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Monitoring and Control MIB for Power and Energy

Abstract

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

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 5741.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc7460.

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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" [RFC7326], 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.

1.1. 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].

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 [RFC7326] for the definitions of the following terminology used in this document.

- 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 [RFC7326] 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 [RFC7326].

The Energy Monitoring MIB has two 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 document is presented. The meaning of the three symbols 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.

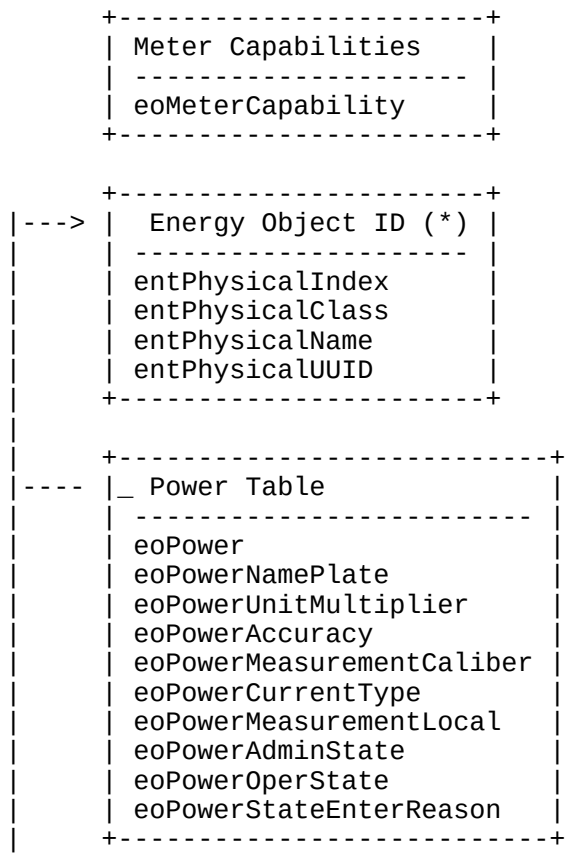
The third table is the eoACPwrAttributesWyePhaseTable. For each Energy Object, it reports information and statistics about the supported Power States. The eoPowerStateTable is indexed by entPhysicalIndex and eoPowerStateIndex.


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 Unified Modeling Language (UML) diagram representation of the MIB objects in the two MIB modules, ENERGY-OBJECT-MIB and POWER-ATTRIBUTES-MIB, is presented.



