EFFECTUATING ENERGIZATION AND REACTIVATION OF PARTICULAR CIRCUITS THROUGH RULES-BASED SMART NODES

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ABSTRACT

Systems for reducing power usage and/or wastage use sensors to gather information about a circuit and its usage. Triggers are identified based on the information from the sensors, and subsequently used to control power delivery by reversibly effectuating energization and deactivation of particular circuits through smart nodes.

![Circuit Diagrams](image-url)
FIG. 1
500 Start

502 Generate Sensor Output Signal Conveying Information Related to Power Delivered From the Power Supply to the Alternate Current Circuit

504 Convey Power Information, Related to the Sensor Output Signal, to the User

506 Identify Trigger Events That Comprise Trigger Events Based on the Sensor Output Signal

508 Reversibly Effectuate Energization and Deactivation of the Alternate Current Circuit Based on Trigger Events

Finish

FIG. 5
EFFECTUATING ENERGIZATION AND REACTIVATION OF PARTICULAR CIRCUITS THROUGH RULES-BASED SMART NODES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 14/484,120, filed Sep. 11, 2014 (status: pending), which is a continuation of U.S. patent application Ser. No. 13/019,952, filed Feb. 2, 2011 (which issued as U.S. Pat. No. 8,849,479 B2 on Sep. 30, 2014), each of which is hereby incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

[0002] The invention relates to electrical power management. In particular, the invention relates to controlling and monitoring power delivery to circuits via a smart node.

BACKGROUND OF THE INVENTION

[0003] Typically local power networks (e.g., electrical infrastructure of a building and/or campus) include power lines, circuits, a distribution board, outlets, loads, as well as circuit breaker panels and/or breaker boxes, which lack dynamic functionality. As such, electrical power management may be performed either manually, or with timers located at individual power outlets within the local power network. Power wastage, such as with standby power usage, may account for a significant percentage of power consumption.

SUMMARY OF THE INVENTION

[0004] One aspect of the invention relates to a system and method of dynamically monitoring and managing power distribution at a point of delivery of power to one or more circuits. For example, power distribution may be monitored and/or managed at a circuit breaker panel of a building or set of buildings, or at other locations. In some implementations, the system and/or method may be implemented in a circuit breaker panel of a residential, commercial, and/or military building in a retrofitted manner. The granular monitoring and dynamic management of power distribution described herein may enhance power efficiency, preserve power supply life (e.g., battery life), and/or provide other enhancements over conventional circuit breaker panel configurations.

[0005] A system configured to control power delivery from a power supply to an alternate current circuit may include a sensor, a smart node, a user interface and one or more processors. The alternate current circuit may include a circuit breaker and a load. The processors may be configured to execute one or more of a trigger module, a control module, an interface module, an analysis module, and/or other modules. The power supply may include one or more of a power plant, a power generator, a power storage device, a utility grid, and/or other components. A power supply may be included within the power management system, and/or power may be delivered from a power supply that is external to the power management system.

[0006] The sensor may generate sensor output conveying information related to power delivered from the power supply to the alternate current circuit. The sensor may include one or more sensor units located at or near a circuit breaker in an alternate current circuit (e.g., within a circuit breaker panel), or near a load, and/or at other locations. A generated sensor output signal may correspond to a sensor output value, either of which may be used to determine and/or measure one or more quantifiers of power delivered to the circuit(s) associated with the sensor. The sensor may include one or more of a voltage sensing circuit, a current sensing circuit, a frequency sensing circuit, a power monitoring circuit, a power quality monitoring circuit (i.e. power factor), an energy usage circuit (i.e. kWh/hr), or other circuitry.

[0007] The smart node may use a control signal to control the amount of power provided to an alternate current circuit—or a particular load in that circuit—from the power supply. Controlling the amount of power may include selectively and reversibly energizing and deactivating a node or relay by selectively and reversibly coupling and decoupling a load and/or circuit from the power supply. Controlling the amount of power may include selectively raising, lowering, or switching off the potential, current, total power, and/or other power parameters of the power provided to a load from the power supply through the node or relay. The smart node may be designed to be retrofitted into a conventional circuit breaker panel using manual circuit breakers for managing power surges, and/or other phenomena. Alternatively, and/or simultaneously, the smart node may be installed between a circuit and one or more loads that are electrically connected to the alternate current circuit outside of a circuit breaker panel. Retrofitting conventional circuit breaker panel with a smart node (and a circuit breaker) may provide some or all of the enhancements of monitoring and power management described herein (and/or other enhancements) within a previously manual, relatively static power management system.

