Chapter 7:
Smart Grid

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Outline

1. Introduction
2. Evolution of the smart grid
3. Smart grid architecture and framework
4. Smart grid applications
5. Power line communication for smart grid
6. Smart grid standards

Technical roadmap for Smart Grid

Smart Grid

Standards

Network Technologies

- IEC 61968 & IEC 61970 & 61950
- ANSI C12.22 & ANSI C12.19
- Zigbee/Homeplug
- Powerline

Evolutions

- Existing grid vs. Smart grid
- AMR vs. AMI vs. Smart grid
- Return on Investments
- Requirements for the communication system

Architecture and Framework

- Smart Transmission Networks
  - Flexible controllability with advance power electronic
  - Facility maintenance
- Smart Control Centre
  - Real-time/predictive modeling and security analysis
  - Proactive/adaptive protection setting
  - Customized information for operator/market
- Smart substation
  - Autonomous Control
  - Adaptive protection
  - Integrated renewable energy resources
  - Demand side management

Applications

Enable Applications

- Demand Response
- Microgrid
- Home area network

Fundamental Application

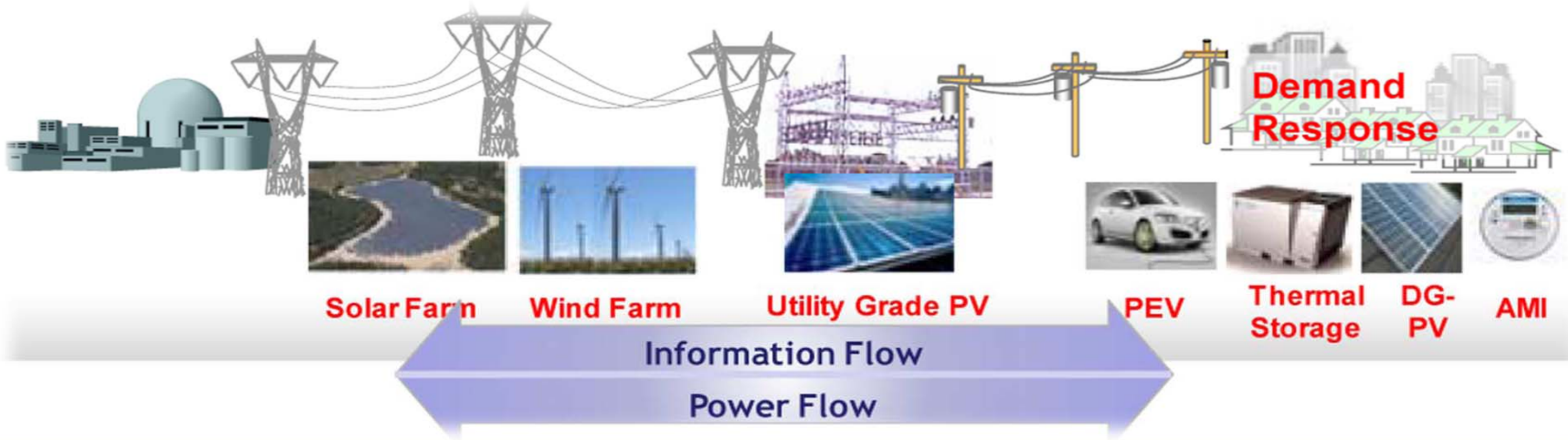
- Smart Meter
- Meter data management system

Introduction

- Almost 8% of its output is lost along its transmission lines, while 20% of its generation capacity exists to meet peak demand only (i.e., it is in use only 5% of the time).
- Because of the hierarchical topology of its assets, the existing electricity grid suffers from domino effect failures.
- The smart grid provide the utility companies with full visibility and pervasive control over their assets and services.
- In an increasingly deregulated and distributed energy market, communication between the points of energy generation, distribution, and consumption becomes an essential constituent of efficient grid control.
- Smart grid cannot and should not be a replacement for the existing electricity grid but a complement to it. The smart grid would and should coexist with the existing electricity grid, adding to its capabilities, functionalities, and capacities by means of an evolutionary path.

Cont.

- The concept of smart grid started with the notion of advanced metering infrastructure (AMI) to improve demand-side management, energy efficiency, and a self-healing electrical grid to improve supply reliability and respond to natural disasters or malicious sabotage.
- Smart grid empowers consumers to interact with the energy management system to adjust their energy use and reduce their energy costs.
- Smart grid predicts looming failures and takes corrective action to avoid or mitigate system problems.



wMNLab NTPU CSIE

Evolution for smart grid

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Comparison

Existing Grid	Intelligent Grid
Electromechanical	Digital
One-Way Communication	Two-Way Communication
Centralized Generation	Distributed Generation
Hierarchical	Network
Few Sensors	Sensors Throughout
Blind	Self-Monitoring
Manual Restoration	Self-Healing
Failures and Blackouts	Adaptive and Islanding
Manual Check/Test	Remote Check/Test
Limited Control	Pervasive Control
Few Customer Choices	Many Customer Choices

AMR

- Automated meter reading (AMR) systems in the distribution network lets utilities read the consumption records, alarms, and status from customers' premises remotely.
- AMR's capability is restricted to reading meter data. It does not let utilities take corrective action based on the information received from the meters. In other words, AMR systems do not allow the transition to the smart grid.

AMI

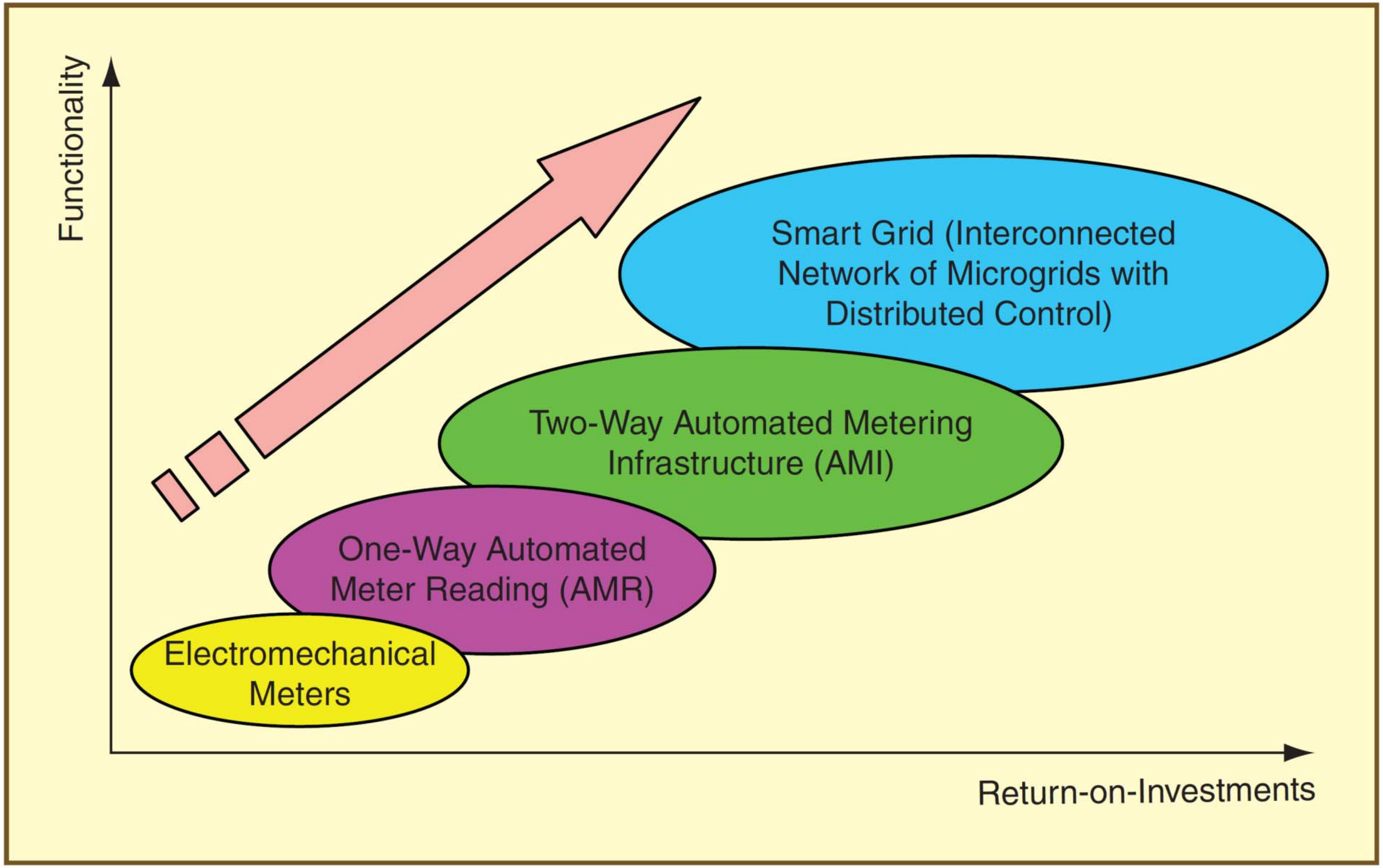
- Advanced metering infrastructure (AMI) is a systems that measure, collect and analyze energy usage, and communicate with metering devices such as electricity meters, gas meters, heat meters, and water meters, either on request or on a schedule.
- These systems include hardware, software, communications, consumer energy displays and controllers, customer associated systems, Meter Data Management (MDM) software, and supplier business systems.
- The network between the measurement devices and business systems allows collection and distribution of information to customers, suppliers, utility companies and service providers.
- This enables these businesses to participate in demand response services.
- Consumers can use information provided by the system to change their normal consumption patterns to take advantage of lower prices. Pricing can be used to curb growth of peak consumption.

