

Utility Source Type Determination Apparatus and Method

The present invention relates to intelligent utility metering and particularly an apparatus and method for determining the source type of an input utility signal of a utility meter.

Background

Utility meters can monitor consumption of a utility such as electricity, gas or water. The utility meter is typically located at a property where the utility consumption is to be monitored, for example, a consumer's home. The utility meter is downstream of the utility source such as an electricity main supply source. Electricity will be provided from the electricity source through a substation, for example, and then to a consumer's home. In some circumstances, there may be reasons for switching to an alternate source – such as a power outage, but also consumer economy for example. In some areas, when there is a power interruption (eg. power cut/electricity outage) from the electricity source, an alternative source of power which can be controlled and maintained by a secondary energy service provider that may be different to the main supply source provider and located away from a consumer's property, may be used temporarily to provide power to a consumer's home. The electricity from this alternative source will also pass through the utility meter so the electricity consumption can be monitored. The alternative source could be a local electricity generator which is activated automatically or manually to provide power. This could be when there is a power interruption from the main electricity source, for consumer economy reasons where a cheaper rate may be offered, or for environmental reasons. The alternative source could be a diesel generator or a renewable source such as a wind turbine or solar generator. The secondary energy service provider could be, for example, a banking institution, a community or specialist energy services company (ESCO).

Utility service providers may wish to determine when power is being provided by the alternative source rather than main source or vice versa. This could be for various reasons including billing where the electricity from the alternative power source would be provided at a different tariff or rate compared to the main electricity source. Further, for example, meters such as prepayment utility (or energy) meters are used

to provide electricity if sufficient credit is available according to the balance on the meter. The rate from the alternative power source may need to be applied to the current balance on the meter such that the balance is updated according to the correct tariff. Another reason could be smart load limiting which could involve
5 automatically switching down certain appliances in a home when power is being delivered by the alternative power source (eg. local generator) in order to help reduce consumption or reduce demand as constrained by the capacity of the alternative source.

10 In some implementations, utility meters may receive a message when the electricity is switched to the alternative power source and to inform the device that the power source has changed. The tariff change or load limiting action can then be initiated if appropriate. This would normally require installation of additional physical infrastructure such as communication links or signal injectors, adding to the cost and
15 complexity of the system.

Summary of the Invention

The inventors have arrived at a solution to allow automatic detection of a change in the source of a utility, at a location where a utility meter is situated, when there is a
20 change in the type of utility source, for example, a change from a main primary power source to an alternative power source, without external assistance. The source of the utility can be determined and a determination of whether or not it has altered can be made.

25 According to a first aspect, the present invention provides an apparatus according to appended claim 1.

According to a second aspect, the present invention provides a utility meter according to appended claim 11.

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According to a third aspect, the present invention provides a method according to appended claim 13.

According to a fourth aspect, the present invention provides a system according to appended claim 23.

Further optional features are provided in the dependent claims.

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Brief Description of the Drawings

In order that the present invention is understood, embodiments will now be described by way of example only with reference to the accompanying drawings in which:

10 Figure 1 shows a simplified schematic diagram of a utility meter according to one embodiment of the invention;

Figure 2 shows a simplified schematic diagram of a device and utility meter according to a second embodiment of the invention;

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Figure 3 shows a schematic diagram of an example of a system which incorporates a utility meter of Figure 1.

Detailed Description

20 The preferred embodiment will be described by reference to a utility meter which, when in use, is connected to a mains supply and measures the consumption of a utility such as electricity. Although the embodiment will be described to operate with the electricity utility which receives a voltage supply, it will be apparent to a skilled person that the apparatus may be configured to operate with other types of utilities
25 such as gas or water.