[0008] The processor’s executable computer program modules may include a trigger module, a control module, an interface module, an analysis module, and/or other modules. The trigger module may be configured to identify trigger events, including schedule-based events, rule-based events, user command events, and/or other events. Schedule-based events may include events that occur based on a temporal schedule. Schedule-based events may include periodic events and non-periodic events. For example, a periodic schedule-based event may reduce power usage and/or power wastage in a store after store hours, and/or on days that the store is closed. Rule-based events may include events that are triggered based on preconfigured rules that determine whether an event should be triggered as a function of one or more input parameters. As an example, a rule-based event may be triggered responsive to detection that a residential alarm system has been activated, which may indicate there are currently no residents in the residence. User command events may include manual user overrides input by one or more users. As such, user command events may reverse the current, or future, state of a particular node or relay in the absence of a manual override.

[0009] The control module may be configured to generate the control signal that controls the amount of power provided from the power supply to a load and/or circuit. The control signal may be based on trigger events identified by the trigger module, any factors that affect the trigger events, commands received from a user (e.g. via a user interface), information related to sensor output, scheduled programming, and/or other bases. Additional factors that may be considered during the operation of the control module are
safe operating limits and programmable delays for various
trigger events. For example, some critical circuits may never
be completely powered down for safety reasons, regardless
of instructions to the contrary from a user or the trigger
module.

[0010] The interface module may be configured to
exchange information with a user. For example, it may
convey power information to a user, related to power deliv-
ered from the power supply to a circuit and/or a load.
Alternatively, and/or simultaneously, the interface module
may receive user commands from a user that affect operation
of one or more computer program module, circuits, and/or
other components of the power management system.

Conveying information may include processing sensor output,
measuring delivered power, and controlling a user interface
to present and/or display any information to a user. Alter-
atively, the interface module may communicate any infor-
mation to a remote control and/or monitoring device, e.g.
by using an open or proprietary wireless communication pro-
ocol, including those currently used for commercially avail-
able power switching devices.

[0011] The analysis module may be configured to deter-
mine the basis for new trigger events and/or alter—i.e.
fine-tune—the basis for existing trigger events. The power
usage of the various alternate current circuits in a power
management system may exhibit certain patterns. By rec-
ognizing those patterns, power usage and/or power wastage
may be reduced. The analysis module may use a prediction
model to aid pattern analysis.

[0012] Some embodiments of the present technology may
be packaged in an enclosure configured to be mounted in
a circuit breaker panel, e.g. in a retrofitted manner.
Alternatively, only part of a particular embodiment may be pack-
gaged in an enclosure configured to be mounted in a circuit
breaker panel. Communication with and/or within a power
management system may use system and/or component
identifiers, e.g. to distinguish easily between sensor output
from different sensors.

[0013] These and other components, objects, features, and
characteristics of the present invention, as well as the
methods of operation and functions of the related elements
of structure and the combination of parts and economies of
manufacture, will become more apparent upon considera-
tion of the following description and the appended claims
with reference to the accompanying drawings, all of which form
a part of this specification, wherein like reference numerals
designate corresponding parts in the various figures. It is to
be expressly understood, however, that the drawings are for
the purpose of illustration and description only and are not
intended as a definition of the limits of the invention. As
used in the specification and in the claims, the singular form
of “a”, “an”, and “the” include plural refers unless the
context clearly dictates otherwise.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 illustrates an exemplary implementation of
a power management system.

[0015] FIG. 2 illustrates an exemplary implementation of
a smart node.

[0016] FIG. 3 illustrates an exemplary implementation of
a smart node.

[0017] FIG. 4 illustrates an exemplary implementation of
a power management system electrically coupled to a
breaker panel.

[0018] FIG. 5 illustrates an exemplary method for con-
 trolling power delivery to a circuit, in accordance with one
or more embodiments of the present invention.

DETAILED DESCRIPTION OF THE
INVENTION

[0019] FIG. 1 illustrates an exemplary implementation of
a power management system 100. Power management sys-
tem 100 may be configured to control power delivery from
a power supply to a circuit, and may include one or more of
electronic storage 160, bus 150, processor 110, user inter-
face 180, one or more circuits such as circuit 170, circuit
171, and circuit 172, and/or other components.

