

SMART GRID SYSTEMS

PE/PE/HT/324C

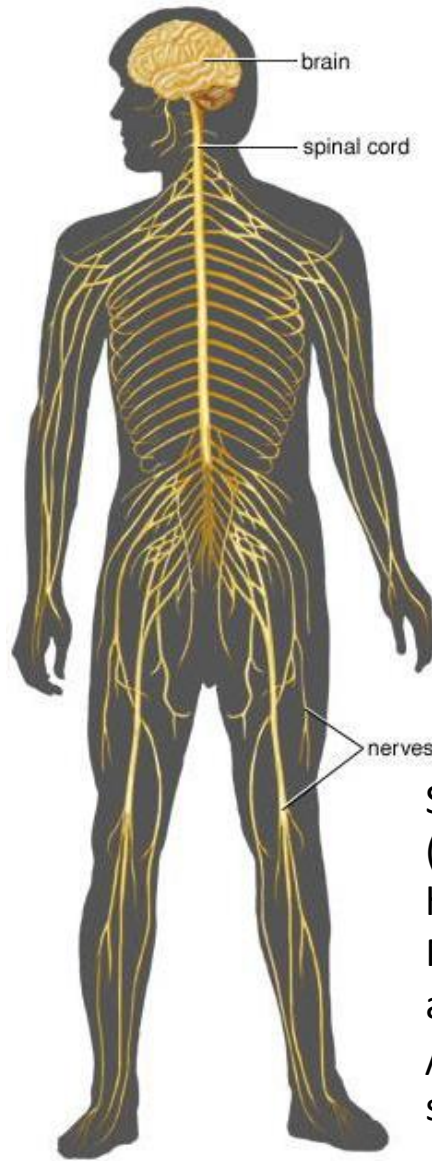
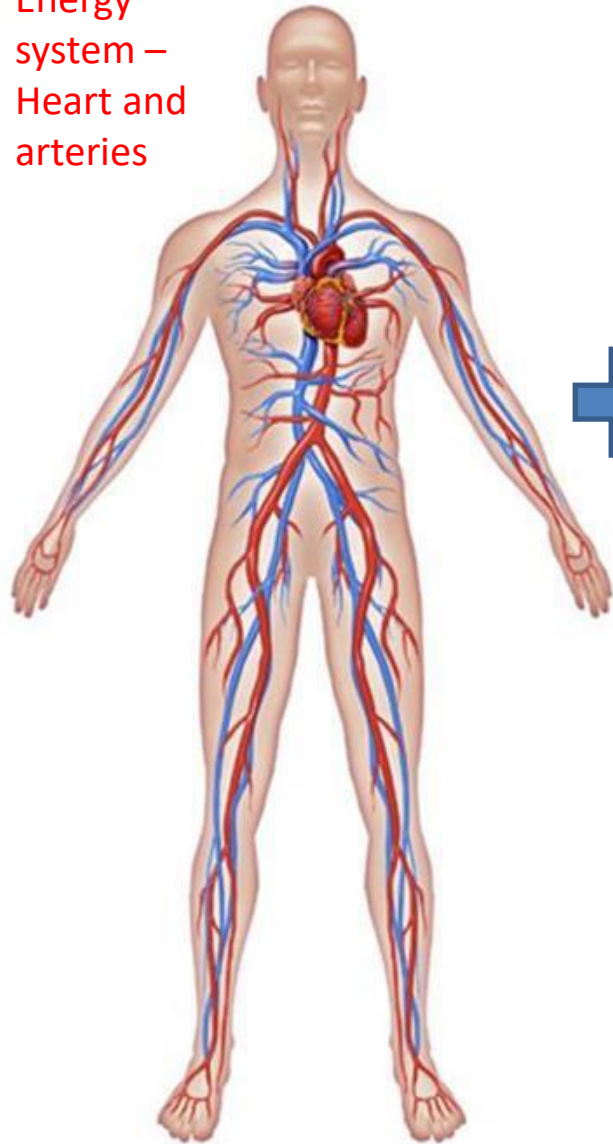
Professional Elective Honors Course

ILOs

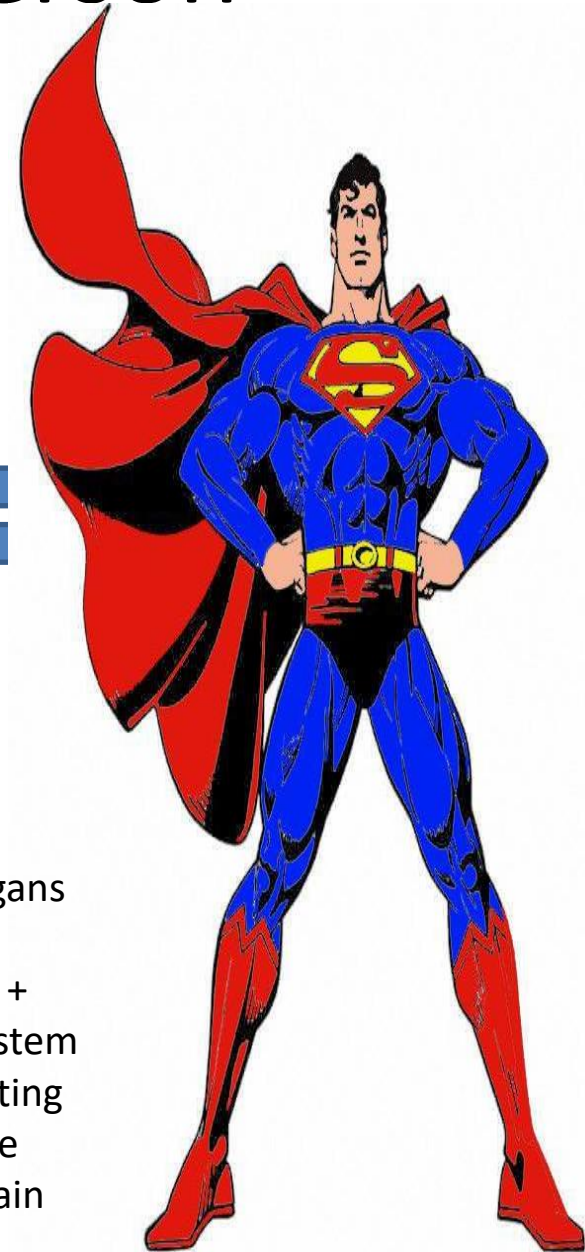
- Introduce and define SMART GRIDS
- Compare conventional grid with smart grid
- Describe the domains of smart grid

Smart and Robust Person

Energy system –
Heart and
arteries

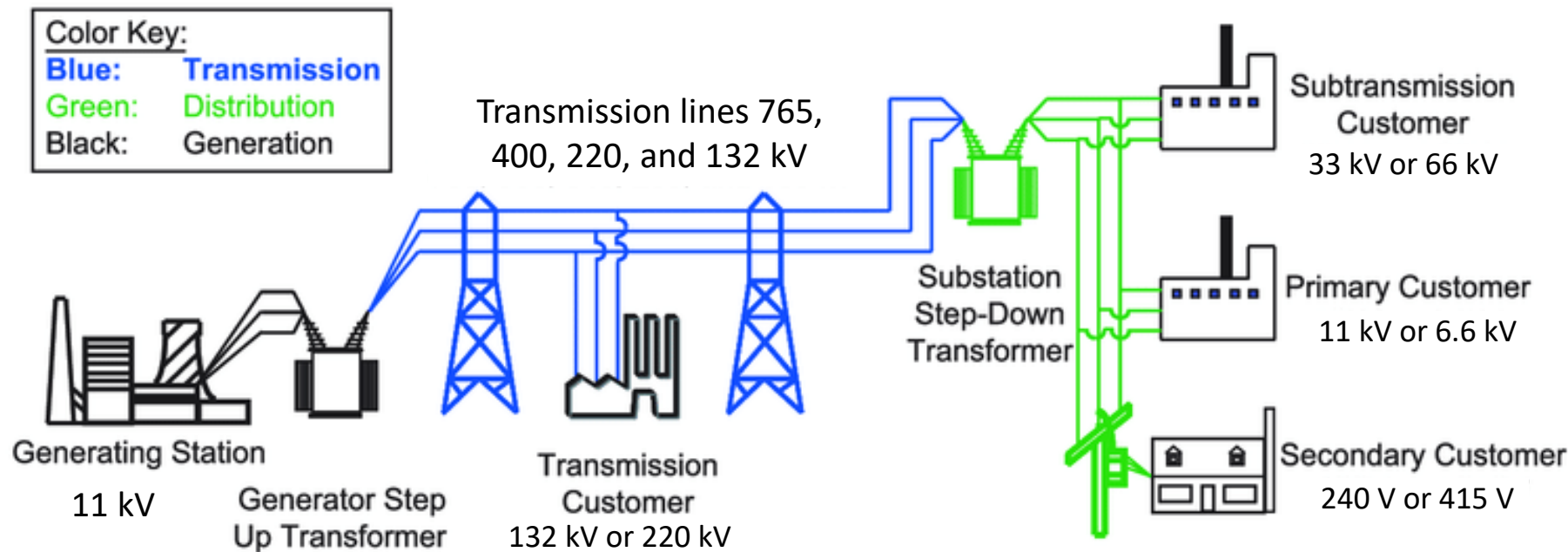


Sensory organs
(ear, nose,
hand, etc.) +
Nervous system
and computing
/intelligence
system - brain



