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Energy Management Framework
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Abstract

This document defines a framework for providing Energy Management for devices and device components within or connected to communication networks. The framework presents a physical reference model and information model. The information model consists of an Energy Management Domain as a set of Energy Objects. Each Energy Object is identified, classified and given context. Energy Objects can be monitored and controlled with respect to Power, Power State, Energy, Demand, Power Attributes, and Battery. Additionally the framework models relationships and capabilities between Energy Objects.

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[1.](#) Introduction

Network management is often divided into the five main areas defined in the ISO Telecommunications Management Network model: Fault, Configuration, Accounting, Performance, and Security Management (FCAPS) [[X.700](#)]. Not covered by this traditional management model is Energy Management, which is rapidly becoming a critical area of concern worldwide, as seen in [[ISO50001](#)].

This document defines an energy management framework for devices within or connected to communication networks. The devices, or components of these devices (such as router line cards, fans, disks), can then be monitored and controlled. Monitoring includes measuring power, energy, demand, and attributes of power. Energy control can be performed by setting a devices' or components' power state.

If a device contains batteries, these can also be monitored and controlled.

This framework further describes how to identify, classify and provide context for such devices. While the context information is not specific to Energy Management, some context attributes are specified in the framework, addressing the following use cases: how important is a device in terms of its business impact, how should devices be grouped for reporting and searching, and how should a device role be described. These context attributes help in fault management and impact analysis while controlling the power states. Guidelines for using context for energy management are described.

The framework introduces the concept of a power interface that is analogous to a network interface. A power interface is defined as an interconnection among devices where energy can be provided, received, or both.

The most basic example of Energy Management is a single device reporting information about itself. In many cases, however, energy is not measured by the device itself, but measured upstream in the power distribution tree. For example, a power distribution unit (PDU) may measure the energy it supplies to attached devices and report this to an energy management system. Therefore, devices often have relationships to other devices or components in the power network. An EnMS (Energy Management System) generally requires an understanding of the power topology (who provides power to whom), the metering topology (who meters whom), and an understanding of the potential aggregation (ex: does a meter aggregate values from other devices).

The relationships build on the power interface concept. The different relationships among devices and components, specified in this document, include: power source relationship, metering relationship, and aggregation relationship.

1.1. Energy Management Documents Overview

The EMAN standard provides a set of specifications for Energy Management. This document specifies the framework, per the Energy Management requirements specified in [EMAN-REQ].

The applicability statement document [[EMAN-AS](#)] includes use cases, a cross-reference between existing standards and the

EMAN standard, and a description of this framework's relationship to other frameworks.

The Energy Object Context MIB [[EMAN-OBJECT-MIB](#)] specifies objects for addressing Energy Object Identification, classification, context information, and relationships from the point of view of Energy Management.

The Power and Energy Monitoring MIB [[EMAN-MON-MIB](#)] specifies objects for monitoring of Power, Energy, Demand, Power Attributes, and Power States.

The Battery Monitoring MIB [[EMAN-BATTERY-MIB](#)] defines managed objects that provide information on the status of batteries in managed devices.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC-2119](#) [[RFC2119](#)].

In this document these words will appear with that interpretation only when in ALL CAPS. Lower case uses of these words are not to be interpreted as carrying [RFC-2119](#) significance.

In this section some terms have a NOTE that is not part of the definition itself, but accounts for differences between terminologies of different standards organizations or further clarifies the definition.

\$ Energy Management

Energy Management is a set of functions for measuring, modeling, planning, and optimizing networks to ensure that the network and network attached devices use energy efficiently and appropriately for the nature of the application and the cost constraints of the organization.

Reference: Adapted from [[ITU-T-M-3400](#)]

NOTES:

1. Energy management refers to the activities, methods, procedures and tools that pertain to measuring, modeling, planning, controlling and optimizing the use of energy in networked systems [[NMF](#)].

2. Energy Management is a management domain which is congruent to any of the FCAPS areas of management in the ISO/OSI Network Management Model [[TMN](#)]. Energy Management for communication networks and attached devices is a subset or part of an organization's greater Energy Management Policies.

\$ Energy Management System (EnMS)

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

NOTES:

1. An Energy Management System according to [[ISO50001](#)] (ISO-EnMS) is a set of systems or procedures upon which organizations can develop and implement an energy policy, set targets, action plans and take into account legal requirements related to energy use. An ISO-EnMS allows organizations to improve energy performance and demonstrate conformity to requirements, standards, and/or legal requirements.

2. Example ISO-EnMS: Company A defines a set of policies and procedures indicating there should exist multiple computerized systems that will poll energy measurements from their meters and pricing / source data from their local utility. Company A specifies that their CFO (Chief Financial Officer) should collect information and summarize it quarterly to be sent to an accounting firm to produce carbon accounting reporting as required by their local government.

3. For the purposes of EMAN, the definition herein is the preferred meaning of an Energy Management System (EnMS). The definition from [[ISO50001](#)] can be referred to as ISO Energy Management System (ISO-EnMS).

\$ Energy Monitoring

Energy Monitoring is a part of Energy Management that deals with collecting or reading information from Energy Objects to aid in Energy Management.

\$ Energy Control

Energy Control is a part of Energy Management that deals with directing influence over Energy Objects.

\$ Electrical Equipment

A general term including materials, fittings, devices, appliances, fixtures, apparatus, machines, etc., used as

a part of, or in connection with, an electric installation.

Reference: [[IEEE100](#)]

\$ Non-Electrical Equipment (Mechanical Equipment)

A general term including materials, fittings, devices, appliances, fixtures, apparatus, machines, etc., used as a part of, or in connection with, non-electrical power installations.

Reference: Adapted from [[IEEE100](#)]

\$ Device

A piece of electrical or non-electrical equipment.

Reference: Adapted from [[IEEE100](#)]

\$ Component

A part of an electrical or non-electrical equipment (Device).

Reference: Adapted from [[ITU-T-M-3400](#)]

\$ Power Inlet

A Power Inlet (or simply inlet) is an interface at which a device or component receives energy from another device or component.

\$ Power Outlet

A Power Outlet (or simply outlet) is an interface at which a device or component provides energy to another device or component.

\$ Energy

That which does work or is capable of doing work. As used by electric utilities, it is generally a reference to electrical energy and is measured in kilowatt hours (kWh).

Reference: [[IEEE100](#)]

NOTES

1. Energy is the capacity of a system to produce external activity or perform work [[ISO50001](#)]

\$ Provide Energy

A device (or component) "provides" energy to another device if there is an energy flow from this device to the other one.

\$ Receive Energy

A device (or component) "receives" energy from another device if there is an energy flow from the other device to this one.

\$ Meter (energy meter)

a device intended to measure electrical energy by integrating power with respect to time.

Reference: Adapted from [[IEC60050](#)]

\$ Battery

one or more cells (consisting of an assembly of electrodes, electrolyte, container, terminals and usually separators) that are a source and/or store of electric energy.

Reference: Adapted from [[IEC60050](#)]

\$ Power

The time rate at which energy is emitted, transferred, or received; usually expressed in watts (joules per second).

Reference: [[IEEE100](#)]

\$ Nameplate Power

The Nameplate Power is the nominal Power of a device as specified by the device manufacturer.

\$ Power Attributes

Measurements of the electrical current, voltage, phase and frequencies at a given point in an electrical power system.

Reference: Adapted from [[IEC60050](#)]

NOTES:

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

\$ Power Quality

Characteristics of the electrical current, voltage, phase and frequencies at a given point in an electric power system, evaluated against a set of reference technical parameters. These parameters might, in some cases, relate to the compatibility between electricity supplied in an electric power system and the loads connected to that electric power system.

