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Requirements for Energy Management

Abstract

This document defines requirements for standards specifications for Energy Management. The requirements defined in this document are concerned with monitoring functions as well as control functions. Monitoring functions include identifying energy-managed devices and their components, as well as monitoring their Power States, Power Inlets, Power Outlets, actual power, Power Attributes, received energy, provided energy, and contained batteries. Control functions include such functions as controlling power supply and Power State of energy-managed devices and their components.

This document does not specify the features that must be implemented by compliant implementations but rather lists features that must be supported by standards for Energy Management.

Status of This Memo

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1. Introduction

With rising energy costs and an increasing awareness of the ecological impact of running information technology equipment, Energy Management (EMAN) functions and interfaces are becoming an additional basic requirement for network management systems and devices connected to a network.

This document defines requirements for standards specifications for Energy Management, both monitoring functions and control functions. Energy Management functions focus mainly on devices and their components that receive and provide electrical energy. Devices such as hosts, routers, and middleboxes may have an IP address or may be connected indirectly to the Internet via a proxy with an IP address providing a management interface for the device, for example, devices in a building infrastructure using non-IP protocols and a gateway to the Internet.

These requirements are concerned with the standards specification process and not the implementation of specified standards. All requirements in this document must be reflected by standards specifications to be developed. However, which of the features specified by these standards will be mandatory, recommended, or optional for compliant implementations is to be defined by Standards Track document(s) and not in this document.

Section 3 elaborates on a set of general needs for Energy Management. Requirements for an Energy Management standard are specified in Sections 4 through 8.

Sections 4 through 6 contain conventional requirements specifying information on entities and control functions.

Sections 7 and 8 contain requirements specific to Energy Management. Due to the nature of power supply, some monitoring and control functions are not conducted by interacting with the entity of interest but rather with other entities, for example, entities upstream in a power distribution tree.

1.1. Conventional Requirements for Energy Management

The specification of requirements for an Energy Management standard starts with Section 4, which addresses the identification of entities and the granularity of reporting of energy-related information. A standard must support the unique identification of entities, reporting per entire device, and reporting energy-related information on individual components of a device or attached devices.

Section 5 specifies requirements related to the monitoring of entities. This includes general (type, context) information and specific information on Power States, Power Inlets, Power Outlets, power, energy, and batteries. The control of Power State and power supply by entities is covered by requirements specified in Section 6.

1.2. Specific Requirements for Energy Management

While the conventional requirements summarized above seem to be all that would be needed for Energy Management, there are significant differences between Energy Management and most well-known network management functions. The most significant difference is the need for some devices to report on other entities. There are three major reasons for this.

- For monitoring a particular entity, it is not always sufficient to communicate only with that entity. When the entity has no instrumentation for determining power, it might still be possible to obtain power values for the entity via communication with other entities in its power distribution tree. A simple example of this would be the retrieval of power values from a power meter at the power line into the entity. A Power Distribution Unit (PDU) and a Power over Ethernet (PoE) switch are common examples. Both supply power to other entities at sockets or ports, respectively, and are often instrumented to measure power per socket or port.

- Similar considerations apply to controlling the power supply of an entity that often needs direct or indirect communications with another entity upstream in the power distribution tree. Again, a PDU and a PoE switch are common examples, if they have the capability to switch power on or off at their sockets or ports, respectively.

- Energy Management often extends beyond entities with IP network interfaces to non-IP building systems accessed via a gateway (sometimes called an Energy Management System or controller). Requirements in this document do not cover the details of these networks and energy devices but specify means for opening IP network management towards them.

These specific issues of Energy Management, as well as other issues, are covered by requirements specified in Sections 7 and 8.

The requirements in these sections need a new Energy Management framework that deals with the specific nature of Energy Management. The actual standards documents, such as MIB module specifications, address conformance by specifying which features must, should, or may be implemented by compliant implementations.

2. Terminology

The terms specified in the terminology section are capitalized throughout the document; the exceptions are the well-known terms "energy" and "power". These terms are generic and are used in generated terms such as "energy-saving", "low-power", etc.

Energy

Energy is the capacity of a system to do work. As used by electric utilities, it is generally a reference to electrical energy and is measured in kilowatt-hours (kWh) [IEEE-100].

Power

Power is the time rate at which energy is emitted, transferred, or received; power is usually expressed in watts (or in joules per second) [IEEE-100]. (The term "power" does not refer to the concept of demand, which is an averaged power value.)