Need for Smart Grid Network

- ❑ Power System in the earlier days
 - ❑ Basic structure of the electric system

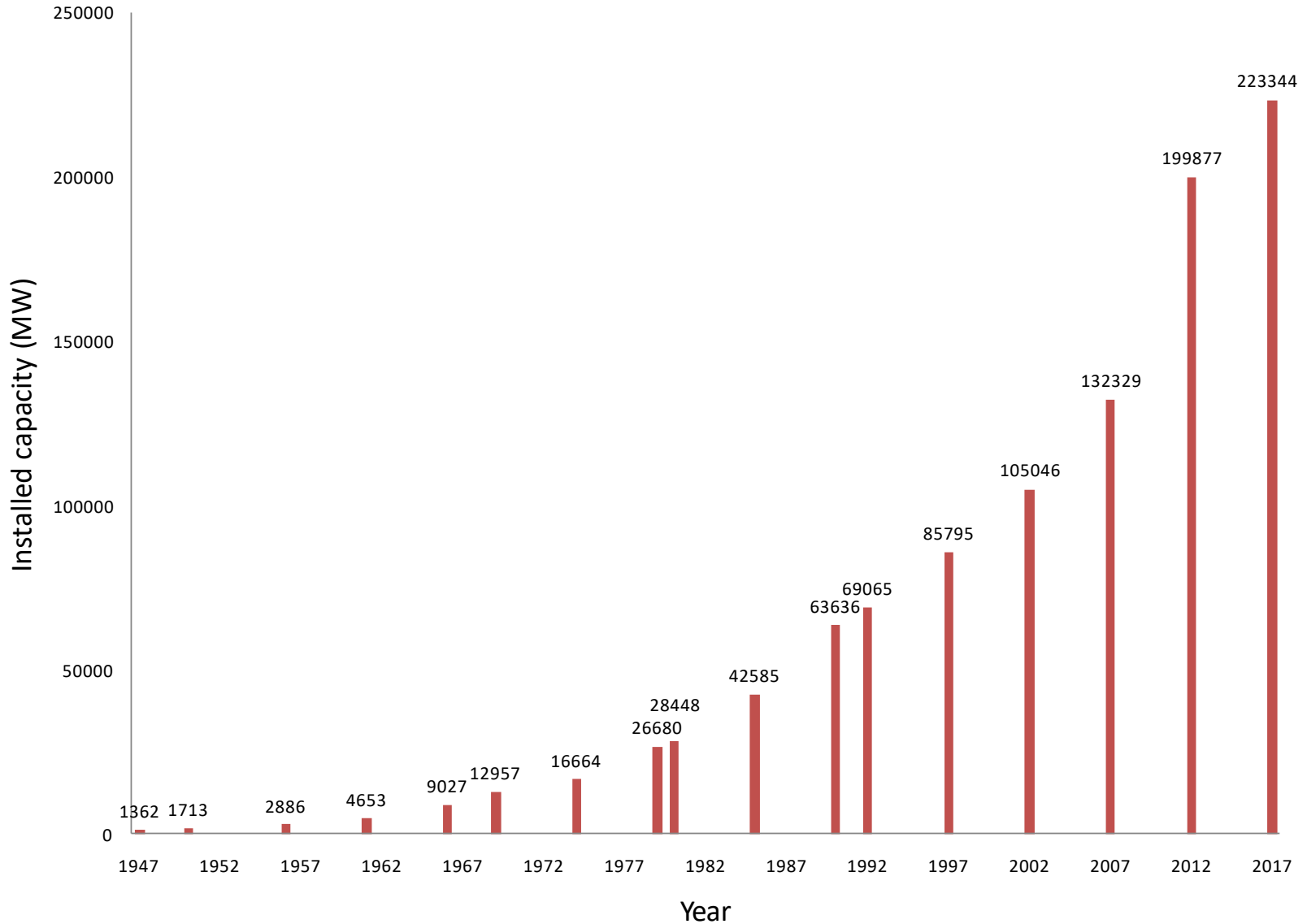


Characteristics of modern power system

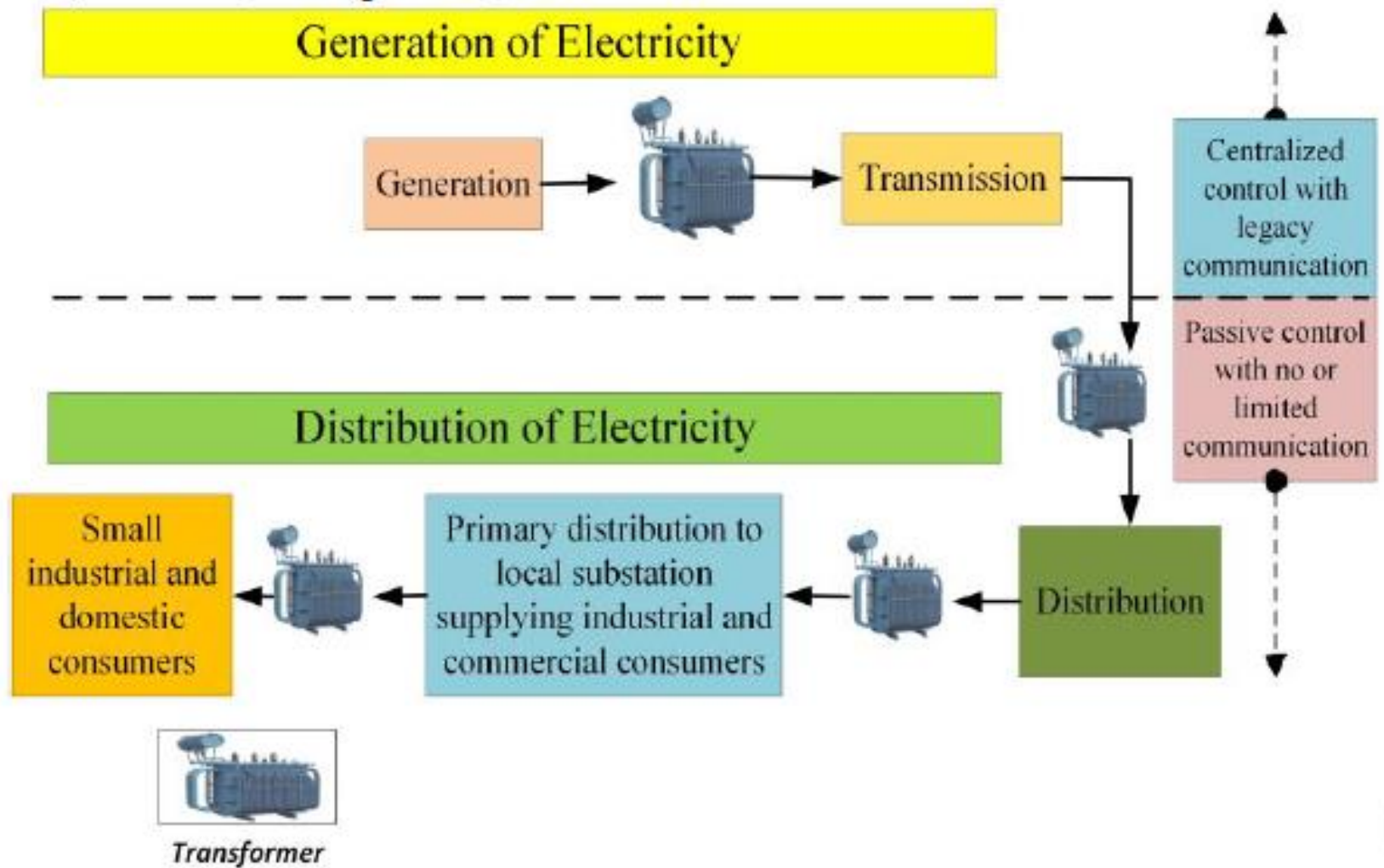
- Wide geographical spread
 - due to typical large distance between major load centres and conventional sources of energy
- Large number of interconnections
 - due to political, economic, environmental, reliability, and stability issues
- Rapid growth in the demand of electricity
 - due to increase in population, standard of living, development of townships
- Power system components are being operated closer to their designed limits
 - more investment needed in the electrical infrastructure
- High penetration of renewable energy sources
 - Intermittency, relay coordination, power quality, system stability
- Competitive electricity market
 - needs real time monitoring and strict regulation