Referring to Figure 1, the utility meter 10 has a housing comprising a conventional utility consumption measurement means 11, An input power signal 12a is received from a utility source at an input of the housing via a mains cable 12. The input signal
30 is provided to a utility consumption measurement means 11 that may include a current sensing means 11a (often a current transformer or shunt) and a voltage sensing means 11b (often a potential divider or voltage transformer) which each generate respective sensed signals. The actual constitution of the utility consumption means 11 does not form part of the present invention and therefore will not be

described in any further detail but will be understood by those skilled in the art. The utility consumption means 11 can measure various aspects of the utility consumption based on electrical parameters of the power signal 12a entering the meter 10 through the mains cable 12.

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Both the sensed signals from the utility consumption measurement means 11 are fed to a processing means which in this embodiment is microcontroller 13. The microcontroller 13 processes and computes various parameters of the energy supply such as voltage, current, frequency, power factor, power and energy (pressure, flow, temperature, volume flow rate in case of gas or water meters) based on the sensed signals. The computed data can be stored in storage means 14 and / or displayed on a meter display means 15 and / or communicated to a remote device via a communications means 16 in the meter 10. The storage means 14, meter display means 15 and communication means 16 can be conventional.

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The microcontroller 13 that is in communication with the utility consumption means 11 can analyse the electrical power signal 12a in order to determine the type of source from which the power signal 12a received by the utility meter 10 originated (explained in further detail below).

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The storage means 14 can also be provided in the meter 10 to store information relevant to the measurement of the utility consumption from the utility consumption means 11 and information related to the processing carried out by the microcontroller 13 in order to determine the source type of the signal. It will be appreciated that the storage may be integral to microcontroller 13 rather than being a separate component. The storage means could be any type of semi-permanent storage such as solid state drive which is capable of being written to and/or read.

The microcontroller 13 is adapted to capture information relating to the utility consumption from the utility consumption means 11 that has measured the signal 12a and can use this information to determine if the signal 12a is from a first source of electricity or a second source of the electricity.

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Each type of electricity source will provide a signal having intrinsic properties which makes it distinct from others. Such intrinsic properties may include the inertia / capacity of the source. For example a mains source has far higher capacity and is very stable compared to a local captive generator giving it higher inertia. Another property could be the availability pattern. For example, local solar or wind renewable sources are dependent on solar or wind levels at the location where the renewable energy is being received. These intrinsic properties can be used to provide a signature to the source and this signature can be used to determine the type of source through source signature analysis. For example, the signature of a power signal from a mains electric power source such as a local electric power substation (first source) that is provided to the property in which the utility meter is located will differ from the signature of a power signal from a local generator (second source). Therefore there are a plurality of possible sources of electrical power. The mains cable 12 will carry power into the property and hence utility meter and the source from the plurality of sources can be differentiated through its signature.

The microcontroller 13 determines the type of source based on identification of the distinguishing intrinsic properties. It may look for stability of the source frequency of supply, load – voltage correlation and time variation of these signals to determine the source. Further, it may be pre-configured for threshold values of measured parameters in order to distinguish between source types (i.e. through pre-experiment to set a threshold) or made to learn automatically over a period of time.

In one example of automatically self-learning, a conventional machine learning clustering technique may be employed where for a predetermined period (for example, twenty days), the meter 10 will collect data relating to a first power source and carry out a clustering analysis. According to this analysis, a threshold will be determined and set in the storage means 14 representing the threshold which when crossed represents a different source of electrical power to the first power source.

It will be apparent from the above that the data which is used to determine the source type may already be selectively measured by conventional meters and the determination of the source of the signal 12a will be an extension to the utility meter 10 through further processing of data already captured by the microcontroller 13.

The communication means 16 that can be a transceiver sends and receives wireless signals. However, unlike conventional techniques where source switching information may be sent by using a suitable communicating means – pilot wires, signal injected into the power line itself (or power line communication) or wireless message using a suitable transceiver, the utility meter 10 does not need to receive specific source switching information from the generator location when there is a switching of power that leads to another alternative power source supplying power to a utility meter. The microcontroller 13 can determine the change in source automatically.

