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Power and Energy YANG Module
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Abstract

This document defines the YANG data model for Power and Energy monitoring of devices within or connected to communication networks.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

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1. Introduction

This document defines a YANG data model for Power and Energy Monitoring and control of devices within or connected to communication networks, for the use cases document in [I-D.ietf-green-use-cases-00].

The data model includes both the monitoring and control of Energy Objects for networked devices.

This YANG data model is based on the the "GREEN framework" [I-D.belmq-green-framework-06], following the "GREEN terminology" [I-D.ietf-green-terminology-00].

Power and Energy Monitoring and Control can be applied to devices in communication networks. All identifiable devices with measurable or representable Power and Energy characteristics fall within the scope of this specification. Target devices include (but are not limited to) routers, switches, Power over Ethernet (PoE) endpoints, smart PDU, storage and compute servers, etc.

Where applicable, device monitoring extends to the components of the device as well as software and service running on the device. As a result, the metrics to be monitored include Device Level Energy Efficiency (DLEE), Component Level Energy Efficiency (CLEE) and potential Service Level Energy Efficiency (SLEE) at the orchestrator-level, etc. For example, a router can contain components such as Line Processing Unit (LPU), Switch Fabric Unit (SFU), Main Processing Unit (MPU).

1.1. Terminology

This document makes use of the terms defined in [I-D.ietf-green-terminology-00]:

- Power
- Energy
- Energy Management
- Energy Monitoring
- Energy Control
- Energy Efficiency/Energy Efficiency Ratio
- Device Level Energy Efficiency (DLEE)
- Component Level Energy Efficiency (CLEE)
- Service Level Energy Efficiency (SLEE)

This document makes use of the terms defined in [I-D.belmq-green-framework-06]

- Energy Object

The terms reused from [I-D.ietf-green-terminology-00] and [I-D.belmq-green-framework-06] are capitalized in this specification.

This document uses the terms Power and Energy in accordance with [I-D.ietf-green-terminology-00]. Power refers to the instantaneous rate at which a device consumes or produces electrical energy (typically expressed in Watts). Energy, by contrast, represents the cumulative amount of work performed over time (typically expressed in Joules or Watt-hours). Both concepts are required within this YANG module. Power enables real-time monitoring, control, and optimization of device operation, while Energy provides a time-integrated view necessary for accounting, reporting, and even for sustainability analysis. This specification includes both Power and Energy attributes.

The terminology for describing YANG modules is defined in [RFC7950]. The meanings of the symbols in the YANG tree diagrams are defined in [RFC8340].

2. The GREEN Framework

The "GREEN framework" described in [I-D.belmq-green-framework-06] covers monitoring and controlling devices and components where monitoring includes measuring Power, Energy, demand and attributes of Power.

For the whole picture of the monitoring interfaces and the relevant requirements, please refer to "GREEN reference model" in section 4 in [I-D.belmq-green-framework-06].

3. Power and Energy Data Model

The Power and Energy Data Model reports the Power and Energy consumption of each Energy Object as well as the units, sign, measurement accuracy, etc. A containment tree view of the Power and Energy Monitoring is presented.

```
module: ietf-power-and-energy
  +--ro energy-objects
     +--ro energy-entry* [object-id]
        +--ro object-id              string
        +--ro source-component-id?   -> /hw:hardware/component/name
        +--ro power
        |  +--ro instantaneous-power     int32
        |  +--ro nameplate-power?        uint32
        |  +--ro unit-multiplier         identityref
        |  +--ro data-source-accuracy?   identityref
        |  +--ro power-factor?           power-factor
        |  +--ro measurement-local?      boolean
        +--ro energy
        |  +--ro total-energy-consumed?    uint64
        |  +--ro total-energy-delivered?   uint64
        |  +--ro unit-multiplier?          identityref
        |  +--ro data-source-accuracy?     identityref
        |  +--ro measurement-local?        boolean
        |  +--ro certifications*           identityref
        +--ro energy-relationship* [relationship-id]
           +--ro relationship-id            string
           +--ro relationship-type?         identityref
           +--ro relationship-peer-entry* [peer-object-id]
              +--ro peer-object-id      -> /hw:hardware/component/name
              +--ro peer-description?   string
```

4. Relationship to the Hardware YANG Data Model

The ietf-hardware YANG module [RFC8348] is required by the Power and Energy YANG module. In the ietf-hardware YANG model, there are three identifiers for hardware components, which are "name", "physical-index" and "uuid". Among them, "name" is the key to "List of components", "physical-index" matches entPhysicalIndex in the legacy Entity MIB [RFC6933] if it exists, and UUID is the Universally Unified IDentifier [RFC4122] of the component.

