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(54) System for assigning an energy consumer to an energy provider

(57) The invention relates to a system for assigning at least one energy consumer to at least one energy provider comprising: a consumer preferences retrieval device configured to retrieve data on at least one of the following: at least one consumption data, at least one desired source of energy, a location of the at least one energy consumer; a data retrieval device, wherein the data retrieval device is configured to gather continuously or in time intervals data from a plurality of energy providers comprising at least one energy production provider and/or at least one energy storage provider and from at least one energy grid provider, and preferably from at least one regulator and/or at least one meta-information source; a prediction engine device, wherein the prediction engine device is configured to predict a demand of energy based on the data gathered by the consumer preferences retrieval device and a production of energy based on the data gathered by the data retrieval device; and a ranking engine device, wherein the ranking engine device is configured to rank pairs of energy consumers and candidate energy providers or preferably to rank triples of energy consumers, candidate energy providers and candidate energy grid provider under consideration of the data gathered by the consumer preferences retrieval device, the data gathered by the data retrieval device and the prediction performed by the prediction engine device.

The invention also relates to a system for joint optimization of energy availability and network capacity in an energy grid using at least one of the following: load balancing, transport loss minimization, stable operation of the power supply, in particular without oscillations, and robust power supply, using a system for assigning at least one energy consumer to at least one energy provider.

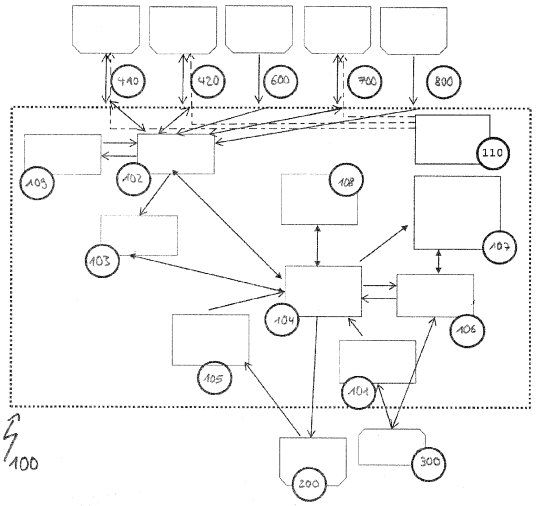


Fig. 3

EP 2 775 446 A1

Description

[0001] This invention relates to a system for assigning at least one energy consumer to at least one energy provider. Further, a system for joint optimization of energy availability and network capacity in an energy grid using load balancing and/or transport loss minimization is provided.

[0002] In recent years, energy grid has been materialized in many countries as an efficient way to distribute energy and interconnect the energy production points in the public distribution network of energy. All types of energy sources are nowadays interconnected with the energy grid, such as traditional power plants (e.g. coal and nuclear) as well as renewable energy (e.g. solar, wind, etc). In many energy grids, accumulators of energy have been introduced in order to store the overproduction of energy and deal with the spikes in energy consumption demands.

[0003] An energy grid can potentially assist in the optimal scheduling and assignment of energy production and the adaption to the energy consumer needs.

[0004] Today, most of the energy is typically distributed along a tree-like structure, i.e., the energy between producers and consumers flows along unique paths.

[0005] However, energy flow topologies become more complex and use multi-path propagation. This multi-path propagation, i.e. not only propagation along a single path, increases the transport capacity of the network and allows for new ways to route energy flows by setting corresponding energy potentials, resistances, shifting phases. Thus, energy consumers can be assigned "close-by" producers along appropriate paths, depending on current supply and transport network state.

[0006] The report "Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0" (http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf) released by the National Institutes of Standards and Technology lays out a plan for transforming the nation's aging electric power system into an interoperable Smart Grid-a network that will integrate information and communication technologies with the power-delivery infrastructure, enabling two-way flows of energy and communications.

[0007] In "The path of the smart grid", IEEE Power & Energy Magazine, Volume 8, issue 1, p. 18-28, January/February 2010, Hassan Farhangi reports on the rising cost of energy, the mass electrification of everyday life, and climate change as the major drivers that will determine the speed at which such transformations will occur. Farhangi discusses flexibilities of future electricity grids and points out potential network capacity problems.

[0008] US 6,745,105 B1 relates to a distribution network including an energy source; a hydrogen production facility connected to the energy source; a recipient for hydrogen from the hydrogen production facility; and a controller.

[0009] In "Column Generation for Transmission Switching of Electricity Networks with Unit Commitment", Proceedings of the International MultiConference of Engineers and Computer Scientists 2011 Vol II, IMECS 2011, March 16-18, Hong Kong (http://www.iaeng.org/publication/IMECS2011/IMECS2011_pp1440-1443.pdf), Villumsen et al. refer to the problem of finding the minimum cost dispatch and commitment of power generation units in a transmission network with active switching.

[0010] In "RPL: The IP Routing protocol designed for low power and lossy networks", Internet Protocol for Smart Objects (IPSO) Alliance (http://www.cs.berkeley.edu/~jwhui/61owpan/IPSO-WP-7.pdf), Vasseur et al. describe an IP routing protocol using dynamic metrics changing over a period of time being configured to adapt changing of node and link metrics.

[0011] In "Cloud-based demand response for smart grid: Architecture and distributed algorithms", Smart Grid Communications (SmartGridComm), 2011 IEEE International Conference on Communication, Networking & Broadcasting , Components, Circuits, Devices & Systems, Computing & Processing (Hardware/Software), Power, Energy, & Industry Applications, Hongseok Kim et al., propose cloud-based demand response (CDR), a novel demand response architecture for fast response times in large scale deployments. The proposed architecture by Hongseok Kim et al., is in contrast to master/slave based demand response where the participants directly interact with the utility using host address-centric communication.

[0012] The object of the invention is to provide an improved system for assigning at least one energy consumer to at least one energy provider and to provide an improved system for joint optimization of energy availability and network capacity.

[0013] The object of the invention is solved with the features of the independent claims. Dependent claims refer to preferred embodiments.

[0014] The invention provides a system for assigning at least one energy consumer to at least one energy provider comprising a consumer preferences retrieval device configured to retrieve data on at least one of the following: at least one consumption data, at least one desired source of energy, a location of the at least one energy consumer.

[0015] The at least one consumption data may comprise at least one of the following: a desired amount of energy, a desired time of delivery of the desired amount energy which should be delivered, a desired period of time of delivery of the desired amount of energy, a desired price for the desired amount of energy, a desired price range for the desired amount of energy.

[0016] The system for assigning at least one energy consumer to at least one energy provider further comprises a data retrieval device, wherein the data retrieval device is configured to gather continuously or in time intervals data from a plurality of energy providers compris-

ing at least one energy production provider and/or at least one energy storage provider and from at least one energy grid provider, and preferably from at least one regulator and/or at least one meta-infonnation source.