Reference: [[IEC60050](#)]

NOTES:

1. Electrical characteristics representing power quality information are typically required by customer facility energy management systems. It is not intended to satisfy the detailed requirements of power quality monitoring. Standards typically also give ranges of allowed values; the information attributes are the raw measurements, not the "yes/no" determination by the various standards.

Reference: [[ASHRAE-201](#)]

\$ Demand

The average value of power or a related quantity over a specified interval of time. Note: Demand is expressed in kilowatts, kilovolt-amperes, kilovars, or other suitable units.

Reference: [[IEEE100](#)]

NOTES:

1. For EMAN we use kilowatts.

\$ Power State

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

Reference: Adapted from [[IEEE1621](#)]

\$ Power State Set

A Power State Set is a collection of Power States that comprises a named or logical control grouping.

\$ Energy Object

An Energy Object (EO) is an information model (class) that represents a piece of equipment that is part of, or attached to, a communications network which is monitored, controlled, or aids in the management of another device for Energy Management.

\$ Power Interface

A Power Interface (or simply interface) is an information model (class) that represents the interconnections among devices or components where energy can be provided, received, or both.

\$ Energy Management Domain

An Energy Management Domain is a set of Energy Objects that is considered one unit of management.

\$ Energy Object Identification

Energy Object Identification is a set of attributes that enable an Energy Object to be universally unique or linked to other systems.

\$ Energy Object Context

Energy Object Context is a set of attributes that allow an Energy Management System to classify an Energy Object within an organization.

\$ Energy Object Relationship

An Energy Object Relationship is an association among Energy Objects.

NOTES

1. Relationships can be named and could include Aggregation, Metering, and Power Source.

Reference: Adapted from [[CHEN](#)]

\$ Power Source Relationship

A Power Source Relationship is an Energy Object Relationship where one Energy Object provides power to one or more Energy Objects. These Energy Objects are referred to as having a Power Source Relationship.

\$ Metering Relationship

A Metering Relationship is an Energy Object Relationship where one Energy Object measures power, energy, demand or power attributes of one or more other Energy Objects. The measuring Energy Object has a Metering Relationship with each of the measured objects.

\$ Aggregation Relationship

An Aggregation Relationship is an Energy Object Relationship where one Energy Object aggregates Energy Management information of one or more other Energy Objects. The aggregating Energy Object has an Aggregation Relationship with each of the other Energy Objects.

3. Concerns Specific to Energy Management

This section explains areas of concern for Energy Management that do not exist in traditional Network Management. This section describes target devices, outlines physical reference models, and lists the major concerns specific to Energy Management.

3.1. Target Devices

With Energy Management, there exists a wide variety of devices that may be contained in the same deployment as a communication network but comprise a separate facility, home, or power distribution network.

Energy Management has special challenges because a power distribution network supplies energy to devices and components, while a separate communications network monitors and controls the power distribution network.

The target devices for Energy Management are all devices that can be monitored or controlled (directly or indirectly) by an Energy Management System (EnMS). These target devices include:

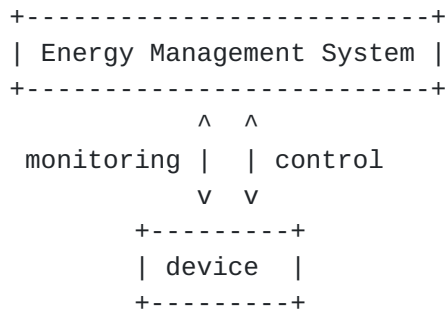
- o Simple electrical appliances and fixtures
- o Hosts, such as a PC, a server, or a printer
- o Switches, routers, base stations, and other network equipment and middle boxes
- o Components within devices, such as a battery inside a PC, a line card inside a switch, etc.
- o Power over Ethernet (PoE) endpoints
- o Power Distribution Units (PDU)
- o Protocol gateway devices for Building Management Systems (BMS)
- o Electrical meters
- o Sensor controllers with subtended sensors

Target devices will primarily communicate via Internet Protocols (IP). The target devices may also include those communicating via non-IP protocols deployed among the power distribution and IP communication network. These types of target devices are expected to be managed through gateways or proxies that can communicate using IP.

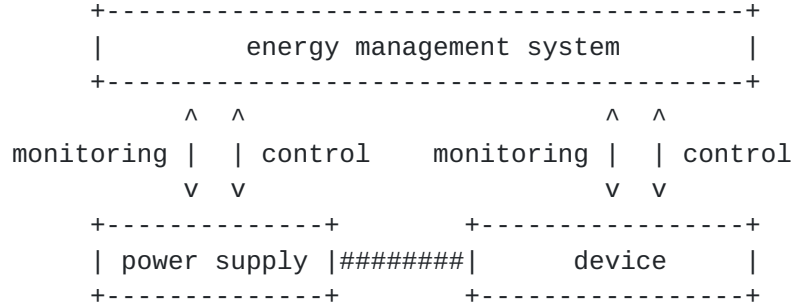
3.2. Physical Reference Model

The following reference models describe physical power topologies that exist in parallel to the communication topology. While many more permutations of topologies can be created the following are some basic ones that show how Energy Management topologies differ from Network Management topologies.

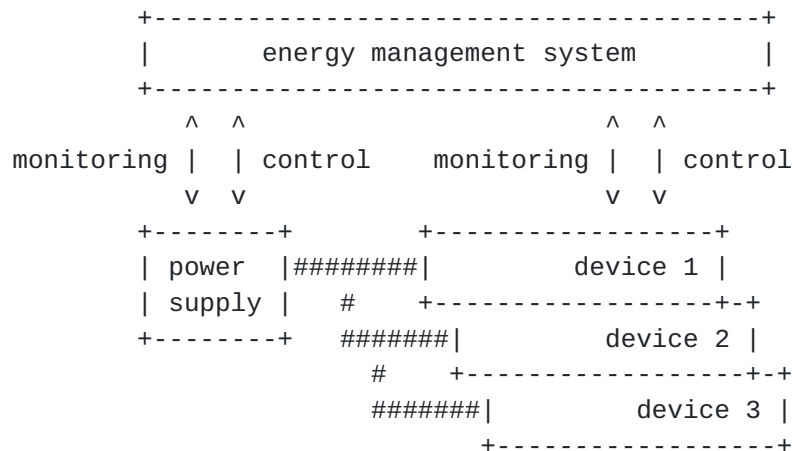
Basic Energy Management



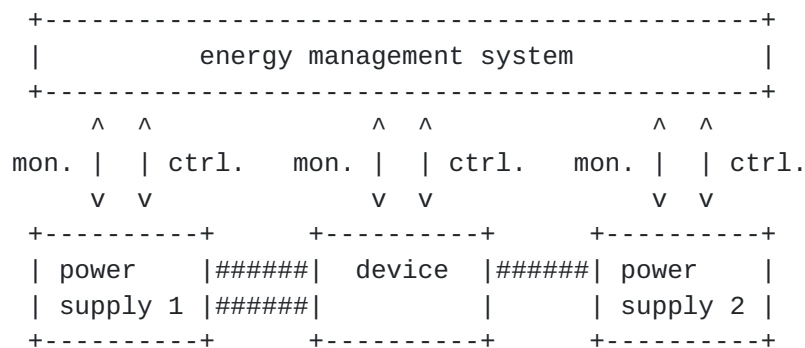
Basic Power Supply



Single Power Supply with Multiple Devices



Multiple Power Supplies with Single Devices

**3.3. Concerns Differing from Network Management**

- o Identification of the power source of a device may be independent of the communication network and require unique identifiers.
- o Controlling power for a device may have to be fulfilled by addressing the power source as opposed to directing control to the device. For example controlling a device by controlling the outlet of the PDU or controlling a simple light by controlling its outlet.
- o Control of a device may need to be coordinated if there are multiple power supplies.
- o Modeling of power when the flow of energy can be bi-directional and require a separate interface model from Network Management. For example energy received into a battery or energy provided from battery).
- o Some devices may need out-of-band or proxy capabilities to respond to communications request even though it is in a non-operational power state.
- o Estimates and source of measurements may vary among devices. For example when devices do not have the capability to measure power an estimate can be provided from the device or estimated by the EnMS. This may require annotation of a measurement.
- o A device may require a separate abstract model to describe its components and interconnections than a model used to describe it for Network Management.