In the Power and Energy YANG Module defined in this specification, there is a leaf named "source-component-id" which refers to the component name in the ietf-hardware model. The "source-component-id" can in turn reuse the UUID in the ietf-hardware YANG module.

The mapping between energy-object entries in this YANG Module and the hardware-components in ietf-hardware YANG module [RFC8348] is designed to be 1:1, architecturally aligning each energy-entry with exactly one physical hardware component via source-component-id.

There are also cases where the controllers also generate its own set of UUIDs for the hardware (components). In such a case, it might be necessary to document the mappings between the UUIDs generated on the hardware side and the UUIDs on the controller side. Basically, the devices (such as routers) generate the UUID and the controller can query it.

The ietf-hardware YANG module [RFC8348] allows to discover all the device components, including the containment tree, and the parent/child relationship, which is important for energy/power aggregation (see the contains-child relationship in RFC 8348).

5. Relationship to the EMAN Work

The EMAN IETF Working Group (https://datatracker.ietf.org/wg/eman/about/) is a concluded Working Group that produces a couple of RFCs in the domain of Power and Energy. The Working Group produced MIB modules for monitoring and control for power and energy, for the context information, for battery monitoring, and an extension to the ENITY-MIB to add the UUID definition [RFC6933].

For various reasons, those MIB modules were not implemented by vendors.

The Power and Energy data model defined in this specification use the Monitoring and Control MIB for Power and Energy [RFC7460] as a starting point to discuss the solution to the different use cases in [I-D.ietf-green-use-cases-00].

However, it has not been the goal to simply map the MIB module to a YANG module. The changes compared to the EMAN MIB modules are mainly due to the alignment with the up-to-date requirements of the network carriers on Energy Efficiency. Compared to the MIB modules, some definitions and types are optimized, some new Energy Objects are added and some legacy Energy Objects are removed accordingly.

6. Power and Energy YANG Module

This YANG Module is used to monitor and control Power and Energy usage of network devices and the components on these devices.

```
<CODE BEGINS>
module ietf-power-and-energy {
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-power-and-energy";
  prefix eo;
```

```
     import ietf-hardware {
       prefix hw;
       reference
         "RFC 8348: A YANG Data Model for Hardware Management";
     }

     organization
       "IETF GREEN Working Group";

     contact
       "WG Web: <https://datatracker.ietf.org/wg/green/>
        WG List: <mailto:green@ietf.org>";



     description
       "This YANG module specifies for Power and Energy monitoring and
        control of devices within or connected to communication
        networks.

        Copyright (c) 2025 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
        (https://trustee.ietf.org/license-info).

        This version of this YANG module is part of RFC XXXX
        (https://www.rfc-editor.org/info/rfcXXXX); see the RFC itself
        for full legal notices.";

     revision 2026-01-22 {
       description
         "Initial revision";
       reference
         "RFC XXXX: Energy Object YANG Data Model";
     }

     identity data-source-accuracy {
       description
         "Base identity for all possible data accuracy types.
          This identity serves as the root for a hierarchy of accuracy
          types, allowing for extensibility while maintaining alignment
          with current and future industry standards.
```

The hierarchy, as defined in this YANG module, is as follows. Other modules may extend this hierarchy with additional accuracy base- and sub-types as needed.

```
data-source-accuracy
  ├── accuracy-like-parent
  ├── accuracy-unknown
  │     └── accuracy-unavailable
  ├── accuracy-estimated
  │     ├── accuracy-static
  │     ├── accuracy-historic
  │     └── accuracy-learned
  └── accuracy-measured
       ├── accuracy-measured-bronze
       │     ├── accuracy-measured-bronze-1
       │     ├── accuracy-measured-bronze-10
       │     ├── accuracy-measured-bronze-100
       │     └── accuracy-measured-bronze-1000
       ├── accuracy-measured-silver
       │     └── accuracy-measured-silver-...
       ├── accuracy-measured-gold
       │     └── accuracy-measured-gold-...
       ├── accuracy-measured-red
       │     └── accuracy-measured-red-...
       └── accuracy-measured-ones
```

The accuracy levels under accuracy-measured are based on percent-wise accuracy classes:

```
   bronze:  +/- 30%
   silver:  +/- 10%
   gold:    +/- 5%
   red:     +/- 2%
```

In addition, the accuracy-measured-ones identity indicates a power data measurement with all digits valid, except trailing zeros.

Since percent-wise accuracy works poorly for very small values, standards such as IEC 62053, IEC 61850-7-4 and IEEE 1451 define accuracy classes based on a combination of percent-wise accuracy and absolute accuracy thresholds. E.g. +/-1 % of reading + +/-0.05 absolute units.

