Activities of the ITU-T on Smart Grid

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Green ICTs and Smart Grids
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Bangkok, Thailand

International Telecommunication Union

Recent Trend of Standardization

- Use Cases

- Requirements

- Reference Architecture

- Specifications / Recommendations

Focus Group on Smart Grid (FG Smart)

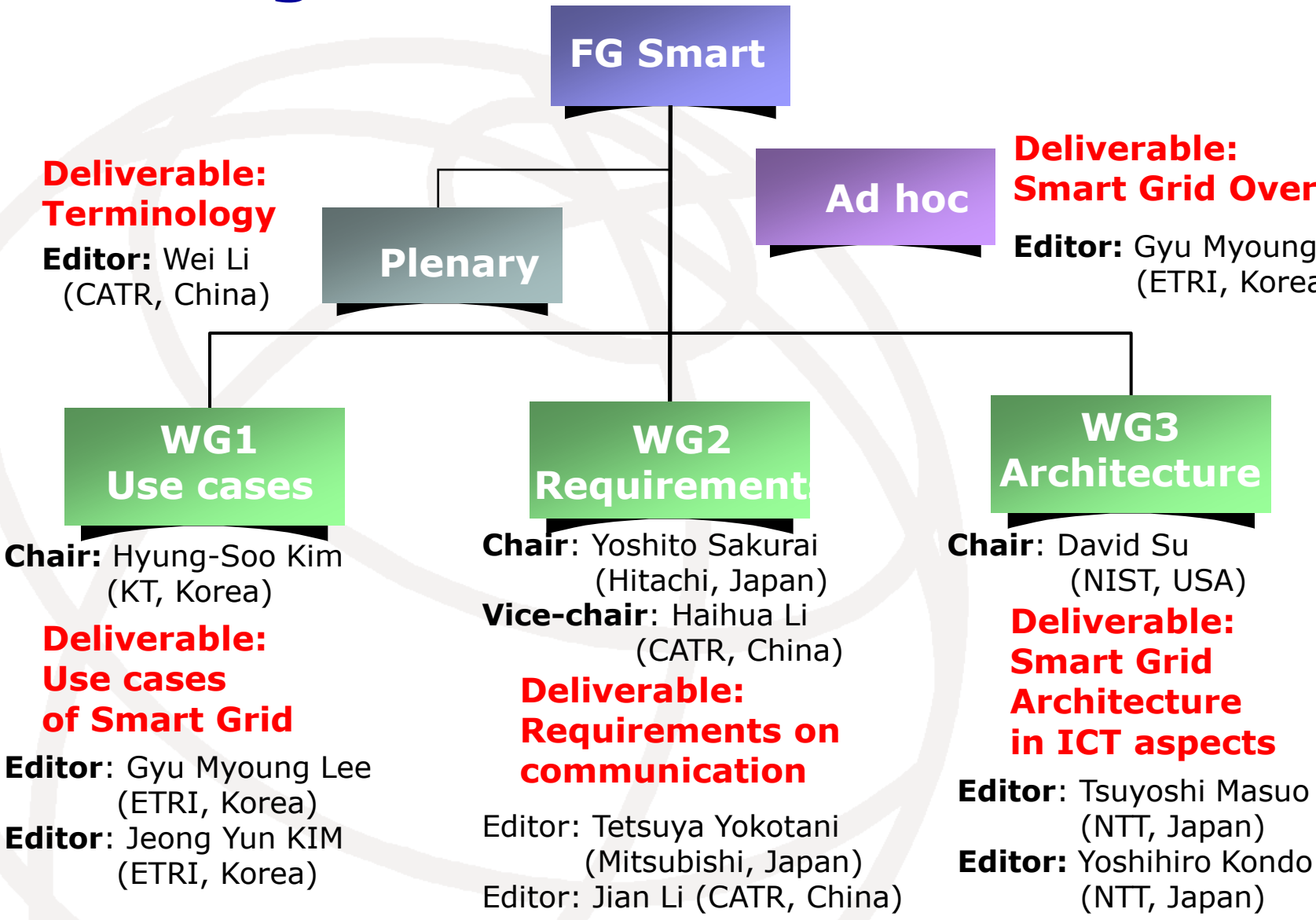
Date of Establishment

ITU-T TSAG agreement at its meeting in Geneva, 8-11 February 2010 to establish ITU-T Focus Group on Smart Grid (FG Smart)

Management Team

Title	Name
Chairman	Mr Les Brown (Lantiq, Germany)
Vice Chairman	Ms Li Haihua (MIIT, China)
Vice Chairman	Mr Hyungsoo Kim (Korea Telecom, Korea)
Vice Chairman	Mr Yoshito Sakurai (Hitachi, Japan)
Vice Chairman	Mr David Su (NIST, USA)
TSB Secretariat	Mr Hiroshi Ota
TSB Assistant	Ms Emmanuelle Labar

Organization of FG Smart



3 Working Groups, 5 deliverables

FG Smart Strategic Direction

FG Smart objective (from ToR)

The objective of the Focus Group is to collect and document information and concepts that would be helpful for developing Recommendations to support smart grid from a telecommunication/ICT perspective. Therefore, the objective is limited to the telecommunication/ICT aspects of smart grid, i.e., things like the standardization of metering aspects of smart meter devices and work within the responsibilities of energy standardization bodies are out of scope.

Complete Terms of Reference:

http://www.itu.int/en/ITU-T/focusgroups/smart/Pages/tor.aspx

FG Smart Strategic Direction

FG Smart rationale (from ToR)

In WTSA-08 Resolution 73 (Information and communication technologies and climate change) ITU-T called for the development of appropriate Recommendations within its mandate and competency in order to support the reduction of CO2 emissions and the impacts of climate change.

The term “smart grid” is used for a concept of “intelligent” electricity networks aiming to save energy and to reduce CO2 emissions.

FG Smart Strategic Direction

Smart grid in ITU-T (from ToR)

- A smart grid concept will need harmonized support from telecommunication/ICT and electric power technologies and may result in the need for flexible network and service capabilities to accommodate demands.
- Smart grid principles may also be applied to the telecommunication/ICT system itself, consisting of networks and service platforms, in the course of providing services with more efficient use of energy not only for the core network and access domains but also for home networks.

FG Smart Strategic Direction

The Focus Group (FG) aims to

- identify potential impacts on standards development;
- investigate future ITU-T study items and related actions;
- familiarize ITU-T and standardization communities with emerging attributes of smart grid, and
- encourage collaboration between ITU-T and smart grid communities;

The Focus Group will collaborate with worldwide smart grid communities (e.g., research institutes, forums, academia) including other SDOs and consortia.

FG Smart Activities

Meetings and Events

- 1st meeting of FG-Smart: 14-16 June 2010, Geneva
- 2nd meeting of FG-Smart: 2-5 Aug 2010, Geneva
- 3rd meeting of FG-Smart: 11-15 Oct 2010, Geneva
- 4th meeting of FG-Smart: 29 Nov-3 Dec 2010, Chicago, USA
- 5th meeting of FG-Smart: 10-14 Jan 2011, Yokohama, Japan
- 6th meeting of FG-Smart: 4-8 Apr 2011, Sophia Antipolis, France
- 7th meeting of FG-Smart: 9-15 Jun 2011, Jeju Island, Korea
- 8th meeting of FG-Smart: 22-26 Aug 2011, Geneva

All of the meeting documents can be found at:

- http://ifa.itu.int/t/fg/smart/docs/
- http://www.itu.int/en/ITU-T/focusgroups/smart/Pages/Default.aspx

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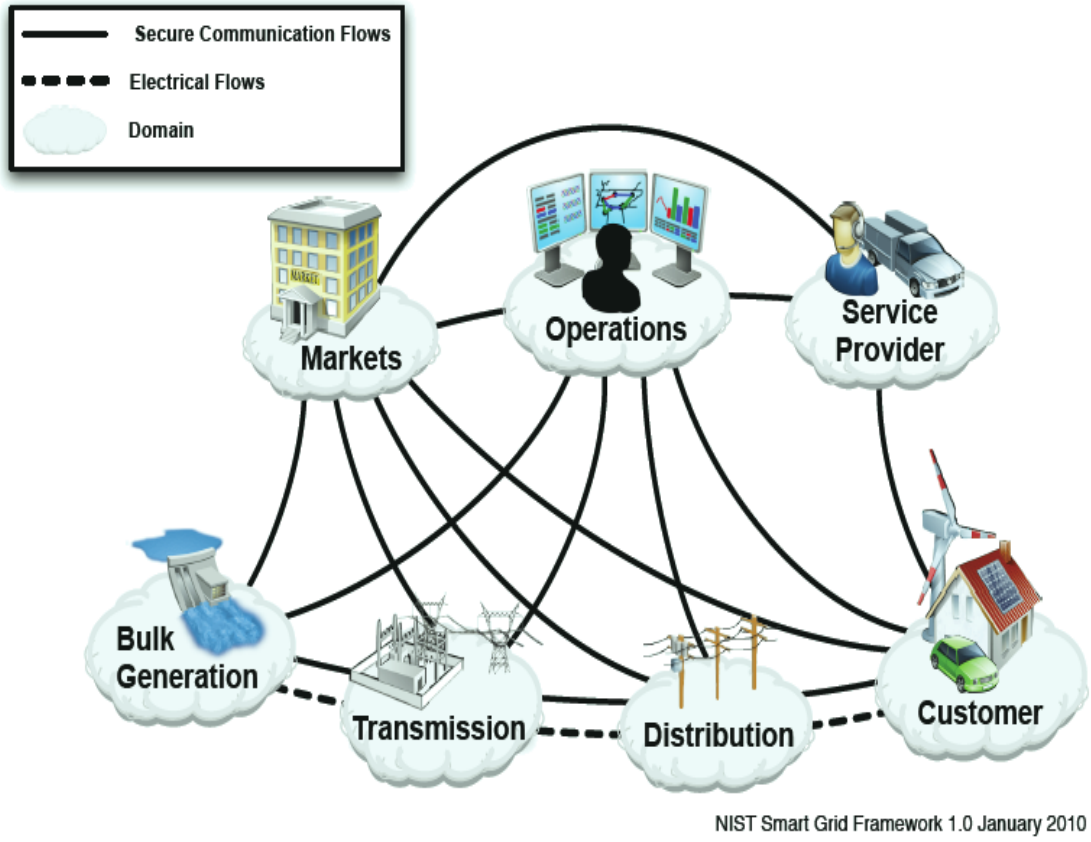
Smart Grid Conceptual Model