3.4. Concerns Not Addressed

Non-Electrical Equipment

The primary focus of this framework is the management of Electrical Equipment. Some Non-Electrical Equipment may be connected to communication networks and could have their energy managed if normalized to the electrical units for power and energy. Non-Electrical equipment that do not convert-to or present-as equivalent to Electrical Equipment is not addressed.

Energy Procurement and Manufacturing

While an EnMS may be a central point for corporate reporting, cost computation, environmental impact analysis, and regulatory compliance reporting - Energy Management in this framework excludes energy procurement and the environmental impact of energy use.

As such the framework does not include:

- o Cost in currency or environmental units of manufacturing a device.
- o Embedded carbon or environmental equivalences of a device
- o Cost in currency or environmental impact to dismantle or recycle a device.
- o Supply chain analysis of energy sources for device deployment
- o Conversion of the usage or production of energy to units expressed from the source of that energy (such as the greenhouse gas emissions associated with 1000kW from a diesel source).

4. Energy Management Abstraction

Network management is often divided into the five main areas defined in the ISO Telecommunications Management Network model: Fault, Configuration, Accounting, Performance, and Security Management (FCAPS) [[X.700](#)]. This traditional management model does not cover Energy Management.

This section describes a conceptual model of information that can be used for Energy Management. The classes and categories of attributes in the model are described with rationale for each.

4.1. Conceptual Model

This section describes an information model addressing issues specific to Energy Management, which complements existing Network Management models.

An information model for Energy Management will need to describe a means to report information, provide control, and model the interconnections among physical entities (equipment).

Therefore, this section proposes a similar conceptual model for physical entities to that used in Network Management: devices, components, and interfaces. This section then defines the additional attributes specific to Energy Management for those entities that are not available in existing Network Management models.

For modeling the physical entities this section describes three classes: a Device, a Component, and a Power Interface. These classes are sub-types of an abstract Energy Object class.

For modeling additional attributes, this section describes attributes of an Energy Object for: identification, classification, context, control, power and energy.

Since the interconnections between physical entities for Energy Management may have no relation to the interconnections for Network Management the Energy Object classes contain a separate Relationships class as an attribute to model these types of interconnections.

The remainder of this section describes the conceptual model of the classes and categories of attributes in the information model. The formal definitions of the classes and attributes are specified in [Section 5](#).

4.2. Energy Object

An Energy Object is an abstract class that contains the base attributes for Energy Management. There are three types of Energy Objects: Device, Component and Power Interface.

4.2.1. Device Class

The Device Class is a sub-class of Energy Object that represents a physical piece of equipment.

A Device Class instance may represent a device that is a consumer, producer, meter, distributor, or store of energy.

A Device Class instance may represent a physical device that contains other components.

4.2.2. Component Class

The Component Class is a sub-class of Energy Object that represents a part of a physical piece of equipment.

4.2.3. Power Interface Class

The power interface class is a sub-class of Energy Object that represents the interconnection among devices and components.

There are some similarities between Power Interfaces and network interfaces. A network interface can be set to different states, such as sending or receiving data on an attached line. Similarly, a Power Interface can be receiving or providing power.

Physically, a Power Interface instance can represent an AC power socket, an AC power cord attached to a device, or an 8P8C (RJ45) PoE socket, etc.

4.3. Energy Object Attributes

This section describes categories of attributes for an Energy Object.

4.3.1. Identification

A Universal Unique Identifier (UUID) [[RFC4122](#)] is used to uniquely and persistently identify an Energy Object. Ideally the UUID is used to distinguish the Energy Object within the EnMS.

Every Energy Object has an optional unique printable name. Possible naming conventions are: textual DNS name, MAC address of the device, interface ifName, or a text string uniquely identifying the Energy Object. As an example, in the case of IP phones, the Energy Object name can be the device's DNS name.

Additionally an alternate key is provided to allow an Energy Object to be optionally linked with models in different systems.

4.3.2. Context in General

In order to aid in reporting and in differentiation between Energy Objects, each object optionally contains information establishing its business, site, or organizational context within a deployment.

Energy Objects contain a category attribute that broadly describes how the object is used in a deployment. The category indicates if the Energy Object is primarily functioning as a consumer, producer, meter, distributor or store of energy.

Given the category and context of an object, an EnMS can summarize or analyze measurements. For example, metered usage reported by a meter and consumption usage reported by a device connected to that meter may measure the same usage. With the two measurements identified by category and context an EnMS can make summarizations and inferences.

4.3.3. Context: Importance

An Energy Object can provide an importance value in the range of 1 to 100 to help rank a device's use or relative value to the site. The importance range is from 1 (least important) to 100 (most important). The default importance value is 1.

For example: A typical office environment has several types of phones, which can be rated according to their business impact. A public desk phone has a lower importance (for example, 10) than a business-critical emergency phone (for example, 100). As another example: A company can consider that a PC and a phone for a customer-service engineer are more important than a PC and a phone for lobby use.

Although EnMS and administrators can establish their own ranking, the following example is a broad recommendation for commercial deployments [[CISCO-EW](#)]:

- 90 to 100 Emergency response
- 80 to 90 Executive or business-critical
- 70 to 79 General or Average
- 60 to 69 Staff or support
- 40 to 59 Public or guest

1 to 39 Decorative or hospitality

4.3.4. Context: Keywords

An Energy Object can provide a set of keywords. These keywords are a list of tags that can be used for grouping, summary reporting within or between Energy Management Domains, and for searching. All alphanumeric characters and symbols (other than a comma), such as #, (, \$, !, and &, are allowed. Potential examples are: IT, lobby, HumanResources, Accounting, StoreRoom, CustomerSpace, router, phone, floor2, or SoftwareLab. There is no default value for a keyword.

Multiple keywords can be assigned to a device. White spaces before and after the commas are excluded, as well as within a keyword itself. In such cases, commas separate the keywords and no spaces between keywords are allowed. For example, "HR,Bldg1,Private".

4.3.5. Context: Role

An Energy Object contains a "role description" string that indicates the purpose the Energy Object serves in the deployment. This could be a string describing the context the device fulfills in deployment.

Administrators can define any naming scheme for the role of a device. As guidance, a two-word role that combines the service the device provides along with type can be used [[IPENERGY](#)].

Example types of devices: Router, Switch, Light, Phone, WorkStation, Server, Display, Kiosk, HVAC.

Example Services by Line of Business:

Line of Business	Service
Education	Student, Faculty, Administration, Athletic
Finance	Trader, Teller, Fulfillment
Manufacturing	Assembly, Control, Shipping
Retail	Advertising, Cashier
Support	Helpdesk, Management
Medical	Patient, Administration, Billing

Role as a two-word string: "Faculty Desktop", "Teller Phone", "Shipping HVAC", "Advertising Display", "Helpdesk Kiosk", "Administration Switch".

