can be forwarded directly as a generated electrical power output 132 to a power line or passed through a generated electrical power output 132 before being output as the generated electrical power output 132. The inverted power can be used to operate a wired or wireless communication circuit 131. The wired or wireless communication circuit 131 provides a communication link, which enables conveyance of data respective to the microscale energy cogeneration system 100 to a third party, a monitoring computer, a service person, and the like. The data can include operating data, such as electrical power output 132, consumption of fuel 129, rotational speed of the micro/nano-turbine 122, the compressor 120, and/or the micro electric generator 124, operating temperature, any vibrations, lubrication status, and the like. The wired communication circuit 131 can operated in accordance with any suitable wired communication protocol, including Universal Serial Bus (USB), serial communication, parallel communication, Ethernet, and the like. The wireless communication circuit 131 can operated in accordance with any suitable wireless communication protocol, including Wi-Fi, Bluetooth, Zigbee, any radio frequency (RF), Near Field Communications (NFC), radio frequency identification (RFID), and the like.

[0058] The generated electrical power output 132 can be used immediately, stored for later use, or delivered to a network for distribution within the network, such as an electric company grid. Storage of the generated electrical power output 132 can be provided by batteries or any other suitable storage medium.

[0059] Air is provided into the microscale energy cogeneration system 100 by an input air to nano-turbine 160. The input air to nano-turbine 160 enters through the ventilation grill 105 of the frontal end cap 104. The hot output gases from the micro/nano-turbine 122 are fed into the heat exchanger (hot side) 144 of the heat exchanger 140 and subsequently forwarded to the heated air exhaust port 107 to exhaust the hot exhaust air (combustor) 162. The hot output gases from the micro/nano-turbine 122 are directed towards the heat exchanger (hot side) 144 of the heat exchanger 140 and are used to draw heat from the heat exchanger (cold side) 142 of the heat exchanger 140.

[0060] An element of the system is a water processing system 200. Operational components of the water processing system 200 are illustrated in an isometric schematic illustration presented in FIG. 8 and a schematic diagram illustrated in FIG. 10. The water processing system 200 and the microscale energy cogeneration system 100 include a number of like elements. Like elements are numbered in a similar manner, where like elements of the water processing system 200 and the microscale energy cogeneration system 100 are numbered the same, except the reference characters of the elements of the water processing system 200 are preceded by the numeral “2”. The housing of the water processing system 200 is similar to the housing of the microscale energy cogeneration system 100. The hot exhaust air (combustor) 162 is transferred from the microscale energy cogeneration system 100 to the water processing system 200 by the exhaust transfer element 108. The hot exhaust air (combustor) 162 is directed towards a heat exchanger (hot side) 242 of a heat exchanger 240 located within an interior of the energy generating system housing 202. Water 271 is supplied to the heat exchanger 240 by a hot water heater or boiler 270. The hot water heater or boiler 270 transitions into a condenser 272. The condenser 272 passes through a heat exchanger (cold side) 244 of the heat exchanger 240. As the water 271 passes through the hot water heater or boiler 270, and continues into the condenser 272, the output from the water processing system 200 is potable water 273. Since only a portion of the heat from the

hot exhaust air (combustor) 162 is absorbed by the heat exchanger 240, the residual heated gases are passed along as a hot exhaust air 262 through an exhaust transfer element 208 of the water processing system 200.

[0061] The water processing system 200 can be modified to provide heated air to a water system. For example, the water system may provide hot air to an internal or external hot water heater or water boiler 270. The water can then be forwarded to a separate condenser to produce potable water 273. The water heater would be connected to an exhaust heat conduit from heat exchanger, similar to the heating duct 376 of the heating system 370 (Shown in FIG. 6).

[0062] The microscale energy cogeneration system 100 may be additionally used to support an air heating system. Another optional element of the system is an air heating system 300. Operational components of the air heating system 300 being illustrated in an isometric schematic illustration presented in FIG. 9 and a schematic diagram illustrated in FIG. 10. The air heating system 300 and the microscale energy cogeneration system 100 include a number of like elements. Like elements are numbered in a similar manner, where like elements of the air heating system 300 and the microscale energy cogeneration system 100 are numbered the same, except the reference characters of the elements of the air heating system 300 are preceded by the numeral “3”. The housing of the air heating system 300 is similar to the housing of the air heating system 300. The hot exhaust air (combustor) 162 or the hot exhaust air 262 is transferred from the microscale energy cogeneration system 100 or the water processing system 200 to the air heating system 300 by the respective exhaust transfer element 108 or the exhaust transfer element 208. The hot exhaust air (combustor) 162, 262 is directed towards a heat exchanger (hot side) 342 of a heat exchanger 340 located within an interior of the energy generating system housing 302. Input air 360 is directed towards the heat exchanger 340. As the input air to the heat exchanger 360 passes across the heat exchanger 340, the temperature of the air increases. The air is discharged as an output air (hot side) 364. The input air to the heat exchanger 360, converting into the output air (hot side) 364 can be contained within a ducting (not shown) that passes through the heat exchanger 340. Conversely, the hot exhaust air (combustor) 162, 262 passes through and/or around the heat exchanger, with the residually heated air being discharged as a hot exhaust air 362 through the exhaust transfer element 208.