Distributed Power Generation

- not explicitly shown in the model
- May occur in the Customer, Distribution, and Transmission domains.
- new paths for electrical and communication flows need to be shown in relevant domains if depicted in the model

Figure 1. A conceptual model of Smart Grid

ICT Perspective of Smart Grid

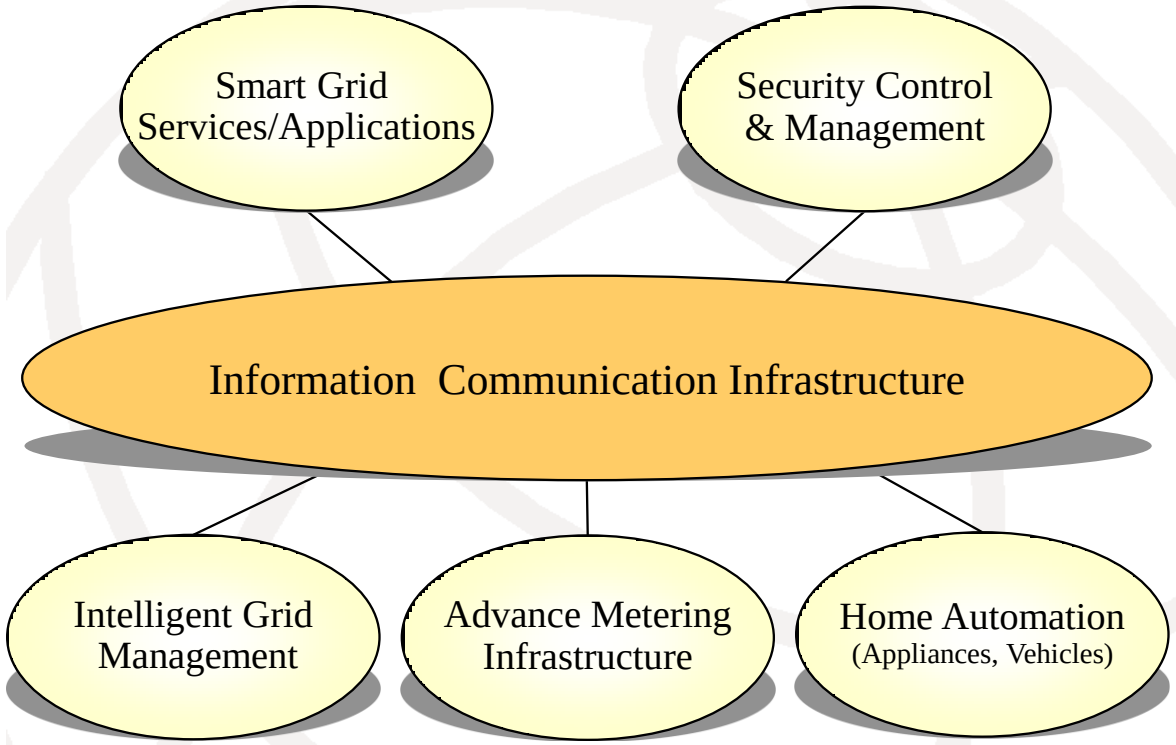


Figure 2. Key areas for standardization in the ICT perspective

key areas for Smart Grid standards:

- Technologies for automated energy management and decentralized power generation in customer premises, including home, building, and factories
- Intelligent grid management at the power transport and distribution level
- Smart meters and AMI
- Information and communication infrastructure to provide energy intelligence, control and security
- Applications and services for the coordination the energy system on the business level
- Security control and management with the different level of requirements for Smart Grid

Modified Domain Model

5 domains+4 reference points

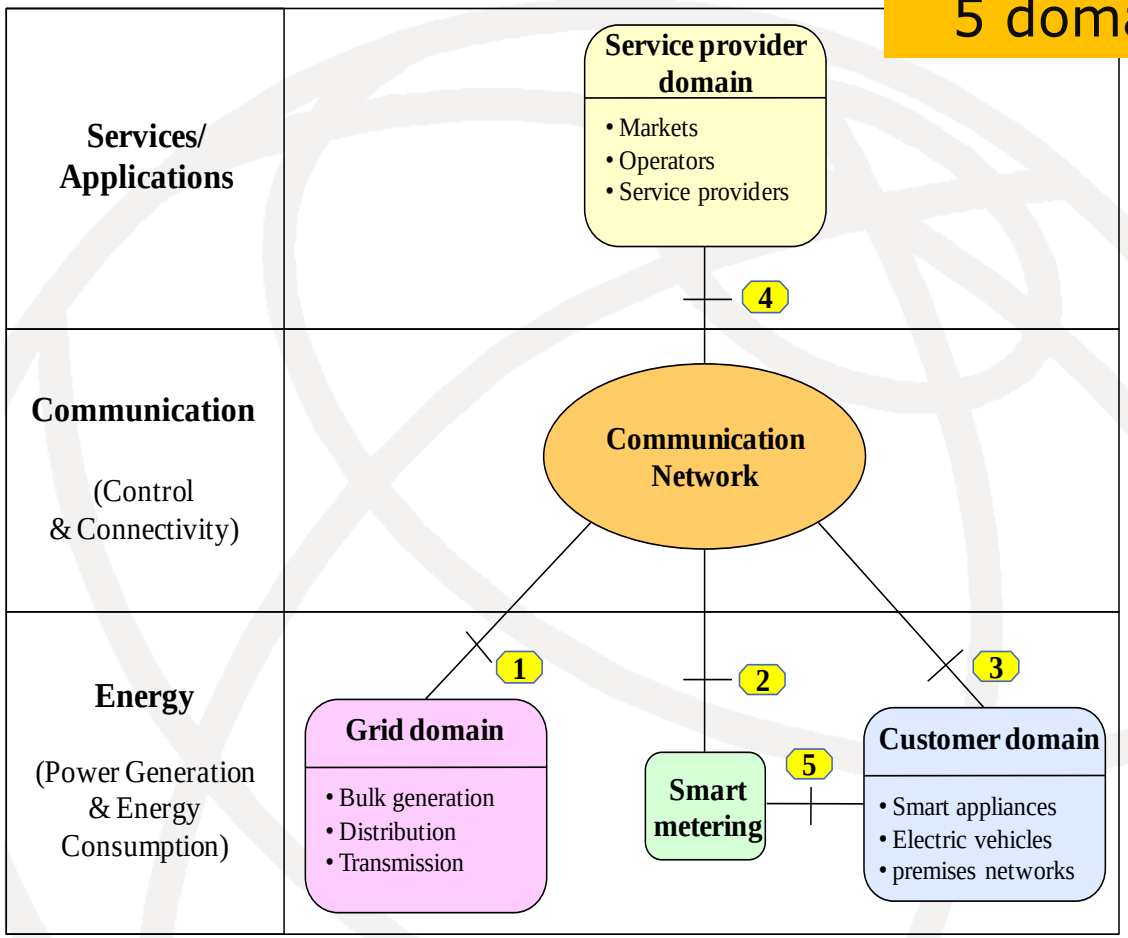


Figure 3. Simplified Smart Grid domain model in ICT perspective

- **RP 1--**enables exchange of information and control signals between devices in the Grid Domain and the Service Providers domains
- **RP 2--**enables exchange of metering information and interactions with customers in the Customer domain
- **RP 3--**enables interactions between operators and service providers in the Service Provider domain
- **RP 4--**enables communications between services and applications in the Service provider domain to all actors in others domains
- **RP 5—**optional, Between Smart metering and Customer domain, through energy service gateway

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Template for Detailed Use Cases