4.3.6. Context: Domain

An Energy Object contains a string to indicate membership in an Energy Management Domain. An Energy Management Domain can be any collection of devices in a deployment, but it is recommended to map 1:1 with a metered or sub-metered portion of the site.

In building management, a meter refers to the meter provided by the utility used for billing and measuring power to an entire building or unit within a building. A sub-meter refers to a customer- or user-installed meter that is not used by the utility to bill but is instead used to get measurements from sub portions of a building. An Energy Object should be a member of a single Energy Management Domain therefore one attribute is provided. The Energy Management Domain may be configured on an Energy Object.

4.4. Measurements

An Energy Object contains attributes to describe power, energy and demand measurements.

For the purposes of this framework, energy will be limited to electrical energy in watt-hours. Other forms of Energy Objects that use or produce non-electrical energy may be modeled as an Energy Object but must provide information converted to and expressed in watt-hours.

An analogy for understanding power versus energy measurements can be made to speed and distance in automobiles. Just as a speedometer indicates the rate of change of distance (speed), a power measurement indicates the rate of transfer of energy. The odometer in an automobile measures the cumulative distance traveled and similarly an energy measurement indicates the accumulated energy transferred.

Demand measurements are averages of power measurements over time. So using the same analogy to an automobile: measuring the average vehicle speed over multiple intervals of time for a given distance travelled, demand is the average power measured over multiple time intervals for a given energy value.

4.4.1. Measurements: Power

Each Energy Object contains a Nameplate Power attribute that describes the nominal power as specified by the manufacturer. The EnMS can use the Nameplate Power for provisioning, capacity planning and (potentially) billing.

Each Energy Object will have information that describes the present power information, along with how that measurement was obtained or derived (e.g., actual, estimated, or static).

A power measurement is qualified with the units, magnitude and direction of power flow, and is qualified as to the means by which the measurement was made.

Power measurement magnitude conforms to the [[IEC61850](#)] definition of unit multiplier for the SI (System International) units of measure. Measured values are represented in SI units obtained by $\text{BaseValue} * (10^{\text{Scale}})$. For example, if current power usage of an Energy Object is 3, it could be 3 W, 3 mW, 3 KW, or 3 MW, depending on the value of the scaling factor. 3W implies that the BaseValue is 3 and Scale = 0, whereas 3mW implies BaseValue = 3 and ScaleFactor = -3.

An Energy Object indicates how the power measurement was obtained with a caliber attribute that indicates:

- o Whether the measurements were made at the device itself or at a remote source.
- o Description of the method that was used to measure the power and whether this method can distinguish actual or estimated values.
- o Accuracy for actual measured values

4.4.2. Measurements: Power Attributes

Optionally, an Energy Object describes the Power measurements with Power Attribute information reflecting the electrical characteristics of the measurement. These Power Attributes adhere to the [IEC-61850-7-2] standard for describing AC measurements.

4.4.3. Measurements: Energy

Optionally, an Energy Object that can report actual power readings will have energy attributes that provide the energy used, produced, or stored in kWh.

4.4.4. Measurements: Demand

Optionally, an Energy Object will provide demand information over time. Demand measurements can be provided when the Energy Object is capable of measuring actual power.

4.5. Control

An Energy Object can be controlled by setting a Power State. An Energy Object implements at least one set of Power States consisting of at least two states, an on state and an off state.

Each Energy Object should indicate the sets of Power States that it implements. Well-known Power State Sets are registered with IANA.

When a device is set to a particular Power State, it may be busy. The device will set the desired Power State and then update the actual Power State when it changes. There are then two Power State control variables: actual and requested.

There are many existing standards for and implementations of Power States. An Energy Object can support a mixed set of Power States defined in different standards. A basic example is given by the three Power States defined in IEEE1621 [[IEEE1621](#)]: on, off, and sleep. The DMTF [[DMTF](#)], ACPI [[ACPI](#)], and PWG define larger numbers of Power States.

The semantics of a Power State are specified by

- a) the functionality provided by an Energy Object in this state,
- b) a limitation of the power that an Energy Object uses in this state,
- c) a combination of a) and b)

The semantics of a Power State should be clearly defined. Limitation (curtailment) of the power used by an Energy Object in a state may specified by:

- o an absolute power value
- o a percentage value of power relative to the energy object's nameplate power
- o an indication of power relative to another power state. For example: Specify that power in state A is less than in state B.
- o For supporting Power State management an Energy Object provides statistics on Power States including the time an Energy Object spent in a certain Power State and the number of times an Energy Object entered a power state.

When requesting an Energy Object to enter a Power State an indication of the Power State's name or number can be used. Optionally an absolute or percentage of Nameplate Power can be provided to allow the Energy Object to transition to a nearest or equivalent Power State.

4.5.1. Power State Sets

There are several standards and implementations of Power State Sets. An Energy Object can support one or multiple Power State Set implementation(s) concurrently.

There are currently three Power State Sets advocated:

IEEE1621(256) - [[IEEE1621](#)]
DMTF(512) - [[DMTF](#)]
EMAN(768) - [[EMAN-MON-MIB](#)]

The respective specific states related to each Power State Set are specified in the following sections. The guidelines for the modification of Power State Sets are specified in the IANA Considerations Section.

4.5.2. Power State Set: IEEE1621

The IEEE1621 Power State Set [[IEEE1621](#)] consists of 3 rudimentary states: on, off or sleep.

- o on(0) - The device is fully On and all features of the device are in working mode.
- o off(1) - The device is mechanically switched off and does not consume energy.
- o sleep(2) - The device is in a power saving mode, and some features may not be available immediately.

4.5.3. Power State Set: DMTF

The DMTF [[DMTF](#)] standards organization has defined a power profile standard based on the CIM (Common Information Model) model that consists of 15 power states:

{ON (2), SleepLight (3), SleepDeep (4), Off-Hard (5), Off-Soft (6), Hibernate(7), PowerCycle Off-Soft (8), PowerCycle Off-Hard (9), MasterBus reset (10), Diagnostic Interrupt (11), Off-Soft-Graceful (12), Off-Hard Graceful (13), MasterBus reset Graceful (14), Power-Cycle Off-Soft Graceful (15), PowerCycle-Hard Graceful (16)}

The DMTF standard is targeted for hosts and computers. Details of the semantics of each Power State within the DMTF Power State Set can be obtained from the DMTF Power State Management Profile specification [[DMTF](#)].

The DMTF power profile extends ACPI power states. The following table provides a mapping between DMTF and ACPI Power State Set:

DMTF	ACPI
Reserved(0)	
Reserved(1)	
ON (2)	G0-S0
Sleep-Light (3)	G1-S1 G1-S2
Sleep-Deep (4)	G1-S3
Power Cycle (Off-Soft) (5)	G2-S5
Off-hard (6)	G3
Hibernate (Off-Soft) (7)	G1-S4
Off-Soft (8)	G2-S5
Power Cycle (Off-Hard) (9)	G3
Master Bus Reset (10)	G2-S5
Diagnostic Interrupt (11)	G2-S5
Off-Soft Graceful (12)	G2-S5
Off-Hard Graceful (13)	G3
MasterBus Reset Graceful (14)	G2-S5
Power Cycle off-soft Graceful (15)	G2-S5
Power Cycle off-hard Graceful (16)	G3

4.5.4. Power State Set: IETF EMAN

An EMAN Power State Set represents an attempt at a standard approach for modeling the different levels of power of a device. The EMAN Power States are an expansion of the basic Power States as defined in [[IEEE1621](#)] that also incorporates the Power States defined in [[ACPI](#)] and [[DMTF](#)]. Therefore, in addition to the non-operational states as defined in [[ACPI](#)] and [[DMTF](#)] standards, several intermediate operational states have been defined.