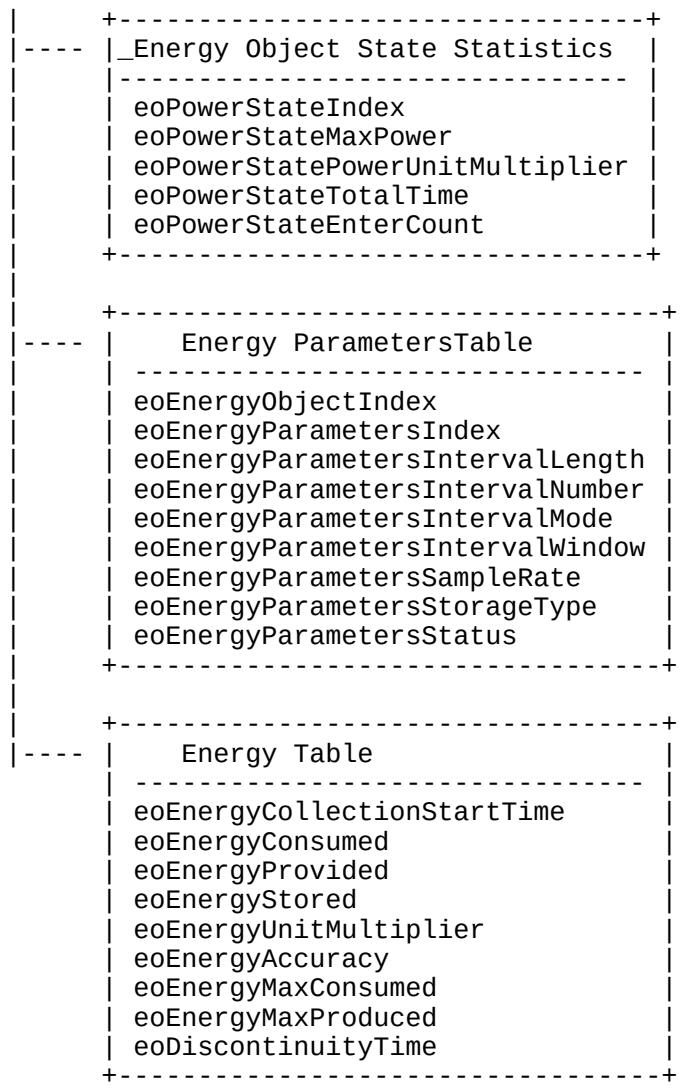


Figure 1: UML Diagram for energyObjectMib

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

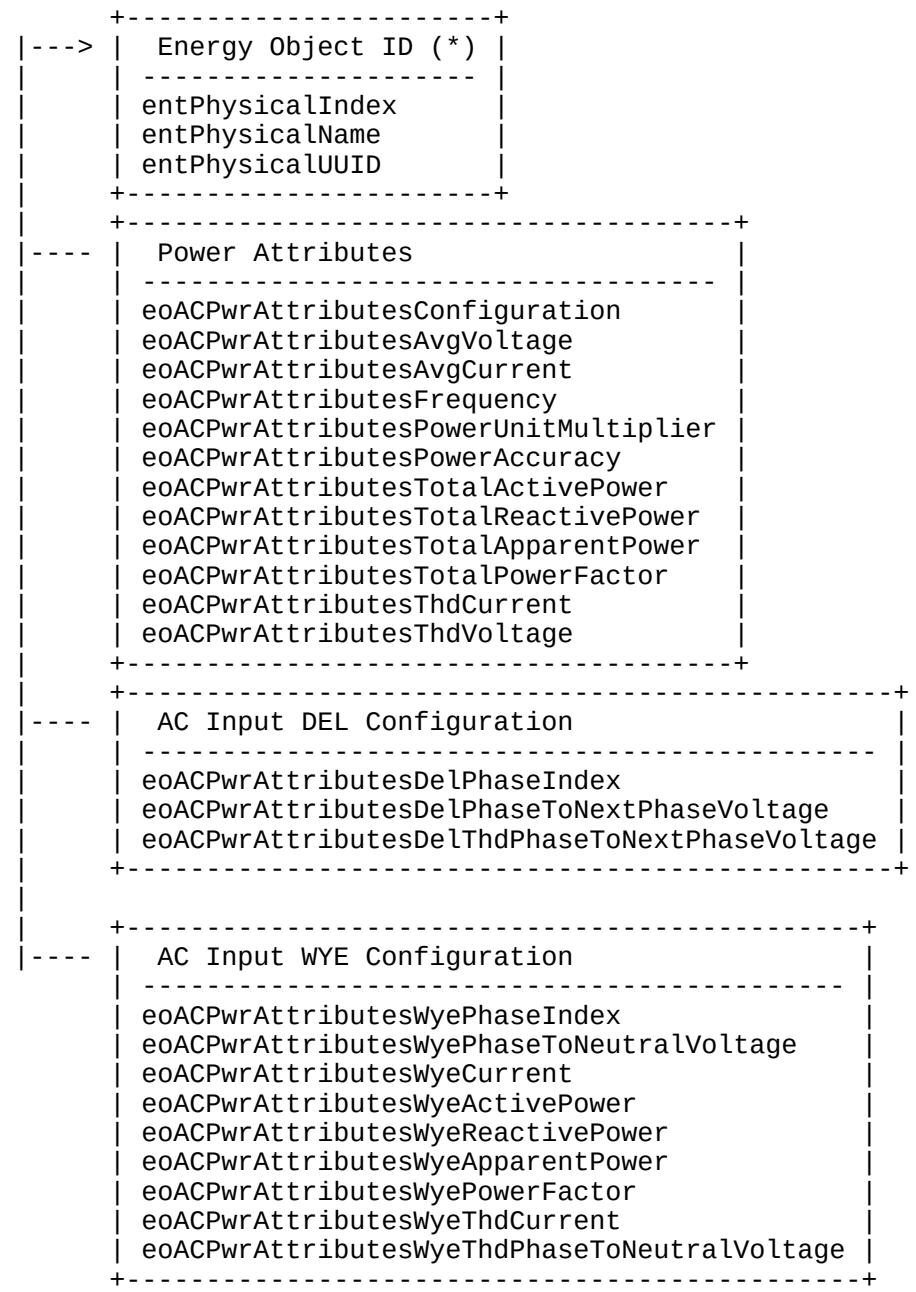


Figure 2: UML Diagram for the POWER-ATTRIBUTES-MIB

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

5.2. Energy Object Identity

The Energy Object identity information is specified in the ENERGY-OBJECT-CONTEXT-MIB module [RFC7461] 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 [RFC7461].