[0017] An energy grid is an interconnected network configured to deliver and/or route energy from energy providers to energy consumers via one or more paths, preferably a plurality of paths (multi-path), more preferably a plurality of redundant paths. An energy grid can be preferably configured to deliver and/or route electric power from energy providers to energy consumers, i.e. a so-called electric grid, e.g. using wires. An energy grid may also be configured to deliver and/or route gas from energy providers to energy consumers, i.e. a so-called gas grid, e.g. using pipelines.

[0018] An energy consumer can be a single consumer, e.g. a single household, or a larger entity e.g. a company, production site having several facilities. An energy consumer can also be an administration unit, e.g. a city or municipality. A consumer can have one or more appliances and/or loads and/or entities.

[0019] In case the energy grid being configured to deliver and/or route electric power, an energy production provider can be for example a provider having one or more power plants, e.g. nuclear power plants or power plants using fossil fuels, one or more solar collectors or any other kind of renewable energy collectors and/or producing facilities such as wind power stations or the like.

[0020] In case the energy grid being configured to deliver and/or route gas, an energy production provider can be for example a provider having one or more oil refineries or one or more gas processing plants or one or more gas fields, e.g. natural offshore gas fields, or one or more sites/facilities for fracturing, in particular hydraulic fracturing (so-called "fracking"), or one or more town gas production sites/facilities or one or more sites/facilities for producing gas with anaerobic digestion or any other kind of renewable gas.

[0021] The data gathered by the data retrieval device from the energy production providers can be related to the operational status, the amount of energy to be produced within a certain period of time and the interconnection between the energy production provider and the energy storage provider, a current overall energy consumption, an expected energy consumption, the location of the energy production provider in the energy grid and the cost of the energy per unit.

[0022] In case the energy grid being configured to deliver and/or route electric power, an energy storage provider can be for example a telecommunications provider having large battery-stocks as emergency supply for maintaining their telecommunications network. An energy storage provider can also be a hydrogen-storage or the like, e.g. as an intermediate energy storage in a solar collecting farm.

[0023] In case the energy grid being configured to deliver and/or route gas, an energy storage provider can be for example a provider having one or more gas reservoirs, e.g. aquifer reservoirs, gas reservoirs using salt formations, gas holders/gasometers. An energy storage provider can also be a liquefied natural gas producer providing gas, in particular during peak-times when the demand is high or can also be the energy grid provider itself storing gas temporarily using line packing, i.e. increasing the pressure in the pipeline in order to pack more gas into the pipeline.

[0024] The data gathered by the data retrieval device from the energy storage provider can be related to the amount of energy stored in the energy storage, the amount of stored energy to be dispensed within a certain period of time, the interconnection between the energy production provider and the energy storage provider, a current overall energy consumption, an expected energy consumption, the location of the energy storage provider in the energy grid and the cost of the energy per unit.

[0025] An energy grid provider can hold and/or maintain at least one energy grid which is connecting the participants of the energy grid/network. An energy grid can comprise one or more paths (multi-path). The energy grid can particularly comprise on ore more paths which are redundant, i.e. one or more paths of the energy grid may connect the same entities.

[0026] The energy grid providers may not be the same as the energy production providers and/or energy storage providers. However, the invention is not limited to this case, but also applies for a joint energy production and/or storage and/or energy grid provider. The data gathered by the data retrieval device from the energy grid provider can be related to current energy grid status, possible congestion of the energy grid, the level of possible congestion, current capacity of the energy grid, overall capacity of the energy grid, and possible malfunctions of the energy grid.

[0027] The energy regulator can be a public authority which mandates for example use of one sort of energy, e.g. renewable energy, through taxes and tariffs to the disadvantage of another sort of energy, e.g. fossil energy and/or nuclear energy. The data gathered by the data retrieval device from the energy regulator can be related to taxes and tariffs of different sorts of energy and quota of different sorts of energy.

[0028] Meta-information sources can be weather forecasters, news feeds, news networks or goods information portals and first source exchange information portals, e.g. to check the price of fossil fuels, e.g. crude oil. Therefore the data provided by a meta-information source can be weather information data, traffic information data, news information data or data relating to price of fuels.

[0029] The system for assigning at least one energy consumer to at least one energy provider further comprises a prediction engine device, wherein the prediction engine device is configured to predict a demand of energy based on the data gathered by the consumer preferences retrieval device and a production of energy based on the data gathered by the data retrieval device. The prediction engine can be further configured to run continuously and

to make prediction of the load in the energy grid.

[0030] The system for assigning at least one energy consumer to at least one energy provider further comprises a ranking engine device, wherein the ranking engine device is configured to rank pairs of energy consumers and candidate energy providers under consideration of the data gathered by the consumer preferences retrieval device, the data gathered by the data retrieval device and the prediction performed by the prediction engine device. Preferably, the ranking engine device is configured to rank triples of energy consumers, candidate energy providers and candidate energy grid providers under consideration of the data gathered by the consumer preferences retrieval device, the data gathered by the data retrieval device and the prediction performed by the prediction engine device.

[0031] According to an embodiment of the invention, the ranking engine device is further configured to send the ranking information to the candidate energy providers and/or to the candidate energy grid providers. The ranking information may comprise an ordered list wherein the list comprises pairs of energy consumer - energy provider. Preferably, the ranking information may comprise an ordered list wherein the list comprises matched triples of energy consumer - candidate energy provider - candidate energy grid provider. The list may comprise ordered data on which entity of the energy consumer, which one or more paths of an energy grid of the energy grid provider as well as which entity of the energy provider match together. The candidate energy provider may be an energy provider which is considered by the ranking engine device to be the most suitable to deliver a certain amount of energy to the energy consumer under consideration of the consumer preferences gathered by the consumer preferences retrieval device. The candidate energy grid provider may be a energy grid provider which is considered being the most suitable by the ranking engine device to have a respective energy grid capacity, the energy grid not being congested or overloaded, currently not having any malfunction in the energy grid.

[0032] The ranking engine device is further configured to receive the response from the candidate energy providers and/or the candidate energy grid providers and further configured to send the confirmation from candidate energy providers and/or the candidate energy grid providers to the at least one energy consumer. In case that the response from the candidate energy providers and/or the candidate energy grid providers is negative, the ranking engine device is further configured to send the ranking information to the candidate energy providers and/or to the candidate energy grid providers which are second most suitable and to receive respective response. In case of a further negative response the ranking engine device is configured to subsequently send ranking information to the candidate energy providers and/or the candidate energy grid providers in the ranking information until positive response (confirmation) is sent back. The ranking engine device is further configured to assign the at least one energy consumer to at least one selected energy provider and/or at least one selected energy grid provider according to an energy consumers selection of the candidate energy providers and/or the candidate energy grid providers based on the ranking information.

