

# TECHNICAL REPORT

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**IIoT applications in power distribution systems management: Architecture and functional requirements**

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IEC Secretariat  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

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## IloT applications in power distribution systems management: Architecture and functional requirements

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IEC TR 63353 has been prepared by IEC technical committee 57: Power systems management and associated information exchange. It is a Technical Report.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
57/2848/DTR	57/2881/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://www.iec.ch/publications).

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## 1 Scope

This technical report provides the general architecture and system components for applying the IoT technology in power distribution networks. It describes the system architecture, system components and several typical applications in integration and intelligent management of power distribution networks.

## 2 Normative references

There are no normative references in this document.

## 3 Terms, definitions and abbreviated terms

### 3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

#### 3.1.1

##### **reference architecture**

architecture description for a specific subject area that guides and constrains the structure and behaviour of a related set of systems of interest

[SOURCE:ISO/IEC 20924:2024, 3.1.26]

#### 3.1.2

##### **Internet of Things**

##### **IoT**

infrastructure of interconnected entities, people, systems and information resources together with services which processes and reacts to information from the physical world and virtual world

[SOURCE:ISO/IEC 20924:2024, 3.2.8]

#### 3.1.3

##### **Power Distribution Internet of Things**

##### **PD-IoT**

information network which applies the IoT technologies for electric power network protection, automation, monitoring, operation and planning applications in power distribution

#### 3.1.4

##### **cloud computing**

paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand

[SOURCE:ISO/IEC 17788:2014,3.25]

### 3.1.5

#### **edge**

boundary between pertinent digital and physical entities, delineated by networked sensors (3.1.9) and actuators (3.1.10)

[SOURCE: ISO/IEC TR 23188:2020, 3.1.2]

### 3.1.6

#### **edge computing**

distributed computing in which processing and storage takes place at or near the edge (3.1.5), where the nearness is defined by the system's requirements

[SOURCE: ISO/IEC TR 23188:2020, 3.1.3]

### 3.1.7

#### **PD-IoT device**

entity of an IoT system that interacts and communicates with the objects and environment related to electric power distribution through sensing or actuating, with embedded or external modules

### 3.1.8

#### **PD-IoT gateway**

entity in an IoT system that connects one or more wide area networks and the PD-IoT devices on those networks to each other and to one or more access networks

### 3.1.9

#### **sensor**

PD-IoT device (3.1.7) with the capability of sensing

[SOURCE:ISO/IEC 20924:2024 3.2.20, modified]

### 3.1.10

#### **actuator**

PD-IoT device (3.1.7) that changes one or more properties of a physical entity in response to an input

[SOURCE:ISO/IEC 20924:2024, 3.2.20, modified]

### 3.1.11

#### **application**

#### **APP**

software designed to fulfil a particular purpose

[SOURCE<sub>1</sub>: ISO/IEC 20924:2024, 3.1.1; SOURCE<sub>2</sub>: ISO/IEC 24713-2:2008, 4.1, modified – "program or piece of" has been deleted from the beginning of the definition. This document applies application software or application program to avoid the misunderstanding of application]

### 3.1.12

#### **tag**

human- or machine-readable mark, or digital identity used to communicate information about an entity

Note 1 to entry: A tag can contain information that can be read by sensors to aid in identification of the physical entity.

[SOURCE: ISO/IEC 20924:2024, 3.1.31]

**3.2 Abbreviated terms**

APP	Application software or application program running on PD-IoT gateways
ASD	Application & Service Domain
CoAP	Constrained Application Protocol
DER	Distributed energy resources
DSO	Distribution System Operator
EV	Electric Vehicle
FAN	Field Area Network
IaaS	Infrastructure as a Service
IED	Intelligent Electronic Device
IoT	Internet of Things
IoT RA	Internet of Things Reference Architecture
LAN	Local Area Network
MQTT	Message Queuing Telemetry Transport
OMD	Operations & Management Domain
PaaS	Platform as a Service
PD-IoT	Power Distribution Internet of Things
PED	Physical Entity Domain
PLC	Power Line Communication
RA	Reference Architecture
RAID	Resource Access & Interchange Domain
RTU	Remote Terminal Unit
SGAM	Smart Grids Architecture Model
SaaS	Software as a Service
SCD	Sensing & Controlling Domain
UD	User Domain
WAN	Wide Area Network

**4 Reference architecture context and methodology****4.1 Overview**

This document specifies a reference architecture for the IoT applications in power distribution systems management and system components.

