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SERIES L: CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Minimum data set and communication interface requirements for data centre energy management

Recommendation ITU-T L.1301

ITU International Telecommunication Union

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Minimum data set and communication interface requirements for data centre energy management

Summary

Recommendation ITU-T L.1301 establishes a minimum data set necessary to manage data centres and telecommunication rooms in an environmentally responsible manner.

The Recommendation specifies the communication interface and defines the parameters to be communicated depending on the equipment used in data centres, such as power systems (alternating current (AC)/direct current (DC) and uninterruptible power supply (UPS) and energy distribution), cooling systems and information and communication technology (ICT) equipment.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

Data centre, energy management.

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Minimum data set and communication interface requirements for data centre energy management

1 Scope

This Recommendation aims to:

– establish a minimum data set necessary to manage data centres in an environmentally responsible manner;

– establish high-level interface requirements for information and communication technology (ICT) and facility equipment communication that contribute to energy saving, energy management and energy-saving evaluation.

2 References

None.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 communication interface: An interface through which the management system communicates with the facility equipment and ICT equipment.

3.2.2 data centre: A physical location dedicated to computing, as well as a telecom operator location, with equipment dedicated to telecommunication functions (e.g., switching functionality, billing).

3.2.3 dynamic data: Data that is periodically obtained from information and communication technology (ICT) equipment and facility equipment.

3.2.4 facility equipment: Equipment that supports the information and communication technology (ICT) equipment (e.g., cooling systems and power feeding systems) used in data centres.

3.2.5 managed entity: An entity, which is a part of an equipment, that is monitored and managed.

3.2.6 management system: A system that collects dynamic/static data and also transmits control data through the communication interface for data centre energy management.

3.2.7 minimum data set: A data set that shall be an essential and minimum set of data transmitted over the communication interface for data centre energy management.

3.2.8 sensor: A device that transforms a physical value (e.g., temperature, current) into an electrical or logical unit. The sensor can be directly connected with a data stream to the management system or via a conversion device.

3.2.9 static data: Data which is constant during operation, such as: specification, configuration and location information.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC Alternating Current

CPU Central Processing Unit

CRAC Computer Room Air Conditioner

DC Direct Current

ICT Information and Communication Technology

ID Identifier

PDU Power Distribution Unit

THD Total Harmonic Distortion

UPS Uninterruptible Power Supply

5 Conventions

None.

6 Architecture of data centre energy management

Figure 1 illustrates the architecture of data centre energy management. It consists of information and communication technology (ICT) and facility equipment, which are managed entities, and a management system. General information on equipment called static data, is transmitted to the management system through a communication interface. Energy-related data from the managed entity should be periodically collected and delivered to the management system. The ICT and facility equipment monitors energy-related data, such as power usage and inlet temperature with an agent program or sensors and transmits them to the management system through a communication interface. The management system collects these dynamic data from the ICT and facility equipment and analyses them to produce effective information for energy-efficient data centres. The management system also transmits control data to manipulate the ICT and facility equipment to manage their energy usage through a communication interface. The requirements of the communication interface and data set from the managed entities are the scope of this Recommendation.