5.3. Power State

An Energy Object may have energy-conservation modes called "Power States". There may be several intermediate energy-saving modes between the ON and OFF states of a device.

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 a 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.

eoPowerStateTable 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, eoPowerStateTable 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)     - [RFC7326]
```

The Power State Sets are listed in [RFC7326] along with each Power State within the Power Set. The Power State Sets are specified by the PowerStateSet Textual Convention (TC) 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 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 units of measure (where SI is the International System of Units). 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. A Network Management System (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 that 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 attributes usage measurement. The POWER-ATTRIBUTES-MIB module is aligned with the IEC 61850 7-2 standard to describe alternating current (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), frequency, power accuracy, total active/reactive power/apparent power, amperage, and voltage.

In case of three-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 [IEC.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, 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.

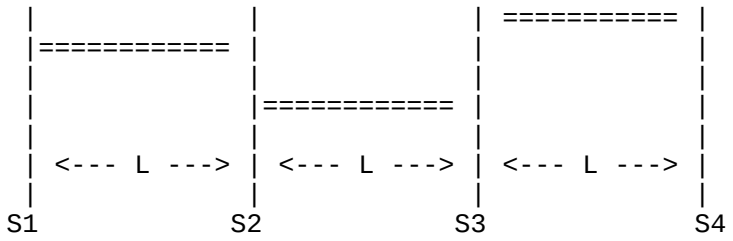


Figure 3: Period eoEnergyParametersIntervalMode

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, ...

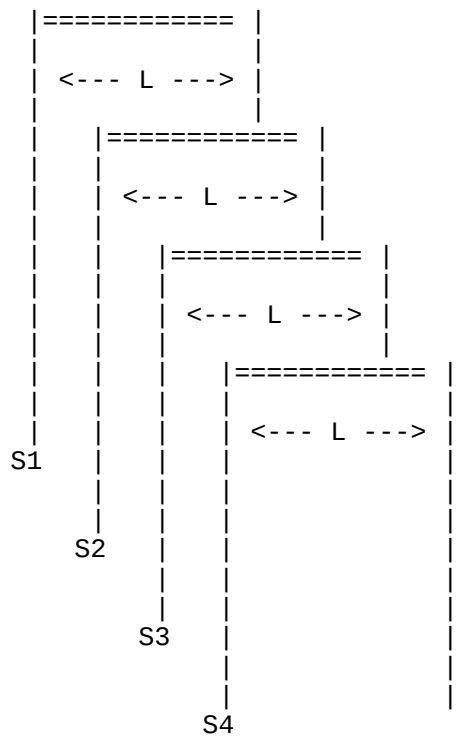


Figure 4: Sliding eoEnergyParametersIntervalMode

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

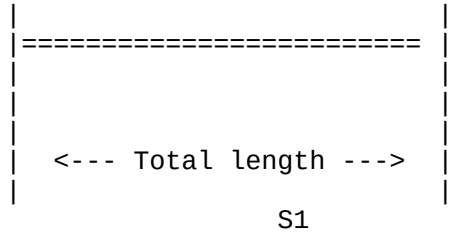


Figure 5: Total eoEnergyParametersIntervalMode

An 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 whether or not eoEnergyTable entries exist. 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 of eoEnergyConsumed, eoEnergyProvided and eoEnergyStored, unit scale of measured energy with eoEnergyUnitMultiplier, percentage accuracy with eoEnergyAccuracy, and the maximum observed energy within a window in eoEnergyMaxConsumed, eoEnergyMaxProduced, and eoEnergyDiscontinuityTime.

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 both 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 [RFC7461] as a prerequisite for this MIB module. In such a case, the 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 [RFC7461], 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

[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.

[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-unit precision) from sensors embedded in networking devices. Sensors are associated with each index of the entPhysicalIndex of the ENTITY-MIB [RFC6933]. While the focus of the Monitoring and Control MIB for Power and Energy 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 the 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 [RFC7461].

The ENTITY-SENSOR MIB [RFC3433] does not have the ANSI C12.x accuracy classes required for electricity (e.g., 1%, 2%, and 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, Power Ethernet [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 MIBs 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 Monitoring and Control MIB for Power and Energy. 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", and "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

The 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 PethPsePortGroupIndexOrZero TCs.

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 Monitoring and Control MIB for Power and Energy.

The 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 root mean square (RMS) volts and RMS amperes. They are not based on the EntitySensorDataScale and EntitySensorDataPrecision of ENTITY-SENSOR-MIB.

Both the Monitoring and Control MIB for Power and Energy 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 [RFC7326].

7.5. Link with the LLDP and LLDP-MED MIBs

The Link Layer Discovery Protocol (LLDP) 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 six 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 Monitoring and Control MIB for Power and Energy, 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 [RFC7461].

Logically, this MIB module is a sparse extension of the ENERGY-OBJECT-CONTEXT-MIB module [RFC7461]. Thus, the following requirements that are applied to [RFC7461] are also applicable. As a requirement for this MIB module, [RFC7461] SHOULD be implemented and as Module Compliance of ENTITY-MIB V4 [RFC6933] with respect to entity4CRCompliance MUST be supported, which requires four MIB objects: entPhysicalIndex, entPhysicalClass, entPhysicalName, and entPhysicalUUID MUST be implemented.

The 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 that 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 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 "201502090000Z"    -- 9 February 2015
       ORGANIZATION "IANA"
       CONTACT-INFO "
                     Internet Assigned Numbers Authority
                     Postal: ICANN
                     12025 Waterfront Drive, Suite 300
                     Los Angeles, CA 90094
                     United States
                     Tel: +1-310-301 5800
                     EMail: iana@iana.org"

       DESCRIPTION
          "Copyright (c) 2015 IETF Trust and the persons identified as
           authors of the code.  All rights reserved.

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           This MIB module defines the PowerStateSet Textual
           Convention, which specifies the Power State Sets and
           Power State Set Values an Energy Object supports.

           The initial version of this MIB module was published in
           RFC 7460; for full legal notices see the RFC itself."

       -- revision history
       REVISION "201502090000Z"     -- 9 February 2015
       DESCRIPTION
           "Initial version of this MIB module, as published as RFC
           7460."

      ::= { mib-2 228 }

   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 Set 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    "201502090000Z"    -- 9 February 2015
       ORGANIZATION    "IETF EMAN Working Group"
       CONTACT-INFO
               "WG charter:
                http://datatracker.ietf.org/wg/eman/charter/

                Mailing Lists:
                General Discussion: eman@ietf.org
```