Similarly, for each percent-wise accuracy class, this module defines a few absolute tolerance classes, indicated by suffixes to the accuracy identity names. The suffixes indicate absolute accuracy thresholds:

```
   no suffix:   +/-0.5  absolute units
```

```
            -1:         +/-1    absolute unit
            -10:        +/-10   absolute units
            -100:       +/-100  absolute units
            -1000:      +/-1000 absolute units
         Thus, for example, accuracy-measured-gold-10 indicates
         a power data measurement with an accuracy of either
         +/-5% or +/-10 absolute units, whichever is larger.

         For example, a power sensor reading might report a value
         of 16250, with unit multiplier of milli (10^-3), under
         accuracy-measured-gold-10. This indicates that the actual
         power value is between 16.2375 and 16.2625 Watts, since
         5% of 16.250 Watts is 0.8125 Watts, which is greater than
         the absolute threshold of 10 milliwatts (0.010 W).

         At another time, the same sensor might report a value
         of 150, with unit multiplier of milli (10^-3), under
         accuracy-measured-gold-10. This indicates that the actual
         power value is between 0.140 and 0.160 Watts, since 5% of
         0.150 Watts is only 0.0075 Watts, which is less than the
         absolute threshold of 10 milliwatts (0.010 W).";
     }
     identity accuracy-unknown {
       base data-source-accuracy;
       description
         "The accuracy of the power data is unknown.";
     }
     identity accuracy-unavailable {
       base accuracy-unknown;
       description
         "A power data is not available for some reason, such
          as a sensor failure or a component being powered off.";
     }
     identity accuracy-like-parent {
       base data-source-accuracy;
       description
         "The accuracy of the power/energy data is the same as this energy
          object’s parent object. This identity is useful for hierarchical
          energy objects where child objects inherit the accuracy
          characteristics.";
     }
     identity accuracy-estimated {
       base data-source-accuracy;
       description
         "The power data is estimated, perhaps based on a model,
          history or calculation rather than a direct measurement.";
     }
     identity accuracy-static {
```

```
       base accuracy-estimated;
       description
         "The power data is based on static data, such as
          manufacturer specifications, datasheet of typical power values
          or nameplate ratings, rather than real-time measurements.";
     }
     identity accuracy-historic {
       base accuracy-estimated;
       description
         "The power data is based on an historic measurement data
          for this specific system and usage pattern.";
     }
     identity accuracy-learned {
       base accuracy-estimated;
       description
         "The power data is based on an machine learning
          model prediction.";
     }
     identity accuracy-measured {
       base data-source-accuracy;
       description
         "The power data is a direct, real-time measurement
          from a sensor.";
     }
     identity accuracy-measured-bronze {
       base accuracy-measured;
       description
         "The power data is a direct, real-time measurement
          from a sensor with precision and accuracy such that
           |actual-sensor|  sensor * 30% OR |actual-sensor|  0.5";
     }
     identity accuracy-measured-bronze-1 {
       base accuracy-measured-bronze;
       description
         "The power data is a direct, real-time measurement
          from a sensor with precision and accuracy such that
          |actual-sensor|  sensor * 30% OR |actual-sensor|  1";
     }
     identity accuracy-measured-bronze-10 {
       base accuracy-measured-bronze;
       description
         "The power data is a direct, real-time measurement
          from a sensor with precision and accuracy such that
          |actual-sensor|  sensor * 30% OR |actual-sensor|  10";
     }
     identity accuracy-measured-bronze-100 {
       base accuracy-measured-bronze;
       description
```

```
           "The power data is a direct, real-time measurement
            from a sensor with precision and accuracy such that
            |actual-sensor|  sensor * 30% OR |actual-sensor|  100";
       }
       identity accuracy-measured-bronze-1000 {
         base accuracy-measured-bronze;
         description
           "The power data is a direct, real-time measurement
            from a sensor with precision and accuracy such that
            |actual-sensor|  sensor * 30% OR |actual-sensor|  1000";
       }
       identity accuracy-measured-silver {
         base accuracy-measured;
         description
           "The power data is a direct, real-time measurement
            from a sensor with precision and accuracy such that
             |actual-sensor|  sensor * 10% OR |actual-sensor|  0.5";
       }
       identity accuracy-measured-silver-1 {
         base accuracy-measured-silver;
         description
           "The power data is a direct, real-time measurement
            from a sensor with precision and accuracy such that
            |actual-sensor|  sensor * 10% OR |actual-sensor|  1";
       }
       identity accuracy-measured-silver-10 {
         base accuracy-measured-silver;
         description
           "The power data is a direct, real-time measurement
            from a sensor with precision and accuracy such that
            |actual-sensor|  sensor * 10% OR |actual-sensor|  10";
       }
       identity accuracy-measured-silver-100 {
         base accuracy-measured-silver;
         description
           "The power data is a direct, real-time measurement
            from a sensor with precision and accuracy such that
            |actual-sensor|  sensor * 10% OR |actual-sensor|  100  ";
       }
       identity accuracy-measured-silver-1000 {
         base accuracy-measured-silver;
         description
           "The power data is a direct, real-time measurement
            from a sensor with precision and accuracy such that
            |actual-sensor|  sensor * 10% OR |actual-sensor|  1000";
       }
       identity accuracy-measured-gold {
         base accuracy-measured;
```

```
       description
         "The power data is a direct, real-time measurement
          from a sensor with precision and accuracy such that
          |actual-sensor|  sensor * 5% OR |actual-sensor|  0.5";
     }
     identity accuracy-measured-gold-1 {
       base accuracy-measured-gold;
       description
         "The power data is a direct, real-time measurement
          from a sensor with precision and accuracy such that
