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Energy Management (EMAN) Applicability Statement  
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Abstract

The objective of Energy Management (EMAN) is to provide an energy management framework for networked devices. This document presents the applicability of the EMAN framework to a variety of scenarios. This document lists use cases and target devices that can potentially implement the EMAN framework and associated SNMP MIB modules. These use cases are useful for identifying requirements for the framework and MIBs. Further, we describe the relationship of the EMAN framework to relevant other energy monitoring standards and architectures.

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## 1. Introduction

The focus of the Energy Management (EMAN) framework is energy monitoring and management of energy objects [EMAN-DEF]. The scope of devices considered are network equipment and its components, and devices connected directly or indirectly to the network. The EMAN framework enables monitoring (heterogeneous devices to report their energy consumption) and, if permissible, control. There are multiple scenarios where this is desirable, particularly considering the increased importance of limiting consumption of finite energy resources and reducing operational expenses.

The EMAN framework [EMAN-FRAMEWORK] describes how energy information can be retrieved from IP-enabled devices using Simple Network Management Protocol (SNMP), specifically, Management Information Base (MIBs) for SNMP.

This document describes typical applications of the EMAN framework, as well as its opportunities and limitations. It also reviews other standards that are similar in part to EMAN those other standards relate to the EMAN framework.

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The rest of the document is organized as follows. Section 2 contains a list of use cases or network scenarios that EMAN addresses. Section 3 contains an abstraction of the use case scenarios to distinct patterns. Section 4 deals with other standards related to EMAN and applicable to EMAN.

#### 1.1. Energy Management Overview

EMAN addresses the electrical energy consumed by devices connected to a network. A first step to increase the energy efficiency in networks and devices attached to the network is to enable energy objects to report their energy usage over time. The EMAN framework addresses this problem with an information model for electrical equipment: energy object identification, energy object context, power measurement and power characteristics.

The EMAN drafts define SNMP MIB modules based on the information model. By implementing the SNMP MIB modules, any energy object can report its energy consumption according to the information model. While the MIB drafts contain MIB modules, the information model can be adapted to other mechanisms such as YANG modules, NETCONF etc.

It is important to distinguish energy objects that can only report their own energy usage from devices that can also collect and aggregate energy usage of other energy objects.

Target devices and scenarios considered for energy management are presented in Section 2 with detailed examples.

#### 1.2. EMAN Document Overview

The EMAN working group charter called for producing a series of Internet standard drafts in the area of energy management. The following drafts were created by the working group.

Applicability Statement [EMAN-AS] this document presents use cases and scenarios for energy management. In addition, other relevant energy standards and architectures are discussed.

Requirements [EMAN-REQ] this document presents requirements of energy management and the scope of the devices considered.

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Framework [EMAN-FRAMEWORK] This document defines a framework  
for providing energy management for devices within or  
connected to communication networks.

Energy-Aware MIB [EMAN-AWARE-MIB] This document proposes a MIB  
module that characterizes a device identity, context and  
relationships to other entities.

Monitoring MIB [EMAN-MONITORING-MIB] This document defines a  
MIB module for monitoring the power and energy consumption of  
a device. The MIB module contains an optional module for  
metrics associated with power characteristics.

Battery MIB [EMAN-BATTERY-MIB] This document contains a MIB  
module for monitoring characteristics of an internal battery.

Energy Management Terminology [EMAN-DEF] This document lists  
the definitions for the common terms used in the Energy  
Management Working Group.

### 1.3. Energy Measurement

More and more devices are able to measure and report their own  
energy consumption. Smart power strips and some Power over  
Ethernet (PoE) switches can meter consumption of connected  
devices. However, when managed and reported through proprietary  
means, this information is minimally useful at the enterprise  
level.

The primary goal of the EMAN MIBs is to enable reporting and  
management within a standard framework that is applicable to a  
wide variety of end devices, meters, and proxies. This enables  
a management system to know who's consuming what, when, and how  
at any time by leveraging existing networks, across various  
equipment, in a unified and consistent manner.

Given that an energy object can consume energy and/or provide  
energy to other devices, there are three types of energy  
measurement: energy input to a device, energy supplied to other  
devices, and net (resultant) energy consumed (the difference  
between energy input and provided).

### 1.4. Energy Management

Beyond energy monitoring, the EMAN framework provides mechanisms  
for energy control.

There are many cases where reducing energy consumption of devices is desirable, such as when the device utilization is low or when the electricity is expensive or in short supply.

In some cases, energy control requires considering the energy object context. For instance, in a building during non-business hours: usually not all phones would be turned off to keep some phones available in case of emergency; and office cooling is usually not turned off totally, but the comfort level is reduced.

Energy object control requires flexibility and support for different policies and mechanisms: from centralized management with a network management station, to autonomous management by individual devices, and alignment with dynamic demand-response mechanisms.

The EMAN framework can be used as a tool for the demand/response scenario where in response to time-of-day fluctuation of energy costs or possible energy shortages, it is possible to respond and reduce the energy consumption for the network devices, effectively changing its power state.

#### 1.5. EMAN Framework Application

A Network Management System (NMS) is the entity that requests information from compatible devices using SNMP protocol. An NMS implements many network management functions, e.g. security management, or identity management. An NMS that deals exclusively with energy is called an Energy Management System (EnMS). It may be limited to monitoring energy use, or it may also implement control functions. An EnMS collects energy information for devices in the network.

Energy management can be implemented by extending existing SNMP support to the EMAN specific MIBs. SNMP provides an industry proven and well-known mechanism to discover, secure, measure, and control SNMP-enabled end devices. The EMAN framework provides an information and data model to unify access to a large range of devices.

The scope of the target devices and the network scenarios considered for energy management are listed in Section 2.



In this section a selection of scenarios for energy management are presented. The fundamental objective of the use cases is to list important network scenarios that the EMAN framework should solve. These use cases then drive the requirements for the EMAN framework.

Each scenario lists target devices for which the energy management framework can be applied, how the reported-on devices are powered, and how the reporting is accomplished. While there is some overlap between some of the use cases, the use cases illustrate network scenarios that the EMAN framework supports.

### 2.1. Network Infrastructure Energy Objects

This scenario covers network devices and their components. Power management of energy objects is a fundamental requirement of energy management of networks.

It can be important to monitor the energy consumption and possibly manage the power state of these devices at a granularity level finer than just the entire device. For these devices, the chassis draws power from one or more sources and feeds all its internal components. It is highly desirable to have monitoring available for individual components, such as line cards, processors, and disk drives as well as peripherals such as USB devices.

As an illustrative example, consider a switch with the following grouping of sub-entities for which energy management could be useful.

- . physical view: chassis (or stack), line cards, service modules of the switch.
- . component view: CPU, ASICs, fans, power supply, ports (single port and port groups), storage and memory.

The ENTITY-MIB provides the containment tree framework, for uniquely identifying the physical sub-components of network devices. A component can be an Energy Object and the ENTITY-MIB containment tree expresses if one Energy Object belongs to another Energy Object (e.g. a line-card Energy Object contained in a chassis Energy Object). The table `entPhysicalContainsTable` which has the index of `entPhysicalChildIndex` and the MIB object `entPhysicalContainedIn` which points to the containing entity.

- . Target devices: network devices such as routers and switches as well as their components.
- . How powered: typically by a Power Distribution Unit (PDU) on a rack or from a wall outlet. The components of a device are powered by the device chassis.
- . Reporting: direct power measurement can be performed at a device level. Components can report their power consumption directly or the chassis/device that can report on behalf of some components.

## 2.2. Devices Powered by and Connected to a Network Device

This scenario covers Power over Ethernet (PoE) devices. A PoE Power Sourcing Equipment (PSE) device [RFC3621] (e.g. a PoE switch) provides power to a Powered Device (PD) (e.g. a desktop phone). For each port, the PSE can control the power supply (switching it on and off) and meter actual power provided. PDs obtain network connectivity as well as power over a single connection so the PSE can determine which device is associated with each port.

PoE ports on a switch are commonly connected to devices such as IP phones, wireless access points, and IP cameras. The switch needs power for its internal use and to supply power to PoE ports. Monitoring the power consumption of the switch (supplying device) and the power consumption of the PoE end-points (consuming devices) is a simple use case of this scenario.

This scenario illustrates the relationships between entities. The PoE IP phone is powered by the switch. If there are many IP phones connected to the same switch and the power consumption of all the IP phones can be aggregated by the switch. In that case, the switch performs the aggregation function for other entities.

The essential properties of this use case are:

- . Target devices: power over Ethernet devices such as IP phones, wireless access points, and IP cameras.
- . How powered: PoE devices are connected to the switch port which supplies power to those devices.
- . Reporting: PoE device power consumption is measured and reported by the switch (PSE) which supplies power. In addition, some edge devices can support the EMAN framework.

This use case can be divided into two sub cases:

- a) The end device supports the EMAN framework, in which case this device is an EMAN Energy Object by itself, with its own UUID, like in scenario "Devices Connected to a Network" below. The device is responsible for its own power reporting and control.
- b) The end device does not have EMAN capabilities, and the power measurement may not be able to be performed independently, and so is only performed by the supplying device. This scenario is similar to the "Mid-level Manager" below.

In the sub case (a) note that two power usage reporting mechanisms for the same device are available: one performed by the PD itself and one performed by the PSE. Device specific implementations will dictate which one to use.

It is also possible to illustrate the relationships between entities. The PoE IP phone is powered by the switch. If there are many IP phones connected to the same switch and the power consumption of all the IP phones can be aggregated by the switch. In that case, the switch performs the aggregation function for other entities.

### 2.3. Devices Connected to a Network

The use case covers the metering relationship between an energy object and the parent energy object it is connected to, while receiving power from a different source.

An example is a PC which has a network connection to a switch, but draws power from a wall outlet. In this case, the PC can report power usage by itself, ideally through the EMAN framework.

The wall outlet the PC is plugged in can be metered for example by a Smart PDU, or unmetered.

- a) If metered, the PC has a powered-by relationship to the Smart PDU, and the Smart PDU acts as a "Mid-Level Manager"
- b) If unmetered - or running on batteries - the PC will report its own energy usage as any other Energy Object to the switch, and the switch can possibly provide aggregation.

In terms of relationships between entities, the PC has a powered by relationship to the PDU and if the power consumption of the PC is metered by the PDU then there is a metered by relation between the PC and the PDU.

The essential properties of this use case are:

- . Target devices: energy objects that have a network connection, but receive power supply from another source.
- . How powered: end devices (e.g. PCs) receive power supply from the wall outlet (unmetered), or a PDU (metered). That can also be powered autonomously (batteries).
- . Reporting: devices can measure and report the power consumption directly via the EMAN framework, or, communicate it to the network device (switch) and the switch can report the device's power consumption via the EMAN framework.

#### 2.4. Power Meters

Some electrical devices are not equipped with instrumentation to measure their own power and accumulated energy consumption. External meters can be used to measure the power consumption of such electrical devices as well as collections of devices. This use case covers energy objects able to measure or report the power consumption of external electrical devices, not natively connected to the network.

Three types of external metering are relevant to EMAN: PDUs, standalone meters, and utility meters. External meters can measure consumption of a single device or a set of devices.

Power Distribution Unit (PDUs) usually have inbuilt meters for each socket and so can measure the power supplied to each device in an equipment rack. The PDUs have remote management functionality which can measure and possibly control the power supply of each outlet.

Standalone meters can be placed anywhere in a power distribution tree and so may measure the total of groups of devices. Utility meters monitor and report accumulated power consumption of the entire building. There can be sub-meters to measure the power consumption of a portion of the building.

- . Target devices: PDUs and meters.
- . How powered: from traditional mains power but as passed through a PDU or meter.
- . Reporting: PDUs report power consumption of downstream devices, usually a single device per outlet.

The meters can have a metering relationship and possibly aggregation relationship between the meters and the devices for which power consumption is accumulated and reported by the meter.

## 2.5. Mid-level Managers

This use case covers aggregation of energy management data at "mid-level managers" that can provide energy management functions for themselves as well as associated devices.

A switch can provide energy management functions for all devices connected to its ports, whether or not these devices are powered by the switch or whether the switch provides immediate network connectivity to the devices. Such a switch is a mid-level manager, offering aggregation of power consumption data for other devices. Devices report their EMAN data to the switch and the switch aggregates the data for further reporting.

The essential properties of this use case:

- . Target devices: devices which can perform aggregation; commonly a switch or a proxy.
- . How powered: mid-level managers are commonly powered by a PDU or from a wall outlet but can be powered by any method.
- . Reporting: the middle-manager aggregates the energy data and reports that data to a NMS or higher mid-level manager.

## 2.6. Non-residential Building System Gateways

This use case describes energy management of non-residential buildings. Building Management Systems (BMS) have been in place for many years using legacy protocols not based on IP. In these buildings, a gateway can provide a proxy function between IP and legacy building automation protocols. The gateway provides an interface between the EMAN framework and relevant building management protocols.

Due to the potential energy savings, energy management of buildings has received significant attention. There are gateway network elements to manage the multiple components of a building energy management system such as Heating, Ventilation, and Air Conditioning (HVAC), lighting, electrical, fire and emergency systems, elevators, etc. The gateway device uses legacy building protocols to communicate with those devices, collects their energy usage, and reports the results.

The gateway performs protocol conversion and communicates via RS-232/RS-485 interfaces, Ethernet interfaces, and protocols specific to building management such as BACNET [ASHRAE], MODBUS [MODBUS], or ZigBee [ZIGBEE].

The essential properties of this use case are:

- . Target devices: building energy management devices - HVAC systems, lighting, electrical, fire and emergency systems.
- . How powered: any method.
- . Reporting: the gateway collects energy consumption of non-IP systems and communicates the data via the EMAN framework.

## 2.7. Home Energy Gateways

This use case describes the scenario of energy management of a home. The home energy gateway is another example of a proxy that interfaces to electrical appliances and other devices in a home. This gateway can monitor and manage electrical equipment (e.g. refrigerator, heating/cooling, or washing machine) using one of the many protocols that are being developed for residential devices.

In its simplest form, metering can be performed at home. Beyond the metering, it is also possible to implement energy saving policies based on energy pricing from the utility grid. The EMAN information model can be applied to energy management of a home.

The essential properties of this use case are:

- . Target devices: home energy gateway and smart meters in a home.
- . How powered: any method.
- . Reporting: home energy gateway can collect power consumption of device in a home and possibly report the metering reading to the utility.

Beyond the canonical setting of a home drawing power from the utility, it is also possible to envision an energy neutral situation wherein the buildings/homes that can produce and consume energy with reduced or zero net importing energy from the utility grid. There are many energy production technologies such as solar panels, wind turbines, or micro generators. This use case illustrates the concept of covers self-contained energy generation and consumption and possibly the aggregation of the energy use of homes.

## 2.8. Data Center Devices

This use case describes energy management of a data center. Energy efficiency of data centers has become a fundamental challenge of data center operation, as datacenters are big energy consumers and have expensive infrastructure. The equipment generates heat, and heat needs to be evacuated through a HVAC system.

A typical data center network consists of a hierarchy of electrical energy objects. At the bottom of the network hierarchy are servers mounted on a rack; these are connected to top-of-the-rack switches, which in turn are connected to aggregation switches, and then to core switches. Power consumption of all network elements, servers, and storage devices in the data center should be measured. Energy management can be implemented on different aggregation levels, at the network level, Power Distribution Unit (PDU) level, and server level.

Beyond the network devices, storage devices and servers, data centers contain UPSs to provide back-up power for the facility in the event of a power outage. A UPS can provide backup power for many devices in a data center for a finite period of time. Energy monitoring of such energy storage devices is vital from a data center network operations point of view. Presently, the UPS MIB can be useful in monitoring the battery capacity, the input load to the UPS and the output load from the UPS. Currently, there is no link between the UPS MIB and the ENTITY MIB.

Thus, for data center energy management, in addition to monitoring the energy usage of IT equipment, it is also important to monitor the remaining capacity of the UPS.

In addition to monitoring the power consumption of a data center, additional power characteristic metrics should be monitored. Some of these are dynamic variations in the input power supply from the grid referred to as power characteristics is one metric. Secondly, it can be useful to monitor how efficiently the devices utilize power.

The nameplate power consumption (the worst case possible power draw) of all devices will make it possible to know an aggregate of the potential worst-case power usage and compare it to the budgeted power in the data center.

The essential properties of this use case are:

- . Target devices: all IT devices in a data center, such as network equipment, servers, and storage devices, as well as power and cooling infrastructure.
- . How powered: any method but commonly by one or more PDUs.
- . Reporting: devices may report on their own behalf, or for other connected devices as described in other use cases.

## 2.9. Energy Storage Devices

There are two types of devices with energy storage: those whose primary function is to provide power to another device (e.g. a UPS), and those with a different primary function, but which have energy storage as a component (e.g. a notebook). This use case covers both.

The energy storage can be a conventional battery, or any other means to store electricity such as a hydrogen cell.

An internal battery can be a back-up or an alternative source of power to mains power. As batteries have a finite capacity and lifetime, means for reporting the actual charge, age, and state of a battery are required. An internal battery can be viewed as a component of a device and so be contained within the device from an ENTITY-MIB perspective.

Battery systems are used in mobile telecom towers including for use in remote locations. It is important to monitor the remaining battery life and raise an alarm when this falls below a threshold.

The essential properties of this use case are:

- . Target devices: devices that have an internal battery.



- . How powered: from internal batteries or mains power.
- . Reporting: the device reports on its internal battery.

#### 2.10. Industrial Automation Networks

Energy consumption statistics in the industrial sector are staggering. The industrial sector alone consumes about half of the world's total delivered energy, and is a significant user of electricity. Thus, the need for optimization of energy usage in this sector is natural.

Industrial facilities consume energy in process loads, and in non-process loads.

The essential properties of this use case are:

- . Target devices: devices used in industrial automation.
- . How powered: any method.
- . Reporting: currently, CIP protocol is currently used for reporting energy for these devices.

#### 2.11. Printers

This use case describes the scenario of energy monitoring and management of printers.

Printers in this use case stand in for all imaging equipment, also including multi-function devices (MFDs), copiers, scanners, fax machines, and mailing machines.

Energy use of printers has been an industry concern for several decades, and they usually have sophisticated power management with a variety of low-power modes, particularly for managing energy-intensive thermo-mechanical components. Printers also have long made extensive use of SNMP for end-user system interaction and for management generally, and cross-vendor management systems manage fleets of printers in enterprises. Power consumption during active modes can vary widely, with high peak levels.

Printers can expose detailed power state information, distinct from operational state information, with some printers reporting transition states between stable long-term states. Many also support active setting of power states, and setting of policies such as delay times when no activity will cause automatic transition to a lower power mode. Other features include

Some large printers also have a "Digital Front End" which is a computer that performs functions on behalf of the physical imaging system. These typically have their own presence on the network and are sometimes separately powered.

There are some unique characteristics of printers from the point of view energy management. While the printer is not in use, there are timer based low power states, which consume little power. On the other hand, while the printer is printing or copying the cylinder needs to be heated so that power consumption is quite high but only for a short period of time. Given this work load, periodic polling of power levels alone would not suffice.

The essential properties of this use case are:

- . Target devices: all imaging equipment.
- . How powered: typically AC from a wall outlet.
- . Reporting: devices report for themselves.

#### 2.12. Off-Grid Devices

This use case concerns self-contained devices that use energy but are not connected to an infrastructure power delivery grid. These devices typically scavenge energy from environmental sources such as solar energy or wind power. The device generally contains a closely coupled combination of

- . power scavenging or generation component(s)
- . power storage component(s) (e.g., battery)
- . power consuming component(s)

With scavenged power, the energy input is often dependent on the random variations of the weather. These devices therefore require energy management both for internal control and remote reporting of their state. In order to optimize the performance of these devices and minimize the costs of the generation and storage components, it is desirable to vary the activity level, and, hopefully, the energy requirements of the consuming components in order to make best use of the available stored and instantaneously generated energy. With appropriate energy management, the overall device can be optimized to deliver an

In many cases these devices are expected to operate autonomously, as continuous communications for the purposes of remote control is either impossible or would result in excessive power consumption. Non continuous polling requires the ability to store and access later the information collected while the communication was not possible.

The essential properties of this use case are:

Target Devices: remote network devices (mobile network) that consume and produce energy.

How Powered: can be battery powered or using local energy sources.

Reporting: devices report their power usage, but only occasionally.

#### 2.13. Demand Response

The theme of demand response from a utility grid spans across several use cases. In some situations, in response to time-of-day fluctuation of energy costs or sudden energy shortages due power outages, it may be important to respond and reduce the energy consumption of the network.

From EMAN use case perspective, the demand response scenario can apply to a Data Center or a Building or a residential home. As a first step, it may be important to monitor the energy consumption in real-time of a Data center, building or home which is already discussed in the previous use cases. Then based on the potential energy shortfall, the EnMS could formulate a suitable response. The EnMS could shut down selected devices that are considered lower priority or uniformly reduce the power supplied to all devices. For multi-site data centers it may be possible to formulate policies such as follow-the-sun type of approach, by scheduling the mobility of VMs across Data centers in different geographical locations.

#### 2.14. Power Capping

Power capping is a technique to limit the total power consumption of a server, and it can be useful for power limited data centers. Based on workload measurements, the server can choose the optimal power state of the server in terms of performance and power consumption. When the server operates at

less than the power supply capacity, it runs at full speed. When the server power would be greater than the power supply capacity, it runs at a slower speed so that its power consumption matches the available power supply capacity. This gives vendors the option to use smaller, cost-effective power supplies that allow real world workloads to run at nominal themselves.

### 3. Use Case Patterns

The use cases presented above can be abstracted to the following broad patterns.

#### 3.1. Metering

- energy objects which have capability for internal metering
- energy objects which are metered by an external device

#### 3.2. Metering and Control

- energy objects that do not supply power, but can perform only power metering for other devices
- energy objects that do not supply power, but can perform both metering and control for other devices

#### 3.3. Power Supply, Metering and Control

- energy objects that supply power for other devices but do not perform power metering for those devices
- energy objects that supply power for other devices and also perform power metering
- energy objects supply power for other devices and also perform power metering and control for other devices

#### 3.4. Multiple Power Sources

- energy objects that have multiple power sources and metering and control are performed by the same power source
- energy objects that have multiple power sources supplying power to the device and metering is performed by one source and control is performed by another source

The EMAN framework is tied to other standards and efforts that deal with energy. EMAN leverages existing standards when possible, and it helps enable adjacent technologies such as Smart Grid.

The standards most relevant and applicable to EMAN are listed below with a brief description of their objectives, the current state and how that standard relates to EMAN.

#### 4.1. Data Model and Reporting

##### 4.1.1. IEC - CIM

The International Electro-technical Commission (IEC) has developed a broad set of standards for power management. Among these, the most applicable to EMAN is IEC 61850, a standard for the design of electric utility automation. The abstract data model defined in 61850 is built upon and extends the Common Information Model (CIM). The complete 61850 CIM model includes over a hundred object classes and is widely used by utilities worldwide.

This set of standards was originally conceived to automate control of a substation (facilities which transfer electricity from the transmission to the distribution system). However, the extensive data model has been widely used in other domains, including Energy Management Systems (EMS).

IEC TC57 WG19 is an ongoing working group to harmonize the CIM data model and 61850 standards.

Several concepts from IEC Standards have been reused in the EMAN drafts. In particular, AC Power Quality measurements have been reused from IEC 61850-7-4. The concept of Accuracy Classes for measure of power and energy has been adapted from ANSI C12.20 and IEC standards 62053-21 and 62053-22.

##### 4.1.2. DMTF

The Distributed Management Task Force (DMTF) has defined a Power State Management profile [DMTF.DSP1027] for managing computer systems using the DMTF's Common Information Model (CIM). These specifications provide physical, logical, and virtual system management requirements for power-state control services. The DMTF standard does not include energy monitoring.

The Power State Management profile is used to describe and manage the Power State of computer systems. This includes controlling the Power State of an entity for entering sleep mode, re-awaking, and rebooting. The EMAN framework references the DMTF Power Profile and Power State Set.

#### 4.1.2.1. Common Information Model Profiles

The DMTF uses CIM-based (Common Information Model) 'Profiles' to represent and manage power utilization and configuration of managed elements (note that this is not the 61850 CIM). Key profiles for energy management are 'Power Supply' (DSP 1015), 'Power State' (DSP 1027) and 'Power Utilization Management' (DSP 1085). These profiles define many features for monitoring and configuration of a Power Managed Element's static and dynamic power saving modes, power allocation limits and power states.

Reduced power modes can be established as static or dynamic. Static modes are fixed policies that limit power use or utilization. Dynamic power saving modes rely upon internal feedback to control power consumption.

Power states are eight named operational and non operational levels. These are On, Sleep-Light, Sleep-Deep, Hibernate, Off-Soft, and Off-Hard. Power change capabilities provide immediate, timed interval, and graceful transitions between on, off, and reset power states. Table 3 of the Power State Profile defines the correspondence between the ACPI and DMTF power state models, although it is not necessary for a managed element to support ACPI. Optionally, a `TransitingToPowerState` property can represent power state transitions in progress.

#### 4.1.2.2. DASH

DMTF DASH (DSP0232) (Desktop And Mobile Architecture for System Hardware) addresses managing heterogeneous desktop and mobile systems (including power) via in-band and out-of-band communications. DASH provides management and control of managed elements like power, CPU, etc. using the DMTF's WS-Management web services and CIM data model.

Both in-service and out-of-service systems can be managed with the DASH specification in a fully secured remote environment. Full power lifecycle management is possible using out-of-band management.

The Open DeviceNet Vendors Association (ODVA) is an association for industrial automation companies and defines the Common Industrial Protocol (CIP). Within ODVA, there is a special interest group focused on energy and standardization and interoperability of energy-aware devices.

The Open DeviceNet Vendors Association (ODVA) is developing an energy management framework for the industrial sector. There are synergies and similar concepts between the ODVA and EMAN approaches to energy monitoring and management. In particular, one of the concepts being considered different energy meters based on if the device consumes electricity or produces electricity or a passive device.

ODVA defines a three-part approach towards energy management: awareness of energy usage, consuming energy more efficiently, and exchanging energy with the utility or others. Energy monitoring and management promote efficient consumption and enable automating actions that reduce energy consumption.

The foundation of the approach is the information and communication model for entities. An entity is a network-connected, energy-aware device that has the ability to either measure or derive its energy usage based on its native consumption or generation of energy, or report a nominal or static energy value.

#### 4.1.4. Ecma SDC

The Ecma International committee on Smart Data Centre (TC38-TG2 SDC [Ecma-SDC]) is defining semantics for management of entities in a data center such as servers, storage, and network equipment. It covers energy as one of many functional resources or attributes of systems for monitoring and control. It only defines messages and properties, and does not reference any specific protocol. Its goal is to enable interoperability of such protocols as SNMP, BACNET, and HTTP by ensuring a common semantic model across them. Four power states are defined, Off, Sleep, Idle, and Active. The standard does not include actual energy or power measurements.

The 14th draft of SDC process was published in March 2011 and the development of the standard is still underway. When used with EMAN, the SDC standard will provide a thin abstraction on top of the more detailed data model available in EMAN.

The IEEE-ISTO Printer Working Group [PWG5106.4] defines open standards for printer related protocols, for the benefit of printer manufacturers and related software vendors. The Printer WG covers power monitoring and management of network printers and imaging systems in the PWG Power Management Model for Imaging Systems [PWG5106.4]. Clearly, these devices are within the scope of energy management since these devices receive power and are attached to the network. In addition, there is ample scope of power management since printers and imaging systems are not used that often.

The IEEE-ISTO Printer Working Group (PWG) defines SNMP MIB modules for printer management and in particular a "PWG Power Management Model for Imaging Systems v1.0" [PWG5106.4] and a companion SNMP binding in the "PWG Imaging System Power MIB v1.0" [PWG5106.5]. This PWG model and MIB are harmonized with the DMTF CIM Infrastructure [DSP0004] and DMTF CIM Power State Management Profile [DSP1027] for power states and alerts.

These MIB modules can be useful for monitoring the power and Power State of printers. The EMAN framework takes into account the standards defined in the Printer working group. The PWG may harmonize its MIBs with those from EMAN. The PWG covers many topics in greater detail than EMAN, as well as some that are specific to imaging equipment. The PWG also provides for vendor-specific extension states (beyond the standard DMTF CIM states).

The IETF Printer MIB RFC3805 [RFC3805] has been standardized, however, this MIB module does not address power management.

#### 4.1.6. ASHRAE

In the U.S., there is an extensive effort to coordinate and develop standards related to the "Smart Grid". The Smart Grid Interoperability Panel, coordinated by the government National Institute of Standards and Technology, identified the need for a building side information model (as a counterpart to utility models) and specified this in Priority Action Plan (PAP) 17. This was designated to be a joint effort by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the National Electrical Manufacturers Association (NEMA), both ANSI approved SDO's. The result is to be an information model, not a protocol.



The ASHRAE effort addresses data used only within a building as well as data that may be shared with the grid, particularly as it relates to coordinating future demand levels with the needs of the grid. The model is intended to be applied to any building type, both residential and commercial. It is expected that existing protocols will be adapted to comply with the new information model, as would new protocols.

There are four basic types of entities in the model: generators, loads, meters, and energy managers.

The metering part of the model overlaps with the EMAN framework to a large degree, though there are features unique to each. The load part speaks to control capabilities well beyond what EMAN covers. Details of generation and of the energy management function are outside of EMAN scope.

A public review draft of the ASHRAE standard was released in July, 2012. There are no apparent major conflicts between the two approaches, but there are areas where some harmonization is possible.

#### 4.1.7. ZigBee

The ZigBee Smart Energy 2.0 effort [ZIGBEE] focuses on wireless communication to appliances and lighting. ZigBee 1.x is not based on IP, whereas ZigBee 2.0 is supposed to interoperate with IP. It is intended to enable building energy management and enable direct load control by utilities.

ZigBee protocols are intended for use in embedded applications with low data rates and low power consumption. ZigBee defines a general-purpose, inexpensive, self-organizing mesh network that can be used for industrial control, embedded sensing, medical data collection, smoke and intruder warning, building automation, home automation, etc.

ZigBee is currently not an ANSI recognized SDO.

The EMAN framework addresses the needs of IP-enabled networks through the usage of SNMP, while ZigBee looks for completely integrated and inexpensive mesh solution.

#### 4.2. Measurement

The American National Standards Institute (ANSI) has defined a collection of power meter standards under ANSI C12. The primary standards include communication protocols (C12.18, 21 and 22), data and schema definitions (C12.19), and measurement accuracy (C12.20). European equivalent standards are provided by IEC 62053-22. ANSI C12.20 defines accuracy classes for power meters.

These standards are oriented to the meter itself, are very specific, and used by electricity distributors and producers.

The EMAN standard references ANSI C12 accuracy classes.

#### 4.2.2. IEC 62301

IEC 62301, "Household electrical appliances Measurement of standby power", specifies a power level measurement procedure. While nominally for appliances and low-power modes, many aspects of it apply to other device types and modes and it is commonly referenced in test procedures for energy using products.

While the standard is intended for laboratory measurements of devices in controlled conditions, many aspects of it are informative to those implementing measurement in products that ultimately report via EMAN.

#### 4.3. Other

##### 4.3.1. ISO

The International Organization for Standardization (ISO) [ISO] is developing an energy management standard, ISO 50001, to complement ISO 9001 for quality management, and ISO 14001 for environmental management. The intent is to facilitate the creation of energy management programs for industrial, commercial, and other entities. The standard defines a process for energy management at an organization level. It does not define the way in which devices report energy and consume energy.

ISO 50001 is based on the common elements found in all of ISO's management system standards, assuring a high level of compatibility with ISO 9001 and ISO 14001. ISO 50001 benefits include:

- o Integrating energy efficiency into management practices and throughout the supply chain
- o Energy management best practices and good energy management behaviors
- o benchmarking, measuring, documenting, and reporting energy intensity improvements and their projected impact on reductions in greenhouse gas (GHG) emissions
- o Evaluating and prioritizing the implementation of new energy-efficient technologies

ISO 50001 has been developed by ISO project committee ISO PC 242, Energy management. EMAN is complementary to ISO 9001.

#### 4.3.2. Energy Star

The U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) jointly sponsor the Energy Star program [ESTAR]. The program promotes the development of energy efficient products and practices.

To qualify as Energy Star, products must meet specific energy efficiency targets. The Energy Star program also provides planning tools and technical documentation to encourage more energy efficient building design. Energy Star is a program; it is not a protocol or standard.

For businesses and data centers, Energy Star offers technical support to help companies establish energy conservation practices. Energy Star provides best practices for measuring current energy performance, goal setting, and tracking improvement. The Energy Star tools offered include a rating system for building performance and comparative benchmarks.

There is no immediate link between EMAN and EnergyStar, one being a protocol and the other a set of recommendations to develop energy efficient products. However, Energy Star could include EMAN standards in specifications for future products, either as required or rewarded with some benefit.

#### 4.3.3. Smart Grid

The Smart Grid standards efforts underway in the United States are overseen by the U.S. National Institute of Standards and Technology [NIST]. NIST is responsible for coordinating a public-private partnership with key energy and consumer

stakeholders in order to facilitate the development of smart grid standards. These activities are monitored and facilitated by the SGIP (Smart Grid Interoperability Panel). This group has working groups for specific topics including homes, commercial buildings, and industrial facilities as they relate to the grid. A stated goal of the group is to harmonize any new standard with the IEC CIM and IEC 61850.

When a working group detects a standard or technology gap, the team seeks approval from the SGIP for the creation of a Priority Action Plan (PAP), a private-public partnership to close the gap. PAP 17 is discussed in section 4.1.6.

PAP 10 addresses "Standard Energy Usage Information". Smart Grid standards will provide distributed intelligence in the network and allow enhanced load shedding. For example, pricing signals will enable selective shutdown of non critical activities during peak price periods. Both centralized and distributed management controls are in scope.

