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(73) Patenthaver: **Chemin GmbH, Am Mittleren Moos 46 A, 86167 Augsburg, Tyskland**

(72) Opfinder: **SPIEGEL, Wolfgang, Dr. Rothermel-Strasse, 16, 86415 Mering, Tyskland**
ALBERT, Franz, Werner, Maxstrasse, 17 c, 68199 Mannheim-Neckarau, Tyskland

(74) Fuldmægtig i Danmark: **Chas. Hude A/S, H.C. Andersens Boulevard 33, 1780 København V, Danmark**

(54) Benævnelse: **Apparat og fremgangsmåde til integrering af elektriske apparater i et system inden for rammen af demand-side-management**

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The present invention relates to a device and a method for integrating electrical appliances in a system in the context of demand side management.

The energy balance of the power supply system is subject to fluctuations. These fluctuations can last over short and long time periods. For example, supply and demand can change over years, months, days, but also in a matter of seconds. Especially in wind turbine generators or solar energy plants the supply of electric current is dependent on the prevailing weather conditions and may change within a short period of time if rapid changes in the weather occur.

Consumer behavior, too, can cause perceivable short-term changes in the energy balance of the power supply system, for example, when an international soccer match is broadcast.

To compensate for such changes in the energy balance, so far certain power plants or single large electricity-consuming appliances are switched off or switched on when shortages occur in the generation of electric power or if there is an oversupply of electric power, in order to regulate the energy balance with this load.

One way to switch large electricity-consuming appliances off or on is being realized as part of demand side management. Here, for example, freezer chests and freezer appliances are switched off in supermarkets for a certain time. The thermostats are set in advance so that they cool or freeze the food at a slightly lower temperature.

The disadvantage of the previous methods is that they do not include in the demand side management a wide range of electrical appliances that can serve as compensators, namely the electrical appliances in private households.

With the integration of electrical appliances of private households in the context of demand side management there is usually the problem that these appliances are not located near an area where they can be easily controlled remotely. For

example, heaters are often located in cellar rooms, which as a rule do not have an Internet or phone connection or are even shielded from radio signals.

In addition, with the existing systems there is the problem that there has been no possibility so far of making an optimal estimate of the consumption resources that are available for the demand side management.

The object of the present invention is to provide a device and a method which overcome the aforementioned disadvantages and which enable ordinary electrical appliances in private households to be optimally integrated in the demand side management.

The object is achieved by a device according to claim 1 which selectively controls electrical appliances in private households in order to use them to control the energy supply.

This device comprises at least one switching unit that switches the electric current to the electrical appliance in question on or off, and at least one control unit which is in a data transmission contact with the switching unit and which can receive control signals from an external control point and can preferably also transmit same.

The control unit is an entity that measures how the supply of electric power behaves relative to demand and makes decisions on what measures need to be taken to compensate for energy peaks or insufficient supply.

The said control point may, for example, be a control center of an energy provider, or a device that autonomously measures the energy balance.

The control signals are preferably transmitted to the control unit via a data network, such as Internet, telephone networks or radio networks; such a network may even consist of a single data link between the control point and the control unit.

The control unit converts the data received from the control point into switching signals and sends them via a data channel to the switching unit. Preferably, a transmission of data from the switching unit to the control unit is possible as well.

The switching signals are preferably transmitted to the switching unit via data lines, radio or a data network, such as a wired network (LAN) or a wireless network (WLAN); such a network may consist of only a single data connection between the control unit and the switching unit.

A preferred data channel for the transmission of switching signals is the power line leading to the electrical appliance. The switching signals are preferably modulated as an amplitude modulation to the mains voltage.

As a rule, only a few different signals are necessary for switching on or off (e.g. ON, Off and control or demand signals). These signals consist only of little information (a few bits, a few bytes or a few kilobytes). For a person skilled in the art, the noise on the lines does not present a problem for the transmission of such small amounts of data. Also, suitable protocols for such data traffic on noisy lines are known in the art.

