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(54) **APPARATUS AND METHOD FOR DETERMINING LOAD OF ENERGY CONSUMING APPLIANCES WITHIN A PREMISES**

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(63) Continuation-in-part of application No. 13/370,095, filed on Feb. 9, 2012, which is a continuation-in-part of application No. 13/005,306, filed on Jan. 12, 2011, Continuation-in-part of application No. 29/417,233, filed on Mar. 30, 2012, now Pat. No. D,672,666.

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CPC .................................. ***F24F 11/0086*** (2013.01)
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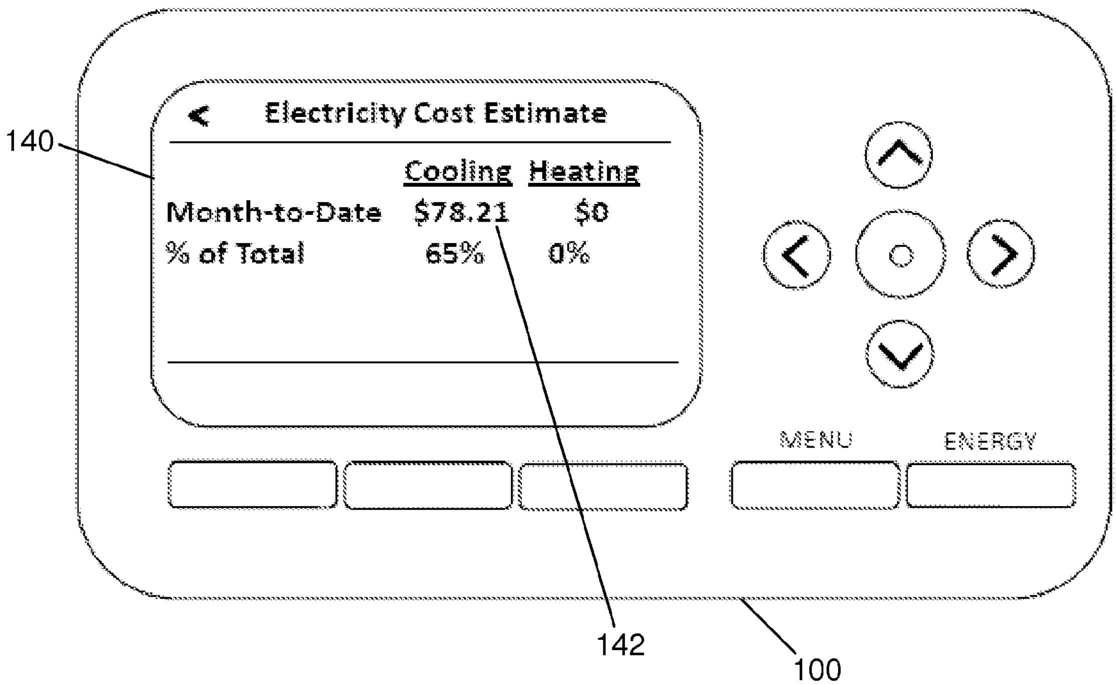
(57) **ABSTRACT**

Disclosed herein are exemplary embodiments of apparatus and methods for determining and/or monitoring load of energy consuming appliances within a premises. In an exemplary embodiment, there is a thermostat for monitoring energy consumption associated with an HVAC unit having a compressor. The thermostat is configured to communicate information on energy consumption and/or information on duration of time of operation associated with the HVAC unit to a user. In another exemplary embodiment, there is a system for monitoring energy consumption for an energy consuming load in a premises that is supplied with power monitored by a utility meter. A gateway is in connection with the controller for enabling connection via the internet to a website. At least one of the gateway and the controller is configured to communicate information on energy consumption associated with the energy consuming load to an energy service provider and/or a consumer.



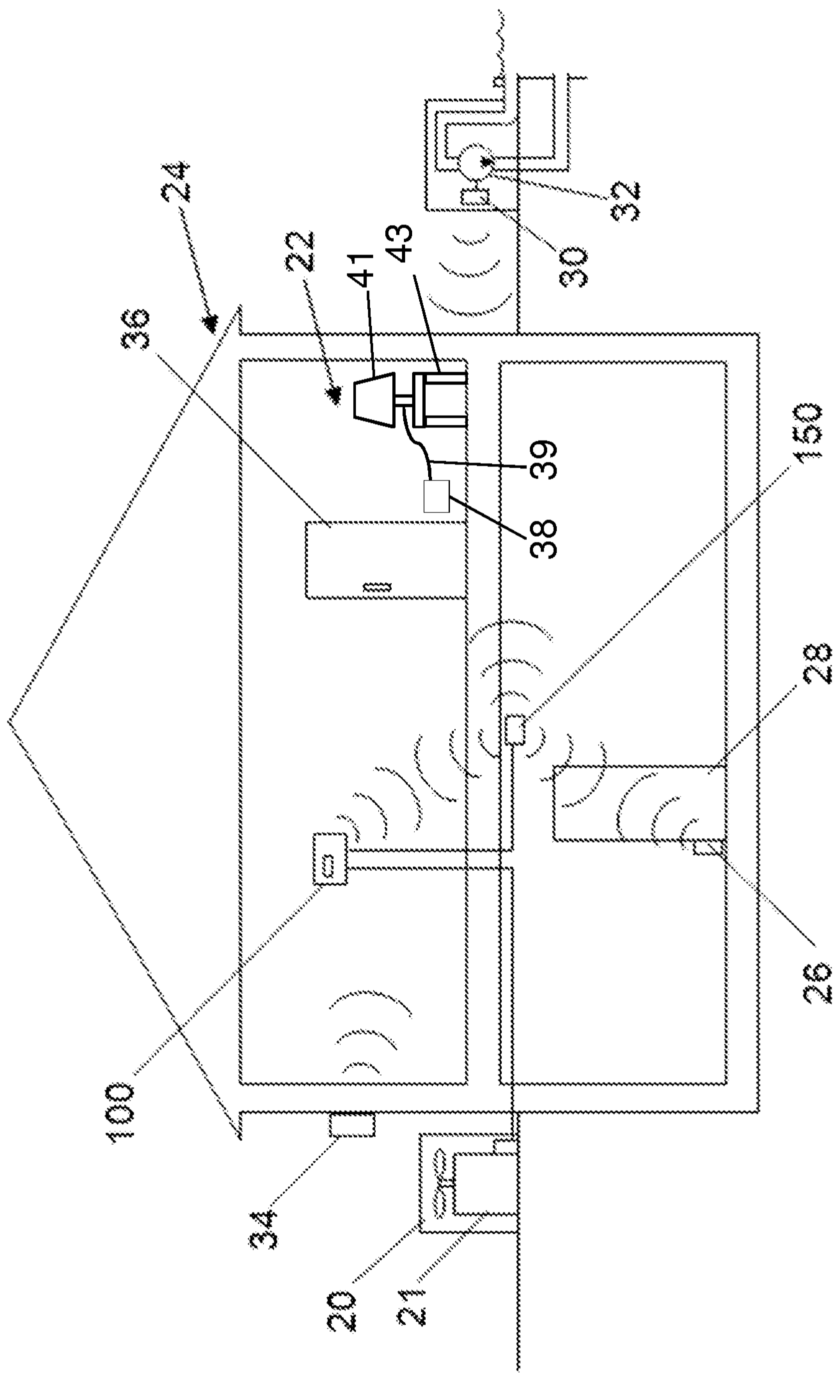



FIG. 1

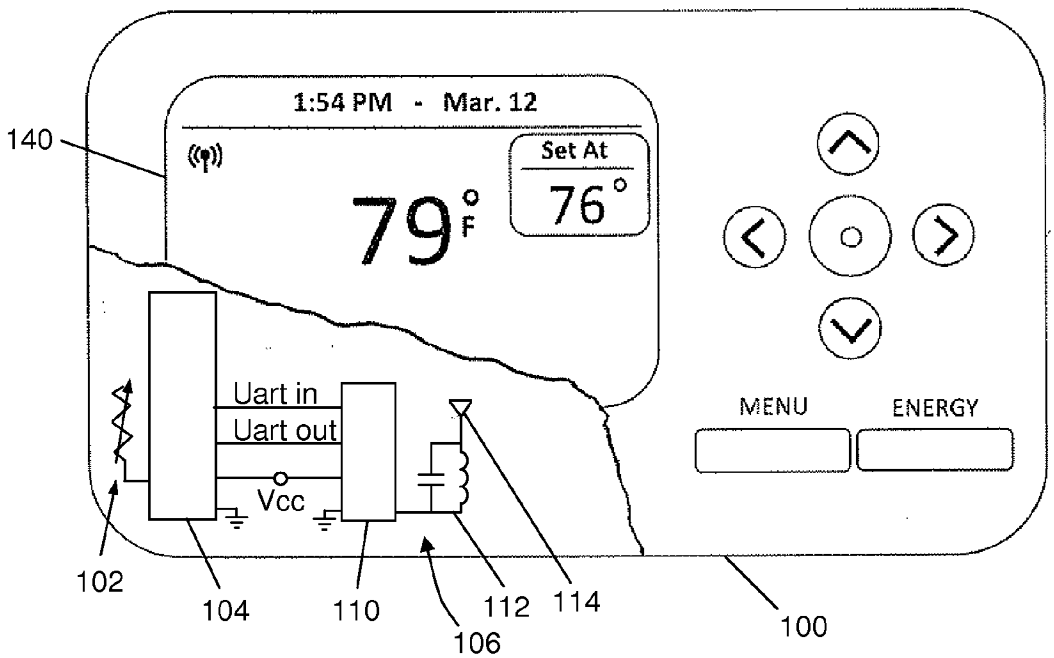

1:54 PM - Mar. 12
140
Set At
76°
79°F
MENU
ENERGY
Uart in
Uart out
Vcc
102
104
110
106
112
114
100