[0020] Power management system 100 may receive elec-
trical power from at least one power supply. The power
supply, or power supplies, may comprise any source or
sources of electrical power, including the utility grid. For
example, the power supply may include a remote power
generation installation such as a power plant. Such a power
plant may include coal-burning power plant, a nuclear
power plant, and so on. As another example, the power
supply may include a power generator that converts tidal
energy of the ocean into power that is usable within power
management system 100. Additionally or alternatively,
the power supply may include a local power generation instal-
sation such as one or more solar cells that convert electro-
magnetic radiation from the sun to power that is usable
within power management system 100. The power supply
may include a portable generator that operates, for example,
on gasoline. The power supply may include power storage
devices such as batteries and/or capacitive storage devices.
According to some implementations, the power supply may
be contained within power management system 100.

Electrical power may be delivered from the power supply to the
circuits and/or loads via power lines or radio frequency.

[0021] In one embodiment, electronic storage 160 com-
prises electronic storage media that electronically stores
information. The electronically storage media of electronic
storage 160 may include one or both of system storage that
is provided integrally (i.e., substantially non-removable)
with power management system 100 and/or removable
storage that is removable connectable to power manage-
ment system 100 via, for example, a port (e.g., a USB port, a
FireWire port, etc.) or a drive (e.g., a disk drive, etc.).
Electronic storage 160 may include one or more of optically
readable storage media (e.g., optical disks, etc.), magneti-
ically readable storage media (e.g., magnetic tape, magnetic
hard drive, floppy drive, etc.), electrical charge-based stor-
age media (e.g., EEPROM, RAM, etc.), solid-state storage
media (e.g., flash drive, etc.), and/or other electronically
readable storage media. Electronic storage 160 may store
software algorithms, information determined by processor
110, information received via user interface 180, and/or
other information that enables power management system
100 to function properly. Electronic storage 160 may be a
separate component within power management system 100,
or electronic storage 160 may be provided integrally with
one or more other components of power management sys-
tem 100 (e.g., processor 110).

[0022] Processor 110 is configured to provide informa-
tion processing capabilities in power management system 100.
As such, processor 110 may include one or more of a digital
processor, an analog processor, a digital circuit designed to
process information, an analog circuit designed to process

information, a state machine, and/or other mechanisms for electronically processing information. Although processor 110 is shown in FIG. 1 as a single entity, this is for illustrative purposes only. In some implementations, processor 110 may include a plurality of processing units. These processing units may be physically located within the same device, or processor 110 may represent processing functionality of a plurality of devices operating in coordination. For example, in one embodiment, the functionality attributed below to processor 110 is divided between a first processor that is operatively connected to a monitor in a device designed to be portable, or even wearable, by a user, and a second processor that communicates with the portable device at least periodically to obtain information generated by a monitor and further process the obtained information. In this embodiment, the second processor of processor 110 may include a processor provided by a host computer. Processors external to other components within power management system 100 (e.g., the second processor mentioned above) may, in some cases, provide redundant processing to the processors that are integrated with components in power management system 100 (e.g., the first processor mentioned above), and/or the external processor(s) may provide additional processing to determine additional information related to the operation of power management system 100.

[0023] As is shown in FIG. 1, processor 110 may be configured to execute one or more computer program modules. The one or more computer program modules may include one or more of a trigger module 111, an interface module 112, a control module 113, an analysis module 114, and/or other modules. Processor 110 may be configured to execute modules 111, 112, 113, and/or 114 by software; hardware; firmware; some combination of software, hardware, and/or firmware; and/or other mechanisms for configuring processing capabilities on processor 110.

[0024] It should be appreciated that although modules 111, 112, 113, and 114 are illustrated in FIG. 1 as being collocated within a single processing unit, in implementations in which processor 110 includes multiple processing units, one or more of modules 111, 112, 113, and/or 114 may be located remotely from the other modules. The description of the functionality provided by the different modules 111, 112, 113, and/or 114 described below is illustrative for purposes, and is not intended to be limiting, as any of modules 111, 112, 113, and/or 114 may provide more or less functionality than is described. For example, one or more of modules 111, 112, 113, and/or 114 may be eliminated, and some or all of its functionality may be provided by other ones of modules 111, 112, 113, and/or 114. As another example, processor 110 may be configured to execute one or more additional modules that may perform some or all of the functionality attributed below to one of modules 111, 112, 113, and/or 114.