Demand response

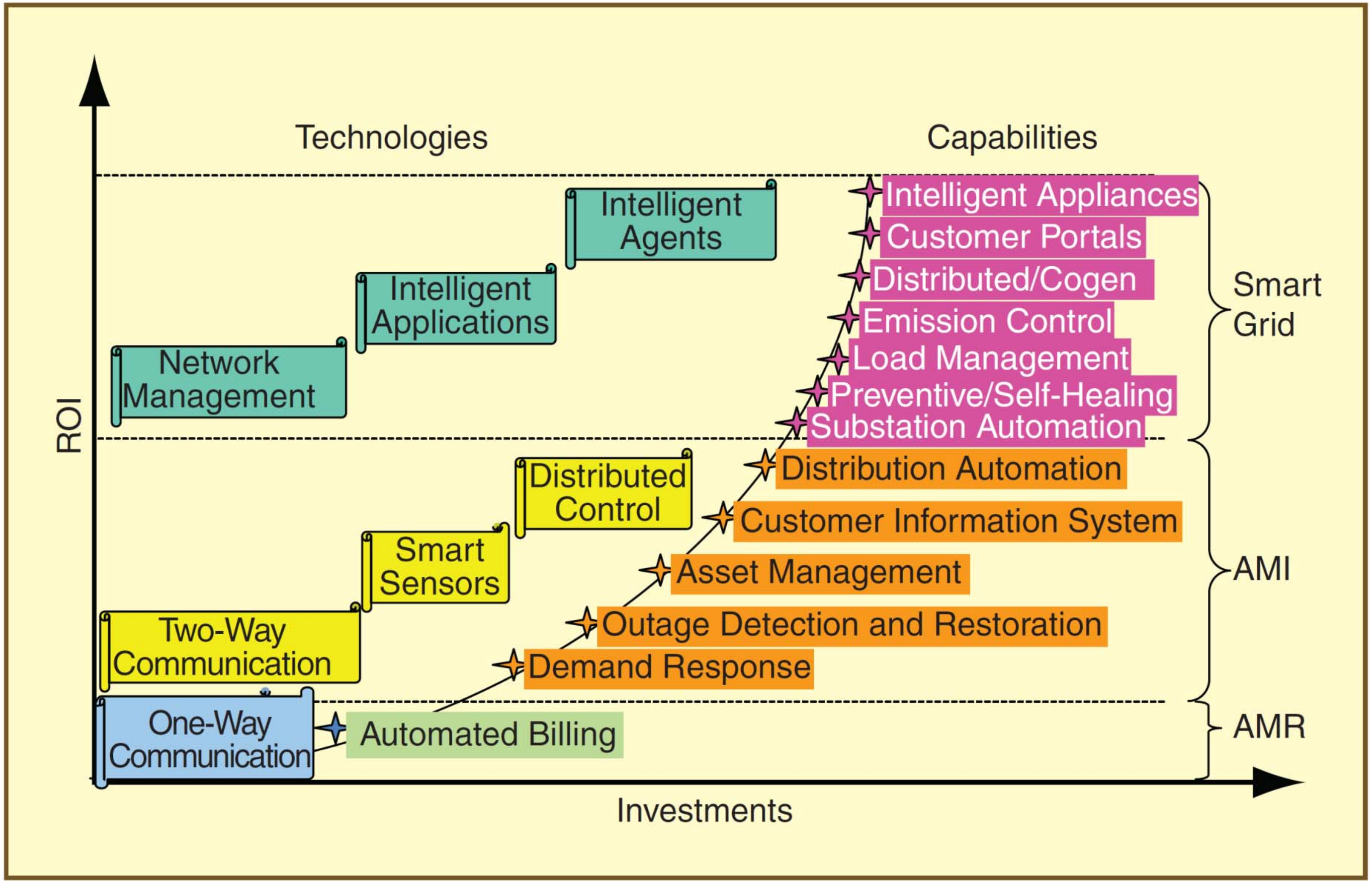
- Demand response (DR) is an information system, through dynamic and timely information flow two-way communication with the power flow, stabilize and improve the electricity peak excess off-peak electricity and other phenomena.

- End-user consumption patterns change from the normal use of electricity in response over time price change, or the retail market price in the high damage or system reliability.

Evolution of smart grid



Smart grid return on investments



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Requirements of smart grid

- High reliability and availability
- High coverage and distances
- Automatic management of redundancies
- Large number of communication nodes
- Appropriate communication delay and system responsiveness
- Communication security
- Ease of deployment and maintenance

High reliability and availability

- Nodes should be reachable under all circumstances. While this is normally not a problem in a wired network, it may be challenging for wireless or powerline infrastructures because communication channels can change during operation.
- Switching actions are initiated via various supervisory control and data acquisition (SCADA) and controlling systems (or even manually) using specific communication protocols that may not be modified Automatic management of redundancies.
- Therefore, there is no straightforward way to simply inform the communication system management about topology changes that are about to occur.

- Automatic management of redundancies
  - Some applications are time critical, real-time properties of the network have to be maintained even during topology changes.
  - As stated before, such changes must not be regarded as exceptional situations due to error conditions but occur in normal operation.

High coverage and distances

- The nodes to be connected by the communication network are distributed in a wide area.
- Network concepts based on telecommunication systems or powerlines have the potential to fulfill this requirement.

Large number of communication nodes

- If we assume that only one energy meter per customer is connected, a primary station can supply up to tens of thousands of nodes.
- Even though the commands and data packets are usually short, total data volume to be transferred in the network is substantial, and communication overheads can become an issue.

- Appropriate communication delay and system responsiveness
  - The Quality-of-Service (QoS) management needs to take care of different data classes such as metering, control, or alarm data.
  - It may be necessary to foresee something like a fast event channel to transmit, e.g., alarms from the meters to the control room.

Communication security

- Data related to energy distribution are considered critical, in particular, when they are relevant for billing purposes or grid control.
- Secure communication is therefore important.

Cont.

- Ease of deployment and maintenance
  - For any distributed communication system, mechanisms must be foreseen which facilitate not only the initial installation but particularly the maintenance of the infrastructure during the operation.
  - Features like error mode analysis and error localization, easy update of firm- and software and remote configuration are essential.

Architecture and framework

Architecture and Framework

Smart Transmission Grid

- Smart Transmission Networks
  - o Flexible controllability with advance power electronic
  - o Facility maintenance
- Smart Control Centre
  - o Real-time/predictive modeling and security analysis
  - o Proactive/adaptive protection setting
  - o Customized information for operator/market
- Smart substation
  - o Autonomous Control
  - o Adaptive protection
  - o Integrated renewable energy resources
  - o Demand side management

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Fundamental Application

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Challenges for smart grid

- Environmental challenges
  - Traditional electric power production, as the largest man-created CO2 emission source, must be changed to mitigate the climate change.
  - A shortage of fossil energy resources has been foreseen in the next few decades. Natural catastrophes, such as hurricanes, earthquakes, and tornados can destroy the transmission grids easily.
  - The available and suitable space for the future expansion of transmission grids has decreased dramatically.
- Market/Customer needs
  - Full-fledged system operation technologies and power market policies need to be developed to sustain the transparency and liberty of the competitive market.
  - Customer satisfaction with electricity consumption should be improved by providing high quality/price ratio electricity and customers’ freedom to interact with the grid.