Growth in Electricity Sector in India

- Installed generation capacity

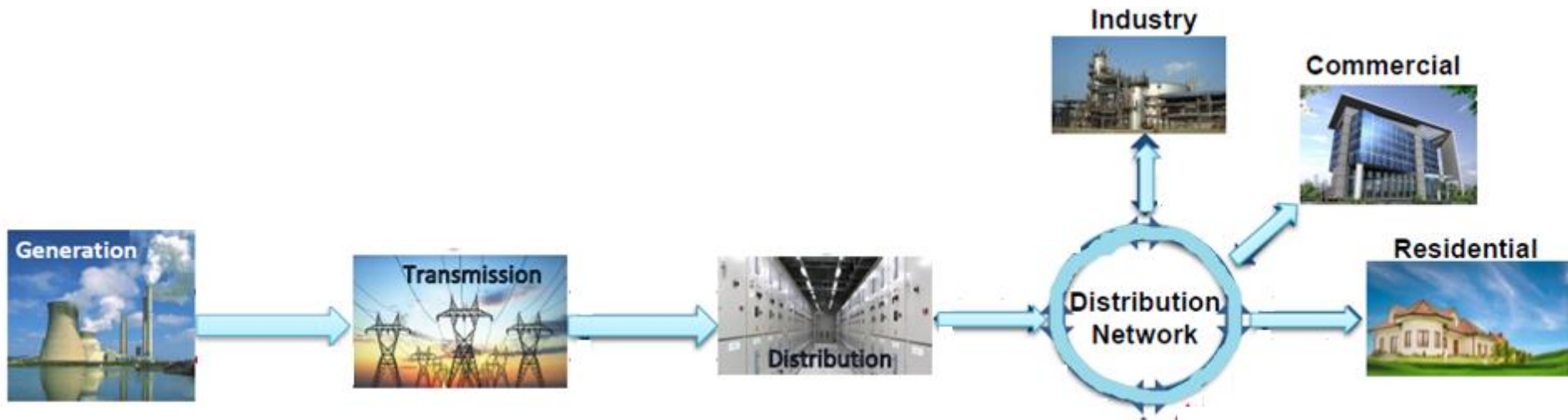


Conventional Grid



Smart Grid Network

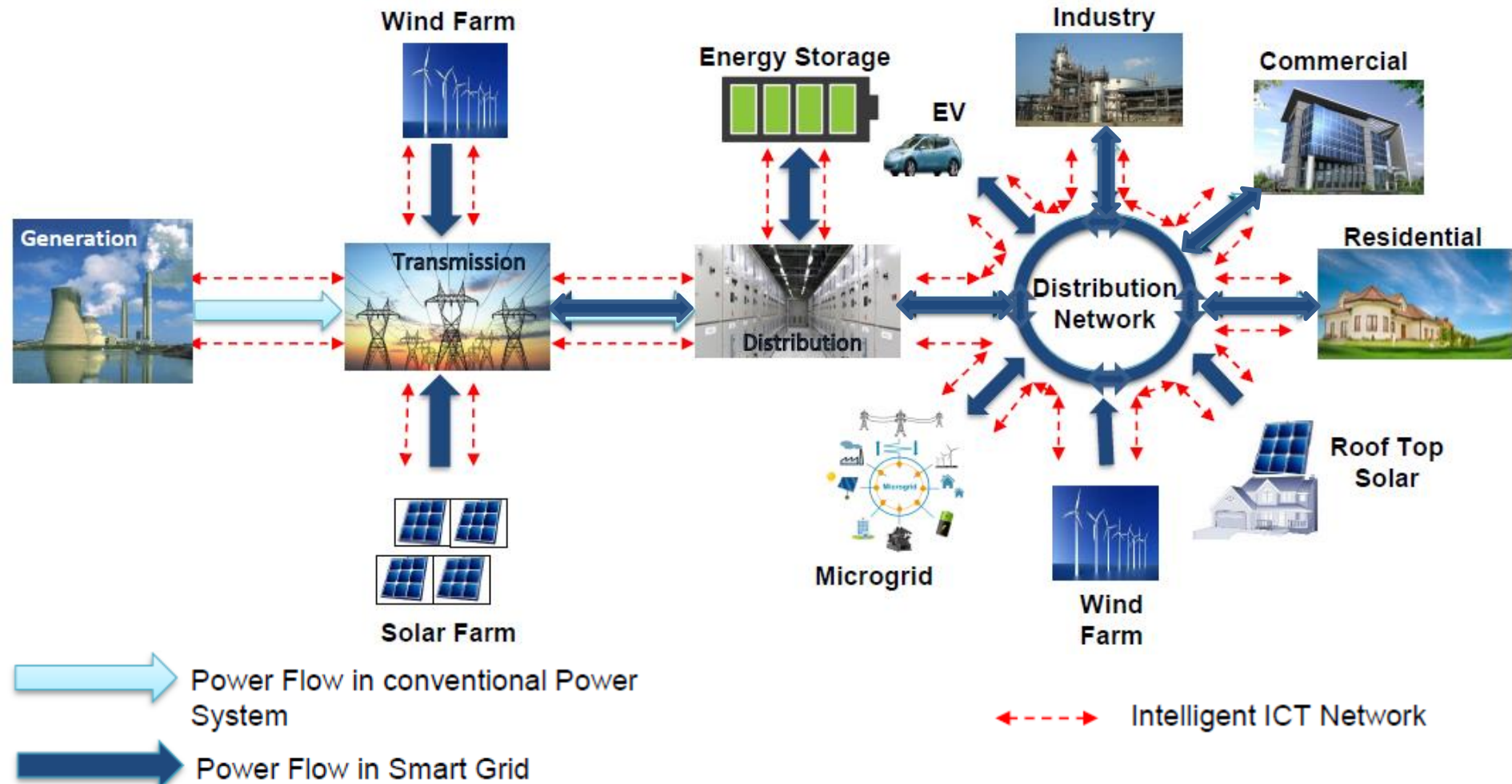
- ❑ **Transformed power system network** – Utilities are poised to move from the traditional power system to a highly flexible, secured and green power system by using integrated two-way communications and advanced control technology



➡ Power Flow in conventional Power System

Smart Grid Network

- ❑ **Transformed power system network** – Utilities are poised to move from the traditional power system to a highly flexible, secured and green power system by using integrated two-way communications and advanced control technology



Smart Grid

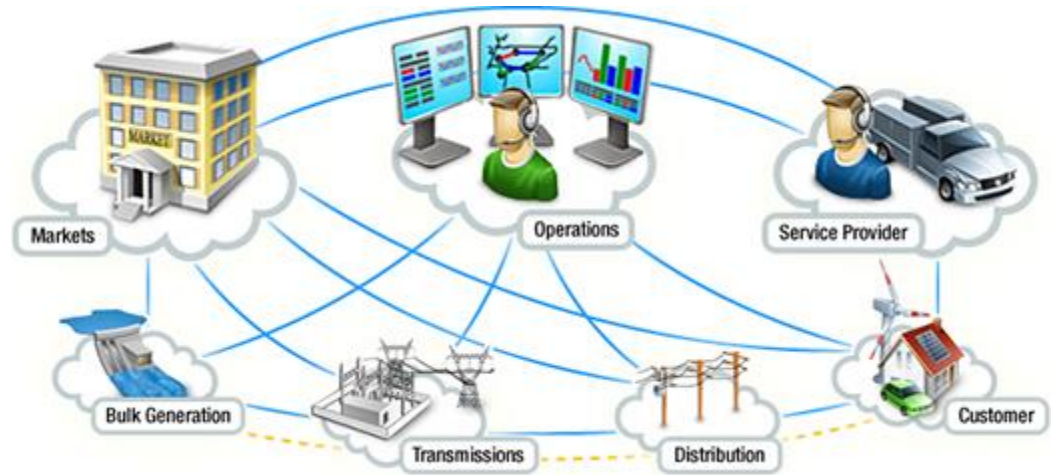
- ❖ A smart grid is not a completely new grid, but an upgraded version of the conventional power grid
- ❖ Equipped with the best emerging technologies – hardware and software
- ❖ The objective is to make the grid more beneficial for everyone – the consumers, generation companies, and the environment
- ❖ A smart grid is a network whereas conventional grids are radial
- ❖ More welcoming to renewable energy; Smarter the grid, more will be the penetration of renewable energy into the overall energy landscape.
- ❖ More reliable, self reliant, pro-active, efficient, and secure



Smart Grid

Smarter

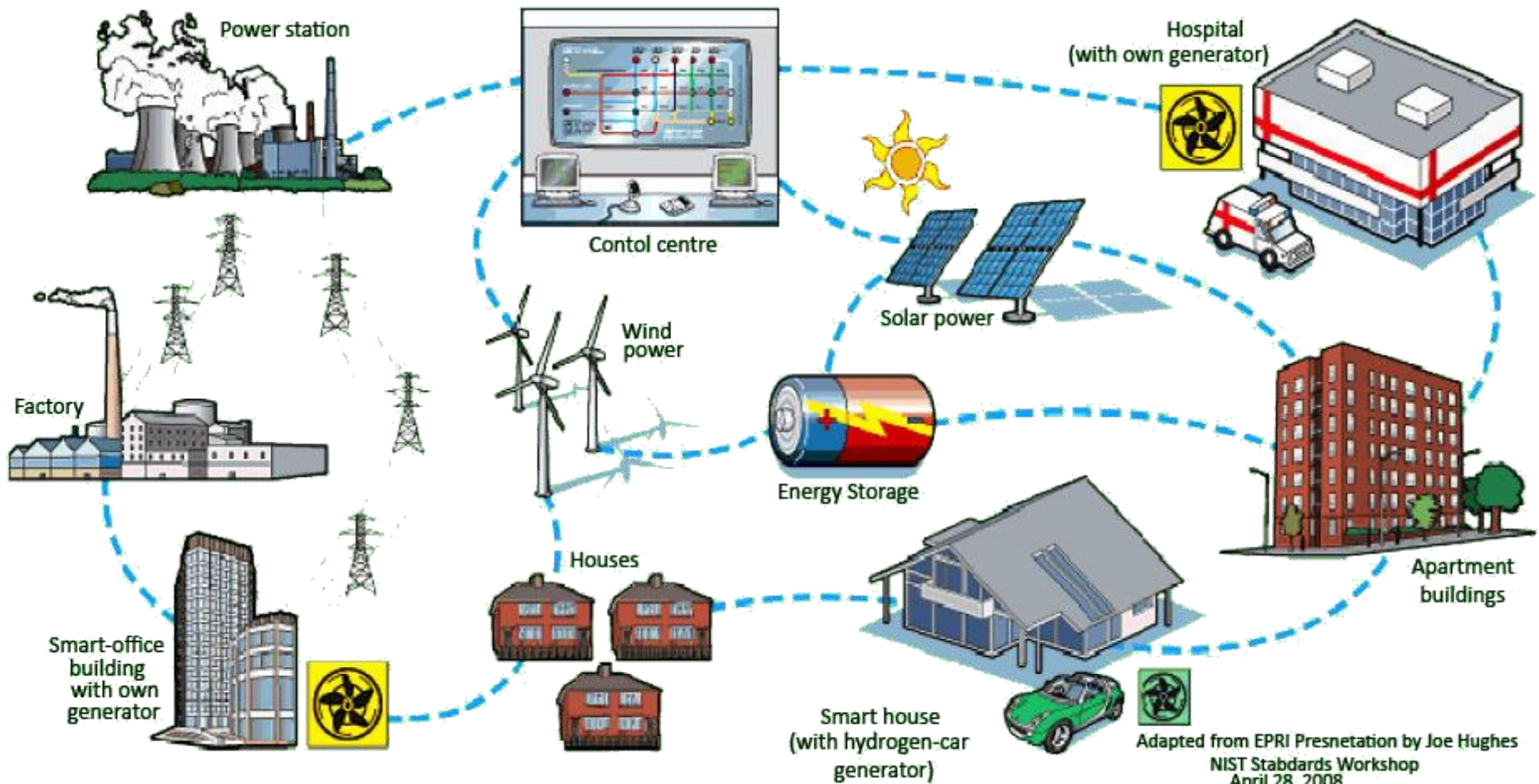
- Generation
- Transmission
- Distribution
- Customer participations
- Operations
- Markets
- Service providers