[0025] User interface 180 is configured to provide an interface between power management system 100 and a user through which the user may provide information to and receive information from power management system 100. This enables sensor output values, results, system status information, user commands, instructions, and/or any other communicable items, collectively referred to as “information,” to be communicated between the user and one or more of a monitor, processor 110, and electronic storage 160. Examples of interface devices suitable for inclusion in user interface 180 include a keypad, buttons, switches, a keyboard, knobs, levers, a display screen, a touch screen, speakers, a microphone, an indicator light, an audible alarm, and a printer. In one embodiment, user interface 180 may include a plurality of separate interfaces, including one interface that is provided in a device integral with a monitor, and a separate interface provided to view and/or manage stored information that has been retrieved from the device integrated with said monitor (e.g., provided by a host computer to which information from the monitor and other accompanying components of power management system 100 can be received).

[0026] It is to be understood that other communication techniques, either hard-wired or wireless, are also contemplated by the present invention as user interface 180. For example, the present invention contemplates that user interface 180 may be integrated with a removable storage interface provided by electronic storage 160. In this example, information may be loaded into power management system 100 from removable storage (e.g., a smart card, a flash drive, a removable disk, etc.) that enables the user(s) to customize the implementation of power management system 100. Other exemplary input devices and techniques adapted for use with power management system 100 as user interface 180 include, but are not limited to, an RS-232 port, RF link, an IR link, modem (telephone, cable, Ethernet, internet, or other). In short, any technique for communicating information with power management system 100 is contemplated by the present invention as user interface 180.

[0027] Bus 150 may be configured to transport control signals to a circuit such as circuit 170. Sensor output values from a sensor such as sensor 130 to another component of power management system 100, sensor output values and/or other information to be stored in electronic storage 160, and other control signals and information pertaining to the operation of power management system 100. Control signals and sensor output values may use separate buses, share the same bus, or use point-to-point connections. The depiction of bus 150 in FIG. 1 as a single element will be understood to not be limiting the scope of this disclosure. The connections between components illustrated in FIG. 1 as being embodied in bus 150 may include wired and/or wireless connections.

[0028] Circuit 170 may include a smart node 120, a circuit breaker 145, sensor 130, load 140, and/or other components. Some or all of the components of circuit 170 may be electrically connected to form a circuit, e.g. an AC circuit, a DC circuit, and/or other circuits. Sensor 130 may be associated with smart node 120 and/or circuit 170. Sensor 130 may be configured to generate a sensor output signal conveying information related to power delivered from the power supply to the associated circuit 170. Circuit 171 and circuit 172, depicted in FIG. 1, may include similar or substantially the same components as circuit 170. As such, circuit 171 may include smart node 121, circuit breaker 146, sensor 131 which may be associated with smart node 121 and/or circuit 171, load 141, and/or other components. Similarly, circuit 172 may include smart node 122, circuit breaker 147, sensor 132 which may be associated with smart node 122 and/or circuit 172, load 142, and/or other components.

[0029] Smart node 120 may be configured to be controlled by a control signal originating from control module 113, or any other computer program module of processor 110. For example, smart node 120 may be controlled by user commands received via user interface 180. Smart node 120 may
be controlled to control the amount of power provided to load 140 from the power supply. Controlling the amount of power may include selectively and reversibly energizing and deactivating smart node 120 by selectively and reversibly coupling and decoupling load 140 from the power supply. Controlling the amount of power may include selectively raising, lowering, or switching off the potential, current, total power, and/or other power parameters of the power provided to load 140 from the power supply through smart node 120. Smart node 120 may be designed to be retrofitted into a conventional circuit breaker panel with manual circuit breakers for monitoring or managing power surges, and/or other phenomena. Alternatively, and/or simultaneously, smart node 120 may be installed between a circuit and one or more loads that are electrically connected to the circuit outside of a circuit breaker panel. Retrofitting smart node 120 and circuit breaker 145 into a conventional circuit breaker panel may provide some or all of the enhancements of power management described herein (and/or other enhancements) within a previously manual, relatively static power management system.