The meter 10 may include an optional discrete state input port 17 where can receive discrete state (ON / OFF) input signals. Such a port 17 can connect to an another compatible device.

An output 18 of the utility meter 10 may be connected to a load (not shown) which could be one or more electrical appliances in an electricity consumer's home.

The utility meter may be powered by the power signal 12a and/or may contain a battery such as a rechargeable battery (not shown).

In another embodiment as shown in Fig. 2, the analysis of supply signature could be carried out external to the housing of the utility meter and upstream of the utility meter. This can be achieved by using a source identifier device 100 that includes a housing comprising a microcontroller 130 and a storage means 140. The device 100 is positioned upstream of a utility meter 10. The utility meter 10 can be the same as that in Figure 1 (as is apparent through use of the same reference numeral as Figure 1) or it can be another type of conventional electricity meter that is already located in a consumer's premises.

The device 100 is adapted to carry out the similar analysis of the source signal 12a that enters through mains cable 12 as the utility meter 10 and therefore the description relating to the functionality is not repeated here for brevity. In this embodiment, consumption of the utility is not necessarily measured by the device 100 and therefore a utility consumption means is not required. Signal analysis is

performed on the signal entering the device 100 solely for the purpose of continually monitoring when there is a change in source and determining the source. The particular type of signal analysis could be same as in the first embodiment. The analysis is performed by the microcontroller 130 which is operable to interact with the storage means 140 in a similar way to the microcontroller 13 and storage means 14 of the first embodiment.

In this embodiment, the device 100 may also contain a transceiver (not shown) to enable transmission and reception of wireless signals, if required. If this is the case, the transceiver will at least communicate with the microcontroller 130 and may communicate wirelessly with the utility meter 10.

As with the first embodiment, the utility meter 10 will be connectable to a load (not shown). Although the utility meter in this embodiment is designated the same reference numeral as the utility meter 10 of the first embodiment and thus contains the same features, the source signal analysis functionality would not be required by the utility meter 10 of this embodiment given the presence of the device 100 that can carry out the appropriate processing. However, a microcontroller 13 may still be present in the utility meter 10 to carry out other functionality related to electricity consumption analysis based on information from the utility consumption means 11 such as billing, and/or load management.

The device 100 may be powered by the power signal 12a and/or may contain a battery such as a rechargeable battery (not shown).

In this embodiment, local communications means 120 is provided between the device 100 and utility meter 10. The means 120 could be in the form of a medium such as a single wire or at least two wires. Alternatively it can be an ON / OFF state discrete output. Other types of communications means may be provided to enable short range communication with only a small amount of information needing to be sent to the utility meter. Regarding the ON / OFF state discrete output, the device 100 carries out the analysis on the power signal 12a and produces a discrete state output (ON / OFF) which is fed to the discrete port 17 of the meter 10 as shown in Fig. 1. This local communication means 120 is provided in addition to the mains cable

12 to communicate when a change in source supply is detected so the necessary action can be taken by the utility meter which could be changing the tariff rate and/or lowering the load. Alternatively, local communication means 120 may not be needed and data relating to the change in source supply could be sent along the mains power cable 12.

Although this embodiment is described with reference to the device 100 being located outside the housing of the meter 10, it will be appreciated that the device 100 could be an extension or module to be fixed to an existing meter to provide the analysis and determination functionality. The device 100 may share the storage means 14 of the utility meter 10 and therefore not require its own storage device 140.

A system in which an embodiment of the invention can be used will now be described with reference to Figure 3. In this system, there are a plurality of utility meters 10 based on those described in relation to Figure 1 and therefore features of Figure 1 will also be referred to in order to explain an example of the system operation. Each utility meter 10 will be located in a respective consumer's residence 19. A power line 12 will enter each utility meter 10 as explained in the first embodiment. The power signal entering the utility meter will depend on which source is providing the electrical power.

