ELECTRICAL APPLIANCE ENERGY CONSUMPTION CONTROL METHODS AND ELECTRICAL ENERGY CONSUMPTION SYSTEMS

STATEMENT OF GOVERNMENT RIGHTS

This invention was made with Government support under contract DE-AC0676RLO1830 awarded by the U.S. Department of Energy. The Government has certain rights in the invention.

TECHNICAL FIELD

This invention relates to electrical appliance energy consumption control methods and electrical energy consumption systems.

BACKGROUND OF THE INVENTION

Consumption of and reliance upon electrical energy is increasing. Usage of electrical energy is ubiquitous in almost every aspect of life. Businesses, entertainment, communications, etc. are heavily dependent upon electrical energy for fundamental operation. Power distribution systems or grids provide electrical energy to households, businesses, manufacturing facilities, hospitals, etc. Such systems are typically reliable, however, numerous systems employ backup electrical supplies in case of failure of the power distribution system being utilized.

Some electrical power distribution systems are ever-changing dynamic systems and operations are often concerned with balancing generation with load. Frequency of the voltage of the electrical energy may be used as an indicator of variances between generation of electrical energy and usage of electrical energy by loads coupled with the electrical power distribution system. For example, when demand exceeds generation, the frequency of the electrical energy on the electrical power distribution system may drop, and conversely, when there is excess electrical energy available, the frequency increases. Over a given 24 hour period, it is desired to balance energy surplus and deficit so the average frequency is 60 Hz, or other desired frequency.

Typically, control of the state of the electrical power distribution system is implemented by controlling operations of generators coupled with the system. For example, at times of increased demand, the output of generators may be increased and/or other generators may be brought on-line to assist with supplying the electrical energy. In addition, spinning reserves may be utilized to accommodate unexpected significant fluctuations in demand for electrical energy. Provision of spinning reserves is costly, and much of the time, not used.

Some electrical power distribution approaches have been designed to curtail peak loads through the utilization of Demand Side Management (DSM). DSM techniques include direct load control wherein a utility has the ability to curtail specific loads as conditions warrant. In these arrangements, a utility may broadcast a control signal to specific loads when curtailment is desired (e.g., during peak usage periods).

Other electrical power distribution approaches attempt to stabilize bulk-power transmission corridors using external Flexible AC Transmission System (FACTS) devices to improve dynamic performance of transmission systems. FACTS devices, such as Static-Var Compensation (SVC) and Thyristor-Controlled Series Capacitors (TSCSs), are designed to provide stability enhancements allowing transmission facilities to be loaded to levels approaching their ultimate thermal capacity. These devices may supply reactive power to support voltage or provide modulation to damp electromechanical oscillations.

Utilities may use other devices at distribution points (e.g., substations and/or switchyards) to manage electrical power distribution operations. Exemplary management devices include underfrequency and undervoltage relays. These devices may "black out" entire neighborhoods when a grid is in trouble allowing the grid to recover before power is reapplied to the blacked out customers.

Aspects of the present invention provide improved apparatus and methods for supplying electrical energy.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are described below with reference to the following accompanying drawings.

FIG. **1** is a functional block diagram of an electrical power distribution system according to one embodiment.

FIG. **2** is a functional block diagram illustrating a power management device and an appliance according to one embodiment.

FIG. **3** is a functional block diagram of a temperature management system according to one embodiment.

FIG. **4** is a functional block diagram of an HVAC system according to one embodiment.

FIG. **5** is a functional block diagram of a clothes dryer according to one embodiment.

FIG. **6** is a functional block diagram of a clothes washer according to one embodiment.

FIG. **7** is a functional block diagram of a water management system according to one embodiment.

FIG. **8** is a functional block diagram of a dish washer according to one embodiment.

FIG. **9** is a functional block diagram of a personal computer system according to one embodiment.

FIG. **10** is a functional block diagram of a water heater according to one embodiment.

FIG. **11** is a functional block diagram of a refrigerator according to one embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to one aspect of the invention, an electrical appliance energy consumption control method includes providing an electrical appliance coupled with a power distribution system, receiving electrical energy within the appliance from the power distribution system, consuming the received electrical energy using a plurality of loads of the appliance, monitoring electrical energy of the power distribution system, and adjusting an amount of consumption of the received electrical energy via one of the loads of the appliance from an initial level of consumption to an other level of consumption different than the initial level of consumption responsive to the monitoring.

According to another aspect of the invention, an electrical appliance energy consumption control method comprises providing an electrical appliance coupled with a power distribution system, the appliance comprising a plurality of loads, receiving electrical energy within the appliance from the power distribution system, operating the appliance at a normal mode of operation wherein one of the loads consumes a first amount of electrical energy, monitoring an