Sensor 130 may be located at or near smart node 120, and may be configured to generate a sensor output signal—having a sensor output value—conveying information related to power delivered from the power supply to circuit 170. Sensors such as sensor 130, sensor 131, and sensor 132 may comprise a voltage sensing circuit, a current sensing circuit, or both. Power supply management system 100 may also include a power monitoring circuit, a power quality monitoring circuit, an energy usage circuit, or other circuitry configured to provide power information that may be used to determine and/or measure a level of power delivered to the circuit associated with the sensor. The depiction of sensor 130—or any other sensor in FIG. 1—as a single element will be understood not to be limiting the scope of this disclosure. For example, sensor 130 may comprise multiple circuits monitoring various electrical parameters related to circuit 170, including voltage, current, frequency, energy usage, delivered power, and/or other parameters a power meter commonly monitors, measures, and/or tracks.

Load 140 (and/or load 141 and/or load 142) may include any apparatus (or apparatuses) that requires electrical power to perform at least one functionality attributed thereto. Examples of the loads may include appliances such as HVAC systems and kitchen appliances, lighting fixtures, consumer electronic devices such as computers and stereos, and/or any other apparatus that can be configured to consume electrical power. Some of the loads may be permanently integrated with the local power network. In contrast, some of the loads may be remotely coupled with the local power network. For example, power outlets (e.g., conventional wall outlets, and/or other power outlets) associated with circuit 170 may provide power interfaces at which loads may be remotely coupled with circuit 170. The loads may be controlled in various manners including, but not limited to, turning on, turning off, and/or changing a power level (e.g., brightness for lights, temperature for HVAC systems, and so forth).

Power management system 100 may reduce usage and/or wastage of electrical power, which may occur at one or more levels of the power grid represented by circuits 170, 171, and 172. Local power networks, such as may be found in buildings, homes, and businesses, typically lack the dynamic functionality to manage power distribution effectively at a fine granularity. Power management system 100 may be configured to control power delivery from a power supply to circuit 170 and/or other circuits, e.g., at or near the circuit breaker level by using smart node 120. This granular control may reduce power leakage by deactivating loads during inoperation, reduce power loss in lines between smart node 120 and load 140 when load 140 is not actively in operation, and/or reduce other power loss.

Electrical power is delivered from a power supply to a circuit such as circuit 170 via various network components, including, at some point, a circuit breaker. Replacing a traditional circuit breaker by smart node 120—and associated components and/or (management) systems described herein—provides many advantages.

One or more components of power management system 100 may be communicatively coupled with at least one smart node—e.g., smart node 120—or a constituent component thereof. Alternatively, one or more components of power management system 100 may be communicatively coupled with multiple smart nodes—e.g., smart node 120, smart node 121, and smart node 122—or respective constituent components thereof (e.g., via bus 150 as described above). In some implementations, one or more components of power management system 100 and one or more smart nodes may be integrated as a single device having some or all of the functionalities attributed herein with one or more of the components of a power management system and a smart node.

Sensor output values from smart node 120 may be stored in electronic storage 160, which is depicted in FIG. 1 to be coupled with bus 150. Simultaneously and/or alternatively, sensor output values from any circuit breaker may be communicatively coupled to electronic storage 160 by other means that may or may not require any bus in general or bus 150 in particular.

Regarding the executable computer program modules of processor 110 in FIG. 1, trigger module 111 may be configured to identify trigger events. Trigger events may be events that trigger one or more parameters of the operation of one or more of smart nodes 120, 121, and/or 122 to be adjusted, optionally through and/or via other computer program modules, e.g., control module 113. Trigger events may include schedule-based events, rule-based events, user command events, and/or other events.

Schedule-based events may take into account scheduling criteria, planning requirements, time and/or date. For example, certain businesses may adhere to a particular holiday schedule when offices are closed. Schedule-based events may take place periodically (e.g., daily, monthly, weekly, yearly), based on individually planned events or activities (e.g., a party, meeting, a game, and/or other events or activities), and/or based on other events that are scheduled.