          |actual-sensor|  sensor * 5% OR |actual-sensor|  1";
     }
     identity accuracy-measured-gold-10 {
       base accuracy-measured-gold;
       description
         "The power data is a direct, real-time measurement
          from a sensor with precision and accuracy such that
          |actual-sensor|  sensor * 5% OR |actual-sensor|  10";
     }
     identity accuracy-measured-gold-100 {
       base accuracy-measured-gold;
       description
         "The power data is a direct, real-time measurement
          from a sensor with precision and accuracy such that
          |actual-sensor|  sensor * 5% OR |actual-sensor|  100";
     }
     identity accuracy-measured-gold-1000 {
       base accuracy-measured-gold;
       description
         "The power data is a direct, real-time measurement
          from a sensor with precision and accuracy such that
          |actual-sensor|  sensor * 5% OR |actual-sensor|  1000";
     }
     identity accuracy-measured-red {
       base accuracy-measured;
       description
         "The power data is a direct, real-time measurement
          from a sensor with precision and accuracy such that
          |actual-sensor|  sensor * 2% OR |actual-sensor|  0.5";
     }
     identity accuracy-measured-red-1 {
       base accuracy-measured-red;
       description
         "The power data is a direct, real-time measurement
          from a sensor with precision and accuracy such that
          |actual-sensor|  sensor * 2% OR |actual-sensor|  1";
     }
     identity accuracy-measured-red-10 {
```

```
        base accuracy-measured-red;
        description
          "The power data is a direct, real-time measurement
           from a sensor with precision and accuracy such that
           |actual-sensor|  sensor * 2% OR |actual-sensor|  10";
      }
      identity accuracy-measured-red-100 {
        base accuracy-measured-red;
        description
          "The power data is a direct, real-time measurement
           from a sensor with precision and accuracy such that
           |actual-sensor|  sensor * 2% OR |actual-sensor|  100";
      }
      identity accuracy-measured-red-1000 {
        base accuracy-measured-red;
        description
          "The power data is a direct, real-time measurement
           from a sensor with precision and accuracy such that
           |actual-sensor|  sensor * 2% OR |actual-sensor|  1000";
      }
      identity accuracy-measured-ones {
        base accuracy-measured;
        description
          "The power data is a direct, real-time measurement
           from a sensor with all digits valid, except trailing zeros.
           For example, a sensor reading of 12300 represents
           a sensor value between 12250 and 12350.";
      }

      typedef power-factor {
        type uint8 {
          range "0 .. 100";
        }
        default 100;
        description
          "The percent value of the power factor measurement.
           Leaf often omitted, implying 100%.";
        reference
          "Replaces RFC 7460: eoPowerCurrentType object";
      }

      identity certification-type {
        description
          "Base identity for certification types applicable to energy
           objects. This identity serves as the root for a hierarchy of
           certification types, allowing for extensibility.";

        reference
```

```
        "Industry sustainability and energy efficiency certifications";
     }

     identity energy-star {
       base certification-type;
       description
         "ENERGY STAR certification for energy efficiency.";
       reference
         "https://www.energystar.gov/";
     }

     identity c80-PLUS{
       base certification-type;
       description
         "80 PLUS Power Supply Certification";
       reference
         "https://www.clearesult.com/80plus/";
     }

     identity epeat {
       base certification-type;
       description
         "Electronic Product Environmental Assessment Tool ratings (Bronze/Silver/Gold)."
;
       reference
         "https://www.epeat.net/";
     }

     identity EU-energy-level{
       base certification-type;
       description
         "EU Energy Label: European efficiency ratings";
       reference
         "https://eprel.ec.europa.eu/screen/home";
     }

     identity CQC{
       base certification-type;
       description
         "China Quality Certification for energy efficiency";
       reference
         "https://www.cqc.com.cn/";
     }

     identity power-state {
       description
         "Base identity for all possible power states. This identity
          serves as the root for a hierarchy of power states, allowing
          for extensibility while maintaining alignment with the IANA
```

```
          Power State Set Registry.";
       reference
         "IANA: Power State Set Registry";
     }

     identity unit-multiplier {
       description
         "Base identity for unit multipliers as defined in IEC 61850-7-3
          Annex A. These represent exponents of 10 for scaling units
          associated with the integer units used to measure the power or
          energy.
              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
           ";
       reference
         "RFC 7460: UnitMultiplier";
     }
     identity multiplier-yocto {
       description
         "Represents a multiplier of 10^-24 associated with the
          integer units used to measure the power or energy.";
     }
     identity multiplier-zepto {
       description
         "Represents a multiplier of 10^-21 associated with the
          integer units used to measure the power or energy.";
     }
     identity multiplier-atto {
       description
         "Represents a multiplier of 10^-18 associated with the
          integer units used to measure the power or energy.";
     }
     identity multiplier-femto {
```

```
       description
         "Represents a multiplier of 10^-15 associated with the
          integer units used to measure the power or energy.";
     }
     identity multiplier-pico {
       description
         "Represents a multiplier of 10^-12 associated with the
          integer units used to measure the power or energy.";
     }
     identity multiplier-nano {
       description
         "Represents a multiplier of 10^-9 associated with the
          integer units used to measure the power or energy.";
     }
     identity multiplier-micro {
       description
         "Represents a multiplier of 10^-6 (0.000001) associated with the
          integer units used to measure the power or energy.";
     }
     identity multiplier-milli {
       description
         "Represents a multiplier of 10^-3 (0.001) associated with the
          integer units used to measure the power or energy.";
     }
     identity multiplier-units {