This document can be used by those people looking to

- Develop software or hardware
- Provide services involving IoT application
- Procure or implement IoT system

in power distribution management for creating interoperability and alignment.

## 4.2 Methodology

This document follows the approach and terminology that is defined in ISO/IEC/IEEE 42010. ISO/IEC/IEEE 42010 specifies requirements for the use of architectural concepts and their relationships, and provides a precise and structured approach of defining architectures.

IEC TR 62357-1 provides a clear and comprehensive map of interactions between different systems in the power system management. ISO/IEC 30141 specifies a general IoT reference architecture in term of defining system characteristics, a conceptual model, a reference model and architecture views for IoT. Both documents are very helpful in generating the reference architecture of the IIoT application in power system management. Therefore this document is also aligned with IEC TR 62357-1 and ISO/IEC 30141.

## 4.3 Stakeholders and concerns

IoT application on a power distribution system can bring different types of businesses to the power distribution system. The stakeholders that can be involved in the system include:

- Suppliers and production engineers: Design, supply, and deploy the hardware and software on edge computing devices, end devices (sensors, IEDs, etc.) and local/field area network.
- Cloud service or hardware supplier: Provide cloud service or server hardware where the PD-IoT Cloud functions can be deployed.
- Cloud application software engineering: Design and deploy the software on the cloud (control centre, controlling station, Network management system, Remote asset management, PD-IoT device management, etc.).
- Wide area network operator: Provide wide area network for the remote communication between Cloud and Edge.
- Edge APP software engineering: Design and supply application software for the edge computing devices for different purposes.
- Developer and builders: Construct and deploy the PD-IoT system to the power grid.
- Regulators and standard associations: Define the legal, standard, regulatory, and domain-specific norms for safety, reliability, security, privacy, and resilience.
- Testers and assessors: Test the hardware and software to ensure that they are suitable for use based on standards and legal regulation.
- Owners and users: Derive the benefits of PD-IoT when in use (DSOs, electricity market operator, Virtual power plant, etc.).
- Operators and maintainers: Run the PD-IoT once it has been deployed and manage the evolution.

Table 1 shows a list of viewpoints, stakeholders and concerns:

**Table 1 – list of viewpoints, stakeholders and concerns**

<b>Viewpoint</b>	<b>Stakeholders</b>	<b>Concerns</b>
Usage viewpoint	<ul style="list-style-type: none"> <li>– Developer and builders</li> <li>– Operators and maintainers</li> <li>– Owners and users</li> <li>– Suppliers and production engineers</li> </ul>	<ul style="list-style-type: none"> <li>– How to interact with and what information can be available to external systems</li> <li>– How do users interact with the PD-IoT?</li> <li>– How to interact with the Physical Power Grid</li> <li>– Is it able to support new business requirements?</li> <li>– How to reduce the cost (especially the communication costs)</li> <li>– How to update software or deploy new functions</li> <li>– How to monitor the status of the PD-IoT system</li> </ul>
Functional viewpoint	<ul style="list-style-type: none"> <li>– Cloud service or hardware supplier</li> <li>– Wide area network operator</li> <li>– Suppliers and production engineers</li> <li>– Cloud application software engineering</li> <li>– Edge APP software engineering</li> <li>– Suppliers and production engineers</li> <li>– Testers and assessors</li> <li>– Owners and users</li> </ul>	<ul style="list-style-type: none"> <li>– What is necessary for the data operations (create, read, update, process, delete)?</li> <li>– What data is available?</li> <li>– Is a time stamp available for the operating data?</li> <li>– How can all nodes have timing signals traceable to the same time scale with accuracies as required?</li> <li>– Is it possible to incorporate the PD-IoT system within a network of other systems?</li> </ul>
Construction viewpoint	<ul style="list-style-type: none"> <li>– Developer and builders</li> <li>– Owners and users</li> <li>– Suppliers and production engineers</li> </ul>	<ul style="list-style-type: none"> <li>– How to adapt the PD-IoT in different situations</li> <li>– How to exchange information between internal system, including WAN and FAN(LAN)</li> <li>– What protocol and information model are used?</li> </ul>
Dependability viewpoint	<ul style="list-style-type: none"> <li>– Testers and assessors</li> <li>– Operators and maintainers</li> <li>– Regulators and standard associations</li> <li>– Suppliers and production engineers</li> <li>– Regulators and standard associations</li> </ul>	<ul style="list-style-type: none"> <li>– How to ensure the functionality, performance of the deployed APPs</li> <li>– How to protect the PD-IoT from security vulnerabilities</li> <li>– Is this PD-IoT system free of maintenance? If no, is there any other systems required for the maintenance service?</li> <li>– How to prevent unauthorized entities from gaining access to the data?</li> <li>– How does the system deliver stable and predictable performance in expected conditions?</li> <li>– How does the system withstand instability and unexpected conditions?</li> </ul>