Preferably, the switching signals consist of a few kilobytes, especially a few bytes or even just a few bits.

In a preferred embodiment, the switching signal also includes an address in order to be able to specifically address a number of different switching units with only a single control unit.

On receiving an ON switching signal, the switching unit switches the energy supply for the electrical appliance on and, preferably upon receipt of an ON switching signal, it switches the electrical appliance off, if appropriate, after the occurrence of further conditions.

In a further preferred embodiment, the switching unit switches the energy supply for the electrical appliance on upon receiving an ON switching signal and switches the electrical appliance off when it does not receive such an ON switching signal, if appropriate, after the occurrence of additional conditions.

The switching unit is preferably able to switch the current for the electrical appliance in question only, or for the entire circuit with which this appliance is connected.

It is also possible with such a device to make the energy to be potentially consumed by the individual systems known to the energy provider and thus open up the possibility of integrating the consumption resources in the side demand management.

For this purpose, the device additionally comprises at least one demand determination unit that determines the remaining energy needs of the consumer load.

In a preferred embodiment, a demand determination unit sends a demand information to the switching unit. This is preferably done by sending this demand information to the switching unit, which retransmits this information via the control unit to the control point. This demand information preferably contains information identifying the demand determining unit, the switching unit or the consumer (appliance address), and information on the energy that can be consumed by the appliance in the following time interval (energy demand). This time interval is preferably a period of time from the group of the whole night, the whole day, hours, minutes, seconds.

The demand determination unit determines the data from the consumer that are required for the demand information, e.g. by measuring or determining the sequence program of the consumer and/or the switching unit. Preferably, however, the appliance address is excluded from this as this address should be predefined by the energy suppliers themselves. For this purpose, the demand determination unit includes at least one measuring instrument and/or at least one processor

which can determine the expected consumption of the consumer and are able to convert this into information comprehensible to the switching unit.

For example, this would be realized for an electric heating cartridge, for a heating or for a boiler by determining, by means of a temperature sensor and a processor, on the basis of the temperature of the medium to be heated, the amount of heat that can be introduced until the morning. The demand determination unit is formed here by the temperature sensor and the processor.

This can similarly be applied to refrigerators, in which case the temperature is measured as well, and it is calculated how often a cooling cycle must take place in the time interval.

Another example is a washing machine or a dryer, which can be switched on by the switching signal and which transmits to the switching unit the amount of energy that will be consumed by the appliance during the time of its operating cycle.

In an advantageous embodiment, in a heating that is controlled by the switching unit a measuring unit measures the degrees of freedom of the heat that can be stored additionally in the boiler or hot water tank and, within these conditions, permits the acquisition of electricity from the power supply systems in accordance with the specifications of the network control, or sends these data to the control unit, which transmits them to the control point.

In this way, the control point receives additional data that are useful in making decisions on load compensation.

Suitable electrical appliances in private households are those devices whose ON/OFF states are not usually bound to a time desired by the consumer.

These are, for example, electric heaters, a washing machine, dishwasher, dryer or refrigerator. With these electrical appliances, access can be spontaneous at

certain times, if for example there is an urgent need to wash or the refrigerator light is needed, but normal operation, for example cooling, heating or normal washing, is not dependent on the consumer at least during the night.

Especially in heating processes, short-term switching dynamics is possible because no complete program needs to take place, but each switching-on introduces an amount of heat.

In a preferred embodiment, the switching unit has, in addition, at least one unit by means of which switching on or off can be achieved independently of the control signal. These are preferably units from the group of switches for manual switch-on, and time switches. The switches have the advantage that a spontaneous access to the device is possible, for example, if the refrigerator light is to burn or when washing is carried out spontaneously.

The time switch has the advantage that the device is turned on, if necessary, even without a control signal, so that the device does its work even without the prevalence of an oversupply of power or if a failure of the control signal occurs, for example, food will still be cooled or the laundry will still be washed overnight.

In a private household, problems can occur in that the switching unit cannot be integrated simply and inexpensively into an existing electrical appliance.