There is an obvious functional link between Smart Grid and EMAN in the form of demand response, even though the EMAN framework itself does not address any coordination with the grid. As EMAN enables control, it can be used by an EnMS to accomplish demand response through translation of a signal from an outside entity.

## 5. Limitations

EMAN addresses the needs of energy monitoring in terms of measurement and, considers limited control capabilities of energy monitoring of networks.

EMAN does not create a new protocol stack, but rather defines a data and information model useful for measuring and reporting energy and other metrics over SNMP.

EMAN does not address questions regarding Smart Grid, electricity producers, and distributors.

## 6. Security Considerations

EMAN uses the SNMP protocol and thus has the functionality of SNMP's security capabilities. SNMPv3 [RFC3411] provides important security features such as confidentiality, integrity, and authentication.

This memo includes no request to IANA.

## 8. Acknowledgements

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Definition of Managed Objects for Battery Monitoring  
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Abstract

This memo defines a portion of the Management Information Base (MIB) for use with network management protocols in the Internet community. In particular, it defines managed objects that provide information on the status of batteries in managed devices.

Status of this Memo

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## 1. Introduction

Today, more and more managed devices contain batteries that supply them with power when disconnected from electrical power distribution grids. Common examples are nomadic and mobile devices, such as notebook computers, netbooks, and smart phones. The status of batteries in such a device, particularly the charging status is typically controlled by automatic functions that act locally on the device and manually by users of the device.

In addition to this, there is a need to monitor battery status of these devices by network management systems. This document defines a portion of the Management Information Base (MIB) that provides a means for monitoring batteries in or attached to managed devices. The Battery MIB module defined in Section 4 meets the requirements for monitoring the status of batteries specified in RFC 6988 [RFC6988].

The Battery MIB module provides for monitoring the battery status. According to the framework for energy management [I-D.ietf-eman-framework] it is an Energy Managed Object, and thus, MIB modules such as the Power and Energy Monitoring MIB [I-D.ietf-eman-energy-monitoring-mib] could in principle be implemented for batteries. The Battery MIB extends the more generic aspects of energy management by adding battery-specific information. Amongst other things, the Battery MIB enables the monitoring of:

- o the current charge of a battery,
- o the age of a battery (charging cycles),
- o the state of a battery (e.g. being re-charged),
- o last usage of a battery,
- o maximum energy provided by a battery (remaining and total capacity).

Further, means are provided for battery-powered devices to send notifications when the current battery charge has dropped below a certain threshold to inform the management system of needed replacement. The same applies to the age of a battery.

Many battery-driven devices have existing instrumentation for monitoring the battery status, because this is already needed for local control of the battery by the device. This reduces the effort for implementing the managed objects defined in this document. For many devices only additional software will be needed but no additional hardware instrumentation for battery monitoring.

Since there are a lot of devices in use that contain more than one battery, means for battery monitoring defined in this document

support addressing multiple batteries within a single device. Also, batteries today often come in packages that can include identification and might contain additional hardware and firmware. The former allows tracing a battery and allows continuous monitoring even if the battery is e.g. installed in another device. The firmware version is useful information as the battery behavior might be different for different firmware versions.

Not explicitly in scope of definitions in this document are very small backup batteries, such as for example, batteries used on PC motherboard to run the clock circuit and retain configuration memory while the system is turned off. Other means may be required for reporting on these batteries. However, the MIB module defined in Section 3.1 can be used for this purpose.

A traditional type of managed device containing batteries is an Uninterruptible Power Supply (UPS) system; these supply other devices with electrical energy when the main power supply fails. There is already a MIB module for managing UPS systems defined in RFC 1628 [RFC1628]. The UPS MIB module includes managed objects for monitoring the batteries contained in an UPS system. However, the information provided by the UPS MIB objects is limited and tailored the particular needs of UPS systems.

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

## 2. The Internet-Standard Management Framework

For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to section 7 of RFC 3410 [RFC3410].

Managed objects are accessed via a virtual information store, termed the Management Information Base or MIB. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP). Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This memo specifies MIB modules that are compliant to the SMIV2, which is described in STD 58, RFC 2578 [RFC2578], STD 58, RFC 2579 [RFC2579] and STD 58, RFC 2580 [RFC2580].

### 3. Design of the Battery MIB Module

#### 3.1. MIB Module Structure

The Battery MIB module defined in this document defines objects for reporting information about batteries. All managed objects providing information of the status of a battery are contained in a single table called `batteryTable`. The `batteryTable` contains one conceptual row per battery.

Batteries are indexed by the `entPhysicalIndex` of the `entPhysicalTable` defined in the ENTITY-MIB module [RFC6933]. An implementation of the ENTITY-MIB module complying with the `entity4CRCompliance MODULE-COMPLIANCE` statement is required for compliant implementations of the BATTERY-MIB module.

If batteries are replaced with the replacing battery using the same physical connector as the replaced battery had used, then the replacing battery SHOULD be indexed with the same value of object `entPhysicalIndex` as the replaced battery.

The kind of entity in the `entPhysicalTable` of the Entity MIB module is indicated by the value of enumeration object `entPhysicalClass`. All batteries SHOULD have the value of object `entPhysicalClass` set to `battery(14)` in their row of the `entPhysicalTable`.

The `batteryTable` contains three groups of objects. The first group (OIDs ending with 1-10) provides information on static properties of the battery. The second group of objects (OIDs ending with 11-18) provides information on the current battery state, if it is charging or discharging, how much it is charged, its remaining capacity, the number of experienced charging cycles, etc.

```

batteryTable(1)
+--batteryEntry(1) [entPhysicalIndex]
    +-- r-n SnmpAdminString batteryIdentifier(1)
    +-- r-n SnmpAdminString batteryFirmwareVersion(2)
    +-- r-n Enumeration      batteryType(3)
    +-- r-n Unsigned32       batteryTechnology(4)
    +-- r-n Unsigned32       batteryDesignVoltage(5)
    +-- r-n Unsigned32       batteryNumberOfCells(6)
    +-- r-n Unsigned32       batteryDesignCapacity(7)
    +-- r-n Unsigned32       batteryMaxChargingCurrent(8)
    +-- r-n Unsigned32       batteryTrickleChargingCurrent(9)
    +-- r-n Unsigned32       batteryActualCapacity(10)
    +-- r-n Unsigned32       batteryChargingCycleCount(11)
    +-- r-n DateAndTime      batteryLastChargingCycleTime(12)
    +-- r-n Enumeration      batteryChargingOperState(13)
    +-- rwn Enumeration      batteryChargingAdminState(14)
    +-- r-n Unsigned32       batteryActualCharge(15)
    +-- r-n Unsigned32       batteryActualVoltage(16)
    +-- r-n Integer32        batteryActualCurrent(17)
    +-- r-n Integer32        batteryTemperature(18)
    +-- r-n SnmpAdminString  batteryCellIdentifier(19)
    +-- rwn Unsigned32       batteryAlarmLowCharge(20)
    +-- rwn Unsigned32       batteryAlarmLowVoltage(21)
    +-- rwn Unsigned32       batteryAlarmLowCapacity(22)
    +-- rwn Unsigned32       batteryAlarmHighCycleCount(23)
    +-- rwn Integer32        batteryAlarmHighTemperature(24)
    +-- rwn Integer32        batteryAlarmLowTemperature(25)

```

The third group of objects in this table (OIDs ending with 20-25) indicates thresholds which can be used to raise an alarm if a property of the battery exceeds one of them. Raising an alarm may include sending a notification.

The Battery MIB defines seven notifications for indicating

1. a battery charging state change that was not triggered by writing to object batteryChargingAdminState,
2. a low battery charging state,
3. a critical battery that cannot be used anymore for power supply,
4. an aged battery that may need to be replaced,
5. a battery exceed a temperature threshold,
6. a battery that has been connected,
7. disconnection of one or more batteries.

Notifications 2.-5. can use object batteryCellIdentifier to indicate a specific cell or a set of cells within the battery that have triggered the notification.

### 3.2. Battery Technologies

Static information in the batteryTable includes battery type and technology. The battery type distinguishes primary (not rechargeable) batteries from rechargeable (secondary) batteries and capacitors. The battery technology describes the actual technology of a battery, which typically is a chemical technology.

Since battery technologies are subject of intensive research and widely used technologies are often replaced by successor technologies within an few years, the list of battery technologies was not chosen as a fixed list. Instead, IANA has created a registry for battery technologies at <http://www.iana.org/assignments/eman> where numbers are assigned to battery technologies (TBD).

The table below shows battery technologies known today that are in commercial use with the numbers assigned to them by IANA. New entries can be added to the IANA registry if new technologies are developed or if missing technologies are identified. Note that there exists a huge number of battery types that are not listed in the IANA registry. Many of them are experimental or cannot be used in an economically useful way. New entries should be added to the IANA registry only if the respective technologies are in commercial use and relevant to standardized battery monitoring over the Internet.

battery technology	assigned number
Unknown	1
Other	2
Zinc-carbon	3
Zinc chloride	4
Nickel oxyhydroxide	5
Lithium-copper oxide	6
Lithium-iron disulfide	7
Lithium-manganese dioxide	8
Zinc-air	9
Silver oxide	10
Alkaline	11
Lead acid	12
Nickel-cadmium	13
Nickel-metal hybride	14
Nickel-zinc	15
Lithium-ion	16
Lithium polymer	17
Double layer capacitor	18

### 3.3. Battery Identification

There are two identifiers to be used: The `entPhysicalUUID` defined in the ENTITY-MIB [RFC6933] module and the `batteryIdentifier` defined in this module. A battery is linked to an `entPhysicalUUID` through the shared `entPhysicalIndex`.

The `batteryIdentifier` uniquely identifies the battery itself while the `entPhysicalUUID` identifies the slot of the device in which the battery is (currently) contained. For a non-replaceable battery both identifiers are always linked to the same physical battery. But for batteries that can be replaced, the identifiers have different functions.

The `entPhysicalUUID` is always the same for a certain battery slot of a containing device even if the contained battery is replaced by another one. The `batteryIdentifier` is a representation of the battery identifier set by the battery manufacturer. It is tied to the battery and usually cannot be changed.

Many manufacturers deliver not just plain batteries but battery packages including additional hardware and firmware. Typically, these modules include a battery identifier that can be retrieved by a device in which a battery has been installed. The value of the object `batteryIdentifier` is an exact representation of this identifier. The `batteryIdentifier` is useful when batteries are removed and re-installed in the same device or in other devices. Then the device or the network management system can trace batteries and achieve continuity of battery monitoring.

### 3.4. Charging Cycles

The lifetime of a battery can be approximated using the measure of charging cycles. A commonly used definition of a charging cycle is the amount of discharge equal to the design (or nominal) capacity of the battery [SBS]. This means that a single charging cycle may include several steps of partial charging and discharging until the amount of discharging has reached the design capacity of the battery. After that the next charging cycle immediately starts.

## 4. Definitions

```
BATTERY-MIB DEFINITIONS ::= BEGIN
```

```
IMPORTS
```

```
    MODULE-IDENTITY, OBJECT-TYPE, NOTIFICATION-TYPE,  
    mib-2, Integer32, Unsigned32
```



```
FROM SNMPv2-SMI -- RFC2578
SnmpAdminString
FROM SNMP-FRAMEWORK-MIB -- RFC3411
DateAndTime
FROM SNMPv2-TC -- RFC2579
MODULE-COMPLIANCE, OBJECT-GROUP, NOTIFICATION-GROUP
FROM SNMPv2-CONF -- RFC2580
entPhysicalIndex
FROM ENTITY-MIB -- RFC6933
Unsigned64TC
FROM APPLICATION-MIB; -- RFC2564
```

## batteryMIB MODULE-IDENTITY

```
LAST-UPDATED "201401071200Z" -- 07 January 2014
ORGANIZATION "IETF EMAN Working Group"
CONTACT-INFO
  "General Discussion: eman@ietf.org
  To Subscribe: http://www.ietf.org/mailman/listinfo/eman
  Archive: http://www.ietf.org/mail-archive/web/eman
```

## Editor:

```
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```

## DESCRIPTION

"This MIB module defines a set of objects for monitoring batteries of networked devices and of their components.

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This version of this MIB module is part of RFC yyyy; see the RFC itself for full legal notices."

-- replace yyyy with actual RFC number & remove this notice

```

-- Revision history

REVISION "201401071200Z"          -- 07 January 2014
DESCRIPTION
    "Initial version, published as RFC yyyy."
-- replace yyyy with actual RFC number & remove this notice

 ::= { mib-2 zzz }
-- zzz to be assigned by IANA.

--*****
-- Top Level Structure of the MIB module
--*****

batteryNotifications OBJECT IDENTIFIER ::= { batteryMIB 0 }
batteryObjects       OBJECT IDENTIFIER ::= { batteryMIB 1 }
batteryConformance   OBJECT IDENTIFIER ::= { batteryMIB 2 }

=====
-- 1. Object Definitions
=====

-----
-- 1.1. Battery Table
-----

batteryTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF BatteryEntry
    MAX-ACCESS   not-accessible
    STATUS       current
    DESCRIPTION
        "This table provides information on batteries.  It contains
        one conceptual row per battery.

        Batteries are indexed by the entPhysicalIndex of the
        entPhysicalTable defined in the ENTITY-MIB (RFC6933).

        For implementations of the BATTERY-MIB an implementation of
        the ENTITY-MIB complying with the entity4CRCompliance
        MODULE-COMPLIANCE statement of the ENTITY-MIB is required.

        If batteries are replaced with the replacing battery using
        the same physical connector as the replaced battery had
        used, then the replacing battery SHOULD be indexed with the
        same value of object entPhysicalIndex as the replaced
        battery."
    ::= { batteryObjects 1 }

batteryEntry OBJECT-TYPE

```

```

SYNTAX      BatteryEntry
MAX-ACCESS  not-accessible
STATUS      current
DESCRIPTION
    "An entry providing information on a battery."
INDEX { entPhysicalIndex }
 ::= { batteryTable 1 }

```

```

BatteryEntry ::=
SEQUENCE {
    batteryIdentifier          SnmpAdminString,
    batteryFirmwareVersion    SnmpAdminString,
    batteryType                INTEGER,
    batteryTechnology          Unsigned32,
    batteryDesignVoltage      Unsigned32,
    batteryNumberOfCells      Unsigned32,
    batteryDesignCapacity     Unsigned32,
    batteryMaxChargingCurrent  Unsigned32,
    batteryTrickleChargingCurrent Unsigned32,
    batteryActualCapacity     Unsigned32,
    batteryChargingCycleCount Unsigned32,
    batteryLastChargingCycleTime DateAndTime,
    batteryChargingOperState   INTEGER,
    batteryChargingAdminState  INTEGER,
    batteryActualCharge        Unsigned64TC,
    batteryActualVoltage       Unsigned32,
    batteryActualCurrent       Integer32,
    batteryTemperature         Integer32,
    batteryCellIdentifier      SnmpAdminString,
    batteryAlarmLowCharge      Unsigned32,
    batteryAlarmLowVoltage     Unsigned32,
    batteryAlarmLowCapacity    Unsigned32,
    batteryAlarmHighCycleCount Unsigned32,
    batteryAlarmHighTemperature Integer32,
    batteryAlarmLowTemperature Integer32
}

```

batteryIdentifier OBJECT-TYPE

```

SYNTAX      SnmpAdminString
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION

```

"This object contains an identifier for the battery.

Many manufacturers deliver not only simple batteries but battery packages including additional hardware and firmware. Typically, these modules include an identifier that can be retrieved by a device in which a battery has been installed.

The identifier is useful when batteries are removed and re-installed in the same or other devices. Then the device or the network management system can trace batteries and achieve continuity of battery monitoring.

If the battery identifier cannot be represented using the ISO/IEC IS 10646-1 character set, then a hexadecimal encoding of a binary representation of the battery identifier must be used.

The value of this object must be an empty string if there is no battery identifier or if the battery identifier is unknown."

::= { batteryEntry 1 }

batteryFirmwareVersion OBJECT-TYPE

SYNTAX SnmpAdminString

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This object indicates the version number of the firmware that is included in a battery module.

Many manufacturers deliver not pure batteries but battery packages including additional hardware and firmware.

Since the behavior of the battery may change with the firmware, it may be useful to retrieve the firmware version number.

The value of this object must be an empty string if there is no firmware or if the version number of the firmware is unknown."

::= { batteryEntry 2 }

batteryType OBJECT-TYPE

SYNTAX INTEGER {  
    unknown(1),  
    other(2),  
    primary(3),  
    rechargeable(4),  
    capacitor(5)  
}

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This object indicates the type of battery.  
It distinguishes between primary (not rechargeable)

batteries, rechargeable (secondary) batteries and capacitors which are not really batteries but often used in the same way as a battery.

The value other(2) can be used if the battery type is known but none of the ones above. Value unknown(1) is to be used if the type of battery cannot be determined."

::= { batteryEntry 3 }

batteryTechnology OBJECT-TYPE

SYNTAX Unsigned32

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This object indicates the technology used by the battery. Numbers identifying battery types are registered at IANA. A current list of assignments can be found at <<http://www.iana.org/assignments/eman>>.

Value 0 (unknown) MUST be used if the type of battery cannot be determined.

Value 1 (other) can be used if the battery type is known but not one of the types already registered at IANA."

::= { batteryEntry 4 }

batteryDesignVoltage OBJECT-TYPE

SYNTAX Unsigned32

UNITS "millivolt"

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This object provides the design (or nominal) voltage of the battery in units of millivolt (mV).

Note that the design voltage is a constant value and typically different from the actual voltage of the battery.

A value of 0 indicates that the design voltage is unknown."

::= { batteryEntry 5 }

batteryNumberOfCells OBJECT-TYPE

SYNTAX Unsigned32

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This object indicates the number of cells contained in the battery.

A value of 0 indicates that the number of cells is unknown."  
 ::= { batteryEntry 6 }

batteryDesignCapacity OBJECT-TYPE

SYNTAX Unsigned32  
UNITS "milliampere hours"  
MAX-ACCESS read-only  
STATUS current  
DESCRIPTION

"This object provides the design (or nominal) capacity of the battery in units of milliampere hours (mAh).

Note that the design capacity is a constant value and typically different from the actual capacity of the battery. Usually, this is a value provided by the manufacturer of the battery.

A value of 0 indicates that the design capacity is unknown."  
 ::= { batteryEntry 7 }

batteryMaxChargingCurrent OBJECT-TYPE

SYNTAX Unsigned32  
UNITS "milliampere"  
MAX-ACCESS read-only  
STATUS current  
DESCRIPTION

"This object provides the maximal current to be used for charging the battery in units of milliampere (mA).

Note that the maximal charging current may not lead to optimal charge of the battery and that some batteries can only be charged with the maximal current for a limited amount of time.

A value of 0 indicates that the maximal charging current is unknown."  
 ::= { batteryEntry 8 }

batteryTrickleChargingCurrent OBJECT-TYPE

SYNTAX Unsigned32  
UNITS "milliampere"  
MAX-ACCESS read-only  
STATUS current  
DESCRIPTION

"This object provides the recommended current to be used for trickle charging the battery in units of milliampere (mA).

Typically, this is a value recommended by the manufacturer of the battery or by the manufacturer of the charging circuit.

A value of 0 indicates that the recommended trickle charging current is unknown."

::= { batteryEntry 9 }

batteryActualCapacity OBJECT-TYPE

SYNTAX Unsigned32  
UNITS "milliampere hours"  
MAX-ACCESS read-only  
STATUS current  
DESCRIPTION

"This object provides the actual capacity of the battery in units of milliampere hours (mAh).

Typically, the actual capacity of a battery decreases with time and with usage of the battery. It is usually lower than the design capacity

Note that the actual capacity needs to be measured and is typically an estimate based on observed discharging and charging cycles of the battery.

A value of 'ffffffff'H indicates that the actual capacity cannot be determined."

::= { batteryEntry 10 }

batteryChargingCycleCount OBJECT-TYPE

SYNTAX Unsigned32  
MAX-ACCESS read-only  
STATUS current  
DESCRIPTION

"This object indicates the number of completed charging cycles that the battery underwent. In line with the Smart Battery Data Specification Revision 1.1, a charging cycle is defined as the process of discharging the battery by a total amount equal to the battery design capacity as given by object batteryDesignCapacity. A charging cycle may include several steps of charging and discharging the battery until the discharging amount given by batteryDesignCapacity has been reached. As soon as a charging cycle has been completed the next one starts immediately independent of the battery's current charge at the end of the cycle.

For batteries of type primary(1) the value of this object is

always 0.

A value of 'ffffffff'H indicates that the number of charging cycles cannot be determined."  
 ::= { batteryEntry 11 }

batteryLastChargingCycleTime OBJECT-TYPE

SYNTAX DateAndTime

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The date and time of the last charging cycle. The value '0000000000000000'H is returned if the battery has not been charged yet or if the last charging time cannot be determined.

For batteries of type primary(1) the value of this object is always '0000000000000000'H."  
 ::= { batteryEntry 12 }

batteryChargingOperState OBJECT-TYPE

SYNTAX INTEGER {  
    unknown(1),  
    charging(2),  
    fastCharging(3),  
    maintainingCharge(4),  
    noCharging(5),  
    discharging(6)  
}

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This object indicates the current charging state of the battery.

Value unknown(1) indicates that the charging state of the battery cannot be determined.

Value charging(2) indicates that the battery is being charged in a way that the charge of the battery increases.

Value fastCharging(3) indicated that the battery is being charged rapidly, i.e. faster than in the charging(2) state. If multiple fast charging states exist, all of these states are indicated by fastCharging(3).

Value maintainingCharge(4) indicates that the battery is being charged with a low current that compensates



self-discharging. This includes trickle charging, float charging and other methods for maintaining the current charge of a battery.

Value noCharging(5) indicates that the battery is not being charged or discharged by electric current between the battery and electric circuits external to the battery. Note that the battery may still be subject to self-discharging.

Value discharging(6) indicates that the battery is being discharged and that the charge of the battery decreases."  
 ::= { batteryEntry 13 }

batteryChargingAdminState OBJECT-TYPE

```
SYNTAX      INTEGER {
                charging(2),
                fastCharging(3),
                maintainingCharge(4),
                noCharging(5),
                discharging(6),
                notSet(7)
            }
```

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The value of this object indicates the desired status of the charging state of the battery. The real state is indicated by object batteryChargingOperState. See the definition of object batteryChargingOperState for a description of the values.

When this object is initialized by an implementation of the BATTERY-MIB module, its value is set to notSet(7).

However, a SET request can only set this object to either charging(2), fastCharging(3), maintainingCharge(4), noCharging(5), or discharging(6). Attempts to set this object to notSet(7) will always fail with an 'inconsistentValue' error. In case multiple fast charging states exist, the battery logic can choose an appropriate fast charging state - preferably the fastest.

When the batteryChargingAdminState object is set, then the BATTERY-MIB implementation must try to set the battery to the indicated state. The result will be indicated by object batteryChargingOperState.

Due to operational conditions and limitations of the implementation of the BATTERY-MIB module, changing the battery status according to a set value of object batteryChargingAdminState may not be possible.

Setting the value of object batteryChargingAdminState may result in not changing the state of the battery to this value or even in setting the charging state to another value. For example, setting batteryChargingAdminState to value fastCharging(3) may have no effect when the battery logic is not allowing fast charging due to temperature constraints."

```
::= { batteryEntry 14 }
```

batteryActualCharge OBJECT-TYPE

SYNTAX Unsigned64TC

UNITS "milliampere hours"

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This object provides the actual charge of the battery in units of milliampere hours (mAh).

Note that the actual charge needs to be measured and is typically an estimate based on observed discharging and charging cycles of the battery.

A value of 'ffffffff'H indicates that the actual charge cannot be determined."

```
::= { batteryEntry 15 }
```

batteryActualVoltage OBJECT-TYPE

SYNTAX Unsigned32

UNITS "millivolt"

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This object provides the actual voltage of the battery in units of millivolt (mV).

A value of 'ffffffff'H indicates that the actual voltage cannot be determined."

```
::= { batteryEntry 16 }
```

batteryActualCurrent OBJECT-TYPE

SYNTAX Integer32

UNITS "milliampere"

MAX-ACCESS read-only  
STATUS current  
DESCRIPTION  
    "This object provides the actual charging or discharging current of the battery in units of milliampere (mA). Charging current is represented by positive values, discharging current is represented by negative values.  
  
    A value of '7fffffff'H indicates that the actual current cannot be determined."  
 ::= { batteryEntry 17 }

batteryTemperature OBJECT-TYPE  
SYNTAX Integer32  
UNITS "deci-degrees Celsius"  
MAX-ACCESS read-only  
STATUS current  
DESCRIPTION  
    "The ambient temperature at or near the battery.  
  
    A value of '7fffffff'H indicates that the temperature cannot be determined."  
 ::= { batteryEntry 18 }

batteryCellIdentifier OBJECT-TYPE  
SYNTAX SnmpAdminString  
MAX-ACCESS read-only  
STATUS current  
DESCRIPTION  
    "The value of this object identifies one or more cells of a battery. The format of the cell identifier may vary between different implementations. It should uniquely identify one or more cells of the indexed battery.  
  
    This object can be used for batteries, such as, for example, lithium polymer batteries for which battery controllers monitor cells individually.  
  
    This object is used by notifications of type batteryLowNotification, batteryTemperatureNotification, batteryCriticalNotification, and batteryAgingNotification. These notifications can use the value of this object to indicate the event that triggered the generation of the notification in more details by specifying a single cell or a set of cells within the battery which are specifically addressed by the notification.  
  
    An example use case for this object is a single cell in a

battery that exceeds the temperature indicated by object batteryAlarmHighTemperature. In such a case, a batteryTemperatureNotification can be generated that not just indicates the battery for which the temperature is exceeded but also the particular cell.

The initial value of this object is the empty string. The value of this object is set at each time a batteryLowNotification, a batteryTemperatureNotification, a batteryCriticalNotification, or a batteryAgingNotification is generated.

When a notification is generated that does not indicate a specific cell or set of cells, the value of this object is set to the empty string."

::= { batteryEntry 19 }

batteryAlarmLowCharge OBJECT-TYPE

SYNTAX Unsigned32  
UNITS "milliampere hours"  
MAX-ACCESS read-write  
STATUS current  
DESCRIPTION

"This object provides the lower threshold value for object batteryActualCharge. If the value of object batteryActualCharge falls below this threshold, a low battery alarm will be raised. The alarm procedure may include generating a batteryLowNotification.

This object should be set to a value such that when the batteryLowNotification is generated, the battery is still sufficiently charged to keep the device(s) that it powers operational for a time long enough to take actions before the powered device(s) enter a 'sleep' or 'off' state.

A value of 0 indicates that no alarm will be raised for any value of object batteryActualCharge."

::= { batteryEntry 20 }

batteryAlarmLowVoltage OBJECT-TYPE

SYNTAX Unsigned32  
UNITS "millivolt"  
MAX-ACCESS read-write  
STATUS current  
DESCRIPTION

"This object provides the lower threshold value for object batteryActualVoltage. If the value of object batteryActualVoltage falls below this threshold,

a low battery alarm will be raised. The alarm procedure may include generating a batteryLowNotification.

This object should be set to a value such that when the batteryLowNotification is generated, the battery is still sufficiently charged to keep the device(s) that it powers operational for a time long enough to take actions before the powered device(s) enter a 'sleep' or 'off' state.

A value of 0 indicates that no alarm will be raised for any value of object batteryActualVoltage."

::= { batteryEntry 21 }

batteryAlarmLowCapacity OBJECT-TYPE

SYNTAX Unsigned32

UNITS "milliampere hours"

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"This object provides the lower threshold value for object batteryActualCapacity. If the value of object batteryActualCapacity falls below this threshold, a battery aging alarm will be raised. The alarm procedure may include generating a batteryAgingNotification.

A value of 0 indicates that no alarm will be raised for any value of object batteryActualCapacity."

::= { batteryEntry 22 }

batteryAlarmHighCycleCount OBJECT-TYPE

SYNTAX Unsigned32

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"This object provides the upper threshold value for object batteryChargingCycleCount. If the value of object batteryChargingCycleCount rises above this threshold, a battery aging alarm will be raised. The alarm procedure may include generating a batteryAgingNotification.

A value of 0 indicates that no alarm will be raised for any value of object batteryChargingCycleCount."

::= { batteryEntry 23 }

batteryAlarmHighTemperature OBJECT-TYPE

SYNTAX Integer32

UNITS "deci-degrees Celsius"

MAX-ACCESS read-write

```

STATUS      current
DESCRIPTION
    "This object provides the upper threshold value for object
    batteryTemperature.  If the value of object
    batteryTemperature rises above this threshold, a battery
    high temperature alarm will be raised.  The alarm procedure
    may include generating a batteryTemperatureNotification.

    A value of '7fffffff'H indicates that no alarm will be
    raised for any value of object batteryTemperature."
 ::= { batteryEntry 24 }

```

```

batteryAlarmLowTemperature OBJECT-TYPE
    SYNTAX      Integer32
    UNITS       "deci-degrees Celsius"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "This object provides the lower threshold value for object
        batteryTemperature.  If the value of object
        batteryTemperature falls below this threshold, a battery
        low temperature alarm will be raised.  The alarm procedure
        may include generating a batteryTemperatureNotification.

        A value of '7fffffff'H indicates that no alarm will be
        raised for any value of object batteryTemperature."
 ::= { batteryEntry 25 }

```

```

=====
-- 2. Notifications
=====

```

```

batteryChargingStateNotification NOTIFICATION-TYPE
    OBJECTS      {
        batteryChargingOperState
    }
    STATUS      current
    DESCRIPTION
        "This notification can be generated when a charging state
        of the battery (indicated by the value of object
        batteryChargingOperState) is triggered by an event other
        than a write action to object batteryChargingAdminState.
        Such an event may, for example, be triggered by a local
        battery controller."
 ::= { batteryNotifications 1 }

```

```

batteryLowNotification NOTIFICATION-TYPE

```

```
OBJECTS      {
    batteryActualCharge,
    batteryActualVoltage,
    batteryCellIdentifier
}
```

```
STATUS      current
```

```
DESCRIPTION
```

"This notification can be generated when the current charge (batteryActualCharge) or the current voltage (batteryActualVoltage) of the battery falls below a threshold defined by object batteryAlarmLowCharge or object batteryAlarmLowVoltage, respectively.

Note that typically, this notification is generated in a state where the battery is still sufficiently charged to keep the device(s) that it powers operational for some time. If the charging state of the battery has become critical, i.e., the device(s) powered by the battery must go to a 'sleep' or 'off' state, then the batteryCriticalNotification should be used instead.

The notification should not be sent again before the current voltage or the current charge becomes higher than the respective thresholds through charging before falling below the thresholds again.

If the low charge or voltage has been detected for a single cell or a set of cells of the battery and not for the entire battery, then object batteryCellIdentifier should be set to a value that identifies the cell or set of cells. Otherwise, the value of object batteryCellIdentifier should be set to the empty string when this notification is generated."

```
::= { batteryNotifications 2 }
```

```
batteryCriticalNotification NOTIFICATION-TYPE
```

```
OBJECTS      {
    batteryActualCharge,
    batteryActualVoltage,
    batteryCellIdentifier
}
```

```
STATUS      current
```

```
DESCRIPTION
```

"This notification can be generated when the current charge of the battery falls so low that it cannot provide a sufficient power supply function for regular operation of the powered device(s). The battery needs to be charged before it can be used for regular power supply again. The

battery may still provide sufficient power for a 'sleep' mode of powered device(s) or for a transition into an 'off' mode.

The notification should not be sent again before the battery charge has increased to a non-critical value.

If the critical state is caused a single cell or a set of cells of the battery, then object `batteryCellIdentifier` should be set to a value that identifies the cell or set of cells. Otherwise, the value of object `batteryCellIdentifier` should be set to the empty string when this notification is generated."

::= { batteryNotifications 3 }

`batteryTemperatureNotification` NOTIFICATION-TYPE

OBJECTS {  
    **batteryTemperature**,  
    **batteryCellIdentifier**  
}

STATUS current

DESCRIPTION

"This notification can be generated when the measured temperature (`batteryTemperature`) rises above the threshold defined by object `batteryAlarmHighTemperature` or falls below the threshold defined by object `batteryAlarmLowTemperature`.

If the low or high temperature has been detected for a single cell or a set of cells of the battery and not for the entire battery, then object `batteryCellIdentifier` should be set to a value that identifies the cell or set of cells. Otherwise, the value of object `batteryCellIdentifier` should be set to the empty string when this notification is generated."

::= { batteryNotifications 4 }

`batteryAgingNotification` NOTIFICATION-TYPE

OBJECTS {  
    **batteryActualCapacity**,  
    **batteryChargingCycleCount**,  
    **batteryCellIdentifier**  
}

STATUS current

DESCRIPTION

"This notification can be generated when the actual capacity (`batteryActualCapacity`) falls below a threshold defined by object `batteryAlarmLowCapacity`



or when the charging cycle count of the battery (batteryChargingCycleCount) exceeds the threshold defined by object batteryAlarmHighCycleCount.

If the aging has been detected for a single cell or a set of cells of the battery and not for the entire battery, then object batteryCellIdentifier should be set to a value that identifies the cell or set of cells. Otherwise, the value of object batteryCellIdentifier should be set to the empty string when this notification is generated."

::= { batteryNotifications 5 }

batteryConnectedNotification NOTIFICATION-TYPE

OBJECTS {  
    batteryIdentifier  
}

STATUS current

DESCRIPTION

"This notification can be generated when it has been detected that a battery has been connected. The battery can be identified by the value of object batteryIdentifier as well as by the value of index entPhysicalIndex that is contained in the OID of object batteryIdentifier."

::= { batteryNotifications 6 }

batteryDisconnectedNotification NOTIFICATION-TYPE

STATUS current

DESCRIPTION

"This notification can be generated when it has been detected that one or more batteries have been disconnected."

::= { batteryNotifications 7 }

-----  
-- 3. Conformance Information  
-----

batteryCompliances OBJECT IDENTIFIER ::= { batteryConformance 1 }  
batteryGroups OBJECT IDENTIFIER ::= { batteryConformance 2 }

-----  
-- 3.1. Compliance Statements  
-----

batteryCompliance MODULE-COMPLIANCE

STATUS current

DESCRIPTION

"The compliance statement for implementations of the

BATTERY-MIB module.

A compliant implementation MUST implement the objects defined in the mandatory groups batteryDescriptionGroup and batteryStatusGroup.

Note that compliance with this compliance statement requires compliance with the entity4CRCompliance MODULE-COMPLIANCE statement of the ENTITY-MIB (RFC6933)."