An Energy Object may implement fewer or more Power States than a particular EMAN Power State Set specifies. In this case, the Energy Object implementation can determine its own mapping to the predefined EMAN Power States within the EMAN Power State Set.

There are twelve EMAN Power States that expand on [[IEEE1621](#)]. The expanded list of Power States is derived from [[CISCO-EW](#)] and is divided into six operational states and six non-operational states.

The lowest non-operational state is 1 and the highest is 6. Each non-operational state corresponds to an [\[ACPI\]](#) Global and System state between G3 (hard-off) and G1 (sleeping). Each operational state represents a performance state, and may be mapped to [\[ACPI\]](#) states P0 (maximum performance power) through P5 (minimum performance and minimum power).

In each of the non-operational states (from mechoff(1) to ready(6)), the Power State preceding it is expected to have a lower Power value and a longer delay in returning to an operational state:

mechoff(1) : An off state where no Energy Object features are available. The Energy Object is unavailable. No energy is being consumed and the power connector can be removed.

softoff(2) : Similar to mechoff(1), but some components remain powered or receive trace power so that the Energy Object can be awakened from its off state. In softoff(2), no context is saved and the device typically requires a complete boot when awakened.

hibernate(3): No Energy Object features are available. The Energy Object may be awakened without requiring a complete boot, but the time for availability is longer than sleep(4). An example for state hibernate(3) is a save to-disk state where DRAM context is not maintained. Typically, energy consumption is zero or close to zero.

sleep(4) : No Energy Object features are available, except for out-of-band management, such as wake-up mechanisms. The time for availability is longer than standby(5). An example for state sleep(4) is a save-to-RAM state, where DRAM context is maintained. Typically, energy consumption is close to zero.

standby(5) : No Energy Object features are available, except for out-of-band management, such as wake-up mechanisms. This mode is analogous to cold-standby. The time for availability is longer than ready(6). For example processor context is may not be maintained. Typically, energy consumption is close to zero.

ready(6) : No Energy Object features are available, except for out-of-band management, such as wake-up mechanisms. This mode is analogous to hot-standby. The Energy Object can be quickly transitioned into an

operational state. For example, processors are not executing, but processor context is maintained.

lowMinus(7) : Indicates some Energy Object features may not be available and the Energy Object has taken measures or selected options to provide less than low(8) usage.

low(8) : Indicates some features may not be available and the Energy Object has taken measures or selected options to provide less than mediumMinus(9) usage.

mediumMinus(9): Indicates all Energy Object features are available but the Energy Object has taken measures or selected options to provide less than medium(10) usage.

medium(10) : Indicates all Energy Object features are available but the Energy Object has taken measures or selected options to provide less than highMinus(11) usage.

highMinus(11): Indicates all Energy Object features are available and power usage is less than high(12).

high(12) : Indicates all Energy Object features are available and the Energy Object is consuming the highest power.

[4.5.5. Power State Sets Comparison](#)

A comparison of Power States from different Power State Sets can be seen in the following table:

IEEE1621	DMTF	ACPI	EMAN
Non-operational states			
off	Off-Hard	G3, S5	MechOff(1)
off	Off-Soft	G2, S5	SoftOff(2)
sleep	Hibernate	G1, S4	Hibernate(3)
sleep	Sleep-Deep	G1, S3	Sleep(4)
sleep	Sleep-Light	G1, S2	Standby(5)
sleep	Sleep-Light	G1, S1	Ready(6)
Operational states:			
on	on	G0, S0, P5	LowMinus(7)
on	on	G0, S0, P4	Low(8)
on	on	G0, S0, P3	MediumMinus(9)
on	on	G0, S0, P2	Medium(10)
on	on	G0, S0, P1	HighMinus(11)
on	on	G0, S0, P0	High(12)

4.6. Relationships

Two Energy Objects can establish an Energy Object Relationship to model the deployment topology with respect to Energy Management.

Relationships are modeled with a Relationship class that contains the UUID of the participants in the relationship and a description of the type of relationship. The types of relationships are: power source, metering, and aggregations.

- o The Power Source Relationship gives a view of the physical wiring topology. For example: a data center server receiving power from two specific Power Interfaces from two different PDUs.

Note: A power source relationship may or may not change as the direction of power changes between two Energy Objects. The relationship may remain to indicate the change of power direction was unintended or an error condition.

- o The Metering Relationship gives the view of the metering topology. Physical meters can be placed anywhere in a power distribution tree. For example, utility meters monitor and report accumulated power consumption of the entire building. Logically, the metering topology overlaps with the wiring topology, as meters are connected to the wiring topology. A typical example is meters that clamp onto the existing wiring.
- o The Aggregation Relationship gives a model of devices that may aggregate (sum, average, etc) values for other devices. The Aggregation Relationship is slightly different compared to the other relationships as this refers more to a management function.

In some situations, it is not possible to discover the Energy Object Relationships, and they must be set by an EnMS or administrator. Given that relationships can be assigned manually, the following sections describes guidelines for use.

4.6.1. Relationship Conventions and Guidelines

This Energy Management framework does not impose many "MUST" rules related to Energy Object Relationships. There are always corner cases that could be excluded with too strict specifications of relationships. However, this Energy Management framework proposes a series of guidelines, indicated with "SHOULD" and "MAY".

4.6.2. Guidelines: Power Source

Power Source relationships are intended to identify the connections between Power Interfaces. This is analogous to a Layer 2 connection in networking devices (a "one-hop connection").

The preferred modeling would be for Power Interfaces to participate in Power Source Relationships. In some cases Energy Objects may not have the capability to model Power Interfaces. Therefore a Power Source Relationship can be established between two Energy Objects or two non-connected Power Interfaces.

While strictly speaking Components and Power Interfaces on the same device do provide or receive energy from each other, the Power Source relationship is intended to show energy transfer between Devices. Therefore the relationship is implied when on the same Device.

An Energy Object SHOULD NOT establish a Power Source Relationship with a Component.

- o A Power Source Relationship SHOULD be established with the next known Power Interface in the wiring topology.
- o The next known Power Interface in the wiring topology would be the next device implementing the framework. In some cases the domain of devices under management may include some devices that do not implement the framework. In these cases, the Power Source relationship can be established with the next device in the topology that implements the framework and logically shows the Power Source of the device.

- o Transitive Power Source relationships SHOULD NOT be established. For example, if an Energy Object A has a Power Source Relationship "Poweredby" with the Energy Object B, and if the Energy Object B has a Power Source Relationship "Poweredby" with the Energy Object C, then the Energy Object A SHOULD NOT have a Power Source Relationship "Poweredby" with the Energy Object C.

4.6.3. Guidelines: Metering Relationship

Metering Relationships are intended to show when one Device acting as a Meter is measuring the power or energy at a point in a power distribution system. Since one point of a power distribution system may cover many Devices within a wiring topology, this relationship type can be seen as an arbitrary set.

Some Devices, however, may include measuring hardware for components and Power Interfaces or for the entire Device. For example, some PDUs may have the ability to measure Power for each Power Interface (metered by outlet). Others may be able to control power at each Power Interface but can only measure Power at the Power Inlet and a total for all Power Interfaces (metered by device).

While the Metering Relationship SHOULD be used between devices, in some cases the Device MAY be modeled as an Energy Object that meters all of its Power Outlets and each Power Outlet MAY be metered by the Energy Object representing the Device.