In a preferred embodiment, the switching unit is therefore designed so that it can be connected on one side with the socket by means of which the electrical appliance is connected to the power supply system, and so that it can be connected on the other side with the plug of the electrical appliance. The switching device switches the electric current between the socket and the electrical appliance on or off after receiving the corresponding switching signals.

In another preferred embodiment, the switching unit is configured such that it can be installed like a normal fuse in a fuse box and from there switches the electric circuit of the electrical appliance on or off.

These embodiments have the advantage that the switching unit can switch the electrical appliance in question on or off in a simple manner without causing major installation costs.

In a further preferred embodiment, the switching unit does not switch the electrical appliance off immediately when it receives signals to switch off sent by the control unit or when the time switch switches to OFF mode, but will wait until the electrical appliance has completed its task.

This is preferably achieved in that at least one measuring unit in the switching unit measures the power consumed by the electrical appliance and that the switching unit only switches the appliance off when after a specified time no more energy is being consumed or the energy consumption is below a preferably adjustable threshold.

This has the advantage that, for example, refrigerators will not be interrupted during cooling down and washing machines and dryers will not turn off in the middle of their program.

Preferred measuring units are current measuring instruments that measure the current flowing through the electrical appliance. The current intensity will be much higher during operation than after completion of the program of the electrical appliance in question.

In particular, in the event that the switching unit cannot easily be contacted by the control unit, for example, if the control unit in the apartment is connected to the Internet and the switching unit and the electrical appliance are in the basement, the embodiment described below is advantageous.

In this component the control unit is divided into two components, the "receiving component" and the "transmitting component". The first component, "receiving component", receives the control signals from the control point via a data transmission network.

The receiving component then sends internal data to the transmitting component in accordance with the control data. This can be done via a separate data channel. An advantageous data channel is a radio connection, as used, for example, in cordless telephones. The advantage of this radio link is that no wiring is required in the apartment. The transmitting component is housed in a place where a simple data connection to the control unit can be created. A data connection to the switching unit can be configured in particular as a radio link, in which case the transmitting component rather occupies the status of a relay station. A preferred data connection to the switching unit is established via the circuit of the electrical appliance by means of data transmission via the current lead. In this case, the transmission component is preferably located directly in the fuse box and is integrated in the respective fuse for the circuit of the electrical appliance. Of course, in the event that a contact with the control point can be established in the area of the fuse box, the entire control unit can also be integrated in such a fuse.

Examples of the system according to the invention are illustrated in the drawings.

Figure 1 outlines a preferred embodiment involving radio transmission.

Figure 2 outlines a preferred embodiment in an apartment building.

Figure 3 outlines a preferred embodiment with a heating system.

In a preferred embodiment according to Figure 1, a control point (1), for example, the control center of an energy provider, sends, via the Internet (2), a control signal to a web-enabled receiving set in a private household (3). This set can, for example, be telephone equipment with an attached router or a receiver system for wireless Internet reception. To this system, the control unit (4) is connected, which has been correctly addressed by the control point and which receives the control signals. The control signals are converted by the control unit into switching signals, and sent by radio (5) to the switching unit (6). In this case, the communication may include only a simple ON signal or multiple signals, for example,

ON/OFF signals from the control unit and UNDERSTOOD signals from the switching unit. In addition, the switching signal may also contain an address, in order to address a plurality of switching units.

The switching unit is plugged into a socket like a conventional time switch and the plug of the electrical appliance (7), for example, an electric heating cartridge for a heating system, is connected to the switching unit.

If the switching unit receives the ON signal, it establishes the contact between the electrical appliance and the socket.

Preferably, the electrical appliance (7) has transmitted, at the beginning of the night or of the day or at another pre-set time, a demand information to the control point. Included in this information was, inter alia, information on how much energy was expected to be consumed in the time following the demand information.

In the event that something should change (for example, with regard to the heating cartridge, a sudden drop in temperature), preferably, there is a possibility of sending a respective, up-to-date current demand information a number of times.