[0063] A heating system 370 may use exhaust heat to provide exhaust heat and/or output heat 378 for a location or building. The heating system 370 can be connected to a discharge port of the microscale energy cogeneration system 100 to receive the output air (hot side) 164 (configuration understood by description, but not shown) or a discharge port of the air heating system 300 to receive the output air (hot side) 364 by a heating duct 376, as illustrated in FIG. 6. The heating system 370 would receive high temperature exhaust air 162, 262 from the exhaust passage downstream from the micro/nano-turbine 122 or the water processing system 200 for heat transfer. In this manner, the microscale energy cogeneration system may assist with heating requirements for a location or building.

[0064] As shown in the exemplary embodiment, the output air (hot side) 364 flows towards a heat exchanger 372. Air is drawn into the heating system 370 by a fan setup 374 and passes through the heat exchanger 372. As the air passes through the heat exchanger 372, the air is warmed. The air can also combine with the output air (hot side) 364 to further increase the overall temperature of the air being discharged as an exhaust and/or output heat 378.

[0065] FIG. 11 is a schematic diagram of the microscale energy cogeneration system 100 connected to the electrical power grid 600.

[0066] As shown in FIG. 11, the present microscale energy cogeneration system 100 may be attached by a power line 610 to a switchboard controller and meter 620. The switchboard controller and meter assists in the distribution of electric power to a building or location. Generally, the instant load from a microscale energy cogeneration system 100 follows the controller of a standard home electrical box. The present nano-turbine microscale energy cogeneration system 100 is easily compatible with all standard configurations for electrical box controllers.

[0067] The system may also be controlled using a Transmission Control Protocol/Internet Protocol (TCP/IP) network 400 through a control center 500. Accordingly, the microscale energy cogeneration system 100 may take energy from the grid 600 if necessary, or provide energy to the grid 600 if the consumption of the local system is lower than the energy produced by it. The main feature of the present system comprises its ability to scale up by connecting several units

for the same user, or several units may be interconnected as a grid for balancing out the energy demand of a specific set of users.

[0068] As generally noted above, the nano-turbine microscale energy cogeneration system 100 may be integrated into a house, to supplement or substitute an existing energy system. It should be noted that the energy system can be integrated into all types and sizes of buildings and structures as well as locations requiring energy. As would be understood, the system 100 may either include fewer components and systems or may include additional components or systems.

[0069] The energy system 100 can integrate any one or more of the heating, cooling, water heating and electrical systems into a mobile and portable unit. As would be understood from the above description, the energy system 100 is powered by different types of fuel. Using nano/microscale energy cogeneration system 100, energy system can fulfill the electrical, heating, cooling and/or hot water, and/or potable water needs for a location, building or structure. It may also be used for hybridizing cars, boating power, outdoor applications, and home use applications.

[0070] The home energy system 100 can provide at least part of, if not all the electrical needs of a single location, structure or building, such as house. The energy system 100 is integrated with the grid 600 at a junction box or switchboard controller and meter to distribute electrical load in a location. Either the energy system or grid 600 can be the primary system with the other system serving as an auxiliary or support system. When the energy system produces more electricity than required, the electrical load can be stored in a storage device, such as some type of battery, or returned back to the power grid 600. In systems that are not connected to the electric company, like a system setup located in a remote location, surplus electrical load can be delivered to a specific location over a local grid 600. Alternatively, if surplus electrical load is returned to the grid 600, a house with surplus electricity can designate a specific house or location to receive the electrical load through the electric company's grid. This sharing of electrical loads allows two locations to exchange electrical loads at a cost lower than purchasing from the electric company.

[0071] The present system has several applications, including but not limited to:

(a) Hybridization of electric vehicles

(b) Domestic production of power and heat

(c) Smart power grids

(d) Boating power and heat supply

(e) Outdoor applications

[0072] It will be understood that the embodiments shown in the drawings and described above are merely for illustrative purposes, and are not intended to limit the scope of the invention, which is defined by the claims.

Reference Element List

Ref. No.	Description
100	microscale energy cogeneration system
102	energy generating system housing
103	component mounting hardware
104	frontal end cap
105	ventilation grill
106	rear end cap
107	heated air exhaust port
108	exhaust transfer element
109	energy generating system foot
120	compressor
122	micro/nano-turbine
124	micro electric generator
126	turbine shaft
127	generator shaft
129	fuel supply

130 inverter central processing unit (CPU)
131 wired or wireless communication circuit
132 generated electrical power output
140 heat exchanger
142 heat exchanger (cold side)
144 heat exchanger (hot side)
150 combustor chamber
160 input air to nano-turbine
162 hot exhaust air (combustor)
164 output air (hot side)
170 handle
200 water processing system
202 energy generating system housing
203 component mounting hardware
204 frontal end cap
205 ventilation grill
206 rear end cap
207 heated air exhaust port
208 exhaust transfer element
209 energy generating system foot
240 heat exchanger
242 heat exchanger (hot side)
244 heat exchanger (cold side)
260 input air to nano-turbine
262 hot exhaust air
264 output air (hot side)
270 hot water heater or boiler
271 water
272 condenser
273 potable water

300 air heating system
302 energy generating system housing
303 component mounting hardware
304 frontal end cap
305 ventilation grill
306 rear end cap
307 heated air exhaust port
308 exhaust transfer element
309 energy generating system foot
340 heat exchanger
342 heat exchanger (hot side)
344 heat exchanger (cold side)
360 input air to the heat exchanger
362 hot exhaust air
364 output air (hot side)
370 heating system
372 heat exchanger
374 fan setup
376 heating duct
378 exhaust and/or output heat
400 Transmission Control Protocol/Internet Protocol (TCP/IP) network
500 control center
600 power grid
610 line
620 switchboard controller and meter