[0033] According to another embodiment of the invention, the system for assigning at least one energy consumer to at least one energy provider further comprises a user preferences retrieval device configured to retrieve data on at least one ranking preference and/or ranking algorithm and configured to submit the data to the ranking engine device.

[0034] A ranking preference and/or ranking algorithm may comprise a pre-specified selection of specific energy providers and/or energy grid providers. This pre-specified selection may be dependent on the time of the day, e.g. certain providers are preferred in the morning or at peak hours, or other time conditions. Another ranking preference may depend on the location of the energy consumer, i.e. that the location of the energy consumer falls within a preferred allocated area of a certain energy provider and/or energy grid provider. Another ranking preference may comprise at least one of the following: a desired amount of energy which has to be delivered, a desired time of delivery of the desired amount energy, a desired period of time of delivery of the desired amount of energy, a desired price for the desired amount of energy, a desired price range for the desired amount of energy.

[0035] The ranking engine device is further configured to perform the assignment under consideration of the data submitted by the user preferences retrieval device to the ranking engine device.

[0036] According to another embodiment of the invention, the system for assigning at least one energy consumer to at least one energy provider further comprises a consumer request processing device and a consumer profile database, wherein the consumer request processing device is configured to retrieve at least one energy consumer request. The consumer request may comprise a certain amount of energy within a certain amount of time. The request may further comprise information on whether a certain amount of energy within a certain amount of time should be delivered once or on a regular, e.g. monthly-contract, basis.

[0037] The consumer profile database is further configured to record and store a profile of each of all energy consumers comprising the history of the activity and assignments of each of all energy consumers. The activity may comprise information on how much energy within a certain period of time an energy consumer has consumed and/or purchased or is currently consuming and/or purchasing, which mode of payment the energy consumer had chosen (e.g. on a prepaid or contract basis; payment per purchase or fixed-term contract for a period of time), whether the energy consumer has any open accounts or the like. The assignments which are comprised in the

stored profiles may comprise all previous assignments of the energy consumer to the energy grid provider and/or energy consumer.

[0038] According to another embodiment of the invention, the consumer request processing device is further configured to submit the at least one consumer request to the consumer profile database. The consumer profile database is further configured to subsequently submit data on at least one of the following: the profile of the at least one energy consumer, at least one profile of at least one stored similar energy consumer and the assignments of all stored energy consumers in the energy grid to the consumer request processing device. In addition, the consumer request processing device is further configured to submit the data received by the consumer profile database to the ranking engine device. The ranking engine device is further configured to perform the assignment under consideration of the data submitted by the consumer request processing device to the ranking engine device.

[0039] According to another embodiment of the invention, the system for assigning at least one energy consumer to at least one energy provider further comprises a price estimator device configured to estimate the cost of at least one energy consumption of the at least one energy consumer retrieved by the consumer preferences retrieval device and/or further comprising a data storage device configured to store the data retrieved by the data retrieval device. The price estimator may have access to a price database which may incorporate the current and/or planned prices and cost for energy consumption and/or energy grid usage related to a plurality of energy providers and/or energy grid providers. The ranking engine device is further configured to perform the assignment under consideration of the data submitted by the price estimator device to the ranking engine device.

[0040] According to another embodiment of the invention, the prediction engine device is further configured to predict the demand of energy and the production of energy based on the data submitted by the user preferences retrieval device to the prediction engine device.

[0041] According to another embodiment of the invention, the prediction engine device is further configured to predict the demand of energy and the production of energy based on the data submitted by the consumer request processing device to the prediction engine device.

[0042] According to another embodiment of the invention, the prediction engine device is further configured to predict the demand of energy and the production of energy based on the data submitted by the price estimator device to the prediction engine.

[0043] According to another embodiment of the invention, the prediction engine device is further configured to predict possible congestions of the energy grid, the level of possible congestions, current capacity of the energy grid, overall capacity of the energy grid, and possible malfunctions of the energy grid based on the data submitted by at least one of the following: the consumer preferences retrieval device, the data retrieval device, the user preferences retrieval device, the consumer request processing device as well as price estimator device.

[0044] According to another embodiment of the invention, the system for assigning at least one energy consumer to at least one energy provider further comprises an automated matching device configured to automatically select at least one energy provider of the candidate energy providers and/or select at least one energy grid provider of the candidate energy grid providers based on the ranking information.

[0045] According to another embodiment of the invention, the system for assigning at least one energy consumer to at least one energy provider further comprises a routing device configured to control routing of energy from the at least one energy production provider or the at least one energy storage provider to the at least one energy consumer, wherein the routing device is preferably configured to control routing of energy from the at least one energy production provider or the at least one energy storage provider to the at least one energy consumer by at least one of the following: dynamic switching, adjusting potentials, adjusting resistances, shifting phases, routing the energy through a plurality of energy paths of the energy grid in parallel. Dynamic switching in this context refers to switching the current between different paths. For example, dynamic switching techniques known from computer switches can be used for switching between different energy paths.

[0046] According to another embodiment of the invention, the routing device is configured to control routing of energy from the at least one energy production provider or the at least one energy storage provider to the at least one energy consumer under consideration of the data gathered from the at least one energy grid provider.

[0047] According to another embodiment of the invention, the routing device is configured to control routing of energy from at least one energy plant and/or at least one energy storage to at least one appliance of the at least one consumer via at least one path of the at least one energy grid.

[0048] The invention also relates to a system for joint optimization of energy availability and network capacity in an energy grid using one or several of the following: load balancing and/or transport loss minimization, stable operation of the power supply, in particular without oscillations, and/or robust power supply using a system for assigning at least one energy consumer to at least one energy provider and/or using a system for predicting a demand and production of energy preferably according to any of the aforementioned systems.

[0049] The present invention relates to a universal system that assigns energy consumption of a user to an energy supply in a user-specified manner, i.e. jointly optimizing resource availability, consumer preferences as well as energy grid capacity constraints, taking into account multifaceted needs of the energy consumption users in real time, the production of energy from all the

energy producers, the capacity and state of the energy grid electricity transport network, the location of the energy production and the location of the user in the energy grid, as well as meta-information such as the weather and the price of energy per unit. Moreover, existing approaches focus on when to schedule production and consumption, not being aware of the transport network between producers and consumers, and when these approaches assign consumers to producers, they do not jointly optimize energy availability and transport network by taking into account various external information.