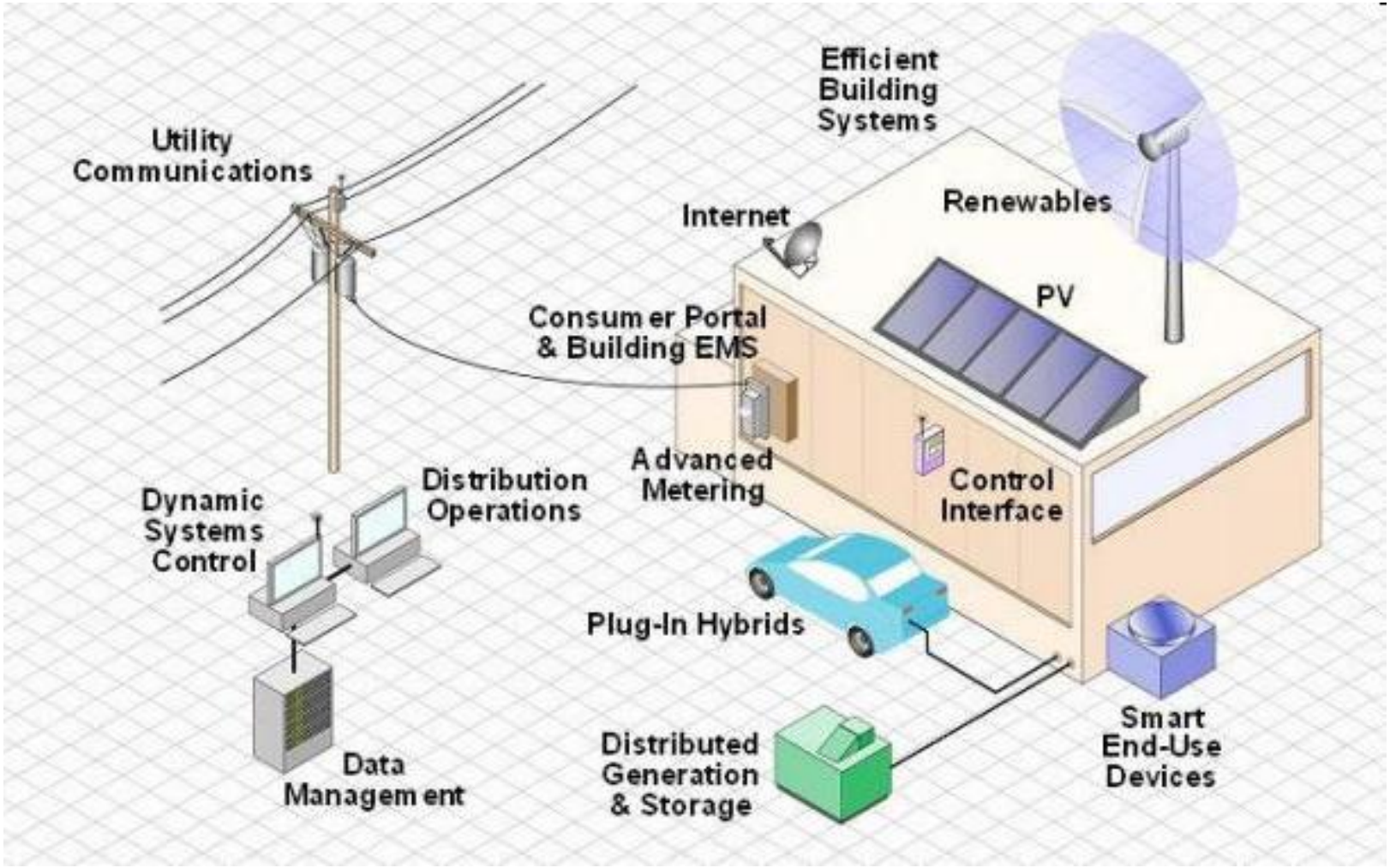
Deliverable: Use Cases for smart grid

Title - X: high-level use case title	***Sub-title***: Specific title of use case related to the high-level use case
Description	General description for use case of smart grid in the ICT perspective
Stakeholders (Actors)/ Domains	Roles of related stakeholders and domains in the Appendix II
Information Exchanges	Protocol procedures between entities
Potential new requirements	Requirements in terms of interface/system and component
Source* ***(References)***	FG-Smart contribution number and/or reference document, websites

* Source will be deleted in the final version

Example of Detailed Use Cases

Deliverable:
use cases for smart grid
Managing Appliances through/by Energy Gateway



Example of Detailed Use Cases

Deliverable:
use cases for smart grid
Managing Appliances through/by Energy Gateway

MA 1	**Charging management for appliances including electric vehicle at home**
Description	Inside the user's premise, PEV (plug-in electric vehicle), PV (photo voltaic system), home appliance, and household equipments participate in a home network and in load management that GW (gateway) governs. PEV is considered both an electric load and an electric storage. PEV communicates to the home network.
Stakeholders (Actors)/ Domains	Organization (company), Device, System, Stored information in computer memory or on media, Computer program(s) and displays / Operators, Customer(Home/Building/Commercial/Industrial)
Information Exchanges	a. GW detects PEV coming into the garage. GW authenticates and authorizes PEV. PEV sends to GW information on e.g. charge level, miles driven, driving pattern. b. GW, while monitoring power generation of PV and electricity consumption of home appliances/household equipments, receives the information. GW decides whether to charge PEV, inject PEV's power to home, or do nothing. c. For charging of PEV, GW dictates PEV to change into the charge mode. PEV detects when it's fully charged. PEV informs GW and stays stand-by. d. For injection of PEV's power to home, GW dictates PEV to change into the discharge mode. GW monitors status of discharging and load balance at home. GW judges and dictates PEV to stop discharging. PEV stays stand-by. e. When PEV goes out of the garage, GW detects it.
Potential new requirements	Following functional requirement may need to be considered as GW requirement. -Electric power load management at home, including PEV energy consumption control based on the PEV charging status - Status management of such as charge level, miles driven, driven pattern, status of whether or not PEV is in e.g., garage - Device management e.g., change PEV to charge mode
Source (References)	Smart-I-0067

Categories of High-level Use Cases

Deliverable: Use Cases of smart grid

No	Title
1	Demand Response
2	WASA (Wide Area Situation Awareness)
3	Energy Storage
4	Electric Transportation
5	AMI systems
6	Distribution Grid Management
7	Market Operations
8	Cyber security
9	Network/System management
10	Existing user's screens
11	Managing Appliances through/by Energy G/W
12	Electric Vehicle
13	Local Energy Generation/ Injection
14	Other use cases

Example Description of High-level Use Cases

Deliverable: Use Cases for smart grid

No	Title	Description
1	**Demand Response**	Mechanisms and incentives for utilities, business, industrial, and residential customers to cut energy use during times of peak demand or when power reliability is at risk. Demand response is necessary for optimizing the balance of power supply and demand.
2	**WASA**	Monitoring and display of power-system components and performance across interconnections and over large geographic areas in near real-time. The goals of situational awareness are to understand and ultimately optimize the management of power-network components, behavior, and performance, as well as to anticipate, prevent, or respond to problems before disruptions can arise.
3	**Energy Storage**	Means of storing energy, directly or indirectly. Smaller forms of energy storage are anticipated within distribution systems as well as bulk power systems. New storage capabilities—especially for distributed storage—would benefit the entire grid, from generation to end use, but the resources need to be correctly integrated into T&D operations.

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Procedure 1 (Requirements)

- Use cases → Requirements
  - 83 use cases → 174 requirements

All the requirements are described with template.

→ See example

Template for Requirements

New Requirement No.	Identification of requirements in main text
Requirement No.	Identification of requirements
Domains / Address	
Position of Requirements	Identification of planes and layers
Requirement	**Description of requirement(s)**
Type of requirement	Required or May Optionally, and its condition if needed.
Background	Description for readability is provided.
Reference	
Gap analysis	Relationship between this requirement and conventional standard

Example (Requirement)

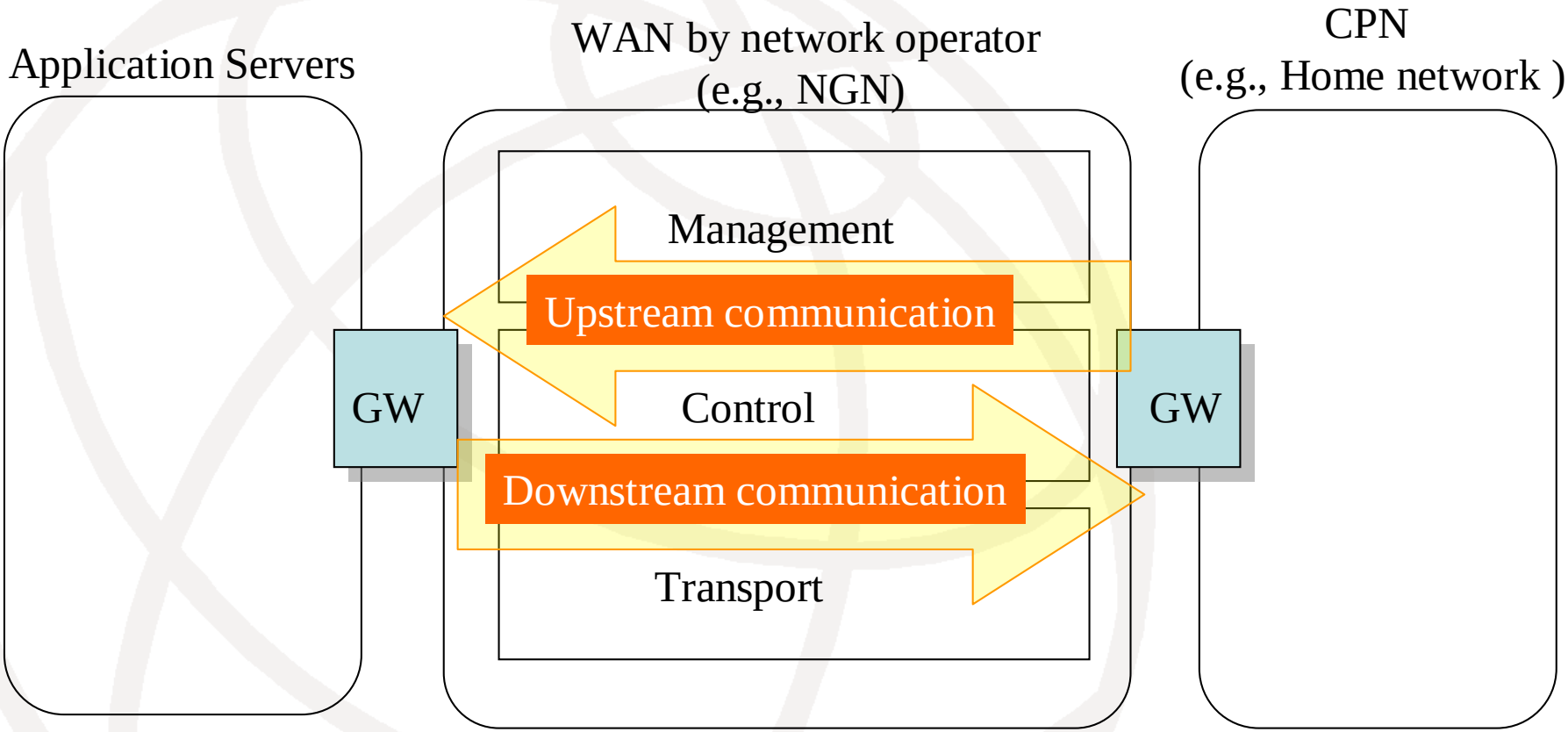

Figure 4 Network architecture for ecology related services

Example (Requirement)