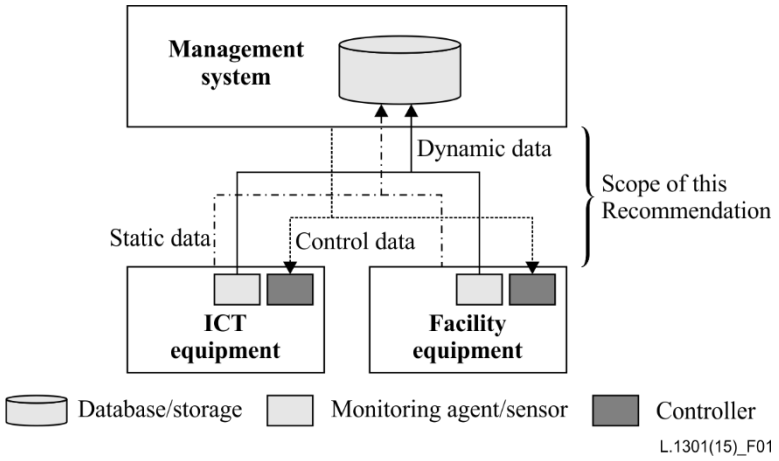

Figure 1 – Architecture of data centre energy management

7 Managed entities

Managed entities for energy efficiency in data centres are categorized into ICT equipment and facility equipment. Managed entities in ICT equipment are server, storage and networking equipment. Facility equipment includes power feeding systems and cooling systems, which are infrastructures to support stable operation of data centres. The power feeding system includes a backup generator, rectifier, alternating current (AC) uninterruptible power supply (UPS), battery, power distribution unit (PDU), etc. The cooling system includes a chiller, cooling tower, economizer, computer room air conditioner (CRAC), modular cooling systems, humidifier, etc. These are the managed entities that should be identified and managed. Specification, configuration and location information on the managed entities are managed as static data. Operating data related to energy management such as energy consumption and temperature is periodically measured and managed as dynamic data. Table 1 shows managed entities for energy management in data centres.

Table 1 – Managed entities for energy management in data centres

Equipment type		Managed entities
ICT equipment		Server equipment
		Storage equipment
		Networking equipment (e.g., switch, router)
Facility equipment	Cooling system	Chiller
		Cooling tower
		Economizer
		Air cooling unit
		Computer room air conditioner (CRAC)
		Modular cooling systems (in-row, in-rack, in-chassis)
		Humidifier
		Outdoor air system
		Heat exchanging system
	Power feeding system	Backup generator
		Rectifier
		Battery
		Power distribution unit (PDU)
		AC high/medium voltage power distribution system
		AC low voltage power distribution system
		AC uninterruptible power supply (UPS)
		AC/direct current (DC) converters (up to 400 V system, -48 V system, etc.)
		DC/AC inverter
		Other energy system

8 General requirements for data centre energy management

8.1 Requirements for communication interfaces

- Compatibility of communication interfaces should be provided in order to manage data collected from multivendor equipment in an identical way.

- Data should be collected without loss and within allowable delay times through a communication interface.
- Communication interfaces should provide a method to retain the integrity of collected data. Errors in data should be detected.
- Communication interfaces should provide a method to gather dynamic data from a monitoring agent or sensors.
- Communication interfaces and control data should be scalable to the number and size of items of equipment.
- Communication interfaces and control data should be extensible to support various types of equipment, including multivendor solutions.

8.2 Requirements for measuring data

- Equipment should have a monitoring agent or sensors to gather dynamic data.
- Equipment should hold static data and make it available to the management system.
- Equipment should be uniquely identified also under a multivendor environment.
- Dynamic and static data should have a unique identifier in view of the management system.
- Data collected from equipment including multivendor solutions should consistently be maintained in the management system.
- Data should have a specific form to be easily stored and processed in the management system.

9 Minimum data set for energy management in data centres

Data on data centre configuration (e.g., room layout) and facility connection to ICT equipment are stored in the management system.

9.1 Minimum set of static data

Data collected from equipment for energy management in data centres are about managed entities. Equipment identifiers (IDs), specifications and configurations for managed entities must be collected in order to manage operating and energy related information in data centres. Table 2 shows the minimum set of static data for energy management in data centres.

Table 2 – Minimum set of static data for energy management in data centres

Equipment type	Data set
ICT equipment	Equipment ID and description
	Operating temperature range
Cooling equipment	Equipment ID and description
	Energy consumption characteristics of devices used to cool the refrigerant
	Energy consumption characteristics of devices used to transport the refrigerant
	Presence or absence of the mode controlling the amount of refrigerant transported
	Temperature setting range of refrigerant supplied from the indoor unit
	Temperature setting step size of refrigerant supplied from the indoor unit
	Rated amount of refrigerant supplied from the indoor unit
Power equipment	Equipment ID and description
	Total capacity of generator, AC UPS and up to 400 V DC system
	Number of battery strings and capacity of each battery string
	Efficiency characteristics

9.2 Minimum set of dynamic data

Dynamic data refers to data that is obtained from managed entities periodically for energy management in data centres. Table 3 lists the minimum data set necessary for evaluating energy efficiency and for controlling ICT and facility equipment in order to save power in data centres. "G" (Get) in the "Data flow direction" column represents data that should be obtained from equipment and "S" (Set) data represents data that should be set to equipment.