Power Attributes

Power Attributes are measurements of electric current, voltage, phase, and frequencies at a given point in an electrical power system (adapted from [IEC.60050]).

NOTE: Power Attributes are not intended to be "judgmental" with respect to a reference or technical value and are independent of any usage context.

Energy Management

Energy Management is a set of functions for measuring, modeling, planning, and optimizing networks to ensure that the network elements and attached devices use energy efficiently and in a manner appropriate to the nature of the application and the cost constraints of the organization [ITU-M.3400].

Energy Management System

An Energy Management System is a combination of hardware and software used to administer a network with the primary purpose being Energy Management.

Energy Monitoring

Energy Monitoring is a part of Energy Management that deals with collecting or reading information from network elements and attached devices and their components to aid in Energy Management.

Energy Control

Energy Control is a part of Energy Management that deals with controlling energy supply and Power State of network elements, as well as attached devices and their components.

Power Interface

A Power Interface is an interface at which a device is connected to a power transmission medium, at which it can in turn receive power, provide power, or both.

Power Inlet

A Power Inlet is a Power Interface at which a device can receive power from other devices.

Power Outlet

A Power Outlet is a Power Interface at which a device can provide power to other devices.

Power State

A Power State is a condition or mode of a device that broadly characterizes its capabilities, power consumption, and responsiveness to input [IEEE-1621].

3. General Considerations Related to Energy Management

The basic objective of Energy Management is to operate sets of devices using minimal energy, while maintaining a certain level of service. [EMAN-STATEMENT] presents the applicability of the EMAN framework to a variety of scenarios and also lists use cases and target devices.

3.1. Power States

Entities can be set to an operational state that results in the lowest power level that still meets the service-level performance objectives. In principle, there are three basic types of Power States for an entity or for a whole system:

- o full Power State
- o sleep state (not functional but immediately available)
- o off state (may require significant time to become operational)

In specific devices, the number of Power States and their properties vary considerably. Simple entities may only have the extreme states: full Power State and off state. Many devices have three basic Power States: on, off, and sleep. However, more finely grained Power States can be implemented. Examples are various operational low Power States in which a device requires less energy than in the full power "on" state, but -- compared to the sleep state -- is still operational with reduced performance or functionality.

3.2. Saving Energy versus Maintaining Service Level

One of the objectives of Energy Management is to reduce energy consumption. While this objective is clear, attaining that goal is often difficult. In many cases, there is no way to reduce power without the consequence of a potential service (performance or capacity) degradation. In this case, a trade-off needs to be made between service-level objectives and energy minimization. In other cases, a reduction of power can easily be achieved while still maintaining sufficient service-level performance, for example, by switching entities to lower Power States when higher performance is not needed.

3.3. Local versus Network-Wide Energy Management

Many energy-saving functions are executed locally by an entity; it monitors its usage and dynamically adapts its power according to the required performance. It may, for example, switch to a sleep state when it is not in use, or outside of scheduled business hours. An Energy Management System may observe an entity’s Power State and configure its power-saving policies.

Energy savings can also be achieved with policies implemented by a network management system that controls Power States of managed entities. Information about the power received and provided by entities in different Power States may be required in order to set such policies. Often, this information is best acquired through monitoring.

Network-wide and local Energy Management methods both have advantages and disadvantages, and it is often desirable to combine them. Central management is often favorable for setting Power States of a large number of entities at the same time, for example, at the beginning and end of business hours in a building. Local management is often preferable for power-saving measures based on local observations, such as the high or low functional load of an entity.

3.4. Energy Monitoring versus Energy Saving

Monitoring energy, power, and Power States alone does not reduce the energy needed to run an entity. In fact, it may even increase it slightly due to monitoring instrumentation that needs energy. Reporting measured quantities over the network may also increase energy use, though the acquired information may be an essential input to control loops that save energy.

Monitoring energy and Power States can also be required for other purposes, including:

- o investigating energy-saving potential
- o evaluating the effectiveness of energy-saving policies and measures
- o deriving, implementing, and testing power management strategies
- o accounting for the total power received and provided by an entity, a network, or a service
- o predicting an entity’s reliability based on power usage
- o choosing the time of the next maintenance cycle for an entity

3.5. Overview of Energy Management Requirements

The following basic management functions are required:

- o monitoring Power States
- o monitoring power (energy conversion rate)
- o monitoring (accumulated) received and provided energy

- monitoring Power Attributes

- setting Power States

Power control is complementary to other energy-saving measures, such as low-power electronics, energy-saving protocols, energy-efficient device design (for example, low-power modes for components), and energy-efficient network architectures. Measurement of received and provided energy can provide useful data for developing these technologies.

