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Power and Energy Monitoring MIB
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Status of this Memo

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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 Unsigned32       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 PowerStateSet    eoPowerAdminState(8)
  |   +-- r-n PowerStateSet    eoPowerOperState(9)
  |   +-- r-n OwnerString      eoPowerStateEnterReason(10)
  |
  |
  +---eoPowerStateTable(3)
  |
```

```
     |      +--eoPowerStateEntry(1)
```

```
     |      |     [entPhysicalIndex, eoPowerStateIndex]
     |      |
     |      +-- --n PowerStateSet 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)
     |   +-- rwn TimeInterval   eoEnergyParametersIntervalLength(3)
     |   +-- rwn Unsigned32     eoEnergyParametersIntervalNumber(4)
     |   +-- rwn INTEGER        eoEnergyParametersIntervalMode(5)
     |   +-- rwn TimeInterval   eoEnergyParametersIntervalWindow(6)
     |   +-- rwn Unsigned32     eoEnergyParametersSampleRate(7)
     |   +-- rwn StorageType    eoEnergyParametersStorageType(8)
     |   +-- rwn RowStatus      eoEnergyParametersStatus(9)
     |
     +eoEnergyTable(5)
     |
     +---eoEnergyEntry(1)
     |    [eoEnergyParametersIndex,eoEnergyCollectionStartTime]
     |
     |   +-- r-n TimeTicks      eoEnergyCollectionStartTime(1)
     |   +-- r-n Unsigned32     eoEnergyConsumed(2)
     |   +-- r-n Unsigned32     eoEnergyProvided(3)
     |   +-- r-n Unsigned32     eoEnergyStored(4)
     |   +-- r-n UnitMultiplier eoEnergyUnitMultiplier(5)
     |   +-- r-n Integer32      eoEnergyAccuracy(6)
     |   +-- r-n Unsigned32     eoEnergyMaxConsumed(7)
     |   +-- r-n Unsigned32     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.

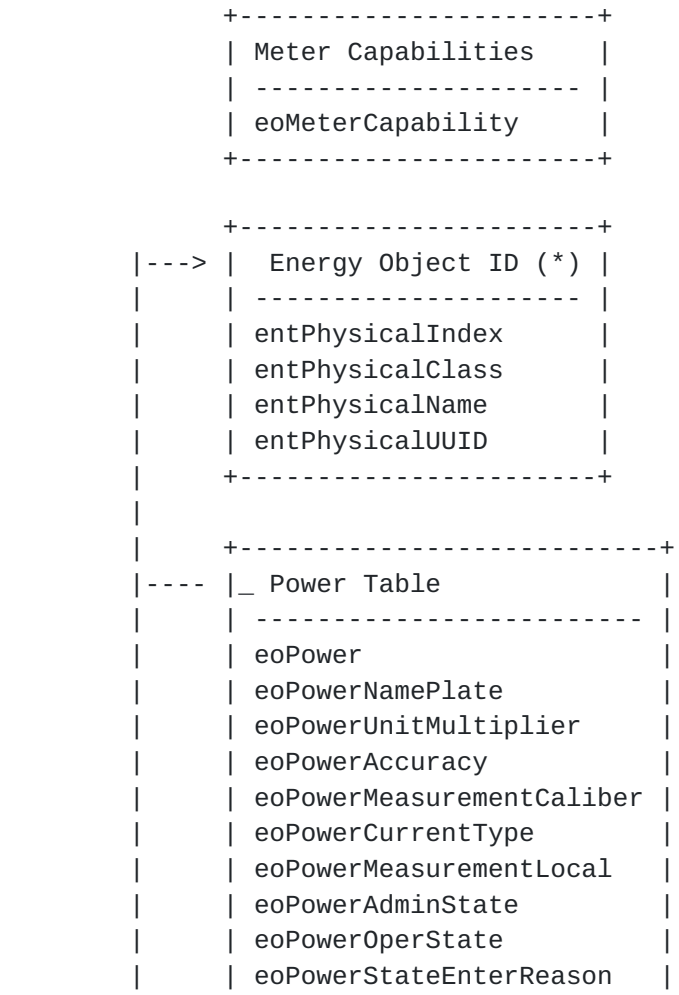
```
eoACPwrAttributesTable(1)
  |
  +---eoACPwrAttributesEntry(1) [ entPhysicalIndex]
  |   |
  |   +---r-n INTEGER    eoACPwrAttributesConfiguration(1)
  |   +-- r-n Integer32  eoACPwrAttributesAvgVoltage(2)
  |   +-- r-n Unsigned32 eoACPwrAttributesAvgCurrent(3)
  |   +-- r-n Integer32  eoACPwrAttributesFrequency(4)
  |   +-- 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)
```