FIG. 2

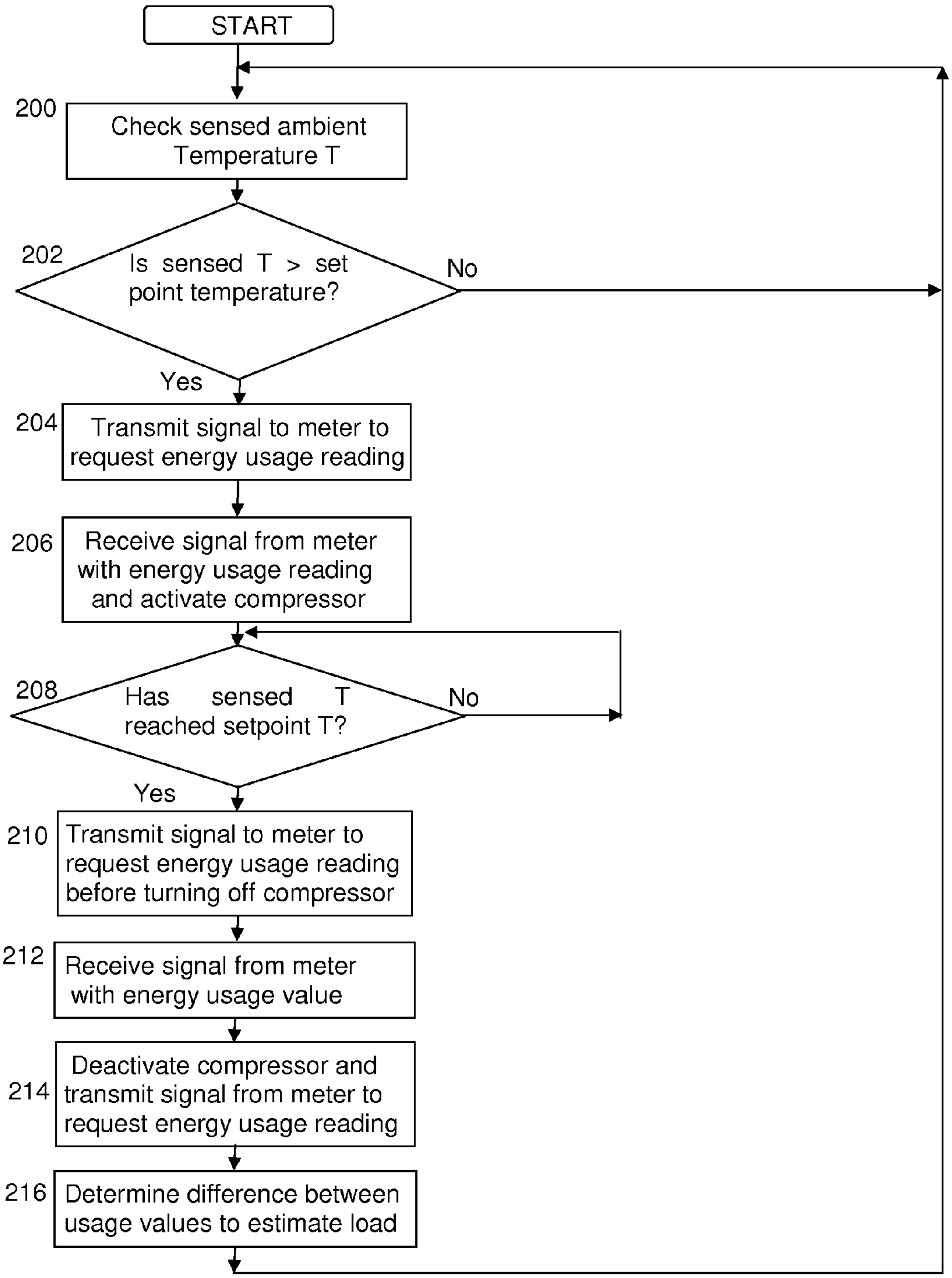
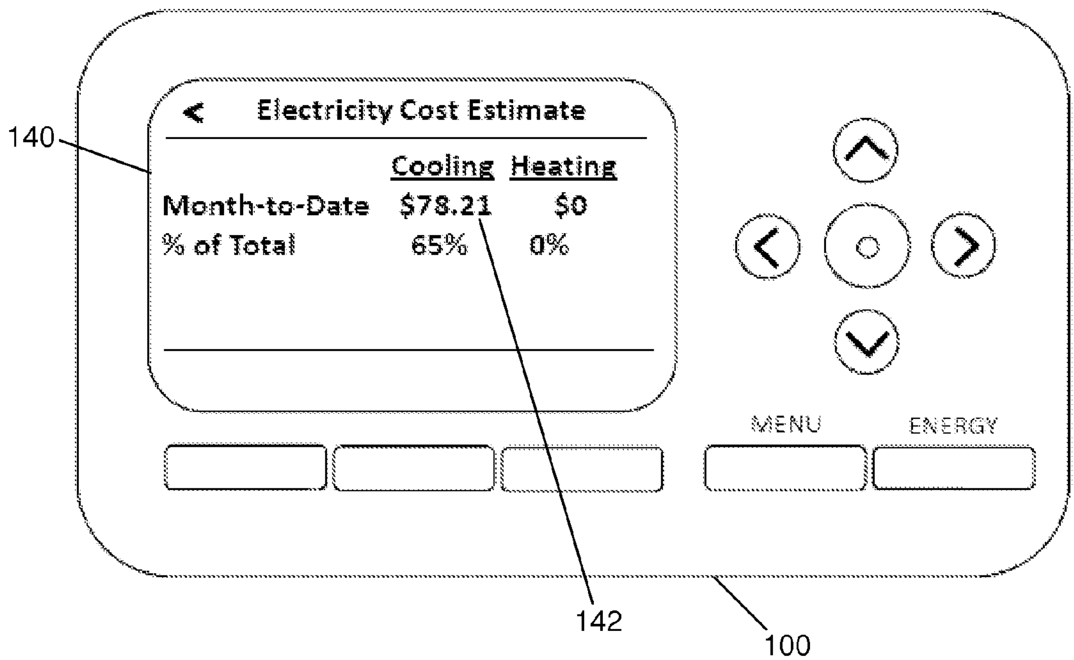

START
200
Check sensed ambient Temperature T
202
Is sensed T > set point temperature?
No
Yes
204
Transmit signal to meter to request energy usage reading
206
Receive signal from meter with energy usage reading and activate compressor
208
Has sensed T reached setpoint T?
No
Yes
210
Transmit signal to meter to request energy usage reading before turning off compressor
212
Receive signal from meter with energy usage value
214
Deactivate compressor and transmit signal from meter to request energy usage reading
216
Determine difference between usage values to estimate load

FIG. 3



140
Electricity Cost Estimate
Cooling
Heating
Month-to-Date
$78.21
$0
% of Total
65%
0%
MENU
ENERGY
142
100


FIG. 4

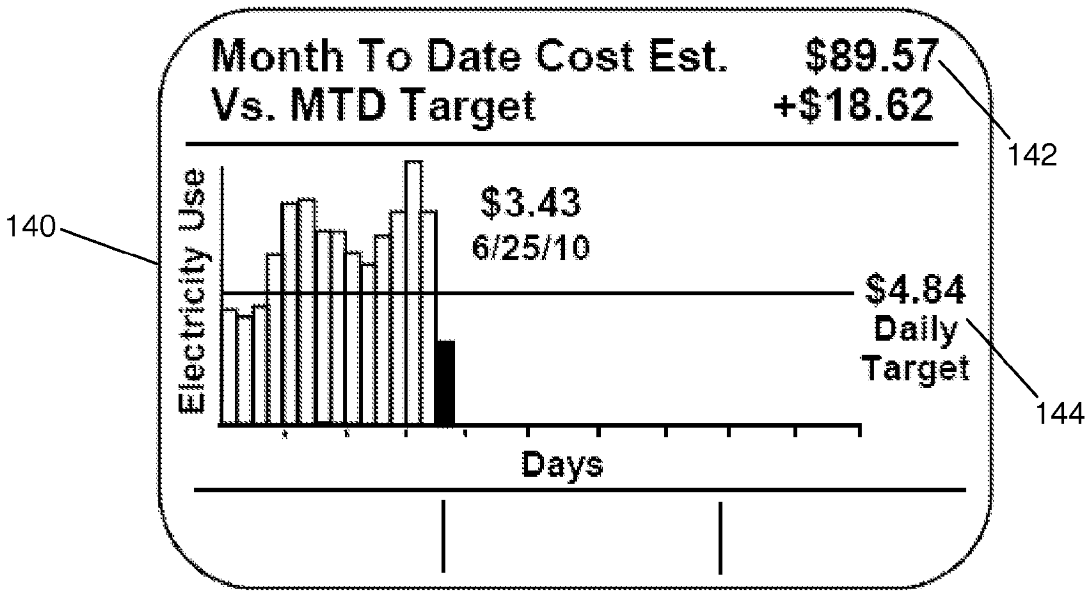

Month To Date Cost Est.
$89.57
Vs. MTD Target
+$18.62
142
140
Electricity Use
$3.43
6/25/10
$4.84
Daily
Target
144
Days