4. Identification of Entities

Entities must be capable of being uniquely identified within the context of the management system. This includes entities that are components of managed devices as well as entire devices.

Entities that report on or control other entities must identify the entities they report on or control: see Section 7 or Section 8, respectively, for the detailed requirements.

An entity may be an entire device or a component of it. Examples of components of interest are a hard drive, a battery, or a line card. The ability to control individual components to save energy may be required. For example, server blades can be switched off when the overall load is low, or line cards at switches may be powered down at night.

Identifiers for devices and components are already defined in standard MIB modules, such as the Link Layer Discovery Protocol (LLDP) MIB module [IEEE-802.1AB] and the Link Layer Discovery Protocol -- Media Endpoint Discovery (LLDP-MED) MIB module [ANSI-TIA-1057] for devices, and the Entity MIB module [RFC6933] and the power Ethernet MIB [RFC3621] for components of devices. Energy Management needs a means to link energy-related information to such identifiers.

Instrumentation for measuring the received and provided energy of a device is typically more expensive than instrumentation for retrieving its Power State. Many devices may provide Power State information for all individual components separately, while reporting the received and provided energy only for the entire device.

4.1. Identifying Entities

The standard must provide means for uniquely identifying entities. Uniqueness must be preserved such that collisions of identities are avoided at potential receivers of monitored information.

4.2. Persistence of Identifiers

The standard must provide means for indicating whether identifiers of entities are persistent across a restart of the entity.

4.3. Change of Identifiers

The standard must provide means to indicate any change of entity identifiers.

4.4. Using Entity Identifiers of Existing MIB Modules

The standard must provide means for reusing entity identifiers from existing standards, including at least the following:

- the entPhysicalIndex in the Entity MIB module [RFC6933]

- the LldpPortNumber in the LLDP MIB module [IEEE-802.1AB] and in the LLDP-MED MIB module [ANSI-TIA-1057]

- the pethPsePortIndex and the pethPsePortGroupIndex in the Power Ethernet MIB [RFC3621]

Generic means for reusing other entity identifiers must be provided.

5. Information on Entities

This section describes information on entities for which the standard must provide means for retrieving and reporting.

Required information can be structured into seven groups. Section 5.1 specifies requirements for general information on entities, such as type of entity or context information. Requirements for information on Power Inlets and Power Outlets of entities are specified in Section 5.2. The monitoring of power and energy is covered by Sections 5.3 and 5.5, respectively. Section 5.4 covers requirements related to entities' Power States. Section 5.6 specifies requirements for monitoring batteries. Finally, the reporting of time series of values is covered by Section 5.7.

5.1. General Information on Entities

For Energy Management, understanding the role and context of an entity may be required. An Energy Management System may aggregate values of received and provided energy according to a defined grouping of entities. When controlling and setting Power States, it may be helpful to understand the grouping of the entity and role of an entity in a network. For example, it may be important to exclude some mission-critical network devices from being switched to lower power or even from being switched off.

5.1.1. Type of Entity

The standard must provide means to configure, retrieve, and report a textual name or a description of an entity.

5.1.2. Context of an Entity

The standard must provide means for retrieving and reporting context information on entities, for example, tags associated with an entity that indicate the entity's role.

5.1.3. Significance of Entities

The standard must provide means for retrieving and reporting the significance of entities within its context, for example, how important the entity is.

5.1.4. Power Priority

The standard must provide means for retrieving and reporting power priorities of entities. Power priorities indicate an order in which Power States of entities are changed, for example, to lower Power States for saving power.

5.1.5. Grouping of Entities

The standard must provide means for grouping entities. This can be achieved in multiple ways, for example, by providing means to tag entities, assign them to domains, or assign device types to them.

5.2. Power Interfaces

A Power Interface is an interface at which a device is connected to a power transmission medium, at which it can in turn receive power, provide power, or both.

A Power Interface is either an inlet or an outlet. Some Power Interfaces change over time from being an inlet to being an outlet and vice versa. However, most Power Interfaces never change.