```
MODULE -- this module
  MANDATORY-GROUPS {
    batteryDescriptionGroup,
    batteryStatusGroup
  }

  GROUP batteryAlarmThresholdsGroup
  DESCRIPTION
    "A compliant implementation does not have to implement
    the batteryAlarmThresholdsGroup."

  GROUP batteryNotificationsGroup
  DESCRIPTION
    "A compliant implementation does not have to implement
    the batteryNotificationsGroup."

  GROUP batteryPerCellNotificationsGroup
  DESCRIPTION
    "A compliant implementation does not have to implement
    the batteryPerCellNotificationsGroup."

  GROUP batteryAdminGroup
  DESCRIPTION
    "A compliant implementation does not have to implement
    the batteryAdminGroup."

  OBJECT batteryAlarmLowCharge
  MIN-ACCESS read-only
  DESCRIPTION
    "A compliant implementation is not required
    to support set operations to this object."

  OBJECT batteryAlarmLowVoltage
  MIN-ACCESS read-only
  DESCRIPTION
    "A compliant implementation is not required
    to support set operations to this object."
```

```
OBJECT batteryAlarmLowCapacity
MIN-ACCESS read-only
DESCRIPTION
    "A compliant implementation is not required
    to support set operations to this object."
```

```
OBJECT batteryAlarmHighCycleCount
MIN-ACCESS read-only
DESCRIPTION
    "A compliant implementation is not required
    to support set operations to this object."
```

```
OBJECT batteryTemperatureNotification
MIN-ACCESS read-only
DESCRIPTION
    "A compliant implementation is not required
    to support set operations to this object."
```

```
::= { batteryCompliances 1 }
```

```
-----
-- 3.2. MIB Grouping
-----
```

```
batteryDescriptionGroup OBJECT-GROUP
    OBJECTS {
        batteryIdentifier,
        batteryFirmwareVersion,
        batteryType,
        batteryTechnology,
        batteryDesignVoltage,
        batteryNumberOfCells,
        batteryDesignCapacity,
        batteryMaxChargingCurrent,
        batteryTrickleChargingCurrent
    }
    STATUS current
    DESCRIPTION
        "A compliant implementation MUST implement the objects
        contained in this group."
    ::= { batteryGroups 1 }
```

```
batteryStatusGroup OBJECT-GROUP
    OBJECTS {
        batteryActualCapacity,
        batteryChargingCycleCount,
        batteryLastChargingCycleTime,
        batteryChargingOperState,
```

```
        batteryActualCharge,
        batteryActualVoltage,
        batteryActualCurrent,
        batteryTemperature
    }
    STATUS          current
    DESCRIPTION
        "A compliant implementation MUST implement the objects
        contained in this group."
    ::= { batteryGroups 2 }

batteryAdminGroup OBJECT-GROUP
    OBJECTS {
        batteryChargingAdminState
    }
    STATUS          current
    DESCRIPTION
        "A compliant implementation does not have to implement the
        object contained in this group."
    ::= { batteryGroups 3 }

batteryAlarmThresholdsGroup OBJECT-GROUP
    OBJECTS {
        batteryAlarmLowCharge,
        batteryAlarmLowVoltage,
        batteryAlarmLowCapacity,
        batteryAlarmHighCycleCount,
        batteryAlarmHighTemperature,
        batteryAlarmLowTemperature
    }
    STATUS          current
    DESCRIPTION
        "A compliant implementation does not have to implement the
        objects contained in this group."
    ::= { batteryGroups 4 }

batteryNotificationsGroup NOTIFICATION-GROUP
    NOTIFICATIONS {
        batteryChargingStateNotification,
        batteryLowNotification,
        batteryCriticalNotification,
        batteryAgingNotification,
        batteryTemperatureNotification,
        batteryConnectedNotification,
        batteryDisconnectedNotification
    }
    STATUS          current
    DESCRIPTION
```

```
        "A compliant implementation does not have to implement the
        notifications contained in this group."
 ::= { batteryGroups 5 }

batteryPerCellNotificationsGroup OBJECT-GROUP
    OBJECTS {
        batteryCellIdentifier
    }
    STATUS      current
    DESCRIPTION
        "A compliant implementation does not have to implement the
        object contained in this group."
 ::= { batteryGroups 6 }
END
```

## 5. Security Considerations

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. These are the tables and objects and their sensitivity/vulnerability:

- o batteryChargingAdminState  
Setting the battery charging state can be beneficial for an operator for various reasons such as charging batteries when the price of electricity is low. However, setting the charging state can be used by an attacker to discharge batteries of devices and thereby switching these devices off if they are powered solely by batteries. In particular, if the batteryAlarmLowCharge and batteryAlarmLowVoltage can also be set, this attack will go unnoticed (i.e. no notifications are sent).
- o batteryAlarmLowCharge and batteryAlarmLowVoltage  
These objects set the threshold for an alarm to be raised when the battery charge or voltage falls below the corresponding one of them. An attacker setting one of these alarm values can switch off the alarm by setting it to the 'off' value 0 or modify the alarm behavior by setting it to any other value. The result may be loss of data if the battery runs empty without warning to a recipient expecting such a notification.
- o batteryAlarmLowCapacity and batteryAlarmHighCycleCount  
These objects set the threshold for an alarm to be raised when the battery becomes older and less performant than required for stable operation. An attacker setting this alarm value can switch off

the alarm by setting it to the 'off' value 0 or modify the alarm behavior by setting it to any other value. This may either lead to a costly replacement of a working battery or too old or too weak batteries being used. The consequence of the latter could e.g. be that a battery cannot provide power long enough between two scheduled charging actions causing the powered device to shut down and potentially lose data.

- o batteryAlarmHighTemperature and batteryAlarmLowTemperature  
These objects set thresholds for an alarm to be raised when the battery rises above/falls below them. An attacker setting one of these alarm values can switch off these alarms by setting them to the 'off' value '7fffffff'H or modify the alarm behavior by setting them to any other value. The result may e.g. be an unnecessary shutdown of a device if batteryAlarmHighTemperature is set to too low or damage to the device by too high temperatures if switched off or set to too high values or by damage to the battery when it e.g. is being charged. Batteries can also be damaged e.g. in an attempt to charge them at too low temperatures.

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. These are the tables and objects and their sensitivity/vulnerability:

All potentially sensible or vulnerable objects of this MIB module are in the batteryTable. In general, there are no serious operational vulnerabilities foreseen in case of an unauthorized read access to this table. However, privacy issues need to be considered. It may be a trade secret of the operator

- o how many batteries are installed in a managed node (batteryIndex)
- o how old these batteries are (batteryActualCapacity and batteryChargingCycleCount)
- o when the next replacement cycle for batteries can be expected (batteryAlarmLowCapacity and batteryAlarmHighCycleCount)
- o what battery type and make are used with which firmware version (batteryIdentifier, batteryFirmwareVersion, batteryType, and batteryTechnology)

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

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 this MIB module 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.

## 6. IANA Considerations

### 6.1. SMI Object Identifier Registration

The Battery MIB module defined in this document uses the following IANA-assigned OBJECT IDENTIFIER value recorded in the SMI Numbers registry:

Descriptor	OBJECT IDENTIFIER value
-----	-----
batteryMIB	{ mib-2 xxx }

[NOTE for IANA: Please allocate an object identifier at <http://www.iana.org/assignments/smi-numbers> for object batteryMIB.]

### 6.2. Battery Technology Registration

Object batteryTechnology defined in Section 4 reports battery technologies. Eighteen values for battery technologies have initially been defined. They are listed in a table in Section 3.2.

For ensuring extensibility of this list, IANA has created a registry for battery technologies at <http://www.iana.org/assignments/eman> and filled it with the initial list given in Section 3.2.

New assignments of numbers for battery technologies will be administered by IANA through Expert Review ([RFC5226]). Experts must check for sufficient relevance of a battery technology to be added.

[NOTE for IANA: Please create a new registry under <http://www.iana.org/assignments/eman> for battery types. Please fill the registry with values from the table in Section 3.2]

## 7. Acknowledgements

We would like to thank Steven Chew and Bill Mielke for their valuable input.

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Energy Object Context MIB  
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#### Abstract

This document defines a subset of a Management Information Base (MIB) for energy management of devices. The module addresses device identification, context information, and the energy relationships between devices.

#### Conventions used in this document

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

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## 1. Introduction

The EMAN standards provide a specification for Energy Management. This document defines a subset of a Management Information Base (MIB) for use with network management protocols for Energy monitoring of network devices and devices attached to the network and possibly extending to devices in the industrial automation setting with a network interface.

The focus of the MIB module specified in this document is on the identification of Energy Objects and reporting the context and relationships of Energy Objects as defined in [EMAN-FMWK]. The module addresses Energy Object identification, Energy Object context, and Energy Object relationships.

### 1.1. Energy Management Document Overview

This document specifies the Energy Object Context (ENERGY-OBJECT-CONTEXT-MIB) and IANA Energy Relationship (IANA-ENERGY-RELATION-MIB) modules. The Energy Object Context MIB module specifies MIB objects for identification of Energy Objects, and reporting context and relationship of an Energy Object. The IANA Energy Relationship MIB module specifies the first version of the IANA-maintained definitions of relationships between Energy Objects.

Firstly, to illustrate the importance of energy monitoring in networks and secondly to list some of the important areas to be addressed by the Energy Management Framework, several use cases and network scenarios are presented in the EMAN applicability statement document [EMAN-AS]. In addition, for each scenario, the target devices for energy management, and how those devices powered and metered are also presented. To address the network scenarios, requirements for power and energy monitoring for networking devices are specified in [RFC6988]. Based on the requirements [RFC6988], the [EMAN-FMWK] presents a solution approach.

Accordingly, the scope of the MIB modules in this document is in accordance to the requirements specified in [RFC6988] and the concepts from [EMAN-FMWK].

This document is based on the Energy Management Framework [EMAN-FMWK] and meets the requirements on identification of Energy Objects and their context and relationships as specified in the Energy Management requirements [RFC6988].

A second MIB module meeting the EMAN requirements [RFC6988] the Power and Energy Monitoring MIB [EMAN-MON-MIB], monitors the Energy Objects for Power States, for the Power and Energy consumption. Power State monitoring includes: retrieving Power States, Power State properties, current Power State, Power State transitions, and Power State statistics. In addition, this MIB module provides the Power Characteristics properties of the Power and Energy, along with optional characteristics.

The applicability statement document [EMAN-AS] provides the list of use cases, and describes the common aspects of between existing Energy standards and the EMAN standard, and shows how the EMAN framework relates to other frameworks.

## 2. The Internet-Standard Management Framework

For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to section 7 of RFC 3410 [RFC3410].

Managed objects are accessed via a virtual information store, termed the Management Information Base or MIB. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP). Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This memo specifies MIB modules that are compliant with SMIV2, which is described in STD 58, RFC 2578 [RFC2578], STD 58, RFC 2579 [RFC2579] and STD 58, RFC 2580 [RFC2580].

## 3. Terminology

Please refer to [EMAN-FMWK] for the definitions of the following terminology used in this draft:



Energy Management System (EnMS)

Energy Monitoring

Energy Control

electrical equipment

non-electrical equipment (mechanical equipment)

device

component

power inlet

power outlet

energy

power

demand

provide energy

receive energy

meter (energy meter)

battery

Power Interface

Nameplate Power

Power Attributes

Power Quality

Power State

Power State Set

## 4. Architecture Concepts Applied to the MIB Module

This section describes the basic concepts specified in the Energy Management Architecture [EMAN-FMWK], with specific information related to the MIB modules specified in this document.

The Energy Object Context (ENERGY-OBJECT-CONTEXT-MIB) MIB module in this document specifies MIB objects for identification of Energy Objects, and reporting context and relationship of an Energy Object. The managed objects are contained in two tables eoTable and eoRelationTable.

The first table eoTable focuses on the link to the other MIB modules, and secondly on identification, context of the Energy Object. The second table eoRelationTable specifies the relationships between Energy Objects. This is a simplified representation of relationship between Energy Objects.

A "smidump-style" tree presentation of the MIB modules contained in the draft is presented. The meaning of the three symbols in is a compressed representation of the object's MAX-ACCESS clause which may have the following values:

```
"not-accessible"->"---"
"accessible-for-notify"->"--n"
"read-only"->"r-n"
"read-write"->"rwn"
```

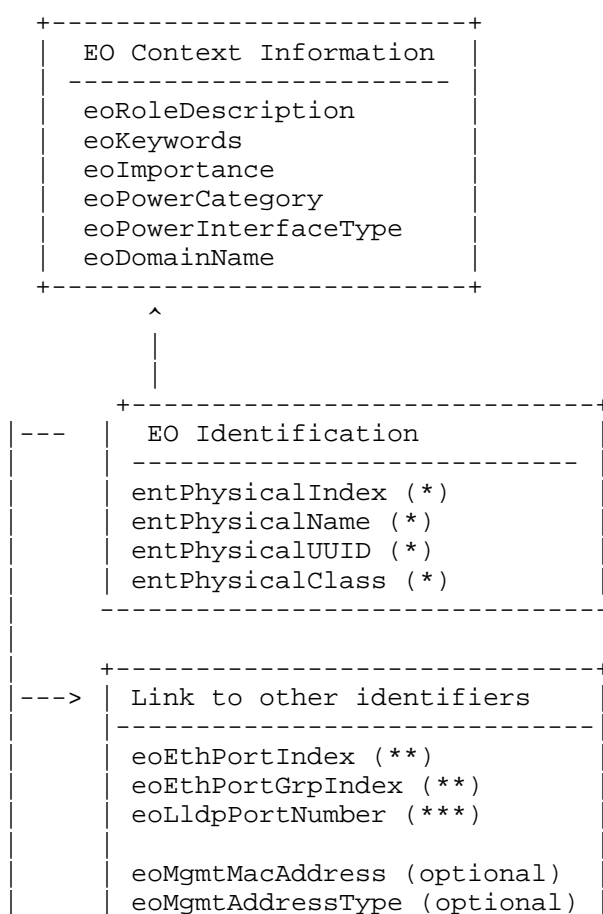
```
+-- eoTable(1)
|
+-- eoEntry(1) [entPhysicalIndex]
|
|   +-- r-n PethPsePortIndexOrZero          eoEthPortIndex(1)
|   +-- r-n PethPsePortGroupIndexOrZero     eoEthPortGrpIndex(2)
|   +-- r-n LldpPortNumberOrZero            eoLldpPortNumber(3)
|   +-- rwn MacAddress                      eoMgmtMacAddress(4)
|   +-- r-n InetAddressType                 eoMgmtAddressType(5)
|   +-- r-n InetAddress                     eoMgmtAddress(6)
|   +-- r-n OCTET STRING                    eoMgmtDNSName(7)
|   +-- rwn SnmpAdminString                 eoDomainName(8)
|   +-- rwn SnmpAdminString                 eoRoleDescription(9)
|   +-- rwn EnergyObjectKeywordList         eoKeywords(10)
|   +-- rwn Integer32                       eoImportance(11)
|   +-- r-n INTEGER                         eoPowerCategory(12)
|   +-- rwn SnmpAdminString                 eoAlternateKey(13)
|   +-- r-n INTEGER                         eoPowerInterfaceType(14)
```

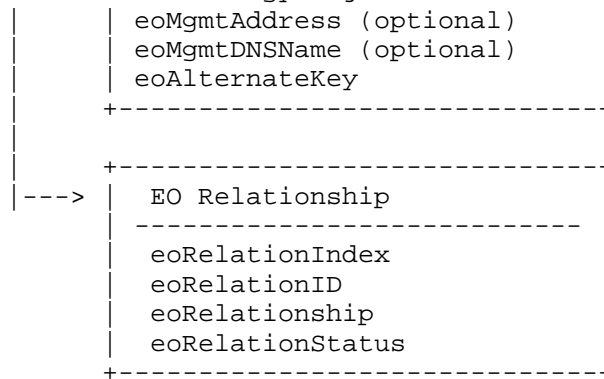
```

+- eoRelationTable(2)
|
+- eoRelationEntry(1) [entPhysicalIndex, eoRelationIndex]
|
+-- --n Integer32                eoRelationIndex(1)
+-- rwn UUIDorZero              eoRelationID(2)
+-- rwn IANAEnergyRelationship   eoRelationship(3)
+-- rwn RowStatus                eoRelationStatus(4)

```

The following UML diagram illustrates the relationship of the MIB objects in the eoTable, eoRelationTable and ENTITY-MIB. The MIB objects describe the identity, context and relationship of an Energy Object. The UML diagram furthermore contains objects from the ENTITY-MIB [RFC6933].





- (\*) Compliance with entity4CRCompliance ENTITY MIB[RFC6933]
- (\*\*) Link with the Power over Ethernet MIB [RFC3621]
- (\*\*\*) Link with LLDP MIBs [LLDP-MIB] [LLDP-MED-MIB]

Figure 1: MIB Objects Grouping

As displayed in figure 1, the MIB objects can be classified in different logical grouping of MIB objects.

- 1) The Energy Object Identification. See Section 5.1 "Energy Object Identification". Devices and their sub-components are characterized by the power-related attributes of a physical entity present in the ENTITY MIB [RFC6933].
- 2) The Context Information. See Section 5.2 "Energy Object Context"
- 3) The links to other MIB modules. See Section 5.3 "Links to other Identifiers"
- 4) The Energy Object Relationships specific information. See Section 5.4
- 5) The Energy Object Identity Persistence. See Section 5.5 "Energy Object Identity Persistence"

## 5.1 Energy Object Identification

Refer to the "Energy Object Information" section in [EMAN-FMWK] for background information about Energy Objects.

Every Energy Object MUST implement the unique index, entPhysicalIndex, entPhysicalName, entPhysicalClass, and entPhysicalUUID from the ENTITY MIB [RFC6933]. Module Compliance with respect to entity4CRCompliance of ENTITY-MIB MUST be

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supported which require a limited number of objects supported  
(entPhysicalIndex, entPhysicalName, entPhysicalClass, and  
entPhysicalUUID). entPhysicalIndex is used as index for the  
Energy Object in the ENERGY-OBJECT-CONTEXT-MIB module.  
Every Energy Object MUST have a printable name assigned to it.  
Energy Objects MUST implement the entPhysicalName object  
specified in the ENTITY-MIB [RFC6933], which must contain the  
Energy Object name.

For the ENERGY-OBJECT-CONTEXT-MIB compliance, every Energy  
Object instance MUST implement the entPhysicalUUID from the  
ENTITY MIB [RFC6933].

As displayed in [RFC4122], the following is an example of the  
string representation of a UUID as a URN: urn:uuid:f81d4fae-  
7dec-11d0-a765-00a0c91e6bf6.

For example, to understand the relationship between Energy  
Object Components and Energy Objects, the ENTITY-MIB physical  
containment tree [RFC6933] MUST be implemented.

A second example deals with one of the ENTITY-MIB extensions: if  
the Energy Object temperature is required, the managed objects  
from the ENTITY-SENSOR-MIB [RFC3433] should be supported.

Each Energy Object MUST belong to a single Energy Management  
Domain or in other words, an Energy Object cannot belong to more  
than one Energy Management Domain. Refer to the "Energy  
Management Domain" section in [EMAN-FMWK] for background  
information. The eoDomainName, which is an element of the  
eoTable, is a read-write MIB object. The Energy Management  
Domain should map 1-1 with a metered or sub-metered portion of  
the network. The Energy Management Domain MUST be configured on  
the Energy Object. The Energy Object MAY inherit the some of the  
domain parameters (possibly domain name, some of the context  
information such as role or keywords, importance) from the  
Energy Object or the Energy Management Domain MAY be configured  
directly in an Energy Object.

When an Energy Object acts as a Power Aggregator, the Energy  
Objects for which Power should be aggregated MUST be members of  
the same Energy Management Domain, specified by the eoDomainName  
MIB Object.

Refer to the "Energy Object Context" section in [EMAN-FMWK] for background information.

An Energy Object must provide a value for eoImportance in the range of 1...100 to help differentiate the use or relative value of the device. The importance range is from 1 (least important) to 100 (most important). The default importance value is 1.

An Energy Object can provide a set of eoKeywords. These keywords are a list of tags that can be used for grouping and summary reporting within or between Energy Management Domains.

An Energy Object can have Power Interfaces and those interfaces can be classified as Power Inlet, Power Outlet or both.

An Energy Object can be classified based on the physical properties of the Energy Object. That Energy Object can be classified as consuming power or supplying power to other devices or that Energy Object can perform both of those functions and finally, an Energy Object can be a passive meter.

Additionally, an Energy Object can provide an eoRoleDescription string that indicates the purpose the Energy Object serves in the network.

### 5.3 Links to Other Identifiers

While the entPhysicalIndex is the primary index for all MIB objects in the ENERGY-OBJECT-CONTEXT-MIB module, the Energy Management Systems (EnMS) must be able to make the link with the identifier(s) in other supported MIB modules.

If the Energy Object is a Power over Ethernet (PoE) port, and if the Power over Ethernet MIB [RFC3621] is supported by the SNMP agent managing the Energy Object, then the Energy Object eoethPortIndex and eoethPortGrpIndex MUST contain the corresponding values of pethPsePortIndex and pethPsePortGroupIndex [RFC3621].

If the LLDP-MED MIB [LLDP-MIB] is supported by the Energy Object SNMP agent, then the Energy Object eoLldpPortNumber MUST contain the corresponding lldpLocPortNum from the LLDP MIB.

The intent behind the links to the other MIB module identifier(s) is to correlate the instances in the different MIB modules. This will allow the ENERGY-OBJECT-CONTEXT-MIB module to reference other MIB modules in cases where the Power over Ethernet and the LLDP MIB modules are supported by the SNMP agent. Some use cases may not implement any of these two MIB modules for the Energy Objects. However, in situation where any of these two MIB modules are implemented, the EnMS must be able to correlate the instances in the different MIB modules.

The eoAlternateKey object specifies an alternate key string that can be used to identify the Energy Object. Since an EnMS may need to correlate objects across management systems, this alternate key is provided to facilitate such a link. This optional value is intended as a foreign key or alternate identifier for a manufacturer or EnMS to use to correlate the unique Energy Object Id in other systems or namespaces. If an alternate key is not available or is not applicable then the value is the zero-length string.

An Energy Object can have additional MIB objects that can be used for easier identification by the EnMS. The optional objects eoMgmtMacAddress, eoMgmtAddressType eoMgmtDNSName can be used to help identify the relationship between the Energy Objects and other NMS objects. These objects can be used as an alternate key to help link the Energy Object with other keyed information that may be stored within the EnMS(s). For the optional objects that may not be included in some vendor implementations, the expected behavior when those objects are polled is a response noSuchInstance.

#### 5.4 Energy Object Relationships

Refer to the "Energy Object Relationships" section in [EMAN-FMWK] for the definition and background information. In order to link two Energy Objects a separate table (eoRelationTable) has been introduced in this MIB module.

Each Energy object can have one or more Energy Object relationships with other Energy Objects. The relationship between Energy Objects are specified in eoRelationTable. The relationship between the Energy Objects is specified with the entPhysicalIndex of the Energy Object and the UUID of the remote Energy Object. The UUID MUST comply to the RFC 4122 specifications. It is important to note that it is possible

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that an Energy Object may not have an Energy Object relationship  
with other Energy Objects.

The following relationships between Energy objects have been  
considered in the eoRelationTable.

Metering Relationship -> meteredBy / metering

Power Source Relationship -> poweredBy / powering

Aggregation Relationship -> aggregatedBy / aggregating

An Energy Object B has "meteredBy" relationship with Energy  
Object A, if the energy consumption of Energy Object B is  
measured by Energy Object A. Equivalently, it is possible to  
indicate that Energy Object A has "metering" relationship with  
Energy Object B.

An Energy Object B has "poweredBy" relationship with Energy  
Object A, if the power source of Energy Object B Energy Object  
A. Equivalently, it is possible to indicate that Energy Object A  
has "powering" relationship with Energy Object B.

An Energy Object B has "aggregatedBy" relationship with Energy  
Object A, if Energy Object A is an aggregation point for energy  
usage of Energy Object B. Equivalently, it is possible to  
indicate that Energy Object A has "aggregating" relationship  
with Energy Object B.

The IANA Energy Relationship MIB module in Section 6 below  
specifies the first version of the IANA-maintained definitions  
of relationships. This way, for Energy Relationships, new  
textual conventions can be specified, without updating the  
primary Energy Object Context MIB module.

## 5.5 Energy Object Identity Persistence

In some situations, the Energy Object identity information  
should be persistent even after a device reload. For example, in  
a static setup where a switch monitors a series of connected PoE  
phones, there is a clear benefit for the EnMS if the Energy  
Object Identification and all associated information persist, as  
it saves a network discovery. However, in other situations,  
such as a wireless access point monitoring the mobile user PCs,  
there is not much advantage to persist the Energy Object



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Information. The identity information of an Energy Object  
should be persisted and there is value in the writable MIB  
objects persisted.

## 5. MIB Definitions

```
-- *****  
--  
--  
-- This MIB is used for describing the identity and the  
-- context information of Energy Objects in network  
--  
--  
-- *****
```

ENERGY-OBJECT-CONTEXT-MIB DEFINITIONS ::= BEGIN

IMPORTS

```
    MODULE-IDENTITY,  
    OBJECT-TYPE,  
    mib-2, Integer32  
        FROM SNMPv2-SMI                -- RFC2578  
    TEXTUAL-CONVENTION, MacAddress, TruthValue, RowStatus  
        FROM SNMPv2-TC                -- RFC2579  
    MODULE-COMPLIANCE, OBJECT-GROUP  
        FROM SNMPv2-CONF                -- RFC2580  
    SnmpAdminString  
        FROM SNMP-FRAMEWORK-MIB        -- RFC3411  
    InetAddressType, InetAddress  
        FROM INET-ADDRESS-MIB          -- RFC3291  
    entPhysicalIndex  
        FROM ENTITY-MIB                -- RFC6933  
    UUIDorZero  
        FROM UUID-TC-MIB                -- RFC6933  
    IANAEnergyRelationship  
        FROM IANA-ENERGY-RELATION-MIB;
```

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energyObjectContextMIB MODULE-IDENTITY  
LAST-UPDATED "201402100000Z"

ORGANIZATION "IETF EMAN Working Group"  
CONTACT-INFO

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<http://datatracker.ietf.org/wg/eman/charter/>

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DESCRIPTION

"This MIB is used for describing the identity and the  
context information of Energy Objects"

REVISION

DESCRIPTION

"Initial version, published as RFC YYY."

::= { mib-2 XXX1 }

-- RFC Editor, please replace XXX1 with the IANA allocation  
-- for this MIB module and YYY with the number of the  
-- approved RFC

energyObjectContextMIBNotifs OBJECT IDENTIFIER

::= { energyObjectContextMIB 0 }

energyObjectContextMIBObjects OBJECT IDENTIFIER

::= { energyObjectContextMIB 1 }

energyObjectContextMIBConform OBJECT IDENTIFIER

::= { energyObjectContextMIB 2 }

-- Textual Conventions

PethPsePortIndexOrZero ::= TEXTUAL-CONVENTION

DISPLAY-HINT "d"

STATUS current

DESCRIPTION

"This textual convention is an extension of the  
pethPsePortIndex convention, which defines a greater than  
zero value used to identify a power Ethernet PSE port.  
This extension permits the additional value of zero. The  
semantics of the value zero are object-specific and must,  
therefore, be defined as part of the description of any  
object that uses this syntax. Examples of the usage of  
this extension are situations where none or all physical  
entities need to be referenced."

SYNTAX Integer32 (0..2147483647)

PethPsePortGroupIndexOrZero ::= TEXTUAL-CONVENTION

DISPLAY-HINT "d"

STATUS current

DESCRIPTION

"This textual convention is an extension of the  
pethPsePortGroupIndex convention from the Power Over

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Ethernet MIB RFC 3621, which defines a greater than zero  
value used to identify group containing the port to which  
a power Ethernet PSE is connected. This extension  
permits the additional value of zero. The semantics of  
the value zero are object-specific and must, therefore,  
be defined as part of the description of any object that  
uses this syntax. Examples of the usage of this  
extension are situations where none or all physical  
entities need to be referenced."  
SYNTAX Integer32 (0..2147483647)

LldpPortNumberOrZero ::= TEXTUAL-CONVENTION  
DISPLAY-HINT "d"  
STATUS current  
DESCRIPTION  
"This textual convention is an extension of the  
LldpPortNumber convention specified in the LLDP MIB,  
which defines a greater than zero value used to uniquely  
identify each port contained in the chassis (that is  
known to the LLDP agent) by a port number. This  
extension permits the additional value of zero. The  
semantics of the value zero are object-specific and must,  
therefore, be defined as part of the description of any  
object that uses this syntax. Examples of the usage of  
this extension are situations where none or all physical  
entities need to be referenced."  
SYNTAX Integer32(0..4096)

EnergyObjectKeywordList ::= TEXTUAL-CONVENTION  
STATUS current  
DESCRIPTION  
"A list of keywords that can be used to group Energy  
Objects for reporting or searching. If multiple keywords  
are present, then this string will contain all the  
keywords separated by the ',' character. All alphanumeric  
characters and symbols (other than a comma), such as #,  
(, \$, !, and &, are allowed. White spaces before and  
after the commas are ignored, as well as within a keyword  
itself.

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 For example, if an Energy Object were to be tagged with  
 the keyword values 'hospitality' and 'guest', then the  
 keyword list will be 'hospitality,guest'."  
 SYNTAX OCTET STRING (SIZE (0..2048))

-- Objects

eoTable OBJECT-TYPE  
 SYNTAX SEQUENCE OF EoEntry  
 MAX-ACCESS not-accessible  
 STATUS current  
 DESCRIPTION  
 "This table lists Energy Objects."  
 ::= { energyObjectContextMIBObjects 1 }

eoEntry OBJECT-TYPE  
 SYNTAX EoEntry  
 MAX-ACCESS not-accessible  
 STATUS current  
 DESCRIPTION  
 "An entry describes the attributes of an Energy Object.  
 Whenever a new Energy Object is added or an existing  
 Energy Object is deleted, a row in the eoTable is added  
 or deleted."

INDEX {entPhysicalIndex }  
 ::= { eoTable 1 }

EoEntry ::= SEQUENCE {  
 eoEthPortIndex PethPsePortIndexOrZero,  
 eoEthPortGrpIndex PethPsePortGroupIndexOrZero,  
 eoLldpPortNumber LldpPortNumberOrZero,  
 eoMgmtMacAddress MacAddress,  
 eoMgmtAddressType InetAddressType,  
 eoMgmtAddress InetAddress,  
 eoMgmtDNSName OCTET STRING,,  
 eoDomainName SnmpAdminString,  
 eoRoleDescription SnmpAdminString,  
 eoKeywords EnergyObjectKeywordList,  
 eoImportance Integer32,  
 eoPowerCategory INTEGER,  
 eoAlternateKey SnmpAdminString,  
 eoPowerInterfaceType INTEGER  
 }

eoEthPortIndex OBJECT-TYPE  
 SYNTAX PethPsePortIndexOrZero

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This variable uniquely identifies the power Ethernet port to which a Power over Ethernet device is connected . If the Power over Ethernet MIB RFC 3621 is supported by the SNMP agent managing the Energy Object, then the Energy Object eoethPortIndex MUST contain the corresponding value of pethPsePortIndex. f such a power Ethernet port cannot be specified or is not known then the object is zero."

REFERENCE "RFC 3621 "

DEFVAL { 0 }

::= { eoEntry 1 }

eoEthPortGrpIndex OBJECT-TYPE

SYNTAX PethPsePortGroupIndexOrZero

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This variable uniquely identifies the group containing the port to which a power over Ethernet device PSE is connected [RFC3621]. If the Power over Ethernet MIB RFC 3621 is supported by the SNMP agent managing the Energy Object, then the Energy Object eoEthPortGrpIndex MUST contain the corresponding value of eoethPortGrpIndex. If such a power Ethernet port cannot be specified or is not known then the object is zero."

REFERENCE "RFC 3621"

DEFVAL { 0 }

::= { eoEntry 2 }

eoLldpPortNumber OBJECT-TYPE

SYNTAX LldpPortNumberOrZero

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This variable uniquely identifies the port component (contained in the local chassis with the LLDP agent) as defined by the lldpLocPortNum in the [LLDP-MIB] and [LLDP-MED-MIB]. If the [LLDP-MIB] is supported by the SNMP agent managing the Energy Object, then the Energy Object eoLldpPortNumber MUST contain the corresponding value of lldpLocPortNum from the [LLDP-MIB]. If such a

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port number cannot be specified or is not known then the  
object is zero."

REFERENCE "LLDP MIB, IEEE 802.1AB-2005,  
LLDP-MED-MIB, ANSI/TIA-1057, "  
DEFVAL { 0 }

::= { eoEntry 3 }

eoMgmtMacAddress OBJECT-TYPE

SYNTAX MacAddress  
MAX-ACCESS read-only  
STATUS current

DESCRIPTION

"This object specifies a MAC address of the Energy  
Object."

::= { eoEntry 4 }

eoMgmtAddressType OBJECT-TYPE

SYNTAX InetAddressType  
MAX-ACCESS read-only  
STATUS current

DESCRIPTION

"This object specifies the eoMgmtAddress type, i.e. an  
IPv4 address or an IPv6 address. This object MUST be  
populated when eoMgmtAddress is populated."

::= { eoEntry 5 }

eoMgmtAddress OBJECT-TYPE

SYNTAX InetAddress  
MAX-ACCESS read-only  
STATUS current

DESCRIPTION

"This object specifies the management address as an IPv4  
address or IPv6 address of Energy Object. The IP address  
type, i.e. IPv4 or IPv6, is determined by the  
eoMgmtAddressType value. This object can be used as an  
alternate key to help link the Energy Object with other  
keyed information that may be stored within the EnMS(s)."

::= { eoEntry 6 }

eoMgmtDNSName OBJECT-TYPE

SYNTAX OCTET STRING  
MAX-ACCESS read-only  
STATUS current

DESCRIPTION

"This object specifies a DNS name of the eoMgmtAddress.  
This object can be used as an alternate key to help link

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the Energy Object with other keyed information that may  
be stored within the EnMS(s). A DNS Name must always be a  
fully qualified name. This MIB uses the same encoding as  
the DNS protocol."

REFERENCE

"RFC-1034 section 3.1."

::= { eoEntry 7 }

eoDomainName OBJECT-TYPE

SYNTAX                SnmpAdminString

MAX-ACCESS            read-write

STATUS                current

DESCRIPTION

"This object specifies the name of an Energy Management  
Domain for the Energy Object. By default, this object  
should be an empty string. The value of eoDomainName must  
remain constant at least from one re-initialization of  
the entity local management system to the next re-  
initialization."

::= { eoEntry 8 }

eoRoleDescription OBJECT-TYPE

SYNTAX                SnmpAdminString

MAX-ACCESS            read-write

STATUS                current

DESCRIPTION

"This object specifies an administratively assigned name  
to indicate the purpose an Energy Object serves in the  
network.

For example, we can have a phone deployed to a lobby with  
eoRoleDescription as 'Lobby phone'.

This object specifies that the value is the zero-length  
string value if no role description is configured.

The value of eoRoleDescription must remain constant at  
least from one re-initialization of the entity local  
management system to the next re-initialization. "

::= { eoEntry 9 }

eoKeywords OBJECT-TYPE

SYNTAX                EnergyObjectKeywordList

MAX-ACCESS            read-write

STATUS                current

DESCRIPTION

"This object specifies a list of keywords that can be  
used to group Energy Objects for reporting or searching.  
The value is the zero-length string if no keywords have



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    been configured. If multiple keywords are present, then  
    this string will contain all the keywords separated by  
    the ',' character. For example, if an Energy Object were  
    to be tagged with the keyword values 'hospitality' and  
    'guest', then the keyword list will be  
    'hospitality,guest'.

    If write access is implemented and a value is written  
    into the instance, the agent must retain the supplied  
    value in the eoKeywords instance associated with  
    the same physical entity for as long as that entity  
    remains instantiated. This includes instantiations  
    across all re-initializations/reboots of the local  
    management agent. "  
::= { eoEntry 10     }

eoImportance OBJECT-TYPE

    SYNTAX             Integer32 (1..100)

    MAX-ACCESS        read-write

    STATUS             current

    DESCRIPTION

        "This object specifies a ranking of how important the  
        Energy Object is (on a scale of 1 to 100) compared with  
        other Energy Objects in the same Energy Management  
        Domain. The ranking should provide a business or  
        operational context for the Energy Object as compared to  
        other similar Energy Objects. This ranking could be used  
        as input for policy-based network management.

Although network managers must establish their own  
ranking, the following is a broad recommendation:

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

The value of eoImportance must remain constant at least  
from one re-initialization of the Energy Object local  
management system to the next re-initialization. "

    DEFVAL             { 1 }

::= { eoEntry 11     }

eoPowerCategory OBJECT-TYPE

    SYNTAX             INTEGER {