FIG. 5

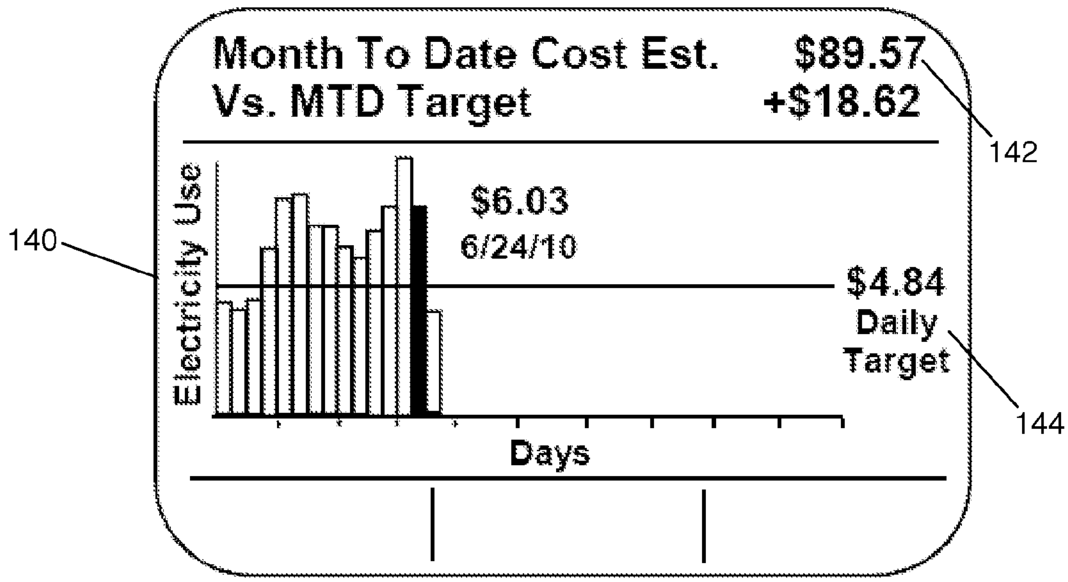
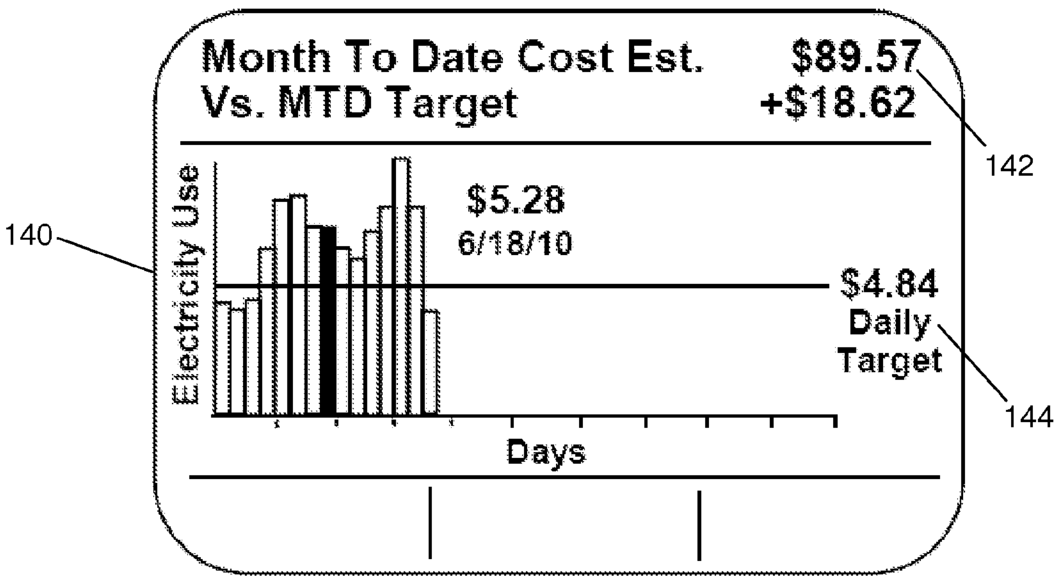

Month To Date Cost Est.
$89.57
Vs. MTD Target
+$18.62
142
140
Electricity Use
$6.03
6/24/10
$4.84
Daily
Target
144
Days

FIG. 6



Month To Date Cost Est.
$89.57
Vs. MTD Target
+$18.62
142
140
Electricity Use
$5.28
6/18/10
$4.84
Daily
Target
144
Days


FIG. 7

# APPARATUS AND METHOD FOR DETERMINING LOAD OF ENERGY CONSUMING APPLIANCES WITHIN A PREMISES

## CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is also a continuation-in-part of U.S. patent application Ser. No. 13/005,306 filed Jan. 12, 2011.

[0002] This application is also a continuation-in-part of U.S. patent application Ser. No. 13/370,095 filed Feb. 9, 2012, which, in turn, is a continuation-in-part of U.S. patent application Ser. No. 13/005,306 filed Jan. 12, 2011.

[0003] This application is also a continuation-in-part of U.S. Design patent application No. 29/440,051, which issued as U.S. Design Pat. No. D699,130 on Feb. 11, 2014. U.S. Design patent application No. 29/440,051 was a continuation-in-part of:

[0004] U.S. Design patent application No. 29/417,233 filed Mar. 30, 2012 (now U.S. Design Pat. No. D672,666); and

[0005] U.S. patent application Ser. No. 13/370,095 filed Feb. 9, 2012; and

[0006] U.S. patent application Ser. No. 13/005,306 filed Jan. 12, 2011.

[0007] The entire disclosures of the above applications are incorporated herein by reference.

## FIELD

[0008] The present disclosure relates to thermostats for controlling operating of a heat-pump or air-conditioning unit, which thermostats may be configured to provide demand side management to an electric utility provider.

## BACKGROUND

[0009] This section provides background information related to the present disclosure which is not necessarily prior art.

[0010] As the demand for electrical power increases during the day, the utility provider experiences an increase in the cost of generating electrical power as a result of secondary peak power plants that are switched on to supplement off-peak power generating plants. Many utility providers establish demand response programs to reduce energy demand as an alternative to building more plants.

[0011] In situations where the peak demand begins to exceed the capacity of the utility provider's peak and off-peak power plants, the utility provider may engage in demand side management. This may include curtailing operation of air-conditioning units to reduce demand for electrical power during peak demand periods in an effort to keep energy demand from exceeding capacity.

[0012] Utility providers engaging in demand side management may transmit a signal to a thermostat to control an air-conditioning unit to reduce the amount of energy used in peak demand periods. But the utility provider may have little idea about how much load it is reducing by setting back a temperature setting or shutting off random air-conditioning units, and thus may not succeed in actually curbing energy consumption despite its efforts.

## SUMMARY

[0013] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0014] Disclosed herein are exemplary embodiments of apparatus and methods for determining and/or monitoring load of energy consuming appliances within a premises. In an exemplary embodiment, there is a thermostat for monitoring energy consumption associated with an HVAC unit having a compressor. The thermostat is configured to communicate information on energy consumption and/or information on duration of time of operation associated with the HVAC unit to a user.

[0015] In another exemplary embodiment, there is a system for monitoring energy consumption for an energy consuming load in a premises that is supplied with power monitored by a utility meter. A gateway is in connection with the controller for enabling connection via the internet to a website. At least one of the gateway and the controller is configured to communicate information on energy consumption associated with the energy consuming load to an energy service provider and/or a consumer.

[0016] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

## DRAWINGS

[0017] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0018] FIG. **1** is an illustration of a premises including one or more controllers configured to determine an estimate of the energy consumption level associated with one or more energy consuming appliances for a premises;

[0019] FIG. **2** is a schematic illustration of exemplary embodiment of a thermostat configured to determine an estimate of the energy consumption level associated with a heat-pump or air-conditioning unit in accordance with the present disclosure;

[0020] FIG. **3** is a flow chart illustrating operation of the exemplary embodiment of the thermostat shown in FIG. **1** in accordance with the present disclosure;

[0021] FIG. **4** illustrates the exemplary embodiment of the thermostat shown in FIG. **1** displaying a cost estimate for energy consumed by an appliance;

[0022] FIG. **5** shows the thermostat in FIG. **4** displaying a graph of daily energy consumption for an appliance; and

[0023] FIGS. **6** and **7** show the thermostat in FIG. **4** displaying selection of a given day within the graph of daily energy consumption for an appliance.

[0024] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

## DETAILED DESCRIPTION

[0025] Example embodiments will now be described more fully with reference to the accompanying drawings.