Table 3 – Minimum data set controlling ICT and facility equipment for energy saving management in data centres

Equipment type		Data set	Data flow direction
ICT equipment		Input power	G
		Inlet temperature	G
		Power state (off mode, sleep, active)	G
		Power state (off mode, activate)	S
Facility equipment	Cooling equipment	Power state	G/S (Note 2)
		Supply air temperature	G
		Return air temperature	G
		Outdoor air temperature	G
		Temperature setting	G/S (Note 1)
		Relative humidity	G
		Power consumption	G
		Energy consumption	G
		Fan speed	G/S (Note 2)
	Power equipment (UPS, rectifier, PDU)	Output power	G
		Input power	G
		Input voltage input current of AC UPS/up to 400 V DC/ Inverter/ other energy system	G
		Battery voltage charging/discharging current	G
		Total harmonic distortion (THD) of AC system input current	G (Note 3)
		AC system power factor	G

NOTE 1 – Temperature measure is normally taken from a sensor at room level and not inside an item of cooling equipment but is considered part of the cooling system.

NOTE 2 – Setting of this dataset is an optional functionality.

NOTE 3 – Optional information.

10 Data definition and requirements

10.1 Requirements for data items of ICT equipment

10.1.1 Measured parameters for energy management

The inlet temperature and input power of the ICT equipment shall be provided as measurement parameters.

In energy management, it is necessary to maintain ICT equipment that operates under varying load conditions within a specified temperature range and to monitor how much energy the equipment consumes.

ICT equipment generally has a number of embedded sensors placed in necessary locations. What measured data are collected or how the data are aggregated may depend on each operator's management applications, but the abovementioned parameters, aggregated in some cases, shall be provided as common parameters for monitoring and control. Precise location information of embedded sensors in the equipment is not necessarily required.

10.1.2 Common identification of measured parameters

The names and IDs of sensors used for measuring data parameters are assigned by equipment vendors. Thus, when monitoring the inlet temperature of equipment, for example, it is necessary to identify the sensor name (or ID) corresponding to the inlet temperature and to configure necessary settings for each piece of equipment. This adds unnecessary inconvenience and ineffectiveness to the management operations of many equipment resources.

Each parameter corresponding to the inlet temperature and input power of equipment shall therefore have a common name and/or ID that are not dependent on vendors.

10.1.3 Measurement interval

For energy efficient operation of ICT equipment, related data should immediately be measured and collected. Considerations on setting the interval of measurement include the importance of timeliness of data, the performance of the measuring tool and the amount of measured data. For example, it is desirable to set a very short time interval of measurement when the data varies in time or the variation of the data in time is regarded as significant. On the other hand, if the data does not vary significantly in time or if the amount of measured data is high, it may be desirable to set a longer measurement interval.

Real-time measuring is not always possible due to the features and limitations of equipment measuring tools. Even though measurement is carried out in a real-time manner, a management system may not collect or store measurements in the same way. For example, when a measuring tool measures and collects data every 30 seconds from ICT equipment, a management system may average the data out over 5 minutes or 1 hour.

10.1.4 Indication of allowable temperature range

The use of monitoring and control shall be applied in order to maintain the temperature environment of ICT equipment within an allowable range during its operation. Parameters of threshold value(s) shall be provided as information representing such a range. Examples of thresholds are "Non critical", "Critical", "Non recoverable", etc.

10.1.5 Measurement resolution and accuracy of the measurement data

The accuracy of measurement values depends on a sensor's capability, stability and location, i.e., whether the sensor is embedded or externally installed. The degree of precision necessary for these factors can be determined by the deployed ICT equipment specifications, management applications, and in a broader sense, the operator's management policy, capital costs and operational costs.

The accuracy of measured data, however, is essential for ensuring effective monitoring and control. First, the "resolution" of inlet temperature and input power of equipment shall be provided as the fundamental measurement unit concerning accuracy. Here "resolution" represents the smallest scale unit measurable by the sensor. Second, it is required to keep an acceptable error range of measured data in order to provide effective energy management. Therefore, the "accuracy" shall be provided as an acceptable error range of measured data.