       description
         "Represents a multiplier of 10^0 (1) associated with
          the integer units used to measure the power or energy.";
     }
     identity multiplier-kilo {
       description
         "Represents a multiplier of 10^3 (1,000) associated with the
          integer units used to measure the power or energy.";
       reference
         "RFC 7460: UnitMultiplier";
     }
     identity multiplier-mega {
       description
         "Represents a multiplier of 10^6 (1,000,000) associated with
          the integer units used to measure the power or energy.";
     }
     identity multiplier-giga {
       description
         "Represents a multiplier of 10^9 (1,000,000,000) associated
          with the integer units used to measure the power or energy.";
     }
     identity multiplier-tera {
       description
```

```
         "Represents a multiplier of 10^12 associated
          with the integer units used to measure the power or energy.";
     }
     identity multiplier-peta {
       description
         "Represents a multiplier of 10^15 associated
          with the integer units used to measure the power or energy.";
     }
     identity multiplier-exa {
       description
         "Represents a multiplier of 10^18 associated
          with the integer units used to measure the power or energy.";
     }
     identity multiplier-zetta {
       description
         "Represents a multiplier of 10^21 associated
          with the integer units used to measure the power or energy.";
     }
     identity multiplier-yotta {
       description
         "Represents a multiplier of 10^24 associated
          with the integer units used to measure the power or energy.";
     }
     identity energy-relationship-type {
       description "Base identity for energy object relationships";
       reference "RFC 7461: IANAEnergyRelationship";
     }
     identity powered-by {
       base energy-relationship-type;
       description "Energy Object A is powered by Energy Object B";
     }
     identity powering {
       base energy-relationship-type;
       description "Energy Object A is powering Energy Object B";
     }
     identity metered-by {
       base energy-relationship-type;
       description "Energy Object A is metered by Energy Object B";
     }
     identity metering {
       base energy-relationship-type;
       description "Energy Object A is metering Energy Object B";
     }
     identity aggregated-by {
       base energy-relationship-type;
       description "Energy Object A is aggregated by Energy Object B";
     }
     identity aggregating {
```

```
        base energy-relationship-type;
        description "Energy Object A is aggregating Energy Object B";
      }

      container energy-objects {
        config false;
        description
          "Energy objects container for power and energy attributes.";
        reference
          "RFC 7460: eoPowerTable";

        list energy-entry {
          key "object-id";
          description
            "Power and energy entry for an energy object, indexed by object id.
             Each entry contains the complete set of power and energy attributes
             for a specific physical component.";
          reference
            "RFC 7460: EoPowerEntry";

          leaf object-id {
            type string;
            description
              "An identifier that uniquely identifies the energy object
              in an energy object.";
          }

          leaf source-component-id {
            type leafref {
              path "/hw:hardware/hw:component/hw:name";
            }
            description
              "Reference to the component name in the ietf-hardware
              model. This leaf creates a direct semantic link between the
              power/energy attributes and the physical component they describe.
              ";
          }

          container power {
            description
              "Container for power measurement attributes.";
            reference
              "RFC 7460: eoPowerEntry attributes";
            leaf instantaneous-power {
              type int32;
              units "Watts";
              mandatory true;
              description
```

```
            "The power usage measurement for the energy object right now.
            This value represents the instantaneous power consumption
            of the component. This value is specified in SI units of watts
            with the magnitude of watts (milliwatts, kilowatts, etc.) indicated
            separately as unit-multiplier in this container. Positive values
            indicate power consumption, while negative values can indicate power
            generation (e.g., for devices with battery backup or
            renewable energy sources).";
          reference
            "RFC 7460: eoPower object";
        }

        leaf nameplate-power {
          type uint32;
          units "Watts";
          description
            "The nameplate power rating of an energy object. This is
            the maximum power that the energy object is designed to consume or
            produce, as specified by the manufacturer. Essential for
            power budget calculations and capacity planning.";
          reference
            "RFC 7460: eoPowerNameplate object";
        }

        leaf unit-multiplier {
          type identityref {
            base unit-multiplier;
          }
          mandatory true;
          description
            "The unit multiplier used to measure the power.
            This multiplier applies to both instantaneous-power and nameplate-power
            values, allowing representation of power values from milliwatts
            to gigawatts using integer arithmetic.";
          reference
            "RFC 7460: eoPowerUnitMultiplier object";
        }

        leaf data-source-accuracy {
          type identityref {
            base data-source-accuracy;
          }
          default accuracy-like-parent;
          description
            "The accuracy of the power data source. Indicates whether
            the data source is a direct measurement, an estimate, or
            unavailable and also the accuracy level of the data source.
            By default, the accuracy is inherited from the parent energy
```

```
              object, facilitating hierarchical accuracy definitions
              without the need to specify accuracy at every level.
              This metadata is crucial for network management
              applications to assess the reliability and accuracy of the
              power data.";
            reference
              "RFC 7460: eoPowerMeasurementCaliber object";
          }

          leaf power-factor {
            type power-factor;