In general:

- o A Metering Relationship MAY be established with any other Energy Object, Component, or Power Interface.
- o Transitive Metering relationships MAY be used.
- o When there is a series of meters for one Energy Object, the Energy Object MAY establish a Metering relationship with one or more of the meters.

4.6.4. Guidelines: Aggregation

Aggregation relationships are intended to identify when one device is used to accumulate values from other devices. Typically this is for energy or power values among devices and not for Components or Power Interfaces on the same device.

The intent of Aggregation relationships is to indicate when one device is providing aggregate values for a set of other devices when it is not obvious from the power source or simple containment within a device.

Establishing aggregation relationships within the same device would make modeling more complex and the aggregated values can be implied from the use of Power Inlets, outlet and Energy Object values on the same device.

Since an EnMS is naturally a point of aggregation it is not necessary to model aggregation for Energy Management Systems.

Aggregation SHOULD be used for power and energy. It MAY be used for aggregation of other values from the information model, but the rules and logical ability to aggregate each attribute is out of scope for this document.

In general:

- o A Device SHOULD NOT establish an Aggregation Relationship with Components contained on the same device.
- o A Device SHOULD NOT establish an Aggregation Relationship with the Power Interfaces contained on the same device.
- o A Device SHOULD NOT establish an Aggregation Relationship with an EnMS.
- o Aggregators SHOULD log or provide notification in the case of errors or missing values while performing aggregation.

4.6.5. Energy Object Relationship Extensions

This framework for Energy Management is based on three relationship types: Aggregation , Metering, and Power Source.

This framework is defined with possible future extension of new Energy Object Relationships in mind.

For example:

- o Some Devices that may not be IP connected. This can be modeled with a proxy relationship to an Energy Object within the domain. This type of proxy relationship is left for further development.

- o A Power Distribution Unit (PDU) that allows physical entities like outlets to be "ganged" together as a logical entity for simplified management purposes, could be modeled with an extension called a "gang relationship", whose semantics would specify the Energy Objects' grouping.

5. Energy Management Information Model

This section presents an information model expression of the concepts in this framework as a reference for implementers. The information model is implemented as a MIB in the different related IETF EMAN documents. However, other programming structures with different data models could be used as well.

Data modeling specifications of this information model may where needed specify which attributes are required or optional.

EDITORS NOTE: The working group is converging on the use of code/pseudo-code rather than ascii UML diagram. IF so we would have to define primitive type as reference (eg. Int, string, etc) If agreeable we can either indicate a BNF syntax in a formal syntax section or use the following table if obvious:

Syntax

UML Construct	[ISO-IEC-19501-2005] Equivalent Notation
Notes	// Notes
Class	
(Generalization)	CLASS name {member..}
Sub-Class	
(Specialization)	CLASS subclass
	EXTENDS superclass {member..}
Class Member	
(Attribute)	attribute : type

Model

```
CLASS EnergyObject {

    // identification / classification
    index      : int
    identifier  : uuid
    alternatekey : string

    // context
    domainName  : string
    role        : string
    keywords [0..n] : string
    importance   : int

    // relationship
    relationships [0..n] : Relationship

    // measurements
    nameplate    : Nameplate
    power        : PowerMeasurement
    energy       : EnergyMeasurment
    demand       : DemandMeasurement

    // control
    powerControl [0..n] : PowerStateSet
}

CLASS Device EXTENDS EnergyObject {
    eocategory : enum { producer, consumer, meter,
distributor, store }
}

CLASS Component EXTENDS EnergyObject
    eocategory : enum { producer, consumer, meter,
distributor, store }
}

CLASS Interface EXTENDS EnergyObject{
    eoIfType : enum ( inlet, outlet, both)
}

CLASS Nameplate {
    nominalPower : PowerMeasurement
    details      : URI
}
```



```
CLASS Relationship {
    relationshipType    : enum { meters, meteredby,
powers, poweredby, aggregates, aggregatedby }
    relationshipObject  : uuid
}

CLASS Measurement {
    multiplier: enum { -24..24}
    caliber    : enum { actual, estimated, static }
    accuracy   : enum { 0..10000} // hundreds of percent
}

CLASS PowerMeasurement EXTENDS Measurement {
    value          : long
    units          : "W"
    powerAttribute : PowerAttribute
}

CLASS EnergyMeasurement EXTENDS Measurement {
    startTime : time
    units     : "kWh"
    provided  : long
    used      : long
    produced  : long
    stored    : long
}

CLASS TimedMeasurement EXTENDS Measurement {
    startTime : timestamp
    value     : Measurement
    maximum   : Measurement
}

CLASS TimeInterval {
    value      : long
    units      : enum { seconds, milliseconds,...}
}

CLASS DemandMeasurement EXTENDS Measurement {
    intervalLength : TimeInte
rval
    interval       : long
    intervalMode   : enum { periodic, sliding, total }
    intervalWindow : TimeInterval
    sampleRate     : TimeInterval
    status         : enum { active, inactive }
    measurements[0..n] : TimedMeasurements
}
```



```
CLASS PowerStateSet {
    powerSetIdentifier : int
    name               : string
    powerStates [0..n] : PowerState
    operState          : int
    adminState         : int
    reason             : string
    configuredTime     : timestamp
}

CLASS PowerState {
    powerStateIdentifier : int
    name                 : string
    cardinality          : int
    maximumPower         : PowerMeasurement
    totalTimeInState     : time
    entryCount           : long
}

CLASS PowerAttribute {

    // container for attributes
    acQuality : ACQuality
}

CLASS ACQuality {
    acConfiguration : enum {SNGL, DEL,WYE}
    avgVoltage      : long
    avgCurrent      : long
    frequency       : long
    unitMultiplier  : int
    accuracy        : int
    totalActivePower : long
    totalReactivePower : long
    totalApparentPower : long
    totalPowerFactor : long
    phases [0..2] : ACPhase
}

CLASS ACPhase {
    phaseIndex : long
    avgCurrent : long
    activePower : long
    reactivePower : long
    apparentPower : long
    powerFactor : long
}
```



```
CLASS DelPhase EXTENDS ACPhase {  
    phaseToNextPhaseVoltage : long  
    thdVoltage : long  
    thdCurrent : long  
}
```

```
CLASS WYEPHASE EXTENDS ACPhase {  
    phaseToNeutralVoltage : long  
    thdCurrent : long  
    thdVoltage : long  
}
```

6. Modeling Relationships between Devices

In this section we give examples of how to use the Energy Management framework relationships to model physical topologies. Where applicable, we show how the framework can be applied when Devices have the capability to model Power Interfaces. We also show how the framework can be applied when devices cannot support Power Interfaces but only monitor information or control the Device as a whole. For instance, a PDU may only be able to measure power and energy for the entire unit without the ability to distinguish among the inlets or outlet.

6.1. Power Source Relationship

The Power Source relationship is used to model the interconnections between Devices, Components and/Power Interfaces to indicate the source of energy for an Energy Object. In the following examples we show variations on modeling the reference topologies using relationships.

Given for all cases:

Device W: A computer with one power supply. Power interface 1 is an inlet for Device W.

Device X: A computer with two power supplies. Power interface 1 and power interface 2 are both inlets for Device X.

Device Y: A PDU with multiple Power Interfaces numbered 0..10. Power interface 0 is an inlet and power interface 1..10 are outlets.

Device Z: A PDU with multiple Power Interfaces numbered 0..10. Power interface 0 is an inlet and power interface 1..10 are outlets.

Case 1: Simple Device with one Source

Physical Topology:

- o Device W inlet 1 is plugged into Device Y outlet 8.