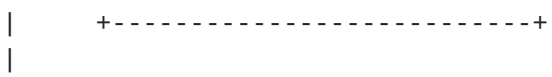
```
     |     +-- r-n Integer32
     |     |     eoACPwrAttributesWyePhaseToNeutralVoltage(2)
```

```
|     +-- 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.





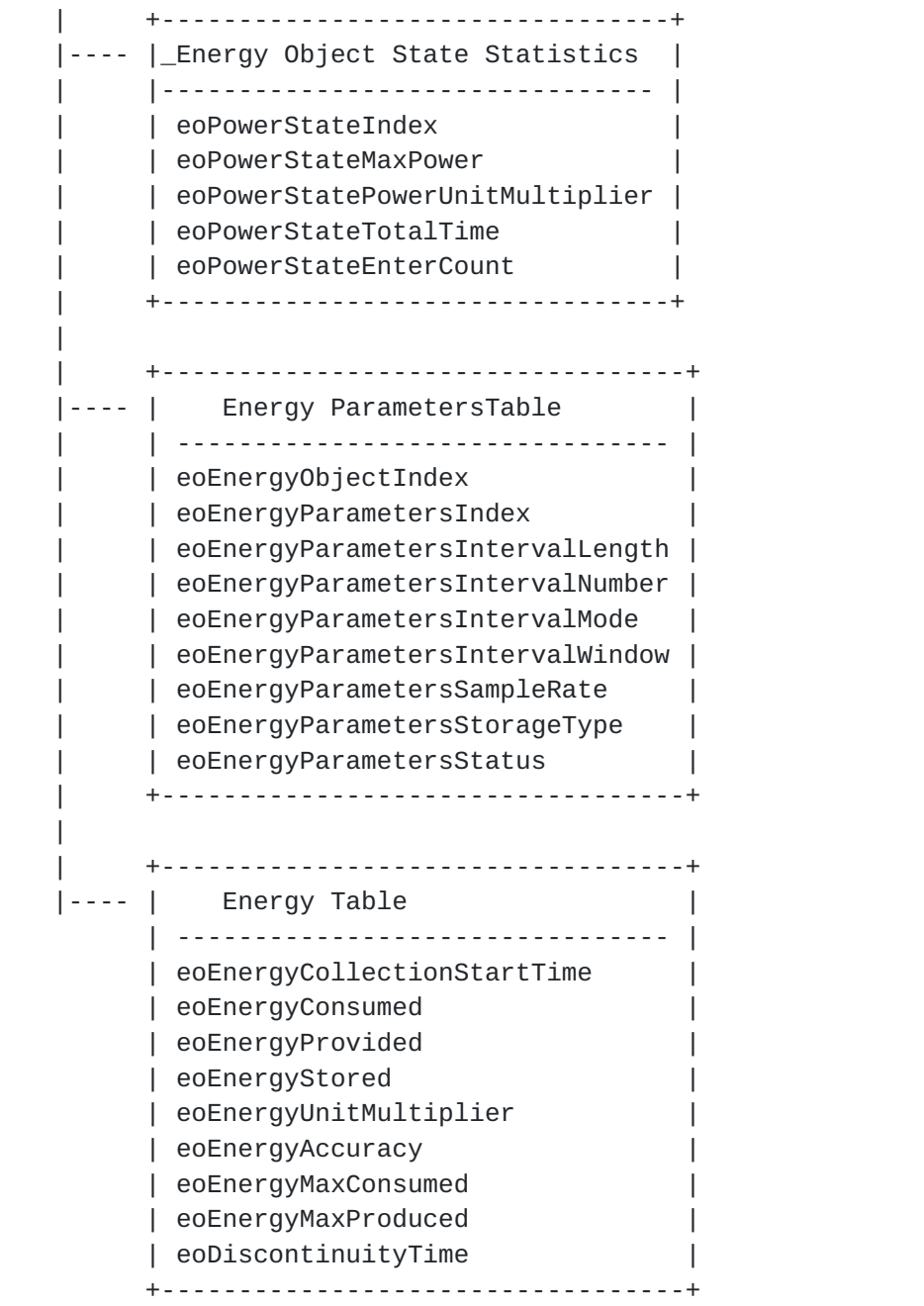
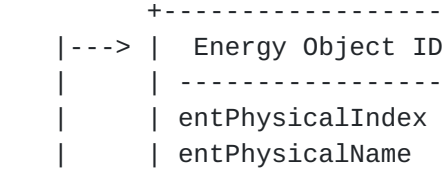


Figure 1:UML diagram for energyObjectMib

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



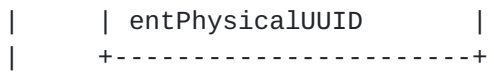

| entPhysicalUUID |

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 indicates 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. The Power State Sets are specified by the PowerStateSet Textual as an IANA-maintained MIB module. The initial version of this MIB module is specified in this document.

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 oACPwrAttributesPowerUnitMultiplier.

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. 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. Demand information can be represented. The eoEnergyParametersTable consists of the parameters defining

eoEnergyParametersIndex - an index for the 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.

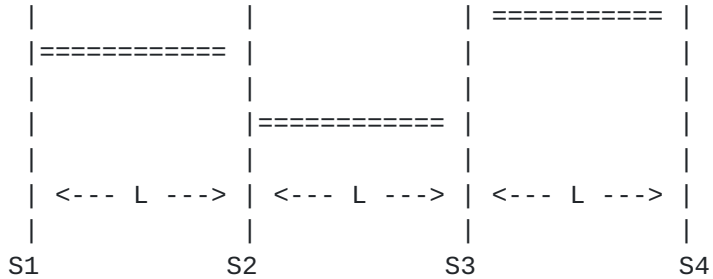


Figure 3 : Period eoEnergyParametersIntervalMode

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, ...