            description
              "The percent value of the power factor measurement for the
              energy object. This information is important for
              understanding the electrical characteristics of the energy object
              and for correctly interpreting the power data.";
            reference
              "Replaces RFC 7460: eoPowerCurrentType object";
          }

          leaf measurement-local {
            type boolean;
            description
              "Indicates whether the power measurement is local (true) or
               remote (false). A local measurement is taken directly at
               the energy object, while a remote measurement is collected from
               an external source. This information can be useful for
               troubleshooting and understanding the data source.";
             reference
               "RFC 7460: eoPowerMeasurementLocal object";
          }

        }
        container energy {
          description
            "Container for energy measurement attributes.";
          reference
            "RFC 7460: eoEnergyEntry attributes";

          leaf total-energy-consumed {
            type uint64;
            units "Watt-hours";
            description
              "The total cumulative energy consumed by the energy object
              since the last reset. This value is specified as
              watt-hours with the magnitude of watt-hours (milliwatt-hours,
              kilowatt-hours, etc.) indicated separately as unit-multiplier
              in this container. This value is useful for tracking
```

```
            overall energy usage over time for billing, reporting,
            or optimization purposes.";
          reference
            "RFC 7460: eoEnergyConsumed object";
        }

        leaf total-energy-delivered {
          type uint64;
          units "Watt-hours";
          description
            "The total cumulative energy delivered by the energy object
            since the last reset. This value is specified as
            watt-hours with the magnitude of watt-hours (milliwatt-hours,
            kilowatt-hours, etc.) indicated separately as unit-multiplier
            in this container. This value is relevant for energy objects
            capable of generating power, such as those with renewable
            energy sources or battery backup systems, or capable of providing
            energy to other energy objects (e.g., PoE switches).";
          reference
            "RFC 7460: eoEnergyProduced object";
        }
        leaf unit-multiplier {
          type identityref {
            base unit-multiplier;
          }
          description
            "This multiplier applies to both total-energy-consumed
             and total-energy-delivered values. It determines the scale
             of the energy measurements, allowing representation of
             energy values from milliwatt-hours to gigawatt-hours
             using integer arithmetic.";
          reference
            "RFC 7460: eoPowerUnitMultiplier object";
        }

        leaf data-source-accuracy {
          type identityref {
            base data-source-accuracy;
          }
          default accuracy-like-parent;
          description
            "The accuracy of the energy data source. Indicates whether
            the data source is a direct measurement, an estimate, or
            unavailable and also the accuracy level of the data source.
            By default, the accuracy is inherited from the parent energy
            object, facilitating hierarchical accuracy definitions
            without the need to specify accuracy at every level.
            This metadata is crucial for network management
```

```
              applications to assess the reliability and accuracy of the
              energy data.";
            reference
              "RFC 7460: eoPowerMeasurementCaliber object";
          }
          leaf measurement-local {
            type boolean;
            description
              "Indicates whether the energy measurement is local (true) or
               remote (false). A local measurement is taken directly at
               the energy object, while a remote measurement is collected from
               an external source. This information can be useful for
               troubleshooting and understanding the data source.";
             reference
               "RFC 7460: eoPowerMeasurementLocal object";
          }
          leaf-list certifications {
            type identityref {
              base certification-type;
            }
            description
              "List of certifications applicable to this energy object. If
              this list is empty, the energy object has no certifications.";
          }
        }

        list energy-relationship {
          key "relationship-id";
          description "Relationships for this energy entry. Replaces
          RFC 7461 eoRelationTable.";
          reference
            "RFC 7461: eoRelationTable, eoRelationEntry";

          leaf relationship-id {
            type string;
            description
              "Arbitrary unique identifier for this relationship entry
              within the component.";
          reference
            "RFC 7461: eoRelationIndex";
          }

          leaf relationship-type {
            type identityref {
              base energy-relationship-type;
              // powered-by, powering, metered-by, metering, etc.
            }
            description
```

```
              "The type of relationship this energy object has with peer
              objects.";
            reference
              "RFC 7461: eoRelationship, IANAEnergyRelationship";
          }

          list relationship-peer-entry {
            key "peer-object-id";
            description "Multiple peers for this relationship type.";
            reference
              "RFC 7461: eoRelationID";

            leaf peer-object-id {
              type leafref {
              path "/hw:hardware/hw:component/hw:name";
              }
              description "This object specifies the Universally Unique
              Identifier (UUID) of the peer (other) Energy Object. If the
              UUID of the Energy Object is unknown or nonexistent, the
              peer-object-id will be set to a zero-length string instead.
              ";
              reference
                "RFC 7461: eoRelationID (UUIDorZero)";
            }

            leaf peer-description {
              type string;
              description
                "Human-readable description of the peer relationship.
                 Useful when peer-object-id is zero-length (unknown).";
            }
          }
        }
      }
    }
  }
  <CODE ENDS>
```