```

        consumer(0),
        producer(1),
        meter(2),
        distributor(3),
        store(4)
    }
MAX-ACCESS      read-only
STATUS          current
DESCRIPTION

```

"This object describes the Energy Object category, which indicates the expected behavior or physical property of the Energy Object, based on its design. An Energy Object can be a consumer(0), producer(1), meter(2), distributor(3) or store(4).

In some cases, a meter is required to measure the power consumption. In such a case, this meter Energy Object category is meter(2). If a device is distributing electric Energy, the category of the Energy Object is distributor (3). If a device is storing electric Energy, the category of the device can be store (4). "

```
 ::= { eoEntry 12 }
```

eoAlternateKey OBJECT-TYPE

```

SYNTAX          SnmpAdminString
MAX-ACCESS      read-write
STATUS          current
DESCRIPTION

```

"The eoAlternateKey object specifies an alternate key string that can be used to identify the Energy Object. Since Energy Management Systems (EnMS) and Network Management Systems (NMS) may need to correlate objects across management systems, this alternate key is provided to provide such a link. This optional value is intended as a foreign key or alternate identifier for a manufacturer or EnMS/NMS to use to correlate the unique Energy Object Id in other systems or namespaces. If an alternate key is not available or is not applicable then the value is the zero-length string.

The value of eoAlternateKey must remain constant at least from one re-initialization of the entity local management system to the next re-initialization. "

```
 ::= { eoEntry 13 }
```

eoPowerInterfaceType OBJECT-TYPE

```

SYNTAX          INTEGER {
                    inlet(0),
                    outlet(1),

```

```
    }  
    MAX-ACCESS      read-only  
    STATUS          current  
    DESCRIPTION  
        "This object describes the Power Interface for an Energy  
        Object. A Power Interface is an interface at which a  
        Energy Object is connected to a power transmission  
        medium, at which it can in turn receive power, provide  
        power, or both. A Power Interface type can be an inlet(0)  
        or outlet(1) or both(2), respectively."  
    ::= { eoEntry 14 }
```

```
eoRelationTable OBJECT-TYPE  
    SYNTAX          SEQUENCE OF EoRelationEntry  
    MAX-ACCESS      not-accessible  
    STATUS          current  
    DESCRIPTION  
        "This table describes the relationships between Energy  
        Objects."  
    ::= { energyObjectContextMIBObjects 2 }
```

```
eoRelationEntry OBJECT-TYPE  
    SYNTAX          EoRelationEntry  
    MAX-ACCESS      not-accessible  
    STATUS          current  
    DESCRIPTION  
        "An entry in this table specifies the Energy relationship  
        between Energy objects. Energy relations between two  
        Energy objects are defined in the EMAN-FMWK."  
    REFERENCE  
        "EMAN-FMWK, Energy Management Framework, RFC abcs,  
        Jan 2014"  
    INDEX           { entPhysicalIndex, eoRelationIndex }  
    ::= { eoRelationTable 1 }
```

```
EoRelationEntry ::= SEQUENCE {  
    eoRelationIndex      Integer32,  
    eoRelationID         UUIDorZero,  
    eoRelationship       IANAEnergyRelationship,  
    eoRelationStatus     RowStatus  
}
```

```
eoRelationIndex OBJECT-TYPE  
    SYNTAX          Integer32 (0..2147483647)  
    MAX-ACCESS      not-accessible
```

STATUS current

DESCRIPTION

"This object is an arbitrary index to identify the Energy Object related to another Energy Object"  
::= { eoRelationEntry 1 }

eoRelationID OBJECT-TYPE

SYNTAX UUIDorZero

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"This object specifies the Universally Unique Identifier (UUID) of the peer (other) Energy Object. The UUID must comply the specifications of UUID in UUID-TC-MIB.

If UUID of the energy object is unknown or non-existent, the eoRelationID will be set to a zero-length string instead. It is preferable that the value of entPhysicalUUID from ENTITY-MIB is used for values for this object."

REFERENCE

"RFC 6933, Entity MIB - version 4, May 2013 "  
::= { eoRelationEntry 2 }

eoRelationship OBJECT-TYPE

SYNTAX IANAEnergyRelationship

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"This object describes the relations between Energy objects. For each Energy object, the relations between the other Energy objects are specified using the bitmap."  
::= { eoRelationEntry 3 }

eoRelationStatus OBJECT-TYPE

SYNTAX RowStatus

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The status controls and reflects the creation and activation status of a row in this table to specify energy relationship between Energy objects.

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An entry status may not be active(1) unless all objects in  
the entry have the appropriate values.  
No attempt to modify a row columnar object instance value  
in the eoRelationTable should be issued while the value of  
eoRelationStatus is active(1). The data can be destroyed by  
setting up the eoRelationStatus to destroy(2)."

::= { eoRelationEntry 4 }

-- Conformance

energyObjectContextMIBCompliances    OBJECT IDENTIFIER  
::= { energyObjectContextMIBConform 1    }

energyObjectContextMIBGroups    OBJECT IDENTIFIER  
::= { energyObjectContextMIBConform 2    }

energyObjectContextMIBFullCompliance MODULE-COMPLIANCE  
STATUS                    current  
DESCRIPTION  
    "When this MIB is implemented with support for  
    read-write, then such an implementation can  
    claim full compliance. Such devices can then  
    be both monitored and configured with this MIB.  
    Module Compliance of ENTITY-MIB with respect to  
    entity4CRCompliance MUST be supported."

MODULE                    -- this module  
MANDATORY-GROUPS {  
    energyObjectContextMIBTableGroup,  
    energyObjectRelationTableGroup  
}

GROUP            energyObjectOptionalMIBTableGroup  
DESCRIPTION  
    "A compliant implementation does not have to  
    implement. "  
::= { energyObjectContextMIBCompliances 1 }

energyObjectContextMIBReadOnlyCompliance MODULE-COMPLIANCE  
STATUS                    current  
DESCRIPTION  
    "When this MIB is implemented without support for  
    read-write (i.e. in read-only mode), then such an  
    implementation can claim read-only compliance.  
    Such a device can then be monitored but cannot be

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Configured with this MIB.  
Module Compliance of ENTITY-MIB with respect to  
entity4CRCompliance MUST be supported."

MODULE                -- this module

MANDATORY-GROUPS {  
    energyObjectContextMIBTableGroup,  
    energyObjectRelationTableGroup  
}

GROUP energyObjectOptionalMIBTableGroup  
DESCRIPTION  
    "A compliant implementation does not have to implement  
    the managed objects in this GROUP. "

::= { energyObjectContextMIBCompliances 2 }

-- Units of Conformance

energyObjectContextMIBTableGroup OBJECT-GROUP  
OBJECTS                {

    eoDomainName,  
    eoRoleDescription,  
    eoAlternateKey,  
    eoKeywords,  
    eoImportance,  
    eoPowerCategory,  
    eoPowerInterfaceType

}

STATUS                current

DESCRIPTION  
    "This group contains the collection of all the objects  
    related to the EnergyObject. "

::= { energyObjectContextMIBGroups 1 }

energyObjectOptionalMIBTableGroup OBJECT-GROUP  
OBJECTS                {

    eoEthPortIndex,  
    eoEthPortGrpIndex,  
    eoLldpPortNumber,  
    eoMgmtMacAddress,  
    eoMgmtAddressType,  
    eoMgmtAddress,  
    eoMgmtDNSName

}

STATUS                current

DESCRIPTION

```
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    "This group contains the collection of all the objects
    related to the Energy Object."
    ::= { energyObjectContextMIBGroups 2 }
```

```
energyObjectRelationTableGroup OBJECT-GROUP
    OBJECTS
```

```
        eoRelationID,
        eoRelationship,
        eoRelationStatus
    }
```

```
    STATUS          current
DESCRIPTION
```

```
    "This group contains the collection of all objects
    specifying the relationship between Energy Objects."
    ::= { energyObjectContextMIBGroups 3 }
```

```
END
```

```
IANA-ENERGY-RELATION-MIB DEFINITIONS ::= BEGIN
    IMPORTS
```

```
        MODULE-IDENTITY, mib-2
        FROM SNMPv2-SMI
        TEXTUAL-CONVENTION
        FROM SNMPv2-TC;
```

```
ianaEnergyRelationMIB MODULE-IDENTITY
```

```
    LAST-UPDATED "201402100000Z" -- February 10, 2014
    ORGANIZATION "IANA"
    CONTACT-INFO "
```

```
        Internet Assigned Numbers Authority
        Postal: ICANN
        4676 Admiralty Way, Suite 330
        Marina del Rey, CA 90292
        Tel: +1-310-823-9358
        EMail: iana@iana.org"
```

```
DESCRIPTION
```

```
    "This MIB module defines a TEXTUAL-CONVENTION that
    describes the relationships between Energy Objects.
```

```
    Copyright (C) The IETF Trust (2013).
```

```
    The initial version of this MIB module was published in
    RFC YYY; for full legal notices see the RFC itself.
```

REVISION "201402100000Z" -- February 10, 2014  
DESCRIPTION "Initial version of this MIB as published in  
RFC YYY."  
::= { mib-2 XXX2 }

-- RFC Editor, please replace XXX2 with the IANA allocation  
-- for this MIB module and YYY with the number of the  
-- approved RFC

-- Textual Conventions

IANAEnergyRelationship ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"An enumerated value specifying the type of  
relationship between an Energy Object A, on  
which the relationship is specified, with the  
Energy Object B, identified by the UUID.

The enumeration 'poweredBy' is applicable if the  
Energy Object A is poweredBy Energy Object B.

The enumeration 'powering' is applicable if the  
Energy Object A is powering Energy Object B.

The enumeration 'meteredBy' is applicable if the  
Energy Object A is meteredBy Energy Object B.

The enumeration 'metering' is applicable if the  
Energy Object A is metering Energy Object B.

The enumeration 'aggregatedBy' is applicable if the  
Energy Object A is aggregatedBy Energy Object B.

The enumeration 'aggregating' is applicable if the  
Energy Object A is aggregating Energy Object B."

SYNTAX INTEGER {  
poweredBy(1), -- power relationship  
powering(2),  
meteredBy(3), -- meter relationship  
metering(4),  
aggregatedBy(5), -- aggregation relationship



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                         aggregating(6)  
                         }

END

## 6. Implementation Status

[Note to RFC Editor: Please remove this section and the reference to [RFC6982] before publication.]

This section records the status of known implementations of the EMAN-Monitoring MIB at the time of posting of this Internet-Draft, and is based on a proposal described in [RFC6982].

The description of implementations in this section is intended to assist the IETF in its decision processes in progressing drafts to RFCs.

### 11.1 SNMP Research

Organization:        SNMP Research, Inc.

Maturity:        Prototype based upon early drafts of the MIBs.  
                  We anticipate updating it to more recent documents as development schedules allow.

Coverage:        Code was generated to implement all MIB objects in ENTITY-MIB (Version 4), ENERGY-OBJECT-CONTEXT-MIB, ENERGY-OBJECT-MIB, POWER-CHARACTERISTICS-MIB, and BATTERY-MIB.

Implementation experience: The documents are implementable.

Comments:        Technical comments about the ENERGY-OBJECT-CONTEXT-MIB, ENERGY-OBJECT-MIB, and BATTERY-MIB were submitted to the EMAN Working Group E-mail list.

Licensing:        Proprietary, royalty licensing

Contact:        Alan Luchuk, luchuk at snmp.com

URL:            <http://www.snmp.com/>

Priyanka Rao mentioned on the mailing list  
(<http://www.ietf.org/mail-archive/web/eman/current/msg02063.html>)  
that she has a python implementation.

## 7. Security Considerations

Some of the readable objects in these 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 thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP.

There are a number of management objects defined in these MIB modules with a MAX-ACCESS clause of read-write and/or read-create. Such objects MAY be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. The following are the tables and objects and their sensitivity/vulnerability:

- . Unauthorized changes to the eoDomainName, entPhysicalName, eoRoleDescription, eoKeywords, and/or eoImportance MAY disrupt power and energy collection, and therefore any predefined policies defined in the network.

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

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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.

## 8. IANA Considerations

The MIB modules in this document use the following IANA-assigned OBJECT IDENTIFIER values recorded in the SMI Numbers registry:

Descriptor	OBJECT IDENTIFIER value
-----	-----
energyAwareMIB	{ mib-2 XXX1 }

Editor's Note (to be removed prior to publication): IANA is requested to assign a value for "XXX1" under the 'mib-2' subtree and to record the assignment in the SMI Numbers registry. When the assignment has been made, the RFC Editor is asked to replace "XXX1" (here and in the MIB module) with the assigned value and to remove this note.

This document defines the first version of the IANA-maintained IANA-ENERGY-RELATION-MIB module, which allows new definitions of relationships between Energy Objects.

A Specification Required as defined in RFC 5226 [RFC5226], is REQUIRED for each modification of the energy relationships.

The MIB module in this document uses the following IANA-assigned OBJECT IDENTIFIER values recorded in the SMI Numbers registry.

Descriptor	OBJECT IDENTIFIER value
-----	-----
ianaEnergyRelationMIB	{ mib-2 XXX2 }

Editor's Note (to be removed prior to publication): IANA is requested to assign a value for "XXX2" under the 'mib-2' subtree and to record the assignment in the SMI Numbers registry. When the assignment has been made, the RFC Editor is asked to replace "XXX2" (here and in the MIB module) with the assigned value and to remove this note.

## 9. Acknowledgement

We would like to thank Juergen Quittek and Juergen Schoenwalder for their suggestions on the new design of eoRelationTable which was a proposed solution for the open issue on the representation of Energy Object as a UUIDlist.

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Power and Energy Monitoring MIB  
draft-ietf-eman-energy-monitoring-mib-09

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## Abstract

This document defines a subset of the Management Information Base (MIB) for power and energy monitoring of devices.

## Conventions used in this document

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

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## 1. Introduction

This document defines a subset of the Management Information Base (MIB) for use in energy management of devices within or connected to communication networks. The MIB modules in this document are designed to provide a model for energy management, which includes monitoring for Power State and energy consumption of networked elements. This MIB takes into account the Energy Management Framework [EMAN-FMWK], which, in turn, is based on the Requirements for Energy Management [RFC6988].

Energy management can be applied to devices in communication networks. Target devices for this specification include (but are not limited to): routers, switches, Power over Ethernet (PoE) endpoints, protocol gateways for building management systems, intelligent meters, home energy gateways, hosts and servers, sensor proxies, etc. Target devices and the use cases for Energy Management are discussed in Energy Management Applicability Statement [EMAN-AS].

Where applicable, device monitoring extends to the individual components of the device and to any attached dependent devices. For example: A device can contain components that are independent from a power-state point of view, such as line cards, processor cards, hard drives. A device can also have dependent attached devices, such as a switch with PoE endpoints or a power distribution unit with attached endpoints.

## 2. The Internet-Standard Management Framework

For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to section 7 of RFC 3410 [RFC3410].

Managed objects are accessed via a virtual information store, termed the Management Information Base or MIB. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP). Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This memo specifies MIB modules that are compliant to SMIv2, which is described in STD 58, RFC 2578 [RFC2578], STD 58, RFC 2579 [RFC2579] and STD 58, RFC 2580 [RFC2580].

## 3. Use Cases

Requirements for power and energy monitoring for networking devices are specified in [RFC6988]. The requirements in [RFC6988] cover devices typically found in communications networks, such as switches, routers, and various connected endpoints. For a power monitoring architecture to be useful, it should also apply to facility meters, power distribution units, gateway proxies for commercial building control, home automation devices, and devices that interface with the utility and/or smart grid. Accordingly, the scope of the MIB modules in this document are broader than that specified in [RFC6988]. Several use cases for Energy Management have been identified in the "Energy Management (EMAN) Applicability Statement" [EMAN-AS].

## 4. Terminology

Please refer to [EMAN-FMWK] for the definitions of the following terminology used in this draft.

- Energy Management
- Energy Management System (EnMS)
- Energy Monitoring
- Energy Control
- electrical equipment
  
- non-electrical equipment (mechanical equipment)
- device
- component
- power inlet

- power outlet
- energy
- power
- demand
- provide energy
- receive energy
- meter (energy meter)
- battery
- Power Interface
- Nameplate Power
- Power Attributes
- Power Quality
- Power State
- Power State Set

## 5. Architecture Concepts Applied to the MIB Modules

This section describes the concepts specified in the Energy Management Framework [EMAN-FMWK] that pertain to power usage, with specific information related to the MIB module specified in this document. This subsection maps concepts developed in the Energy Management Framework [EMAN-FMWK].

The Energy Monitoring MIB has 2 independent MIB modules, ENERGY-OBJECT-MIB and POWER-ATTRIBUTES-MIB. The first, ENERGY-OBJECT-MIB, is focused on measurement of power and energy. The second, POWER-ATTRIBUTES-MIB, is focused on power quality measurements for Energy Objects.

Devices and their sub-components can be modeled using the containment tree of the ENTITY-MIB [RFC6933].

### 5.1. Energy Object Tables

#### 5.1.1. ENERGY-OBJECT-MIB

The ENERGY-OBJECT-MIB module consists of five tables.

The first table is the eoMeterCapabilitiesTable. It indicates the instrumentation available for each Energy Object. Entries in this table indicate which other tables from the ENERGY-OBJECT-MIB and POWER-ATTRIBUTES-MIB are available for each Energy Object. The eoMeterCapabilitiesTable is indexed by entPhysicalIndex [RFC6933].

The second table is the eoPowerTable. It reports the power consumption of each Energy Object, as well as the units, sign, measurement accuracy, and related objects. The eoPowerTable is indexed by entPhysicalIndex.

The third table is the eoPowerStateTable. For each Energy Object, it reports information and statistics about the supported Power States. The eoPowerStateTable is indexed by entPhysicalIndex and eoPowerStateIndex.

The fourth table is the `eoEnergyParametersTable`. The entries in this table configure the parameters of energy and demand measurement collection. This table is indexed by `eoEnergyParametersIndex`.

The fifth table is the `eoEnergyTable`. The entries in this table provide a log of the energy and demand information. This table is indexed by `eoEnergyParametersIndex`.

A "smidump-style" tree presentation of the MIB modules contained in the draft is presented. The meaning of the three symbols in is a compressed representation of the object's MAX-ACCESS clause which may have the following values:

```
"not-accessible"->"---"  
"accessible-for-notify"->"---n"  
"read-only"->"r-n"  
"read-write"->"rwn"
```

```

eoMeterCapabilitiesTable(1)
|
+---eoMeterCapabilitiesEntry(1)[entPhysicalIndex]
|
|   +---r-n   BITS                               eoMeterCapability
|
|
eoPowerTable(2)
|
+---eoPowerEntry(1) [entPhysicalIndex]
|
|   +---r-n Integer32                               eoPower(1)
|   +--- r-n Integer32                               eoPowerNamePlate(2)
|   +--- r-n UnitMultiplier                           eoPowerUnitMultiplier(3)
|   +--- r-n Integer32                               eoPowerAccuracy(4)
|   +--- r-n INTEGER                                 eoPowerMeasurementCaliber(5)
|   +--- r-n INTEGER                                 eoPowerCurrentType(6)
|   +--- r-n TruthValue                             eoPowerMeasurementLocal(7)
|   +--- rwn IANAPowerStateSet                       eoPowerAdminState(8)
|   +--- r-n IANAPowerStateSet                       eoPowerOperState(9)
|   +--- r-n OwnerString                             eoPowerStateEnterReason(10)
|
+---eoPowerStateTable(3)

```

```

    +---eoPowerStateEntry(1)
    |       [entPhysicalIndex, eoPowerStateIndex]
    |
    +--- --n IANAPowerStateSet eoPowerStateIndex(1)
    +--- r-n Integer32          eoPowerStateMaxPower(2)
    +--- r-n UnitMultiplier
    |       eoPowerStatePowerUnitMultiplier(3)
    +--- r-n TimeTicks          eoPowerStateTotalTime(4)
    +--- r-n Counter32          eoPowerStateEnterCount(5)
+eoEnergyParametersTable(4)
+----eoEnergyParametersEntry(1) [eoEnergyParametersIndex]
    +--- --n PhysicalIndex      eoEnergyObjectIndex(1)
    +   r-n Integer32           eoEnergyParametersIndex(2)
    +--- r-n TimeInterval      eoEnergyParametersIntervalLength(3)
    +--- r-n Integer32          eoEnergyParametersIntervalNumber(4)
    +--- r-n INTEGER            eoEnergyParametersIntervalMode(5)
    +--- r-n TimeInterval      eoEnergyParametersIntervalWindow(6)
    +--- r-n Integer32          eoEnergyParametersSampleRate(7)
    +--- r-n RowStatus          eoEnergyParametersStatus(8)
+eoEnergyTable(5)
+----eoEnergyEntry(1)
    |       [eoEnergyParametersIndex, eoEnergyCollectionStartTime]
    |
    +--- r-n TimeTicks          eoEnergyCollectionStartTime(1)
    +--- r-n Integer32          eoEnergyConsumed(2)
    +--- r-n Integer32          eoEnergyProvided(3)
    +--- r-n Integer32          eoEnergyStored(4)
    +--- r-n UnitMultiplier    eoEnergyUnitMultiplier(5)
    +--- r-n Integer32          eoEnergyAccuracy(6)
    +--- r-n Integer32          eoEnergyMaxConsumed(7)
    +--- r-n Integer32          eoEnergyMaxProduced(8)
    +--- r-n TimeTicks          eoEnergyDiscontinuityTime(9)

```

### 5.1.2. POWER-ATTRIBUTES-MIB

The POWER-ATTRIBUTES-MIB module consists of three tables.

The first table is the eoACPwrAttributesTable. It indicates the power quality available for each Energy Object. The eoACPwrAttributesTable is indexed by entPhysicalIndex [RFC6933].

The second table is the eoACPwrAttributesDelPhaseTable. The entries in this table configure the parameters of energy and demand measurement collection. This table is indexed by eoEnergyParametersIndex.

The third table is the eoACPwrAttributesWyePhaseTable. For each Energy Object, it reports information and statistics about the supported Power States. The eoPowerStateTable is indexed by entPhysicalIndex and eoPowerStateIndex.

```

eoACPwrAttributesTable(1)
|
+---eoACPwrAttributesEntry(1) [ entPhysicalIndex]
|
|   +---r-n INTEGER      eoACPwrAttributesConfiguration(1)
|   +--- r-n Integer32   eoACPwrAttributesAvgVoltage(2)
|   +--- r-n Integer32   eoACPwrAttributesAvgCurrent(3)
|   +--- r-n Integer32   eoACPwrAttributesFrequency(4)
|   +--- r-n UnitMultiplier
|                       eoACPwrAttributesPowerUnitMultiplier(5)
|   +--- r-n Integer32   eoACPwrAttributesPowerAccuracy(6)
|   +--- r-n Integer32
|                       eoACPwrAttributesTotalActivePower(7)
|   +--- r-n Integer32
|                       eoACPwrAttributesTotalReactivePower(8)
|   +--- r-n Integer32
|                       eoACPwrAttributesTotalApparentPower(9)
|   +--- r-n Integer32
|                       eoACPwrAttributesTotalPowerFactor(10)
|   +--- r-n Integer32   eoACPwrAttributesThdCurrent(11)
|   +--- r-n Integer32   eoACPwrAttributesThdVoltage(12)
|
+eoACPwrAttributesDelPhaseTable(2)
+--- eoACPwrAttributesDelPhaseEntry(1)
|   [entPhysicalIndex, eoACPwrAttributesDelPhaseIndex]
|
|   +--- r-n Integer32
|   |   eoACPwrAttributesDelPhaseIndex(1)
|   +--- r-n Integer32
|   |   eoACPwrAttributesDelPhaseToNextPhaseVoltage(2)
|   +--- r-n Integer32
|   |   eoACPwrAttributesDelThdPhaseToNextPhaseVoltage(3)
|
+eoACPwrAttributesWyePhaseTable(3)
+--- eoACPwrAttributesWyePhaseEntry(1)
|   [entPhysicalIndex, eoACPwrAttributesWyePhaseIndex]
|
|   +--- r-n Integer32
|   |   eoACPwrAttributesWyePhaseIndex(1)
|   +--- r-n Integer32
|   |   eoACPwrAttributesWyePhaseToNeutralVoltage(2)
|   +--- r-n Integer32
|   |   eoACPwrAttributesWyeCurrent(3)
|   +--- r-n Integer32

```

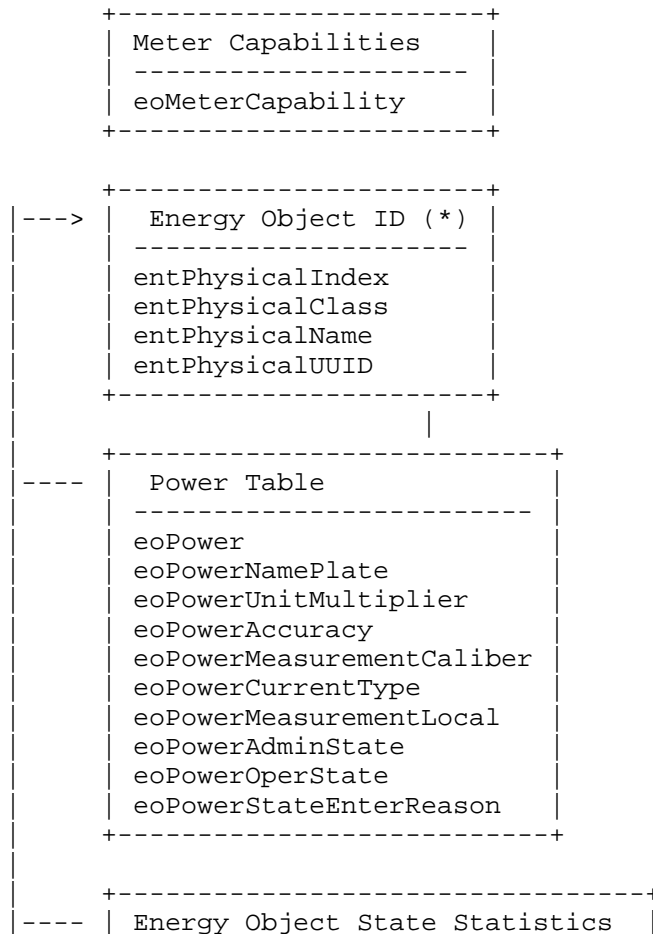
```