[0050] The invention achieves network-aware assignment of energy consumers to energy providers comprising energy production providers and energy storage providers using the energy grid. The assignment is performed in the sense that the decision of assigning consumption to a particular energy producer or source of energy as well as energy routing is based on information that is collected from the user activity, the load in the energy grid, supply/demand statistical data (e.g., weather), the type of the source of energy, the distance of the user from the energy production point or the energy accumulator. The system achieves optimal assignment (with respect to criteria indicated by system users, e.g. a joint optimization of energy availability and network capacity) of consumers based on the available energy providers and their state. For example, the system may jointly balance the network and supply load in the energy grid, thus offering robustness and efficient operation.

[0051] The invention provides an information system that is also aware of the transport network between producers and consumers, and when assigning consumers to producers, jointly optimizes energy availability and transport network by taking into account various external information.

BRIEF DESCRIPTION OF THE DRAWINGS

[0052]

Fig. 1 shows a schematic diagram of a system for assigning at least one energy consumer to at least one energy provider according to an embodiment of the invention;

Fig. 2 shows a schematic diagram of the input data of system for assigning at least one energy consumer to at least one energy provider according to an embodiment of the invention; and

Fig. 3 shows a schematic diagram of a system for assigning at least one energy consumer to at least one energy provider according to another embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0053] Figure 1 shows a schematic diagram of a system for assigning at least one energy consumer to at least one energy provider according to an embodiment of the invention. This and the following embodiments of the invention relate to the case that the energy grid is configured to deliver and/or route electric power. However, the invention is not limited to this particular case but is analogous applicable and/or adaptable to other types of energy grids delivering and/or routing other types of energy, e.g. gas. When consumers (300) provide information about their energy consumption - per one-time request or on a regular, e.g. monthly basis - the system for assigning at least one energy consumer to at least one energy provider computes an assignment for theses consumers (300) to an energy provider (410, 420), i.e. an energy production provider (410) or an energy storage provider (420).

[0054] The energy production provider (410) can be for example a provider having one or more power plants - e.g. nuclear power plants or power plants using fossil fuels - solar collectors or any other kind of renewable energy collectors and/or producing facilities such as wind power stations or the like. The energy storage provider (420) can be for example a telecommunications provider having large battery-stocks as emergency supply for maintaining their telecommunications network. The energy storage provider (420) can also be a hydrogen-storage or the like, e.g. as an intermediate energy storage in a solar collecting farm.

[0055] The energy consumers (300) as well as the energy providers (410, 420) are connected to the energy grid (500). The assignment is performed according to preferences of the user (200) of the system (100) and optimization requests by the system users (200).

[0056] Once the assignment is performed the energy flow is routed from the energy providers (410, 420) to the energy consumer (300) by traversing the energy grid (500) infrastructure by using a plurality of paths, e.g. redundant paths in parallel known as multi-path electricity routing and by adjusting energy potentials, and resistances accordingly. In other words, the routing is not only performed by conventional switching.

[0057] Hence, the system (100) finds a match between the demand and request for energy of one or more energy consumers (300) leading to an energy consumer (300) being assigned to an appropriate energy provider (410, 420), in a user-specified manner resulting in a joint optimization of supply availability and other crucial factors as e.g. minimized distance that the energy is transferred, minimized load of the energy grid (500), maximized capacity of the energy grid (500), or balance in the energy grid (500). The consumer assignment also depends on the consumer preferences, e.g. the price of the electricity per unit or the source of the electricity (e.g. nuclear, fossil, or renewable).

[0058] Fig. 2 shows a schematic diagram of the input data of the system for assigning at least one energy consumer (300) to at least one energy provider (410, 420) according to another embodiment of the invention.

[0059] The energy consumer (300) sends consumption information/consumption data to the system (100) on a regular basis or per request, and demands for a certain amount of energy for a given time. Alternatively, the energy consumer (300) can request for receiving energy as long as its request is valid or is not revoked. The consumer (300) may also specify its budget, the source of the energy (nuclear, renewable, coal etc.), and also send data related to his/her location. The consumption information/consumption data may also comprise the desired time of delivery of the desired amount energy, the desired period of time of delivery of the desired amount of energy, the desired price for the desired amount of energy, and/or the desired price range for the desired amount of energy the consumer (300) is willing to pay.

[0060] The location may vary over time, so that data related to the location may be particularly important, in case the energy is required for an electric vehicle.

[0061] In addition the system (100) also requests and/or retrieves data from the energy provider (410, 420). The data comprises operational status of the energy provider (410, 420) as well as their respective energy providing facilities, plants, or storages, the amount of energy to be produced or ready to be delivered within a certain period of time, the possible interconnection between the energy production provider (410) and the energy storage provider (420), the current overall energy consumption, the expected energy consumption, the location of the energy provider (410, 420) in the energy grid (500) and the cost of the energy per unit. The request and/or retrieval of data from the energy provider (410, 420) can be performed on a regular basis, i.e. it may vary from seconds to minutes depending on the agreement between the energy providers (410, 420) and the operator of the system (200) about the energy consumption, the remaining energy consumption, the location that interconnect in the energy grid (500) and the cost of the energy per unit. The communication between the system (100) and the energy production providers can be either on a pull- or push-basis.

[0062] Another input data of the system (100) is the data requested and/or retrieved from the energy regulator (600). The energy regulator (600) is a public authority which mandates for example the use of one sort/source of energy, e.g. renewable energy. The data gathered by system (100) from the energy regulator (600) can be related to taxes and tariffs of different sorts of energy and quota of different sorts of energy.

[0063] The system (100) also requests and/or retrieves as another input data from the energy grid provider (700). The energy grid provider (700) holds and maintains the energy grid (500) which is connecting the participants of the energy grid (500) /network, e.g. the consumer (300) and the energy provider (410, 420). The data retrieved by the system (100) from the energy grid provider (700) can be related to current energy grid status, possible congestion of the energy grid (500), the level of possible congestion, current capacity of the energy grid (500), overall capacity of the energy grid (500), and possible malfunctions of the energy grid (500).

[0064] A further input data of the system are data provided by meta-information sources (800) related to the weather - e.g. current and expected weather conditions - , related to the car and public transportation traffic, related to the latest news - e.g. major sports events or important political speeches, or related to current and expected price of fossil fuels as petroleum for example. Meta-information sources (800) are therefore weather forecasters, news feeds, news networks or goods and first source exchange information portals. The data can be retrieved automatically either using a pull mechanism or a push mechanisms from the Meta-information sources (800), e.g., by RSS (rich site summary).