7. Operational Considerations

Heterogeneous sensor capabilities across components complicate power and energy aggregation. Operators must use the data-source-accuracy identities (e.g., accuracy-measured-bronze vs. accuracy-estimated) to weight data reliability carefully before aggregating Power (instantaneous-power) and Energy (total-energy-consumed and/or total-energy-delivered) values to avoid skewing Device-Level Energy Efficiency (DLEE) metrics.

Operators might not always be interested to get the individual component accuracy. What counts is the device level or domain level, identity accuracy-like-parent is introduced to meet their demands. From an implementation point of view, to facilitate data collection and aggregation on runtime and avoid post-aggregation data confidence interval issues, operators and implementers should use as much as possible this accuracy-like-parent identity.

YANG Push support eliminates device-side bucket storage by streaming energy telemetry directly to controller-side via subscriptions. Operators must verify the ’yang-push’ bundle is enabled and validate push-max-operational limits accommodate all component subscriptions, preventing notification flooding while avoiding memory overhead on the device.

7.1. Measurement Accuracy and Data Source Classification

Power and energy metrics may originate from a wide range of sources and estimation methods, each with different levels of reliability. These include direct sensor measurements, manufacturer-provided specifications, historical observations, and predictive models. Without explicit characterization of data quality, comparisons and aggregations may be misleading. The GREEN YANG data model therefore requires all power and energy values to be associated with an accuracy classification.

The model defines the following primary accuracy categories using YANG identities:

* Unknown Accuracy: Data accuracy cannot be determined, or measurements are unavailable due to sensor failures, powered-off components, or other operational constraints.