[0026] Various exemplary embodiments are disclosed herein of control systems, apparatus, or controllers for determining energy consumption levels or loads of energy consuming appliances and devices. In an exemplary embodiment, a controller (e.g., thermostat, etc.) is in communication with one or more energy consuming loads or appliances for a premises, such as an HVAC unit including heat-pump or air-conditioning components, an electric water heater, a refrigerator, a pool pump, etc. The controller includes a processor configured to receive energy consumption information from a utility meter for the premises prior to activation of a compressor of an HVAC unit and subsequent to activation of the compressor. The processor is further configured to estimate the energy consumption of the HVAC unit based at least in part upon the difference between the energy consumption prior to activation and subsequent to activation of the compressor.

**[0027]** In another exemplary embodiment in which a controller is in communication with one or more energy consuming loads or appliances for a premises, the controller includes a transmitter device for transmitting wireless signals to a utility meter to request an energy consumption reading. Also in this example, the controller includes a receiver device to receive wireless signals including energy consumption information. The controller is configured to receive a signal from an energy consuming appliance indicating the appliance was actuated, and to responsively transmit a signal to the utility meter to request an energy consumption reading, and thereafter receive a signal including an energy consumption value. The controller is also configured to transmit a signal to the utility meter to request an energy consumption reading following deactivation of the appliance, and to thereafter receive a signal from the utility meter including another energy consumption value. The controller is further configured to determine from a difference between the energy consumption values an estimate of the energy consumption level associated with the appliance.

**[0028]** According to another aspect of the present disclosure, exemplary embodiments of thermostats are disclosed for monitoring energy consumption associated with HVAC units having electrically powered compressors. In an exemplary embodiment, a thermostat includes a sensor operable to provide an output indicative of a temperature within a space of a premises. The thermostat also includes a processor for controlling activation of at least the compressor of the HVAC unit to control the temperature in the space relative to a desired set-point temperature. The processor is configured to receive energy consumption information from a utility meter for the premises prior to activation of the compressor and subsequent to activation of the compressor. The processor is further configured to estimate the energy consumption of the HVAC unit based at least in part upon the difference between the energy consumption prior to activation and subsequent to activation of the compressor. The thermostat further includes a display operable to display an indication of the energy consumption for the HVAC system based at least in part upon the estimate. Accordingly, this exemplary thermostat may thus display energy consumption of an HVAC unit or other appliance in communication with the thermostat or a gateway connected to the thermostat

**[0029]** In various exemplary embodiments of the present disclosure, controllers are disclosed that are operable for determining an estimate of the energy consumption associated with one or more energy consuming loads or appliances for a premises. This, in turn, may provide value in understanding how consumer behavior impacts energy consumption. With an estimate of the energy consumption, a consumer may make a more informed decision (e.g., turning off heating or air conditioning at night during sleeping house or prior to going away on vacation, etc.).

**[0030]** Also disclosed herein are exemplary embodiments of thermostats having display devices and processors. In an exemplary embodiment, a thermostat includes a processor configured to receive a signal including energy consumption information (e.g., energy consumption values, etc.). For example, the thermostat may include a receiver device to receive wireless signals including energy consumption information provided by a utility or energy provider, a sensor device for sensing current and/or voltage to an appliance, another energy monitoring sensor device that transmits signals including energy consumption information, etc. The thermostat's processor is further configured to control the display device to display a graph indicating an estimated cost of energy consumed for each day within a given month. The thermostat is configured to allow a user to select a day within the given month to view the estimated cost for that selected day. Accordingly, the thermostat may thus display an estimate of energy consumption associated with one or more energy consuming loads or appliances for a premise.

**[0031]** With reference now to the figures, FIG. **1** illustrates an exemplary embodiment of a thermostat **100** embodying one or more aspects of the present disclosure. In operation, the thermostat **100** may be used for determining the energy consumption level of a heat-pump or air-conditioning unit **20**. As shown in FIG. **1**, the thermostat **100** is connected to (or in communication with) the heat-pump or air-conditioning unit **20** (also generally referred to herein as HVAC unit or appliance) for heating or cooling a space **22** in a premises **24**. The thermostat **100** may also be connected to or in communication with other system controllers. For example, and as shown in FIG. **1**, the thermostat **100** is in communication with a controller **26** for an electric water heater **28** and a pump controller **30** for a pool water pump **32**. In other exemplary embodiments, the thermostat **100** may be in communication with additional or different controllers.

**[0032]** Also shown in FIG. **1**, the thermostat **100** may further be connected to a gateway **150** (or an ESI device) for enabling connection via the internet to a website. In this example, the gateway **150** is also shown in communication with a plurality of energy consuming appliances or loads, including the thermostat **100**, electric water heater **28**, pool water pump **32**, and refrigerator **36**. In other exemplary embodiments, the gateway **150** may also be in communication with additional or different energy consuming appliances or loads, such as a media center, etc.

**[0033]** A utility meter **34** is associated with the premises **24** in which the thermostat **100** is disposed. The utility meter **34** may be a utility meter with Advanced Metering Infrastructure (AMI), which can transmit wireless signals that include energy consumption information. Energy consumption information may comprise, for example, the rate of power usage (expressed in kilowatts for example) or the amount of energy or power used (expressed as kilowatt-hours, for example) as explained below.

**[0034]** By way of background, operating a compressor of an HVAC system requires electrical energy, which is usually measured and expressed in watt-hours. A watt is an electrical unit of power that is the rate of energy transfer. Thus, the rate of energy transferred to or used while operating the compressor is the power to the compressor that may be expressed in units of kilowatts. A watt-hour is an electric energy unit of measure equal to 1 watt of power supplied to, or used by, a load steadily for 1 hour. Thus, the energy consumption of a compressor over a period of time may be expressed in units of kilowatt-hours. The cumulative energy consumption expressed in units of kilowatt-hours may be determined from the product of the rate of energy usage expressed in kilowatts (e.g., power) and the duration of time that the compressor operated (e.g., hours), to arrive at a kilowatt-hour amount of energy consumed by a compressor over a period of time. Accordingly, energy consumption information (as used herein) may comprise power (expressed in kilowatts) as well as power consumed over a time period (expressed in kilowatt-hours).

**[0035]** The energy consumption information communicated by an electric utility meter may instead be provided or expressed in one or more forms. For example, the energy consumption reading may be a cumulative running total of the kilowatt-hours consumed for the premises. The difference between two such successive readings of kilowatt-hours used over a given time interval can be used to determine an amount of energy consumption (expressed as kilowatt-hours) for the time between the successive readings. The utility meter may also communicate energy consumption information that is representative of the present rate of energy usage (or power) expressed in kilowatts. The energy consumption expressed as kilowatt-hours may be determined from the product of the rate of energy usage (kilowatts) and the duration of time of operation (hours). Thus, the energy consumption of a compressor may be determined from the rate of energy usage expressed in kilowatts (e.g., power) and the duration of time that the compressor operated, to arrive at a kilowatt-hour amount of energy consumed by the compressor. With either form of energy consumption information provided by a utility meter (kilowatts or kilowatt-hours), it is possible to determine an estimate of the energy consumption for a period of operation of a compressor for a heat-pump/air-conditioning unit.

**[0036]** Referring now to FIG. **2**, the illustrated thermostat **100** includes a sensor **102** that is capable of sensing a temperature in the space **22**. The sensed temperature may be used in controlling the operation of a heat-pump or air-conditioning unit **20** (or HVAC unit) to condition the space **22**. The thermostat **100** further includes a processor **104** in communication with the sensor **102**. The processor **104** is operable for controlling activation and deactivation of at least a compressor **21** of the heat-pump or air-conditioning unit **20** (as shown in FIG. **1**), for controlling the temperature within the space **22** relative to a desired set-point temperature.

**[0037]** Accordingly, the thermostat **100** (shown in FIG. **2**) includes at least one sensor **102** or temperature responsive device, which periodically outputs a value indicative of the temperature in the space **22**. The sensor **102** may be any of a number of sensor types. For example, the sensor **102** may comprise a crystal, oscillator, or other electronic device with a reactance or frequency that changes in response to temperature. Alternatively, the sensor **102** may comprise a thermistor having a resistance value that changes in response to changes in temperature. The sensor **102** could also be a device capable of communicating a voltage value that correlates to, or is indicative of, the temperature sensed in the space **22**. The sensor **102** may include circuitry to permit the sensor to communicate a value indicative of the temperature that is accurate to a tenth of degree Fahrenheit. The sensor **102** may also include circuitry to enable communication of temperature information on a periodic basis or upon request, such as when prompted by a processor **104** of the thermostat **100**. Accordingly, the sensor **102** is configured to sense and communicate information that is indicative of a temperature to a processor **104** having a program and a set-point temperature. And, the processor **104** is configured to control operation of the heat-pump or air-conditioning unit to adjust the sensed temperature in the space **22** to maintain or substantially maintain the set-point temperature.

**[0038]** With continued reference to FIG. **2**, the thermostat **100** further includes a receiver device **106** configured to receive a signal transmitted by a utility meter (e.g., utility meter **34** shown in FIG. **1**, etc.) outside the premises **24**. The utility meter may utilize an Advanced Metering Infrastructure (AMI) for transmitting/receiving signals that include energy consumption information. The receiver device **106** is in communication with the processor **104** of the thermostat **100**.