[0065] After the system (100) has taken into account all input data, it makes a prediction of pairs of energy consumer (300) - energy provider (410, 420) and additionally gives a ranking of the best matched pairs in an ordered fashion. Preferably, the system (100) makes a prediction of triples of energy consumer (300) - energy provider (410, 420) - energy grid provider (700) and additionally gives a ranking of the best matched triples in an ordered fashion. Consequently the system (100) outputs different options to the user (200) of the system (100) according to the ranking. The system user (200) can manually select the best matched pair or the best matched triple, or the system user (200) can rely on an automated matching algorithm performed by the system (100). With the automated matching algorithm enabled, the consumer (300) is automatically assigned to the best choice according to best matched pair with the highest score to the energy provider (410, 420), in case the system (100) makes a prediction of pairs of energy consumer (300) - energy provider (410, 420). With the automated matching algorithm enabled, the consumer (300) is automatically assigned to the best choice according to best matched triple with the highest score to the energy provider (410, 420) and the energy grid provider (700), in case the system (100) makes a prediction of triples of energy consumer (300) - energy provider (410, 420) - energy grid provider (700). A receipt of the purchase of power is also sent back to the user (200).

[0066] The system also reports to the user (200) which energy consumer (300) is assigned to each energy provider (410, 420) for billing and operational reasons. In addition, an energy production provider (410) can also be a consumer (300) and/or user (200) of the system (100) by requesting for storing over-produced energy to an energy storage of an energy storage provider (420). The communication between the system and the energy providers (410, 420) can be either on a pull- or push-basis. The system (100) also reports back to user (200) statistics of the operation and maintains logs of all its decision on assigning consumers (300) to energy production providers (410) and energy storage providers (420). The logs can be used for troubleshooting and also can prove the smooth operation of the system (100).

[0067] Fig. 3 shows a schematic diagram of a system for assigning at least one energy consumer to at least one energy provider according to another embodiment of the invention. The user (200) queries the system (100) and specifies ranking preferences. The ranking preferences are retrieved by the user preferences retrieval device (105). Alternatively, the user preferences retrieval device (105) can be omitted and default ranking preferences can substitute user ranking preferences.

[0068] As mentioned before, the consumers (300) send consumption information/consumption data or requests to the system (100) on a regular basis or per one-time demand and request either for a certain amount of energy for a given time, or for receiving energy as long as the request is valid or not revoked. The consumer (300) can also specify its budget, the source of the energy (nuclear, renewable, coal etc), and also send his/her location. As already mentioned before, the consumption information/consumption data may also comprise the desired time of delivery of the desired amount energy, the desired period of time of delivery of the desired amount of energy, the desired price for the desired amount of energy, and/or the desired price range for the desired amount of energy the consumer (300) is willing to pay.

[0069] The request is received by the consumer preferences retrieval device (101). The consumer request processing device (106) submits the request retrieved by the consumer preferences retrieval device (101) to the consumer profile database (107). The consumer profile database (107) records the activity and assignment of all the energy consumers (300) in the energy grid (500). The consumer profile database (107) replies with the profile of the respective energy consumer (300), along with the aggregated profile of similar energy consumers, as well as the aggregated profile of all the energy consumers in the energy grid (500).

[0070] When all the data is retrieved, the data along with the request of the energy consumer (300) is sent to the ranking engine device (104) with a request for ranking of all the possible pairs of energy consumer (300) and available candidate energy providers (410, 420), i.e. the available candidate energy production providers (410) and candidate energy storage providers (420). Preferably, when all the data is retrieved, the data along with the request of the energy consumer (300) is sent to the ranking engine device (104) with a request for ranking of all the possible triples of energy consumer (300), available candidate energy providers (410, 420), and available candidate energy grid provider (700). Then, the ranking engine device (104) is sending a request to the prediction engine device (103) and as well as a request to the data retrieval device (102).

[0071] The prediction engine device (103) is always running reporting a prediction of the demand and production of the energy based on the data gathered by the consumer preferences retrieval device (101) and a production of energy based on the data gathered by the data retrieval device (102).

[0072] The data retrieval device (102) gathers information from the stakeholders, namely the energy production providers (410), energy storage providers (420), regulators (600), energy grid providers (700), and meta-information sources (800) as shown in Fig. 2. In case the interfaces of the stakeholders are not reporting correctly or in case of failure a data storage device (109) acts as a backup system that provides the recent view of the energy grid (500) and the reported energy consumption and energy storage. A view represents a snapshot of the state of the energy grid (500) at a particular time. The state of the energy grid (500) comprises at least one of the following: the loads, the topologies as well as the availabilities of the energy grid (500). The data storage device (109) can also store and back up any data retrieved by the data retrieval device (102). The data storage device (109) is regularly updated and also maintains the logs of all the interactions and decisions for billing, troubleshooting and maintenance.

[0073] The price estimator device (108) estimates the cost of the requested energy consumption of the energy consumer (300) considering the cost of the energy per unit of the respective energy providers (410, 420).

[0074] Once all the data from the consumer preferences retrieval device (101), the data retrieval device (102), the prediction engine device (103), the user preferences retrieval device (105), the consumer request processing device (106) as well as price estimator device (108) is available, the ranking engine device (104) combines the prediction from the prediction engine (103), the feedback of the candidate energy production providers (410) and energy storage providers (420) and/or candidate grid provider (700), the preferences of users (200), the preference and location of energy consumer (300), as well as the price as estimated from the price estimator (108).

[0075] In addition, all the data gathered from the consumer preferences retrieval device (101), the data retrieval device (102), the user preferences retrieval device (105), the consumer request processing device (106) as well as price estimator device (108) is available, the ranking engine device (104) can be used by prediction engine device (103) in order to predict the demand and production of the energy as well as possible congestions of the energy grid (500), the level of possible congestions, current capacity of the energy grid (500), overall capacity of the energy grid (500), and possible malfunctions of the energy grid (500).

[0076] Then, the ranking engine device (104) ranks pairs of energy consumer (300) and candidate energy providers (410, 420) or triples of energy consumer (300), candidate energy providers (410, 420), and candidate energy grid providers (700). Then the ranking engine device (104) sends the ranking along with the associated pricing to data retrieval device (102) to be pushed to the selected energy provider (410, 420) and in case of triples to the selected energy grid provider (700), considered being the most suitable by the ranking engine device (104).

[0077] in case the response is positive - i.e. in case of confirmation of both, the selected energy provider (410, 420) as well as to the selected energy grid provider (700) - the confirmed selection is sent to the energy consumer (300). In case that the response from the candidate energy provider (410, 420) and the candidate energy grid provider (700) is negative, the ranking engine device (104) is further configured to send the ranking information to the candidate energy providers (410, 420) and/or to the candidate energy grid providers (700) which are second most suitable and to receive respective response. In case of a further negative response the ranking engine device (104) is configured to subsequently send ranking information to the candidate energy providers (410, 420) and/or the candidate energy grid (700) providers in the ranking information until positive response (confirmation) is sent back.