Rule-based events may take into account events that are internal to power management system 100, such as particular levels of sensor output signals as compared to power usage thresholds, or activation of one or more of circuits such as circuit 170. Alternatively and/or simultaneously, rule-based events may be external to power management system 100, such as a power usage pattern of other systems that draw power from the power supply. For example, a residential power management system may respond to the detection of a garage door opening by energizing a specific set of other circuits (e.g., circuits with
loads likely to be used by a user returning home). As another example, a security system in a building may be aware which floors appear to be currently empty, and provide such information to the power management system in order to prevent power wastage. This type of rule-based event may cause power management system 100 to de-activate circuits associated with floors that appear to be empty. Rule-based events may be based on programmed rules and/or on rules developed based on usage patterns. A usage pattern or scenario may be previously stored or programmed, and/or developed by analyzing power usage over time. A rule could take prior sensor output values into account, or prior usage averages, which may be stored in and retrieved from electronic memory 160 via bus 150. A rule could be based on external information and/or any other factors. For example, a rule could evaluate how many monitors in an office are powered down, and prevent power wastage based on that information. As another example, a usage pattern or scenario may develop over time for a residential local power network whenever multiple football games are broadcasted. Perhaps, in this example, multiple television-sets use power in one area of a residence, in addition to a hot tub elsewhere in the residence. In this scenario, power wastage related to other loads may be probable, and reducible. A usage pattern need not be explicitly programmed to be a trigger event.

[0039] User command events may include business rules, optimization parameters, manual overrides, and/or other factors. User commands may be received via user interface module 112. A user command may simply force a particular circuit to be activated or deactivated. Alternatively, a user command may specify that all circuits matching some criteria are to be activated or deactivated. Criteria may be based on power usage levels, location, and/or any other distinguishing features.

[0040] Different types of trigger events may also be combined. For example, schedule-based and rule-based triggers may be combined: on particular week-days, a low power usage level indicated by sensor 130, combined with a low power usage level indicated by sensor 132, may signify, according to some rule, that power wastage in all three circuits shown in FIG. 1 may be reduced by reversibly effectuating deactivation through smart node 120, smart node 121, and smart node 122. Various basic trigger events, from the same and/or different event trigger types, may be combined to create more complex trigger events.

[0041] Interface module 112 may be configured to convey power information to a user, related to power delivered from the power supply to circuit 170 and/or any other circuits. The power information may be based on sensor output values from sensor 130. Conveying power information may include processing sensor output signals and/or values, measuring delivered power, and controlling user interface 180 to present and/or display any information to a user. Alternatively, interface module 112 may communicate any information to a remote control and/or monitoring device, e.g. by using an open or proprietary wireless communication protocol, including those currently used for commercially available power switching devices.

[0042] Alternatively, and/or simultaneously, interface module 112 may be configured to receive user commands that affect operation of one or more computer program modules, circuits, and/or other components of power management system 100.

[0043] Control module 113 may be configured to control the amount of power provided from the power supply to load 140 and/or other loads. For example, with regard to circuit 170, controlling the amount of power may include selectively and reversibly energizing and deactivating smart node 120 by selectively and reversibly coupling and decoupling load 140 from the power supply. Controlling the amount of power may include selectively raising, lowering, or switching off the potential, current, total power, and/or other power parameters of the power provided to load 140 from the power supply through smart node 120. Operation of control module 113 may be based on trigger events identified by trigger module 111 and/or the factors that affect the trigger events. Additional factors that may be considered during the operation of the control module are safe operating limits and programmable delays for various trigger events. In some embodiments, a control signal may be based on commands received from the user via interface module 112 and/or other information.

[0044] Analysis module 114 may be configured to determine the basis for new triggers events and/or after the basis for existing trigger events by analyzing multiple sensor output values, either simultaneously or across a period of time, optionally augmented by using external information including time, date, and/or other factors. Analysis module 114 may use trigger events as input from trigger module 111. Alternatively, and/or simultaneously, analysis module 114 may generate or adapt rules for use by trigger module 111, and/or directly affect operation of control module 113.

[0045] Analysis module 114 may use a prediction model. For example, power usage in an office building may be significantly reduced during the weekend, or during holidays, or shortly after extreme weather conditions. Should a user override a deactivation effectuated based on a trigger originating from the prediction model, this override information may be added—e.g. heuristically—to the prediction model used by analysis module 114. The prediction model may use different levels of aggressiveness in its attempts to reduce power wastage. Over time, analysis module 114 may become better tuned to the power usage patterns associated with a particular set of circuits within a power management system.

[0046] Information processing and/or manipulation may be performed at various or multiple levels in a local power network and/or power management system 100, with varying degrees of autonomy or user interaction. Fully automated control of power delivery is contemplated, to the extent possible after initial configuration, by the present technology.