Cont.

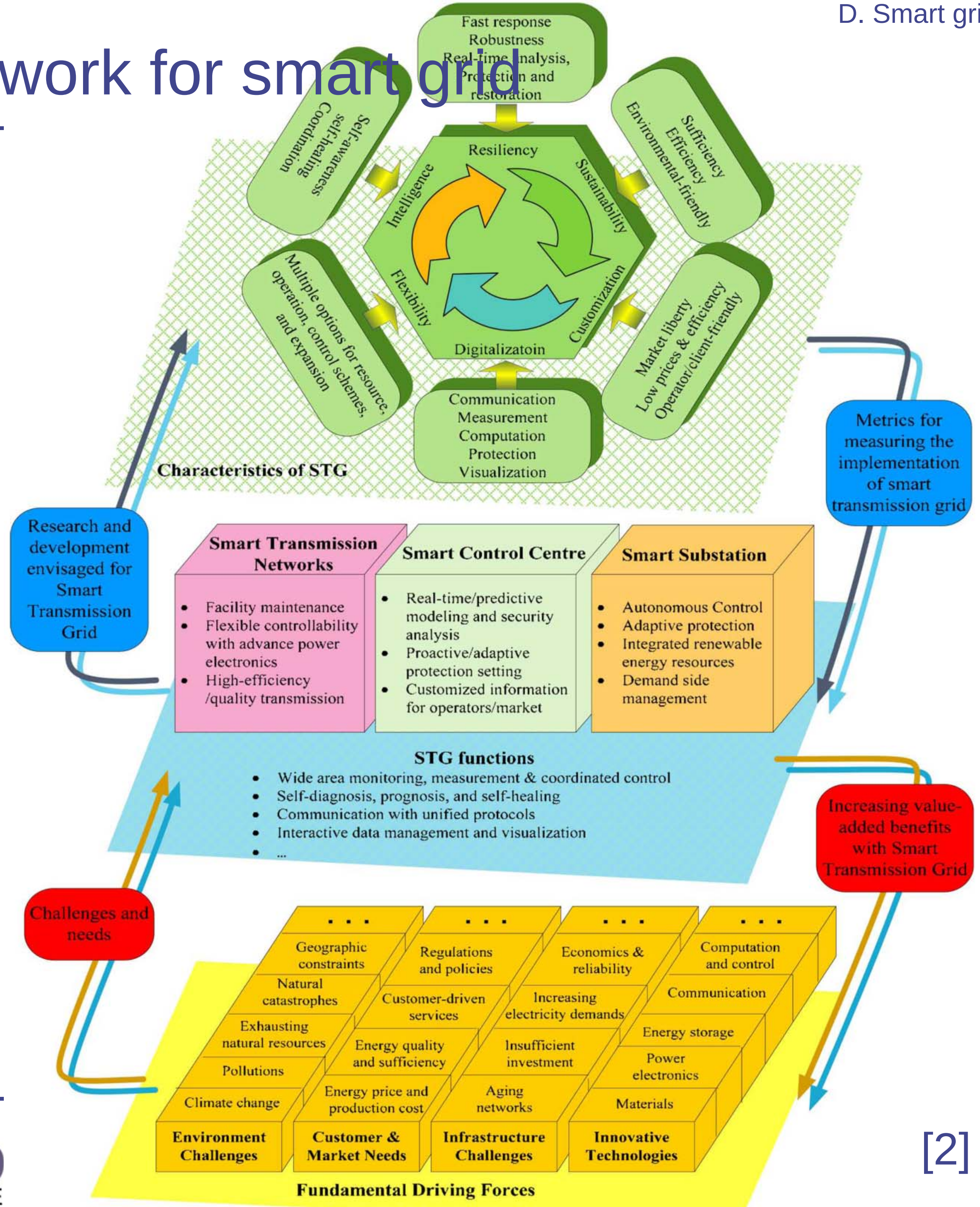
Infrastructure challenges

- The existing infrastructure for electricity transmission has quickly aging components and insufficient investments for improvements.
- With the pressure of the increasing load demands, the network congestion is becoming worse. The fast online analysis tools, wide-area monitoring, measurement and control, and fast and accurate protections are needed to improve the reliability of the networks.

Innovative technologies

- The innovative technologies, including new materials, advanced power electronics, and communication technologies, are not yet mature or commercially available for the revolution of transmission grids.
- The existing grids lack enough compatibility to accommodate the implementation of spear-point technologies in the practical networks.

Framework for smart grid



[2]

Smart grid functions

- SMART TRANSMISSION NETWORKS
  - Facility maintenance
  - Flexible controllability with advance power electronic
  - High-efficiency/quality transmission
- SMART CONTROL CENTERS
  - Real-time/predictive modeling and security analysis
  - Proactive/adaptive protection setting
  - Customized information for operator/market
- SMART SUBSTATION
  - Autonomous Control
  - Adaptive protection
  - Integrated renewable energy resources
  - Demand side management

Characteristics of STG

- **Digitalization**
  - The smart transmission grid will employ a unique, digital, platform for fast and reliable sensing, measurement, communication, computation, control, protection, visualization, and maintenance of the entire transmission system.
- **Flexibility**
  - Expandability for future development, innovative and diverse generation technologies.
  - Multiple options for resource, operation, control schemes among substations and control centers.
- **Intelligence**
  - Self-awareness of the system operation state will be available with the aid of online time-domain analysis such as voltage/angular stability and security analysis.
  - Self-healing will be achieved to enhance the security of transmission grid via coordinated protection and control schemes.

Cont.

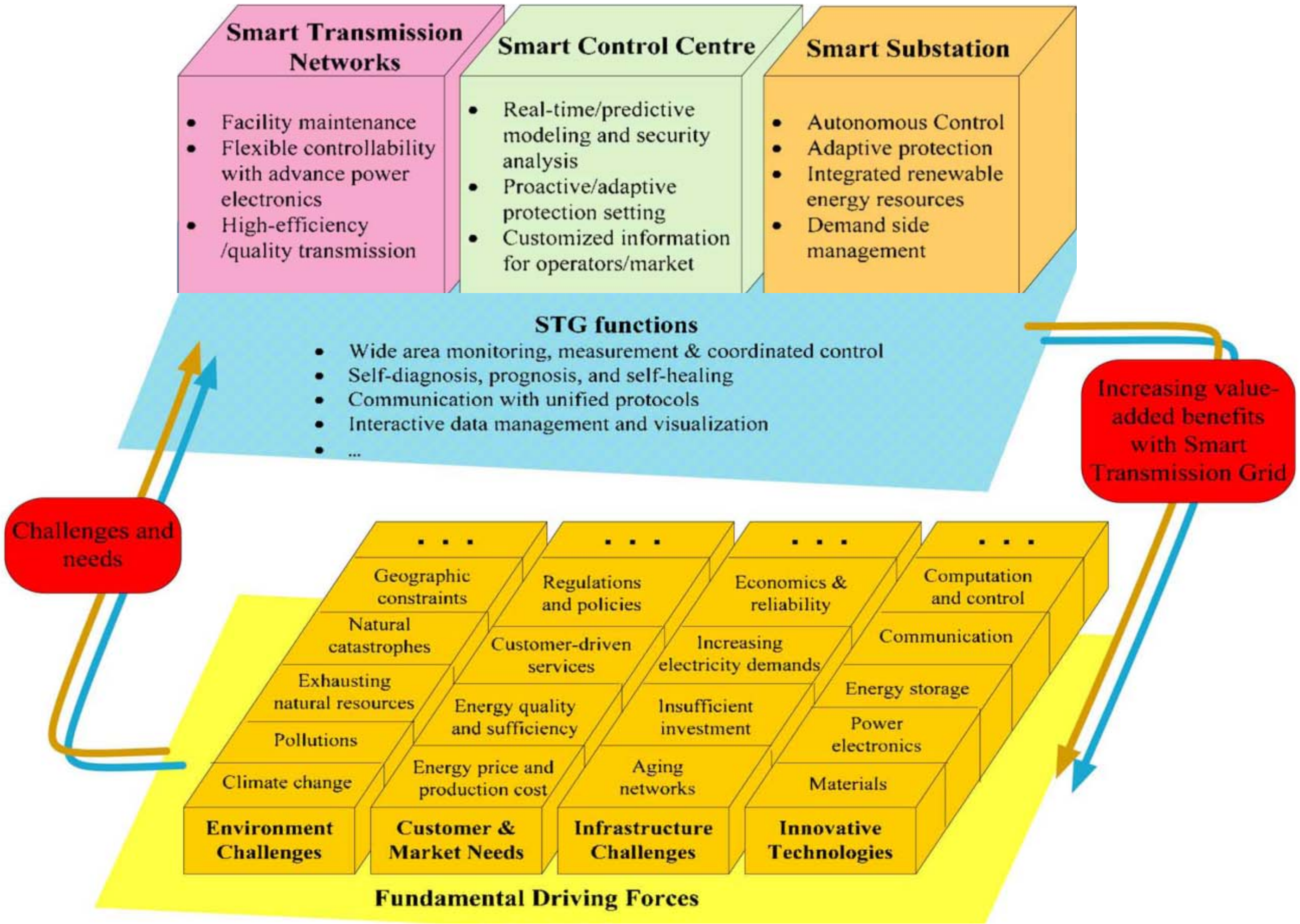
- Resiliency
  - A fast self-healing capability will enable the system to and reconfigure itself dynamically to recover from attacks, natural disasters, blackouts, or network component failures.
  - Online computation and real-time analysis will enable the fast response and flexible network operation and controls.
- Sustainability
  - Smart transmission grid is featured as sufficiency, efficiency, and environment friendly. The growth of electricity demand should be satisfied with the implementation of affordable alternative energy resources, increased energy savings via technology in the electricity delivery and system operation.