10.2 Requirements for data items of facility equipment

10.2.1 Measured parameters for energy management

For cooling equipment, the following parameters are fundamental to energy management. Parameters related to the air-conditioning capability that the cooling system handles include supply air temperature, return air temperature, outdoor air temperature, temperature setting and relative humidity. Power and energy related parameters of cooling equipment include power consumption, energy consumption as well as the power state of the cooling equipment itself.

In addition, fan speed monitoring and control functionality may be necessary. For example, the use cases of coordinated energy management to reduce hot spots, shown in Appendix II, is to be one of the important best practices for data centres. For the power equipment, the input power and output power are fundamental to energy management.

10.2.2 Common identification of measured parameters

The names and IDs of sensors used for measuring data parameters are assigned by equipment vendors. Thus, when monitoring the return air temperature of cooling equipment, for example, it is necessary to identify the sensor name (or ID) corresponding to the return air temperature and to configure necessary settings for each piece of equipment. This adds unnecessary inconvenience and ineffectiveness to the management operations across multivendor environments.

Each measured parameter shall therefore have a common name and/or ID that are not dependent on vendors.

10.2.3 Measurement resolution and accuracy of the measurement data

The accuracy of measured data is essential for ensuring effective monitoring and control. Firstly, the "resolution" of measurement parameters shall be provided as the fundamental measurement unit concerning accuracy. Here "resolution" represents the smallest scale unit measurable by the sensor. Secondly, it is required to keep an acceptable error range of measured data in order to provide effective energy management. Therefore, the "accuracy" shall be provided as an acceptable error range of measured data.

Appendix III contains suggested values for accuracy of measurement data.

Appendix I

Examples of an optional data set for energy management in a cloud data centre

(This appendix does not form an integral part of this Recommendation.)

Appendix I is intended to present an optional data set for energy management of a cloud data centre. A cloud data centre is understood herein as a data centre used to provide mainly "cloud computing" platforms and services. The term "cloud computing" is a paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with on-demand self-service provisioning and administration, for more information, see [b-ITU-T Y.3500].

In a cloud data centre, ICT equipment can be virtualized and integrated into fewer systems according to resource utilization. For example, after analysing the relationship between central processing unit (CPU) utilization and the energy consumption of servers, it may be helpful to integrate distributed workloads in servers with low utilization into fewer servers for energy efficient management. For this purpose, not only the specifications of the CPU, disk and network interfaces but also their operating data should be monitored and managed.

I.1 Managed entities

Managed entities in cloud data centres include server, storage and network equipment. The CPU, disk and network interface whose workload (utilization) can be measured should be included in managed entities for energy management in cloud data centres. The CPU can be a managed entity for the server and the disk can be a managed entity for storage. Networking equipment such as a switch and a router can be composed of a common chassis with line cards and ports. Thus, chassis, line cards and ports in networking equipment can be a managed entity. Table I.1 shows managed entities for energy management in cloud data centres.

Table I.1 – Managed entities for energy management in cloud data centres

Equipment type	Managed entities	
ICT equipment	Server equipment	CPU
	Storage equipment	Disk
	Networking equipment	Chassis, line card, port (network interface)

I.2 Minimum data set

I.2.1 Minimum set of static data

The minimum set of static data for energy management in cloud data centres relates to the configuration and specifications of ICT equipment. Server specification may include the number of CPUs, the number of cores and clock rate. Storage specification may include the total capacity of disks in the storage equipment. Networking equipment specification may include configurations of chassis, line cards and ports and the bandwidth (transmission rate) of network interfaces.

Table I.2 – Minimum set of static data for energy management in cloud data centres

Equipment type	Data	Data flow direction
ICT equipment	Server specification	G
	Storage specification	G
	Networking equipment specification	G

I.2.2 Minimum set of dynamic data

The energy efficiency of cloud data centres could be improved if IT resource utilization is periodically collected and utilized for integrating many systems with low workloads into a few systems with high workloads. For this purpose, CPU utilization, disk utilization and network interface utilization in network equipment should be included in the minimum set of dynamic data as shown in Table I.3.

Table I.3 – Minimum set of dynamic data for energy management in cloud data centres

Equipment type	Data set	Data flow direction
ICT equipment	CPU utilization	G
	Disk utilization	G
	Network interface utilization	G

Appendix II

Examples of use cases for a minimum data set

(This appendix does not form an integral part of this Recommendation.)