|      |      eoACPwrAttributesWyeActivePower(4)
|      +--- r-n Integer32
|      |      eoACPwrAttributesWyeReactivePower(5)
|      +--- r-n Integer32
|      |      eoACPwrAttributesWyeApparentPower(6)
|      +--- r-n Integer32
|      |      eoACPwrAttributesWyePowerFactor(7)
|      +--- r-n Integer32
|      |      eoACPwrAttributesWyeThdCurrent(9)
|      +--- r-n Integer32
|      |      eoACPwrAttributesWyeThdPhaseToNeutralVoltage(10)

```

### 5.1.3. UML Diagram

A UML diagram representation of the MIB objects in the two MIB modules ENERGY-OBJECT-MIB and POWER-ATTRIBUTES-MIB is presented.





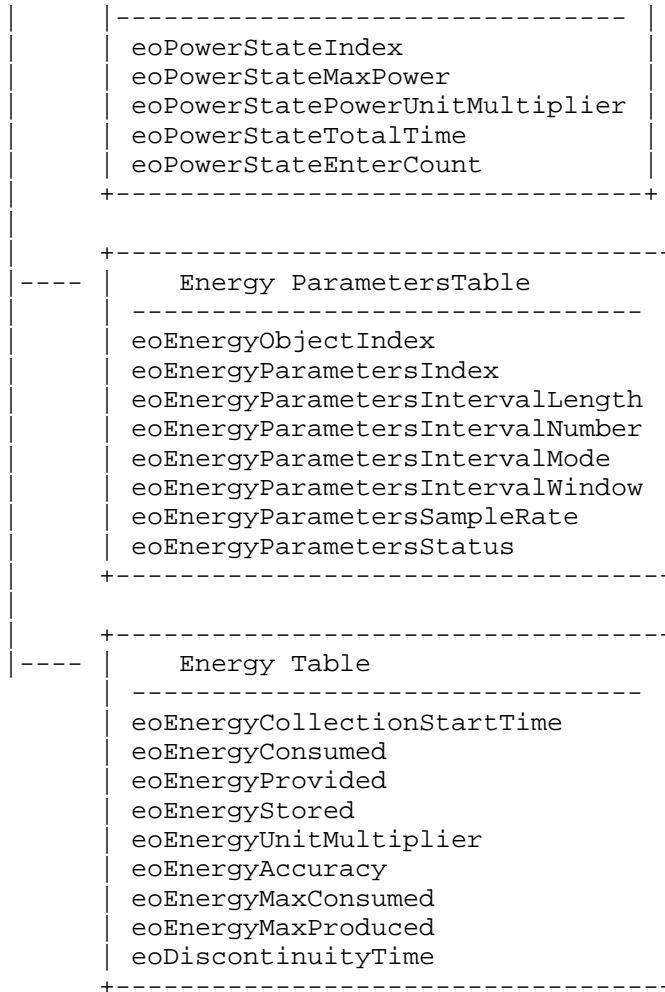
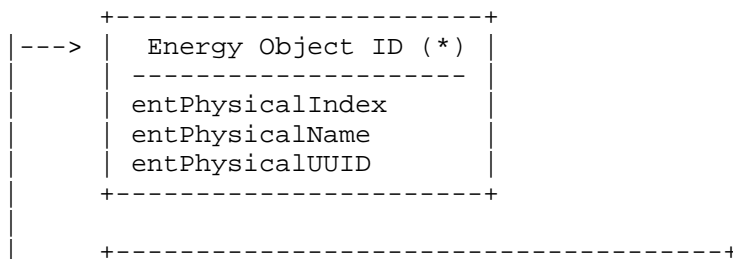


Figure 1:UML diagram for energyObjectMib

(\*) Compliance with the ENERGY-OBJECT-CONTEXT-MIB



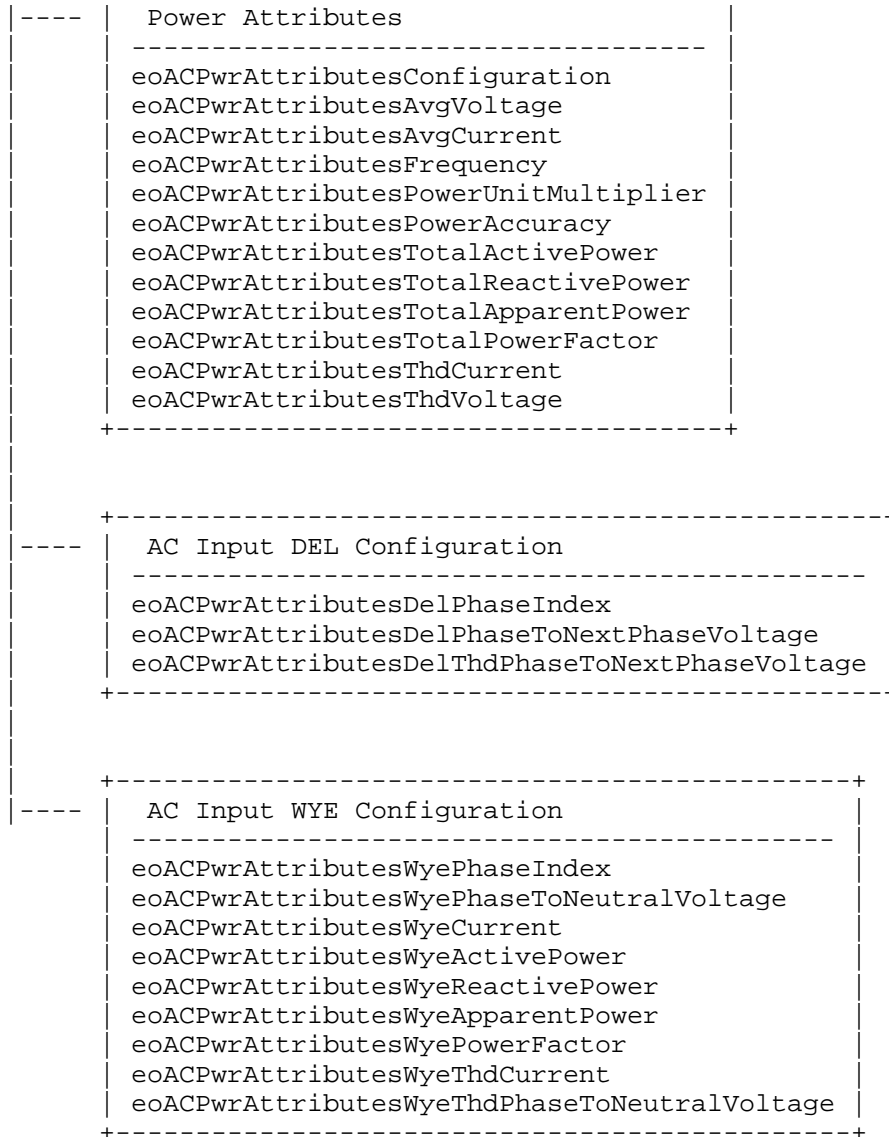


Figure 2: UML diagram for the POWER-ATTRIBUTES-MIB

(\*) Compliance with the ENERGY-OBJECT-CONTEXT-MIB

## 5.2. Energy Object Identity

The Energy Object identity information is specified in the ENERGY-OBJECT-CONTEXT-MIB module [EMAN-AWARE-MIB] primary table, i.e., the eoTable. In this table, Energy Object context such as

domain, role description, and importance are specified. In addition, the ENERGY-OBJECT-CONTEXT-MIB module specifies the relationship between Energy Objects. There are several possible relationships between Energy Objects, such as meteredBy, metering, poweredBy, powering, aggregatedBy, and aggregating as defined in the IANA-ENERGY-RELATION-MIB module [EMAN-AWARE-MIB].

### 5.3. Power State

An Energy Object may have energy conservation modes called Power States. Between the ON and OFF states of a device, there can be several intermediate energy saving modes. Those energy saving modes are called Power States.

Power States, which represent universal states of power management of an Energy Object, are specified by the eoPowerState MIB object. The actual Power State is specified by the eoPowerOperState MIB object, while the eoPowerAdminState MIB object specifies the Power State requested for the Energy Object. The difference between the values of eoPowerOperState and eoPowerAdminState indicate that the Energy Object is busy transitioning from eoPowerAdminState into the eoPowerOperState, at which point it will update the content of eoPowerOperState. In addition, the possible reason for change in Power State is reported in eoPowerStateEnterReason. Regarding eoPowerStateEnterReason, management stations and Energy Objects should support any format of the owner string dictated by the local policy of the organization. It is suggested that this name contain at least the reason for the transition change, and one or more of the following: IP address, management station name, network manager's name, location, or phone number.

The MIB objects eoPowerOperState, eoPowerAdminState, and eoPowerStateEnterReason are contained in the eoPowerTable MIB table.

The eoPowerStateTable table enumerates the maximum power usage in watts for every single supported Power State of each Power State Set supported by the Energy Object. In addition, PowerStateTable provides additional statistics such as eoPowerStateEnterCount, i.e., the number of times an entity has visited a particular Power State, and eoPowerStateTotalTime, i.e., the total time spent in a particular Power State of an Energy Object.

#### 5.3.1. Power State Set

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

There are currently three Power State Sets defined:

IEEE1621(256)	- [IEEE1621]
DMTF(512)	- [DMTF]
EMAN(768)	- [EMAN-FMWK]

The Power State Sets are listed in [EMAN-FMWK] along with each Power State within the Power Set.

#### 5.4. Energy Object Usage Information

For an Energy Object, power usage is reported using eoPower. The magnitude of measurement is based on the eoPowerUnitMultiplier MIB variable, based on the UnitMultiplier Textual Convention (TC). Power measurement magnitude should conform to the IEC 62053-21 [IEC.62053-21] and IEC 62053-22 [IEC.62053-22] definition of unit multiplier for the SI (System International) units of measure. Measured values are represented in SI units obtained by BaseValue \* 10 raised to the power of the unit multiplier.

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 eoPowerUnitMultiplier. Note that other measurements throughout the two MIB modules in this document use the same mechanism, including eoPowerStatePowerUnitMultiplier, eoEnergyUnitMultiplier, and eoACPwrAttributesPowerUnitMultiplier.

In addition to knowing the usage and magnitude, it is useful to know how an eoPower measurement was obtained. An NMS can use this to account for the accuracy and nature of the reading between different implementations. For this eoPowerMeasurementLocal describes whether the measurements were made at the device itself or from a remote source. The eoPowerMeasurementCaliber describes the method that was used to measure the power and can distinguish actual or estimated values. There may be devices in the network, which may not be able to measure or report power consumption. For those devices, the object eoPowerMeasurementCaliber shall report that the measurement mechanism is "unavailable" and the eoPower measurement shall be "0".

The nameplate power rating of an Energy Object is specified in eoPowerNameplate MIB object.

#### 5.5. Optional Power Usage Attributes

The optional POWER-ATTRIBUTES-MIB module can be implemented to further describe power usage attributes measurement. The POWER-ATTRIBUTES-MIB module is aligned with IEC 61850 7-2 standard to describe AC measurements.

The POWER-ATTRIBUTES-MIB module contains a primary table, eoACPwrAttributesTable, that defines power attributes measurements for supported entPhysicalIndex entities, as a sparse extension of the eoPowerTable (with entPhysicalIndex as primary index). This eoACPwrAttributesTable table contains such information as the configuration (single phase, DEL 3 phases, WYE 3 phases), voltage, frequency, power accuracy, total active/reactive power/apparent power, amperage, and voltage.

In case of 3-phase power, an additional table is populated with Power Attributes measurements per phase (hence, double indexed by the entPhysicalIndex and a phase index). This table, describes attributes specific to either WYE or DEL configurations.

In a DEL configuration, the eoACPwrAttributesDelPhaseTable describes the phase-to-phase power attributes measurements, i.e., voltage. In a DEL configuration, the current is equal in all three phases.

In a WYE configuration, the eoACPwrAttributesWyePhaseTable describes the phase-to-neutral power attributes measurements, i.e., voltage, current, active/reactive/apparent power, and power factor.

#### 5.6. Optional Energy Measurement

It is only relevant to measure energy and demand when there are actual power measurements obtained from measurement hardware. If the eoPowerMeasurementCaliber MIB object has values of unavailable, unknown, estimated, or presumed, then the energy and demand values are not useful.

Two tables are introduced to characterize energy measurement of an Energy Object: eoEnergyTable and eoEnergyParametersTable. Both energy and demand information can be represented via the eoEnergyTable. Energy information will be an accumulation with no interval. Demand information can be represented.

The eoEnergyParametersTable consists of the parameters defining

eoEnergyParametersIndex - an index of that specifies the setting for collection of energy measurements for an Energy Object, eoEnergyObjectIndex - linked to the entPhysicalIndex of the Energy Object, the duration of measurement intervals in seconds, (eoEnergyParametersIntervalLength), the number of successive intervals to be stored in the eoEnergyTable, (eoEnergyParametersIntervalNumber), the type of measurement technique (eoEnergyParametersIntervalMode), and a sample rate used to calculate the average (eoEnergyParametersSampleRate). Judicious choice of the sampling rate will ensure accurate measurement of energy while not imposing an excessive polling burden.

There are three eoEnergyParametersIntervalMode types used for energy measurement collection: period, sliding, and total. The choices of the three different modes of collection are based on IEC standard 61850-7-4. Note that multiple eoEnergyParametersIntervalMode types MAY be configured simultaneously. It is important to note that for a given Energy Object, multiple modes (periodic, total, sliding window) of energy measurement collection can be configured with the use of eoEnergyParametersIndex. However, simultaneous measurement in multiple modes for a given Energy Object depends on the Energy Object capability.

These three eoEnergyParametersIntervalMode types are illustrated by the following three figures, for which:

- The horizontal axis represents the current time, with the symbol <--- L ---> expressing the eoEnergyParametersIntervalLength, and the eoEnergyCollectionStartTime is represented by S1, S2, S3, S4, ..., Sx where x is the value of eoEnergyParametersIntervalNumber.

- The vertical axis represents the time interval of sampling and the value of eoEnergyConsumed can be obtained at the end of the sampling period. The symbol ===== denotes the duration of the sampling period.

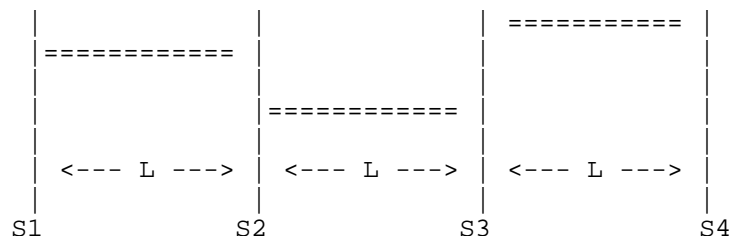


Figure 3 : Period eoEnergyParametersIntervalMode

A eoEnergyParametersIntervalMode type of 'period' specifies non-overlapping periodic measurements. Therefore, the next eoEnergyCollectionStartTime is equal to the previous eoEnergyCollectionStartTime plus eoEnergyParametersIntervalLength.  $S2=S1+L$ ;  $S3=S2+L$ , ...

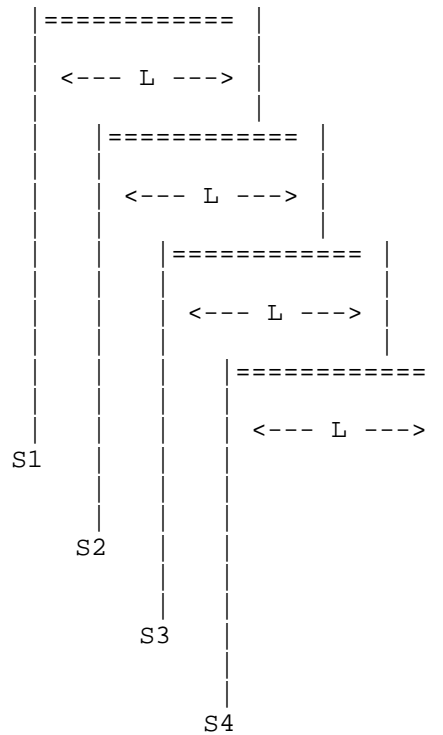


Figure 4 : Sliding eoEnergyParametersIntervalMode

A eoEnergyParametersIntervalMode type of 'sliding' specifies overlapping periodic measurements.

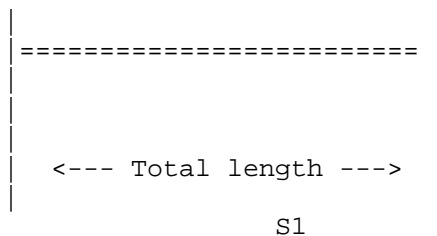


Figure 5 : Total eoEnergyParametersIntervalMode

A eoEnergyParametersIntervalMode type of 'total' specifies a continuous measurement since the last reset. The value of eoEnergyParametersIntervalNumber should be (1) one and eoEnergyParametersIntervalLength is ignored.

The eoEnergyParametersStatus is used to start and stop energy usage logging. The status of this variable is "active" when all the objects in eoEnergyParametersTable are appropriate which in turn indicates if eoEnergyTable entries exist or not.

The eoEnergyTable consists of energy measurements in eoEnergyConsumed, eoEnergyProvided and eoEnergyStored, the units of the measured energy eoEnergyUnitMultiplier, and the maximum observed energy within a window eoEnergyMaxConsumed, eoEnergyMaxProduced.

Measurements of the total energy consumed by an Energy Object may suffer from interruptions in the continuous measurement of energy consumption. In order to indicate such interruptions, the object eoEnergyDiscontinuityTime is provided for indicating the time of the last interruption of total energy measurement. eoEnergyDiscontinuityTime shall indicate the sysUpTime [RFC3418] when the device was reset.

The following example illustrates the eoEnergyTable and eoEnergyParametersTable:

First, in order to estimate energy, a time interval to sample energy should be specified, i.e., eoEnergyParametersIntervalLength can be set to "900 seconds" or 15 minutes and the number of consecutive intervals over which the maximum energy is calculated (eoEnergyParametersIntervalNumber) as "10". The sampling rate internal to the Energy Object for measurement of power usage (eoEnergyParametersSampleRate) can be "1000 milliseconds", as set by the Energy Object as a reasonable value. Then, the eoEnergyParametersStatus is set to active to indicate that the Energy Object should start monitoring the usage per the eoEnergyTable.

The indices for the eoEnergyTable are eoEnergyParametersIndex, which identifies the index for the setting of energy measurement collection Energy Object, and eoEnergyCollectionStartTime, which denotes the start time of the energy measurement interval based on sysUpTime [RFC3418]. The value of eoEnergyConsumed is the measured energy consumption over the time interval specified (eoEnergyParametersIntervalLength) based on the Energy Object



internal sampling rate (eoEnergyParametersSampleRate). While choosing the values for the eoEnergyParametersIntervalLength and eoEnergyParametersSampleRate, it is recommended to take into consideration either the network element resources adequate to process and store the sample values, and the mechanism used to calculate the eoEnergyConsumed. The units are derived from eoEnergyUnitMultiplier. For example, eoEnergyConsumed can be "100" with eoEnergyUnitMultiplier equal to 0, the measured energy consumption of the Energy Object is 100 watt-hours. The eoEnergyMaxConsumed is the maximum energy observed and that can be "150 watt-hours".

The eoEnergyTable has a buffer to retain a certain number of intervals, as defined by eoEnergyParametersIntervalNumber. If the default value of "10" is kept, then the eoEnergyTable contains 10 energy measurements, including the maximum.

Here is a brief explanation of how the maximum energy can be calculated. The first observed energy measurement value is taken to be the initial maximum. With each subsequent measurement, based on numerical comparison, maximum energy may be updated. The maximum value is retained as long as the measurements are taking place. Based on periodic polling of this table, an NMS could compute the maximum over a longer period, e.g., a month, 3 months, or a year.

#### 5.7. Fault Management

[RFC6988] specifies requirements about Power States such as "the current Power State" , "the time of the last state change", "the total time spent in each state", "the number of transitions to each state" etc. Some of these requirements are fulfilled explicitly by MIB objects such as eoPowerOperState, eoPowerStateTotalTime and eoPowerStateEnterCount. Some of the other requirements are met via the SNMP NOTIFICATION mechanism. eoPowerStateChange SNMP notification which is generated when the value of oPowerStateIndex, eoPowerOperState, or eoPowerAdminState have changed.

#### 6. Discovery

It is probable that most Energy Objects will require the implementation of the ENERGY-OBJECT-CONTEXT-MIB [EMAN-AWARE-MIB] as a prerequisite for this MIB module. In such a case, eoPowerTable of the EMAN-ENERGY-OBJECT-MIB is cross-referenced with the eoTable of ENERGY-OBJECT-CONTEXT-MIB via entPhysicalIndex. Every Energy Object MUST implement entPhysicalIndex, entPhysicalClass, entPhysicalName and

entPhysicalUUID from the ENTITY-MIB [RFC6933]. As the primary index for the Energy Object, entPhysicalIndex is used: It characterizes the Energy Object in the ENERGY-OBJECT-MIB and the POWER-ATTRIBUTES-MIB MIB modules (this document).

The NMS must first poll the ENERGY-OBJECT-CONTEXT-MIB MIB module [EMAN-AWARE-MIB], if available, in order to discover all the Energy Objects and the relationships between those Energy Objects. In the ENERGY-OBJECT-CONTEXT-MIB module tables, the Energy Objects are indexed by the entPhysicalIndex.

From there, the NMS must poll the eoPowerStateTable (specified in the ENERGY-OBJECT-MIB module in this document), which enumerates, amongst other things, the maximum power usage. As the entries in eoPowerStateTable table are indexed by the Energy Object ( entPhysicalIndex) and by the Power State Set (eoPowerStateIndex), the maximum power usage is discovered per Energy Object, and the power usage per Power State of the Power State Set. In other words, reading the eoPowerStateTable allows the discovery of each Power State within every Power State Set supported by the Energy Object.

If the Energy Object is an Aggregator, the MIB module would be populated with the Energy Object relationship information, which have its own Energy Object index value (entPhysicalIndex). However, the Energy Object relationship must be discovered via the ENERGY-OBJECT-CONTEXT-MIB module.

Finally, the NMS can monitor the power attributes with the POWER-ATTRIBUTES-MIB MIB module, which reuses the entPhysicalIndex to index the Energy Object.

## 7. Link with the other IETF MIBs

### 7.1. Link with the ENTITY-MIB and the ENTITY-SENSOR MIB

RFC 6933 [RFC6933] defines the ENTITY-MIB module that lists the physical entities of a networking device (router, switch, etc.) and those physical entities indexed by entPhysicalIndex. From an energy-management standpoint, the physical entities that consume or produce energy are of interest.

RFC 3433 [RFC3433] defines the ENTITY-SENSOR MIB module that provides a standardized way of obtaining information (current value of the sensor, operational status of the sensor, and the data units precision) from sensors embedded in networking devices. Sensors are associated with each index of entPhysicalIndex of the ENTITY-MIB [RFC6933]. While the focus

of the Power and Energy Monitoring MIB is on measurement of power usage of networking equipment indexed by the ENTITY-MIB, this MIB supports a customized power scale for power measurement and different Power States of networking equipment, and functionality to configure the Power States.

The Energy Objects are modeled by the entPhysicalIndex through the entPhysicalEntity MIB object specified in the eoTable in the ENERGY-OBJECT-CONTEXT-MIB MIB module [EMAN-AWARE-MIB].

The ENTITY-SENSOR MIB [RFC3433] does not have the ANSI C12.x accuracy classes required for electricity (e.g., 1%, 2%, 0.5% accuracy classes). Indeed, entPhySensorPrecision [RFC3433] represents "The number of decimal places of precision in fixed-point sensor values returned by the associated entPhySensorValue object". The ANSI and IEC Standards are used for power measurement and these standards require that we use an accuracy class, not the scientific-number precision model specified in RFC3433. The eoPowerAccuracy MIB object models this accuracy. Note that eoPowerUnitMultiplier represents the scale factor per IEC 62053-21 [IEC.62053-21] and IEC 62053-22 [IEC.62053-22], which is a more logical representation for power measurements (compared to entPhySensorScale), with the mantissa and the exponent values  $X * 10 ^ Y$ .

Power measurements specifying the qualifier 'UNITS' for each measured value in watts are used in the LLDP-EXT-MED-MIB, POE [RFC3621], and UPS [RFC1628] MIBs. The same 'UNITS' qualifier is used for the power measurement values.

One cannot assume that the ENTITY-MIB and ENTITY-SENSOR MIB are implemented for all Energy Objects that need to be monitored. A typical example is a converged building gateway, which can monitor other devices in a building and provides a proxy between SNMP and a protocol like BACNET. Another example is the home energy controller. In such cases, the eoPhysicalEntity value contains the zero value, using the PhysicalIndexOrZero textual convention.

The eoPower is similar to entPhySensorValue [RFC3433] and the eoPowerUnitMultiplier is similar to entPhySensorScale.

## 7.2. Link with the ENTITY-STATE MIB

For each entity in the ENTITY-MIB [RFC6933], the ENTITY-STATE MIB [RFC4268] specifies the operational states (entStateOper: unknown, enabled, disabled, testing), the alarm (entStateAlarm: unknown, underRepair, critical, major, minor, warning, indeterminate) and the possible values of standby states

(entStateStandby: unknown, hotStandby, coldStandby, providingService).

From a power monitoring point of view, in contrast to the entity operational states of entities, Power States are required, as proposed in the Power and Energy Monitoring MIB module. Those Power States can be mapped to the different operational states in the ENTITY-STATE MIB, if a formal mapping is required. For example, the entStateStandby "unknown", "hotStandby", "coldStandby", states could map to the Power State "unknown", "ready", "standby", respectively, while the entStateStandby "providingService" could map to any "low" to "high" Power State.

### 7.3. Link with the POWER-OVER-ETHERNET MIB

Power-over-Ethernet MIB [RFC3621] provides an energy monitoring and configuration framework for power over Ethernet devices. RFC 3621 defines a port group entity on a switch for power monitoring and management policy and does not use the entPhysicalIndex index. Indeed, pethMainPseConsumptionPower is indexed by the pethMainPseGroupIndex, which has no mapping with the entPhysicalIndex.

If the Power-over-Ethernet MIB [RFC3621] is supported, the Energy Object eoethPortIndex and eoethPortGrpIndex contain the pethPsePortIndex and pethPsePortGroupIndex, respectively. However, one cannot assume that the Power-over-Ethernet MIB is implemented for most or all Energy Objects. In such cases, the eoethPortIndex and eoethPortGrpIndex values contain the zero value, via the new PethPsePortIndexOrZero and textual PethPsePortGroupIndexOrZero conventions.

In either case, the entPhysicalIndex MIB object is used as the unique Energy Object index.

Note that, even though the Power-over-Ethernet MIB [RFC3621] was created after the ENTITY-SENSOR MIB [RFC3433], it does not reuse the precision notion from the ENTITY-SENSOR MIB, i.e., the entPhySensorPrecision MIB object.

### 7.4. Link with the UPS MIB

To protect against unexpected power disruption, data centers and buildings make use of Uninterruptible Power Supplies (UPS). To protect critical assets, a UPS can be restricted to a particular subset or domain of the network. UPS usage typically lasts only for a finite period of time, until normal power supply is restored. Planning is required to decide on the capacity of the

UPS based on output power and duration of probable power outage. To properly provision UPS power in a data center or building, it is important to first understand the total demand required to support all the entities in the site. This demand can be assessed and monitored via the Power and Energy Monitoring MIB.

UPS MIB [RFC1628] provides information on the state of the UPS network. Implementation of the UPS MIB is useful at the aggregate level of a data center or a building. The MIB module contains several groups of variables:

- upsIdent: Identifies the UPS entity (name, model, etc.).
- upsBattery group: Indicates the battery state (upsbatteryStatus, upsEstimatedMinutesRemaining, etc.)
- upsInput group: Characterizes the input load to the UPS (number of input lines, voltage, current, etc.).
- upsOutput: Characterizes the output from the UPS (number of output lines, voltage, current, etc.)
- upsAlarms: Indicates the various alarm events.

The measurement of power in the UPS MIB is in volts, amperes and watts. The units of power measurement are RMS volts and RMS Amperes. They are not based on the EntitySensorDataScale and EntitySensorDataPrecision of ENTITY-SENSOR-MIB.

Both the Power and Energy Monitoring MIB and the UPS MIB may be implemented on the same UPS SNMP agent, without conflict. In this case, the UPS device itself is the Energy Object and any of the UPS meters or submeters are the Energy Objects with a possible relationship as defined in [EMAN-FMWK].

#### 7.5. Link with the LLDP and LLDP-MED MIBs

The LLDP Protocol is a Data Link Layer protocol used by network devices to advertise their identities, capabilities, and interconnections on a LAN network.

The Media Endpoint Discovery is an enhancement of LLDP, known as LLDP-MED. The LLDP-MED enhancements specifically address voice applications. LLDP-MED covers 6 basic areas: capability discovery, LAN speed and duplex discovery, network policy discovery, location identification discovery, inventory discovery, and power discovery.

Of particular interest to the current MIB module is the power discovery, which allows the endpoint device (such as a PoE

phone) to convey power requirements to the switch. In power discovery, LLDP-MED has four Type Length Values (TLVs): power type, power source, power priority and power value. Respectively, those TLVs provide information related to the type of power (power sourcing entity versus powered device), how the device is powered (from the line, from a backup source, from external power source, etc.), the power priority (how important is it that this device has power?), and how much power the device needs.

The power priority specified in the LLDP-MED MIB [LLDP-MED-MIB] actually comes from the Power-over-Ethernet MIB [RFC3621]. If the Power-over-Ethernet MIB [RFC3621] is supported, the exact value from the pethPsePortPowerPriority [RFC3621] is copied over into the lldpXMedRemXPoEPDPowerPriority [LLDP-MED-MIB]; otherwise the value in lldpXMedRemXPoEPDPowerPriority is "unknown". From the Power and Energy Monitoring MIB, it is possible to identify the pethPsePortPowerPriority [RFC3621], via the eoethPortIndex and eoethPortGrpIndex.

The lldpXMedLocXPoEPDPowerSource [LLDP-MED-MIB] is similar to eoPowerMeasurementLocal in indicating if the power for an attached device is local or from a remote device. If the LLDP-MED MIB is supported, the following mapping can be applied to the eoPowerMeasurementLocal: lldpXMedLocXPoEPDPowerSource fromPSE(2) and local(3) can be mapped to false and true, respectively.

## 8. Structure of the MIB

The primary MIB object in this MIB module is the energyObjectMibObjects root. The eoPowerTable table of energyObjectMibObjects describes the power measurement attributes of an Energy Object entity. The identity of a device in terms of uniquely identification of the Energy Object and its relationship to other entities in the network are addressed in [EMAN-AWARE-MIB].

Logically, this MIB module is a sparse extension of the ENERGY-OBJECT-CONTEXT-MIB module [EMAN-AWARE-MIB]. Thus the following requirements which are applied to [EMAN-AWARE-MIB] are also applicable. As a requirement for this MIB module, [EMAN-AWARE-MIB] SHOULD be implemented and as Module Compliance of ENTITY-MIB V4 [RFC6933] with respect to entity4CRCompliance MUST be supported which requires 4 MIB objects: entPhysicalIndex, entPhysicalClass, entPhysicalName and entPhysicalUUID MUST be implemented.

eoMeterCapabilitiesTable is useful to enable applications to determine the capabilities supported by the local management agent. This table indicates the energy monitoring MIB groups that are supported by the local management system. By reading the value of this object, it is possible for applications to know which tables contain the information and are usable without walking through the table and querying every element which involves a trial-and-error process.

The power measurement of an Energy Object contains information describing its power usage (eoPower) and its current Power State (eoPowerOperState). In addition to power usage, additional information describing the units of measurement (eoPowerAccuracy, eoPowerUnitMultiplier), how power usage measurement was obtained (eoPowerMeasurementCaliber), the source of power measurement (eoPowerMeasurementLocal) and the type of power (eoPowerCurrentType) are described.

An Energy Object may contain an optional eoPowerAttributes table that describes the electrical characteristics associated with the current Power State and usage.

An Energy Object may contain an optional eoEnergyTable to describe energy measurement information over time.

An Energy Object may also contain optional battery information associated with this entity.

## 9. MIB Definitions

```
-- *****
--
--
-- This MIB is used to monitor power usage of network
-- devices
--
-- *****
```

```
ENERGY-OBJECT-MIB DEFINITIONS ::= BEGIN
```

```
IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE,
    NOTIFICATION-TYPE,
    mib-2,
    Integer32, Counter32, TimeTicks
    FROM SNMPv2-SMI
```

TEXTUAL-CONVENTION, RowStatus, TimeInterval,  
TimeStamp, TruthValue  
    FROM SNMPv2-TC  
MODULE-COMPLIANCE, NOTIFICATION-GROUP, OBJECT-GROUP  
    FROM SNMPv2-CONF  
OwnerString  
    FROM RMON-MIB  
entPhysicalIndex  
    FROM ENTITY-MIB  
IANAPowerStateSet  
FROM IANA-POWERSTATE-SET-MIB;

energyObjectMib MODULE-IDENTITY  
    LAST-UPDATED     "201402140000Z"     -- 14 Feb 2014  
  
    ORGANIZATION     "IETF EMAN Working Group"  
    CONTACT-INFO  
        "WG charter:  
        <http://datatracker.ietf.org/wg/eman/charter/>  
  
    Mailing Lists:  
        General Discussion: [eman@ietf.org](mailto:eman@ietf.org)  
  
        To Subscribe:  
        <https://www.ietf.org/mailman/listinfo/eman>  
  
        Archive:  
        <http://www.ietf.org/mail-archive/web/eman>  
  
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Belgium  
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Email: bclaise@cisco.com"

DESCRIPTION

"This MIB is used to monitor power and energy in devices.

The tables eoMeterCapabilitiesTable and eoPowerTable are a sparse extension of the eoTable from the ENERGY-OBJECT-CONTEXT-MIB. As a requirement [EMAN-AWARE-MIB] SHOULD be implemented.

Module Compliance of ENTITY-MIB v4 with respect to entity4CRCompliance MUST be supported which requires implementation of 4 MIB objects: entPhysicalIndex, entPhysicalClass, entPhysicalName and entPhysicalUUID."

REVISION

"201402140000Z"      -- 14 Feb 2014

DESCRIPTION

"Initial version, published as RFC XXXX."

::= { mib-2 xxx }

energyObjectMibNotifs OBJECT IDENTIFIER  
::= { energyObjectMib 0 }

energyObjectMibObjects OBJECT IDENTIFIER

```
::= { energyObjectMib 1 }
```

```
energyObjectMibConform OBJECT IDENTIFIER  
 ::= { energyObjectMib 2 }
```

-- Textual Conventions

```
IANAPowerStateSet ::= TEXTUAL-CONVENTION  
    STATUS current  
    DESCRIPTION
```

"IANAPowerState is a textual convention that describes Power State Sets and Power State Set Values an Energy Object supports. IANA has created a registry of Power State supported by an Energy Object and IANA shall administer the list of Power State Sets and Power States.

The textual convention assumes that Power States in a power state set are limited to 255 distinct values. For a Power State Set S, the named number with the value S \* 256 is allocated to indicate the Power State set. For a Power State X in the Power State S, the named number with the value S \* 256 + X + 1 is allocated to represent the Power State."

REFERENCE

"<http://www.iana.org/assignments/eman>

RFC EDITOR NOTE: please change the previous URL if this is not the correct one after IANA assigned it."