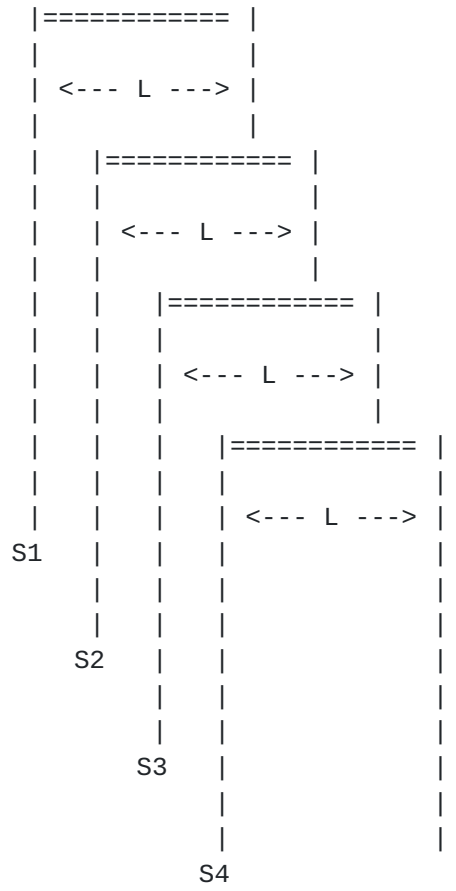


Figure 4 : Sliding eoEnergyParametersIntervalMode

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

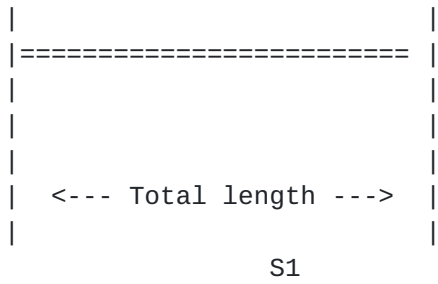


Figure 5 : Total eoEnergyParametersIntervalMode

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. Finally, the eoEnergyParametersStorageType variable indicates the storage type for this row, i.e. whether the persistence is maintained across a device reload.

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 eoEnergyComsumed 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.

The MIB module may 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 eoPowerUnitMultipler 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 eoPowerUnitMultipler 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 the energyObjectMib 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 eoEnergyTable to describe energy measurement information over time.

An Energy Object may contain an optional eoACPwrAttributesTable table (specified in the POWER-ATTRIBUTES-MIB module) that describes the electrical characteristics associated with the current Power State and usage.

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

9. MIB Definitions

9.1. The IANAPowerStateSet-MIB MIB Module