Examples of use cases for a minimum data set are shown in Figure II.1.

– Monitoring the temperature and power of ICT and facility equipment

  To achieve energy saving in a data centre, it is necessary to collect ambient information such as floor temperature distribution and power usage of ICT equipment. As shown in use case 1 of Figure II.1, energy management systems are considered to be capable of detecting hot and cold spots, improving CRAC operation and of analysing the power-usage trends of each piece of equipment by collecting the necessary ambient information from ICT and facility equipment. The inlet temperature, power usage and power state of ICT equipment are examples of dynamic data to be collected. In addition, to maintain ICT equipment within the allowable temperature range, the threshold inlet temperature of ICT equipment can be considered as an example of static data to be collected.

– Coordinated control of multiple cooling units

  It is important that cooling units can be managed appropriately to operate ICT equipment in the data centre with stability in the appropriate temperature environment. Currently in many data centres, multiple ambient type cooling units are installed for cooling entire computer floors and these cooling units are generally controlled individually and autonomously.

The concept of coordinated control of multiple cooling units is shown in use case 2 of Figure II.1.

The left part of use case 2 shows a case in which multiple cooling units are operated at a uniform temperature setting in a machine room with heat load deviation. In this case, hot spots occur locally in the area with a large heat load and the environment temperature cannot be maintained properly. In addition, cold spots occur locally in areas with a small heat load and the power of cooling units is consumed ineffectively.

With the issues mentioned above, the right part of use case 2 shows a solution in which multiple cooling units with individual and dynamic temperature settings and the fan mode for each cooling unit are properly controlled by the management system.

To make such coordinated control possible, it is required that the management system collects the following dynamic data:

- ICT equipment: inlet temperature, power consumption and power state,
- Cooling unit: power state, temperatures (return air, supply air and outside air), temperature setting, frequency of fan, operational mode (normal operation mode, protected operation mode), power consumption and energy consumption.

It is also required that the management system controls the following parameters.

- Cooling unit: temperature setting.