```
SYNTAX            INTEGER {  
                    other(0),            -- indicates other set  
                    unknown(255),       -- unknown  
  
                    ieee1621(256), -- indicates IEEE1621 set  
                    ieee1621On(257),  
                    ieee1621Off(258),  
                    ieee1621Sleep(259),  
  
                    dmtf(512),       -- indicates DMTF set  
                    dmtfOn(513),  
                    dmtfSleepLight(514),  
                    dmtfSleepDeep(515),  
                    dmtfOffHard(516),  
                    dmtfOffSoft(517),  
                    dmtfHibernate(518),  
                    dmtfPowerOffSoft(519),
```

```

    dmtfPowerOffHard(520),
    dmtfMasterBusReset(521),
    dmtfDiagnosticInterrupt(522),
    dmtfOffSoftGraceful(523),
    dmtfOffHardGraceful(524),
    dmtfMasterBusResetGraceful(525),
    dmtfPowerCycleOffSoftGraceful(526),
    dmtfPowerCycleHardGraceful(527),

    eman(1024),          -- indicates EMAN set
    emanmechoff(1025),
    emansoftoff(1026),
    emanhibernate(1027),
    emansleep(1028),
    emanstandby(1029),
    emanready(1030),
    emanlowMinus(1031),
    emanlow(1032),
    emanmediumMinus(1033),
    emanmedium(1034),
    emanhighMinus(1035),
    emanhigh(1036)
}

```

UnitMultiplier ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"The Unit Multiplier is an integer value that represents the IEEE 61850 Annex A units multiplier associated with the integer units used to measure the power or energy.

For example, when used with eoPowerUnitMultiplier, -3 represents 10<sup>-3</sup> or milliwatts."

REFERENCE

"The International System of Units (SI), National Institute of Standards and Technology, Spec. Publ. 330, August 1991."

SYNTAX INTEGER {  
 yocto(-24), -- 10<sup>-24</sup>  
 zepto(-21), -- 10<sup>-21</sup>  
 atto(-18), -- 10<sup>-18</sup>  
 femto(-15), -- 10<sup>-15</sup>  
 pico(-12), -- 10<sup>-12</sup>  
 nano(-9), -- 10<sup>-9</sup>  
 micro(-6), -- 10<sup>-6</sup>  
 milli(-3), -- 10<sup>-3</sup>  
 units(0), -- 10<sup>0</sup>  
 kilo(3), -- 10<sup>3</sup>  
 mega(6), -- 10<sup>6</sup>  
 giga(9), -- 10<sup>9</sup>

```

        tera(12),      -- 10^12
        peta(15),     -- 10^15
        exa(18),      -- 10^18
        zetta(21),    -- 10^21
        yotta(24)     -- 10^24
    }

-- Objects

eoMeterCapabilitiesTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF EoMeterCapabilitiesEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table is useful for helping applications determine the
        monitoring capabilities supported by the local management
        agents. It is possible for applications to know which tables
        are usable without going through a trial-and-error process."
        ::= { energyObjectMibObjects 1 }

eoMeterCapabilitiesEntry OBJECT-TYPE
    SYNTAX      EoMeterCapabilitiesEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An entry describes the metering capability of an Energy
        Object."
        INDEX    { entPhysicalIndex }
        ::= { eoMeterCapabilitiesTable 1 }

EoMeterCapabilitiesEntry ::= SEQUENCE {
    eoMeterCapability          BITS
}

eoMeterCapability OBJECT-TYPE
    SYNTAX      BITS {
        none(0),
        powermetering(1),      -- power measurement
        energymetering(2),     -- energy measurement
        powerattributes(3)    -- power attributes
    }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "An indication of the energy monitoring capabilities supported
        by this agent. This object use a BITS syntax and indicates the

```

MIB groups supported by the probe. By reading the value of this object, it is possible to determine the MIB tables supported. "  
 ::= { eoMeterCapabilitiesEntry 1 }

eoPowerTable OBJECT-TYPE

SYNTAX SEQUENCE OF EoPowerEntry  
 MAX-ACCESS not-accessible  
 STATUS current  
 DESCRIPTION  
 "This table lists Energy Objects."  
 ::= { energyObjectMibObjects 2 }

eoPowerEntry OBJECT-TYPE

SYNTAX EoPowerEntry  
 MAX-ACCESS not-accessible  
 STATUS current  
 DESCRIPTION  
 "An entry describes the power usage of an Energy Object."

INDEX { entPhysicalIndex }  
 ::= { eoPowerTable 1 }

EoPowerEntry ::= SEQUENCE {

eoPower	Integer32,
eoPowerNameplate	Integer32,
eoPowerUnitMultiplier	UnitMultiplier,
eoPowerAccuracy	Integer32,
eoPowerMeasurementCaliber	INTEGER,
eoPowerCurrentType	INTEGER,
eoPowerMeasurementLocal	TruthValue,
eoPowerAdminState	IANAPowerStateSet,
eoPowerOperState	IANAPowerStateSet,
eoPowerStateEnterReason	OwnerString

}

eoPower OBJECT-TYPE

SYNTAX Integer32  
 UNITS "watts"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION  
 "This object indicates the power measured for the Energy Object. For alternating current, this value is obtained as an average over fixed number of AC cycles. This value

is specified in SI units of watts with the magnitude of watts (milliwatts, kilowatts, etc.) indicated separately in eoPowerUnitMultiplier. The accuracy of the measurement is specified in eoPowerAccuracy. The direction of power flow is indicated by the sign on eoPower. If the Energy Object is consuming power, the eoPower value will be positive. If the Energy Object is producing power, the eoPower value will be negative.

The eoPower MUST be less than or equal to the maximum power that can be consumed at the power state specified by eoPowerState.

The eoPowerMeasurementCaliber object specifies how the usage value reported by eoPower was obtained. The eoPower value must report 0 if the eoPowerMeasurementCaliber is 'unavailable'. For devices that can not measure or report power, this option can be used."

```
 ::= { eoPowerEntry 1 }
```

#### eoPowerNameplate OBJECT-TYPE

```
SYNTAX      Integer32
UNITS       "watts"
MAX-ACCESS  read-only
STATUS      current
```

#### DESCRIPTION

"This object indicates the rated maximum consumption for the fully populated Energy Object. The nameplate power requirements are the maximum power numbers and, in almost all cases, are well above the expected operational consumption. Nameplate power is widely used for power provisioning. This value is specified in either units of watts or voltage and current. The units are therefore SI watts or equivalent Volt-Amperes with the magnitude (milliwatts, kilowatts, etc.) indicated separately in eoPowerUnitMultiplier."

```
 ::= { eoPowerEntry 2 }
```

#### eoPowerUnitMultiplier OBJECT-TYPE

```
SYNTAX      UnitMultiplier
MAX-ACCESS  read-only
STATUS      current
```

#### DESCRIPTION

"The magnitude of watts for the usage value in eoPower and eoPowerNameplate."

```
 ::= { eoPowerEntry 3 }
```

#### eoPowerAccuracy OBJECT-TYPE

```
SYNTAX      Integer32 (0..10000)
```



current utilization using some algorithm or heuristic. It is presumed that the entity's state and current configuration were used to compute the value.

- static(5): Indicates that the usage was not determined by physical measurement, algorithm or derivation. The usage was reported based upon external tables, specifications, and/or model information. For example, a PC Model X draws 200W, while a PC Model Y draws 210W."

```
::= { eoPowerEntry 5 }
```

eoPowerCurrentType OBJECT-TYPE

```
SYNTAX      INTEGER {
                    ac(1),
                    dc(2),
                    unknown(3)
                }
```

```
MAX-ACCESS  read-only
```

```
STATUS      current
```

DESCRIPTION

"This object indicates whether the eoPower for the Energy Object reports alternating current 'ac', direct current 'dc', or that the current type is unknown."

```
::= { eoPowerEntry 6 }
```

eoPowerMeasurementLocal OBJECT-TYPE

```
SYNTAX      TruthValue
```

```
MAX-ACCESS  read-only
```

```
STATUS      current
```

DESCRIPTION

"This object indicates the source of power measurement and can be useful when modeling the power usage of attached devices. The power measurement can be performed by the entity itself or the power measurement of the entity can be reported by another trusted entity using a protocol extension. A value of true indicates the measurement is performed by the entity, whereas false indicates that the measurement was performed by another entity."

```
::= { eoPowerEntry 7 }
```

eoPowerAdminState OBJECT-TYPE

```
SYNTAX      IANAPowerStateSet
```

```
MAX-ACCESS  read-write
```

```
STATUS      current
```

DESCRIPTION

"This object specifies the desired Power State and the Power State Set for the Energy Object. Note that other(0) is not a Power State Set and unknown(255) is



not a Power State as such, but simply an indication that the Power State of the Energy Object is unknown. Possible values of eoPowerAdminState within the Power State Set are registered at IANA. A current list of assignments can be found at <<http://www.iana.org/assignments/eman>> RFC-EDITOR: please check the location after IANA"

::= { eoPowerEntry 8 }

eoPowerOperState OBJECT-TYPE

SYNTAX                  IANAPowerStateSet  
MAX-ACCESS              read-only  
STATUS                  current

DESCRIPTION

"This object specifies the current operational Power State and the Power State Set for the Energy Object. other(0) is not a Power State Set and unknown(255) is not a Power State as such, but simply an indication that the Power State of the Energy Object is unknown.

Possible values of eoPowerOperState within the Power State Set are registered at IANA. A current list of assignments can be found at <<http://www.iana.org/assignments/eman>> RFC-EDITOR: please check the location after IANA"

::= { eoPowerEntry 9 }

eoPowerStateEnterReason OBJECT-TYPE

SYNTAX                  OwnerString  
MAX-ACCESS              read-write  
STATUS                  current

DESCRIPTION

"This string object describes the reason for the eoPowerAdminState transition. Alternatively, this string may contain with the entity that configured this Energy Object to this Power State."

DEFVAL { "" }

::= { eoPowerEntry 10 }

eoPowerStateTable OBJECT-TYPE

SYNTAX                  SEQUENCE OF EoPowerStateEntry  
MAX-ACCESS              not-accessible  
STATUS                  current

DESCRIPTION

"This table enumerates the maximum power usage, in watts, for every single supported Power State of each Energy Object.

This table has cross-reference with the eoPowerTable, containing rows describing each Power State for the corresponding Energy Object. For every Energy Object in the eoPowerTable, there is a corresponding entry in this table."

::= { energyObjectMibObjects 3 }

eoPowerStateEntry OBJECT-TYPE

SYNTAX EoPowerStateEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"A eoPowerStateEntry extends a corresponding eoPowerEntry. This entry displays max usage values at every single possible Power State supported by the Energy Object.

For example, given the values of a Energy Object corresponding to a maximum usage of 0 W at the state emanmechoff, 8 W at state 6 (ready), 11 W at state emanmediumMinus, and 11 W at state emanhigh:

State	MaxUsage	Units
emanmechoff	0	W
emansoftoff	0	W
emanhibernate	0	W
emansleep	0	W
emanstandby	0	W
emanready	8	W
emanlowMinus	8	W
emanlow	11	W
emanmediumMinus	11	W
emanmedium	11	W
emanhighMinus	11	W
emnanhigh	11	W

Furthermore, this table also includes the total time in each Power State, along with the number of times a particular Power State was entered."

INDEX { entPhysicalIndex,  
eoPowerStateIndex  
}

::= { eoPowerStateTable 1 }

EoPowerStateEntry ::= SEQUENCE {

eoPowerStateIndex	IANAPowerStateSet,
eoPowerStateMaxPower	INTEGER,
eoPowerStatePowerUnitMultiplier	UnitMultiplier,
eoPowerStateTotalTime	TimeTicks,
eoPowerStateEnterCount	Counter32

```

    }

    eoPowerStateIndex OBJECT-TYPE
        SYNTAX      IANAPowerStateSet
        MAX-ACCESS   not-accessible
        STATUS       current
        DESCRIPTION
            "
            This object specifies the index of the Power State of
            the Energy Object within a Power State Set. The
            semantics of the specific Power State can be obtained
            from the Power State Set definition."
        ::= { eoPowerStateEntry 1 }

    eoPowerStateMaxPower OBJECT-TYPE
        SYNTAX      Integer32
        UNITS        "watts"
        MAX-ACCESS   read-only
        STATUS       current
        DESCRIPTION
            "This object indicates the maximum power for the Energy
            Object at the particular Power State. This value is
            specified in SI units of watts with the magnitude of the
            units (milliwatts, kilowatts, etc.) indicated separately
            in eoPowerStatePowerUnitMultiplier. If the maximum power
            is not known for a certain Power State, then the value is
            encoded as 0xFFFFFFFF.

            For Power States not enumerated, the value of
            eoPowerStateMaxPower might be interpolated by using the
            next highest supported Power State."
        ::= { eoPowerStateEntry 2 }

    eoPowerStatePowerUnitMultiplier OBJECT-TYPE
        SYNTAX      UnitMultiplier
        MAX-ACCESS   read-only
        STATUS       current
        DESCRIPTION
            "The magnitude of watts for the usage value in
            eoPowerStateMaxPower."
        ::= { eoPowerStateEntry 3 }

    eoPowerStateTotalTime OBJECT-TYPE
        SYNTAX      TimeTicks
        MAX-ACCESS   read-only
        STATUS       current
        DESCRIPTION
            "This object indicates the total time in hundredths

```

of second that the Energy Object has been in this power state since the last reset, as specified in the sysUpTime."

::= { eoPowerStateEntry 4 }

eoPowerStateEnterCount OBJECT-TYPE

SYNTAX Counter32

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This object indicates how often the Energy Object has entered this power state, since the last reset of the device as specified in the sysUpTime."

::= { eoPowerStateEntry 5 }

eoEnergyParametersTable OBJECT-TYPE

SYNTAX SEQUENCE OF EoEnergyParametersEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"This table is used to configure the parameters for Energy measurement collection in the table eoEnergyTable. This table allows the configuration of different measurement settings on the same Energy Object. Implementation of this table only makes sense for Energy Objects that an eoPowerMeasurementCaliber of actual."

::= { energyObjectMibObjects 4 }

eoEnergyParametersEntry OBJECT-TYPE

SYNTAX EoEnergyParametersEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"An entry controls an energy measurement in eoEnergyTable."

INDEX { entPhysicalIndex, eoEnergyParametersIndex }

::= { eoEnergyParametersTable 1 }

EoEnergyParametersEntry ::= SEQUENCE {

eoEnergyParametersIndex	Integer32,
eoEnergyParametersIntervalLength	TimeInterval,
eoEnergyParametersIntervalNumber	Integer32,
eoEnergyParametersIntervalMode	INTEGER,
eoEnergyParametersIntervalWindow	TimeInterval,
eoEnergyParametersSampleRate	Integer32,
eoEnergyParametersStatus	RowStatus

}

```

eoEnergyParametersIndex OBJECT-TYPE
    SYNTAX          Integer32 (0..2147483647)
    MAX-ACCESS      not-accessible
    STATUS          current
    DESCRIPTION
        "This object specifies the index of the Energy
        Parameters setting for collection of energy measurements
        for an Energy Object. An Energy Object can have multiple
        eoEnergyParametersIndex, depending on the capabilities
        of the Energy Object"
    ::= { eoEnergyParametersEntry 2 }

```

```

eoEnergyParametersIntervalLength OBJECT-TYPE
    SYNTAX          TimeInterval
    MAX-ACCESS      read-create
    STATUS          current
    DESCRIPTION
        "This object indicates the length of time in hundredths
        of seconds over which to compute the average
        eoEnergyConsumed measurement in the eoEnergyTable table.
        The computation is based on the Energy Object's internal
        sampling rate of power consumed or produced by the Energy
        Object. The sampling rate is the rate at which the Energy
        Object can read the power usage and may differ based on
        device capabilities. The average energy consumption is
        then computed over the length of the interval. The
        default value of 15 minutes is a common interval used in
        industry."
    DEFVAL { 90000 }
    ::= { eoEnergyParametersEntry 3 }

```

```

eoEnergyParametersIntervalNumber OBJECT-TYPE
    SYNTAX          Integer32
    MAX-ACCESS      read-create
    STATUS          current
    DESCRIPTION
        "The number of intervals maintained in the eoEnergyTable.
        Each interval is characterized by a specific
        eoEnergyCollectionStartTime, used as an index to the
        table eoEnergyTable. Whenever the maximum number of
        entries is reached, the measurement over the new interval
        replaces the oldest measurement. There is one exception
        to this rule: when the eoEnergyMaxConsumed and/or
        eoEnergyMaxProduced are in (one of) the two oldest
        measurement(s), they are left untouched and the next
        oldest measurement is replaced."
    DEFVAL { 10 }
    ::= { eoEnergyParametersEntry 4 }

```

eoEnergyParametersIntervalMode OBJECT-TYPE

SYNTAX INTEGER {  
                     period(1),  
                     sliding(2),  
                     total(3)  
                     }

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"A control object to define the mode of interval calculation for the computation of the average eoEnergyConsumed or eoEnergyProvided measurement in the eoEnergyTable table.

A mode of period(1) specifies non-overlapping periodic measurements.

A mode of sliding(2) specifies overlapping sliding windows where the interval between the start of one interval and the next is defined in eoEnergyParametersIntervalWindow.

A mode of total(3) specifies non-periodic measurement. In this mode only one interval is used as this is a continuous measurement since the last reset. The value of eoEnergyParametersIntervalNumber should be (1) one and eoEnergyParametersIntervalLength is ignored. "

::= { eoEnergyParametersEntry 5 }

eoEnergyParametersIntervalWindow OBJECT-TYPE

SYNTAX TimeInterval

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The length of the duration window between the starting time of one sliding window and the next starting time in hundredths of seconds, in order to compute the average of eoEnergyConsumed, eoEnergyProvided measurements in the eoEnergyTable table. This is valid only when the eoEnergyParametersIntervalMode is sliding(2). The eoEnergyParametersIntervalWindow value should be a multiple of eoEnergyParametersSampleRate."

::= { eoEnergyParametersEntry 6 }

eoEnergyParametersSampleRate OBJECT-TYPE

SYNTAX Integer32

UNITS "Milliseconds"

MAX-ACCESS read-create

STATUS current

DESCRIPTION

"The sampling rate, in milliseconds, at which the Energy Object should poll power usage in order to compute the average eoEnergyConsumed, eoEnergyProvided measurements in the table eoEnergyTable. The Energy Object should initially set this sampling rate to a reasonable value, i.e., a compromise between intervals that will provide good accuracy by not being too long, but not so short that they affect the Energy Object performance by requesting continuous polling. If the sampling rate is unknown, the value 0 is reported. The sampling rate should be selected so that eoEnergyParametersIntervalWindow is a multiple of eoEnergyParametersSampleRate. The default value is one second."

DEFVAL { 1000 }  
 ::= { eoEnergyParametersEntry 7 }

eoEnergyParametersStatus OBJECT-TYPE

SYNTAX RowStatus  
 MAX-ACCESS read-create  
 STATUS current

DESCRIPTION

"The status of this row. The eoEnergyParametersStatus is used to start or stop energy usage logging. An entry status may not be active(1) unless all objects in the entry have an appropriate value. If this object is not equal to active, all associated usage-data logged into the eoEnergyTable will be deleted. The data can be destroyed by setting up the eoEnergyParametersStatus to destroy."

::= { eoEnergyParametersEntry 8 }

eoEnergyTable OBJECT-TYPE

SYNTAX SEQUENCE OF EoEnergyEntry  
 MAX-ACCESS not-accessible  
 STATUS current

DESCRIPTION

"This table lists Energy Object energy measurements. Entries in this table are only created if the corresponding value of object eoPowerMeasurementCaliber is active(3), i.e., if the power is actually metered."

::= { energyObjectMibObjects 5 }

eoEnergyEntry OBJECT-TYPE

SYNTAX EoEnergyEntry  
 MAX-ACCESS not-accessible  
 STATUS current

DESCRIPTION

```

        "An entry describing energy measurements."
    INDEX { eoEnergyParametersIndex,
eoEnergyCollectionStartTime }
    ::= { eoEnergyTable 1 }

```

```

EoEnergyEntry ::= SEQUENCE {
    eoEnergyCollectionStartTime      TimeTicks,
    eoEnergyConsumed                 Integer32,
    eoEnergyProvided                 Integer32,
    eoEnergyStored                   Integer32,
    eoEnergyUnitMultiplier           UnitMultiplier,
    eoEnergyAccuracy                 Integer32,
    eoEnergyMaxConsumed              Integer32,
    eoEnergyMaxProduced              Integer32,
    eoEnergyDiscontinuityTime        TimeStamp
}

```

eoEnergyCollectionStartTime OBJECT-TYPE

```

SYNTAX      TimeTicks
UNITS       "hundredths of seconds"
MAX-ACCESS  not-accessible
STATUS      current
DESCRIPTION
    "The time (in hundredths of a second) since the
    network management portion of the system was last
    re-initialized, as specified in the sysUpTime [RFC3418].
    This object specifies the start time of the energy
    measurement sample. "
    ::= { eoEnergyEntry 1 }

```

eoEnergyConsumed OBJECT-TYPE

```

SYNTAX      Integer32
UNITS       "Watt-hours"
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "This object indicates the energy consumed in units of watt-
    hours for the Energy Object over the defined interval.
    This value is specified in the common billing units of watt-
    hours with the magnitude of watt-hours (kW-Hr, MW-Hr, etc.)
    indicated separately in eoEnergyUnitMultiplier."
    ::= { eoEnergyEntry 2 }

```

eoEnergyProvided OBJECT-TYPE

```

SYNTAX      Integer32
UNITS       "Watt-hours"
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION

```



"This object indicates the energy produced in units of watt-hours for the Energy Object over the defined interval. This value is specified in the common billing units of watt-hours with the magnitude of watt-hours (kW-Hr, MW-Hr, etc.) indicated separately in eoEnergyUnitMultiplier."  
 ::= { eoEnergyEntry 3 }

eoEnergyStored OBJECT-TYPE

SYNTAX Integer32  
 UNITS "Watt-hours"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION

"This object indicates the difference of the energy consumed and energy produced for an Energy Object in units of watt-hours for the Energy Object over the defined interval. This value is specified in the common billing units of watt-hours with the magnitude of watt-hours (kW-Hr, MW-Hr, etc.) indicated separately in eoEnergyUnitMultiplier."  
 ::= { eoEnergyEntry 4 }

eoEnergyUnitMultiplier OBJECT-TYPE

SYNTAX UnitMultiplier  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION

"This object is the magnitude of watt-hours for the energy field in eoEnergyConsumed, eoEnergyProvided, eoEnergyStored, eoEnergyMaxConsumed, and eoEnergyMaxProduced."  
 ::= { eoEnergyEntry 5 }

eoEnergyAccuracy OBJECT-TYPE

SYNTAX Integer32 (0..10000)  
 UNITS "hundredths of percent"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION

"This object indicates a percentage accuracy, in 100ths of a percent, of Energy usage reporting. eoEnergyAccuracy is applicable to all Energy measurements in the eoEnergyTable.

For example: 1010 means the reported usage is accurate to +/- 10.1 percent.

This value is zero if the accuracy is unknown."

::= { eoEnergyEntry 6 }

```
eoEnergyMaxConsumed OBJECT-TYPE
    SYNTAX      Integer32
    UNITS       "Watt-hours"
    MAX-ACCESS   read-only
    STATUS      current
    DESCRIPTION
        "This object is the maximum energy observed in
        eoEnergyConsumed since the monitoring started or was
        reinitialized. This value is specified in the common
        billing units of watt-hours with the magnitude of watt-
        hours (kW-Hr, MW-Hr, etc.) indicated separately in
        eoEnergyUnitMultiplier."
    ::= { eoEnergyEntry 7 }

eoEnergyMaxProduced OBJECT-TYPE
    SYNTAX      Integer32
    UNITS       "Watt-hours"
    MAX-ACCESS   read-only
    STATUS      current
    DESCRIPTION
        "This object is the maximum energy ever observed in
        eoEnergyEnergyProduced since the monitoring started. This
        value is specified in the units of watt-hours with the
        magnitude of watt-hours (kW-Hr, MW-Hr, etc.) indicated
        separately in eoEnergyEnergyUnitMultiplier."
    ::= { eoEnergyEntry 8 }

eoEnergyDiscontinuityTime OBJECT-TYPE
    SYNTAX      TimeStamp
    MAX-ACCESS   read-only
    STATUS      current
    DESCRIPTION
        "The value of sysUpTime [RFC3418] on the most recent
        occasion at which any one or more of this entity's energy
        counters in this table suffered a discontinuity:
        eoEnergyConsumed, eoEnergyProvided or eoEnergyStored. If
        no such discontinuities have occurred since the last re-
        initialization of the local management subsystem, then
        this object contains a zero value."
    ::= { eoEnergyEntry 9 }

-- Notifications

eoPowerEnableStatusNotification OBJECT-TYPE
    SYNTAX      TruthValue
```

```

MAX-ACCESS      read-write
STATUS          current
DESCRIPTION
    "This object controls whether the system produces
    notifications for eoPowerStateChange. A false value will
    prevent these notifications from being generated."
DEFVAL          { false }
::= { energyObjectMibNotifs 1 }

```

```

eoPowerStateChange NOTIFICATION-TYPE
    OBJECTS      {eoPowerAdminState, eoPowerOperState,
eoPowerStateEnterReason}
STATUS          current
DESCRIPTION
    "The SNMP entity generates the eoPowerStateChange when
    the values of eoPowerAdminState or eoPowerOperState,
    in the context of the Power State Set, have changed for
    the Energy Object represented by the entPhysicalIndex."
::= { energyObjectMibNotifs 2 }

```

-- Conformance

```

energyObjectMibCompliances OBJECT IDENTIFIER
::= { energyObjectMibConform 1 }

```

```

energyObjectMibGroups OBJECT IDENTIFIER
::= { energyObjectMibConform 2 }

```

```

energyObjectMibFullCompliance MODULE-COMPLIANCE
STATUS          current
DESCRIPTION
    "When this MIB is implemented with support for
    read-create, then such an implementation can
    claim full compliance. Such devices can then
    be both monitored and configured with this MIB.

    Module Compliance of [RFC6933]
    with respect to entity4CRCompliance MUST
    be supported which requires implementation
    of 4 MIB objects: entPhysicalIndex, entPhysicalClass,
    entPhysicalName and entPhysicalUUID."

```

```

MODULE          -- this module
MANDATORY-GROUPS {
    energyObjectMibTableGroup,
    energyObjectMibStateTableGroup,
    eoPowerEnableStatusNotificationGroup,
    energyObjectMibNotifGroup
}

```

}

GROUP            energyObjectMibEnergyTableGroup

DESCRIPTION "A compliant implementation does not  
have to implement.

Module Compliance of [RFC6933]  
with respect to entity4CRCompliance MUST  
be supported which requires implementation  
of 4 MIB objects: entPhysicalIndex, entPhysicalClass,  
entPhysicalName and entPhysicalUUID."

GROUP            energyObjectMibEnergyParametersTableGroup

DESCRIPTION "A compliant implementation does not  
have to implement.

Module Compliance of {RFC6933}  
with respect to entity4CRCompliance MUST  
be supported which requires implementation  
of 4 MIB objects: entPhysicalIndex, entPhysicalClass,  
entPhysicalName and entPhysicalUUID."

GROUP            energyObjectMibMeterCapabilitiesTableGroup

DESCRIPTION "A compliant implementation does not  
have to implement.

Module Compliance of [RFC6933]  
with respect to entity4CRCompliance MUST  
be supported which requires implementation  
of 4 MIB objects: entPhysicalIndex, entPhysicalClass,  
entPhysicalName and entPhysicalUUID."

::= { energyObjectMibCompliances 1 }

energyObjectMibReadOnlyCompliance MODULE-COMPLIANCE

STATUS            current

DESCRIPTION

"When this MIB is implemented without support for  
read-create (i.e., in read-only mode), then such an  
implementation can claim read-only compliance. Such a  
device can then be monitored but cannot be  
configured with this MIB.

Module Compliance of [RFC6933]

with respect to entity4CRCompliance MUST be supported which requires implementation of 4 MIB objects: entPhysicalIndex, entPhysicalClass, entPhysicalName and entPhysicalUUID."

```

MODULE          -- this module
MANDATORY-GROUPS {
    energyObjectMibTableGroup,
    energyObjectMibStateTableGroup,
    energyObjectMibNotifGroup
}

OBJECT          eoPowerOperState
MIN-ACCESS      read-only
DESCRIPTION
    "Write access is not required."
 ::= { energyObjectMibCompliances 2 }

-- Units of Conformance

energyObjectMibTableGroup OBJECT-GROUP
    OBJECTS      {
        eoPower,
        eoPowerNameplate,
        eoPowerUnitMultiplier,
        eoPowerAccuracy,
        eoPowerMeasurementCaliber,
        eoPowerCurrentType,
        eoPowerMeasurementLocal,
        eoPowerAdminState,
        eoPowerOperState,
        eoPowerStateEnterReason
    }
    STATUS        current
DESCRIPTION
    "This group contains the collection of all the objects
    related to the Energy Object."
 ::= { energyObjectMibGroups 1 }

energyObjectMibStateTableGroup OBJECT-GROUP
    OBJECTS      {
        eoPowerStateMaxPower,
        eoPowerStatePowerUnitMultiplier,
        eoPowerStateTotalTime,
        eoPowerStateEnterCount
    }
    STATUS        current
DESCRIPTION
    "This group contains the collection of all the
    objects related to the Power State."

```

::= { energyObjectMibGroups 2 }

energyObjectMibEnergyParametersTableGroup OBJECT-GROUP

OBJECTS

{

    eoEnergyParametersIntervalLength,  
    eoEnergyParametersIntervalNumber,  
    eoEnergyParametersIntervalMode,  
    eoEnergyParametersIntervalWindow,  
    eoEnergyParametersSampleRate,  
    eoEnergyParametersStatus

}

STATUS

current

DESCRIPTION

    "This group contains the collection of all the objects  
    related to the configuration of the Energy Table."

::= { energyObjectMibGroups 3 }

energyObjectMibEnergyTableGroup OBJECT-GROUP

OBJECTS

{

    -- Note that object  
    -- eoEnergyCollectionStartTime is not  
    -- included since it is not-accessible

    eoEnergyConsumed,  
    eoEnergyProvided,  
    eoEnergyStored,  
    eoEnergyUnitMultiplier,  
    eoEnergyAccuracy,  
    eoEnergyMaxConsumed,  
    eoEnergyMaxProduced,  
    eoEnergyDiscontinuityTime

}

STATUS

current

DESCRIPTION

    "This group contains the collection of all the objects  
    related to the Energy Table."

::= { energyObjectMibGroups 4 }

energyObjectMibMeterCapabilitiesTableGroup OBJECT-GROUP

OBJECTS

{

    eoMeterCapability

}

STATUS

current

DESCRIPTION

"This group contains the object indicating the capability of the Energy Object"

::= { energyObjectMibGroups 5 }

eoPowerEnableStatusNotificationGroup OBJECT-GROUP

OBJECTS { eoPowerEnableStatusNotification }

STATUS current

DESCRIPTION "The collection of objects which are used to enable notification."

::= { energyObjectMibGroups 6 }

energyObjectMibNotifGroup NOTIFICATION-GROUP

NOTIFICATIONS {  
eoPowerStateChange  
}

STATUS current

DESCRIPTION "This group contains the notifications for the power and energy monitoring MIB Module."

::= { energyObjectMibGroups 7 }

END

-- \*\*\*\*\*  
--  
-- This MIB module is used to monitor power attributes of  
-- networked devices with measurements.  
--  
-- This MIB module is an extension of energyObjectMib module.  
--  
-- \*\*\*\*\*

POWER-ATTRIBUTES-MIB DEFINITIONS ::= BEGIN

IMPORTS

MODULE-IDENTITY,

OBJECT-TYPE,

mib-2,

Integer32

FROM SNMPv2-SMI

MODULE-COMPLIANCE,

OBJECT-GROUP

FROM SNMPv2-CONF

UnitMultiplier

FROM ENERGY-OBJECT-MIB

entPhysicalIndex

FROM ENTITY-MIB;

powerAttributesMIB MODULE-IDENTITY

LAST-UPDATED     "201402140000Z"     -- 14 Feb 2014

ORGANIZATION     "IETF EMAN Working Group"

CONTACT-INFO

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#### DESCRIPTION

"This MIB is used to report AC power attributes in devices. The table is a sparse augmentation of the eoPowerTable table from the energyObjectMib module. Both three-phase and single-phase power configurations are supported.

As a requirement for this MIB module,  
[EMAN-AWARE-MIB] SHOULD be implemented.

Module Compliance of ENTITY-MIB v4  
with respect to entity4CRCompliance MUST  
be supported which requires implementation  
of 4 MIB objects: entPhysicalIndex, entPhysicalClass,  
entPhysicalName and entPhysicalUUID."

#### REVISION

"201402140000Z"      -- 14 Feb 2014

#### DESCRIPTION

"Initial version, published as RFC YYY."

::= { mib-2 yyy }

powerAttributesMIBConform OBJECT IDENTIFIER  
::= { powerAttributesMIB 0 }

powerAttributesMIBObjects OBJECT IDENTIFIER  
::= { powerAttributesMIB 1 }

-- Objects

eoACPwrAttributesTable OBJECT-TYPE

SYNTAX SEQUENCE OF EoACPwrAttributesEntry  
 MAX-ACCESS not-accessible  
 STATUS current  
 DESCRIPTION  
 "This table contains power attributes measurements for supported entPhysicalIndex entities. It is a sparse extension of the eoPowerTable."  
 ::= { powerAttributesMIBObjects 1 }

eoACPwrAttributesEntry OBJECT-TYPE  
 SYNTAX EoACPwrAttributesEntry  
 MAX-ACCESS not-accessible  
 STATUS current  
 DESCRIPTION  
 "This is a sparse extension of the eoPowerTable with entries for power attributes measurements or configuration. Each measured value corresponds to an attribute in IEC 61850-7-4 for non-phase measurements within the object MMUX."

INDEX {entPhysicalIndex }  
 ::= { eoACPwrAttributesTable 1 }

EoACPwrAttributesEntry ::= SEQUENCE {  
 eoACPwrAttributesConfiguration INTEGER,  
 eoACPwrAttributesAvgVoltage Integer32,  
 eoACPwrAttributesAvgCurrent Integer32,  
 eoACPwrAttributesFrequency Integer32,  
 eoACPwrAttributesPowerUnitMultiplier UnitMultiplier,  
 eoACPwrAttributesPowerAccuracy Integer32,  
 eoACPwrAttributesTotalActivePower Integer32,  
 eoACPwrAttributesTotalReactivePower Integer32,  
 eoACPwrAttributesTotalApparentPower Integer32,  
 eoACPwrAttributesTotalPowerFactor Integer32,  
 eoACPwrAttributesThdCurrent Integer32,  
 eoACPwrAttributesThdVoltage Integer32  
 }

eoACPwrAttributesConfiguration OBJECT-TYPE  
 SYNTAX INTEGER {  
 snl(1),  
 del(2),  
 wye(3)  
 }  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION  
 "Configuration describes the physical configurations of the power supply lines:"

- \* alternating current, single phase (SNGL)
- \* alternating current, three phase delta (DEL)
- \* alternating current, three phase Y (WYE)

Three-phase configurations can be either connected in a triangular delta (DEL) or star Y (WYE) system. WYE systems have a shared neutral voltage, while DEL systems do not. Each phase is offset 120 degrees to each other."