[0047] Some constituent components of the power management system may be located remotely relative to the local power network, for example, within a computing device. Smart nodes may be assigned an identifier, such as a unique number, that may be used to facilitate communication within power management system 100, or externally with the user.

[0048] FIG. 2 illustrates an exemplary implementation 200 of a smart node. A smart node, such as smart node 120 in FIG. 1, may be installed in a standard circuit breaker panel, provided that at least part of the smart node is packaged in an enclosure configured to be mounted in a circuit breaker panel. Sample of such enclosures are shown in FIG. 2 and FIG. 3. The specification of the relevant characteristics of a standard circuit breaker panel may be
obtained from organizations like the International Electrotechnical Commission (IEC). See e.g. IEC Standard 60755. Wires 210 may be designed to fit a standard residential circuit breaker panel. Housing 220 may be designed such that multiple smart nodes fit side-by-side in a standard residential circuit breaker panel, as further illustrated in FIG. 4.

[0049] FIG. 3 illustrates an exemplary implementation 300 of a smart node, such as smart node 120 in FIG. 1. Wires 310 may be designed to fit a standard (residential) circuit breaker panel. Additionally, FIG. 3 illustrates interface 320 that may communicatively couple a smart node to other components in power management system 100 of FIG. 1, as further illustrated in FIG. 4.

[0050] FIG. 4 illustrates an exemplary implementation 400 of a power management system electrically coupled to a breaker panel. Smart node 430, which may be substantially similar to or the same as smart node 120 in FIG. 1, replaces a standard circuit breaker in one slot of a standard breaker panel. Multiple smart nodes may be coupled with information interface 420 to a breaker box 410, which may include a processor substantially similar to or the same as processor 110 from FIG. 1, electronic storage substantially similar to or the same as electronic storage 160 from FIG. 1, and optionally a bus substantially similar to or the same as bus 150 from FIG. 1. Breaker box 410, information interface 420, and the various smart nodes in FIG. 4 form a system substantially similar to power management system 100 as depicted schematically in FIG. 1.

[0051] FIG. 5 illustrates an exemplary method 500 for monitoring and controlling power delivery to a circuit, in accordance with one or more embodiments of the present invention. The operations of method 500 presented below are intended to be illustrative. In some embodiments, method 500 may be implemented in one or more processing devices (e.g., a digital processor, an analog processor, a digital circuit designed to process information, an analog circuit designed to process information, a state machine, and/or other mechanisms for electronically processing information). The one or more processing devices may include one or more devices executing some or all of the operations of method 500 in response to instructions stored electronically on an electronic storage medium. The one or more processing devices may include one or more devices configured through hardware, firmware, and/or software to be specifically designed for execution of one or more of the operations of method 500.

[0052] In some embodiments, method 500 may be implemented in one or more processing devices (e.g., a digital processor, an analog processor, a digital circuit designed to process information, an analog circuit designed to process information, a state machine, and/or other mechanisms for electronically processing information). The one or more processing devices may include one or more devices executing some or all of the operations of method 500 in response to instructions stored electronically on an electronic storage medium. The one or more processing devices may include one or more devices configured through hardware, firmware, and/or software to be specifically designed for execution of one or more of the operations of method 500.

[0053] At an operation 502, a sensor output signal is generated conveying information related to power delivered from the power supply to an AC circuit. In one embodiment, operation 502 is performed by a sensor substantially similar to or the same as sensor 130 (shown in FIG. 1 and described above) under the control of a control module substantially similar to or the same as control module 113 (shown in FIG. 1 and described above).

[0054] At an operation 504, power information—related to sensor output values—is conveyed to the user. In one embodiment, operation 504 is performed by a interface module substantially similar to or the same as interface module 112 (shown in FIG. 1 and described above) under the control of a control module substantially similar to or the same as control module 113 (shown in FIG. 1 and described above).

[0055] At an operation 506 a trigger event is identified comprising the sensor output signal. In one embodiment, operation 506 is performed by a trigger module substantially similar to or the same as trigger module 111 (shown in FIG. 1 and described above) under the control of a control module substantially similar to or the same as control module 113 (shown in FIG. 1 and described above).

[0056] At an operation 508 energization and deactivation of the circuit is reversibly effected based on the trigger signal. In one embodiment, operation 508 is performed by a control module substantially similar to or the same as control module 113 (shown in FIG. 1 and described above).