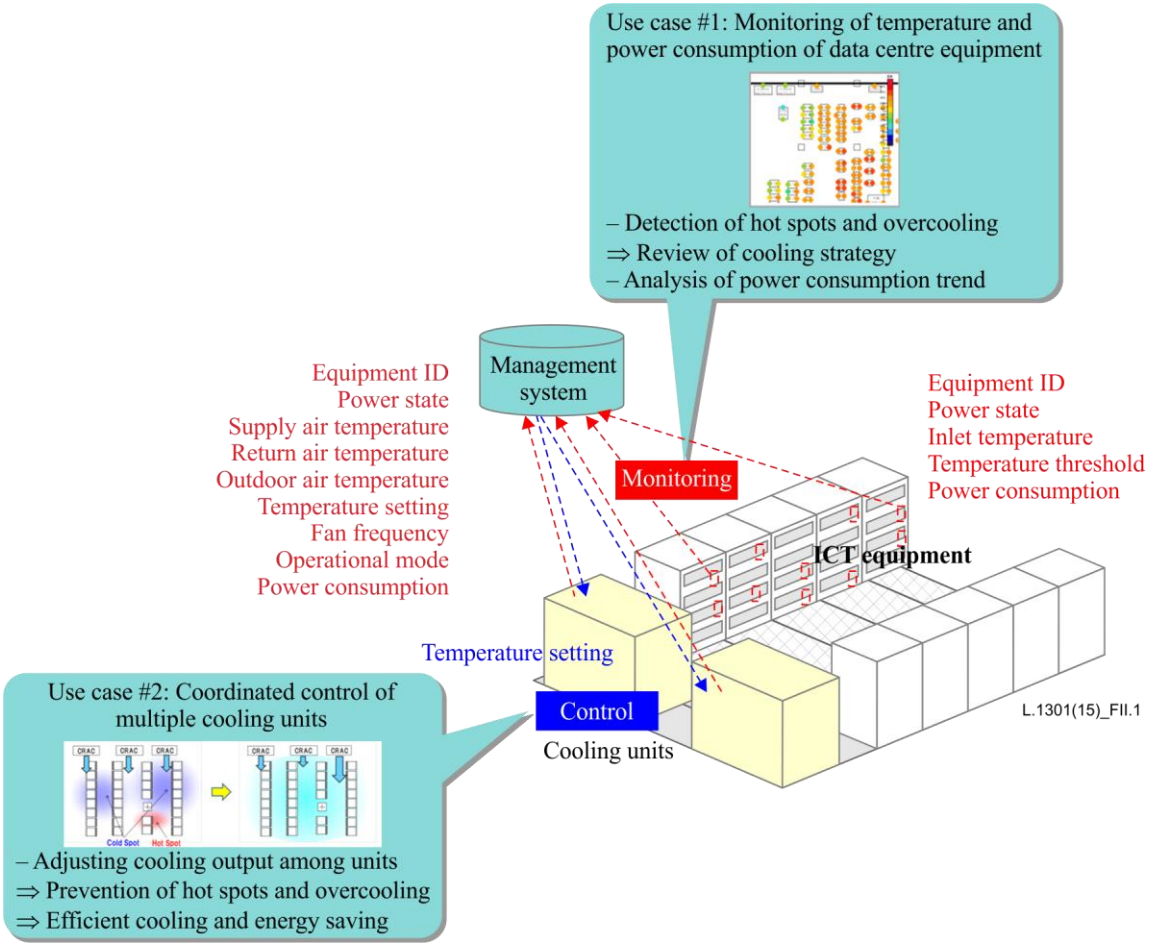

Figure II.1 – Examples of use cases for a minimum data set

Appendix III

Suggested accuracy value of measurement data

(This appendix does not form an integral part of this Recommendation.)

III.1 ICT equipment

Suggested accuracies of measurement data of ICT equipment may be:

For input power: ±3% from 25% to 100% load and ±5% below 25% load

For inlet temperature: ±1°C in the range of 20-50°C

As a means for ICT equipment to achieve required accuracy, the following can be considered.

Employing sensor hardware with required accuracy

Executing some software processes on measurement data (e.g., calculating a mean value of multiple sensors data)

III.2 Cooling equipment

Suggested accuracies of measurement data of cooling equipment may be:

For air temperature: ±0.5°C in the range of 20-50°C

For relative humidity: ±5%

For power consumption: ±2%

For energy consumption: ±2%

III.3 Power equipment

Suggested accuracies of measurement data of power equipment may be:

For voltage: ±1%

For current: AC current ±1%, DC current ±5%

Appendix IV

Related standardization activities in other standards development organizations

(This appendix does not form an integral part of this Recommendation.)

Other standardizing organizations and initiatives study and address energy management aspects of facility and ICT equipment at telecommunication and data centre sites.

IV.1 Activities in ETSI

[b-ETSI ES 300 202 336-1] defines a generic interface that applies to monitoring and control of the infrastructure environment, i.e., power, cooling and building environment systems for telecommunication centres. Further, [b-ETSI ES 300 202 336-12], as a related document series, is under development. This applies to a monitoring and control interface for telecom/ICT equipment power, energy and environmental parameters in telecommunication or data centres or customer premises.

It discusses measurement both inside and outside of equipment, metrics and conditions such as input voltages and currents of equipment, air temperature and humidity at inlets and precision and accuracy, for larger and more complex sites that have many types of equipment provided by different manufacturers.

IV.2 Activities in ECMA

[b-ECMA-400] describes modelled resources by using common information models (CIMs) of IT and facility equipment, systems and components in a data centre.

IT systems refer mainly to computer systems and facility equipment refers to cooling systems. The energy management aspect of computer systems deals with properties of the input power and detailed power statuses.

IV.3 Activities in IETF

[b-IETF RFC 7326] defines an energy management framework for devices within or connected to communication networks. The devices, or components of these devices (such as router line cards, fans and disks), can then be monitored and controlled. [b-IETF RFC 6988] defines requirements. [b-IETF RFC 7461] and [b-IETF RFC 7460] provide energy management related management information base (MIB) information to cover energy management functionality that is not covered by the Telecommunications Management Network model.

Energy management objects applied to network equipment include, for example, measured power, measurement caliber (actual/estimated/presumed), power consumption over a certain interval, unit multiplier and accuracy. In addition, relationships are provided as powered by/powering, metered by/metering and aggregated by/aggregating.

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