Cont.

Customization

- The design of the STG will be client-tailored for the operators' convenience without the loss of its functions and interoperability.
- It will also cater to customers with more energy consumption options for a high quality/price ratio.
- It's will further liberate the power market by increasing transparency and improving competition for market participants.

Framework


Smart Transmission Networks
Facility maintenance
Flexible controllability with advance power electronics
High-efficiency /quality transmission
Smart Control Centre
Real-time/predictive modeling and security analysis
Proactive/adaptive protection setting
Customized information for operators/market
Smart Substation
Autonomous Control
Adaptive protection
Integrated renewable energy resources
Demand side management
STG functions
Wide area monitoring, measurement & coordinated control
Self-diagnosis, prognosis, and self-healing
Communication with unified protocols
Interactive data management and visualization
...
Challenges and needs
Increasing value-added benefits with Smart Transmission Grid
Geographic constraints
Natural catastrophes
Exhausting natural resources
Pollutions
Climate change
Regulations and policies
Customer-driven services
Energy quality and sufficiency
Energy price and production cost
Economics & reliability
Increasing electricity demands
Insufficient investment
Aging networks
Computation and control
Communication
Energy storage
Power electronics
Materials
Environment Challenges
Customer & Market Needs
Infrastructure Challenges
Innovative Technologies
Fundamental Driving Forces

[2]

Smart control centers

- Monitoring
  - The present monitoring system in a control center depends on state estimators, which are based on data collected via SCADA systems and remote terminal units (RTUs).
  - In the future control center, the system-level information will be obtained from the state measurement modules based on phasor measurement units (PMUs) .
  - As a comparison, the present state estimation demands additional running time and is less robust, since the data collected from the RTUs is not synchronized and significant effort must be made for topology checking and bad data detection.

Cont.

- Controllability
  - In the present control centers, the ultimate control action, such as separation, is taken based on offline studies and lacks the sufficient coordination of protection and control systems.
  - In the future, the system separation will be performed in real time to better utilize the dynamic system condition.
  - The future control centers shall have the capability to coordinate multiple control devices distributed in the system such that optimal coordination can be achieved simultaneously for better controllability.
- Interactions With Electricity Market
  - Smart grid would not be called “smart” without achieving higher market efficiency.

Cont.

- The constantly changing electricity market requires the control center to adapt to the dynamic transition during the market's development.
- More sophisticated tools should be provided by the control centers to facilitate the system operators' ability to monitor and mitigate market power.

Smart substations

- Digitalization
  - The smart substation provides a unique and compatible platform for fast and reliable sensing, measurement, communication, control, protection, and maintenance of all the equipment and apparatus installed in a variety of substations. All of these tasks can be done in the digital form, which allows for easy connection with control centers and business units.
- Autonomy
  - The smart substation is autonomous.The operation of the smart substation does not depend upon the control centers and other substations, but they can communicate with each other to increase the efficiency and stability of power transmission. Within a substation, the operation of individual components and devices is also autonomous to ensure fast and reliable response, especially under emergency conditions.

Cont.

Coordination

- The smart substation should be ready and find it easy to communicate and coordinate with other substations and control centers.
- Adaption of protection and control schemes should be achieved under coordination of control centers to improve the security of the whole power grid.

Self-healing

- The smart substation is able to reconfigure itself dynamically to recover from attacks, natural disasters, blackouts, or network component failures.

Smart transmission network

- High-Efficiency and High-Quality Transmission Networks
  - In the concept of smart transmission networks, ultrahigh- voltage, high-capacity transmission corridors can link major regional interconnections.
  - Within each regional interconnection, long-distance transmission is accomplished by using controllable high-capacity ac and dc facilities.
- Flexible Controllability, Improved Transmission Reliability and Asset Utilization Through the Use of Advanced Power Electronics
  - In a smart transmission network, flexible and reliable transmission capabilities can be facilitated by the advanced Flexible AC Transmission Systems (FACTS), high-voltage dc (HVDC) devices, and other power electronics-based devices.

Cont.

- Self-Healing and Robust Electricity Transmission
  - Based on the parameters and operating conditions of transmission facilities, it can automatically detect, analyze, and respond to emerging problems before they impact service.

- Advanced Transmission Facility Maintenance
  - live-line maintenance can be used to clean and deice conductors, clean and lubricate moving parts that open and close, replace spacer/dampers, disconnect/connect breakers, tighten or replace bolts, and install sensors and measuring devices.
  - This reduces catastrophic failures and maintenance costs, and improves the overall reliability of the transmission system.

Cont.

- Extreme Event Facility Hardening System
  - An extreme event facility hardening system is able to identify potential extreme contingencies that are not readily identifiable.
  - Develop modular equipment designs for lines and novel system configuration to manage failures, and enable rapid system restoration under catastrophic events.

Technical roadmap for Smart Grid

Green Computing via Smart Grid

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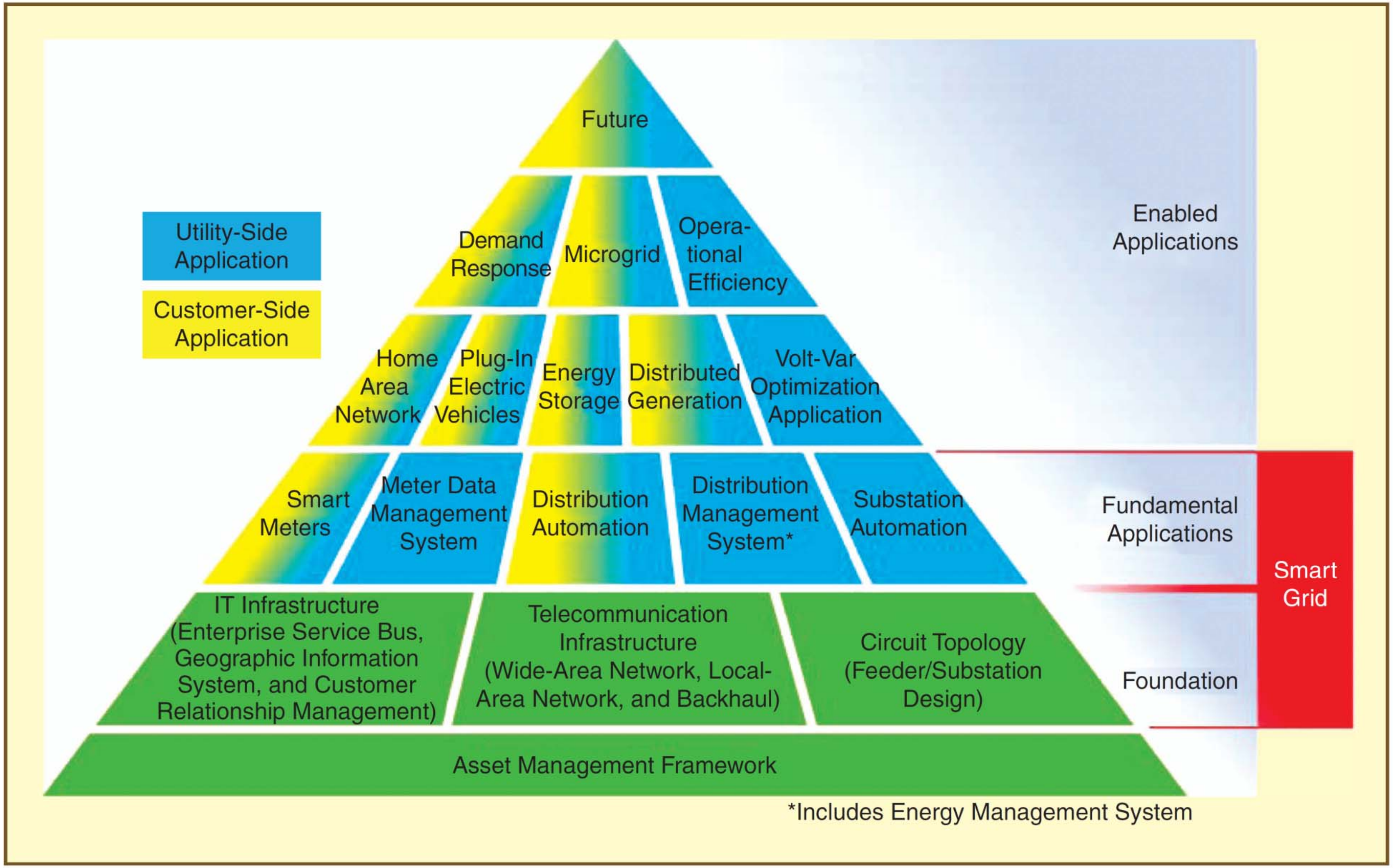
Smart grid Pyramid