```
-- ************************************************************
--
--
-- This MIB, maintained by IANA, contains a single Textual
-- Convention: PowerStateSet
--
-- ************************************************************

IANAPowerStateSet-MIB DEFINITIONS ::= BEGIN

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

ianaPowerStateSet MODULE-IDENTITY
    LAST-UPDATED    "201406070000Z"    -- 07 June 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 the PowerStateSet Textual
          Convention, which specifies the Power State Sets and
          Power State Set Values an Energy Object supports

          Copyright (C) The IETF Trust (2014).
          The initial version of this MIB module was published in
          RFC YYY; for full legal notices see the RFC itself.

          Supplementary information may be available at
          http://www.ietf.org/copyrights/ianamib.html"

      -- revision history

      REVISION "201406070000Z"     -- 07 June 2014
      DESCRIPTION
          "Initial version of this MIB module, as published as RFC
          XXXX."

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

     ::= { mib-2 xxx }


  PowerStateSet ::= 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.

          Requests for new values should be made to IANA via email
          (iana&iana.org)."

      REFERENCE
```

```
          "http://www.iana.org/assignments/power-state-sets"

       SYNTAX      INTEGER {
           other(0),        -- indicates other set
           unknown(255),    -- unknown

           ieee1621(256),    -- indicates IEEE1621 set
           ieee1621Off(257),
           ieee1621Sleep(258),
           ieee1621On(259),

           dmtf(512),        -- indicates DMTF set
           dmtfOn(513),
           dmtfSleepLight(514),
           dmtfSleepDeep(515),
           dmtfOffHard(516),
           dmtfOffSoft(517),
           dmtfHibernate(518),
           dmtfPowerOffSoft(519),
           dmtfPowerOffHard(520),
           dmtfMasterBusReset(521),
           dmtfDiagnosticInterrapt(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)

                }
      END
```

9.2. The ENERGY-OBJECT-MIB MIB Module

```
   -- ************************************************************
   --
   --
```

```
   -- 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, Unsigned32, TimeTicks
           FROM SNMPv2-SMI
       TEXTUAL-CONVENTION, RowStatus, TimeInterval,
       TimeStamp, TruthValue, StorageType
           FROM SNMPv2-TC
       MODULE-COMPLIANCE, NOTIFICATION-GROUP, OBJECT-GROUP
           FROM SNMPv2-CONF
       OwnerString
         FROM RMON-MIB
       entPhysicalIndex
          FROM ENTITY-MIB
       PowerStateSet
          FROM IANAPowerStateSet-MIB;

   energyObjectMib MODULE-IDENTITY
       LAST-UPDATED    "201406070000Z"     -- 07 June 2014

       ORGANIZATION    "IETF EMAN Working Group"
       CONTACT-INFO
               "WG charter:
               http://datatracker.ietf.org/wg/eman/charter/

             Mailing Lists:
                General Discussion: eman@ietf.org

                To Subscribe:
                https://www.ietf.org/mailman/listinfo/eman

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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 "201406070000Z"     -- 07 June 2014
```