Overall objective

Smart / best / optimal utilization of all the available resources

Smart Grid



Adapted from EPRI Presentation by Joe Hughes
NIST Standards Workshop
April 28, 2008

Smart Grid - Definition

❑ National Institute of Standards and Technology (NIST) - USA

- ❑ A modernized grid that enables bidirectional flows of energy and uses two-way communication and control capabilities that will lead to an array of new functionalities and applications

❑ IEEE

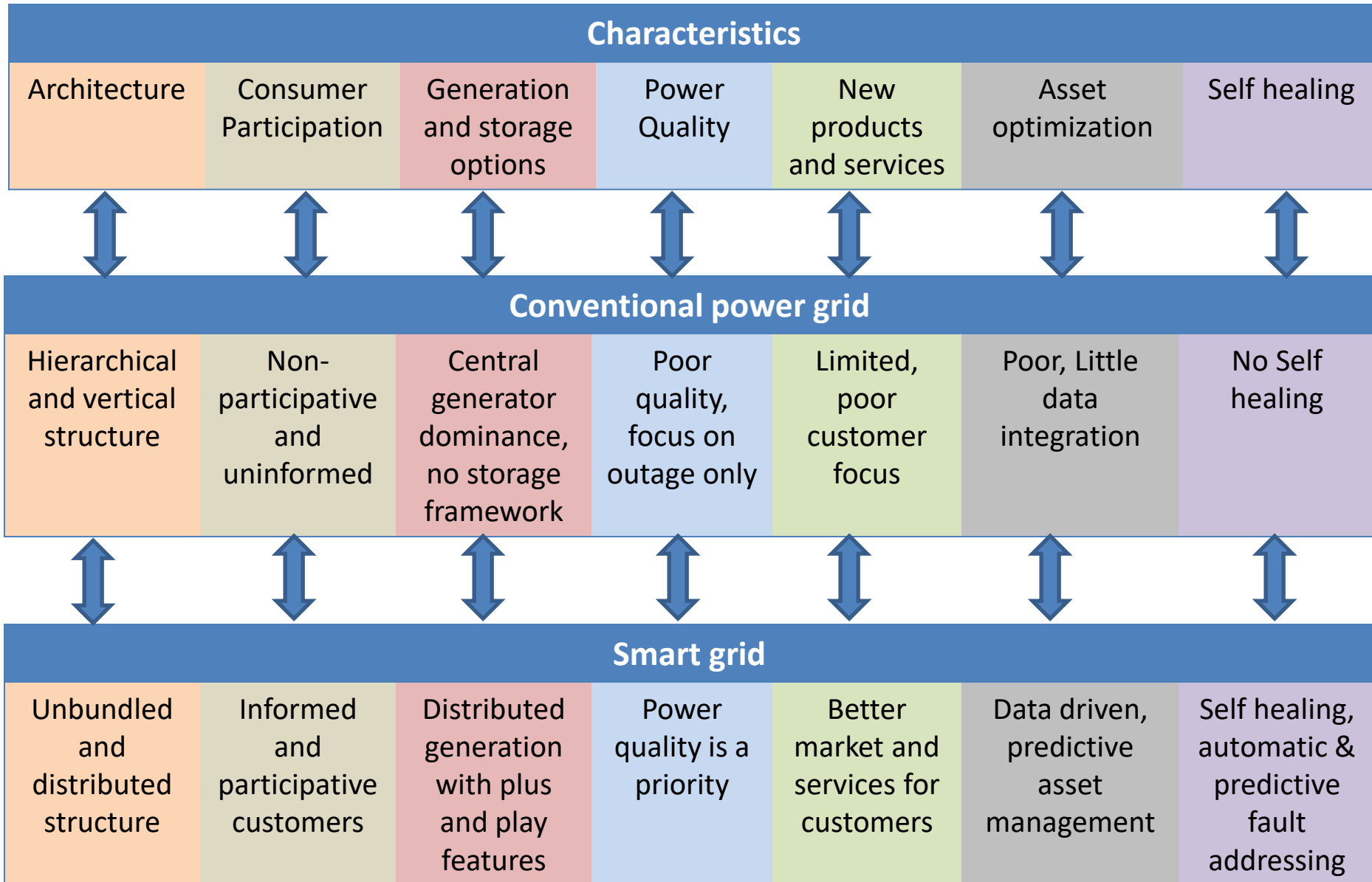
- ❑ Smart Grid is a large 'System of Systems', where each functional domain consists of three layers:
 - 1) The power and energy layer
 - 2) The communication layer
 - 3) The IT/computer layer
- ❑ Layers (2) and (3) above are enabling infrastructure that makes the existing power infrastructure 'smarter'

Smart Grid - Definition

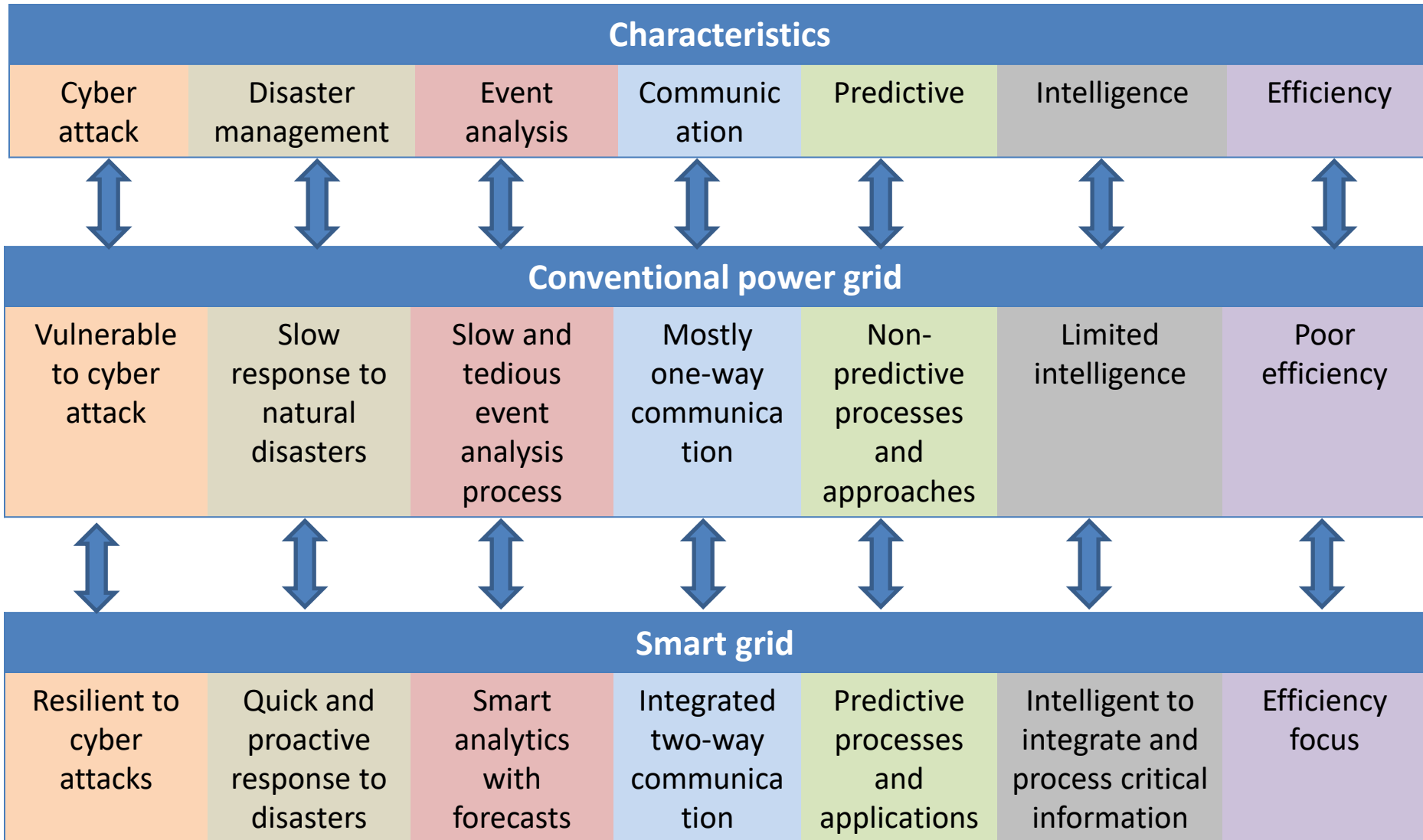
❑ **National Smart Grid Mission (NSGM)- India**