**[0039]** In the illustrated embodiment of FIG. **2**, the receiver device **106** may further comprise a transmitter, which is configured to transmit wireless signals. The receiver device and transmitter may thus be referred to herein as a transceiver device **106**. The transceiver device **106** is connected to the processor **104** of the thermostat **100**, where the transceiver device **106** and processor **104** are connected to a low voltage power supply Vcc. The transceiver device **106** may generally comprise a transceiver chip **110**, which may be connected to a resistor-capacitor filter circuit **112** and an antenna **114**.

**[0040]** The transceiver device **106** is configured to receive wireless signals transmitted by the utility meter **34** for the premises **24**. In an exemplary operation, the transceiver device **106** receives a signal from the utility meter **34** via the antenna **114**, and may then compare the signal to a reference signal. For example, the signal may be compared to a local oscillator having a frequency of 418 millihertz, and then demodulated into a digital data stream. This data may then be output via a Universal Asynchronous Serial transmission (UART) communication link, and may be decoded and transmitted as a serial bit stream signal from a data port pin of the transceiver chip **110** to an input port pin (such as a UART Port) on the processor **104**.

**[0041]** The processor **104** may be configured to load the signal data into a software buffer for protocol verification, and to strip the data and analyze a synchronization bit at the beginning of the signal to synchronize the signal and the utility meter **34** of the premises **24**, for identifying the unique serial number within the transmission to verify signal protocol with a serial number for utility meter **34** of the premises **24**. When protocol verification of a transmitted signal is complete and the signal for the utility meter **34** is verified, the processor **104** receives the signal data that includes energy consumption information.

**[0042]** In exemplary embodiments, the thermostat **100** may be configured to periodically receive utility meter signals including energy consumption information in a continuous manner, without transmitting a signal to the utility meter to request such information. In this configuration, the thermostat **100** may periodically receive energy consumption information at regularly spaced time intervals. Accordingly, the thermostat **100** may include the sensor **102** and processor **104** for controlling activation of at least a compressor of an HVAC unit to control the temperature in the space relative to a desired set-point temperature, where the processor **104** is configured to receive energy consumption information from a utility meter **34** for the premises **24** prior to activation of the compressor and subsequent to activation of the compressor.

The processor **104** of the thermostat **100** is further configured to estimate the energy consumption of the HVAC unit based at least in part upon the difference between the energy consumption prior to activation and subsequent to activation of the compressor. The thermostat **100** further includes a display device **140** that displays an indication of the energy consumption associated with the operation of the HVAC system based at least in part upon the estimate. Where the energy consumption information received from the utility meter **34** is in terms of the rate of power usage (expressed in units of kilowatts), the difference between energy consumption prior to and subsequent to activation of the compressor is indicative of an increase in the rate of power usage by the HVAC unit, expressed in kilowatts.

**[0043]** In exemplary embodiments, the thermostat **100** is configured to monitor the duration of time in which the compressor is activated, and energy consumption information received from the utility meter **34** expressed in units of kilowatts, such that an estimate of consumption of the HVAC unit may be determined from the increase in the rate of power usage (kilowatts) and the time the HVAC unit was activated. Thus, the thermostat **100** is configured to receive via wireless signals from the utility meter **34** information that is indicative of consumption before and after deactivation of the compressor, which is used to estimate consumption of the HVAC unit based at least in part upon the difference between the energy consumption prior to and subsequent to deactivation of the compressor.

**[0044]** In another configuration in which the utility meter **34** does not continuously transmit signals including energy consumption information, the thermostat **100** includes a processor **104** configured to communicate via the transceiver device **106** (or receiver device and transmitter device) to the utility meter **34** to request energy consumption information prior to activation of the compressor, and to receive (via the receiver device **106**) a first energy consumption value from the utility meter that is indicative of the energy consumption for the premises prior to activation of the compressor. After activation of the compressor, the processor **104** is configured to communicate via the transceiver device **106** (or receiver device and transmitter device) to the utility meter **34** to request energy consumption information after activation of the compressor, and to receive (via the receiver device **106**) a second energy consumption value from the utility meter that is indicative of the energy consumption for the premises after activation of the compressor. Accordingly, the first energy consumption value and the second energy consumption value may each be readings of the rate of energy usage (e.g., kilowatts) for the premises, such that the difference between the first energy consumption value and the second energy consumption value is indicative of an increase in the rate of power usage (expressed in kilowatts) being used at the premises as a result of activation of the compressor of the HVAC unit. The energy consumption of the HVAC unit may be estimated or determined based on the increase in the rate of usage expressed in kilowatts (e.g., power) and the duration of time the compressor/HVAC unit was activated, to arrive at a kilowatt-hour amount of energy consumed by the HVAC unit.

**[0045]** The thermostat **100** may further configured to determine a second estimate of the energy consumption associated with the heat-pump or air-conditioning unit **20**. After deactivation of the heat-pump or air-conditioning unit **20**, the processor **104** of the thermostat **100** may be configured to communicate via the transmitter device to the utility meter **34** to request energy consumption information, and to receive via the receiver device **106** a third energy consumption value. In such exemplary embodiment, the processor **104** is further configured to determine a second estimate of the energy consumption for the HVAC unit from or by using a difference between the second energy consumption value and the third energy consumption value. In the determination of the second estimate, the difference between the second energy consumption value and the third energy consumption value is indicative of a decrease in the rate of power usage expressed in kilowatts as a result of the deactivation of the compressor of and/or HVAC unit. This decrease provides the second estimate of the information on the energy consumption associated with the HVAC unit. The determination of the energy consumption for the HVAC unit could then be determined based in part on the decrease in the rate of power usage expressed in kilowatts and the time duration that the HVAC unit was activated. Alternatively, where the energy consumption information received from the utility meter is expressed in units of kilowatt hours, the difference between the third energy consumption value and either the first or second energy consumption value would be indicative of the energy consumption of the HVAC unit (expressed in units of kilowatt-hours) for the time that the HVAC unit was activated.

**[0046]** Referring to FIG. **3**, a flow chart is shown illustrating various steps, processes, or operations of an example of the operational control of the processor **104** in a cooling mode for the thermostat **100** in FIG. **2**. In this example, the processor **104** is configured to perform various steps, processes, or operations shown in FIG. **3**. For example, the processor **104** is configured so as to check the sensed temperature (at step **200**) and to determine if it is above a set-point temperature (at step **202**). If the processor **104** determines that the sensed temperature is above the set-point temperature, then the processor **104** is configured to then transmit signals (at step **204**) via the transceiver device **106** to the utility meter **34** for the premises **24** to request energy consumption information, such as an energy consumption reading. Prior to activation of the compressor **21** (e.g., within a predetermined time before activation), the processor **104** is configured to transmit a signal to the utility meter **34** to request an energy consumption reading and to receive a signal (at step **206**) from the utility meter **34** including a first energy consumption value.

**[0047]** During operation of the compressor **21**, the processor **104** is configured to determine when the sensed temperature has reached the set-point temperature (at step **208**). When the set-point temperature is reached but before deactivation of the compressor **21**, the processor **104** is configured to transmit a signal (at step **210**) to the utility meter **34** to request an energy consumption reading, and to receive a signal (at step **212**) from the utility meter **34** including a second energy consumption reading. After deactivation of the compressor **21** (at step **214**), the processor **104** is configured to determine (at step **216**), from a difference between the first energy consumption value and second energy consumption value, a first estimate of the energy consumption associated with the heat-pump or air-conditioning unit **20**. The processor **104** is thereby able to determine a load profile for the heat-pump or air-conditioning unit **20**. The thermostat **100** may further include the display device **140** (FIG. **2**), which may be configured to display an indication of the energy consumption for the heat-pump or air-conditioning unit **20**, as well as other information such as the sensed temperature within the premises **24**.

**[0048]** With reference back to FIG. **1**, the thermostat **100** may be configured to be operable for determining energy consumption level of an energy consuming load. As shown in FIG. **1**, the thermostat **100** may further be connected to a gateway **150** for enabling connection via the internet to a website. In this exemplary embodiment of a system that includes the thermostat **100** and gateway **150**, the thermostat **100** is configured to communicate the information on the energy consumption associated with the heat-pump or air-conditioning unit **20** to the gateway **150**. Communication of energy consumption information for the heat-pump or air-conditioning unit **20** through the gateway **150** may then permit an energy service provider to access the information on the energy consumption associated with the heat-pump or air-conditioning unit **20**. This, in turn, would then enable energy service providers seeking to shed load during peak demand periods by turning off air-conditioning units to evaluate which premises air-conditioning units use the most energy and would provide the most reduction in load.

**[0049]** Furthermore, many energy service provider entities would like to have access to disaggregated load information within residences and buildings. Utility companies and energy service providers are willing to invest significantly to implement demand response and energy efficiency programs. Disaggregated load information would enable them to greatly enhance efficacy of both types of programs.

**[0050]** Air-conditioning systems account for up to 75 percent of peak load. As such, understanding each home's air-conditioning load and thermal profile would offer utility companies and energy service provider's tremendous value in optimizing how they mitigate peak demand. For example, a utility company may have 200,000 homes participating in demand response programs that allow a broadband signal to be sent to smart thermostats, which sets back the set-point temperature by 4 degrees Fahrenheit, or cycles on and off during peak demand periods. But the energy service provider has little idea about the specific load profile or efficiencies of each home. As such, the demand response programs are designed less than optimally, since a 4 degrees Fahrenheit set-back of a thermostat in a home with an inefficient compressor or poor insulation would shed far less load than one that has excellent insulation.