There may be a situation where a power signal 12a is normally provided to a residence 19 from a first source such as power station 20 or substation situated near the residence 19. The residence 19 has an associated utility meter 10 to measure the consumption of the utility. When there is a power outage from the power station 20, a switch 30 or some other mechanism will be activated to enable an alternative source of power to provide power to the residence 19. The switch 30 will be normally open when the first source is providing power to the residence 19. A junction 17 at an intersection point between the first source 20 and alternative source 25 will output the power signal from either the first source 20 or alternative source 25.

In this embodiment, the alternative source is an electric power generator 25. The generator 25 will provide a power signal 12b which may have a different signature to

the signal 12a. The signature has already been explained in relation to the first and second embodiment so will not be described again in detail here for brevity.

The microcontroller 13 (fig. 1) will be operable to determine if the power signal entering the utility meter is a first signal 12a indicating that it originates from the first source 20 or a second signal 12b indicating that it originates from the second, alternative source 25. It will be appreciated by the skilled person that there could be more than two signal sources for the power signal to a property and other signals from other signal sources (for the same utility) could also be analysed through the signal signature analysis as described in relation to the above embodiments.

Although the source of power may be changeable (either from the first source 20 or alternative source 25), it will be apparent that the power signal will enter into the meter through a common power line 12.

In Figure 3, a plurality of residences 19 are shown to help explain that a single generator 25 could be providing power to multiple residences 19 each provided with a respective utility meter 10 having the appropriate signal signature analysis capabilities.

Compared to conventional systems explained in the background, it will be apparent from the system arrangement of Figure 3 that communication circuitry is not required near the generator 25 when switch 30 is activated in order to inform the utility meters that the source has changed. Instead, the utility meter 10 can determine the change in source itself without needing to receive and interpret commands from communication circuitry near the generator.

The utility meter 10 may operate in a similar way to conventional utility meters described in the background once a determination in the change in the source of the electricity has been made. That is, the tariff may be changed or the load may be managed. In particular, where there are two different possible sources of utility, a credit payment type meter can store relevant data in two different registers in the storage means 14; one register is associated with the first utility source provider such as a utility company and the other register is associated with the other alternative source provider. Each register can only be accessed by the respective

associated provider. The register may contain consumption data and tariff data and therefore appropriate billing information can be generated separately by each source provider. For a prepayment type meter, the prepaid credit is automatically deducted based on the rate of the respective source provider. Other operations may be performed once a change in source of electricity has been detected as would be understood by those skilled in the art and are therefore not been described in further detail.

It will be appreciated by those skilled in the art that the device 100 of Figure 2 could be used instead of or in addition to the utility meter 10 in the system of Figure 3 to analyse power signals in the supply line 12 and to determine the utility source type in a similar manner described in relation to Figure 2. The location of the device 100 will be upstream of the utility meter 10 in a similar way to that in Figure 2.

The embodiments above refer to a microcontroller that can carry out the processing on the incoming power signal to determine the source. It will be appreciated that this could instead be a microprocessor that can carry out the processing along with a separate storage means that would normally provide the storage functionality of the embedded storage such as RAM and/or ROM in a microcontroller.

It will be appreciated that although the above embodiments have been described in relation to electrical energy, signature analysis could be used for determining the source of another type of utility such as water that is entering a water meter located in a consumer's premises and monitoring consumption of the water. Different sources of water may have different associated tariffs and a water meter can be adapted accordingly to include a microcontroller that can analyse the source and then determine the source. Further action can then be carried out such as tariff change. The energy may therefore be any type of utility such as electricity, water or gas but the energy type between which a determination is made is the same (e.g. first and second source of the utility are both electricity, water or gas sources).

Numerous modifications, adaptations and variations to the embodiments described herein will become apparent to a person skilled in the art having the benefit of the present disclosure, and such modifications, adaptations and variations that result in

additional embodiments of the present invention are also within the scope of the accompanying claims.