[0078] The confirmation is send to the consumer (300). If the energy consumer (300) has activated the automatic matching device of the system (100) (not shown) then the confirmation is approved by sending an automatic reply to the consumer request processing device (106). The energy consumer (300) can also manually approve the selection or even request for a new selection by sending a revised request to the system (100). Until the energy consumer (300) approves the request, the assignment transaction is not complete. Only when the assignment transaction is complete the data storage device and the consumer profile database (107) mark the assignment as valid. The chosen and confirmed selection, i.e. the decision of an energy provider (410, 420) as well as a energy grid provider (700) is sent back to the system user (200). A copy of the decision is stored in the data storage device (109) as well as in the consumer profile database (107).

[0079] The system (100) additionally comprises a routing device (110). The routing device is configured to control routing of the requested energy from the selected energy production provider (410) or the selected energy storage provider (420) to the energy consumer (300) via the energy grid (500). Therefore, the routing device (110) is connected to the energy production provider (410), the energy storage provider (420) and the energy grid provider (700) and is configured to provide requests or commands for routing to them, see dash-dotted arrows in Fig. 3. The routing device (110) is thus controlling the routing of the energy from the energy production provider (410) or the energy storage provider (420) to the energy consumer (300) via the energy grid (500) of the energy grid provider (700) using dynamic switching, adjusting potentials, adjusting resistances, shifting phases. In other words, the routing device (110) can control routing of the energy through a plurality of energy paths of the energy grid (500) in parallel.

[0080] When routing, the routing device (110) considers the data gathered from the at least one energy grid provider (700) by the data retrieval device (102), e.g. under consideration of the current energy grid status, possible congestion of the energy grid (500), the level of possible congestion, current capacity of the energy grid (500), overall capacity of the energy grid (500), or possible malfunctions of the energy grid (500).

[0081] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and non-restrictive; the invention is thus not limited to the disclosed embodiments. Variations to the disclosed embodiments can be understood and effected by those skilled in the art and practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality and may mean "at least one".

Claims

1. A system for assigning an energy consumer to an energy provider comprising:

   a consumer preferences retrieval device configured to retrieve data on at least one of the following: at least one consumption data, at least one desired source of energy, a location of the at least one energy consumer;
   a data retrieval device, wherein the data retrieval device is configured to gather continuously or in time intervals data from a plurality of energy providers comprising at least one energy production provider and/or at least one energy storage provider and from at least one energy grid provider, and preferably from at least one regulator and/or at least one meta-information source;
   a prediction engine device, wherein the prediction engine device is configured to predict a demand of energy based on the data gathered by the consumer preferences retrieval device and a production of energy based on the data gathered by the data retrieval device; and
   a ranking engine device, wherein the ranking engine device is configured to rank pairs of energy consumers and candidate energy providers or preferably to rank triples of energy consumers, candidate energy providers and candidate energy grid providers under consideration of the data gathered by the consumer preferences retrieval device,
   the data gathered by the data retrieval device and the prediction performed by the prediction engine device.

2. The system according to claim 1, wherein the ranking engine device is configured to send the ranking information to the candidate energy providers and/or to the candidate energy grid providers and is config-

ured to receive the response from the candidate energy providers and/or the candidate energy grid providers and further configured to send the confirmation from candidate energy providers and/or the candidate energy grid providers to the at least one energy consumer and is further configured to assign the at least one energy consumer to at least one selected energy provider and/or at least one selected energy grid provider according to an energy consumers selection of the candidate energy providers and/or the candidate energy grid providers based on the ranking information.

3. The system according to claims 1 or 2, further comprising:

a user preferences retrieval device configured to retrieve data on at least one ranking preference and/or ranking algorithm and configured to submit the data to the ranking engine device; and
wherein the ranking engine device is further configured to perform the assignment under consideration of the data submitted by the user preferences retrieval device to the ranking engine device.

4. The system according to any of the claims 1 to 3, further comprising a consumer request processing device and a consumer profile database;
wherein the consumer request processing device is configured to retrieve at least one energy consumer request from the consumer preferences retrieval device; and
wherein the consumer profile database is configured to record and store a profile of each of all energy consumers comprising the history of the activity and assignments of each of all energy consumers.

5. The system of claim 4, wherein the consumer request processing device is further configured to submit the at least one consumer request to the consumer profile database and;
wherein the consumer profile database is further configured to subsequently submit data on at least one of the following: the profile of the at least one energy consumer, at least one profile of at least one stored similar energy consumer and the assignments of all stored energy consumers in the energy grid to the consumer request processing device; and
wherein the consumer request processing device is further configured to submit the data received by the consumer profile database to the ranking engine device; and
wherein the ranking engine device is further configured to perform the assignment under consideration of the data submitted by the consumer request processing device to the ranking engine device.

6. The system of any of claims 1 to 5, further comprising a price estimator device configured to estimate the cost of at least one energy consumption of the at least one energy consumer retrieved by the consumer preferences retrieval device and/or further comprising a data storage device configured to store the data retrieved by the data retrieval device; and
wherein the ranking engine device is further configured to perform the assignment under consideration of the data submitted by the price estimator device to the ranking engine device.

7. The system of any of claims 1 to 6, further comprising an automated matching device configured to automatically select at least one energy provider of the candidate energy providers and/or select at least one energy grid provider of the candidate energy grid providers based on the ranking information.

8. The system of any of claims 3 to 7, wherein the prediction engine device is further configured to predict the demand of energy and the production of energy based on the data submitted by the user preferences retrieval device to the prediction engine device.

9. The system of any of claims 4 to 8, wherein the prediction engine device is further configured to predict the demand of energy and the production of energy based on the data submitted by the consumer request processing device to the prediction engine device.

10. The system of any of claims 6 to 9, wherein the prediction engine device is further configured to predict the demand of energy and the production of energy based on the data submitted by the price estimator device to the prediction engine.

11. The system of any of claims 1 to 10, wherein the data on the at least one energy grid provider comprises data on at least one of the following: the energy grid capacity, the current energy grid capacity utilization, the state of a energy grid; and/or
wherein the meta-information source provided at least one of the following data:

weather information data, traffic information data, news information data, data relating to price of fuels.

12. The system of any of claims 1 to 11, further comprising a routing device configured to control routing of energy from the at least one energy production provider or the at least one energy storage provider to the at least one energy consumer, wherein the routing device is preferably configured to control routing of energy from the at least one energy production provider or the at least one energy storage provider

to the at least one energy consumer by at least one of the following: dynamic switching, adjusting potentials, adjusting resistances, shifting phases, routing the energy through a plurality of energy paths of the energy grid in parallel.

13. The system of claim 12, wherein the routing device is configured to control routing of energy from the at least one energy production provider or the at least one energy storage provider to the at least one energy consumer under consideration of the data gathered from the at least one energy grid provider.