## 5 Reference models

### 5.1 IEC TR 62357-1 Smart Grids Architecture Model

IEC Technical Committee 57 published a Smart Grids Architecture Model (SGAM). This SGAM partitioned the smart grid into the physical **domains** of the electrical energy conversion chain, and the hierarchical **zones** for the management of the electrical process, in which "zones" illustrate the physical and management aspects of the grid and "domains" represent the complete electrical energy conversion chain (Generation, Transmission, Distribution, Distributed Energy Resources (DER) and Customer Premises). Figure 1 shows the domains and zones.

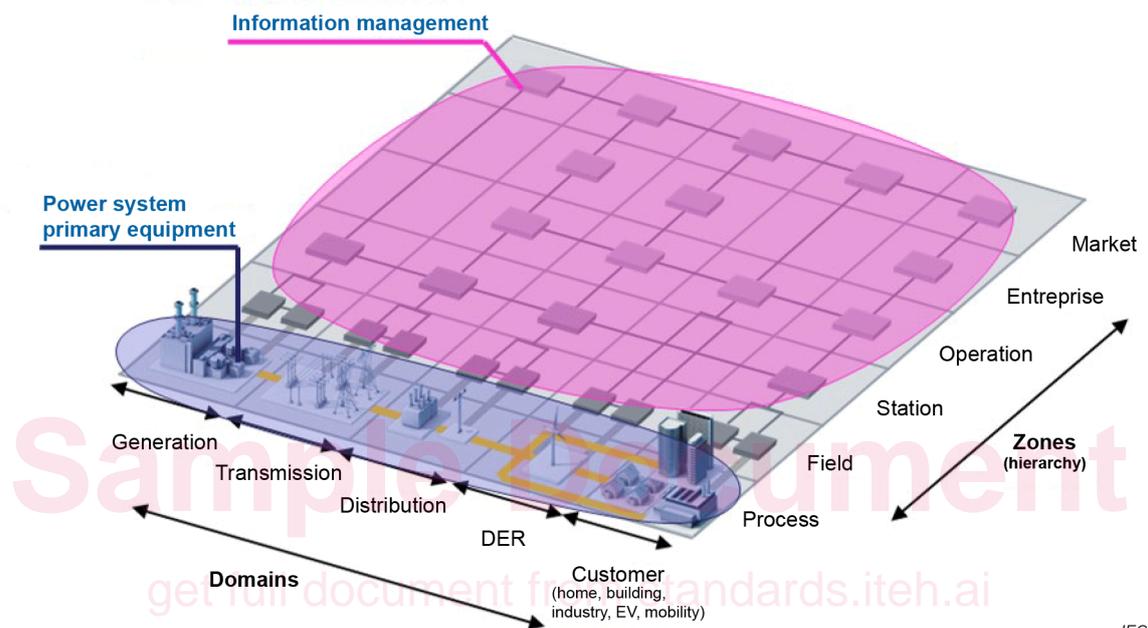


Figure 1 – SGAM plane

Interoperability is a key enabler for Smart Grids. In order to achieve interoperability between different stakeholders, five superimposed interoperability layers are defined in SGAM as Component, Communication, Information, Function and Business. The Smart Grids Architecture Model is illustrated in Figure 2.