[0057] Although the invention has been described in detail for the purpose of illustration based on what is currently considered to be the most practical and preferred embodiments, it is to be understood that such detail is solely for that purpose and that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover modifications and equivalent arrangements that are within the spirit and scope of the appended claims. For example, it is to be understood that the present invention contemplates that, to the extent possible, one or more features of any embodiment can be combined with one or more features of any other embodiment.

What is claimed is:

1. An electrical system that controls power delivery from a power supply to one or more loads, the electrical system comprising:
   - storage that stores processor-executable instructions;
   - a processor that executes the processor-executable instructions;
   - a first circuit of the one or more circuits, the first circuit comprising:
     - a first node that controls an amount of power from a power supply delivered to a first load in accordance with control signals from the processor; and
     - a first sensor that monitors power delivery to the first load via the first node; and
   - a first enclosure configured to be mounted in a circuit breaker panel, the first node and the first sensor packaged in the first enclosure;
   - wherein the processor-executable instructions configure the processor to:
     - receive first information from the first sensor related to power delivered to the first load;
     - analyze power usage of the one or more circuits to determine power usage patterns of the one or more circuits, based at least in part on the first information from the first sensor, and
     - create new rules and/or adapt existing rules based on the determined power usage patterns of the one or more circuits, wherein a first rule is created and/or adapted based on a power usage pattern of the first circuit;
     - identify trigger events, wherein the trigger events comprise a first trigger event identified based on application of the first rule, and
     - transmit the control signals based on the trigger events, wherein the control signals convey a first instruction...
to the first node to control the amount of power delivered to the first load based on the first trigger event.

2. The electrical system of claim 1, wherein the first sensor comprises one or more of a voltage sensing circuit, a current sensing circuit, a frequency sensing circuit, a power monitoring circuit, an energy usage monitoring circuit, and a power quality monitoring circuit.

3. The electrical system of claim 1, wherein the first circuit further comprises a circuit breaker connected in series between the first node and the first load, the first enclosure also packaging the circuit breaker.

4. The electrical system of claim 1, wherein controlling the amount of power comprises raising or lowering potential, current, and/or total power delivered to the first load.

5. The electrical system of claim 1, wherein controlling the amount of power comprises reversibly coupling and decoupling the first load to the power supply.

6. The electrical system of claim 1, wherein the first node comprises a relay.

7. The electrical system of claim 1, further comprising: a second circuit of the one or more circuits, the second circuit comprising:
   a second node that controls an amount of power from the power supply delivered to a second load in accordance with the control signals from the processor; and
   a second sensor that monitors power delivery to the second load via the second node; and
a second enclosure configured to be mounted in the circuit breaker panel, the second node and the second sensor packaged in the second enclosure;
wherein the processor further analyzes power usage based on second information from the second sensor, and the first rule is created and/or adapted further based on the power usage of the second circuit.

8. The electrical system of claim 1, wherein the processor-executable instructions further configure the processor to:
generate a second trigger event based on the command, wherein the control signals further convey a second instruction to the first node to control the amount of power delivered to the first load based on the second trigger event.

9. The electrical system of claim 1, wherein the processor-executable instructions further configure the processor to:
receive a command via a user interface to override the first instruction to the first node; add occurrence of the override to a prediction model used by the processor to analyze the power usage of the one or more circuits to determine the usage patterns; and
adjust the first trigger event, based on the prediction model after adding the occurrence of the override.

10. The electrical system of claim 1, wherein the processor-executable instructions to identify trigger events further configure the processor to identify a second trigger event based on a power usage threshold for power delivered from the power supply to the first circuit.

11. The electrical system of claim 1, wherein the processor-executable instructions to identify trigger events further configure the processor to identify a second trigger event based on detection of an event external to the electrical system.

12. The electrical system of claim 1, wherein the first instruction to the first node to control the amount of power delivered to the first load is based on the first trigger event in combination with a schedule-based trigger.

13. The electrical system of claim 1, wherein the first enclosure is configured to fit in a slot for a circuit breaker in the circuit breaker panel, the circuit breaker panel being of a standards-based design for mounting circuit breakers.

14. The electrical system of claim 1, wherein the processor communicates with the first circuit using a wireless communication protocol.

15. The electrical system of claim 1, wherein the first circuit is an alternating current (AC) circuit.

16. The electrical system of claim 1, wherein the first circuit is a direct current (DC) circuit.