Devices have Power Inlets at which they are supplied with electric power. Most devices have a single Power Inlet, while some have multiple inlets. Different Power Inlets on a device are often connected to separate power distribution trees. For Energy

Monitoring, it is useful to retrieve information on the number of inlets of a device, the availability of power at inlets, and which inlets are actually in use.

Devices can have one or more Power Outlets for supplying other devices with electric power.

For identifying and potentially controlling the source of power received at an inlet, identifying the Power Outlet of another device at which the received power is provided may be required. Analogously, for each outlet, it is of interest to identify the Power Inlets that receive the power provided at a certain outlet. Such information is also required for constructing the wiring topology of electrical power distribution to devices.

Static properties of each Power Interface are required information for Energy Management. Static properties include the kind of electric current (AC or DC), the nominal voltage, the nominal AC frequency, and the number of AC phases. Note that the nominal voltage is often not a single value but a voltage range, such as, for example, (100V-120V), (100V-240V), (100V-120V,220V-240V).

5.2.1. List of Power Interfaces

The standard must provide means for monitoring the list of Power Interfaces of a device.

5.2.2. Operational Mode of Power Interfaces

The standard must provide means for monitoring the operational mode of a Power Interface, which is either "Power Inlet" or "Power Outlet".

5.2.3. Corresponding Power Outlet

The standard must provide means for identifying the Power Outlet that provides the power received at a Power Inlet.

5.2.4. Corresponding Power Inlets

The standard must provide means for identifying the list of Power Inlets that receive the power provided at a Power Outlet.

5.2.5. Availability of Power

If the Power States allow it, the standard must provide means for monitoring the availability of power at each Power Interface. This includes indicating whether a power supply at a Power Interface is switched on or off.

5.2.6. Use of Power

The standard must provide means for monitoring each Power Interface if it is actually in use. For inlets, this means that the device actually receives power at the inlet. For outlets, this means that power is actually provided from the outlet to one or more devices.

5.2.7. Type of Current

The standard must provide means for reporting the type of current (AC or DC) for each Power Interface as well as for a device.

5.2.8. Nominal Voltage Range

The standard must provide means for reporting the nominal voltage range for each Power Interface.

5.2.9. Nominal AC Frequency

The standard must provide means for reporting the nominal AC frequency for each Power Interface.

5.2.10. Number of AC Phases

The standard must provide means for reporting the number of AC phases for each Power Interface.

5.3. Power

Power is measured as an instantaneous value or as the average over a time interval.

Obtaining highly accurate values for power and energy may be costly if dedicated metering hardware is required. Entities without the ability to measure with high accuracy their power, received energy, and provided energy may just report estimated values, for example, based on load monitoring, Power State, or even just the entity type.

Depending on how power and energy values are obtained, the confidence in a reported value and its accuracy will vary. Entities reporting such values should qualify the confidence in the reported values and quantify the accuracy of measurements. For reporting accuracy, the accuracy classes specified in IEC 62053-21 [IEC.62053-21] and IEC 62053-22 [IEC.62053-22] should be considered.

Further properties of the power supplied to a device are also of interest. For AC power supply in particular, several Power Attributes beyond the real power are of potential interest to Energy Management Systems. The set of these properties includes the complex Power Attributes (apparent power, reactive power, and phase angle of the current or power factor) as well as the actual voltage, the actual AC frequency, the Total Harmonic Distortion (THD) of voltage and current, and the impedance of an AC phase or of the DC supply. A new standard for monitoring these Power Attributes should be in line with already-existing standards, such as [IEC.61850-7-4].

For some network management tasks, it is desirable to receive notifications from entities when their power value exceeds or falls below given thresholds.

5.3.1. Real Power / Power Factor

The standard must provide means for reporting the real power for each Power Interface as well as for an entity. Reporting power includes reporting the direction of power flow.

5.3.2. Power Measurement Interval

The standard must provide means for reporting the corresponding time or time interval for which a power value is reported. The power value can be measured at the corresponding time or averaged over the corresponding time interval.

5.3.3. Power Measurement Method

The standard must provide means to indicate the method used to obtain these values. Based on how the measurement was conducted, it is possible to associate a certain degree of confidence with the reported power value. For example, there are methods of measurement such as direct power measurement, estimation based on performance values, or hard-coding average power values for an entity.

5.3.4. Accuracy of Power and Energy Values

The standard must provide means for reporting the accuracy of reported power and energy values.