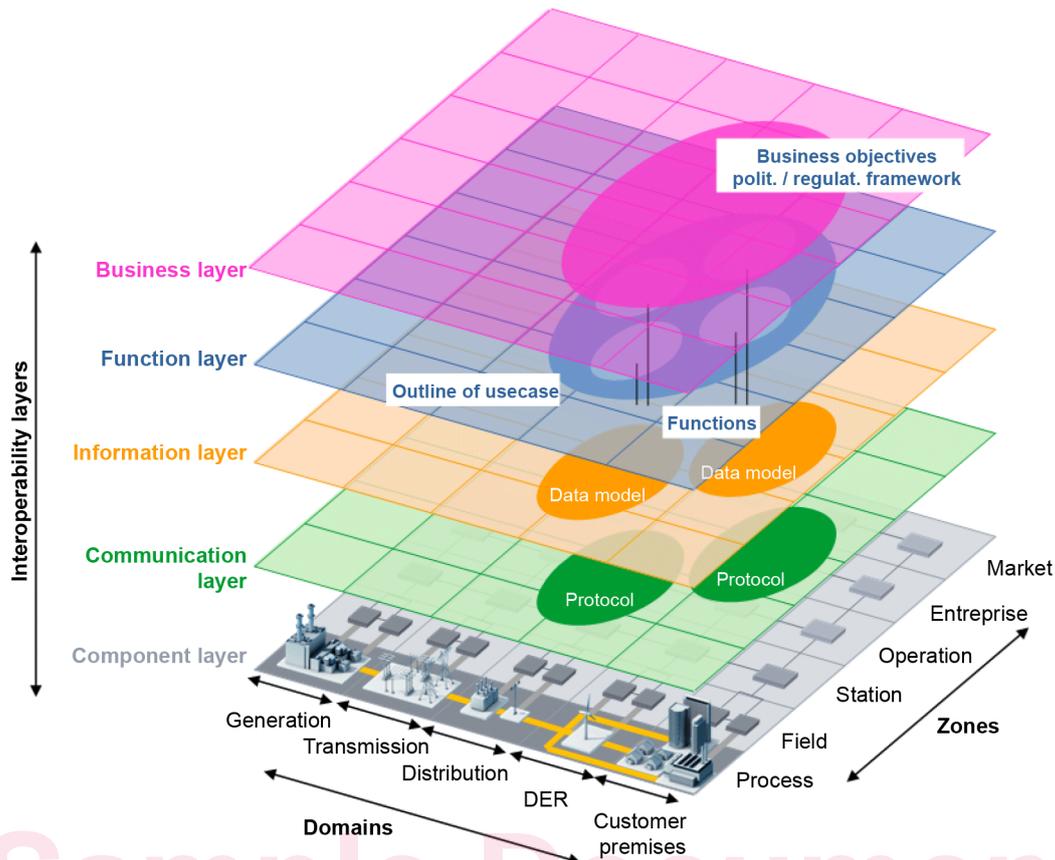


Figure 2 – SGAM Model

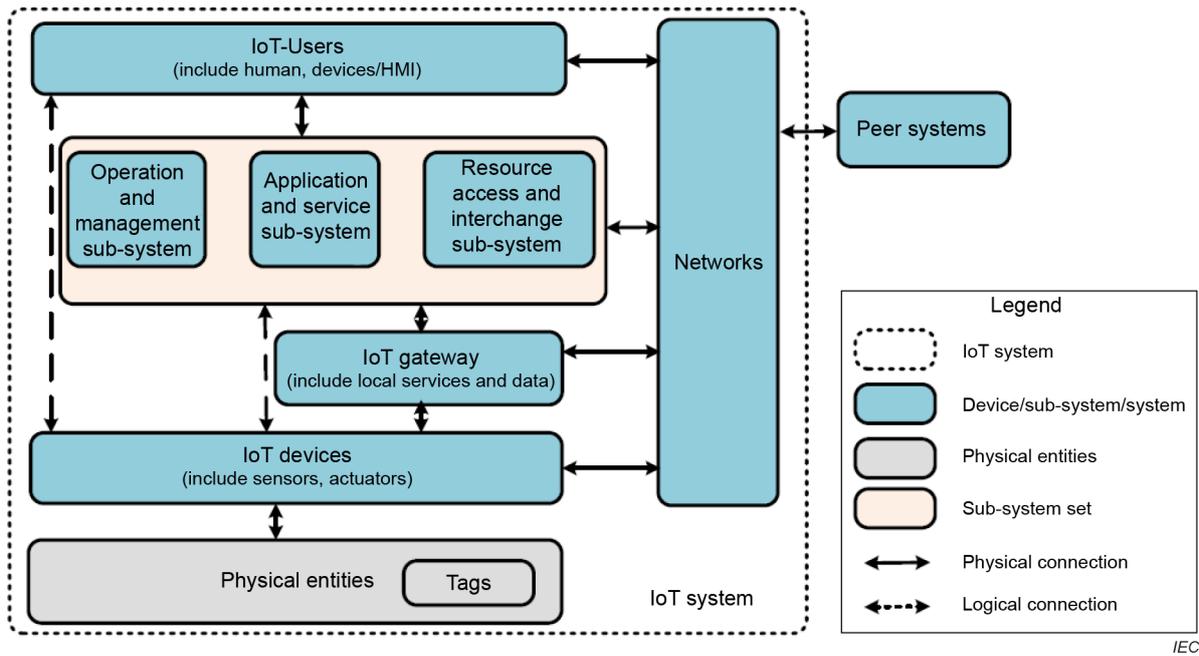
## 5.2 ISO/IEC 30141 IoT Reference Models

ISO/IEC 30141 developed an entity-based reference model and a domain-based reference model (Figure 4) of the IoT systems.

The entity-based reference model consists of 10 IoT entities:

- Physical entities,
- Tags, in various types that can be attached to Physical Entities,
- IoT devices, including sensors and actuators,
- IoT gateways, including local services and data,
- IoT communication networks,
- Application and service subsystem,
- Operation and management subsystem,
- Resource access and interchange subsystem,
- Users. including both human users and digital users,