[1]

Demand response

- Time-Based Rates DR:

1. Time-of-use rates: a static price schedule is applied.
2. Critical peak pricing: a less predetermined variant of TOU.
3. Real-time pricing (RTP): wholesale market prices are forwarded to end customers.

Cont.

- Incentive-Based DR:

1. Direct load control (DLC): utility or grid operator gets free access to customer processes.
2. Interruptible/curtailable rates: customers get special contract with limited sheds.
3. Emergency demand response programs: voluntary response to emergency signals.
4. Capacity market programs: customers guarantee to pitch in when the grid is in need.
5. Demand bidding programs: customers can bid for curtailing at attractive prices

Cont.

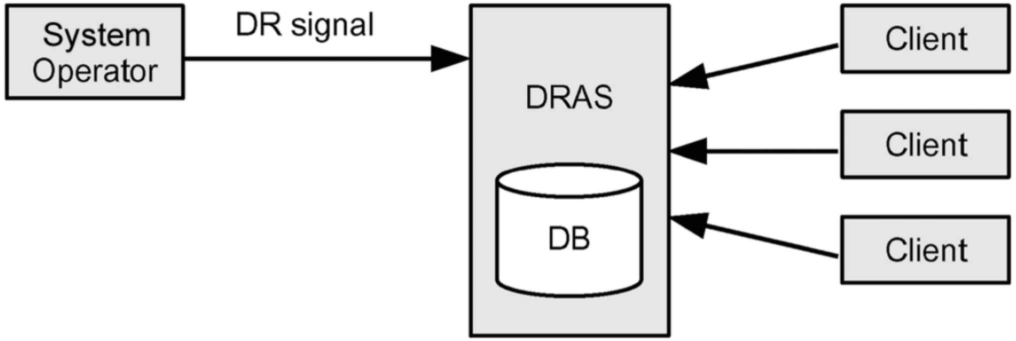
- Market DR:

1. real-time pricing, price signals and incentives.
2. Such market places are not arbitrarily quick, which is why most transactions are done a day ahead.
3. An exception is real-time pricing (RTP), where the figures of an energy spot market (e.g., EEX—European Energy Exchange) are forwarded to end users without delay.

- Physical DR:

1. Reflecting grid congestion or an excess supply of wind power onto the price can provoke stabilizing customer behavior.
2. It sends out binding requests for demand management if the grid or parts of its infrastructure are in a reduced performance due to maintenance or failure

Cont.



- Demand Response Automation Server (DRAS).
- DRAS Clients at the customers' sites.
- The Internet as communication infrastructure.

- The client side is often just a communication library, used by controls manufacturers to make their product OpenADR-capable.

[3]

Microgrid

- The microgrid encompasses a portion of an electric power distribution system that is located downstream of the distribution substation, and it includes a variety of distributed energy resource (DER) units.

- DER units include both distributed generation (DG) and distributed storage (DS) units with different capacities and characteristics.

- DER units, in terms of their interface with a microgrid, are divided into two groups.
  - The first group includes conventional or rotary units that are interfaced to the microgrid through rotating machines.
  - The second group consists of electronically coupled units that utilize power electronic converters to provide the coupling media with the host system.

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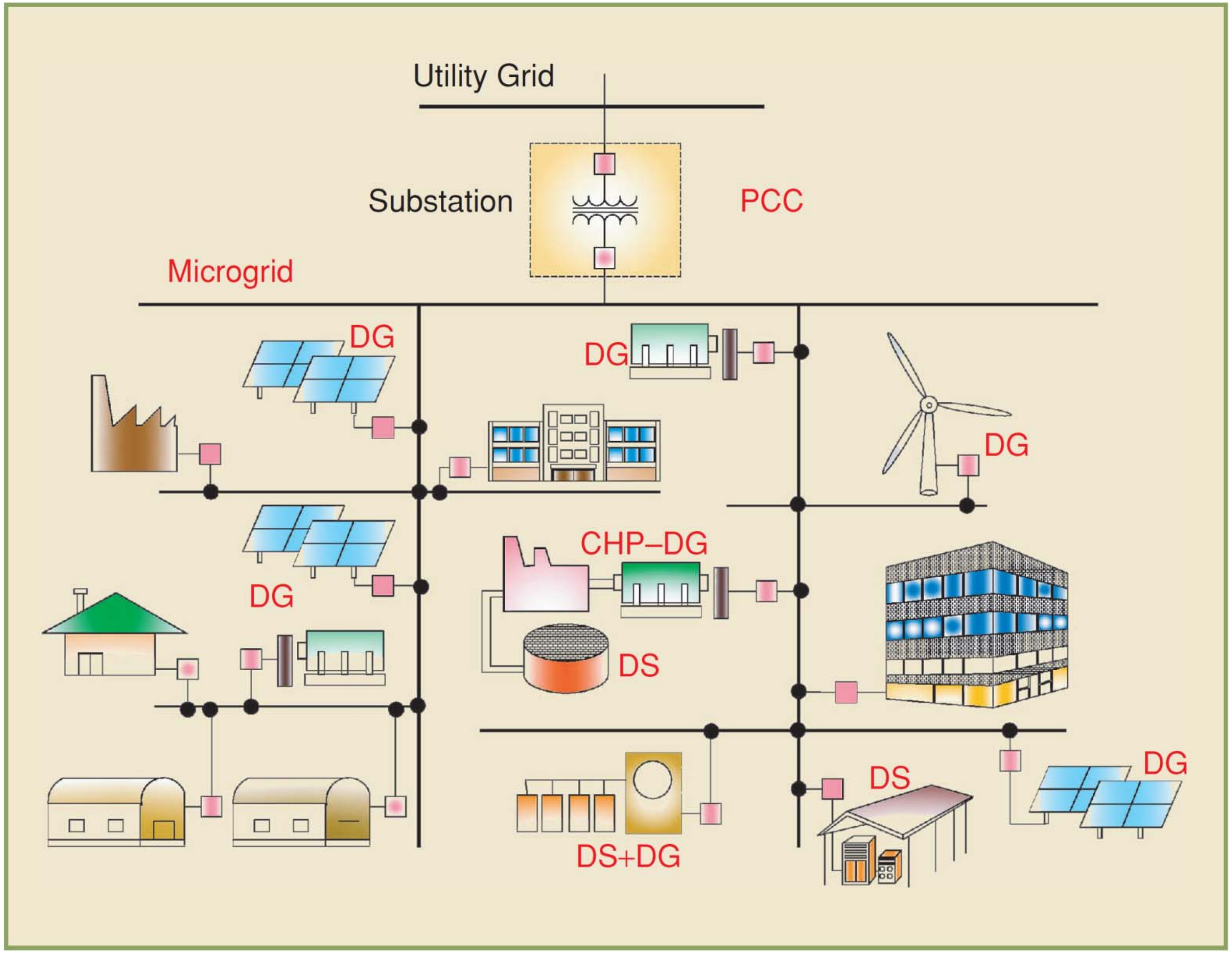

Utility Grid
Substation
PCC
Microgrid
DG
DG
DG
CHP–DG
DG
DS
DS
DG
DS+DG

Cont.