14. The system of any of claims 1 to 13, wherein at least one energy grid is operated and/or maintained by the at least one energy grid provider;
wherein the at least one energy grid comprises a plurality of paths; and, if referring to claims 12 or 13, wherein the routing device is configured to control routing of energy from at least one energy plant and/or at least one energy storage to at least one appliance of the at least one consumer via at least one path of the at least one energy grid.

15. A system for joint optimization of energy availability and network capacity in an energy grid using at least one of the following: load balancing, transport loss minimization, stable operation of the power supply, in particular without oscillations, and robust power supply, using a system for assigning at least one energy consumer to at least one energy provider preferably according to any of claims 1 to 14.

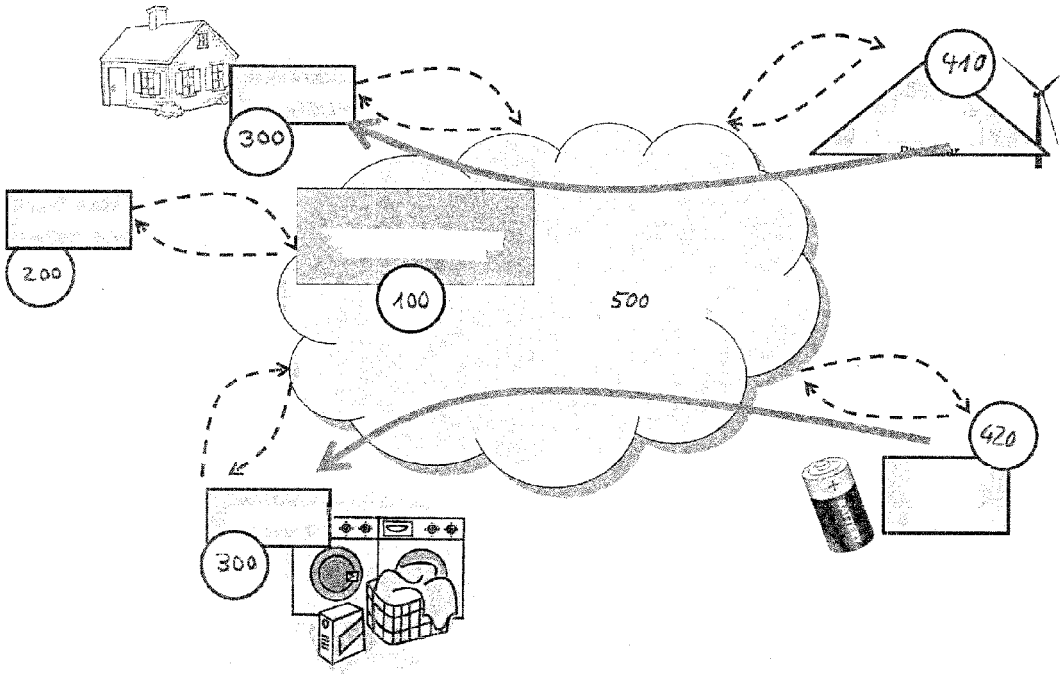


Fig. 1

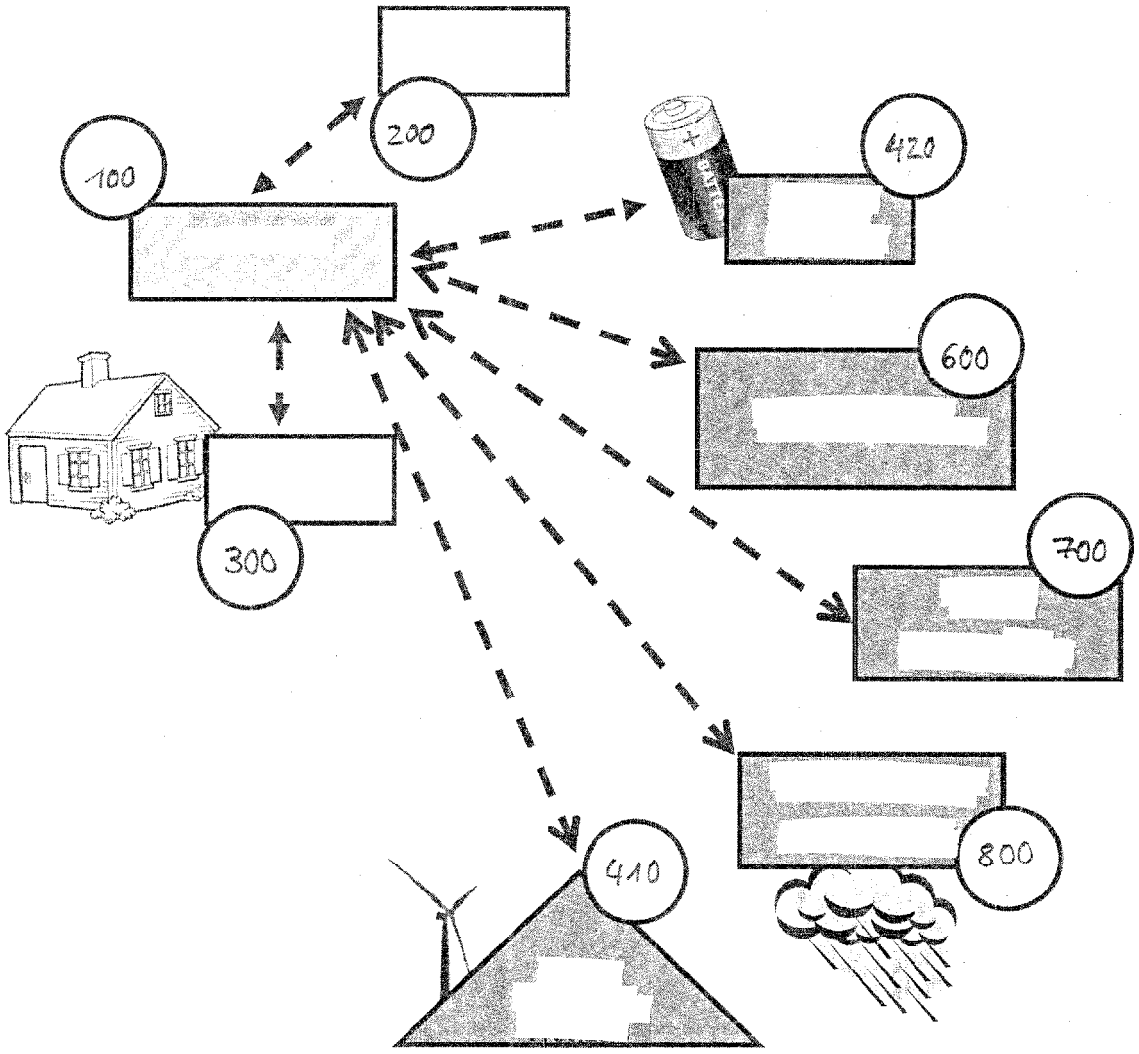


Fig. 2

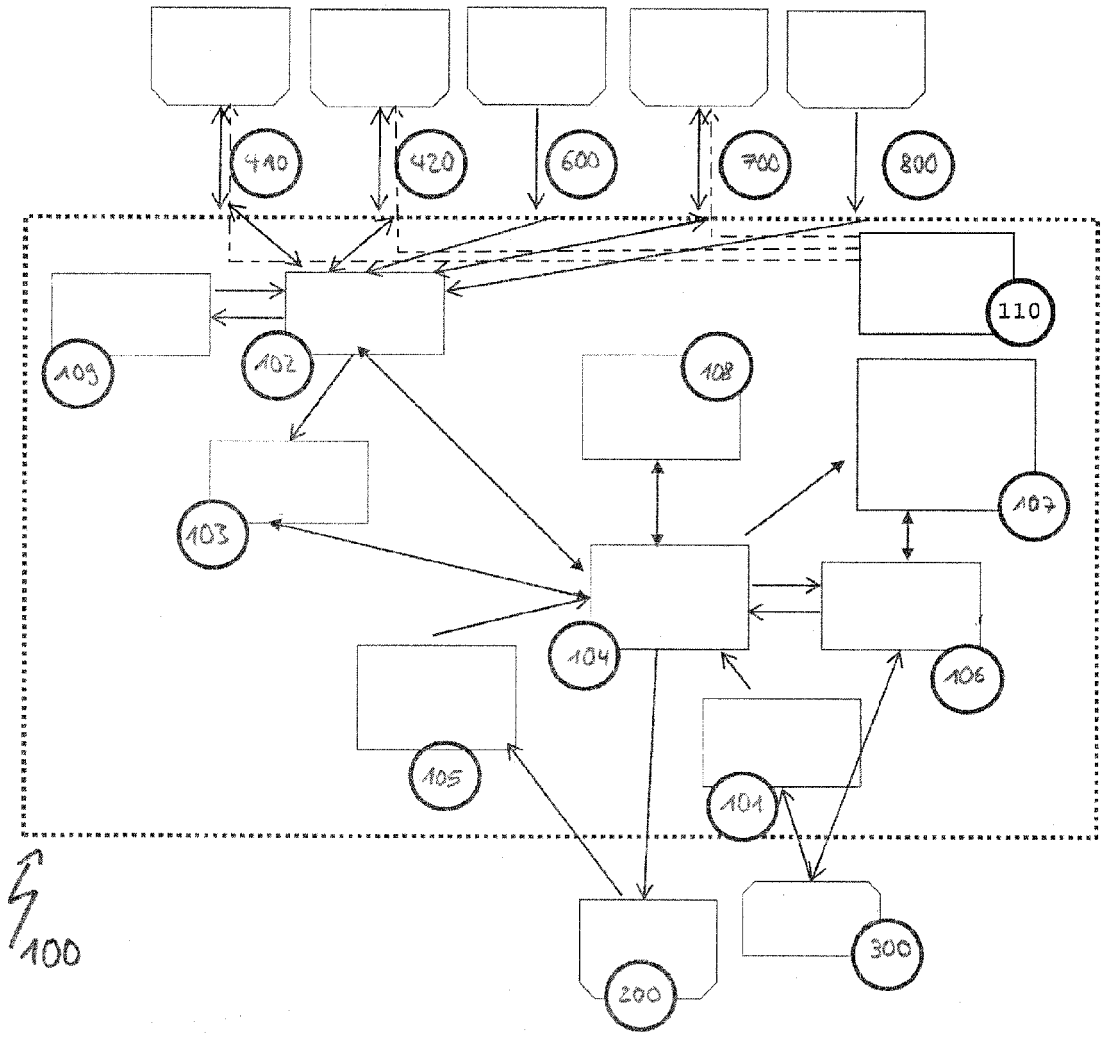

410
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Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 13 15 8042

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
L	EPO: "Mitteilung des Europäischen Patentamts vom 1. Oktober 2007 über Geschäftsmethoden = Notice from the European Patent Office dated 1 October 2007 concerning business methods = Communiqué de l'Office européen des brevets,en date du 1er octobre 2007, concernant les méthodes dans le domaine des activités", JOURNAL OFFICIEL DE L'OFFICE EUROPEEN DES BREVETS.OFFICIAL JOURNAL OF THE EUROPEAN PATENT OFFICE.AMTSBLATTT DES EUROPAEISCHEN PATENTAMTS, OEB, MUNCHEN, DE, vol. 30, no. 11, 1 November 2007 (2007-11-01), pages 592-593, XP007905525, ISSN: 0170-9291 * The claimed subject matter, with due regard to the description and drawings, relates to processes comprised in the list of subject matter and activities excluded from patentability under Art.52(2) and (3) EPC. The applicant is advised that in accordance with the established practice of the EPO, no search