New Requirement No.	COM-CN-QoS-05-I-R, COM-CN-QoS-06-I-R
Requirement No.	I-i-0035-1
Domains / Address	WAN
Position of requirements	Plane: Transport Layer: Network and Data Link Layers
Requirement	If information is communicated on IP, QoS class should be specified in each communication for smart grid. Required performance between edges of WAN on IP layer should be specified every application, and should be categorized into Classes 0, 1, 2, 3, 4, U according to ITU-T Y.1541 [ITU-T Y.1541]. Moreover, on data link layer, performance should be controlled to comply with IP layer performance.
Type of requirement	Required in the case of transport on NGN or managed IP network May Optionally in other cases
Background	Information for smart grid includes critical data which is sensitive of delay, delay variation, and loss. Therefore, performance on WAN should be clarified.
Reference	ITU-T Y.1541
Gap analysis	Currently, ITU-T Y.1541 does not mention smart gird in guidance for IP QoS classes. Since smart grid can be supported as an application on NGN or other managed IP network including utility network, smart grid should be added to guidance for IP QoS classes.

Example (Requirement)

New Requirement No.	COM-CN-QoS-05-I-R, COM-CN-QoS-06-I-R
Requirement No.	I-i-0035-1
Address	WAN
Position of requirements	Plane: T Lay
Requirement	If in ed sh Y. sh
Type of requirement	Re M
Background	In de sh
Reference	IT
Gap analysis	Cu IP NG grid sho

<A-B-XX-C-D>

A S/A: Services/Applications
COM: Communication
PHY: Physical Equipment

B Sub-clause title

XX Sequential number

C Source of a requirement
I: Input document / U: Use case

D Requirement type
RQ: Required / P: Prohibited /
R: Recommended / O: may Optionally

Example (Requirement)

New Requirement No.	COM-CN-QoS-05-I-R, COM-CN-QoS-06-I-R
Requirement No.	I-i-0035-1
Address	WAN
Position of requirements	Pla e: Trans L r: Netw
Requirement	ormation is communicated on IP, QoS class should be specified h communication for smart grid. Required performance between of WAN on IP layer should be specified every application, and be categorized into Classes 0, 1, 2, 3, 4, U according to ITU-T T Y.1541]. Mor formance trolled to compl e case of transp network May Optionally in other cases
Background	Information for smart grid inc critical data which is sensitive of delay, delay variation, an ss. Therefore, performance on WAN should be clarified.
Reference	ITU-T Y.1541
Gap analysis	Currently, ITU-T Y.1541 does not mention smart gird in guidance for IP QoS classes. Since smart grid can be supported as an application on NGN or other managed IP network including utility network, smart grid should be added to guidance for IP QoS classes.

Original Contribution Number

Related Domain or Target Address

Reference Documents

Example (Requirement)

New Requirement No.	COM-CN-
Requirement No.	I-i-0035-1
Address	WAN
Position of requirements	Plane: Tra Layer: N
Requirement	If i in each co edges of WAN on IP layer should be specified every application, and should be categorized into Classes 0, 1, 2, 3, 4, U according to ITU-T Y.1541 [ITU-T Y.1541]. Moreover, on data link layer, performance should be controlled to comply with IP layer performance.
Type of requirement	Required in the case of transport on NGN or managed IP network May Optionally in other cases
Background	Info tion for smart grid includes critical data which is sensitive of delay, de should be cl
Reference	ITU-T Y.1541
Gap analysis	Currently, ITU IP QoS classes NGN or other n grid should be added to guidance for IP QoS classes.

Requirement: Required performance between edges of WAN on IP layer should be specified every application, and should be categorized into Classes 0, 1, 2, 3, 4, U according to ITU-T Y.1541.

Type of requirement:

Required in the case of transport on NGN or managed IP network,

May Optionally in other cases.

Example (Requirement)

New Requirement No.	COM-CN-QoS-05-I-R, COM-CN-QoS-06-I-R
Requirement No.	I-i-0035-1
Ad	
Po	Tran : Netv
Re	ormati n each con dges of W ould be c 1541 [IT ould be c
Type of requirement	equired i May Opti
Background	In orma delay, d should c
Reference	ITU-T .154
Gap analysis	Curr tly, ITU-T IP QoS classes. Since smart grid can be supported as an application on NGN or other managed IP network including utility network, smart grid should be added to guidance for IP QoS classes.

Background information

Gap analysis:
Currently, ITU-T Y.1541 does not mention smart gird in guidance for IP QoS classes. Since smart grid can be supported as an application on NGN or other managed IP network including utility network, smart grid should be added to guidance for IP QoS classes

Procedure 2 (Requirements)

- Categorize
  - Smart Grid Services/Applications area
  - Communication area
  - Physical Equipment area

Procedure 3: Example of Mapping b/w Use cases & Requirements

Use cases		Services/ Applications	Communi-cation area	Physical Equipment
Demand Response	---	---	---	---
. . .	. . .	. . .	. . .	. . .
DR & CEE2	Customer Uses an EMS or IHD	N/A	COM-CN-Gen-01-I-R	PHY-MaSP-02-I-O
DR & CEE3	Customer Uses Smart Appliances	N/A	COM-CN-Gen-02-I-R	PHY-MaSP-03-I-O

Procedure 4 (Requirements)

- Gap Analysis
  - 174 requirements →
    273 relations with SDOs (incl. ITU-T)

Note: One requirement often relates plural SDOs such as

…… IEC and ITU-T, IEEE and IETF, etc.

Smart Grid Overview(Cont.)

Table 4. ITU-T SGs activities directly related to Smart Grid (as of 2011)

Items	SGs and aspects	
(1) M2M	SG13	Q3/13 USN, MOC Q12/13 Ubiquitous networking (object to object communication)
	SG15	Q1/15 IP home network
	SG16	Q25/16 USN applications and services
(2) Smart metering	SG16	Q25/16 Smart metering
(3) Vehicle communication	SG13	Q12/13 networked vehicle
	SG16	Q27/16 Vehicle gateway platform for telecommunication/ITS services /applications
(4) Home networking	SG13	Q12/13 Next generation home network
	SG15	Q1/15 IP home network Q2/15 access network QoS Q4/15 wideband (G.hn - G.9960, G.9961) and narrowband (G.hnem) home networking transceivers
	SG16	Q21/16 home network services
(5) Energy saving network	SG13	Q21/13 Future network

Standardization Activities for Smart Grid Networks

Communications technologies	Standardization activities	Status	Note (related works)
IMT	ITU-R IMT-2000 family ITU-R IMT-Advanced family ITU-T SG13 3GPP	Already studied	NIST SGIP PAP02
Power Line Communication (PLC)	TU-T SG15 G.9960/9961(G.hn), G.9963 (G.hn-MIMO), G.9972 (G.cx), G.9955/9956 (G.hnem)	Already studied	
	IEEE 1901	Already studied	IEEE1901.2
	ISO/IEC	Study in progress	ISO/IEC15118 (V2G CI)

Gap analysis (Requirements)

- 174 requirements → 273 relations with study status

SDOs	Already studied	For further study	Study in progress	Not identified	Total
ITU-T	89	24	27		140
IEC	5	8	23	19	55
3GPP	5		18		23
ETSI	8	1	8		17
IEEE	10		4	2	16
ISO/IEC JTC 1	6	2	1		9
IETF	5		2	1	8
ITU-R	4		1		5
Total	**132**	**35**	**84**	**22**	**273**