If the electrical appliance during its normal operation is bound to a sequence program (for example, in a washing machine or a dryer), it is advantageous if a measuring instrument that is built-in in the switching unit measures the current flowing through the switching unit to the electrical appliance. If this current rises, then it is clear that the device is operating; if the current drops below a certain threshold and stays for a certain time period at this low level, the switching unit switches off, as in that case the duty cycle of the electrical appliance should be terminated.

It makes sense to set refrigerators at a slightly lower cooling temperature because the intervals between necessary cooling cycles can then be further apart in time.

In Figure 2 there is shown an embodiment in which several electrical appliances (e.g. washing machines or dryers) in an apartment building are controlled by a single control unit (3). The following structure is particularly advantageous when the central phone line reaches the apartment house near the fuse box (8).

In this case, there is a possibility of using a switching unit which on the one hand works as an ordinary household fuse and which transmits the switching signals as modulations of the alternating voltage via the electric circuit (9) of the electrical appliances. The switching unit is connected via a cable (such as USB) with an Internet receiver unit (2), via which it receives the control signals.

The switching signals in this case contain the address of the respective switching unit (6a, 6b or 6c) addressed.

The control units receive the signals on the power line and upon receiving their individual address in combination with the ON signal, turn the relevant electrical appliance (7a, 7b, or 7c) on. The switching units are in this case connected with the electrical appliances as is the case in the embodiment according to Figure 1. In this connection, protocols from the area of the Ethernet can be used.

Figure 3 shows an embodiment in which a heating (7) that contains an electric heating unit (10) can be switched on or off by the switching unit (4), whose data connection with the switching point is not shown here, and the switching unit (6).

Analogously to refrigerators, it may be advantageous to adjust the heating temperature slightly above the normal level since in this case longer pauses between the heating cycles are possible. In particular, the heating system as a heating unit comprises an electric heating cartridge (roughly 3-4 kW).

In an advantageous embodiment, a measuring unit in the switching unit measures the degrees of freedom of the heat additionally storable in the boiler or hot water tank and, within these conditions, permits the acquisition of electricity from the

power supply systems in accordance with the specifications of the network control, or sends these data to the control unit, which transmits them to the control point.

In this way, the control point receives additional data that are useful in making decisions on load compensation.

A preferred mode for controlling the energy supply is that, in a predefined time interval, the switching point always sends signals for switching on to a proportion of the electrical appliances controlled in this manner, in particular, normally to half of the appliances.

In the case of an oversupply of energy, this proportion is reduced, or it is raised if there is an insufficient supply of energy.

In particular, the electrical appliances to which the switch-on signals are sent should vary continually, so that normally the total proportion does not change. In this way, the probability is highest that each appliance can perform its activities once within a defined time period. In this way it is ensured that at times of higher energy supply there are more consumer loads using energy and at times of lower energy supply fewer consumer loads use energy.

Patentkrav

1. Apparat til integrering af elektroapparater i et system inden for rammen af demand-side-management, **kendetegnet ved,** at det mindst omfatter en omskifterenhed, som til- og frakobler strømmen til det pågældende elektroapparat, mindst en behovsberegningsenhed, som bestemmer det energibehov, der kan forventes af det pågældende elektroapparat inden for et bestemt tidsinterval, og mindst en styreenhed, som står i datakontakt med omskifterenheden og modtager styresignaler fra et eksternt styrested og fortrinsvis også kan sende, hvorved hver omskifterenhed efter modtagelsen af et for denne bestemt til-signal ved hjælp af styreenheden tilkobler det pågældende elektroapparat.

2. Apparat ifølge krav 1, **kendetegnet ved,** at omskifterenheden er således indrettet, at strømmen kun omskiftes for det pågældende elektroapparat eller omskiftes for hele strømkredsløbet, hvormed dette elektroapparat er forbundet, og især er omskifterenheden således indrettet, at den ligesom en normal sikring kan indbygges i sikringskassen og derfra omskifte elektroapparatets strømkreds.