With Power Interfaces:

- o Device W has an Energy Object representing the computer itself as well as one Power Interface defined as an inlet.
- o Device Y would have an Energy Object representing the PDU itself (the Device), with a Power Interface 0 defined as an inlet and Power Interfaces 1..10 defined as outlets.

The interfaces of the devices would have a Power Source Relationship such that:

Device W inlet 1 is powered by Device Y outlet 8.

```

+-----+-----+          poweredBy +-----+-----+
| PDU Y | PI 8 |-----| PI 1 | Device W |
+-----+-----+ powers          +-----+-----+

```

Without Power Interfaces:

- o Device W has an Energy Object representing the computer.
- o Device Y would have an Energy Object representing the PDU.

The devices would have a Power Source Relationship such that:

Device W is powered by Device Y.

```

+-----+          poweredBy +-----+
| PDU Y |-----| Device W |
+-----+ powers          +-----+

```

Case 2: Multiple Inlets

Physical Topology:

- o Device X inlet 1 is plugged into Device Y outlet 8.
- o Device X inlet 2 is plugged into Device Y outlet 9.

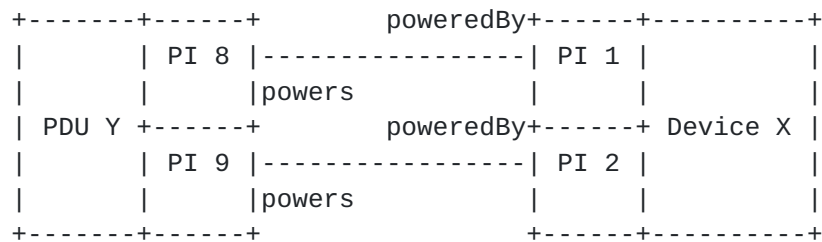
With Power Interfaces:

- o Device X has an Energy Object representing the computer itself. It contains two Power Interfaces defined as inlets.
- o Device Y would have an Energy Object representing the PDU itself (the Device), with a Power Interface 0 defined as an inlet and Power Interfaces 1..10 defined as outlets.

The interfaces of the devices would have a Power Source Relationship such that:

Device X inlet 1 is powered by Device Y outlet 8.

Device X inlet 2 is powered by Device Y outlet 9.

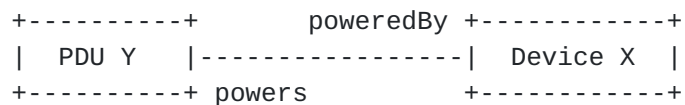


Without Power Interfaces:

- o Device X has an Energy Object representing the computer. Device Y has an Energy Object representing the PDU.

The devices would have a Power Source Relationship such that:

Device X is powered by Device Y.



Case 3: Multiple Sources

Physical Topology:

- o Device X inlet 1 is plugged into Device Y outlet 8.
- o Device X inlet 2 is plugged into Device Z outlet 9.

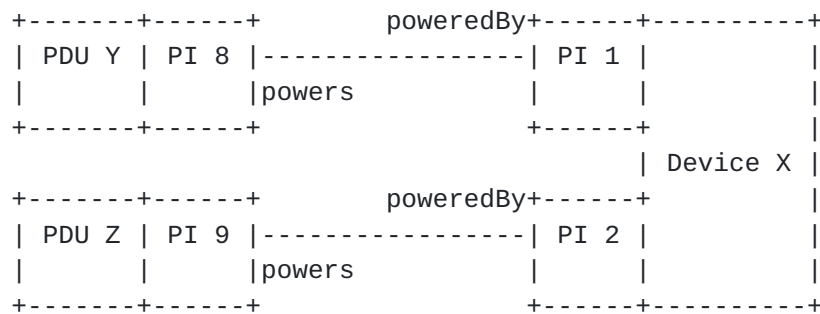
With Power Interfaces:

- o Device X has an Energy Object representing the computer itself. It contains two Power Interface defined as inlets.
- o Device Y would have an Energy Object representing the PDU itself (the Device), with a Power Interface 0 defined as an inlet and Power Interfaces 1..10 defined as outlets.
- o Device Z would have an Energy Object representing the PDU itself (the Device), with a Power Interface 0 defined as an inlet and Power Interfaces 1..10 defined as outlets.

The interfaces of the devices would have a Power Source Relationship such that:

Device X inlet 1 is powered by Device Y outlet 8.

Device X inlet 2 is powered by Device Z outlet 9.

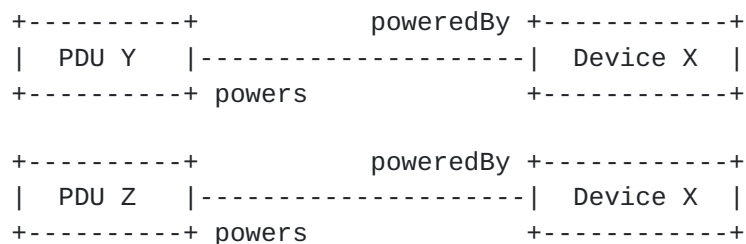


Without Power Interfaces:

- o Device X has an Energy Object representing the computer. Device Y and Z would both have respective Energy Objects representing each entire PDU.

The devices would have a Power Source Relationship such that:

Device X is powered by Device Y and powered by Device Z.



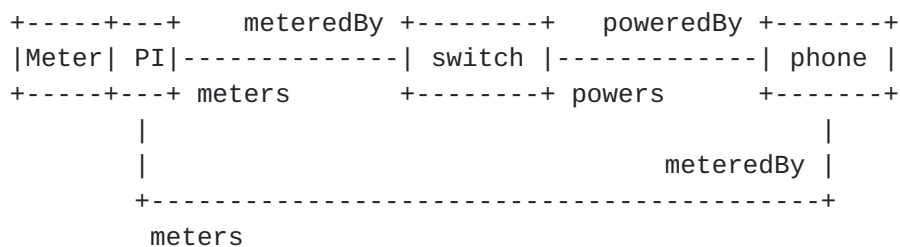
6.2. Metering Relationship

Case 1: Metering between two Devices

The metering topology between two devices is closely related to the power source topology. It is based on the assumption that in many cases the power provided and the power received is the same for both peers of a power source relationship.

We define in this case a Metering Relationship between two Devices or Power Interfaces of Devices that have a power source relationship. Power and energy values measured at one peer of the power source relationship are reported for the other peer as well.

The Metering Relationship is independent of the direction of the Power Source Relationship. The most common case is that values measured at the power provider are reported for the power receiver.



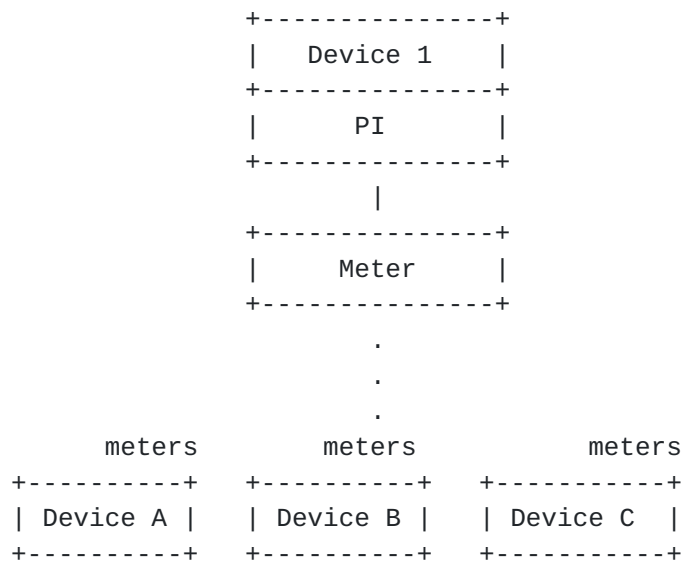
Case 2: Metering among many Devices

A Sub-meter in a power distribution system can logically measure the power or energy for all devices downstream from the meter in the power distribution system. As such, a Power metering relationship can be seen as a relationship between a meter Device and all of the devices downstream from the meter.