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Modified Domain Model

5 domains+4 reference points

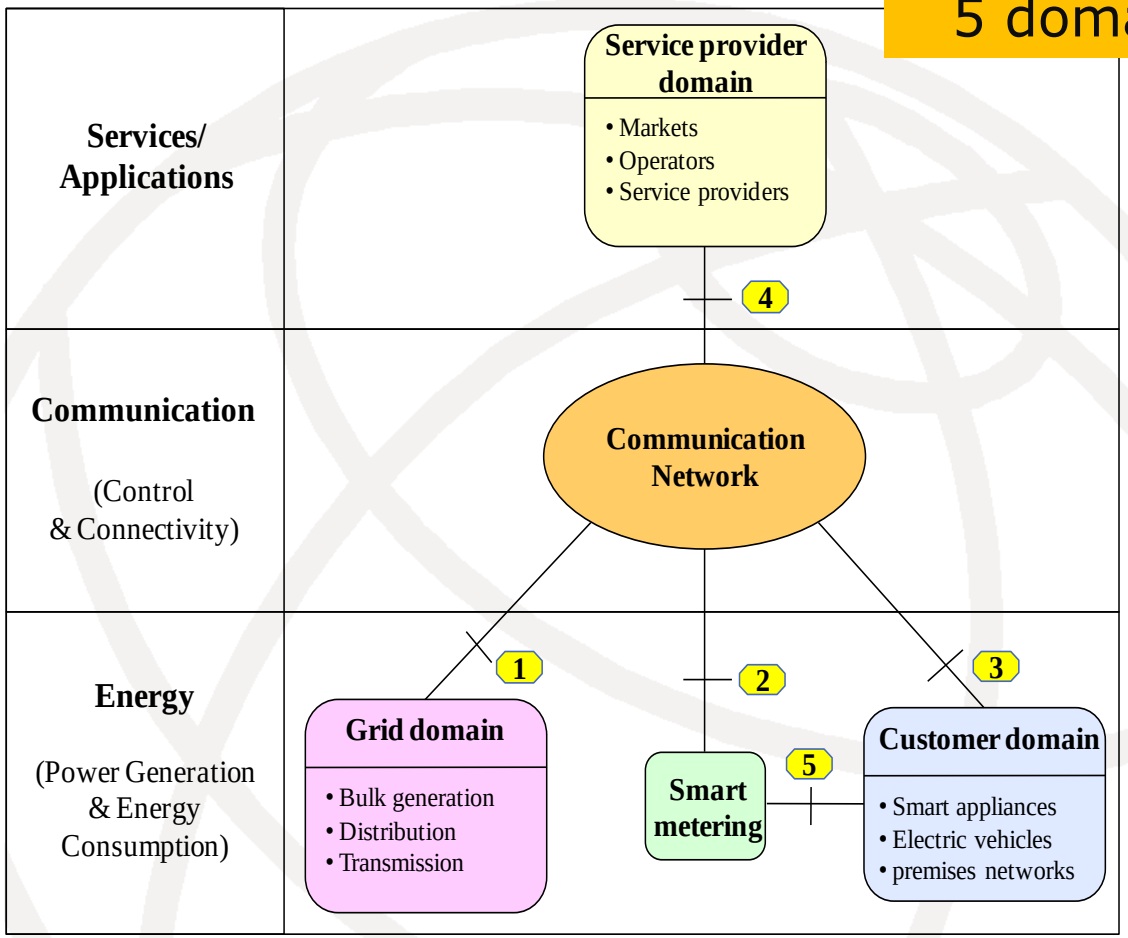

Figure 5. Simplified Smart Grid domain model in ICT perspective

- **RP 1--**enables exchange of information and control signals between devices in the Grid Domain and the Service Providers domains
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Smart Grid Refernce Architecture

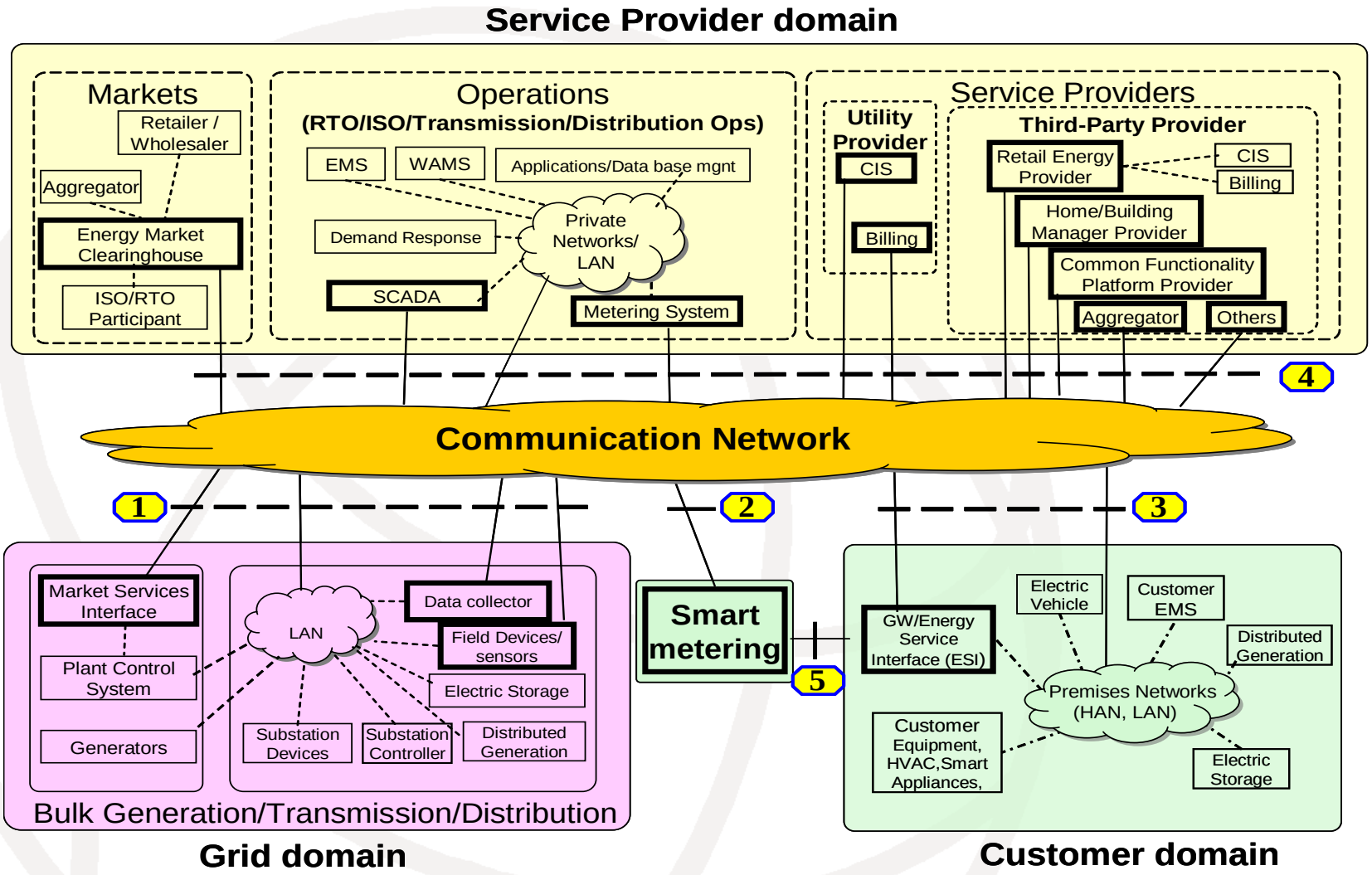


Figure 6. Simplified reference architecture for Smart Grid

Analysis of Reference Point Functions

Reference Point	Information/ Operations Across the Reference Point	Gaps being Addressed by SGIP Priority Action Plans and Related Standards	Partial List of Relevant Standards in Addition to those in PAP Column
Reference Point 1	This reference point provides connectivity between the power grid domain and service provider, customer, and smart meter domains through communication networks. ……..		
	Distributed Energy Resources (DER):	**PAP07: Energy Storage Interconnection Guidelines:**	**HD 60634:** **IEC 61850-7-420:** **IEC 61850-7-410:** **EN 61400-25:**