- A microgrid may be required to provide prespecified power quality levels or preferential services to some loads.
- The microgrid serves a variety of customers, e.g., residential buildings, commercial entities, and industrial parks.
- Short-term and long-term energy storage units can play a major role in control and operation of a microgrid.
- It is also expected to provide sufficient generation capacity, controls, and operational strategies to supply at least a portion of the load after being disconnected from the distribution system and remain operational as an autonomous entity.

Smart meter

- A smart meter is usually an electrical meter that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing purposes.
- Smart meters usually involve real-time or near real-time sensors, power outage notification, and power quality monitoring. These additional features are more than simple automated meter reading (AMR).
- Smart meters enable two-way communication between the meter and the central system. Unlike home energy monitors, smart meters can gather data for remote reporting.
- AMI differs from traditional automatic meter reading (AMR) in that it enables two-way communications with the meter.

Cont.

- Real Time:

  The installation of systems will tell both users and distributors how much electricity is being used at each consumption point, in real time.

- Sensors:

  The instant control of the power flowing into the network branches requires sensors to provide the most accurate power measurements possible.

- Decision-making Algorithms

  Devices with decision-making algorithms will control information coming from the electric grid apparatus and sensors that measure the electrical quantities of power networks.

- Automatic Control

  All decisions that will be made in the automatic control of electric grids will result in correct or consistent decisions.

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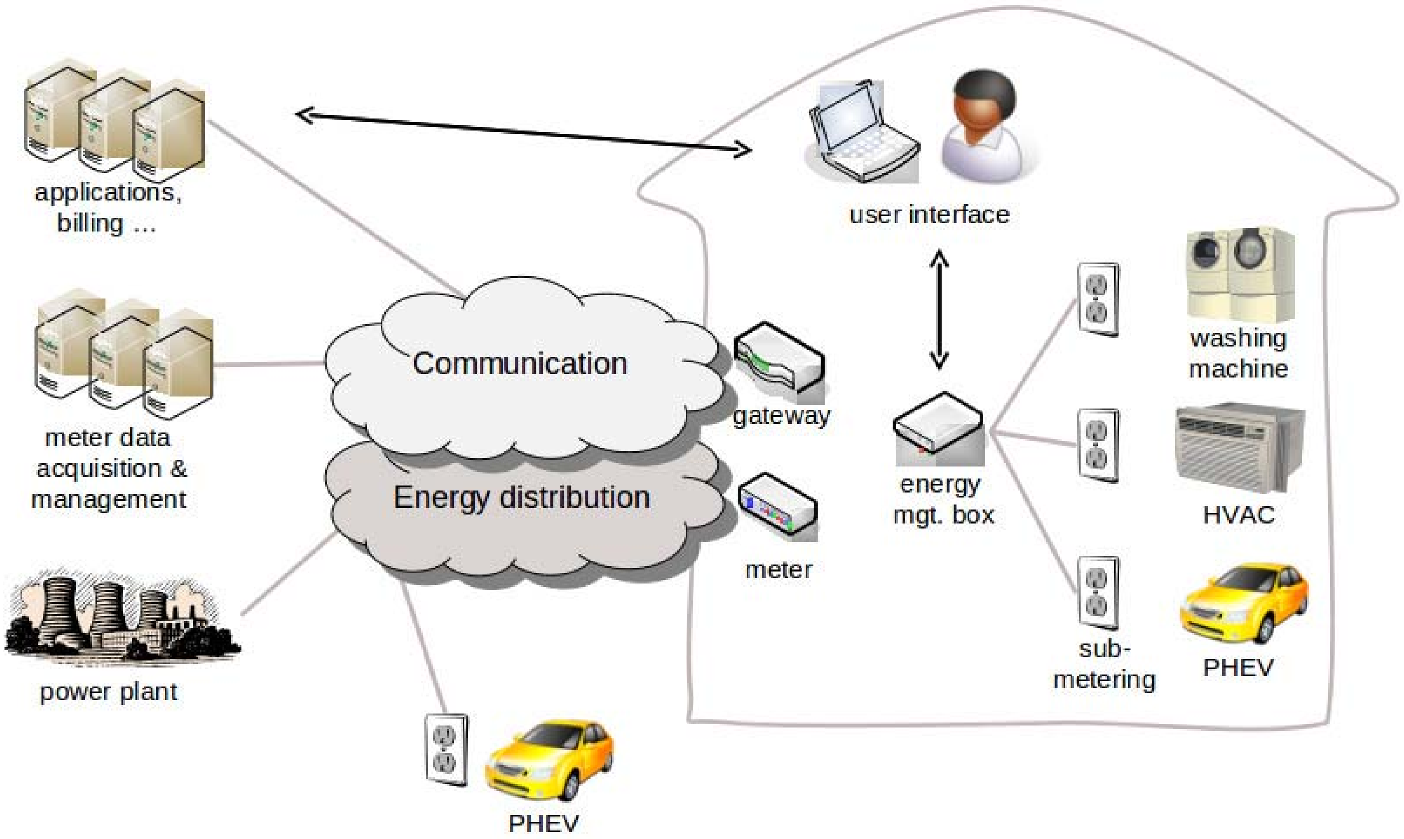
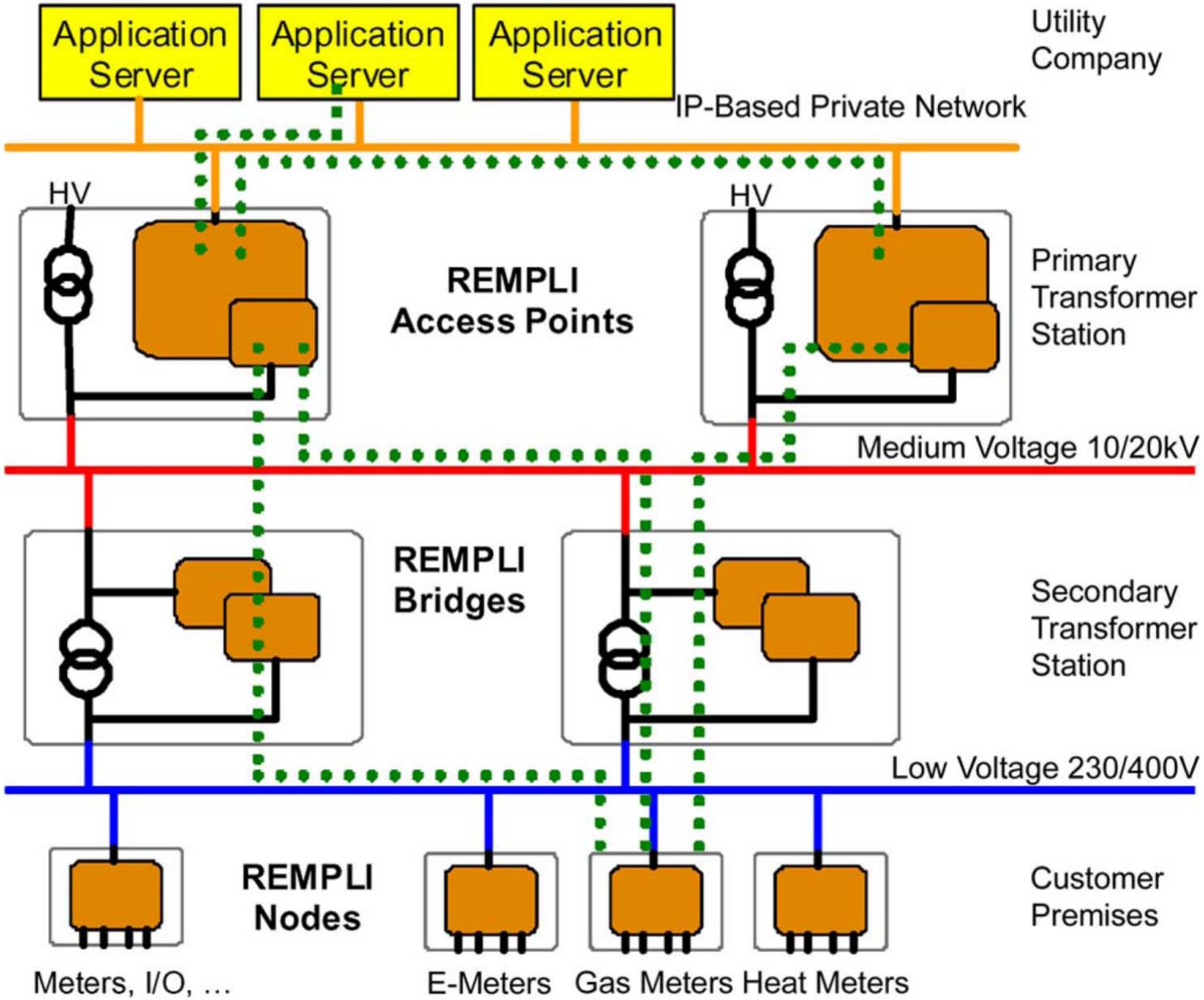


in-Home Energy Management (iHEM)

Power line communication for smart grid



[4]

Cont.