5.3.5. Actual Voltage and Current

The standard must provide means for reporting the actual voltage and actual current for each Power Interface as well as for a device. For AC power supply, means must be provided for reporting the actual voltage and actual current per phase.

5.3.6. High-Power/Low-Power Notifications

The standard must provide means for creating notifications if power values of an entity rise above or fall below given thresholds.

5.3.7. Complex Power / Power Factor

The standard must provide means for reporting the complex power for each Power Interface and for each phase at a Power Interface. In addition to the real power, at least two of the following three quantities need to be reported: apparent power, reactive power, and phase angle. The phase angle can be substituted by the power factor.

5.3.8. Actual AC Frequency

The standard must provide means for reporting the actual AC frequency for each Power Interface.

5.3.9. Total Harmonic Distortion

The standard must provide means for reporting the Total Harmonic Distortion (THD) of voltage and current for each Power Interface. For AC power supply, means must be provided for reporting the THD per phase.

5.3.10. Power Supply Impedance

The standard must provide means for reporting the impedance of a power supply for each Power Interface. For AC power supply, means must be provided for reporting the impedance per phase.

5.4. Power State

Many entities have a limited number of discrete Power States.

There is a need to report the actual Power State of an entity and to provide the means for retrieving the list of all supported Power States.

Different standards bodies have already defined sets of Power States for some entities, and others are creating new Power State sets. In this context, it is desirable that the standard support many of these Power State standards. In order to support multiple management systems that possibly use different Power State sets while simultaneously interfacing with a particular entity, the Energy Management System must provide means for supporting multiple Power State sets used simultaneously at an entity.

Power States have parameters that describe their properties. It is required to have a standardized means for reporting some key properties, such as the typical power of an entity in a certain state.

There is also a need to report statistics on Power States, including the time spent as well as the received and provided energy in a Power State.

5.4.1. Actual Power State

The standard must provide means for reporting the actual Power State of an entity.

5.4.2. List of Supported Power States

The standard must provide means for retrieving the list of all potential Power States of an entity.

5.4.3. Multiple Power State Sets

The standard must provide means for supporting multiple Power State sets simultaneously at an entity.

5.4.4. List of Supported Power State Sets

The standard must provide means for retrieving the list of all Power State sets supported by an entity.

5.4.5. List of Supported Power States within a Set

The standard must provide means for retrieving the list of all potential Power States of an entity for each supported Power State set.

5.4.6. Typical Power Per Power State

The standard must provide means for retrieving the typical power for each supported Power State.

5.4.7. Power State Statistics

The standard must provide means for monitoring statistics per Power State, including the total time spent in a Power State, the number of times each state was entered, and the last time each state was entered. More Power State statistics are addressed by the requirements in Section 5.5.3.

5.4.8. Power State Changes

The standard must provide means for generating a notification when the actual Power State of an entity changes.

5.5. Energy

The monitoring of electrical energy received or provided by an entity is a core function of Energy Management. Since energy is an accumulated quantity, it is always reported for a certain interval of time. This can be, for example, the time from the last restart of the entity to the reporting time, the time from another past event to the reporting time, the last given amount of time before the reporting time, or a certain interval specified by two timestamps in the past.

It is useful for entities to record their received and provided energy per Power State and report these quantities.

5.5.1. Energy Measurement

The standard must provide means for reporting measured values of energy and the direction of the energy flow received or provided by an entity. The standard must also provide the means to report the energy passing through each Power Interface.

5.5.2. Time Intervals

The standard must provide means for reporting the time interval for which an energy value is reported.

5.5.3. Energy Per Power State

The standard must provide means for reporting the received and provided energy for each individual Power State. This extends the requirements on Power State statistics described in Section 5.4.7.

5.6. Battery State

Batteries are special entities that supply power. The status of these batteries is typically controlled by automatic functions that act locally on the entity, and manually by users of the entity. There is a need to monitor the battery status of these entities by network management systems.

Devices containing batteries can be modeled in two ways. The entire device can be modeled as a single entity on which energy-related information is reported, or the battery can be modeled as an individual entity for which energy-related information is monitored individually according to requirements in Sections 5.1 through 5.5.

Further information on batteries is of interest for Energy Management, such as the current charge of the battery, the number of completed charging cycles, the charging state of the battery, its temperature, and additional static and dynamic battery properties. It is desirable to receive notifications if the charge of a battery becomes very low or if a battery needs to be replaced.