- ❑ Smart Grid is an Electrical Grid with Automation, Communication and IT systems that can monitor power flows from generation to consumption (even down to appliances level) and control the power flow or curtail the load to match generation in real time or near real time
- ❑ Smart Grids can be achieved by implementing efficient transmission & distribution systems, system operations, consumer integration and renewable integration

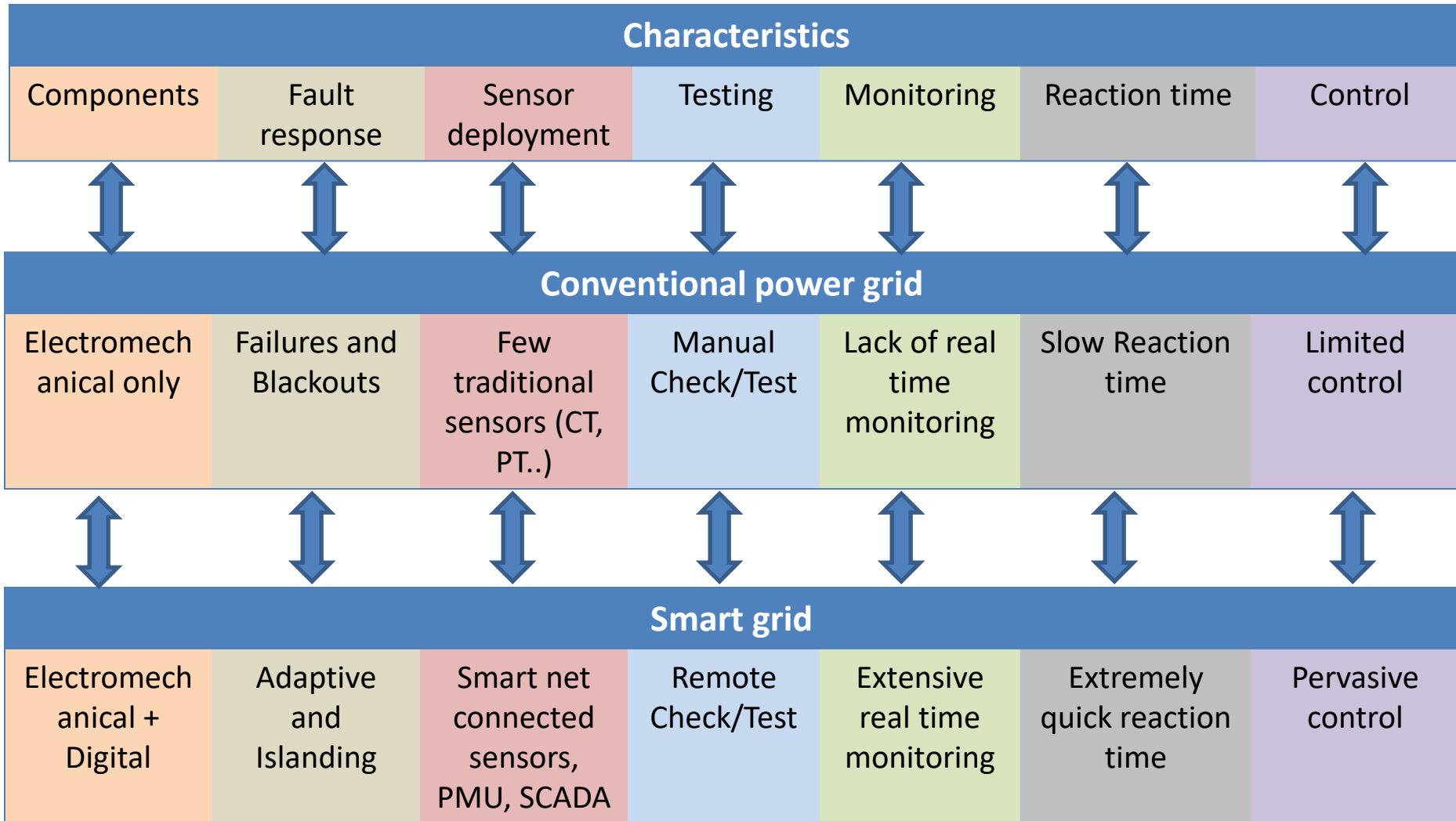
Conventional grid vs. Smart grid



Conventional grid vs. Smart grid (Contd..)



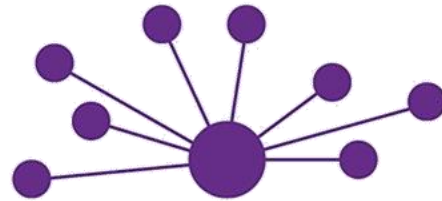
Conventional grid vs. Smart grid (Contd..)