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```
       DESCRIPTION
          "Copyright (c) 2015 IETF Trust and the persons identified as
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           (http://trustee.ietf.org/license-info).

           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,
           [RFC7461] 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 "201502090000Z"     -- 9 February 2015
       DESCRIPTION
          "Initial version, published as RFC 7460."

      ::= { mib-2 229 }

   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 cannot 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 hundredths 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 cannot 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           Integer32,
      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 a 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 a second 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, used 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 a second"
       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 RFC 3418.
          This object specifies the start time of the energy
          measurement sample."
       REFERENCE
         "RFC 3418: Management Information Base (MIB) for the
          Simple Network Management Protocol (SNMP)"
       ::= { 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
          kWh, MWh, 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 (kWh, MWh,
          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 (kWh, MWh, 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 hundredths
          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 (kWh, MWh, 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 (kWh, MWh, etc.) indicated
          separately in eoEnergyEnergyUnitMultiplier."
       ::= { eoEnergyEntry 8 }

    eoEnergyDiscontinuityTime OBJECT-TYPE
       SYNTAX       TimeStamp
       MAX-ACCESS  read-only
       STATUS      current
       DESCRIPTION
          "The value of sysUpTime RFC 3418 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."
       REFERENCE
          "RFC 3418: Management Information Base (MIB) for the
           Simple Network Management Protocol (SNMP)"
       ::= { 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 RFC 6933
           with respect to entity4CRCompliance MUST
           be supported, which requires implementation
           of four MIB objects: entPhysicalIndex, entPhysicalClass,
           entPhysicalName and entPhysicalUUID."
        REFERENCE
           "RFC 6933: Entity MIB (Version 4)"
        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."
       REFERENCE
          "RFC 6933: Entity MIB (Version 4)"
       MODULE          -- this module
       MANDATORY-GROUPS {
                           energyObjectMibTableGroup,
                           energyObjectMibStateTableGroup,
                           energyObjectMibNotifGroup
                         }