Smart Grid Architecture

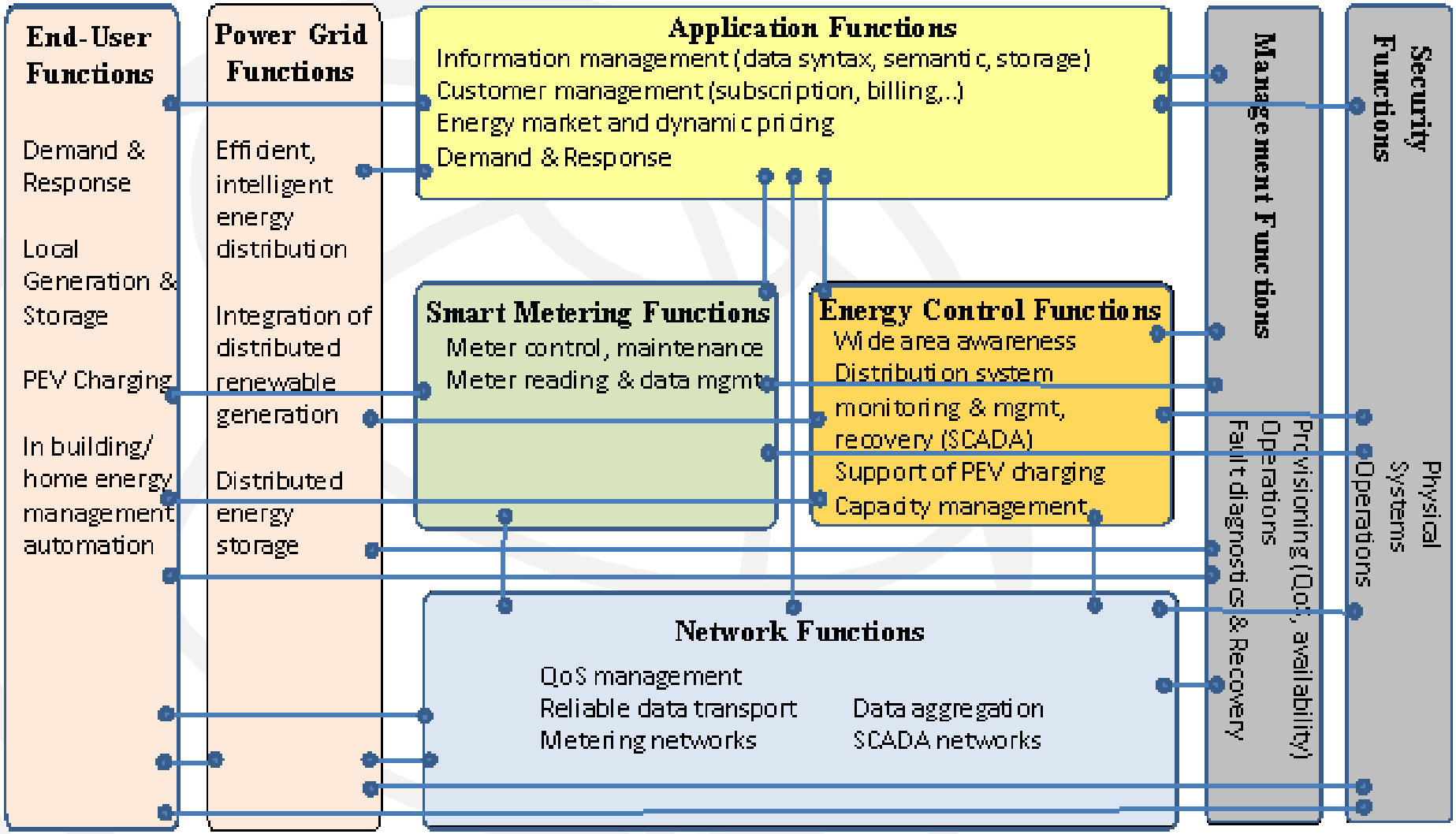
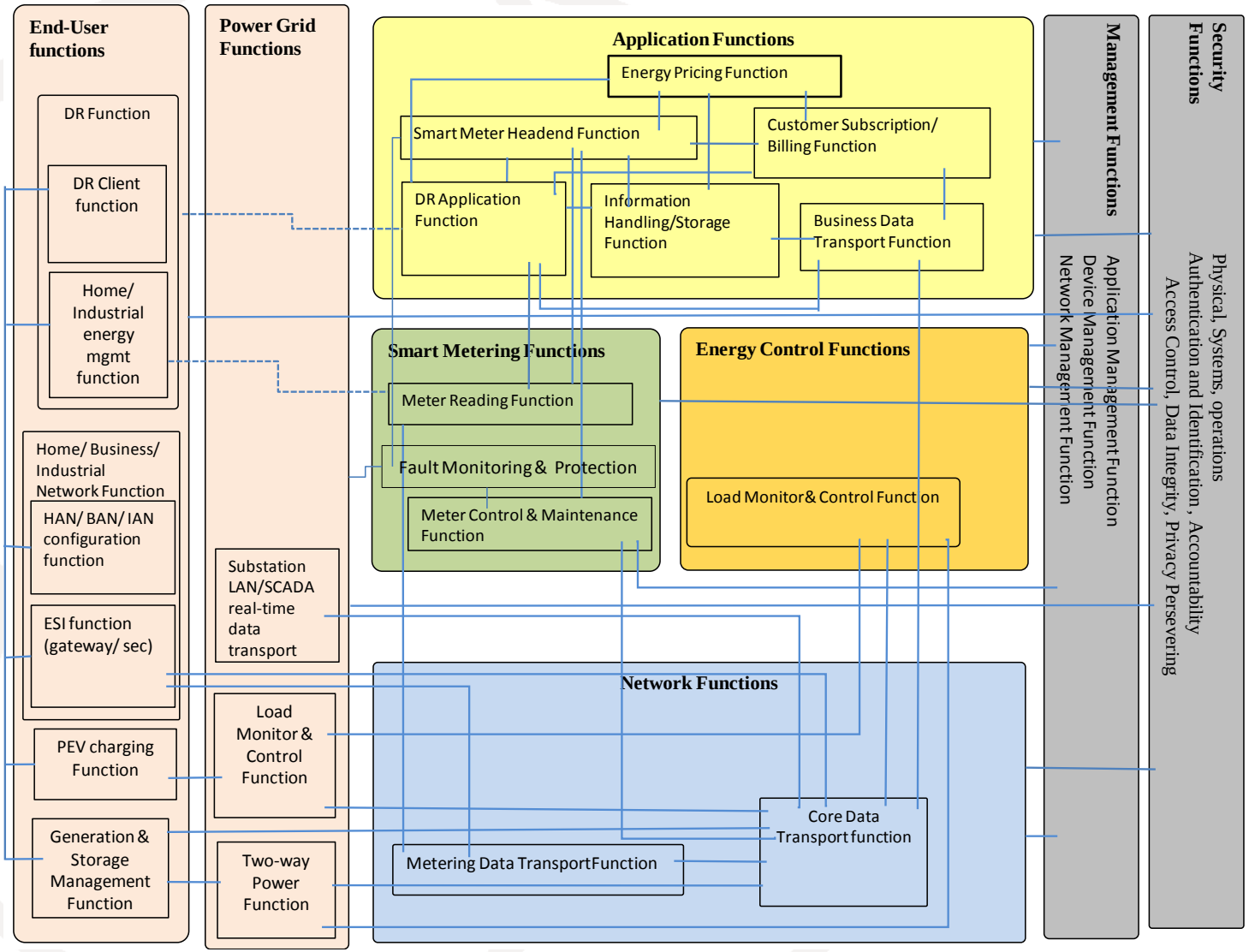
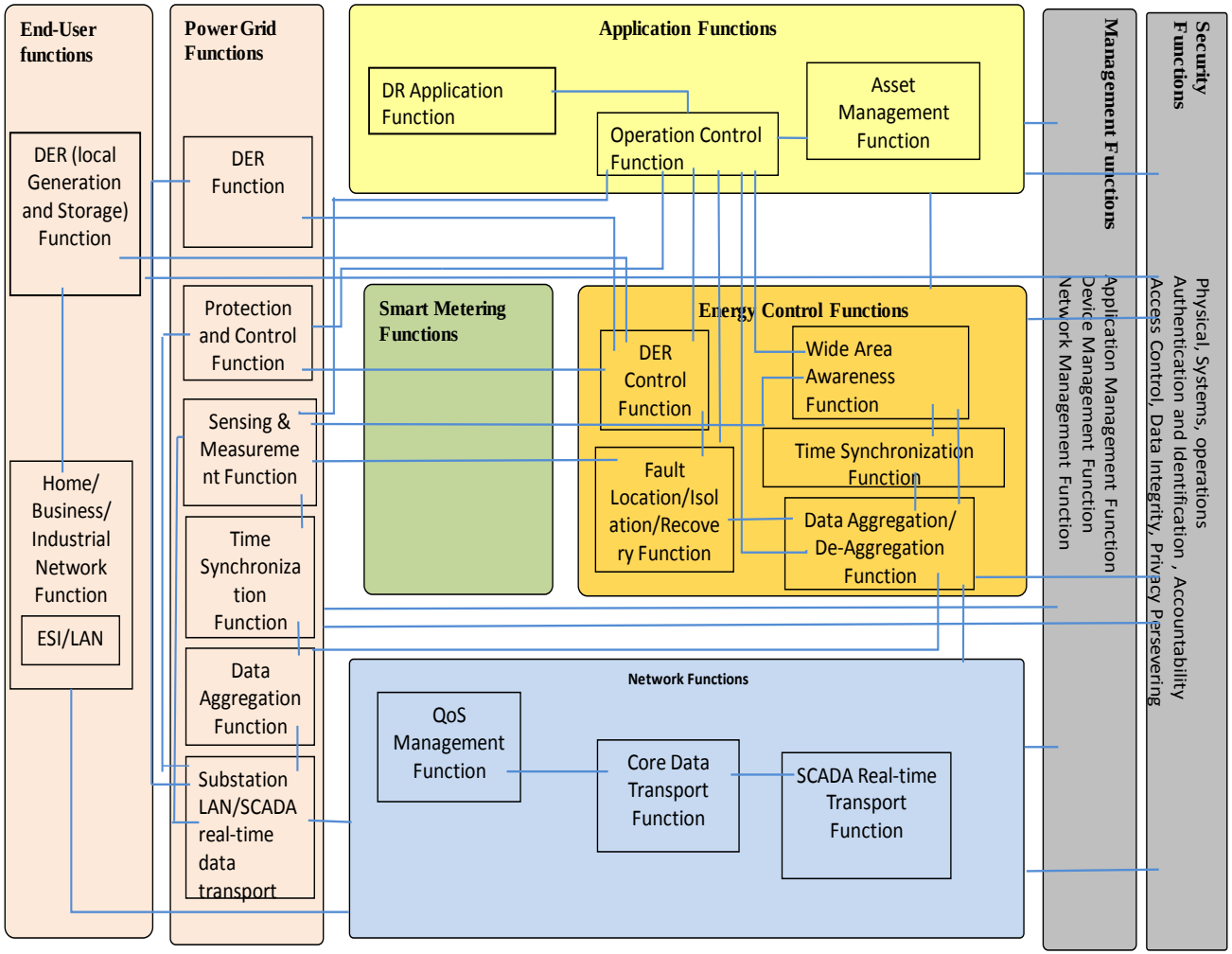