5.6.1. Battery Charge

The standard must provide means for reporting the current charge of a battery, in units of milliampere-hours (mAh).

5.6.2. Battery Charging State

The standard must provide means for reporting the charging state (charging, discharging, etc.) of a battery.

5.6.3. Battery Charging Cycles

The standard must provide means for reporting the number of completed charging cycles of a battery.

5.6.4. Actual Battery Capacity

The standard must provide means for reporting the actual capacity of a battery.

5.6.5. Actual Battery Temperature

The standard must provide means for reporting the actual temperature of a battery.

5.6.6. Static Battery Properties

The standard must provide means for reporting static properties of a battery, including the nominal capacity, the number of cells, the nominal voltage, and the battery technology.

5.6.7. Low Battery Charge Notification

The standard must provide means for generating a notification when the charge of a battery decreases below a given threshold. Note that the threshold may depend on the battery technology.

5.6.8. Battery Replacement Notification

The standard must provide means for generating a notification when the number of charging cycles of a battery exceeds a given threshold.

5.6.9. Multiple Batteries

If the battery technology allows, the standard must provide means for meeting requirements in Sections 5.6.1 through 5.6.8 for each individual battery contained in a single entity.

5.7. Time Series of Measured Values

For some network management tasks, obtaining time series of measured values from entities, such as power, energy, battery charge, etc., is required.

In general, time series measurements could be obtained in many different ways. Means should be provided to either push such values from the location where they are available to the management system or to have them stored locally for a sufficiently long period of time such that a management system can retrieve the full time series.

The following issues are to be considered when designing time series measurement and reporting functions:

1. Which quantities should be reported?

2. Which time interval type should be used (total, delta, sliding window)?

3. Which measurement method should be used (sampled, continuous)?

4. Which reporting model should be used (push or pull)?

The most discussed and probably most needed quantity is energy. But a need for others, such as power and battery charge, can be identified as well.

There are three time interval types under discussion for accumulated quantities such as energy. They can be reported as total values, accumulated between the last restart of the measurement and a certain timestamp. Alternatively, energy can be reported as delta values between two consecutive timestamps. Another alternative is reporting values for sliding windows as specified in [IEC.61850-7-4].

For non-accumulative quantities, such as power, different measurement methods are considered. Such quantities can be reported using values sampled at certain timestamps or, alternatively, by mean values for these quantities averaged between two (consecutive) timestamps or over a sliding window.

Finally, time series can be reported using different reporting models, particularly push-based or pull-based. Push-based reporting can, for example, be realized by reporting power or energy values using the IP Flow Information Export (IPFIX) protocol [RFC7011] [RFC7012]. The Simple Network Management Protocol (SNMP) [RFC3411] is an example of a protocol that can be used for realizing pull-based reporting of time series.

For reporting time series of measured values, the following requirements have been identified. Further decisions concerning issues discussed above need to be made when developing concrete Energy Management standards.

5.7.1. Time Series of Energy Values

The standard must provide means for reporting time series of energy values. If the comparison of time series between multiple entities is required, then time synchronization between those entities must be provided (for example, with the Network Time Protocol [RFC5905]).

5.7.2. Time Series Interval Types

The standard must provide means for supporting alternative interval types. The requirement in Section 5.5.2 applies to every reported time value.

5.7.3. Time Series Storage Capacity

The standard should provide means for reporting the number of values of a time series that can be stored for later reporting.

6. Control of Entities

Many entities control their Power State locally. Other entities need interfaces for an Energy Management System to control their Power State.

A power supply is typically not self-managed by devices, and control of a power supply is typically not conducted as an interaction between an Energy Management System and the device itself. It is rather an interaction between the management system and a device providing power at its Power Outlets. Similar to Power State control, power supply control may be policy driven. Note that shutting down the power supply abruptly may have severe consequences for the device.

6.1. Controlling Power States

The standard must provide means for setting Power States of entities.

6.2. Controlling Power Supply

The standard must provide means for switching a power supply off or turning a power supply on at Power Interfaces providing power to one or more devices.

7. Reporting on Other Entities

As discussed in Section 5, not all energy-related information may be available at the entity in question. Such information may be provided by other entities. This section covers only the reporting of information. See Section 8 for requirements on controlling other entities.