```
::= { eoACPwrAttributesEntry 1 }
```

eoACPwrAttributesAvgVoltage OBJECT-TYPE

```
SYNTAX      Integer32
UNITS       "0.1 Volt AC"
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "A measured value for average of the voltage measured
    over an integral number of AC cycles. For a 3-phase
    system, this is the average voltage (V1+V2+V3)/3. IEC
    61850-7-4 measured value attribute 'Vol'."
::= { eoACPwrAttributesEntry 2 }
```

eoACPwrAttributesAvgCurrent OBJECT-TYPE

```
SYNTAX      Integer32
UNITS       "amperes"
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    " A measured value for average of the current measured
    over an integral number of AC cycles. For a 3-phase
    system, this is the average current (I1+I2+I3)/3. IEC
    61850-7-4 attribute 'Amp'."
::= { eoACPwrAttributesEntry 3 }
```

eoACPwrAttributesFrequency OBJECT-TYPE

```
SYNTAX      Integer32 (4500..6500)
UNITS       "0.01 hertz"
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
    "A measured value for the basic frequency of the AC
    circuit. IEC 61850-7-4 attribute 'Hz'."
::= { eoACPwrAttributesEntry 4 }
```

eoACPwrAttributesPowerUnitMultiplier OBJECT-TYPE

```
SYNTAX      UnitMultiplier
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
```

"The magnitude of watts for the usage value in  
 eoACPwrAttributesTotalActivePower,  
 eoACPwrAttributesTotalReactivePower  
 and eoACPwrAttributesTotalApparentPower measurements.  
 For 3-phase power systems, this will also include  
 eoACPwrAttributesWyeActivePower,  
 eoACPwrAttributesWyeReactivePower and  
 eoACPwrAttributesWyeApparentPower"  
 ::= { eoACPwrAttributesEntry 5 }

eoACPwrAttributesPowerAccuracy OBJECT-TYPE

SYNTAX Integer32 (0..10000)  
 UNITS "hundredths of percent"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION

"This object indicates a percentage value, in 100ths of  
 a percent, representing the presumed accuracy of  
 active, reactive, and apparent power usage reporting.  
 For example: 1010 means the reported usage is accurate  
 to +/- 10.1 percent. This value is zero if the  
 accuracy is unknown.

ANSI and IEC define the following accuracy classes for  
 power measurement: IEC 62053-22 & 60044-1 class 0.1,  
 0.2, 0.5, 1 & 3.

ANSI C12.20 class 0.2 & 0.5"

::= { eoACPwrAttributesEntry 6 }

eoACPwrAttributesTotalActivePower OBJECT-TYPE

SYNTAX Integer32  
 UNITS "watts"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION

"A measured value of the actual power delivered to or  
 consumed by the load. IEC 61850-7-4 attribute 'TotW'."

::= { eoACPwrAttributesEntry 7 }

eoACPwrAttributesTotalReactivePower OBJECT-TYPE

SYNTAX Integer32  
 UNITS "volt-amperes reactive"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION

"A measured value of the reactive portion of the  
 apparent power. IEC 61850-7-4 attribute 'TotVar'."

::= { eoACPwrAttributesEntry 8 }

eoACPwrAttributesTotalApparentPower OBJECT-TYPE

SYNTAX Integer32  
 UNITS "volt-amperes"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION  
 "A measured value of the voltage and current which determines the apparent power. The apparent power is the vector sum of real and reactive power.

Note: watts and volt-amperes are equivalent units and may be combined. IEC 61850-7-4 attribute 'TotVA'."  
 ::= { eoACPwrAttributesEntry 9 }

eoACPwrAttributesTotalPowerFactor OBJECT-TYPE

SYNTAX Integer32 (-10000..10000)  
 UNITS "hundredths of percent"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION  
 "A measured value ratio of the real power flowing to the load versus the apparent power. It is dimensionless and expressed here as a percentage value in 100ths of a percent. A power factor of 100% indicates there is no inductance load and thus no reactive power. Power Factor can be positive or negative, where the sign should be in lead/lag (IEEE) form. IEC 61850-7-4 attribute 'TotPF'."

::= { eoACPwrAttributesEntry 10 }

eoACPwrAttributesThdCurrent OBJECT-TYPE

SYNTAX Integer32 (0..10000)  
 UNITS "hundredths of percent"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION  
 "A calculated value for the current total harmonic distortion (THD). Method of calculation is not specified. IEC 61850-7-4 attribute 'ThdAmp'."

::= { eoACPwrAttributesEntry 11 }

eoACPwrAttributesThdVoltage OBJECT-TYPE

SYNTAX Integer32 (0..10000)  
 UNITS "hundredths of percent"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION  
 "A calculated value for the voltage total harmonic distortion (THD). Method of calculation is not specified. IEC 61850-7-4 attribute 'ThdVol'."

::= { eoACPwrAttributesEntry 12 }

eoACPwrAttributesDelPhaseTable OBJECT-TYPE

SYNTAX SEQUENCE OF EoACPwrAttributesDelPhaseEntry  
 MAX-ACCESS not-accessible  
 STATUS current  
 DESCRIPTION

"This optional table describes 3-phase power attributes measurements in a DEL configuration with phase-to-phase power attributes measurements. Entities having single phase power shall not have any entities. This is a sparse extension of the eoACPwrAttributesTable.

These attributes correspond to IEC 61850-7.4 MMXU phase related measurements and MHAI phase related measured harmonic or interharmonics."

::= { powerAttributesMIBObjects 2 }

eoACPwrAttributesDelPhaseEntry OBJECT-TYPE

SYNTAX EoACPwrAttributesDelPhaseEntry  
 MAX-ACCESS not-accessible  
 STATUS current  
 DESCRIPTION

"An entry describes power measurements of a phase in a DEL 3-phase power. Three entries are required for each supported entPhysicalIndex entry. Voltage measurements are provided relative to each other.

For phase-to-phase measurements, the eoACPwrAttributesDelPhaseIndex is compared against the following phase at +120 degrees. Thus, the possible values are:

eoACPwrAttributesDelPhaseIndex	Next Phase Angle
0	120
120	240
240	0

"

INDEX { entPhysicalIndex, eoACPwrAttributesDelPhaseIndex}  
 ::= { eoACPwrAttributesDelPhaseTable 1}

EoACPwrAttributesDelPhaseEntry ::= SEQUENCE {

eoACPwrAttributesDelPhaseIndex	Integer32,
eoACPwrAttributesDelPhaseToNextPhaseVoltage	Integer32,
eoACPwrAttributesDelThdPhaseToNextPhaseVoltage	Integer32

}

eoACPwrAttributesDelPhaseIndex OBJECT-TYPE

SYNTAX Integer32 (0..359)  
 MAX-ACCESS not-accessible  
 STATUS current

DESCRIPTION

"A phase angle typically corresponding to 0, 120, 240."  
::= { eoACPwrAttributesDelPhaseEntry 1 }

eoACPwrAttributesDelPhaseToNextPhaseVoltage OBJECT-TYPE

SYNTAX Integer32  
UNITS "0.1 Volt AC"  
MAX-ACCESS read-only  
STATUS current

DESCRIPTION

"A measured value of phase to next phase voltages, where the next phase is IEC 61850-7-4 attribute 'PPV'.  
::= { eoACPwrAttributesDelPhaseEntry 2 }

eoACPwrAttributesDelThdPhaseToNextPhaseVoltage OBJECT-TYPE

SYNTAX Integer32 (0..10000)  
UNITS "hundredths of percent"  
MAX-ACCESS read-only  
STATUS current

DESCRIPTION

"A calculated value for the voltage total harmonic distortion for phase to next phase. Method of calculation is not specified. IEC 61850-7-4 attribute 'ThdPPV'.  
::= { eoACPwrAttributesDelPhaseEntry 3 }

eoACPwrAttributesWyePhaseTable OBJECT-TYPE

SYNTAX SEQUENCE OF EoACPwrAttributesWyePhaseEntry  
MAX-ACCESS not-accessible  
STATUS current

DESCRIPTION

"This optional table describes 3-phase power attributes measurements in a WYE configuration with phase-to-neutral power attributes measurements. Entities having single phase power shall not have any entities. This is a sparse extension of the eoACPwrAttributesTable.

These attributes correspond to IEC 61850-7.4 MMXU phase related measurements and MHAI phase related measured harmonic or interharmonics."

::= { powerAttributesMIBObjects 3 }

eoACPwrAttributesWyePhaseEntry OBJECT-TYPE

SYNTAX EoACPwrAttributesWyePhaseEntry  
MAX-ACCESS not-accessible  
STATUS current

DESCRIPTION

"This table describes measurements of a phase in a WYE 3-phase power system. Three entries are required for each supported entPhysicalIndex entry. Voltage measurements are relative to neutral.

Each entry describes power attributes of one phase of a WYE 3-phase power system."  
INDEX { entPhysicalIndex, eoACPwrAttributesWyePhaseIndex }  
::= { eoACPwrAttributesWyePhaseTable 1}

```
EoACPwrAttributesWyePhaseEntry ::= SEQUENCE {
    eoACPwrAttributesWyePhaseIndex      Integer32,
    eoACPwrAttributesWyePhaseToNeutralVoltage Integer32,
    eoACPwrAttributesWyeCurrent          Integer32,
    eoACPwrAttributesWyeActivePower      Integer32,
    eoACPwrAttributesWyeReactivePower    Integer32,
    eoACPwrAttributesWyeApparentPower    Integer32,
    eoACPwrAttributesWyePowerFactor      Integer32,
    eoACPwrAttributesWyeThdCurrent       Integer32,
    eoACPwrAttributesWyeThdPhaseToNeutralVoltage Integer32
}
```

```
eoACPwrAttributesWyePhaseIndex OBJECT-TYPE
    SYNTAX      Integer32 (0..359)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A phase angle typically corresponding to 0, 120, 240."
    ::= { eoACPwrAttributesWyePhaseEntry 1 }
```

```
eoACPwrAttributesWyePhaseToNeutralVoltage OBJECT-TYPE
    SYNTAX      Integer32
    UNITS       "0.1 Volt AC"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "A measured value of phase to neutral voltage. IEC
        61850-7-4 attribute 'PNV'."
    ::= { eoACPwrAttributesWyePhaseEntry 2 }
```

```
eoACPwrAttributesWyeCurrent OBJECT-TYPE
    SYNTAX      Integer32
    UNITS       "0.1 amperes AC"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "A measured value of phase currents. IEC 61850-7-4
        attribute 'A'."
    ::= { eoACPwrAttributesWyePhaseEntry 3 }
```

```
eoACPwrAttributesWyeActivePower OBJECT-TYPE
    SYNTAX      Integer32
    UNITS       "watts"
```



MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION  
 "A measured value of the actual power delivered to or  
 consumed by the load with the magnitude indicated  
 separately in eoPowerUnitMultiplier. IEC 61850-7-4  
 attribute 'W'"  
 ::= { eoACPwrAttributesWyePhaseEntry 4 }

eoACPwrAttributesWyeReactivePower OBJECT-TYPE

SYNTAX Integer32  
 UNITS "volt-amperes reactive"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION  
 "A measured value of the reactive portion of the  
 apparent power with the magnitude of indicated  
 separately in eoPowerUnitMultiplier. IEC 61850-7-4  
 attribute 'VAr'"  
 ::= { eoACPwrAttributesWyePhaseEntry 5 }

eoACPwrAttributesWyeApparentPower OBJECT-TYPE

SYNTAX Integer32  
 UNITS "volt-amperes"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION  
 "A measured value of the voltage and current determines  
 the apparent power with the indicated separately in  
 eoPowerUnitMultiplier. Active plus reactive power  
 equals the total apparent power.

Note: Watts and volt-amperes are equivalent units and  
 may be combined. IEC 61850-7-4 attribute 'VA'."  
 ::= { eoACPwrAttributesWyePhaseEntry 6 }

eoACPwrAttributesWyePowerFactor OBJECT-TYPE

SYNTAX Integer32 (-10000..10000)  
 UNITS "hundredths of percent"  
 MAX-ACCESS read-only  
 STATUS current  
 DESCRIPTION  
 "A measured value ratio of the real power flowing to  
 the load versus the apparent power for this phase. IEC  
 61850-7-4 attribute 'PF'. Power Factor can be positive  
 or negative where the sign should be in lead/lag (IEEE)  
 form."  
 ::= { eoACPwrAttributesWyePhaseEntry 7 }

eoACPwrAttributesWyeThdCurrent OBJECT-TYPE

```
SYNTAX          Integer32 (0..10000)
UNITS           "hundredths of percent"
MAX-ACCESS      read-only
STATUS          current
DESCRIPTION
    "A calculated value for the voltage total harmonic
    distortion (THD) for phase to phase. Method of
    calculation is not specified.
    IEC 61850-7-4 attribute 'ThdA'."
 ::= { eoACPwrAttributesWyePhaseEntry 8 }
```

```
eoACPwrAttributesWyeThdPhaseToNeutralVoltage OBJECT-TYPE
SYNTAX          Integer32 (0..10000)
UNITS           "hundredths of percent"
MAX-ACCESS      read-only
STATUS          current
DESCRIPTION
    "A calculated value of the voltage total harmonic
    distortion (THD) for phase to neutral. IEC 61850-7-4
    attribute 'ThdPhV'."
 ::= { eoACPwrAttributesWyePhaseEntry 9 }
```

-- Conformance

```
powerAttributesMIBCompliances OBJECT IDENTIFIER
 ::= { powerAttributesMIB 2 }
```

```
powerAttributesMIBGroups OBJECT IDENTIFIER
 ::= { powerAttributesMIB 3 }
```

```
powerAttributesMIBFullCompliance MODULE-COMPLIANCE
STATUS          current
DESCRIPTION
    "When this MIB is implemented with support for read-create,
    then such an implementation can claim full compliance.
    Such devices can then be both monitored and configured with
    this MIB.
```

```
Module Compliance of [RFC6933] with respect to
entity4CRCompliance MUST be supported which requires
implementation of 4 MIB objects: entPhysicalIndex,
entPhysicalClass, entPhysicalName and entPhysicalUUID."
```

```
MODULE          -- this module
MANDATORY-GROUPS {
    powerACPwrAttributesMIBTableGroup
```

}

```
GROUP          powerACPwrAttributesOptionalMIBTableGroup
DESCRIPTION
    "A compliant implementation does not have
    to implement."
```

```
GROUP          powerACPwrAttributesDelPhaseMIBTableGroup
DESCRIPTION
    "A compliant implementation does not have to
    implement."
```

```
GROUP          powerACPwrAttributesWyePhaseMIBTableGroup
DESCRIPTION
    "A compliant implementation does not have to
    implement."
```

```
::= { powerAttributesMIBCompliances 1 }
```

-- Units of Conformance

```
powerACPwrAttributesMIBTableGroup OBJECT-GROUP
    OBJECTS
        {
            -- Note that object entPhysicalIndex is NOT
            -- included since it is not-accessible

            eoACPwrAttributesAvgVoltage,
            eoACPwrAttributesAvgCurrent,
            eoACPwrAttributesFrequency,
            eoACPwrAttributesPowerUnitMultiplier,
            eoACPwrAttributesPowerAccuracy,
            eoACPwrAttributesTotalActivePower,
            eoACPwrAttributesTotalReactivePower,
            eoACPwrAttributesTotalApparentPower,
            eoACPwrAttributesTotalPowerFactor
        }
    STATUS          current
    DESCRIPTION
        "This group contains the collection of all the power
        attributes objects related to the Energy Object."
    ::= { powerAttributesMIBGroups 1 }
```

```
powerACPwrAttributesOptionalMIBTableGroup OBJECT-GROUP
    OBJECTS
        {
            eoACPwrAttributesConfiguration,
            eoACPwrAttributesThdCurrent,
```

```

                                eoACPwrAttributesThdVoltage
                                }
STATUS                          current
DESCRIPTION
    "This group contains the collection of all the power
    attributes objects related to the Energy Object."
 ::= { powerAttributesMIBGroups 2 }

powerACPwrAttributesDelPhaseMIBTableGroup OBJECT-GROUP
OBJECTS
    {
        -- Note that object entPhysicalIndex and
        -- eoACPwrAttributesDelPhaseIndex are NOT
        -- included since they are not-accessible
        eoACPwrAttributesDelPhaseToNextPhaseVoltage,
        eoACPwrAttributesDelThdPhaseToNextPhaseVoltage
    }
STATUS                          current
DESCRIPTION
    "This group contains the collection of all power
    attributes of a phase in a DEL 3-phase power system."
 ::= { powerAttributesMIBGroups 3 }

powerACPwrAttributesWyePhaseMIBTableGroup OBJECT-GROUP
OBJECTS
    {
        -- Note that object entPhysicalIndex and
        -- eoACPwrAttributesWyePhaseIndex are NOT
        -- included since they are not-accessible
        eoACPwrAttributesWyePhaseToNeutralVoltage,
        eoACPwrAttributesWyeCurrent,
        eoACPwrAttributesWyeActivePower,
        eoACPwrAttributesWyeReactivePower,
        eoACPwrAttributesWyeApparentPower,
        eoACPwrAttributesWyePowerFactor,
        eoACPwrAttributesWyeThdPhaseToNeutralVoltage,
        eoACPwrAttributesWyeThdCurrent
    }
STATUS                          current
DESCRIPTION
    "This group contains the collection of all power
    attributes of a phase in a WYE 3-phase power system."
 ::= { powerAttributesMIBGroups 4 }