Fig 7. Functional model of Smart Grid

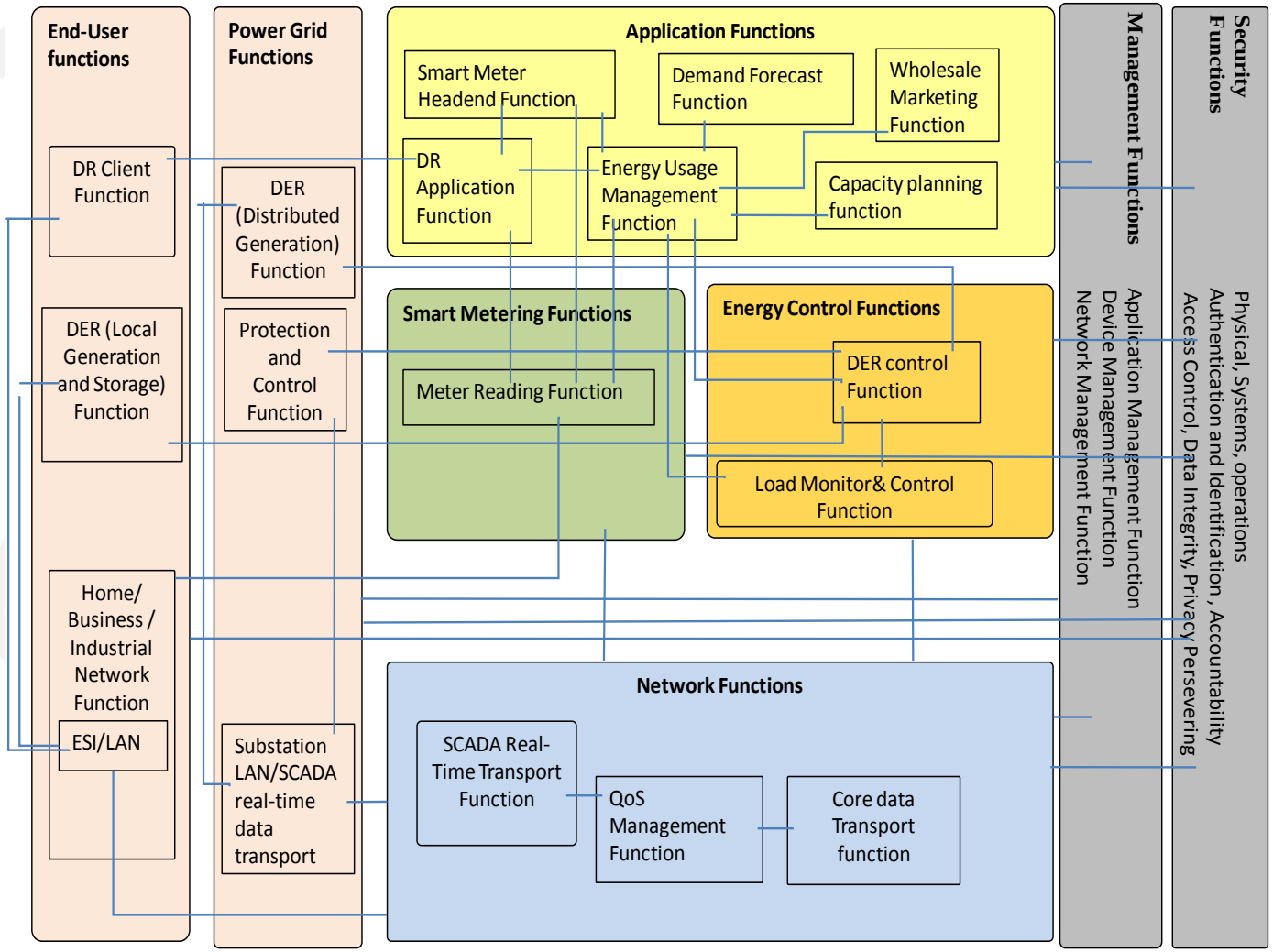
Functional Model
(Smart Metering and Load Control Service)



Functional Model
(Power Grid Monitoring and Control)



Functional Model
(Energy Usage and Distribution Management)



Smart Grid Architecture

Table A-1: Comparisons of architectures ITU-T FG-Smart / IEEE P2030 / ETSI M2M

Item	ITU-T FG-Smart	IEEE P2030	ETSI M2M
Goal	Smart Grid in the ICT perspective	Smart Grid interoperability	All M2M applications
Domain model	Based on NIST 7 domains	Based on NIST 7 domains	3-level model
Reference architecture	Simplified reference architecture	Based on NIST system architecture	End-to-end functional architecture at the "service layer"
Detailed architectures	Functional architecture - Functional model of smart grid - Functional model of smart metering and load control service	- Communications architecture - Power system architecture - IT architecture	- Set of Service capabilities (SCs) - reference points used to expose the SCs to the M2M applications including Smart Metering and Smart Grid

Smart Grid Architecture

Table A-1: Comparisons of architectures ITU-T FG-Smart / IEEE P2030 / ETSI M2M (cont)

Power grid	**Grid domain (bulk generation/ transmission/ distribution)**	**Generation, Transmission, Distribution**	**M2M Enablers for Distribution (at the border between Utility domain and end-user domain, through the telco domain)**
	LAN (substation network function)	**Transmission substation network (hotspot), Distribution substation network (hotspot), Feeder distribution energy resources microgrid network, Field area network, Feeder network, neighbourhood area network**	
Networks	**Communication network (short descriptions of WAN, AN, , etc)**	**Regional interconnection, Wide area network, Backhaul, Public Internet,**	**Agnostic to communication networks (use of the most appropriate)**
	Premises network (HAN, LAN)	**xAN, Customer DER network, workforce mobile network**	
Services	**Markets, Operations, Service providers**	**Markets, Operations, Service providers**	**Mainly Service Providers**

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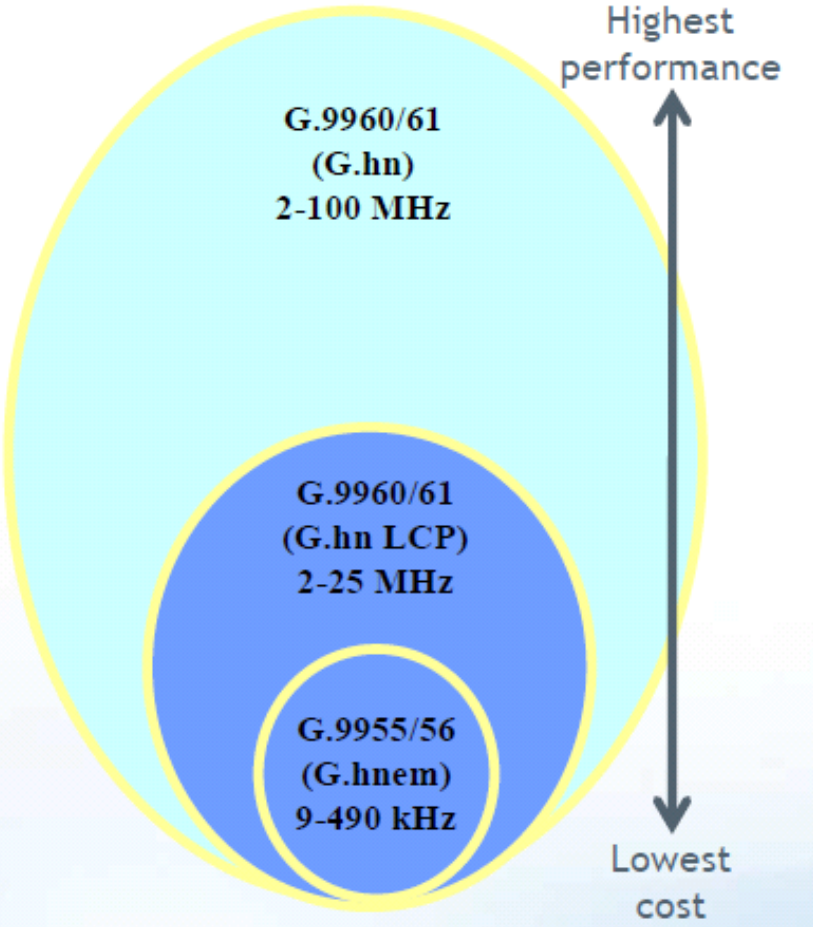
Example Specification for Smart Grid

ITU-T family of next generation PLC standards



ITU-T developed a family of PLC networking technologies based on OFDM modulation and advanced coding methods

G.9960/61:
Multiple media, bit rates to of hundreds Mb/s to 1Gb/s;
BB networking & entertainment

G.9960/61 LCP - Smart Grid BB:
Reduced bit rate (5-20 Mb/s), complexity, and power consumption