**[0051]** In an exemplary embodiment, a thermostat (e.g., thermostat **100**, etc.) provides for polling the utility meter for the aggregate load of the premises directly before the appliance to be measured turns on to establish a data point A. The thermostat further polls the utility meter after the appliance is operating at its run rate or level of energy consumption, to establish data point B. Once the appliance turns off, the thermostat would poll the utility meter to establish data point C. Software associated with the processor of the thermostat would then determine a difference between the energy consumption levels for data points A and B, and data points B and C, to calculate the load profile of the appliance, such as a heat-pump or air-conditioning unit. The processor may be further configured to average the differences over an extended period of time, such as 30 days for example, to ascertain an accurate load profile for the appliance. By keeping an ongoing record of the heat-pump or air-conditioning unit's energy consumption or performance, the thermostat could inform the consumer when the residence or building is experiencing efficiency degradation, possibly due to low refrigerant charge or an antiquated compressor. For example, the ongoing data record could be used to detect degradation of the appliance's performance by comparison to historical data for the previous summer for determining a difference in consumption. This data record monitoring can be performed remotely, where the thermostat communicates data to a server at a remote location for processing. The thermostat could display the difference that the performance degradation will cost the user as an extra amount, or indicate how much the user could save by upgrading to a new system.

**[0052]** Understanding which homes have inefficient or high energy consumption air-conditioning units would enable energy service providers to have much more accuracy in determining the optimum operation of their demand response programs, such as by targeting homes with the highest energy consumption air-conditioning units. Accordingly, in exemplary embodiments disclosed herein, a thermostat (e.g., thermostat **100**, etc.) is configured to receive via a gateway (e.g., gateway **150**, etc.) a signal from an energy service provider requesting curtailment of operation of the heat-pump or air-conditioning unit (e.g., heat-pump or air-conditioning unit **20**, etc.) based on the information on the energy consumption associated with the heat-pump or air-conditioning unit. Additionally, energy efficiency implementation firms, such as White-Rodgers Division of Emerson Electric Co., may also use this information to target homes that are most in need of equipment upgrades or service. The utility company could be provided with an incentive to pay for efficiency upgrade programs for such homes that are in need of equipment upgrades.

**[0053]** In another aspect of the present disclosure, an exemplary embodiment of a thermostat (e.g., thermostat **100**, etc.) is configured to determine a sum of the energy consumption by the heat-pump or air-conditioning unit (e.g., heat-pump or air-conditioning unit **20**, etc.) within a predetermined period of time, such as the current week or a given month. In this exemplary embodiment, the thermostat is also configured to display on a display device (e.g., display device **140**, etc.) an indication of the sum of the energy consumption by the heat-pump or air-conditioning unit for the given month, such as shown in FIG. **4**. Also shown in FIG. **4**, the thermostat **100** may further be configured to display on the display device **140** an indication of a cost estimate **142** associated with the sum of the energy consumed by the heat-pump or air-conditioning unit within the given month.

**[0054]** According to another aspect of the present disclosure, exemplary embodiments of systems are disclosed for determining an estimate of the load of an energy consuming device is provided. In one such exemplary embodiment and with reference to FIG. **1**, the system includes a thermostat **100** and a gateway **150** for determining energy consumption for energy consuming loads in a premises **24**. A sensor **102** is preferably within the thermostat **100**, which provides an output indicative of the sensed temperature of the space **22**. The thermostat **100** further includes a processor **104** (FIG. **2**) that is in communication with the sensor **102**, for controlling activation of at least a compressor **21** (FIG. **1**) of a heat-pump or air-conditioning unit **20**.

**[0055]** Also in this exemplary embodiment, the system further includes a gateway **150**, or an Energy Service Interface (ESI), which is in connection with the thermostat **100**. The gateway **150** is configured to enable connection via the internet to a website. The gateway **150** further includes a transmitter device for transmitting wireless signals to a utility meter **34** for the premises **24** to request energy consumption information, and a receiver device for receiving wireless signals including energy consumption information from the utility meter **34**. The transmitter device and receiver device may comprise a transceiver device **106** such as that described above.

**[0056]** The processor **104** of the thermostat **100** is configured to control activation of at least a compressor **21** of a heat-pump or air-conditioning unit **20** for controlling temperature within a space relative to a set-point temperature, and further configured to signal the gateway **150** before the thermostat **100** activates the compressor **21**. Alternatively, the gateway **150** may be the control that activates the compressor **21**.

**[0057]** The gateway **150** is configured to receive from the thermostat **100** information indicating that the compressor **21** will be activated, and responsively transmit a signal to the utility meter **34** to request energy consumption information. The gateway **150** thereafter receives a signal including a first energy consumption value that is indicative of energy consumption for the premises while the compressor **21** is "off." Alternatively, the gateway **150** may obtain the "off" first energy consumption value after deactivation of the compressor **21**. The gateway **150** is configured to transmit a signal to the utility meter **34** after activation of the compressor to request energy consumption information, and to thereafter receive a signal including a second energy consumption value. The gateway **150** is further configured to determine, from a difference between the first energy consumption value and second energy consumption value, a first estimate of the energy consumption associated with the heat-pump or air-conditioning unit **20**. The gateway **150** and/or the thermostat **100** may be configured to monitor the duration of time in which the compressor **21** is activated.

**[0058]** Also in this exemplary embodiment, the energy consumption information from the utility meter **34** may be provided in one or more forms. For example, the energy consumption reading may be a cumulative running total of the kilowatt-hours consumed for the premises, where the difference between two such successive readings over a given time interval can be used for determining the kilowatt-hours consumed within the time interval, to thereby obtain a level of energy consumption during the time interval. The utility meter **34** may also communicate an energy consumption reading that is the rate of energy used, expressed in units of kilowatts. Accordingly, the gateway **150** may determine a difference between the first energy consumption value and the second energy consumption value, which is indicative of an increase in the rate of power usage expressed in kilowatts. The gateway **150** is configured to estimate the energy consumption of the HVAC unit based on the increase in the rate of power usage and the time duration that the HVAC unit was activated.

**[0059]** After deactivation of the compressor **21** of the heat-pump or air-conditioning unit **20**, the gateway **150** is configured to transmit a signal to the utility meter **34** to request energy consumption information, and to receive a signal from the utility meter **34** including a third energy consumption value. The gateway **150** is further configured to determine, from a difference between the second energy consumption value and the third energy consumption value, a second estimate of the energy consumption associated with the heat-pump or air-conditioning unit **20**. The difference between the second energy consumption value and the third energy consumption value is a decrease in energy consumption as a result of the deactivation of the compressor/heat-pump or air-conditioning unit **20**. The gateway **150** is configured to estimate energy consumption of the HVAC unit based on the decrease in the rate of power usage, and the time duration that the HVAC unit was activated.

**[0060]** Continuing with this exemplary embodiment of a system for monitoring an energy consuming appliance, the gateway **150** is configured to communicate the information on the energy consumption to the thermostat **100**. The thermostat **100** includes a display device **140** configured to display an indication of the energy consumption associated with the compressor and/or heat-pump or air-conditioning unit **20** to a user of the thermostat **100**. The gateway **150** is further configured to communicate the information on the energy consumption associated with the compressor and/or heat-pump or air-conditioning unit **20** via the internet to an energy service provider, to thereby provide the energy provider with information on the energy consumption associated with the heat-pump or air-conditioning unit **20**. This would enable energy service providers seeking to shed load during peak demand periods by turning off air-conditioner systems to evaluate which premises air-conditioning units use the most energy and would provide the most reduction in load. This information could then be utilized by the energy service provider in sending a signal to the premises **24** using the most energy to request curtailment of the heat-pump or air-conditioning unit **20** for the premises **24**. To enable such curtailment, the thermostat **100** is configured to receive a signal via the gateway **150** from the energy service provider requesting curtailment of operation of the heat-pump or air-conditioning unit **20**. The signal from the energy service provider would be based on the information on the energy consumption level or load associated with the particular heat-pump or air-conditioning unit **20**. Additionally, the gateway **150** may be configured to determine a sum of the energy consumption by the heat-pump or air-conditioning unit **20** (and any appliance that can be controllably turned on and off) within a predetermined time period, such as the current week or month. The gateway **150** may be configured to communicate the sum of the energy consumption by the heat-pump or air-conditioning unit **20** for the given month to the thermostat **100** for display on the display device **140**. Alternatively, the thermostat **100** may be configured to determine a sum of the energy consumption by the heat-pump or air-conditioning unit **20** within a given time period and to display on the display device **140** of the thermostat **100** an indication of the energy consumption for the given time period. The thermostat **100** may further be configured to display on the display device **140** an indication of cost estimate **142** associated with the sum of the energy consumed by the heat-pump or air-conditioning unit **20** within the given time period, such as shown in FIG. **4**.

**[0061]** With the disclosed exemplary embodiments, the thermostat enables consumers to be given real time feedback on the costs of their energy consumption associated with a heat-pump or air-conditioning unit. This information may allow consumers to make smarter decisions about how and when they use electricity and reducing energy consumption. This tends to be important because people rarely cut back on consumption until they understand the impact on them as a result of specific behavior. Real time disaggregated load information for appliance energy consumption level can enhance conservation, encourage the use of programming features on the thermostat, and/or encourage equipment upgrades for inefficient appliances. Not only can the thermostat enable the consumers to understand how much electrical power a heat-pump or air-conditioning unit is consuming, the thermostat can also provide value added information on ways the consumers may save.