```
       DESCRIPTION
          "Initial version, published as RFC XXXX."
```

```
      ::= { mib-2 yyy }

   energyObjectMibNotifs OBJECT IDENTIFIER
       ::= { energyObjectMib 0 }

   energyObjectMibObjects OBJECT IDENTIFIER
       ::= { energyObjectMib 1 }

   energyObjectMibConform  OBJECT IDENTIFIER
       ::= { energyObjectMib 2 }


   -- Textual Conventions


   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^-3 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^-24
           zepto(-21),   -- 10^-21
           atto(-18),    -- 10^-18
           femto(-15),   -- 10^-15
           pico(-12),    -- 10^-12
           nano(-9),     -- 10^-9
           micro(-6),    -- 10^-6
           milli(-3),    -- 10^-3
           units(0),     -- 10^0
           kilo(3),      -- 10^3
           mega(6),      -- 10^6
           giga(9),      -- 10^9
           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                Unsigned32,
       eoPowerUnitMultiplier           UnitMultiplier,
       eoPowerAccuracy                 Integer32,
       eoPowerMeasurementCaliber       INTEGER,
       eoPowerCurrentType             INTEGER,
       eoPowerMeasurementLocal         TruthValue,
       eoPowerAdminState               PowerStateSet,
       eoPowerOperState                PowerStateSet,
       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          Unsigned32
       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 given in SI
          Watts 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)
       UNITS           "hundredths of percent"
       MAX-ACCESS      read-only
       STATUS          current
       DESCRIPTION
          "This object indicates a percentage value, in 100ths of a
          percent, representing the assumed accuracy of the usage
          reported by eoPower. For example: The value 1010 means
          the reported usage is accurate to +/- 10.1 percent.  This
          value is zero if the accuracy is unknown or not
          applicable based upon the measurement method.

          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"
       ::= { eoPowerEntry 4 }

   eoPowerMeasurementCaliber   OBJECT-TYPE
       SYNTAX          INTEGER  {
                           unavailable(1) ,
```

```
                    unknown(2),
                    actual(3) ,
```

```
                        estimated(4),
                        static(5)                    }
      MAX-ACCESS      read-only
      STATUS          current
      DESCRIPTION
         "This object specifies how the usage value reported by
         eoPower was obtained:

         - unavailable(1): Indicates that the usage is not
         available. In such a case, the eoPower value must be 0
         for devices that can not measure or report power this
         option can be used.

         - unknown(2): Indicates that the way the usage was
         determined is unknown. In some cases, entities report
         aggregate power on behalf of another device. In such
         cases it is not known whether the usage reported is
         actual, estimated or static.

         - actual(3):  Indicates that the reported usage was
         measured by the entity through some hardware or direct
         physical means. The usage data reported is not estimated
         or static but is the measured consumption rate.

         - estimated(4): Indicates that the usage was not
         determined by physical measurement. The value is a
         derivation based upon the device type, state, and/or
         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          PowerStateSet
       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/power-state-sets"
       ::= { eoPowerEntry 8 }

   eoPowerOperState OBJECT-TYPE
       SYNTAX          PowerStateSet
       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/power-state-sets>"
       ::= { 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              PowerStateSet,
    eoPowerStateMaxPower           INTEGER,
    eoPowerStatePowerUnitMultiplier  UnitMultiplier,
    eoPowerStateTotalTime            TimeTicks,
    eoPowerStateEnterCount            Counter32
}

eoPowerStateIndex OBJECT-TYPE
    SYNTAX          PowerStateSet
    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   Unsigned32,
       eoEnergyParametersIntervalMode     INTEGER,
       eoEnergyParametersIntervalWindow   TimeInterval,
       eoEnergyParametersSampleRate       Unsigned32,
       eoEnergyParametersStorageType      StorageType,
       eoEnergyParametersStatus           RowStatus
                               }

   eoEnergyParametersIndex OBJECT-TYPE
       SYNTAX           Integer32 (1..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          Unsigned32
       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          Unsigned32
      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 }

   eoEnergyParametersStorageType OBJECT-TYPE
       SYNTAX          StorageType
       MAX-ACCESS      read-create
       STATUS          current
       DESCRIPTION
           "This variable indicates the storage type for this row."
       DEFVAL { nonVolatile }
       ::= {eoEnergyParametersEntry 8 }