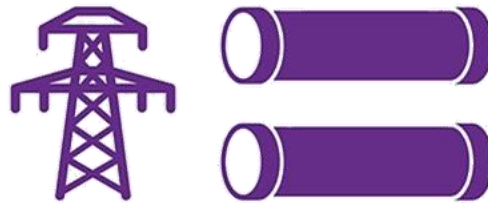
yesterday



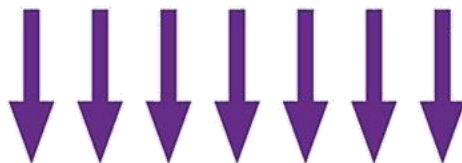
few large power plants



centralized, mostly national



based on large power lines and pipelines



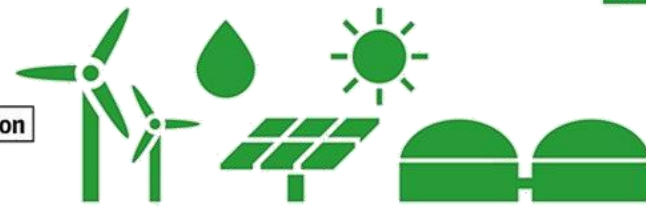
top to bottom



passive, only paying

tomorrow

production



many small power producers

market



decentralized, ignoring boundaries

transmission



including small-scale transmission and regional supply compensation

distribution



both directions

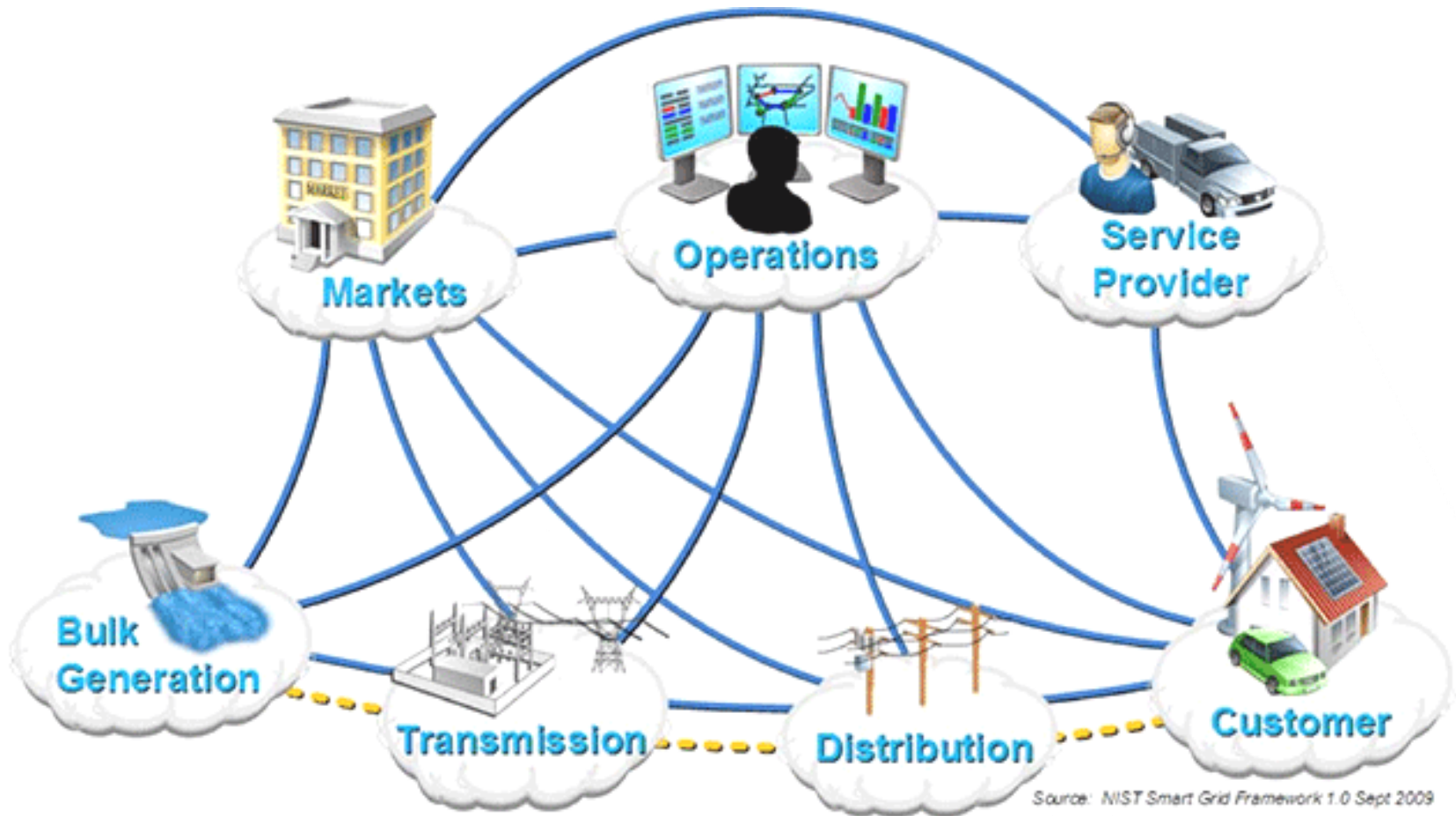
consumer



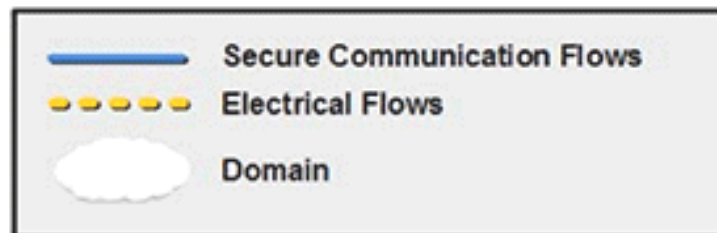
active, participating in the system

Smart Grid Domains

Smart grid domains



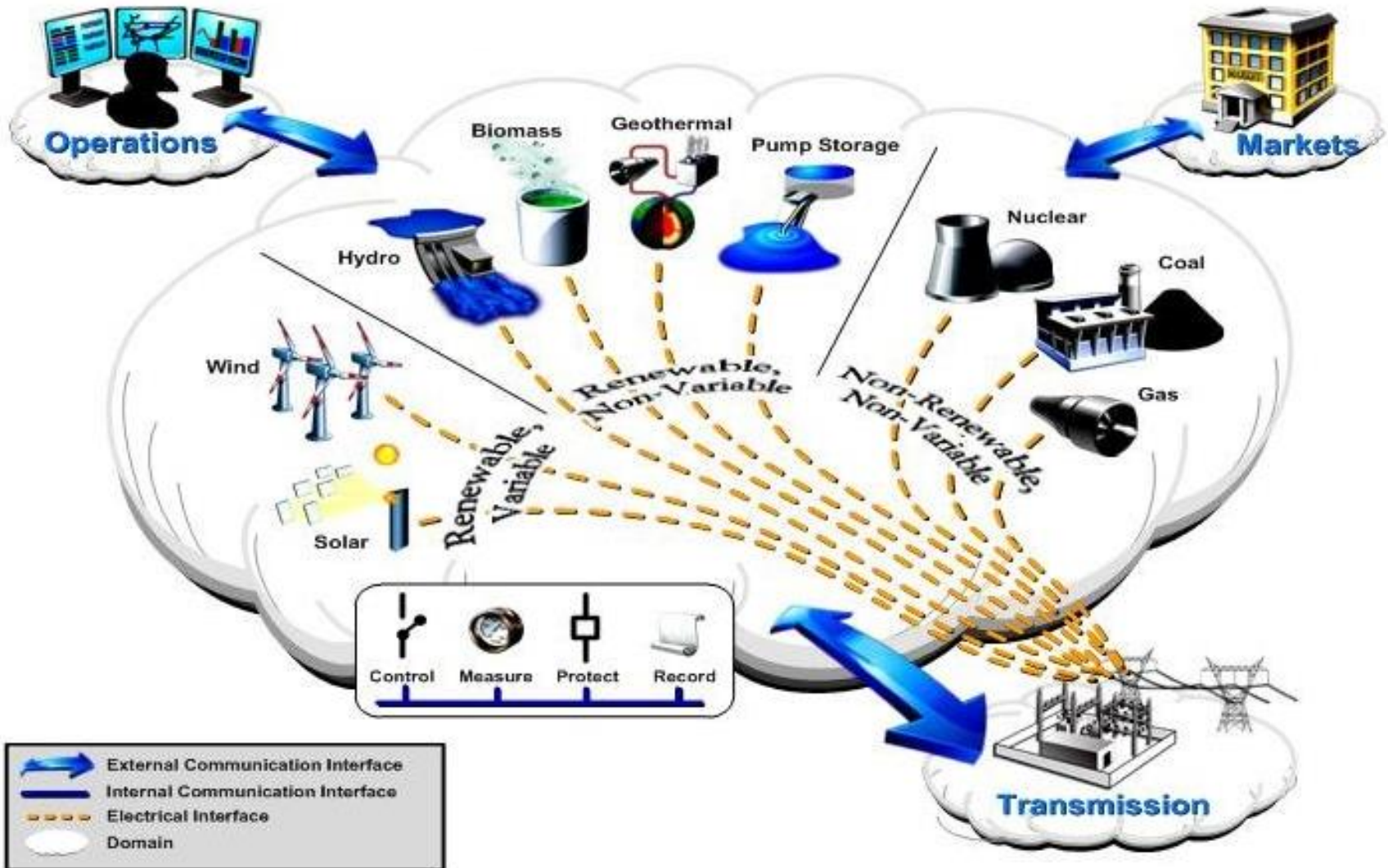
Source: NIST Smart Grid Framework 1.0 Sept 2009



Smart grid domains - Generation

- Co-existence of various types of renewable and non-renewable generating technologies, such as coal, hydro, nuclear, solar, biomass, geothermal, etc.
- System operator has to coordinate the operation of the generation plants, and ensure the stable and secure operation of the system
- Wide-area measurement system (WAMS) enabled by communication technologies need to be used to control the operation of the generating stations
- Communication infrastructure needs to be in place between the generating facilities and the system operator, electricity market, and the transmission system

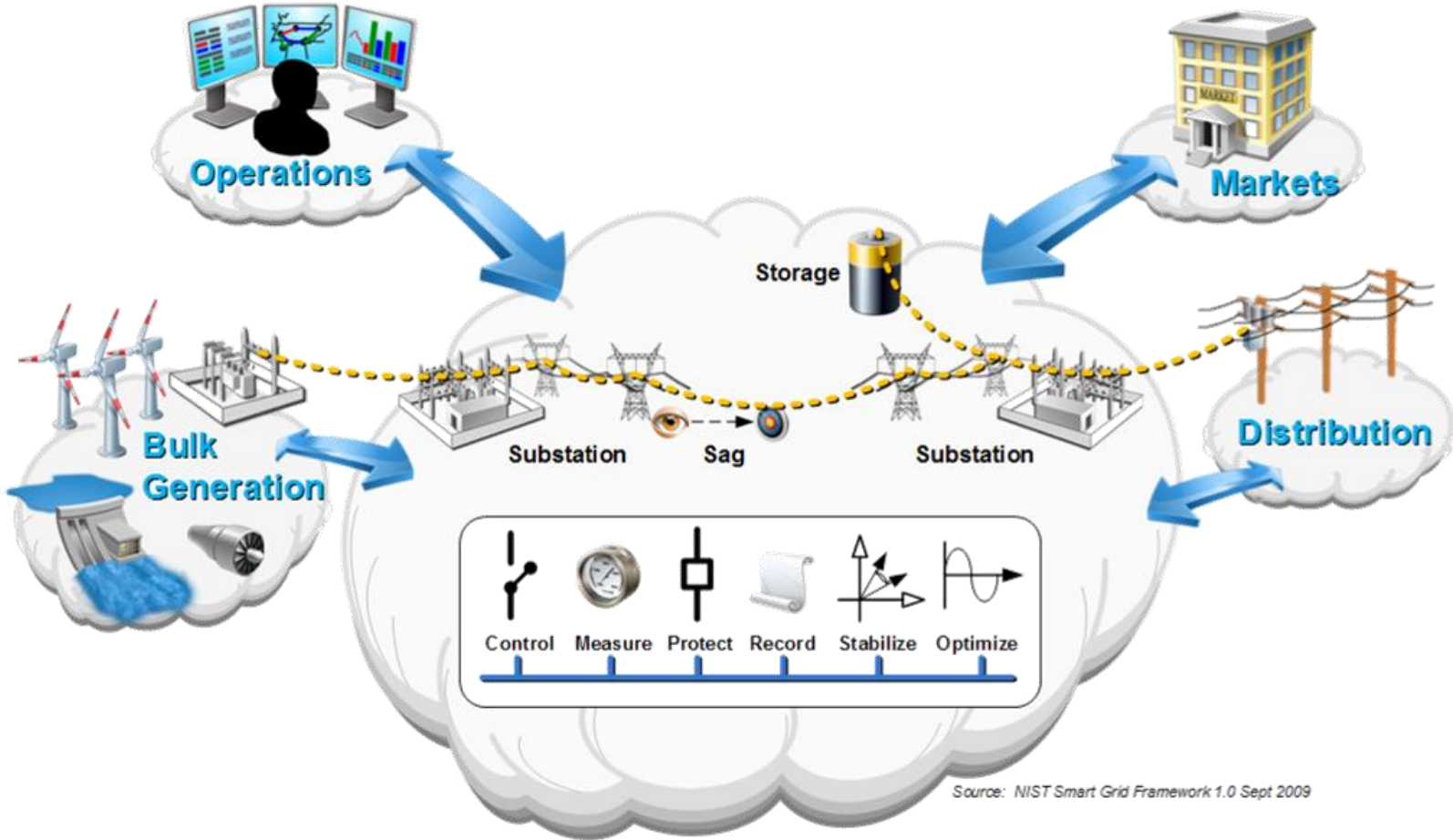
Smart grid domains - Generation



Smart grid domains - Transmission

- Energy-efficient transmission network will carry the power from the bulk generation facilities to the power distribution systems
- Communication interface exists between the transmission network and the bulk-generating stations, system operator, power market, and the distribution system
- The transmission network needs to be monitored in real-time, and protected against any potential disturbance
- The power flow and voltage on the lines need to be controlled in order to maintain stable and secure operation of the system
- An important task of the system operator is to ensure optimal utilization of the transmission network, by minimizing the losses and voltage deviations, and maximizing the reliability of the supply