**[0062]** In an exemplary embodiment, there is provided a thermostat for monitoring the energy consumption associated with an HVAC unit. The thermostat includes a sensor for sensing temperature and a processor for controlling activation of a compressor of an HVAC unit to control the temperature in the space relative to a desired set-point temperature. The processor is configured to receive energy consumption information from a utility meter for the premises prior to activation of the compressor and subsequent to activation of the compressor, and further configured to estimate the energy consumption of the HVAC unit based at least in part upon the difference between the energy consumption prior to activation and the energy consumption subsequent to activation of the compressor. The thermostat includes a display that displays an indication of the energy consumption of the HVAC system based at least in part upon the estimate, wherein the processor of the thermostat is configured to control the display to display a graph indicating an estimated cost of the energy consumed by the heat-pump or air-conditioning unit for each day within a given month.

**[0063]** For example, a thermostat may be configured to display a weekly cost estimate in real time to the user, and predict from the energy consumption load profile the air-conditioning costs to the homeowner to help them with their budgeting. With reference to FIG. **2**, the processor **104** of the thermostat **100** is configured to determine, from the last energy consumption reading received from the utility meter **34** each day, a difference between such daily readings that indicates the aggregate energy consumption for each day. Using a price rate for the energy consumption, the processor **104** of the thermostat **100** may be further configured to display on the display device **140** a graph showing the present day's energy consumption, such as that represented by the black highlighted bar shown in FIG. **5**.

**[0064]** With further reference to FIG. **5**, the display device **140** may further display a daily cost target **144** and a Month-to-date cost estimate **142** for the energy consumption for the premises. By multiplying the daily target by the number of days in the month to date, a difference between a Month-to-date target and the Month-to-date costs can be used to display an amount that the energy costs are above or below the month-to-date target.

**[0065]** The thermostat **100** is configured to display on the display device **140** the sum of the energy consumption by the heat-pump or air-conditioning unit **20** for the given month as shown in FIG. **6**. The thermostat **100** may further be configured to display on the display device **140** a cost estimate **142** associated with the sum of the energy consumed by the heat-pump or air-conditioning unit **20** within the given month. The processor **104** of the thermostat **100** is configured to determine from the energy consumption data received via the receiver device **106** the aggregate energy consumption for each day.

**[0066]** In response to a selection by the user, the display device **140** can display the previous day's energy consumption, as represented by the black highlighted bar shown in FIG. **6**. Similarly, the user can select any day of the current Month to see how much the daily cost of energy consumption was, as shown by the black highlighted bar shown in FIG. **7**. The thermostat can be configured to display the energy consumption data described above, to enable the consumer to scroll through individual days displayed on a graph on the display device **140** of the thermostat, and to select a given day see how much the daily cost of energy consumption was. For example, a user may be able to press an energy and/or menu button (e.g., FIG. **2**) of a thermostat and use the arrows to scroll through and move between the different days of the given month, such between the different days shown in FIG. **5** (6/25/10), FIG. **6** (6/24/10), and FIG. **7** (6/18/10).

**[0067]** A thermostat according to exemplary embodiments may be configured to display energy consumption data, to thereby enable the consumer to set a monthly energy consumption cost target. The thermostat can be configured to prompt the consumer to enter a value for their monthly energy target cost and the day their billing cycle starts so they can track consumption in alignment with their actual billing cycle. For example, the user could enter a start date of the $12^{th}$ and a $150 target cost for the Month, which would be divided by 30 days to obtain a daily target cost of $5 per day. The display would then graph the daily energy consumption on a bar chart showing whether the consumer's energy consumption for each day was above or below their daily target cost, along with a Month-to-date total at the top of the display device **140**. The display device **140** can also display an amount that the energy costs are above or below the month-to-date target to let the consumer know if they are on track to go over or under target. If they are above their target as shown in FIG. **5**, the consumer will then know after viewing the display device **140** to cut back on the remaining days of the Month in order to hit their target Monthly energy consumption costs.

**[0068]** The thermostat **100** may be configured to collect historical data for the summer to determine an estimated energy cost that could have been saved if the user had set back the temperature setting by an additional 1 degree for the entire summer, and to responsively instruct the display device **140** to display the estimated cost. The thermostat **100** may be further be configured to compare the appliance's monthly energy consumption to historical data for the previous summer to determine a prediction of a difference in consumption, and responsively instruct the display device **140** to display a message indicating that if the current summer is like the last summer, an additional 1 degree set back of temperature setting could yield an estimated monthly savings of a determined amount. The thermostat **100** may be configured to provide an easily accessible display of a graph that concisely shows on one display the relevant energy consumption information without requiring the user to look at several charts or scroll through menus. The displayed target also enables the user to more effectively control their appliances (e.g., thermostat set-point temperature, etc.) keep their energy consumption costs under budget, as opposed to merely showing real time energy consumption data.

**[0069]** According to another aspect of the present disclosure, there is provided a system for monitoring an energy consuming load in a premises. The system includes a gateway **150** (FIG. **1**), or an ESI device, for enabling connection via the internet to a website. In this example, the gateway **150** is in communication with a plurality of energy consuming appliances or loads (and their respective controllers and/or smart plugs) including one or more of a thermostat **100**, an electric water heater **28**, a refrigerator **36**, a pool water pump **32**, a smart plug **38** electrically connected via cord **39** to a lamp **41** sitting on a table **43**, a media center, etc.

**[0070]** The gateway **150** is in communication with a plurality of switch controls for a plurality of energy consuming loads in the premises, including one or more devices such as a thermostat **100**, an electric water heater **28**, a refrigerator **36**, and a smart plug **38** of a premises. The gateway **150** is configured to receive a signal from one or more of the thermostat **100**, the electric water heater **28**, the refrigerator **36**, smart plug **38** indicating that the energy consuming load is activated, and configured to receive energy consumption information from a utility meter for the premises when the energy consuming load is operating and when the energy consuming load is not operating. The gateway **150** or a controller (e.g., thermostat **100**, electrical water heater controller, refrigerator controller, and/or smart plug **38**, etc.) is configured to estimate the energy consumption of the energy consuming load unit based at least in part upon the difference between the energy consumption during operation and the energy consumption during non-operation of the energy consuming load.

**[0071]** The gateway **150** may include, for example, a transmitter device for transmitting wireless signals to a utility meter **34** for the premises to request energy consumption information and a receiver device **106** for receiving wireless signals including energy consumption information from the utility meter **34**. The gateway **150** may receive a signal from one or more of the thermostat **100**, the electric water heater **28**, the refrigerator **36**, the pool water pump **32**, the smart plug **38**, etc. indicating that the energy consuming load is operating. The electric water heater **28**, refrigerator **36**, pool water pump **32**, etc. may be connected to a smart outlet or a high amp load control switch device, which is configured to control any appliance plugged into it and to communicate with the gateway **150**.

**[0072]** Accordingly, the gateway **150** is configured to receive a signal from one or more of the thermostat **100**, the electric water heater **28**, the refrigerator **36**, the pool water pump **32**, smart plug **38**, etc. indicating that the energy consuming device is operating, and to responsively transmit a signal to the utility meter **34** to request energy consumption information and to receive a signal from the utility meter including a first energy consumption value. The gateway **150** is further configured to transmit a signal to the utility meter **34** after deactivation of the energy consuming load, to request energy consumption information and thereafter receive a signal from the utility meter **34** including a second energy consumption value. After receiving the energy consumption information, the gateway **150** or a controller (e.g., thermostat **100**, electrical water heater controller, refrigerator controller, and/or smart plug **38**, etc.) may then determine, from a difference between the first and second energy consumption values, an estimate of the energy consumption associated with the energy consuming load.

**[0073]** For example, a controller (e.g., thermostat **100**, electrical water heater controller, refrigerator controller, and/or smart outlet or plug **38**, etc.) may request electrical load information from the utility meter **34** meter before turning on the load. The controller may also request electrical load information from the utility meter **34** after the load is on. After receiving the electrical load information, the controller then determines energy usage from a difference between the electrical load information before the load was turned on and the electrical load information after the load is on. The controller may then send the energy usage information to a remote utility provider or user via the gateway **150**.

**[0074]** The gateway **150** may receive a signal from a controller (e.g., controller **26** of an electric water heater **28**, an associated smart outlet, a smart plug **38** connected to a lamp **41** or other energy consuming appliance or device, etc.) that indicates that the electric water heater **28**, lamp **41**, or other device, etc. was activated and/or operating. The gateway **150** may be configured to responsively transmit a signal (e.g., in response to the controller's request for electrical load information, etc.) to the utility meter **34** to request energy consumption information, and to receive a signal from the utility meter **34** including a first energy consumption value. Following deactivation of the energy consuming load, the gateway **150** may be configured to responsively transmit a signal (e.g., in response to the controller's request for electrical load information, etc.) to the utility meter **34** to request energy consumption information, and to receive a signal from the utility meter **34** including a second energy consumption value. From or via the gateway **150**, the controller **26** may receive the first and second energy consumption values. The controller **26** may then determine, from a difference between the first and second energy consumption values, an estimate of the energy consumption associated with the activated energy consuming appliance. The gateway **150** and/or the controller **26** may further be configured to monitor the activation of the appliance to detect a rapid frequency of activation/deactivation, or an elevated energy consumption level for the appliance, which may be indicative of a fault of the appliance. In response to detecting activation or energy consumption information indicative of a fault, the gateway **150** and/or the controller **26** may be configured to responsively turn off the appliance and notify an occupant or service provider of the fault.