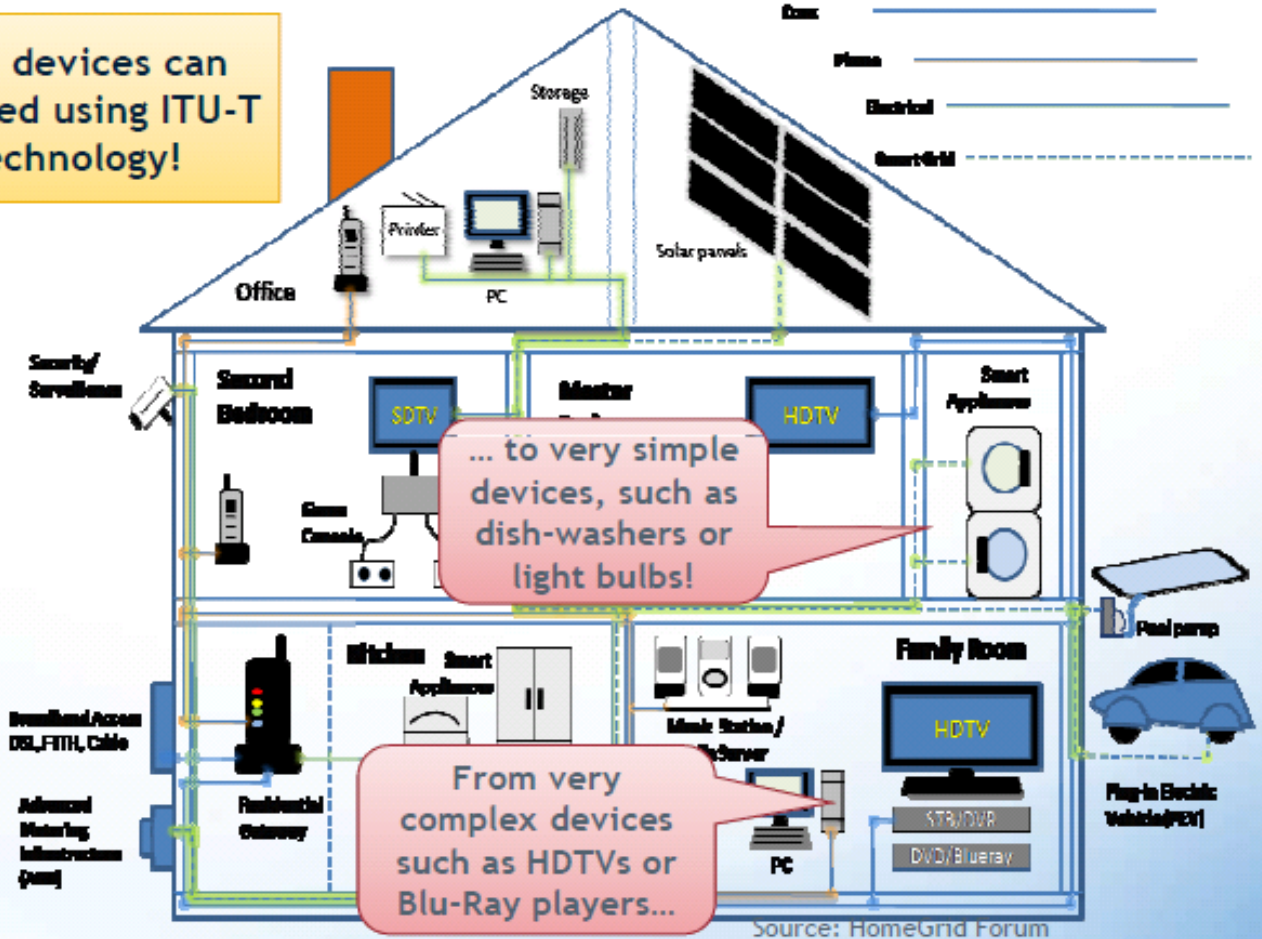
G.9955/56 - Smart Grid NB PLC:
Bit rates up to 1 Mb/s, high robustness; very low complexity and power consumption

http://docbox.etsi.org/Workshop/2011/201104_SMARTGRIDS/02_STANDARDS/ITUT_OKSMAN_NewRecommendations.pdf

Home Networking

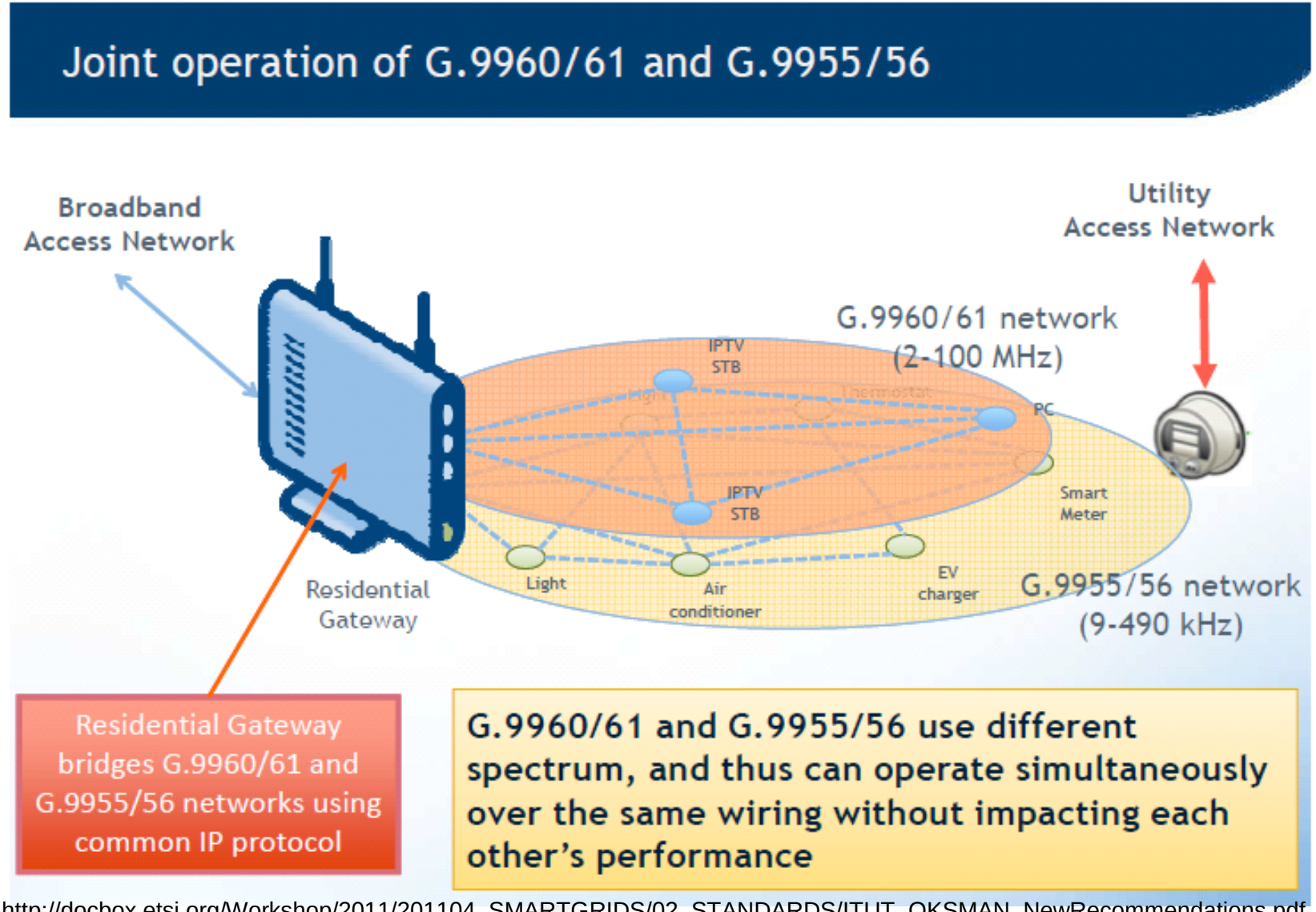
ITU-T BB/NB PLC can fully support future digital home

All these devices can be managed using ITU-T PLC technology!



http://docbox.etsi.org/Workshop/2011/201104_SMARTGRIDS/02_STANDARDS/ITUT_OKSMAN_NewRecommendations.pdf

Example Use Case



http://docbox.etsi.org/Workshop/2011/201104_SMARTGRIDS/02_STANDARDS/ITUT_OKSMAN_NewRecommendations.pdf

ITU-T Recommendations related to the Smart Grid

<Narrowband PLC(Power Line Communications)>

- G.9901: Narrowband orthogonal frequency division multiplexing power line communication transceivers - Power spectral density specification
- G.9902: Narrowband orthogonal frequency division multiplexing power line communication transceivers for ITU-T G.hnem networks
- G.9903: Narrowband orthogonal frequency division multiplexing power line communication transceivers for G3-PLC networks
- G.9904: Narrowband orthogonal frequency division multiplexing power line communication transceivers

<Wireless narrowband short-range communication>

- G.9959: Short range narrow-band digital radio communication transceivers - PHY, MAC, SAR and LLC layer

ITU-T Recommendations related to the Smart Grid (cont.)

<Broadband home networking>

- **G.9960: Unified high-speed wireline-based home networking transceivers - System architecture and physical layer specification**
- **G.9961: Unified high-speed wire-line based home networking transceivers - Data link layer specification**
- **G.9962: Unified high-speed wire-line based home networking transceivers - Management specification**
- **G.9963: Unified high-speed wireline-based home networking transceivers - Multiple input/multiple output specification**
- **G.9964: Unified high-speed wireline-based home networking transceivers - Power spectral density specification**
- **G.9971: Requirements of transport functions in IP home networks**
- **G.9972: Coexistence mechanism for wireline home networking transceivers**

Summary

Recent Standardization activities start from Use Cases, then extract Requirements from them. And based on Gap Analysis of the requirements, you can recognize existing specifications and required new specifications.

If you or your country consider a specific use case, referring ITU-T deliverables such as FG Smart is useful and efficient to know required Specifications or Recommendations.

Thank you for your attention

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