- Peer systems, including both IoT and non-IoT systems.

The connection between different entities is given in Figure 3.

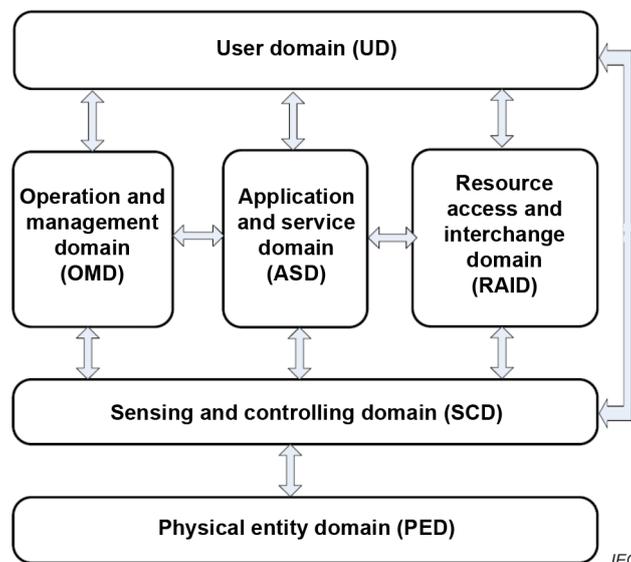


**Figure 3 – Entity-based IoT reference model**

The domain-based IoT reference model abstracts the entities to six domains:

- Physical Entity Domain,
- Sensing & Controlling Domain,
- Operations & Management Domain,
- Application & Service Domain,
- Resource Access & Interchange Domain,
- User Domain.

The communication networks and peer systems are not shown in the domain-based IoT reference model (Figure 4), but both are important components of any IoT system.



**Figure 4 – Domain-based IoT reference model**