**[0075]** Exemplary embodiments are disclosed of apparatus and methods for determining and/or monitoring load of energy consuming appliances within a premises. In an exemplary embodiment, there is a thermostat for monitoring energy consumption associated with an HVAC unit having a compressor. The thermostat is configured to communicate information on energy consumption and/or information on duration of time of operation or run time associated with the HVAC unit to a user.

**[0076]** In another exemplary embodiment, there is a system for monitoring energy consumption for an energy consuming load in a premises that is supplied with power monitored by a utility meter. A gateway is in connection with the controller for enabling connection via the internet to a website. At least one of the gateway and the controller is configured to communicate information on energy consumption associated with the energy consuming load to an energy service provider and/or a consumer.

**[0077]** In some exemplary embodiments, a thermostat or other controller sends information on energy usage to a user, consumer, homeowner, etc. in addition to or as opposed to sending the information via a gateway to a utility or energy service provider. The information on energy usage may be displayed to a consumer, such as on a screen or display of a thermostat, a mobile device (e.g., a smartphone, tablet, phablet, etc.), a computer, etc. The displayed information may be presented in a graphical or pictorial manner.

**[0078]** In some exemplary embodiments, a thermostat or other controller may additionally or alternatively send information on the run time or duration of time of operation to a utility or energy service provider and/or a consumer. For example, the thermostat or other controller may only send information on the duration of time of operation to a utility or energy service provider and/or a consumer. Or, for example, the thermostat or other controller may send information on the duration of time of operation to a utility or energy service provider and/or a consumer separately before or after sending information on energy consumption.

**[0079]** The run time or duration of time of operation may be expressed as hours of a day. The days are the days of a given month. Additionally, or alternatively, the duration of time of operation may be expressed in hours of an entire month. The duration of time of operation can be sent for through the gateway to a utility provider or consumer. The duration of time of operation may be displayed to a utility or energy service provider and/or a consumer, such as on a screen or display of a thermostat, a mobile device (e.g., a smartphone, tablet, phablet, etc.), a computer, etc. The displayed information may be expressed or presented in a graphical or pictorial manner. For example, HVAC run time may be graphically depicted on a mobile device. A consumer may cancel HVAC activation if the energy usage exceeds a pre-set limit or exceeds the duration of time of operation for a given day.

**[0080]** The gateway may send energy usage information from a device to a utility provider or consumer. The information may be displayed in a graphical manner. The device may be a water heater or a smart plug. For example, the gateway may connect to a server, and the server software may be used to configure (e.g., essentially name or identify, etc.) the various smart plugs. The consumer or user would then know what device was sending the information (e.g., TV, bedroom lamp, refrigerator, toaster, etc.). The gateway may then be used for home automation and control. For example, the consumer or utility provider may deactivate the water heater or the smart plug through the gateway.

**[0081]** Example embodiments are provided so that this disclosure will be thorough, and will fully convey the scope to those who are skilled in the art. Numerous specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of embodiments of the present disclosure. It will be apparent to those skilled in the art that specific details need not be employed, that example embodiments may be embodied in many different forms and that neither should be construed to limit the scope of the disclosure. In some example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail.

**[0082]** The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms “a”, “an” and “the” may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms “comprises,” “comprising,” “including,” and “having,” are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

**[0083]** When an element or layer is referred to as being “on”, “engaged to”, “connected to” or “coupled to” another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being “directly on,” “directly engaged to”, “directly connected to” or “directly coupled to” another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., “between” versus “directly between,” “adjacent” versus “directly adjacent,” etc.). As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

**[0084]** Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as “first,” “second,” and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

**[0085]** Spatially relative terms, such as “inner,” “outer,” “beneath”, “below”, “lower”, “above”, “upper” and the like, may be used herein for ease of description to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as “below” or “beneath” other elements or features would then be oriented “above” the other elements or features. Thus, the example term “below” can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

**[0086]** Specific dimensions disclosed herein are example in nature and do not limit the scope of the present disclosure. The disclosure herein of particular values and particular ranges of values for given parameters are not exclusive of other values and ranges of values that may be useful in one or more of the examples disclosed herein. Moreover, it is envisioned that any two particular values for a specific parameter stated herein may define the endpoints of a range of values that may be suitable for the given parameter (i.e., the disclosure of a first value and a second value for a given parameter can be interpreted as disclosing that any value between the first and second values could also be employed for the given parameter). Similarly, it is envisioned that disclosure of two or more ranges of values for a parameter (whether such ranges are nested, overlapping or distinct) subsume all possible combination of ranges for the value that might be claimed using endpoints of the disclosed ranges.

**[0087]** The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the invention, and all such modifications are intended to be included within the scope of the invention.

What is claimed is:

**1**. A thermostat for monitoring energy consumption associated with an HVAC unit having a compressor, the thermostat comprising:

a sensor operable for providing an output indicative of a temperature within a space of a premises; and

a processor operable for controlling activation of at least the compressor of the HVAC unit to control temperature in the space relative to a desired set-point temperature, the processor configured to receive energy consumption information from a utility meter for the premises prior to activation of the compressor and subsequent to activation of the compressor, the processor further configured to estimate energy consumption of the HVAC unit based at least in part upon the difference between the energy consumption prior to activation and the energy consumption subsequent to activation of the compressor;

wherein the thermostat is configured to communicate information on energy consumption and/or information on duration of time of operation associated with the HVAC unit to a user.

**2**. A system comprising the thermostat of claim **1**, and further comprising a gateway for enabling connection via the internet to a website, wherein the thermostat is configured to communicate the information on energy consumption and/or the information on duration of time of operation associated with the HVAC unit to the gateway to thereby permit an energy service provider and/or a consumer to access the information on energy consumption and/or the information on duration of time of operation.

**3**. A system comprising the thermostat of claim **1** and a display device of an electronic device that is operable for displaying the information on energy consumption and/or the information on duration of time of operation associated with the HVAC unit.

**4**. The thermostat of claim **1**, wherein the thermostat includes a display device operable for displaying the information on energy consumption and/or the information on duration of time of operation associated with the HVAC unit.

**5**. The thermostat of claim **1**, wherein the information on energy consumption and/or the duration of time of operation associated with the HVAC unit is displayed graphically or pictorially to a user.

**6**. The thermostat of claim **1**, wherein the thermostat includes a display device operable for displaying a graph indicating estimated cost of energy consumed by the HVAC unit for days within a given month.

**7**. The thermostat of claim **1**, wherein the thermostat is configured to communicate the information on the duration of time of operation associated with the HVAC unit only or separately from the information on energy consumption to an energy service provider or a consumer.

**8**. The thermostat of claim **1**, wherein the duration of time of operation is expressed as hours of a day within a given month or as hours of an entire month.

**9**. The thermostat of claim **1**, wherein the thermostat is configured to allow a consumer to cancel HVAC activation if energy usage exceeds a preset limit or exceeds the duration of time of operation for a given day.

**10**. A system comprising the thermostat of claim **1**, and further comprising a gateway for enabling connection via the internet to a website, wherein the gateway is operable for communicating energy usage information from a device to an energy service provider and/or a consumer.

**11**. The system of claim **10**, wherein the device is a water heater or a smart plug.

**12**. The system of claim **11**, wherein the system is configured to allow a user to deactivate the water heater or the smart plug through the gateway.

**13**. A system for monitoring energy consumption for an energy consuming load in a premises that is supplied with power monitored by a utility meter, the system comprising:

a controller;

a gateway in connection with the controller, for enabling connection via the internet to a website, the gateway including:

a transmitter operable for transmitting wireless signals to a utility meter for the premises to request energy consumption information; and

a receiver operable for receiving wireless signals including energy consumption information from the utility meter;

wherein at least one of the gateway and the controller is configured to estimate energy consumption of the energy consuming load based at least in part upon a difference between energy consumption during operation and energy consumption during non-operation of the energy consuming load; and

wherein at least one of the gateway and the controller is configured to communicate information on energy consumption associated with the energy consuming load to an energy service provider and/or a consumer.

**14**. The system of claim **13**, wherein the energy consuming load is a water heater or a smart plug.

**15**. The system of claim **14**, wherein the system is configured to allow a user to deactivate the water heater or the smart plug through the gateway.

**16**. The system of claim **13**, wherein the information on energy consumption associated with the energy consuming load is displayed graphically or pictorially.

**17**. The system of claim **16**, wherein the information on energy consumption is displayed graphically or pictorially on a display of a thermostat, a computer, or a mobile device.

**18**. The system of claim **13**, wherein the controller is a thermostat.

**19**. The system of claim **13**, wherein at least one of the gateway and the controller is configured to communicate information on duration of time of operation associated with the energy consuming load to an energy service provider and/or a consumer.

**20**. The system of claim **19**, wherein the information on duration of time of operation is displayed graphically or pictorially.

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