       ::= { 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 that are used to enable
       notification."
    ::= { energyObjectMibGroups 6 }

energyObjectMibNotifGroup NOTIFICATION-GROUP
    NOTIFICATIONS    {
                        eoPowerStateChange
                    }
    STATUS          current
    DESCRIPTION
       "This group contains the notifications for
       the Monitoring and Control MIB for Power and Energy."
    ::= { 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    "201502090000Z"    -- 9 February 2015
       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
          "Copyright (c) 2015 IETF Trust and the persons identified as
           authors of the code.  All rights reserved.

           Redistribution and use in source and binary forms, with or
           without modification, is permitted pursuant to, and subject
           to the license terms contained in, the Simplified BSD License
           set forth in Section 4.c of the IETF Trust's Legal Provisions
           Relating to IETF Documents
           (http://trustee.ietf.org/license-info).

           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, RFC 7461 SHOULD be
           implemented.

           Module Compliance of ENTITY-MIB v4 with respect to
           entity4CRCompliance MUST be supported which requires
           implementation of four MIB objects: entPhysicalIndex,
           entPhysicalClass, entPhysicalName, and entPhysicalUUID."
       REVISION "201502090000Z"     -- 9 February 2015
       DESCRIPTION
          "Initial version, published as RFC 7460"

      ::= { mib-2 230 }

   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 MMXN."
      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 three-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 three-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 three-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 hundredths 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 that
          determines the apparent power.  The apparent power is the
          vector sum of real and reactive power.
```

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

   eoACPwrAttributesTotalPowerFactor OBJECT-TYPE
       SYNTAX          Integer32 (-10000..10000)
       UNITS           "hundredths"
       MAX-ACCESS      read-only
       STATUS          current
       DESCRIPTION
          "A measured value ratio of the real power flowing to the
          load versus the apparent power.  It is dimensionless and
          expressed here as a percentage value in hundredths.  A power
          factor of 100% indicates there is no inductance load and
          thus no reactive power.  A 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).  The 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 three-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 measurements related to
          the IEC 61850-7.4 MMXU phase and measured harmonic or
          interharmonics related to the MHAI phase."
       ::= { 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 three-phase power.  Three entries are required for each
          supported entPhysicalIndex entry.  Voltage measurements
          are provided relative to each other.

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

          eoACPwrAttributesDelPhaseIndex    Next Phase Angle
                                  0                 120
                                120                 240
                                240                   0
          "
       INDEX { entPhysicalIndex, eoACPwrAttributesDelPhaseIndex }
       ::= { eoACPwrAttributesDelPhaseTable 1}

   EoACPwrAttributesDelPhaseEntry ::= SEQUENCE {
       eoACPwrAttributesDelPhaseIndex                  Integer32,
       eoACPwrAttributesDelPhaseToNextPhaseVoltage     Integer32,
       eoACPwrAttributesDelThdPhaseToNextPhaseVoltage  Integer32
                                     }

   eoACPwrAttributesDelPhaseIndex OBJECT-TYPE
       SYNTAX          Integer32 (0..359)
       MAX-ACCESS      not-accessible
       STATUS          current
       DESCRIPTION
          "A phase angle typically corresponding to 0, 120, 240."
        ::= { eoACPwrAttributesDelPhaseEntry 1 }

   eoACPwrAttributesDelPhaseToNextPhaseVoltage OBJECT-TYPE
       SYNTAX          Integer32
```

```
        UNITS           "0.1 Volt AC"
        MAX-ACCESS      read-only
        STATUS          current
        DESCRIPTION
           "A measured value of phase to next phase voltages, where
           the next phase is IEC 61850-7-4 attribute 'PPV'."
        ::= { eoACPwrAttributesDelPhaseEntry 2 }

    eoACPwrAttributesDelThdPhaseToNextPhaseVoltage OBJECT-TYPE
        SYNTAX          Integer32 (0..10000)
        UNITS           "hundredths of percent"
        MAX-ACCESS      read-only
        STATUS          current
        DESCRIPTION
           "A calculated value for the voltage total harmonic
           distortion for phase to next phase.  Method of calculation
           is not specified.  IEC 61850-7-4 attribute 'ThdPPV'."
        ::= { eoACPwrAttributesDelPhaseEntry 3 }

    eoACPwrAttributesWyePhaseTable OBJECT-TYPE
        SYNTAX          SEQUENCE OF EoACPwrAttributesWyePhaseEntry
        MAX-ACCESS      not-accessible
        STATUS          current
        DESCRIPTION
           "This optional table describes three-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 measurements related to
           the IEC 61850-7.4 MMXU phase and measured harmonic or
           interharmonics related to the MHAI phase."
        ::= { powerAttributesMIBObjects 3 }

    eoACPwrAttributesWyePhaseEntry OBJECT-TYPE
        SYNTAX          EoACPwrAttributesWyePhaseEntry
        MAX-ACCESS      not-accessible