* Estimated Data: Values derived through indirect methods:

  - Static estimates: From manufacturer datasheets, nameplate ratings (critical for UC 1: Incremental Deployment with legacy devices)

    o Identity: accuracy-static

  - Historic estimates: Based on prior measurements of this specific system under similar conditions

    o Identity: accuracy-historic

  - Learned estimates: Generated by machine learning models predicting consumption from workload patterns (UC 15: AI Training)

    o Identity: accuracy-learned

* Measured Data: Direct, real-time sensor measurements with quantified precision:

* Bronze: ±30% accuracy for typical values.

* Silver: ±10% accuracy for typical values.

* Gold: ±5% accuracy for typical values.

* Red: ±2% accuracy for typical values.

* Ones: All non-zero digits are significant/valid.

Percentage-based accuracy fails for small values. For example, ±5% of 0.1W is only 0.005W, which may be smaller than sensor noise. Industry standards (IEC 62053, IEC 61850-7-4) address this by specifying: Accuracy = MAX(percentage_error, absolute_threshold)

The absolute threshold suffixes (-1, -10, -100, -1000) refer to the unit-multiplier scale. For unit-multiplier: milli, -10 means ±10 milliwatts.

Example - A sensor with accuracy-measured-gold-10 reports:

* 16.25W → actual value between 16.2375W and 16.2625W (5% = 0.8125W > 0.010W threshold)

* 0.15W → actual value between 0.140W and 0.160W (5% = 0.0075W < 0.010W threshold, so ±10mW applies)

Explicit accuracy reporting enables:

* Weighted aggregation: High-precision measurements carry appropriate weight when calculating network-wide energy consumption

* Upgrade prioritization: Identify devices with low-accuracy reporting for sensor upgrades or replacement

* Compliance validation: Automated verification against regulatory thresholds requiring specific measurement precision

* Double-accounting prevention: Understand when PDU-level measurements (±2%) should override device estimates (±30%) to avoid counting the same energy twice (UC 13)

* Cross-domain correlation: Map accuracy expectations when integrating with external systems like 3GPP energy KPIs (UC 6)

The accuracy hierarchy uses YANG identities for extensibility, allowing vendors to define manufacturer-specific accuracy classes while maintaining interoperability through standardized base types.

7.2. Industry-Standard Certifications

Energy efficiency certifications issued by recognized testing organizations provide standardized benchmarks for the expected performance of equipment and components. These certifications are typically based on controlled laboratory measurements and formal evaluation procedures. The GREEN YANG data model supports reporting of such certifications in order to complement operational measurement data.

Common Certifications:

* 80 PLUS (Power Supply Units): Bronze/Silver/Gold/Platinum/Titanium tiers based on efficiency at 20%/50%/100% load

* Energy Star: Government-backed program certifying energy-efficient products

* EPEAT: Electronic Product Environmental Assessment Tool ratings (Bronze/Silver/Gold)

* EU Energy Label: European efficiency ratings

* CQC: China Quality Certification for energy efficiency

Additional certification schemes may be supported through extensible identities.

Certification data and measurement accuracy serve complementary functions within the model.

Certification information describes the verified design-time efficiency characteristics of a device or component, as established through independent testing. Measurement accuracy describes the precision and reliability of reported operational data obtained from sensors or estimation mechanisms.

Key differences include:

* Certification is typically applied at manufacturing time and remains stable throughout the product lifecycle.

* Measurement accuracy may vary over time due to calibration, environmental conditions, or sensor degradation.

* Certification is generally associated with discrete components, such as power supply units.

* Measurement accuracy applies to individual metrics at component, subsystem, or system level.

Both types of information may be reported simultaneously for the same energy object.

Example: A power supply might have:

* Certification: c80-PLUS-Platinum (92% efficient at 50% load, independently verified)

* Measurement Accuracy: accuracy-measured-silver (±10% sensor precision on real-time power readings)

The certification tells operators the energy object, for example, a PSU, is designed to be efficient; the measurement accuracy tells them how precisely they can monitor its actual performance.

8. Security Considerations

This section will be completed once the YANG module is complete, according to https://wiki.ietf.org/group/ops/yang-security-guidelines.

This section is modeled after the template described in Section 3.7.1 of [RFC-to-be draft-ietf-netmod-rfc8407bis].

The Power and Energy YANG module defines a data model that is designed to be accessed via YANG-based management protocols, such as NETCONF [RFC6241] and RESTCONF [RFC8040]. These YANG-based management protocols (1) have to use a secure transport layer (e.g., SSH [RFC4252], TLS [RFC8446], and QUIC [RFC9000]) and (2) have to use mutual authentication.

The Network Configuration Access Control Model (NACM) [RFC8341] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

9. IANA Considerations

This document requests IANA to register the YANG module "ietf-power-energy-monitoring".

Note to IANA: RFC XXXX must be replaced by the newly assigned RFC number.

10. Acknowledgments

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