- Powerline communication has the potential to fulfill requirements, which are high coverage and distance.
- The interconnection of the two network domains is achieved by network elements as Access Points (APs).
- It just describes the fact that these network elements permit the higher network level to access data and services of the lower level.
- Long messages are being fragmented and routed via intermediate network components–Bridges and Repeaters.
- Bridges at the medium-to-low voltage (MV/LV) transformer stations provide transparent data connection between the LV and MV powerlines.
- From there, the data are transmitted over the LV powerline network to the Nodes.

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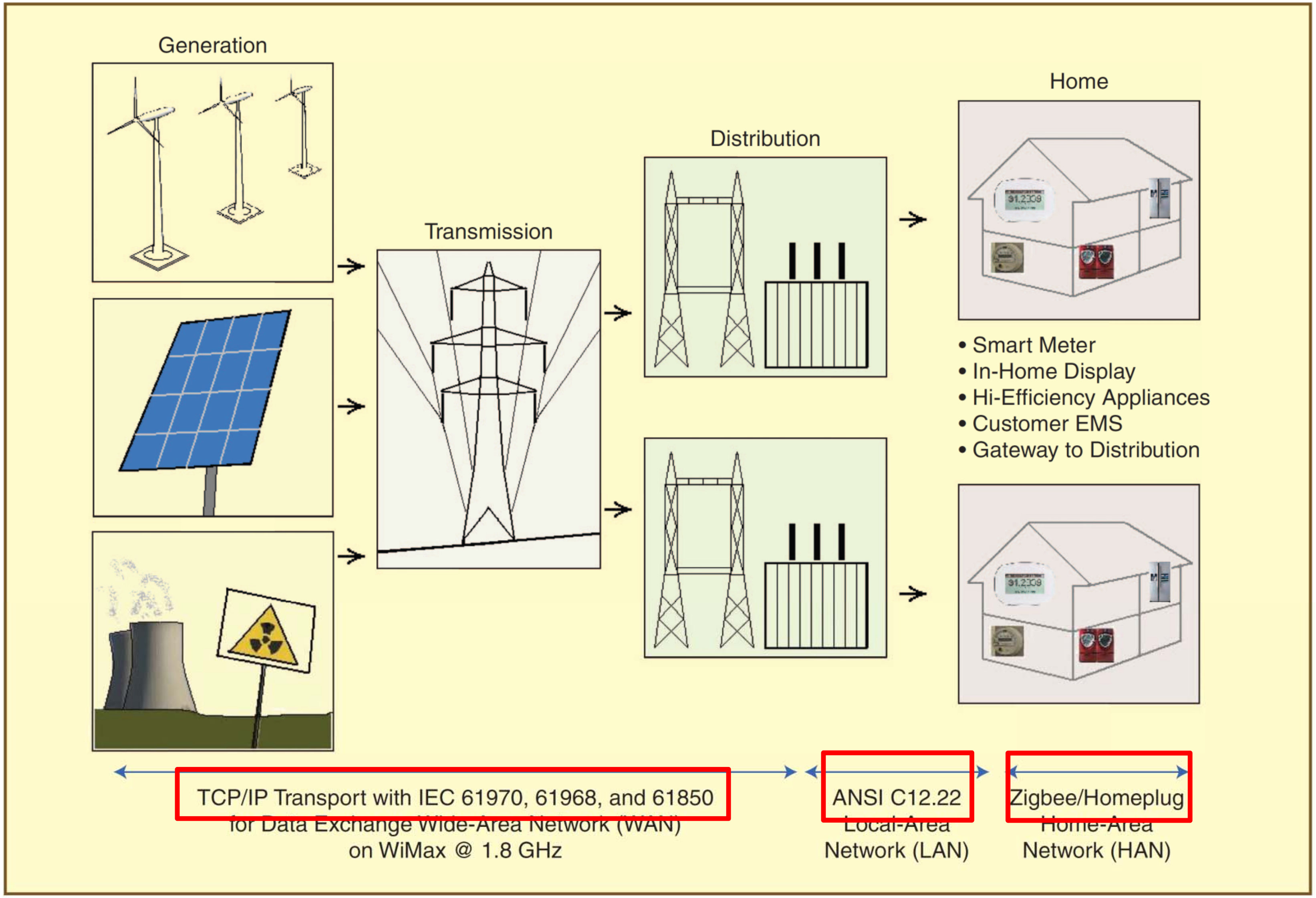

Generation
Transmission
Distribution
Home
• Smart Meter
• In-Home Display
• Hi-Efficiency Appliances
• Customer EMS
• Gateway to Distribution
TCP/IP Transport with IEC 61970, 61968, and 61850
for Data Exchange Wide-Area Network (WAN)
on WiMax @ 1.8 GHz
ANSI C12.22
Local-Area
Network (LAN)
Zigbee/Homeplug
Home-Area
Network (HAN)

[1]

Standard for Smart Grid

- The framework consists of 16 standards

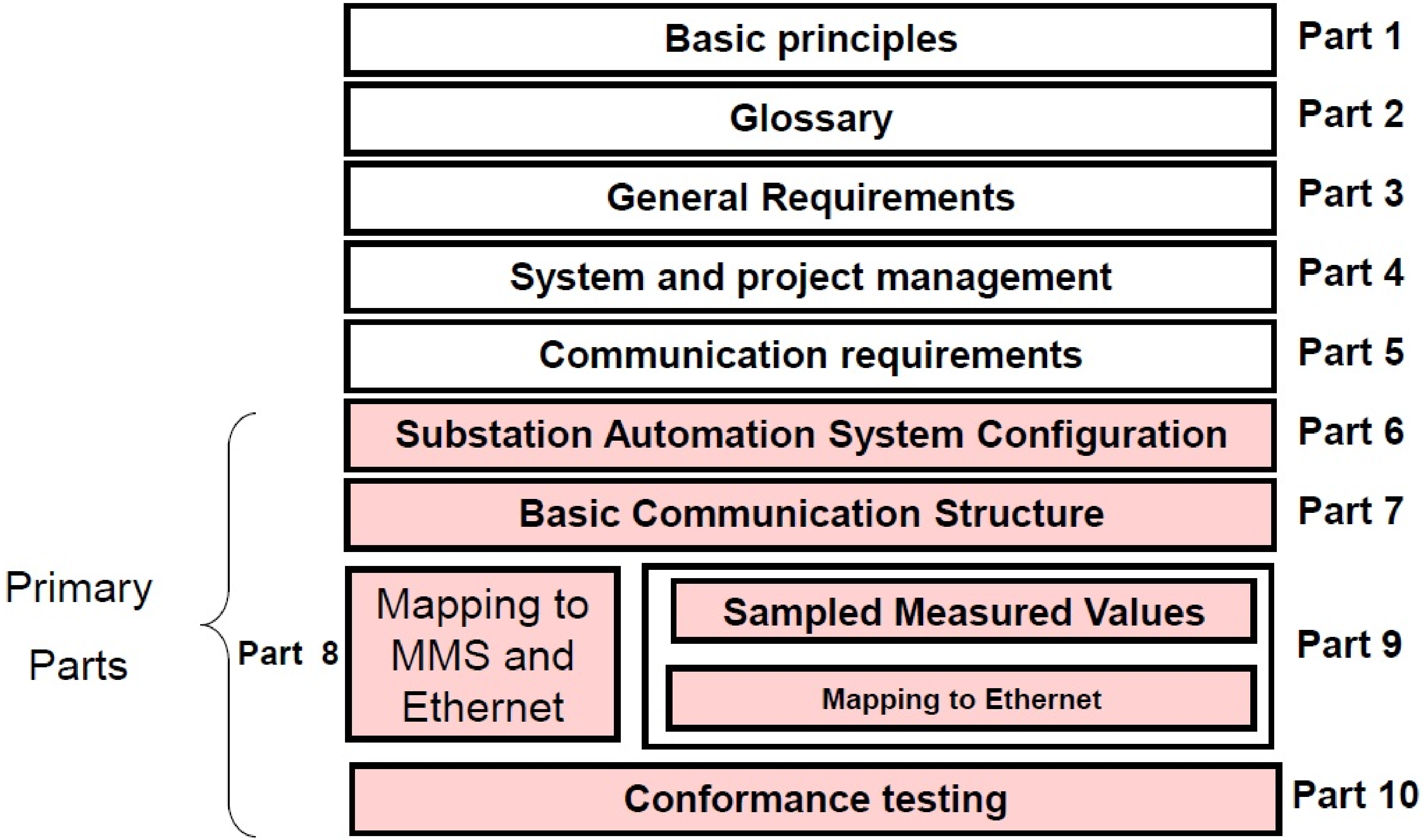
Initial Smart Grid Interoperability Standards Framework Release1.0