        STATUS          current
        DESCRIPTION
           "This table describes measurements of a phase in a WYE
           three-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 three-phase power system."
        INDEX { entPhysicalIndex, eoACPwrAttributesWyePhaseIndex }
```

```
       ::= { eoACPwrAttributesWyePhaseTable 1}

   EoACPwrAttributesWyePhaseEntry ::= SEQUENCE {
        eoACPwrAttributesWyePhaseIndex            Integer32,
        eoACPwrAttributesWyePhaseToNeutralVoltage  Integer32,
        eoACPwrAttributesWyeCurrent              Integer32,
        eoACPwrAttributesWyeActivePower            Integer32,
        eoACPwrAttributesWyeReactivePower          Integer32,
        eoACPwrAttributesWyeApparentPower          Integer32,
        eoACPwrAttributesWyePowerFactor            Integer32,
        eoACPwrAttributesWyeThdCurrent            Integer32,
        eoACPwrAttributesWyeThdPhaseToNeutralVoltage Integer32
                                   }

   eoACPwrAttributesWyePhaseIndex OBJECT-TYPE
       SYNTAX          Integer32 (0..359)
       MAX-ACCESS      not-accessible
       STATUS          current
       DESCRIPTION
          "A phase angle typically corresponding to 0, 120, 240."
        ::= { eoACPwrAttributesWyePhaseEntry 1 }

   eoACPwrAttributesWyePhaseToNeutralVoltage OBJECT-TYPE
       SYNTAX          Integer32
       UNITS           "0.1 Volt AC"
       MAX-ACCESS      read-only
       STATUS          current
       DESCRIPTION
          "A measured value of phase to neutral voltage.  IEC
          61850-7-4 attribute 'PNV'."
       ::= { eoACPwrAttributesWyePhaseEntry 2 }

   eoACPwrAttributesWyeCurrent OBJECT-TYPE
       SYNTAX          Integer32
       UNITS           "0.1 amperes AC"
       MAX-ACCESS      read-only
       STATUS          current
       DESCRIPTION
          "A measured value of phase currents.  IEC 61850-7-4
          attribute 'A'."
       ::= { eoACPwrAttributesWyePhaseEntry 3 }

   eoACPwrAttributesWyeActivePower OBJECT-TYPE
       SYNTAX          Integer32
       UNITS           "watts"
       MAX-ACCESS      read-only
       STATUS          current
       DESCRIPTION
```

```
          "A measured value of the actual power delivered to or
          consumed by the load with the magnitude indicated
          separately in eoPowerUnitMultiplier.  IEC 61850-7-4
          attribute 'W'."
       ::= { eoACPwrAttributesWyePhaseEntry 4 }

   eoACPwrAttributesWyeReactivePower OBJECT-TYPE
       SYNTAX          Integer32
       UNITS           "volt-amperes reactive"
       MAX-ACCESS      read-only
       STATUS          current
       DESCRIPTION
          "A measured value of the reactive portion of the apparent
          power with the magnitude of indicated separately in
          eoPowerUnitMultiplier.  IEC 61850-7-4 attribute 'VAr'."
       ::= { eoACPwrAttributesWyePhaseEntry 5 }

   eoACPwrAttributesWyeApparentPower OBJECT-TYPE
       SYNTAX          Integer32
       UNITS           "volt-amperes"
       MAX-ACCESS      read-only
       STATUS          current
       DESCRIPTION
          "A measured value of the voltage and current determines
          the apparent power with the indicated separately in
          eoPowerUnitMultiplier.  Active plus reactive power equals
          the total apparent power.

          Note: Watts and volt-amperes are equivalent units and may
          be combined.  IEC 61850-7-4 attribute 'VA'."
       ::= { eoACPwrAttributesWyePhaseEntry 6 }

   eoACPwrAttributesWyePowerFactor OBJECT-TYPE
       SYNTAX          Integer32 (-10000..10000)
       UNITS           "hundredths"
       MAX-ACCESS      read-only
       STATUS          current
       DESCRIPTION
          "A measured value ratio of the real power flowing to the
          load versus the apparent power for this phase.  IEC
          61850-7-4 attribute 'PF'.  Power Factor can be positive or
          negative where the sign should be in lead/lag (IEEE)
          form."
       ::= { eoACPwrAttributesWyePhaseEntry 7 }

   eoACPwrAttributesWyeThdCurrent OBJECT-TYPE
       SYNTAX          Integer32 (0..10000)
       UNITS           "hundredths of percent"
```

```
        MAX-ACCESS      read-only
        STATUS          current
        DESCRIPTION
           "A calculated value for the voltage total harmonic
           distortion (THD) for phase to phase.  Method of
           calculation is not specified.
           IEC 61850-7-4 attribute 'ThdA'."
        ::= { eoACPwrAttributesWyePhaseEntry 8 }

    eoACPwrAttributesWyeThdPhaseToNeutralVoltage OBJECT-TYPE
        SYNTAX          Integer32 (0..10000)
        UNITS           "hundredths of percent"
        MAX-ACCESS      read-only
        STATUS          current
        DESCRIPTION
           "A calculated value of the voltage total harmonic
           distortion (THD) for phase to neutral.  IEC 61850-7-4
           attribute 'ThdPhV'."
        ::= { eoACPwrAttributesWyePhaseEntry 9 }

    -- Conformance
    powerAttributesMIBCompliances  OBJECT IDENTIFIER
        ::= { powerAttributesMIB 2 }

    powerAttributesMIBGroups  OBJECT IDENTIFIER
        ::= { powerAttributesMIB 3 }

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

           Module Compliance of RFC 6933 with respect to
           entity4CRCompliance MUST be supported which requires
           implementation of four MIB objects: entPhysicalIndex,
           entPhysicalClass, entPhysicalName, and entPhysicalUUID."
        REFERENCE
           "RFC 6933: Entity MIB (Version 4)"

        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 three-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 three-phase power system."
      ::= { powerAttributesMIBGroups 4 }

   END
```