Claims

1. An apparatus for determining the type of source for a utility being monitored by a utility meter, the apparatus comprising a means for receiving a utility to be
5 monitored by a utility meter, means for analysing the utility to determine whether the received utility is from a first source of the utility or a second source of the utility.
2. The apparatus of claim 1, wherein the analysing means is operable to check a
10 signature of the utility to determine if it is a predetermined signature of the first source of utility or a predetermined signature of the second source of utility.
3. The apparatus of claim 2, wherein the predetermined signature is based on a property of the first source and second source of the utility.
- 15 4. The apparatus of claim 3 wherein the property is one or more of the frequency, rate of change of frequency, perturbation of frequency, voltage, pressure and / or rate of change of voltage or pressure of the first source and second source of the utility.
- 20 5. The apparatus of claims 3 or 4 wherein the property is the capacity of the first source and second source.
6. The apparatus of any preceding claim, wherein the analysing means is operable to monitor stability of the received utility to determine whether the utility is
25 from the first source or second source.
7. The apparatus of any of claims 2 to 6, wherein the predetermined signature relating to each utility source is adapted to be learnt by the analysing means over a period of time.
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8. The apparatus of any of claims 2 to 8, wherein the apparatus further comprises a storage means for storing the predetermined signature.

9. The apparatus of any preceding claim, further comprising means for logging at least one parameter of the received utility and the analysing means is adapted to analyse data relating to the logged parameter in the determination of whether the received utility is from a first source of the utility or a second source of the utility.

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10. The apparatus of any preceding claim, wherein the utility is electricity.

11. A utility meter comprising a housing containing the apparatus of any preceding claim and a means for measuring the consumption of a utility, wherein the measuring means is arranged to provide data relating to the measurement of utility consumption to the analysing means.

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12. The utility meter of claim 11, wherein the meter is an electricity meter.

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13. A method of determining the type of source for a utility being monitored by a utility meter, the method comprising:

receiving a utility to be monitored by a utility meter; and

analysing the utility to determine whether the received utility is from a first source of the utility or a second source of the utility.

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14. The method of claim 13, wherein the analysing step includes checking a signature of the utility to determine if it is a predetermined signature of the first source of utility or a predetermined signature of the second source of utility.

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15. The method of claim 14, wherein the predetermined signature is based on a property of the first source and second source of the utility.

16. The method of claim 15 wherein the property is one or more of the frequency, rate of change of frequency, perturbation of frequency, voltage, pressure and / or rate of change of voltage or pressure of the first source and second source of the utility.

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17. The method of claims 15 or 16 wherein the property is the capacity of the first source and second source.

18. The method of any of claims 13 to 17, wherein the analysing means is operable to monitor stability of the received utility to determine whether the utility is from the first source or second source.

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19. The method of any of claims 14 or 18 wherein the predetermined signature relating to each utility source is learnt over a period of time.

20. The method of any of claims 14, to 19, further comprising storing the predetermined signature.

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21. The method of any of claims 13 to 20, further comprising logging at least one parameter of the received utility and, in the analysing step, analysing data relating to the logged parameter in the determination of whether the received utility is from a first source of the utility or a second source of the utility.

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22. The method of any of claims 13 to 21, wherein the utility is electricity.

23. A system comprising a first source of a utility, a second source of the utility, and a utility meter located downstream of the first and second source of the utility to receive the utility from either the first or second source through a utility supply line and located remote from the utility sources, the system further comprising the apparatus according to any one of claims 1 to 10, the apparatus being located downstream of the first and second source, the system comprising a switching means for controlling switching upstream of the apparatus such that the utility from either the first or second source is delivered to apparatus through a single supply line that is connected to the apparatus.

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24. Apparatus, method, utility meter or system substantially as hereinbefore described with reference to the accompanying drawings.

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