Smart grid domains - Transmission



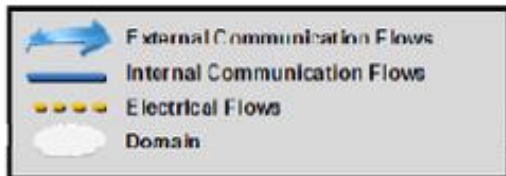
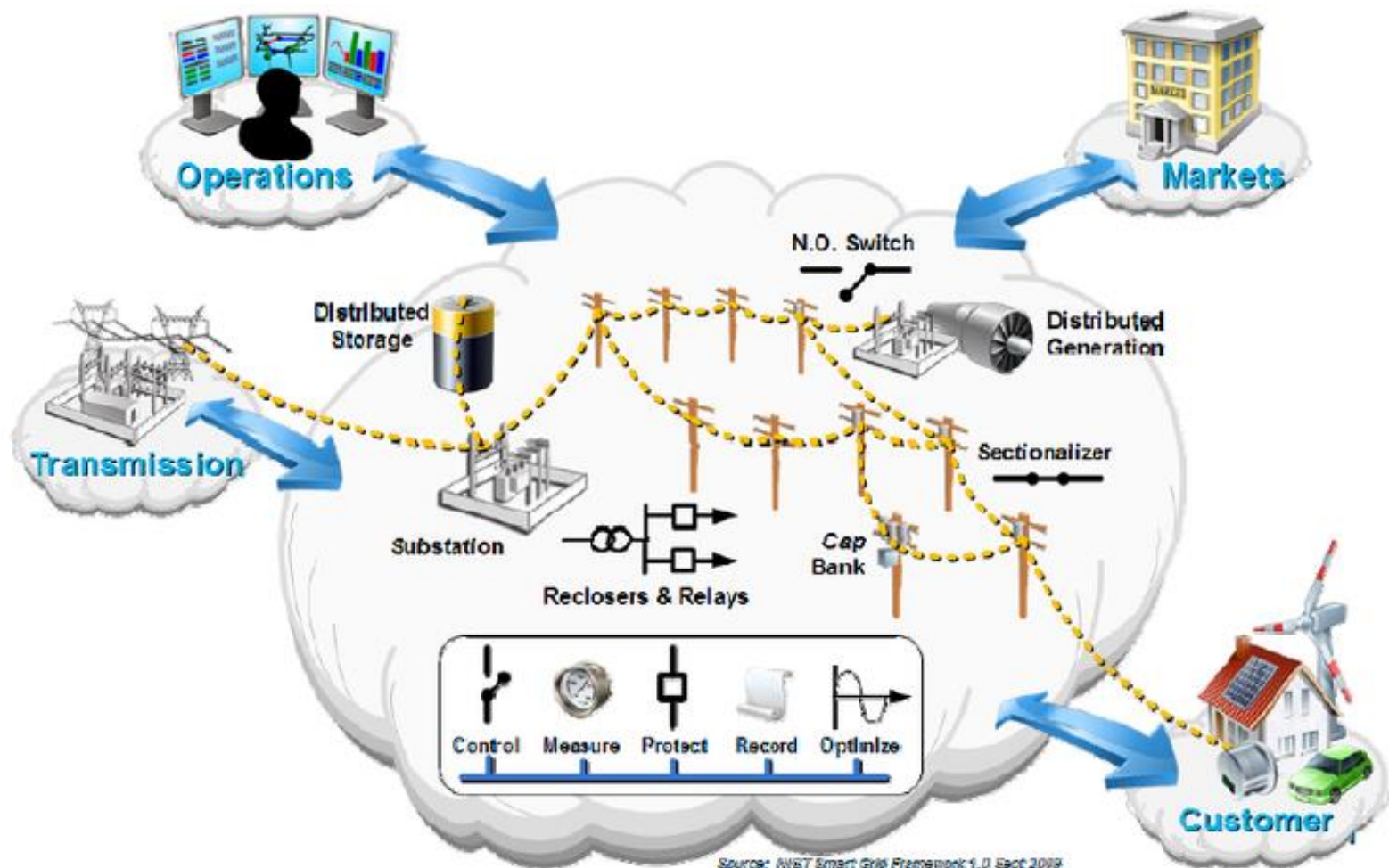
Source: NIST Smart Grid Framework 1.0 Sept 2009

- External Communication Flows
- Internal Communication Flows
- Electrical Flows
- Domain

Smart grid domains - Distribution

- Substation automation and distribution automation will be the key enablers for the smart distribution systems
- Increasing use of distributed energy resources (DERs) will be an important feature of future distribution systems
- Distribution system operator typically controls the distribution system remotely
- Communication infrastructure to exchange information between the substations and a central distribution management system (DMS) therefore should be in place
- An important job of the distribution system operator is to control the DERs in a coordinated way to ensure stability and power quality of the distribution system
- Information exchange between the distribution system operator and the customers for better operation of the distribution system is a new feature of the smart distribution systems

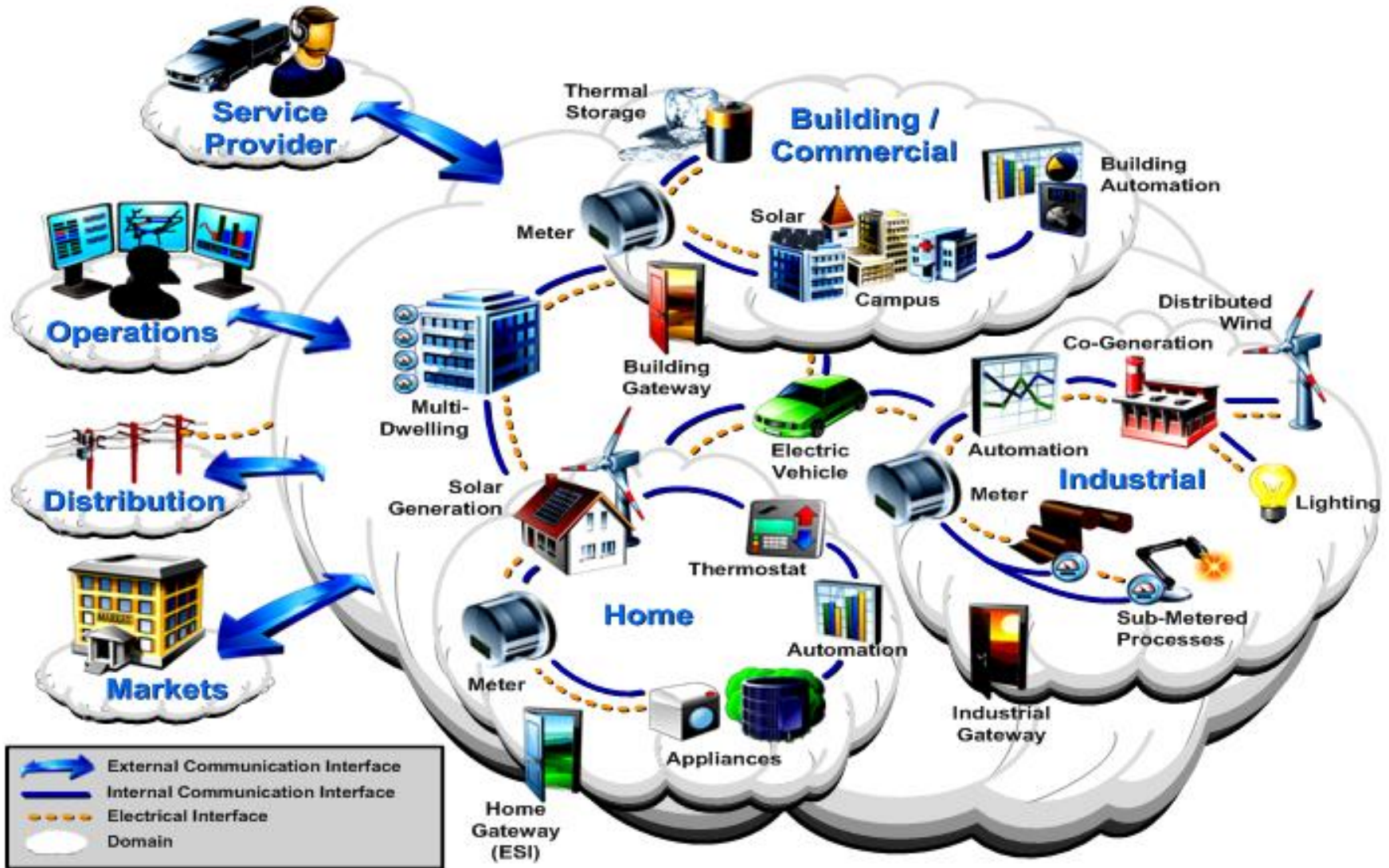
Smart grid domains - Distribution



Smart grid domains - Customers

- Customers can be classified into three main categories:
 - Residential
 - Commercial
 - Industrial
- In smart grids, customers are going to play a very important role through demand response
- By peak-load shaving, valley-filling, and emergency response, customers are going to play an active role in better operation of the distribution system
- Building or home automation system will monitor and control the power consumption at the consumer premises in an intelligent way
- Proper communication infrastructure will be required for the consumers to interact with the operators, distribution systems, and the market