END

```

## 10. Implementation Status

[Note to RFC Editor: Please remove this section and the reference to [RFC6982] before publication.]

This section records the status of known implementations of the EMAN-Monitoring MIB at the time of posting of this Internet-Draft, and is based on a proposal described in [RFC6982].

The description of implementations in this section is intended to assist the IETF in its decision processes in progressing drafts to RFCs.

### 10.1. SNMP Research

Organization: SNMP Research, Inc.

Maturity: Prototype based upon early drafts of the MIBs. We anticipate updating it to more recent documents as development schedules allow.

Coverage: Code was generated to implement all MIB objects in ENTITY-MIB (Version 4), ENERGY-OBJECT-CONTEXT-MIB, ENERGY-OBJECT-MIB, POWER-ATTRIBUTES-MIB, and BATTERY-MIB.

Implementation experience: The documents are implementable.

Comments: Technical comments about the ENERGY-OBJECT-CONTEXT-MIB, ENERGY-OBJECT-MIB, and BATTERY-MIB were submitted to the EMAN Working Group E-mail list.

Licensing: Proprietary, royalty licensing

Contact: Alan Luchuk, luchuk at snmp.com

URL: <http://www.snmp.com/>

### 10.2. Cisco Systems

Organization: Cisco Systems, Inc.

<Claise, et. Al>

Expires August 14, 2014

[Page 62]

Maturity:     Prototype based upon early version drafts of the MIBs. We anticipate updating the MIB modules as when the drafts are updated.

Coverage:     Code was generated to implement all MIB objects in the ENTITY-MIB (Version 4), and ENERGY-OBJECT-MIB.

Implementation experience:     The MIB modules are implemented on Cisco router platforms to measure and report router energy measurements. The documents are implementable.

Licensing:     Proprietary

URL:            <http://www.cisco.com>

## 11. Security Considerations

Some of the readable objects in these 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 thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP.

There are a number of management objects defined in these MIB modules with a MAX-ACCESS clause of read-write and/or read-create. Such objects MAY be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. The following are the tables and objects and their sensitivity/vulnerability:

- Unauthorized changes to the eoPowerOperState (via theeoPowerAdminState ) MAY disrupt the power settings of the differentEnergy Objects, and therefore the state of functionality of the respective Energy Objects.
- Unauthorized changes to the eoEnergyParametersTable MAY disrupt energy measurement in the eoEnergyTable table.

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.

## 12. IANA Considerations

The MIB modules in this document use the following IANA-assigned OBJECT IDENTIFIER values recorded in the SMI Numbers registry:

Descriptor	OBJECT IDENTIFIER value
-----	-----
energyObjectMIB	{ mib-2 xxx }
powerAttributesMIB	{ mib-2 yyy }

Editor's Note (to be removed prior to publication): IANA is requested to assign a value for "XXX" and "YYY" under the 'mib-2' subtree and to record the assignment in the SMI Numbers registry. When the assignment has been made, the RFC Editor is asked to replace "XXX" and "YYY"(here and in the MIB module) with the assigned value and to remove this note.

## 13. Contributors

This document results from the merger of two initial proposals. The following persons made significant contributions either in one of the initial proposals or in this document.

John Parello

Rolf Winter

Dominique Dudkowski

#### 14. Acknowledgment

The authors would like to thank Shamita Pisal for her prototype of this MIB module, and her valuable feedback. The authors would like to Michael Brown for improving the text dramatically.

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Many thanks to Alan Luchuk for the detailed review of the MIB and his comments.

And finally, thanks to the EMAN chairs: Nevil Brownlee and Tom Nadeau.

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Abstract

In the current Internet, it is implicitly assumed that a network node is always active so that it can receive the incoming packets at any time. Current networking services and applications are commonly designed to be fully available at all times with minimal response times. This assumption keeps network nodes from entering sleeping mode in order to reduce energy consumption. Further, during sleeping mode, network nodes may not immediately respond to the incoming packets or even lose them. If network nodes are allowed to go into a sleeping mode, they can effectively reduce energy consumption during idle period. Network proxy allows to delegate network node's traffic processing to an external system within a network, so that the nodes maintain network presence during their sleep. This document describes communication mechanism between network nodes and proxy in order to accelerate the wider deployment of network proxy mechanism.

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## 1. Introduction

Information and Communications Technology (ICT) sector is facing rapid growth and consuming a lot of power in order to provide large bandwidth and complex application services.

According to an ITU-T report, wired and wireless networks consume large amount of power and the amount of green-house gas emissions caused by ICT sector is estimated 2% of total man-made emissions. It is also estimated that network sector including network equipment and equipment connected to networks contributes to 4% of world power consumption. Further, it is observed that the power consumption is

higher at access networks and users, so how to reduce the power consumption in these areas is becoming an important issue [ITU].

According to recent surveys, network equipment show a constant power consumption profile irrespective of their utilization level, i.e., energy-agnostic power profile. Such equipment represent the worst case in terms of utilization and power consumption profile. On the contrary, ideally, energy-aware equipment represent power consumption pattern proportional to their utilization or offered load. Practical approaches for realizing the energy-aware equipment are implementing multi-stepped power profiles in order to adapt to the utilization level [EPC][GreenSurvey][EEE].

There is another research direction for improving energy efficiency of network equipment using network proxy technology [I-D.winter-energy-efficient-internet][PROXZZZY][NCP]. Network proxy describes technologies that maintain network connectivity for other devices so that these can go into low power sleep modes. This mainly targets the reduction of unnecessary energy waste through edge devices.

There are typically two types of network proxies: internal and external, respectively.

- o Internal Proxy: proxy functionality is implemented within the ICT product, such as network interface card.
- o External Proxy: proxy functionality is placed within other network equipment such as switch and external server in networks.

This document describes a protocol that is need for communication between external proxies and network hosts.

ECMA International has published a proxying document [PROXZZZY]. This specification describes an overall architecture for network proxying and provides capabilities that a proxy may expose to a host. Also, information that must be exchanged between a host and a proxy, and required and optional behavior of a proxy during its operation are described.

Within IETF, there are several documents related with the functionality of network proxy [RFC6762][RFC6763][I-D.cheshire-edns0-owner-option]. These documents defines DNS messages-based service discovery mechanisms, which can be used for facilitating various services. These mechanisms may be used for providing some of network proxy functionality, but generalized network proxy functionality is not fully supported.

Generalized network proxy is capable of providing full network presence for a broad range of network protocols and applications. The generalized network proxy include a list of packet types that may require routine reply, autogeneration, and wakeup, as well as the detailed steps and methods for state information transfer each requires [EEEC].

It is well known that many network hosts are in active state in order to maintain network presence and this behavior hinders hosts from entering energy saving state. Even when a node is idle with no running applications, background traffic is received that needs to be processed which inhibits the node from sleeping. Network proxy is one of the possible solutions for resolve this issue. The general framework of network proxy was developed, but the control and communication mechanisms between network hosts and proxies has not been developed. Thus, in order to promote the wider deployment of network proxy mechanism, the control and communication protocol should be specified.

This document defines a control protocol for external network proxy operation and relevant messages in order to increase energy efficiency of network hosts.

## 2. Conventions and 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 [RFC2119].

## 3. Overview of Network Proxy

Network proxy refers to a set of mechanisms dedicated to put network interfaces and network nodes into energy saving sleeping mode. Energy consumption in sleeping mode is less than active mode in general, so the longer the sleeping periods is, the higher the achievable energy saving can be. The network proxy enables network nodes to maintain network connectivity during sleep period. Figure 1 shows the typical operational scenario of network proxy [PROXZZZY]. When a host wants to enter sleeping mode, the host delivers its network status and state to a network proxy and goes into sleeping mode. Then, the network proxy responds to periodic messages on behalf of the host in sleeping mode. If the proxy receives a message that it cannot process, it sends a wake-up message to the host so that the host can process the message after wake-up.

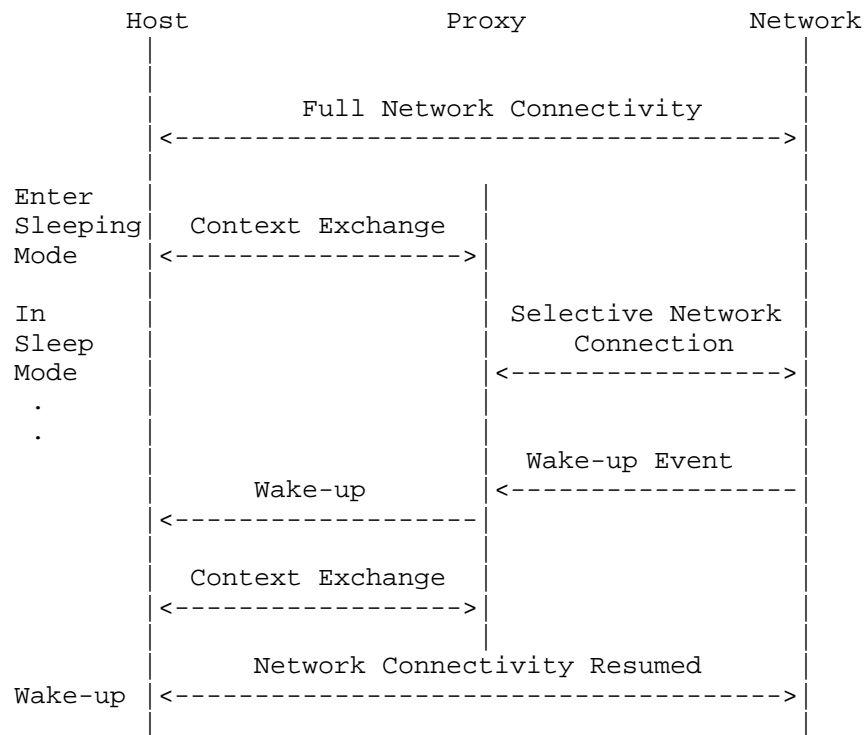


Figure 1: Operational scenario of network proxy

According to the survey, even though a host is in idle mode, background network traffic is received and needs to be processed, which prevents the host from going into sleeping mode. Also, it is known that most of the incoming traffic received during the host's idle period may be simply dropped or do not require more than a minimal computation and response. For instance, most broadcast packets or traffic related to port scanning may simply be ignored. Usual exchanges, such as Address Resolution Protocol (ARP) processing, Internet Control Message Protocol (ICMP) echo answering or Dynamic Host Configuration Protocol (DHCP) rebinding, are simple tasks that could be easily performed directly by network proxy. The idea behind network proxy is delegating the processing of such traffic. Processing can imply plain filtering or may require simple responses (e.g., in the case of ARP, ICMP, DHCP), or even more complex task. Such tasks can be delegated from the CPUs of hosts to an external network proxy in networks [GreenSurvey].

The following list summarizes requirement status about what types of protocols network proxy should support [PROXZZZY]. Among them, this



document describes ARP related operation first and other mandatory protocols will be defined later version of this document.

Mandatory 1: Media (802.3, 802.11)

Mandatory 2: IPv4 ARP

Mandatory 3: IPv6 Neighbor Discovery

Mandatory 4: Wake Packets

Option 1: DNS

Option 2: DHCP

Option 3: IGMP

Option 4: MLD

Option 5: Remote Access using SIP and IPv4

Option 6: Remote Access using Teredo for IPv6

Option 7: SNMP

Option 8: Service Discovery using mDNS

Option 9: Name Resolution with LLMNR

#### 4. Network Proxy Operation

This section describes network proxy operation between proxy server and network nodes to support mandatory protocols. Figure 2 shows network proxy operations. When a network host wants to enter sleeping mode in order to save energy, the host exchanges Proxy Solicitation and Advertisement messages with network proxy in network. Proxy may be implemented as a function within a switch or router, or it may be implemented as a separate server. Proxy Solicitation message queries to network, whether network proxy functionality can be supported within the host's network. If there is a network proxy that can provide proxy functionality, it replies to the host by using Proxy Advertisement message. Network proxy supports required functional requirements defined in [PROXZZZY] in order to support proxy operation.

After the network proxy discovery procedure, the host sends Sleep Request message to network proxy. The Request message contains the host's state information such as MAC address(es), IP address(es),

protocol operations to be delegated to the network proxy, and so on. After receiving the Sleep Confirm message from the network proxy, the host enters sleeping mode. Then the network proxy responds to incoming packets to the sleeping host. By doing so, the host can sleep without processing incoming packets. When the network proxy receives a packet that it cannot process, the proxy sends a Wake-up message to the sleeping host in order to wake it up. During its wake-up process, proxy may buffer additional packets destined to the sleeping hosts. After the sleeping node wakes up, it exchanges the update on the host's state information with the network proxy and communicates with remote hosts. When Sleep Timer expires, the sleeping host wakes up and sends a Wake-up Report message to the network proxy. Then, the network proxy cleans up the state information for the sleeping host and replies with Wake-up confirm message.

Note that Figure 2 shows network proxy high level operation and the detailed operations for mandatory and optional protocols specified in [PROXZZZY] are presented in the following sections. Among the mandatory and optional protocols, this document describes operations for IPv4 ARP and DHCPv4. Operations for other protocols will be presented in the revised version of this document.

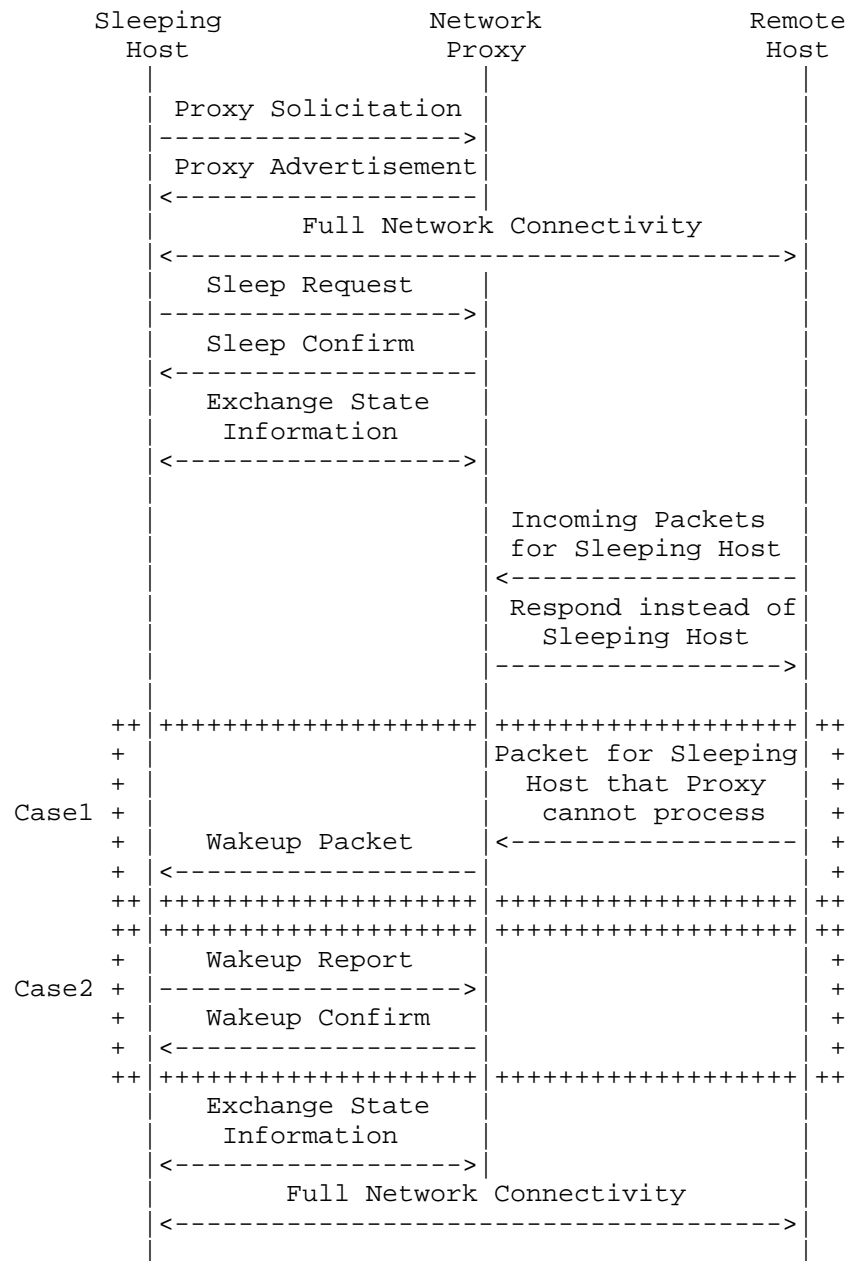


Figure 2: Network proxy high level operation

#### 4.1. ARP Operation

Figure 3 depicts network proxy operation for IPv4 ARP. A host performs network proxy and proxy capability discovery procedures by using Proxy Solicitation/Advertisement messages with Proxy Service Option. After the discovery procedure, the host and discovered network proxy perform Sleep Request/Confirm procedure that exchanges the host's MAC address(es) and IP address(es) by using ARP Configuration Option so that the host can enter sleeping mode. Then the network proxy discards ARP Request messages sent from other hosts in the network. By doing so, the host can sleep without receiving or processing ARP broadcast message not destined to the node itself. If the network proxy receives an ARP request message for sleeping host, it sends a reply message on behalf of the sleeping hosts using the host's MAC and IP address. When the network proxy receives a packet that it cannot process, the proxy wakes up the sleeping hosts so that the host can process the incoming packet.

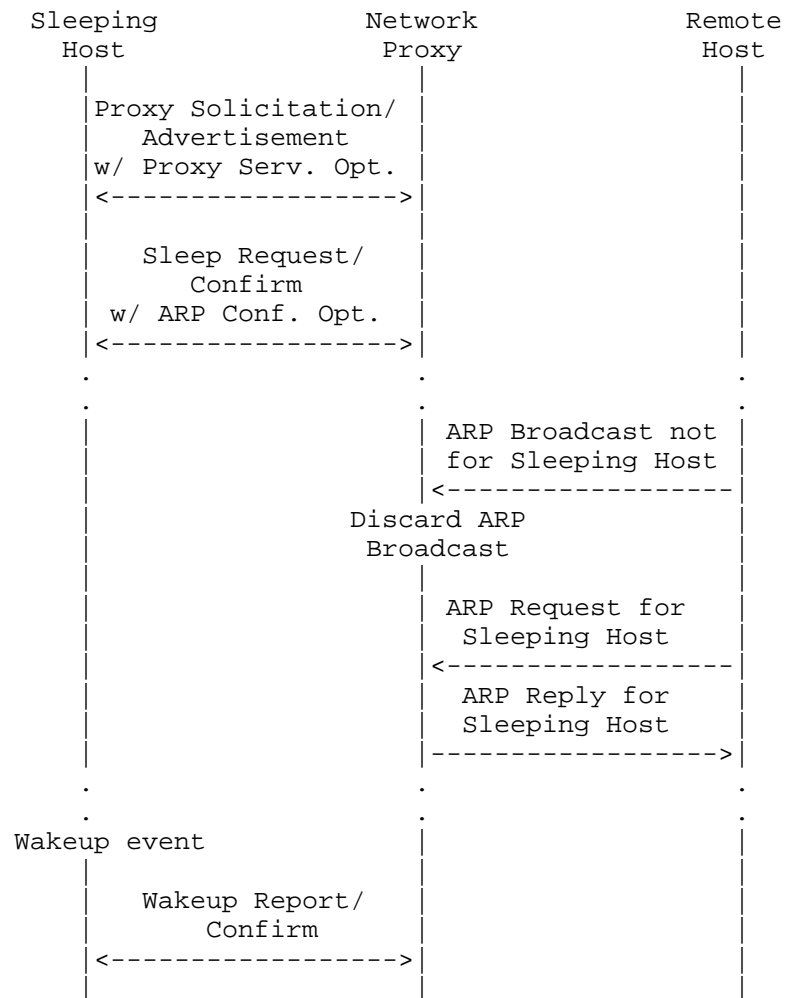


Figure 3: Network proxy operation for IPv4 ARP

#### 4.2. DHCP Operation

Figure 4 depicts network proxy operation for DHCP. After the Sleep Request/Confirm procedure that exchanges the host's DHCP-related parameters, the host enters sleeping mode. When 50% of DHCP Lease Time for the sleeping host expires, the network proxy sends DHCP Request message to the DHCP server and tries to renew the DHCP lease time on behalf of the sleeping host. In case of successful DHCP renewal, the sleeping host can keep sleeping mode. However, in case of DHCP renewal failure as shown in Figure 5, the network proxy initiates wakeup procedure by sending Wakeup packet to the sleeping

host. When the sleeping host wakes up, the network proxy delivers the current DHCP state information to the host by using DHCP Notification Option so that the host can perform relevant DHCP operation.

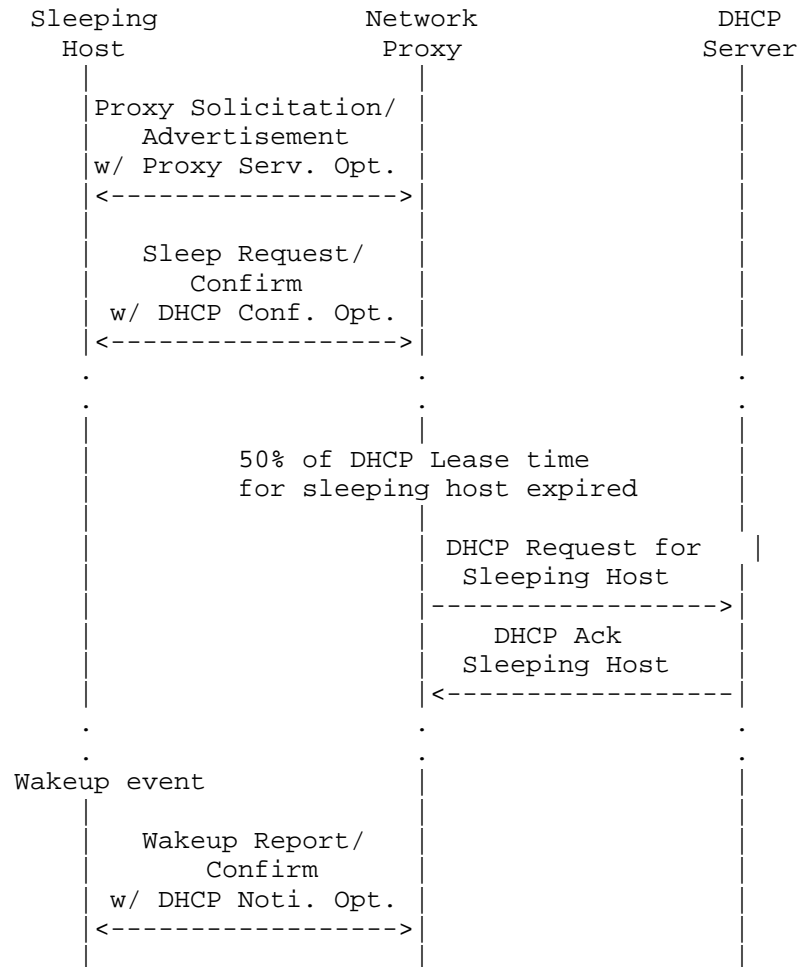


Figure 4: Network proxy operation for DHCP renewal success

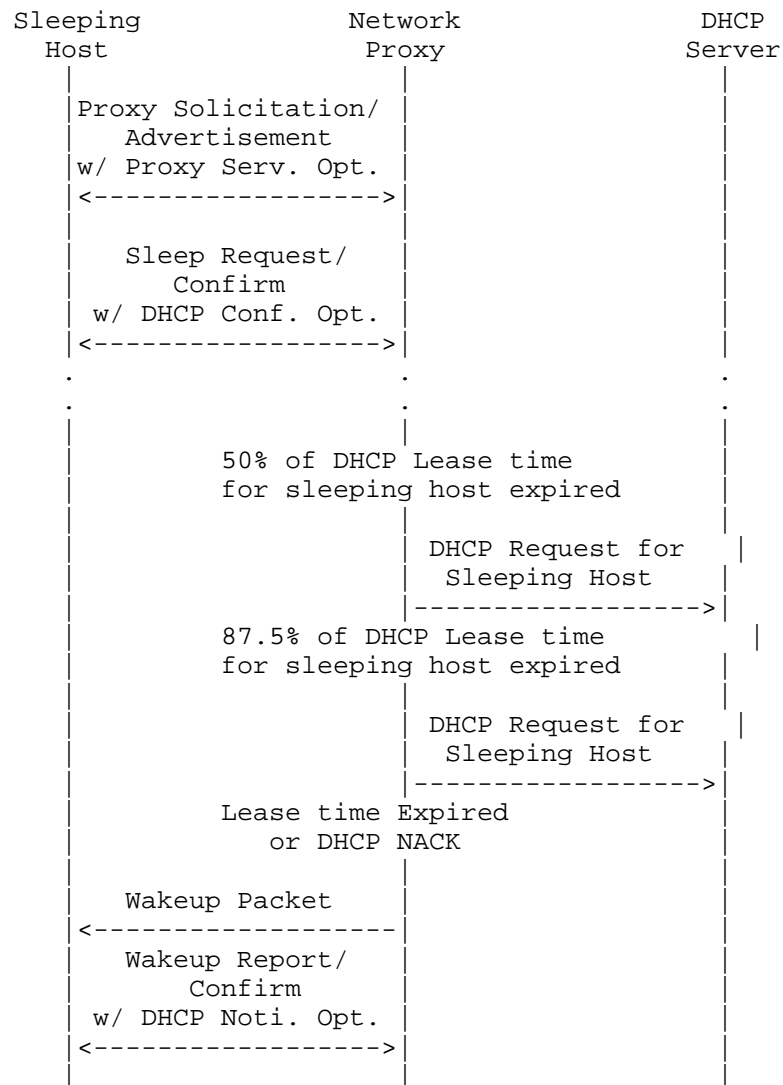


Figure 5: Network proxy operation for DHCP renewal failure

## 5. Message Formats

Figure 6 depicts a new ICMP message for Network Proxy operation. The message is defined as follows.

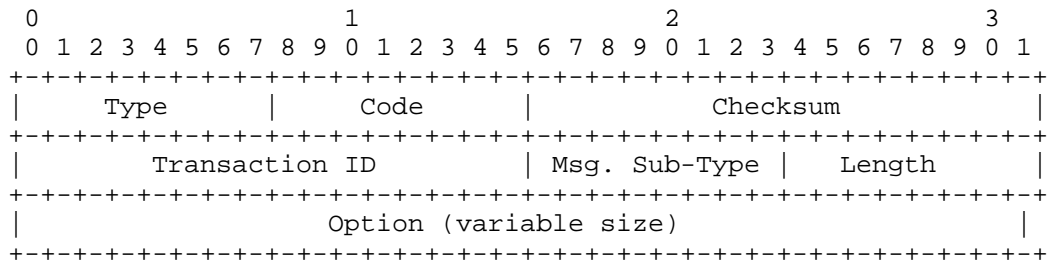


Figure 6: ICMP message for network proxy

Type	<TBD> (Network Proxy Request)
Code	0 Success 1 Fail
Checksum	The 16-bit one's complement of the one's complement sum of the ICMP message, starting with the ICMP Type.
Message Sub-Type	1 Proxy Solicitation Message 2 Proxy Advertisement Message 3 Sleep Request Message 4 Sleep Confirm Message 5 Wakeup Report Message 6 Wakeup Confirm Message
Transaction ID	Unique identifier created each time a host starts proxy operation
Options	Options for Sub-Type messages

Figure 7 shows the Option format for Sub-Type messages. The Option format is defined as a TLV format.

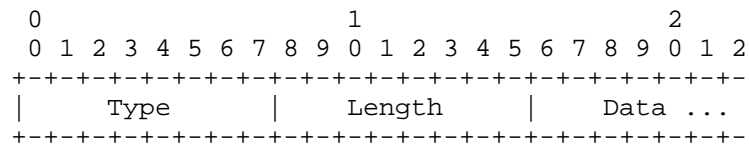


Figure 7: Option format

Type	Indicates the particular sub-type option.
------	---



	1 Proxy Solicitation Option 2 Proxy Advertisement Option 3 Sleep Request Option 4 Sleep Confirm Option 5 Wake-up Report Option 6 Wake-up Confirm Option
Length	Indicates the length (in bytes) of the data field within this option. The length does not include the Type and Length bytes.
Data	The particular data associated with this option. This field may be zero or more bytes in length. The format and length of the data field is determined by the type and length fields.

### 5.1. Proxy Solicitation Message

A host that wants to go into sleeping model sends a Proxy Solicitation message to discover a network proxy in the host's network. Proxy Solicitation message contains Proxy Solicitation Option shown in Figure 8. It contains 2 bytes Identifier and 2 bytes sequence number.

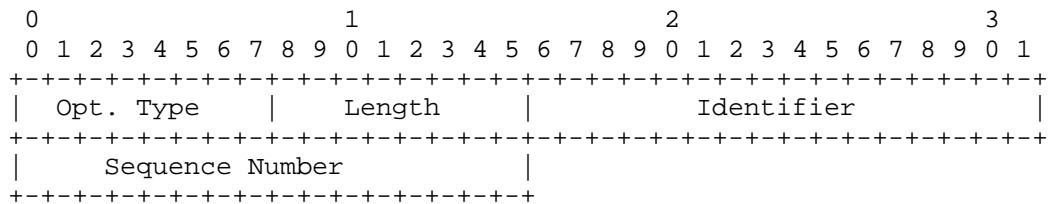


Figure 8: Proxy solicitation option

### 5.2. Proxy Advertisement Message

Proxy Advertisement message is used for notifying the Proxy Server's presence in network and it is periodically broadcasted to networks and unicasted to a network node that sent a Proxy Solicitation message. Proxy Advertisement message it can contain two options, Proxy Advertisement Option and Proxy Service Option. Figure 9 shows format for Proxy Advertisement Option that contains the address of Proxy Server's IP address(es) and Preference(s).

0										1										2										3									
0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1								
Opt. Type										Length										Num. of Addr										Addr Entry Size									
										Lifetime										Proxy Address 1																			
										Proxy Address 1										Address Preference 1																			
										Address Preference 1										Proxy Address 2																			
										Proxy Address 2										Address Preference 2																			
										Address Preference 2										...																			

Figure 9: Proxy advertisement option

Figure 10 indicates Proxy Service Option format that contains the list of services and protocols supported by a proxy server. Service Type indicate the mandatory and optional protocols specified in [PROXZZZY]

Type Indicates the service types supported by network proxy in this document.

- 1 IPv4 ARP
- 2 DHCPv4
- 3 ...

0										1										2										3									
0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1								
Opt. Type										Length										Service Type 1																			
										...										Service Type N																			

Figure 10: Proxy service option

### 5.3. Sleep Request Message

Sleep Request Message is unicasted to Network Proxy Server and it informs the host's entering to sleep mode. It also includes the host's context information for proxied sprotocols. Figure 11 shows Sleep Request option header format. Request Option Type indicates the type of service or protocol to be proxied.

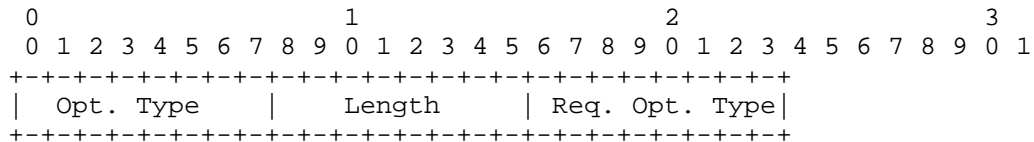


Figure 11: Sleep request option header format

#### 5.3.1. IPv4 ARP Configuration Option

Figure 12 shows the format of IPv4 ARP Configuration Option included within Sleep Request Option. Hardware Address Type and Protocol Type indicate the hardware address type and the protocol address type of ARP entry sleeping host's ARP table. Hardware Length and Protocol Length indicate the length of hardware address and protocol address of sleeping host. Number of addresses indicates the number of hardware and protocol pairs.

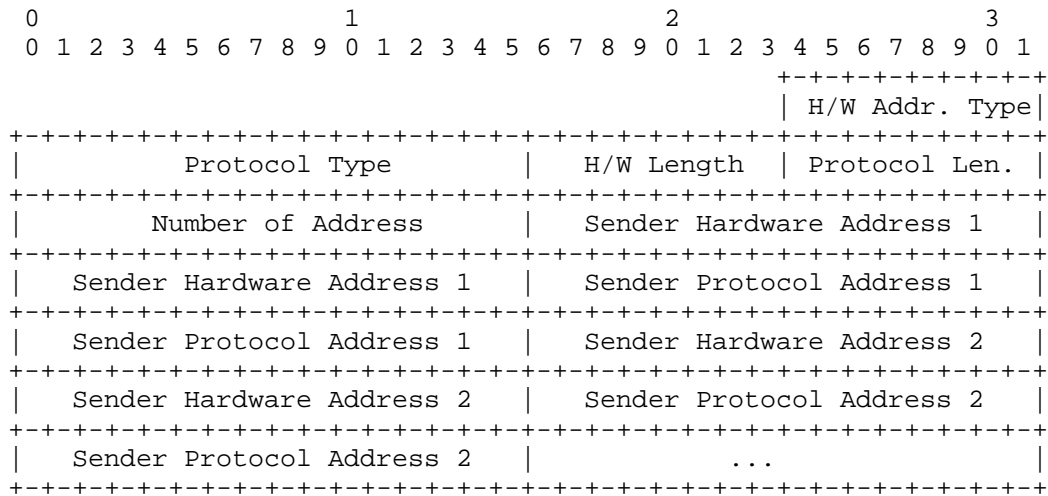


Figure 12: IPv4 ARP configuration option

### 5.3.2. DHCP Configuration Option

Figure 13 shows the format of DHCP Configuration Option included within Sleep Request Option. Total Lease Time and Lease Time Left indicate the total address lease time and remaining address lease time in seconds. DHCP Server IP Address indicates the IPv4 address of DHCP server.

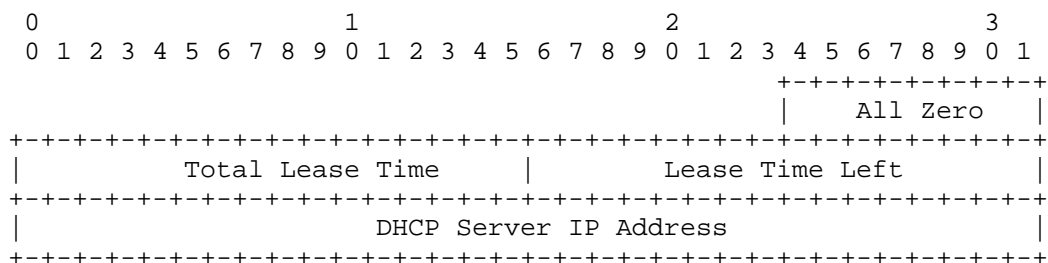


Figure 13: DHCP Configuration Option

### 5.4. Sleep Confirm Message

Figure 14 describes the format for Sleep Confirm message that is sent from a Proxy Server to Client as a response of Sleep Request message. Sleep Confirm message contains Sleep Confirm Option. Code indicates

the result of Sleep Request operation. 0 indicates success and 1 indicates failure. Client Identifier is a unique ID for identifying Client and will be allocated by Proxy Server.

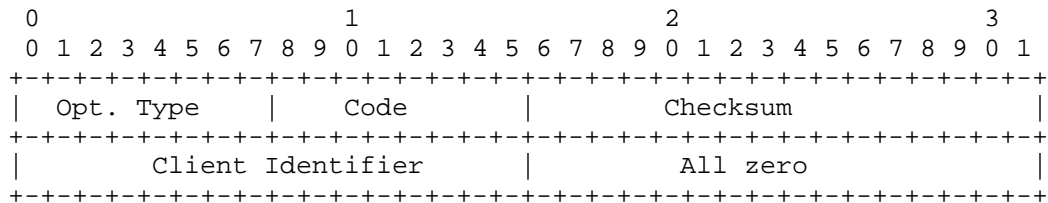


Figure 14: Sleep confirm option

#### 5.5. Wakeup Report Message

Figure 15 describes the format for Wakeup Report message that is sent by a client to Proxy Server in order to notify the wakeup event of the client. It is unicasted to the Proxy Server. Client Identifier is the same Identifier assigned by Sleep Confirm message.

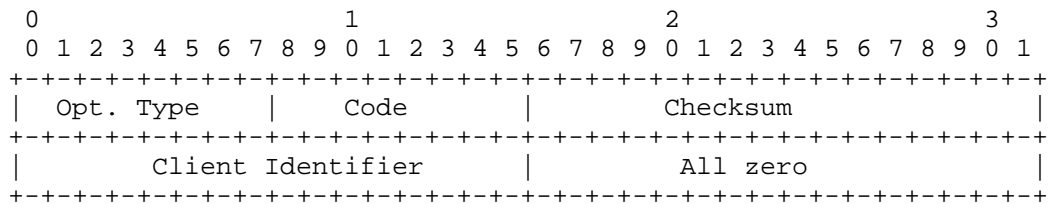


Figure 15: Wakeup report option

#### 5.6. Wakeup Confirm Message

Figure 16 shows the format for Wakeup Confirm message that is unicasted to a Client as a reply of the Client's Wakeup Report message. It contains Wakeup Confirm Option. Code 0 means success and 1 means failure. Client Identifier is the same Identifier assigned by Sleep Confirm message.

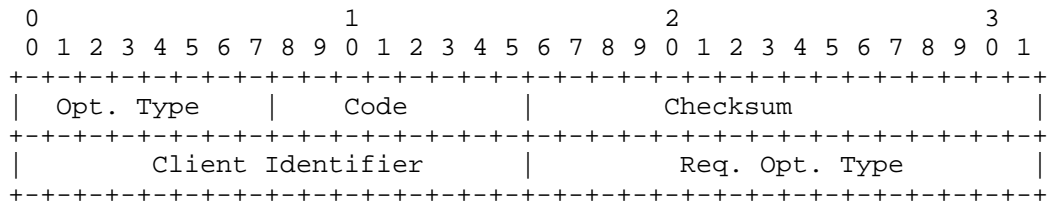


Figure 16: Wakeup confirm option

#### 5.6.1. DHCP Notification Option

Figure 17 describes the format for DHCP Notification Option included within Wakeup Confirm message. It is sent by a Proxy Server to the waken host in order to notify the DHCP lease time information to the host. It is unicasted to the host.

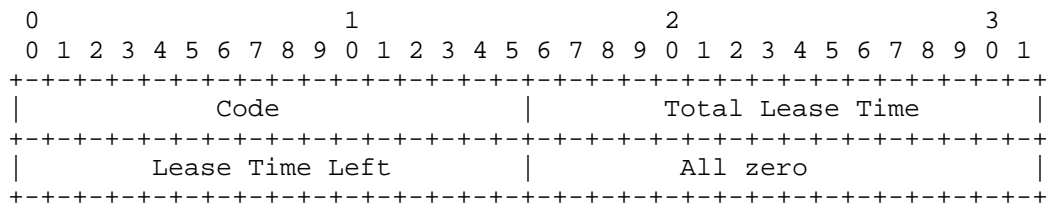


Figure 17: DHCP notification option

Code        1: DHCP Renewal Success  
              2: DHCP Renewal Failure

#### 6. Usecases of Network Proxy

[TBD]

#### 7. Security Considerations

[TBD]

#### 8. IANA Considerations

[TBD]

## 9. References

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## Abstract

This memo defines a portion of the Management Information Base (MIB), the GreenUsage MIB, for use with network management protocols in the Internet community. In particular, the GreenUsage MIB can be used to monitor the power-on/power-off status of electrical devices.

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## 1. The Internet-Standard Management Framework

For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to section 7 of RFC 3410 [RFC3410].

Managed objects are accessed via a virtual information store, termed the Management Information Base or MIB. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP).

Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This memo specifies a MIB module that is compliant to the SMIV2, which is described in STD 58, RFC 2578 [RFC2578], STD 58, RFC 2579 [RFC2579] and STD 58, RFC 2580 [RFC2580].

## 2. Overview

### 2.1. The GreenUsage monitoring concept

Monitor the power-on/power-off status of electrical devices. If a device is in power-on state beyond business hours, it is wasteful usage of electricity. The GreenUsage concept aims to monitor and reduce this wastage.

The GreenUsage-MIB is simple and easy to use and develop. The GreenUsage-MIB aims to reduce the wastage of existing network systems in easy way. The GreenUsage-MIB is a simple structure, but ALL connected devices can be monitored based on their network activity.

This document defines a set of managed objects (MOs) that can be used to monitor the power-on/power-off status of electrical devices.

### 2.2. Terminology

Electrical device: a device that consumes electricity. Power-on/power-off status indicates whether the device is powered on or not. Often it is not possible to get a direct indication of whether a device is powered on or not. But indirect means may be used to infer the power-on/power-off status of a device. For example, if a device shows some network activity, it can be inferred that the device is powered on. Note that it is difficult to infer that a device is powered off. Also, there may be several states between power-on and power-off e.g. sleep state, power-saving state etc.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14, RFC 2119 [RFC2119].

### 3. GreenUsage Monitoring Requirements

Multiple mechanisms may be used to determine whether a device is powered on or not. The mechanisms will depend on the nature of the device. Since the number of devices may be very large, the identification, usage type, and location of devices needs to be addressed with care.

### 4. MIB Design

The basic principle has been to keep the MIB as simple as possible and at the same time to make it effective enough so that the essential needs of monitoring are met.

The GreenUsage-MIB is composed of the following

- device Table: a list of the devices that will be monitored
- deviceStatus Table: the power-on/power-off status of the devices

## 5. MIB Definitions

## 5.1. The GreenUsage MIB

```
GREENUSAGE-MIB DEFINITIONS ::= BEGIN
    IMPORTS
        MODULE-IDENTITY, mib-2, Unsigned32, OBJECT-TYPE
            FROM SNMPv2-SMI -- RFC 2578
        TimeStamp, MacAddress, TEXTUAL-CONVENTION
            FROM SNMPv2-TC -- RFC 2579
        MODULE-COMPLIANCE, OBJECT-GROUP
            FROM SNMPv2-CONF -- RFC 2580
        SnmpAdminString
            FROM SNMP-FRAMEWORK-MIB
    ;

greenUsageMIB MODULE-IDENTITY
    LAST-UPDATED "201401120000Z" -- 12th January, 2014
    ORGANIZATION "PREDICT Working Group"
    CONTACT-INFO
        "
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DESCRIPTION

"This MIB module is for monitoring the power-on/power-off  
status of electrical devices.

Copyright (C) The IETF Trust (2012). This version of  
this MIB module is part of RFC XXXX; see the RFC itself for  
full legal notices.

"

-- RFC Ed.: replace XXXX with the actual RFC number & remove this  
-- note

```
REVISION "201401120000Z"      -- 11th January, 2014
DESCRIPTION
    "added deviceMonitoring to GumStatusDetectionMethod"
REVISION "201301080000Z"      -- 8th January, 2013
DESCRIPTION
    "added gumDevUsageCreatedTimeStamp to usage table"

REVISION "201207070000Z"      -- 7th July, 2012
DESCRIPTION
    "The initial version, published as draft-suganuma-greenmib-00.txt"
```

```
-- RFC Ed.: replace XXXX with the actual RFC number & remove this
-- note
```

```
::= { mib-2 YYY1 }      -- Will be assigned by IANA
```

```
-- IANA Reg.: Please assign a value for "YYY1" under the
-- 'mib-2' subtree and record the assignment in the SMI
-- Numbers registry.
```

```
-- RFC Ed.: When the above assignment has been made, please
--     remove the above note
--     replace "YYY1" here with the assigned value and
--     remove this note.
```

```
-- -----
-- Textual Conventions
-- -----
```

```
GumStatusDetectionMethod ::= TEXTUAL-CONVENTION
    STATUS current
    DESCRIPTION
        "The object specifies the technology which is used
        to detect the power-on/power-off status of a device.
        The enumerated values and the corresponding
        technology are as follows:
        reserved                (0): reserved (Not used)
        arpSensing              (1): arp packets from the
                                device
        neighborDiscoverySensing (2): neighbor discovery
                                packets from the device
        icmpEchoProbing         (3): ICMP echo packets
        switchMonitoring        (4): switch monitoring
        deviceMonitoring        (5): the direct monitoring of
                                device status such as CPU
                                load and memory usage
```

```

"
SYNTAX  INTEGER
{
    reserved                (0),
    arpSensing               (1),
    neighborDiscoverySensing (2),
    icmpEchoProbing          (3),
    switchMonitoring         (4),
    deviceMonitoring         (5)
}

GumDeviceStatus ::= TEXTUAL-CONVENTION
    STATUS current
    DESCRIPTION
        "The object represents the power-on/power-off
        status of a monitored device.
        unknown                (0)
        powerOn                (1): device is powered on
        powerOff               (2): device is powered off
        sleepMode              (3): device is in sleep mode
        powerSavingMode        (4): device is in
                                powersaving mode
"
SYNTAX  INTEGER
{
    unknown                (0),
    powerOn                (1),
    powerOff               (2),
    sleepMode              (3),
    powerSavingMode        (4)
}

-- The GREENUSAGE MIB has the following 3 primary groups

gumNotifications OBJECT IDENTIFIER ::= { greenUsageMIB 0 }
gumObjects        OBJECT IDENTIFIER ::= { greenUsageMIB 1 }
gumConformance    OBJECT IDENTIFIER ::= { greenUsageMIB 2 }

gumDeviceTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF GumDeviceEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table models the device list

        Entries in this table are required to survive
        a reboot of the managed entity.
"

```



```
 ::= { gumObjects 1 }

gumDeviceEntry OBJECT-TYPE
    SYNTAX      GumDeviceEntry
    MAX-ACCESS   not-accessible
    STATUS      current
    DESCRIPTION
        "This entry represents a conceptual row in the
        gumDevice table. It represents a device that
        will be monitored for power-on/power-off status.
        "
    INDEX { gumDeviceID }
    ::= { gumDeviceTable 1 }

GumDeviceEntry ::=
    SEQUENCE {
        gumDeviceID      Unsigned32,
        gumDeviceName     SnmpAdminString,
        gumDeviceMacAddress  MacAddress,
        gumDeviceType     SnmpAdminString,
        gumDeviceLocation  SnmpAdminString
    }

gumDeviceID OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS   not-accessible
    STATUS      current
    DESCRIPTION
        "A unique arbitrary identifier for this device."
    ::= { gumDeviceEntry 1 }

gumDeviceName OBJECT-TYPE
    SYNTAX      SnmpAdminString (SIZE(1..64))
    MAX-ACCESS   read-create
    STATUS      current
    DESCRIPTION
        "Administratively assigned textual name of this
        device."
    ::= { gumDeviceEntry 2 }

gumDeviceMacAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS   read-only
    STATUS      current
    DESCRIPTION
        "MAC Address of this device.
        If there is no MAC address, this object will be
        inaccessible."
```

```

 ::= { gumDeviceEntry 3 }

gumDeviceType OBJECT-TYPE
    SYNTAX      SnmpAdminString (SIZE(1..64))
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "Administratively assigned textual description about
         usage type of this device."
    ::= { gumDeviceEntry 4 }

gumDeviceLocation OBJECT-TYPE
    SYNTAX      SnmpAdminString (SIZE(1..64))
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "Administratively assigned textual location
         name of this device."
    ::= { gumDeviceEntry 5 }

gumDevUsageTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF GumDevUsageEntry
    MAX-ACCESS   not-accessible
    STATUS       current
    DESCRIPTION
        "This table models the device usage status

         Entries in this table are required to survive
         a reboot of the managed entity.
        "
    ::= { gumObjects 2 }

gumDevUsageEntry OBJECT-TYPE
    SYNTAX      GumDevUsageEntry
    MAX-ACCESS   not-accessible
    STATUS       current
    DESCRIPTION
        "This entry represents a conceptual row in the
         gumDevUsage table. It represents a power-on/power-off
         status of a monitored device.
        "
    INDEX { gumDeviceID, gumDevUsageDetID }
    ::= { gumDevUsageTable 1 }

GumDevUsageEntry ::=
    SEQUENCE {
        gumDevUsageDetID          GumStatusDetectionMethod,
        gumDevUsageDetStatus      GumDeviceStatus,

```

```
        gumDevUsageDetTimeStamp      TimeStamp,
        gumDevUsageCreatedTimeStamp TimeStamp
    }

gumDevUsageDetID OBJECT-TYPE
    SYNTAX      GumStatusDetectionMethod
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The detection method by which the usage status is
         computed."
    ::= { gumDevUsageEntry 1 }

gumDevUsageDetStatus OBJECT-TYPE
    SYNTAX      GumDeviceStatus
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "the usage status of the device."
    ::= { gumDevUsageEntry 2 }

gumDevUsageDetTimeStamp OBJECT-TYPE
    SYNTAX      TimeStamp
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "the time at which the usage status of the
         device was computed."
    ::= { gumDevUsageEntry 3 }

gumDevUsageCreatedTimeStamp OBJECT-TYPE
    SYNTAX      TimeStamp
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "the time at which the entry of usage table created."
    ::= { gumDevUsageEntry 4 }

-- Units of conformance
gumGroups      OBJECT IDENTIFIER ::= { gumConformance 1}
gumCompliances OBJECT IDENTIFIER ::= { gumConformance 2}

gumObjectsGroup OBJECT-GROUP
    OBJECTS {
        gumDeviceName,
        gumDeviceMacAddress,
        gumDeviceType,
        gumDeviceLocation,
```

```
        gumDevUsageDetStatus,
        gumDevUsageDetTimeStamp,
        gumDevUsageCreatedTimeStamp
    }
    STATUS current
    DESCRIPTION
        " A collection of objects for basic GreenUsage
        monitoring."
    ::= { gumGroups 1 }

-- Compliance statements
gumCompliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "The compliance statement for SNMP entities
        which implement the GREENUSAGE-MIB
        "
    MODULE -- this module
        MANDATORY-GROUPS { gumObjectsGroup
        }
    ::= { gumCompliances 1 }

END
```

## 6. Security Considerations

There are no management objects defined in this MIB module with a MAX-ACCESS clause of read-write.

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. These are the tables and objects and their sensitivity/vulnerability:

- gumDeviceName,
- gumDeviceMacAddress,
- gumDeviceType,
- gumDeviceLocation,
- gumDevUsageDetStatus,
- gumDevUsageDetTimeStamp,
- gumDevUsageCreatedTimeStamp

The above objects may be used to identify users and their activities. Thus these objects may be considered to be particularly sensitive and/or private.

SNMP versions prior to SNMPv3 did not include adequate security. Even if the network itself is secure (for example by using IPsec), even then, there is no control as to who on the secure network is allowed to access and GET/SET (read/change/create/delete) the objects in this MIB module.

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 this MIB module is properly configured to give access to the objects only to those principals (users) that have legitimate rights to indeed GET or SET (change/create/delete) them.

## 7. IANA Considerations

IANA should assign

1. a base arc in the 'mib-2' (standards track) OID tree for the 'greenUsageMIB' MODULE-IDENTITY defined in the GREENUSAGE-MIB.

## 8. References

### 8.1. Normative References

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- [RFC2863] McCloghrie, K., and Kastenholz., F., The Interfaces Group MIB, RFC 2863, June 2000.

### 8.2. Informative References

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## 9. Acknowledgements

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