10. Security Considerations

There are a number of management objects defined in this MIB module 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 opens devices to attack. These are the tables and objects and their sensitivity/vulnerability:

- Unauthorized changes to the eoPowerOperState (via the eoPowerAdminState) 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 no control as to who on the secure network is allowed to access and GET/SET (read/change/create/delete) the objects in this MIB module.

Implementations SHOULD provide the security features described by the SNMPv3 framework (see [RFC3410]), and implementations claiming compliance to the SNMPv3 standard MUST include full support for authentication and privacy via the User-based Security Model (USM) [RFC3414] with the AES cipher algorithm [RFC3826]. Implementations MAY also provide support for the Transport Security Model (TSM) [RFC5591] in combination with a secure transport such as SSH [RFC5592] or TLS/DTLS [RFC6353].

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

In certain situations, energy and power monitoring can reveal sensitive information about individuals' activities and habits. Implementors of this specification should use appropriate privacy protections as discussed in Section 9 of RFC 6988 and monitoring of individuals and homes should only occur with proper authorization.

11. 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-2 228 }
energyObjectMIB	{ mib-2 229 }
powerAttributesMIB	{ mib-2 230 }

11.1. IANAPowerStateSet-MIB Module

The initial set of Power State Sets are specified in [RFC7326]. IANA maintains a Textual Convention PowerStateSet in the IANAPowerStateSet-MIB module (see Section 9.1), with the initial set of Power State Sets and the Power States within those Power State Sets as proposed in the [RFC7326]. 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 [RFC7326], and will, as a consequence, update the PowerStateSet Textual Convention.

12. References

12.1. Normative References

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12.2. Informative References

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