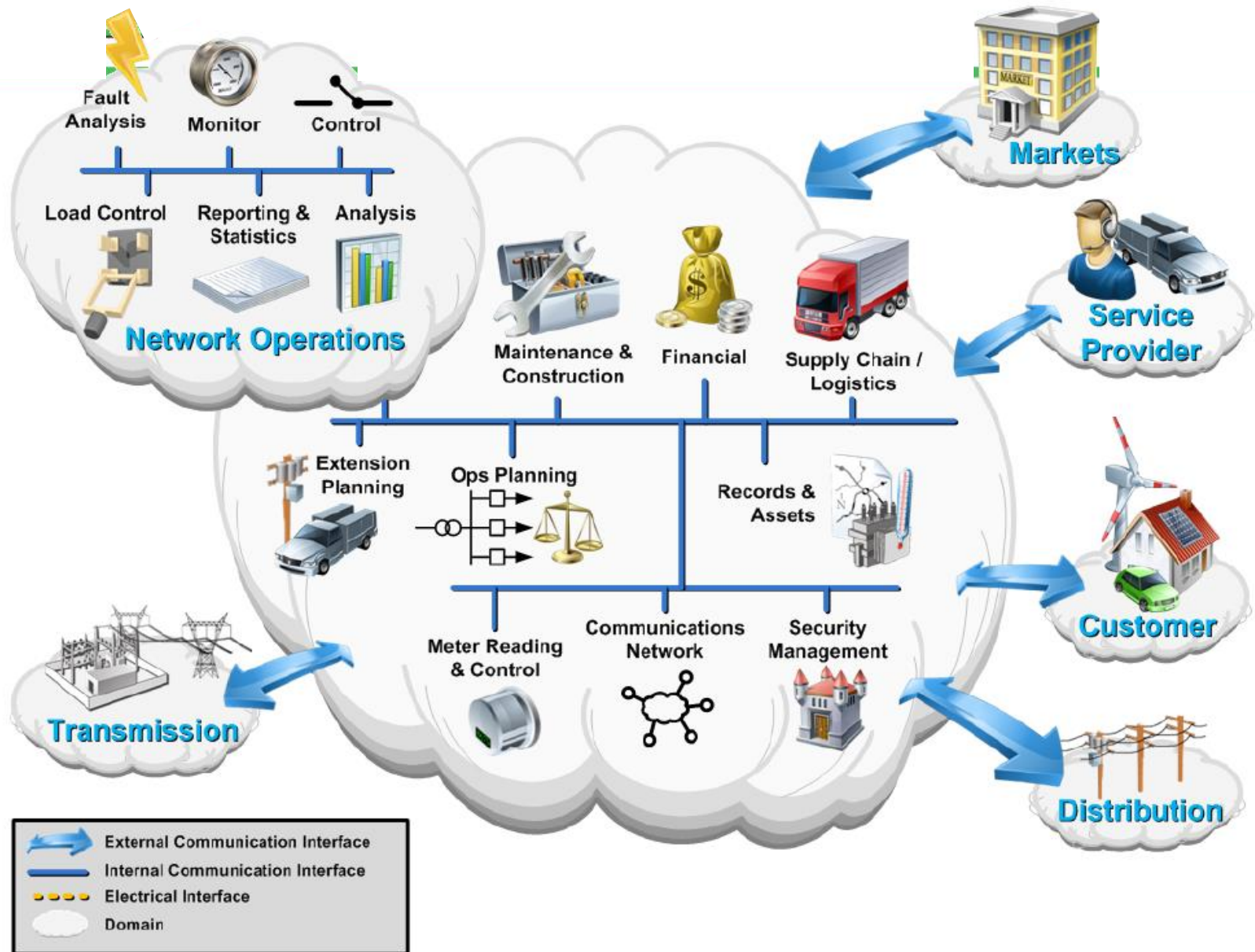
Smart grid domains - Customers



Smart grid domains - Operations

- Smart grid operations require communication interface with the bulk generating facilities, transmission system, substation automation, distribution automation, DMS, consumers, and the market.
- Metering, recording, and controlling operations come under the purview of the smart grid operations
- Real-time information exchange with the power market needs to be established in order to implement power trading and scheduling
- The operators need to interact with various service providers for ensuring proper functioning of the smart grid
- Information exchange with the consumers or prosumers is the key for the operators to implement the so-called demand management system

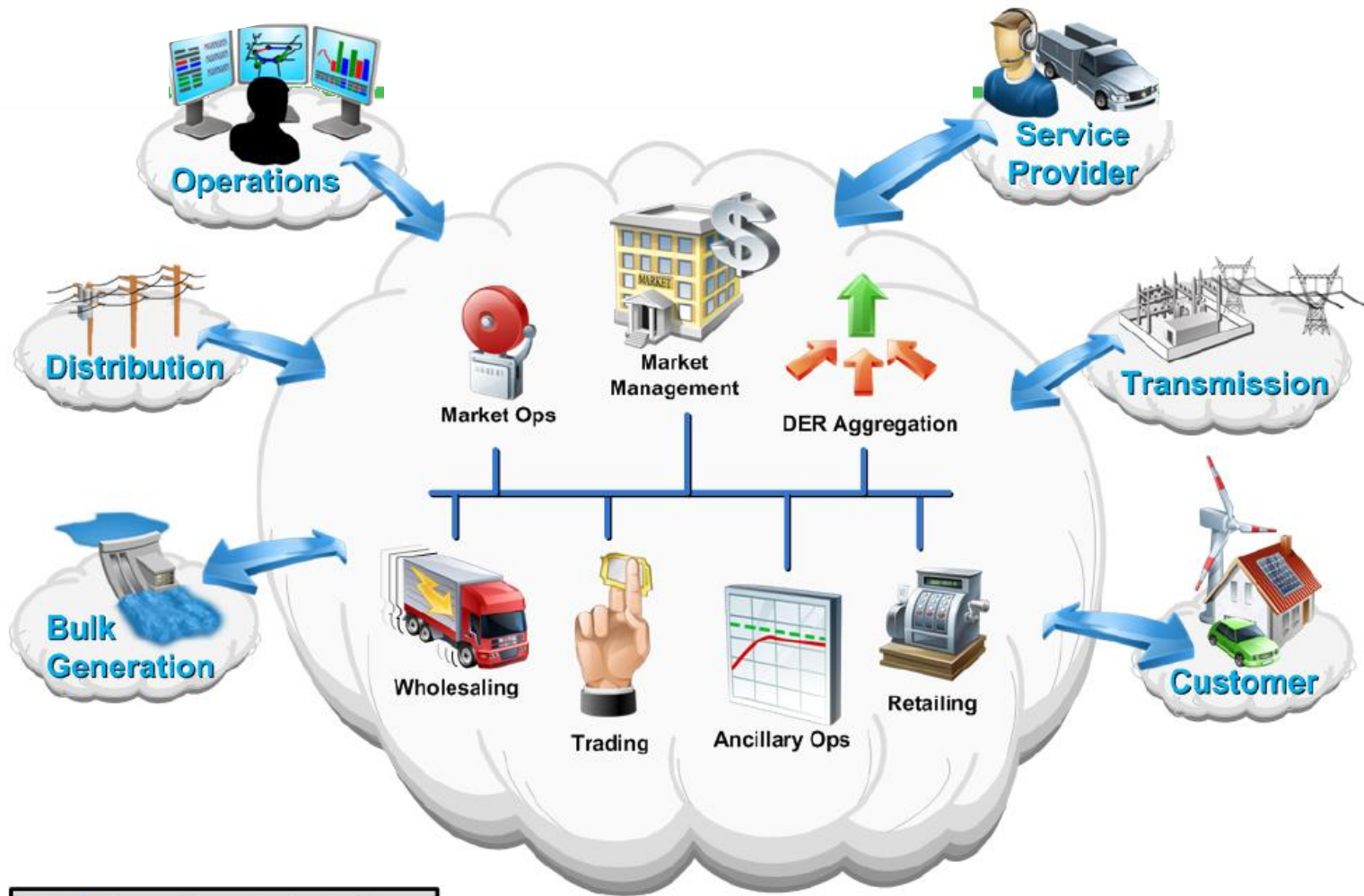
Smart grid domains - Operations



Smart grid domains - Markets

- Smart grid power market needs to develop, keeping in mind all the objectives of the smart grid
- The communication infrastructure integrating the bulk generation, transmission, distribution, consumers, markets, and service providers is the key to the success of the power market in a smart grid
- Appropriate regulatory policies need to be formulated for seamless integration of the various domains, including the storage and DER aggregators into the smart grid market
- The pricing information has to be made available online for shorter intervals (hours or even minutes)

Smart grid domains - Markets



Smart grid domains – Service providers

- Various service providers will emerge, as the smart grid business model matures
- Communication interface with the operator, market, and consumers will be needed for the service providers
- Examples of services:
 - Forecasting for renewable generation
 - Billing and customer complain management
 - Building and home management
 - Installation and commissioning services
 - Account management

Smart grid domains – Service providers