Standard	Application
AMI–SEC System Security Requirements	Advanced metering infrastructure (AMI) and Smart Grid end-to-end security.
ANSI C12.19/MC1219	Revenue metering information model.
BACnet ANSI ASHRAE 135–2008/ISO 16484–5	Building automation.
DNP3	Substation and feeder device automation.
IEC 60870–6/TASE.2	Inter-control center communications.
IEC 61850	Substation automation and protection.
IEC 61968/61970	Application level energy management system interfaces.
IEC 62351 Parts 1–8	Information security for power system control operations.
IEEE C37.118	Phasor measurement unit (PMU) communications.
IEEE 1547	Physical and electrical interconnections between utility and distributed generation (DG).
IEEE 1686–2007	Security for intelligent electronic devices (IEDs).
NERC CIP 002–009	Cyber security standards for the bulk power system.
NIST Special Publication (SP) 800–53, NIST SP 800–82.	Cyber security standards and guidelines for federal information systems, including those for the bulk power system.
Open Automated Demand Response (Open ADR) ..	Price responsive and direct load control.
OpenHAN	Home Area Network device communication, measurement, and control.
ZigBee/HomePlug Smart Energy Profile	Home Area Network (HAN) Device Communications and Information Model.

IEC 61850

- IEC 61850 is a standard for the design of electrical substation automation. It's a flexible, future proofing, open standard, communication between devices in transmission, distribution and substation automation systems.
- To enable seamless data communications and information exchange between the overall distribution networks, it is aimed to increase the scope of IEC 6180 to whole electric network and provide its compatibility with Common Information Model (CIM) for monitoring, control and protection applications.
- The standard has defined the data models, communication services, configuration language and conformance testing for the substation automation system. It allows the devices in substation from different vendors to interoperate with each other.
- A specification of the communication between the IEDs of the substation automation system.

Structure of the IEC 61850



Benefits of IEC 61850

- Supports a comprehensive set of substation functions
- Easy for design, specification, configuration, setup, and maintenance.
  - High-level services enable self-describing devices & automatic object discovery
  - Standardized naming conventions with power system context
  - Configuration file formats eliminate device dependencies and tag mapping and enables exchange of device configuration.
- Strong functional support for substation communication
  - Higher performance multi-cast messaging for inter-relay communications
- Extensible enough to support system evolution

IEC 61968 & IEC 61970

- IEC 61968 define standards for information exchanges between electrical distribution systems. It’s defines interfaces for all the major elements of an interface architecture for Distribution Management Systems (DMS).

- IEC 61970 provide what is called a Common Information Model (CIM), which is necessary for exchanging data between devices and networks. IEC 61970 works in the transmission domain, while IEC 61968 works in the distribution domain.
- CIM standards are integral to the deployment of a smart grid scenario, in which many devices connect to a single network.
  - CIM defines a common vocabulary and basic ontology for aspects of the electric power industry. which describes the basic components used to transport electricity.
  - CIM aims to allow application software to exchange information about the configuration and status of an electrical network.
- The IEC 61970 series of standards deals with the application program interfaces for Energy Management Systems (EMS).

Structure of IEC 61968 & IEC 61970

IEC 61968		IEC 61970	
Part 1	**Interface architecture and general requirements**	Part 1	**Guidelines and general requirements**
Part 2	**Glossary**	Part 2	**Glossary**
Part 3	**Interface standard for network operations**	Part 3XX	**Common Information Model (CIM)**
Part 4	**Interface standard for records and asset management**	Part 4XX	**Component Interface Specification (CIS)**
		Part 5XX	**CIS Technology Mappings**

wMNLab NTPU CSIE

Other Standards

- ANSI C 12.18 (for Meter):

  ANSI C12.18 is an American National Standard (ANSI) standard that is specifically designed for meter communications and responsible for two way communications between smart electricity meters (C12.18 device) .

- ANSI C12.19:

  ANSI C12.19 is an ANSI standard for utility industry end device data tables. This standard is defining a table structure for data transmissions between an end device and a computer for utility applications using binary codes and XML content. ANSI C12.19 is not interested in defining device design criteria or specifying the language or protocol used to transport that data.

- ANSI C12.22:

  Data network communications are supported and C12.19 tables are transported. using AES encryption for enabling strong, secure communications, including confidentiality and data integrity .

PLC standards

- IEEE Standards
- HomePlug Powerline Alliance
- OPERA – Open PLC European Research Alliance
- POWERNET – European Commission
- UPA – Universal Powerline Association
- CEPCA – Consumer Electronics Powerline Communications Alliance
- ETSI PLT

Many standards are available, but none is very strong.

PLC IEEE standards: IEEE P1675 IEEE P1775

- IEEE P1675

  This standards was a "standard for broadband over power line hardware." Developed by the IEEE Standards Association, the IEEE 1901 standard was another related attempt. It provided electric utility companies with a comprehensive standard for safely installing hardware required for Internet access capabilities over their power lines.

  - Its working on hardware installation and safety issues.

- IEEE P1775

  " Powerline Communication Equipment – Electromagnetic Compatibility (EMC) Requirements - Testing and Measurement Methods.“

  - Its focused on :
    - PLC equipment
    - Electromagnetic compatibility requirements
    - testing and measurement methods

PLC IEEE standards: IEEE P1901

- IEEE P1901

  "IEEE P1901 Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications."

  - The IEEE P1901 Working Group (WG) under the sponsorship of the IEEE Communications Society developed the IEEE P1901 standard for high speed power line communications to meet in-home multimedia, utility and smart grid application requirements.
  - Access control and physical layer specifications for broadband over power line networks are analyzed in detail and the access system with cell structure is defined by the IEEE P1901 Working Group.
  - The IEEE P1901 standard has an important effect on communications technology by integrating power line communications into wireless networks with extensive features, such as high-speed, walls-penetration, etc.
  - Its working for delivering broadband over power lines.

HomePlug

- HomePlug:

  HomePlug is a power line technology and the existing home electricity is used to connect the smart appliances to HAN(Home Area Network); HomePlug Command and Control (HPCC) version is designed for low-cost applications. HomePlug is a promising technology to create a reliable HAN between electric appliances and a smart meter.

- HomePlug Green PHY:

  HomePlug Green PHY specification is developed as a low power, cost-optimized power line networking specification standard for smart grid applications used in home area networking by the Smart Energy Technical Working Group within the HomePlug Powerline Alliance.

HomePlug Powerline Alliance

- HomePlug Powerline Alliance
  - Trade group consisting of over 65 companies
  - Founded in March 2000
  - Mission: To enable and promote rapid availability, adoption and implementation of cost-effective, interoperable and standards-based home power line networks and products.
  - Big players: Earthlink, General Electric, Intel, Linksys, Motorola, Radio Shack, Samsung, Sony, Sharp etc.
  - HomePlug technology is based on the contributions of multiple companies from around the world, the resulting standards offer best of class performance.

HomePlug Powerline Alliance Standards

HomePlug Powerline Alliance has defined a number of standards:

- HomePlug 1.0 standards

  This standards is the specification for connecting devices via power lines in the home.

- HomePlug AV standards

  This standards is designed for transmitting HDTV and VoIP around the home.

- HomePlug BPL standards

  This standards is a working group to develop a specification for to-the-home connection.

- Home Plug CC standards

  The Command and Control is a low-speed, very low-cost technology intended to complement the alliance's higher-spe technologies.

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Homework

1.What are the three main factors of the smart grid functions, and to go into details.

2.What are two kinds of demand response? And white down the contents.

3.Try to draw the architecture of power line communication.