3. Apparat ifølge et af de foregående krav, **kendetegnet ved,** at den mindst ene behovsbestemmelsesenhed sender, behovsinformationen, fortrinsvis via omskifterenheden, til styrestedet.

4. Apparat ifølge et af de foregående krav, **kendetegnet ved,** at omskifterenheden på den ene side kan forbindes med den stikdåse, hvormed elektroapparatet tilsluttes strømnettet, og på den anden side er indrettet til at kunne forbindes med elektroapparatets stik, og strømmen imellem stikdåsen og elektroapparatet omskifter efter modtagelsen af det pågældende omskiftersignal.

5. Apparat ifølge et af de foregående krav, **kendetegnet ved,** at omskifterenheden indeholder mindst en måleenhed, som måler den af elektroapparatet forbrugte energi og først frakobler, når der efter en fastlagt tid ikke mere bruges nogen energi, hvorved foretrukne måleenheder er strømmåleapparater, som måler den strøm, der strømmer igennem elektroapparatet.

6. Fremgangsmåde til integrering af elektriske apparater i et system inden for rammen af demand-side-management, **kendetegnet ved,** at mindst en omskifterenhed, som til- og frakobler strømmen til det pågældende elektroapparat, står i datakontakt med mindst en styreenhed, hvorved styreenheden modtager styresignaler fra et eksternt styrested, som omsætter data, der modtages fra styrestedet til omskiftersignaler, og sender disse via en datakanal til omskifterenheden, og mindst en behovsbestemmelsesenhed bestemmer det energibehov, som forventes af elektroapparatet inden for et bestemt tidsinterval.

7. Fremgangsmåde ifølge krav 6, **kendetegnet ved,** at omskiftersignalet sendes via et datanet til omskifterenheden fra gruppen af kabelunderstøttede netværk og radiobaseret lokalnet, hvorved et sådant netværk også kan bestå af blot en enkel dataforbindelse imellem styreenhed og omskifterenhed, og fortrinsvis sendes omskiftersignalerne via strømledningen, som fører til elektroapparatet.

FIG. 1

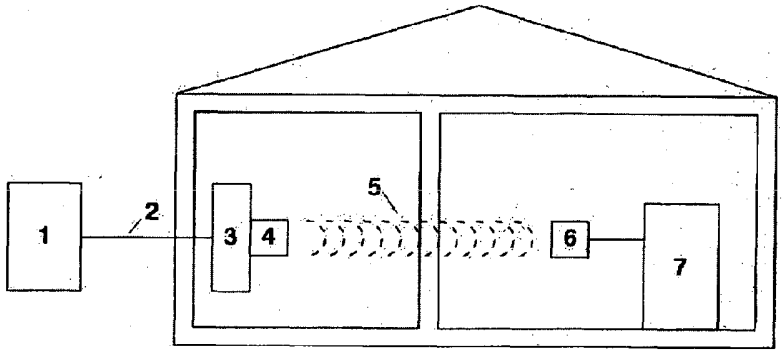

FIG. 2

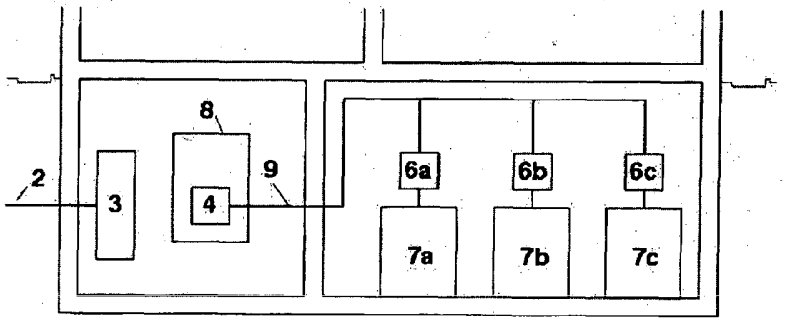

FIG. 3