need be performed in respect of those aspects of the claimed invention. The only identifiable technical aspects of the claimed invention relate to the use of conventional, general-purpose data processing technology for processing data of an inherently non-technical nature. The information technology employed is considered to have been generally known as it was widely available to everyone at the date of filing/priority of the present application. The notoriety of such prior art cannot reasonably be contested. No documentary evidence was therefore considered required. *	1-15	INV. G06Q50/06

TECHNICAL FIELDS SEARCHED (IPC)

G06Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29 October 2013	Falierou, Christina

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EUROPEAN SEARCH REPORT

Application Number
EP 13 15 8042

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)

TECHNICAL FIELDS SEARCHED (IPC)

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Patent documents cited in the description

- US 6745105 B1 **[0008]**

Non-patent literature cited in the description

- **HASSAN FARHANGI.** The path of the smart grid. *IEEE Power & Energy Magazine,* January 2010, vol. 8 (1), 18-28 **[0007]**
- **VILLUMSEN.** Column Generation for Transmission Switching of Electricity Networks with Unit Commitment. *Proceedings of the International MultiConference of Engineers and Computer Scientists,* 16 March 2011, vol. II, http://www.iaeng.org/publication/IMECS2011/IMECS2011_pp1440-1443.pdf **[0009]**
- **VASSEUR.** RPL: The IP Routing protocol designed for low power and lossy networks. *Internet Protocol for Smart Objects (IPSO) Alliance, http://www.cs.berkeley.edu/~jwhui/61owpan/IPSO-WP-7.pdf* **[0010]**
- **HONGSEOK KIM.** Cloud-based demand response for smart grid: Architecture and distributed algorithms. *Smart Grid Communications (SmartGridComm), 2011 IEEE International Conference on Communication, Networking & Broadcasting , Components, Circuits, Devices & Systems, Computing & Processing (Hardware/Software), Power, Energy, & Industry Applications,* 2011 **[0011]**