We define in this case a Power Source relationship between a metering device and devices downstream from the meter.

In cases where the Power Source topology cannot be discovered or derived from the information available in the Energy Management Domain, the Metering Topology can be used to relate the upstream meter to the downstream devices in the absence of specific power source relationships.

A Metering Relationship can occur between devices that are not directly connected, as shown in the following figure:



An analogy to communications networks would be modeling connections between servers (meters) and clients (devices) when the complete Layer 2 topology between the servers and clients is not known.

6.3. Aggregation Relationship

Some devices can act as aggregation points for other devices. For example, a PDU controller device may contain the summation of power and energy readings for many PDU devices. The PDU controller will have aggregate values for power and energy for a group of PDU devices.

This aggregation is independent of the physical power or communication topology.

An Aggregation Relationship is an Energy Object Relationship where one Energy Object (called the Aggregate Energy Object) aggregates the Energy Management information of one or more other Energy Objects. These Energy Objects are said to have an Aggregation Relationship.

The functions that the aggregation point may perform include the calculation of values such as average, count, maximum, median, minimum, or the listing (collection) of the aggregation values, etc.

Based on the experience gained on aggregations at the IETF [[draft-ietf-ipfix-a9n-08](#)], the aggregation function in the EMAN framework is limited to the summation.

When aggregation occurs across a set of entities, values to be aggregated may be missing for some entities. The EMAN

framework does not specify how these should be treated, as different implementations may have good reason to take different approaches. One common treatment is to define the aggregation as missing if any of the constituent elements are missing (useful to be most precise). Another is to treat the missing value as zero (useful to have continuous data streams).

The specifications of aggregation functions are out of scope of the EMAN framework, but must be clearly specified by the equipment vendor.

7. Relationship to Other Standards

This Energy Management framework uses, as much as possible, existing standards especially with respect to information modeling and data modeling [[RFC3444](#)].

The data model for power- and energy-related objects is based on [[IEC61850](#)].

Specific examples include:

- o The scaling factor, which represents Energy Object usage magnitude, conforms to the [[IEC61850](#)] definition of unit multiplier for the SI (System International) units of measure.
- o The electrical characteristic is based on the ANSI and IEC Standards, which require that we use an accuracy class for power measurement. ANSI and IEC define the following accuracy classes for power measurement:
 - o IEC 62053-22 60044-1 class 0.1, 0.2, 0.5, 1 3.
 - o ANSI C12.20 class 0.2, 0.5
- o The electrical characteristics and quality adhere closely to the [[IEC61850-7-2](#)] standard for describing AC measurements.
- o The power state definitions are based on the DMTF Power State Profile and ACPI models, with operational state extensions.

8. Security Considerations

Regarding the data attributes specified here, some or all may be considered sensitive or vulnerable in some network environments. Reading or writing these attributes without proper protection such as encryption or access authorization may have negative effects on the network capabilities.

8.1. Security Considerations for SNMP

Readable objects in MIB modules (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is important to control GET and/or NOTIFY access to these objects and possibly to encrypt the values of these objects when sending them over the network via SNMP.

The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations.

For example:

- o Unauthorized changes to the Energy Management Domain or business context of a device may result in misreporting or interruption of power.
- o Unauthorized changes to a power state may disrupt the power settings of the different devices, and therefore the state of functionality of the respective devices.
- o Unauthorized changes to the demand history may disrupt proper accounting of energy usage.

With respect to data transport, SNMP versions prior to SNMPv3 did not include adequate security. Even if the network itself is secure (for example, by using IPsec), there is still no secure control over who on the secure network is allowed to access and GET/SET (read/change/create/delete) the objects in these MIB modules.

It is recommended that implementers consider the security features as provided by the SNMPv3 framework (see [\[RFC3410\], section 8](#)), including full support for the SNMPv3 cryptographic mechanisms (for authentication and privacy).

Further, deployment of SNMP versions prior to SNMPv3 is not recommended. Instead, it is recommended to deploy SNMPv3 and to enable cryptographic security. It is then a customer/operator responsibility to ensure that the SNMP entity giving access to an instance of these MIB modules is properly configured to give access to the objects only to those principals (users) that have legitimate rights to GET or SET (change/create/delete) them.

9. IANA Considerations

9.1. IANA Registration of new Power State Sets

This document specifies an initial set of Power State Sets. The list of these Power State Sets with their numeric identifiers is given in [Section 4](#). IANA maintains the lists of Power State Sets.

New assignments for Power State Set are administered by IANA through Expert Review [[RFC5226](#)], i.e., review by one of a group of experts designated by an IETF Area Director. The group of experts MUST check the requested state for completeness and accuracy of the description. A pure vendor specific implementation of Power State Set shall not be adopted; since it would lead to proliferation of Power State Sets.

Power states in a Power State Set are limited to 255 distinct values. New Power State Set must be assigned the next available numeric identifier that is a multiple of 256.

9.1.1. IANA Registration of the IEEE1621 Power State Set

This document specifies a set of values for the IEEE1621 Power State Set [[IEEE1621](#)]. The list of these values with their identifiers is given in [Section 4.6.2](#). IANA created a new registry for IEEE1621 Power State Set identifiers and filled it with the initial list of identifiers.

New assignments (or potentially deprecation) for the IEEE1621 Power State Set is administered by IANA through Expert Review [[RFC5226](#)], i.e., review by one of a group of experts designated by an IETF Area Director. The group of experts must check the requested state for completeness and accuracy of the description.

9.1.2. IANA Registration of the DMTF Power State Set

This document specifies a set of values for the DMTF Power State Set. The list of these values with their identifiers is given in [Section 4](#). IANA has created a new registry for DMTF Power State Set identifiers and filled it with the initial list of identifiers.

New assignments (or potentially deprecation) for the DMTF Power State Set is administered by IANA through Expert Review [[RFC5226](#)], i.e., review by one of a group of experts designated by an IETF Area Director. The group of experts

must check the conformance with the DMTF standard [[DMTF](#)], on the top of checking for completeness and accuracy of the description.

9.1.3. IANA Registration of the EMAN Power State Set

This document specifies a set of values for the EMAN Power State Set. The list of these values with their identifiers is given in [Section 4.6.4](#). IANA has created a new registry for EMAN Power State Set identifiers and filled it with the initial list of identifiers.

New assignments (or potentially deprecation) for the EMAN Power State Set is administered by IANA through Expert Review [[RFC5226](#)], i.e., review by one of a group of experts designated by an IETF Area Director. The group of experts must check the requested state for completeness and accuracy of the description.

9.1.4. Batteries Power State Set

Batteries have operational and administrative states that could be represented as a power state set. Since the work for battery management is parallel to this document, we are not proposing any Power State Sets for batteries at this time.

9.2. Updating the Registration of Existing Power State Sets

With the evolution of standards, over time, it may be important to deprecate some of the existing the Power State Sets, or to add or deprecate some Power States within a Power State Set.

The registrant shall publish an Internet-draft or an individual submission with the clear specification on deprecation of Power State Sets or Power States registered with IANA. The deprecation or addition shall be administered by IANA through Expert Review [[RFC5226](#)], i.e., review by one of a group of experts designated by an IETF Area Director. The process should also allow for a mechanism for cases where others have significant objections to claims on deprecation of a registration.

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