   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 9 }

    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                  Unsigned32,
         eoEnergyProvided                  Unsigned32,
         eoEnergyStored                    Unsigned32,
         eoEnergyUnitMultiplier            UnitMultiplier,
         eoEnergyAccuracy                  Integer32,
         eoEnergyMaxConsumed               Unsigned32,
         eoEnergyMaxProduced               Unsigned32,
         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          Unsigned32
```

```
        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          Unsigned32
        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          Unsigned32
        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          Unsigned32
       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          Unsigned32
       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."

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

       GROUP     energyObjectMibMeterCapabilitiesTableGroup
          DESCRIPTION "A compliant implementation does not
          have to implement."
       ::= { 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,
                           eoEnergyParametersStorageType,
                           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
```

9.3. The POWER-ATTRIBUTES-MIB MIB Module

```
-- ************************************************************
--
-- 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, Unsigned32
       FROM SNMPv2-SMI
    MODULE-COMPLIANCE,
    OBJECT-GROUP
        FROM SNMPv2-CONF
   UnitMultiplier
      FROM ENERGY-OBJECT-MIB
    entPhysicalIndex
       FROM ENTITY-MIB;

powerAttributesMIB MODULE-IDENTITY

    LAST-UPDATED   "201406070000Z"     -- 07 June 2014

    ORGANIZATION    "IETF EMAN Working Group"
    CONTACT-INFO
            "WG charter:
            http://datatracker.ietf.org/wg/eman/charter/

          Mailing Lists:
             General Discussion: 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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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 "201406070000Z"     -- 07 June 2014
        DESCRIPTION
           "Initial version, published as RFC XXXX"
       ::= { mib-2 zzz }


   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          Unsigned32,
```

```
       eoACPwrAttributesFrequency           Integer32,
```

```
       eoACPwrAttributesPowerUnitMultiplier UnitMultiplier,
       eoACPwrAttributesPowerAccuracy      Integer32,
       eoACPwrAttributesTotalActivePower    Integer32,
       eoACPwrAttributesTotalReactivePower  Integer32,
       eoACPwrAttributesTotalApparentPower  Integer32,
       eoACPwrAttributesTotalPowerFactor    Integer32,
       eoACPwrAttributesThdCurrent          Integer32,
       eoACPwrAttributesThdVoltage         Integer32
                            }

   eoACPwrAttributesConfiguration OBJECT-TYPE
       SYNTAX INTEGER {
                 sngl(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          Unsigned32
       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           "ten-thousandths"
        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 a dimensionless
           value between -1 and 1. A power factor of 1 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
           disortion 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           "ten-thousandths"
       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.  It is a
          dimensionless value between -1 and 1. 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
          disortion (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.

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
IANAPowerStateSet-MIB	{ mib-2 xxx }
energyObjectMIB	{ mib-2 yyy }
powerAttributesMIB	{ mib-2 zzz }

EDITOR'S NOTE (to be removed prior to publication): IANA is requested to assign a value for "yyy" and "zzz" 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 "yyy" and "zzz"(here and in the MIB module) with the assigned value and to remove this note.

12.1. IANAPowerStateSet-MIB module

This document defines the initial version of the IANA-maintained The initial set of Power State Sets are specified in [EMAN-FMWK]. IANA maintains a Textual Convention PowerStateSet in the IANAPowerStateSet-MIB module, with the initial set of Power State Sets and the Power States within those Power State Sets as proposed in the [EMAN-FMWK]. The current version of PowerStateSet Textual convention can be accessed http://www.iana.org/assignments/power-state-sets.

New Assignments (and potential deprecation) to Power State Sets shall be administered by IANA and the guidelines and procedures

are specified in [EMAN-FMWK], and will, as a consequence, the IANAPowerStateSet Textual Convention should be updated.

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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