There are cases where a power supply unit switches power for several entities by turning power on or off at a single Power Outlet or where a power meter measures the accumulated power of several entities at a single power line. Consequently, it should be possible to report that a monitored value does not relate to just a single entity but is an accumulated value for a set of entities. All of the entities belonging to that set need to be identified.

7.1. Reports on Other Entities

The standard must provide means for an entity to report information on another entity.

7.2. Identity of Other Entities on Which Information Is Reported

For entities that report on one or more other entities, the standard must provide means for reporting the identity of other entities on which information is reported. Note that, in some situations, a manual configuration might be required to populate this information.

7.3. Reporting Quantities Accumulated over Multiple Entities

The standard must provide means for reporting the list of all entities from which contributions are included in an accumulated value.

7.4. List of All Entities on Which Information Is Reported

For entities that report on one or more other entities, the standard must provide means for reporting the complete list of all those entities on which energy-related information can be reported.

7.5. Content of Reports on Other Entities

For entities that report on one or more other entities, the standard must provide means for indicating what type or types of energy-related information can be reported, and for which entities.

8. Controlling Other Entities

This section specifies requirements for controlling Power States and power supply of entities by communicating with other entities that have the means for doing that control.

8.1. Controlling Power States of Other Entities

Some entities have control over Power States of other entities. For example, a gateway to a building system may have the means to control the Power State of entities in the building that do not have an IP interface. For this scenario and other similar cases, a way to make this control accessible to the Energy Management System is needed.

In addition, it is required that an entity that has its state controlled by other entities has the means to report the list of these other entities.

8.1.1. Control of Power States of Other Entities

The standard must provide means for an Energy Management System to send Power State control commands to an entity that controls the Power States of entities other than the entity to which the command was sent.

8.1.2. Identity of Other Power State Controlled Entities

The standard must provide means for reporting the identities of the entities for which the reporting entity has the means to control their Power States. Note that, in some situations, a manual configuration might be required to populate this information.

8.1.3. List of All Power State Controlled Entities

The standard must provide means for an entity to report the list of all entities for which it can control the Power State.

8.1.4. List of All Power State Controllers

The standard must provide means for an entity that receives commands controlling its Power State from other entities to report the list of all those entities.

8.2. Controlling Power Supply

Some entities may have control of the power supply of other entities, for example, because the other entity is supplied via a Power Outlet of the entity. For this and similar cases, means are needed to make this control accessible to the Energy Management System. This need is already addressed by the requirement in Section 6.2.

In addition, it is required that an entity that has its supply controlled by other entities has the means to report the list of these other entities. This need is already addressed by requirements in Sections 5.2.3 and 5.2.4.

9. Security Considerations

Controlling Power State and power supply of entities are considered highly sensitive actions, since they can significantly affect the operation of directly and indirectly connected devices. Therefore, all control actions addressed in Sections 6 and 8 must be sufficiently protected through authentication, authorization, and integrity protection mechanisms.

Entities that are not sufficiently secure to operate directly on the public Internet do exist and can be a significant cause of risk, for example, if the remote control functions described in Sections 6 and 8 can be exercised on those devices from anywhere on the Internet. The standard needs to provide means for dealing with such cases. One solution is providing means that allow the isolation of such devices, e.g., behind a sufficiently secured gateway. Another solution is to allow compliant implementations to disable sensitive functions, or to not implement such functions at all.

The monitoring of energy-related quantities of an entity as addressed in Sections 5 through 8 can be used to derive more information than just the received and provided energy; therefore, monitored data requires protection. This protection includes authentication and authorization of entities requesting access to monitored data as well as confidentiality protection during transmission of monitored data. Privacy of stored data in an entity must be taken into account. Monitored data may be used as input to control, accounting, and other actions, so integrity of transmitted information and authentication of the origin may be needed.

9.1. Secure Energy Management

The standard must provide privacy, integrity, and authentication mechanisms for all actions addressed in Sections 5 through 8. The security mechanisms must meet the security requirements detailed in Section 1.4 of [RFC3411].

9.2. Isolation of Insufficiently Secure Entities

The standard must provide means to allow the isolation of entities that are not sufficiently secure to operate on the public Internet, e.g., behind a gateway that implements sufficient security that the vulnerable entities are not directly exposed to the Internet.

9.3. Optional Restriction of Functions

The standard must allow compliant implementations to disable sensitive functions, or to not implement such functions at all, when operating in environments that are not sufficiently secured. This applies particularly to the control functions described in Sections 6 and 8.

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