Integrating Small Generations to a Smart Grid Environment

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- **What is Smart Grid?**
- **Is the present grid not smart?**
- **Why Smart Grid?**
- **Smart or Intelligent ???**

Some of the Recent Concerns

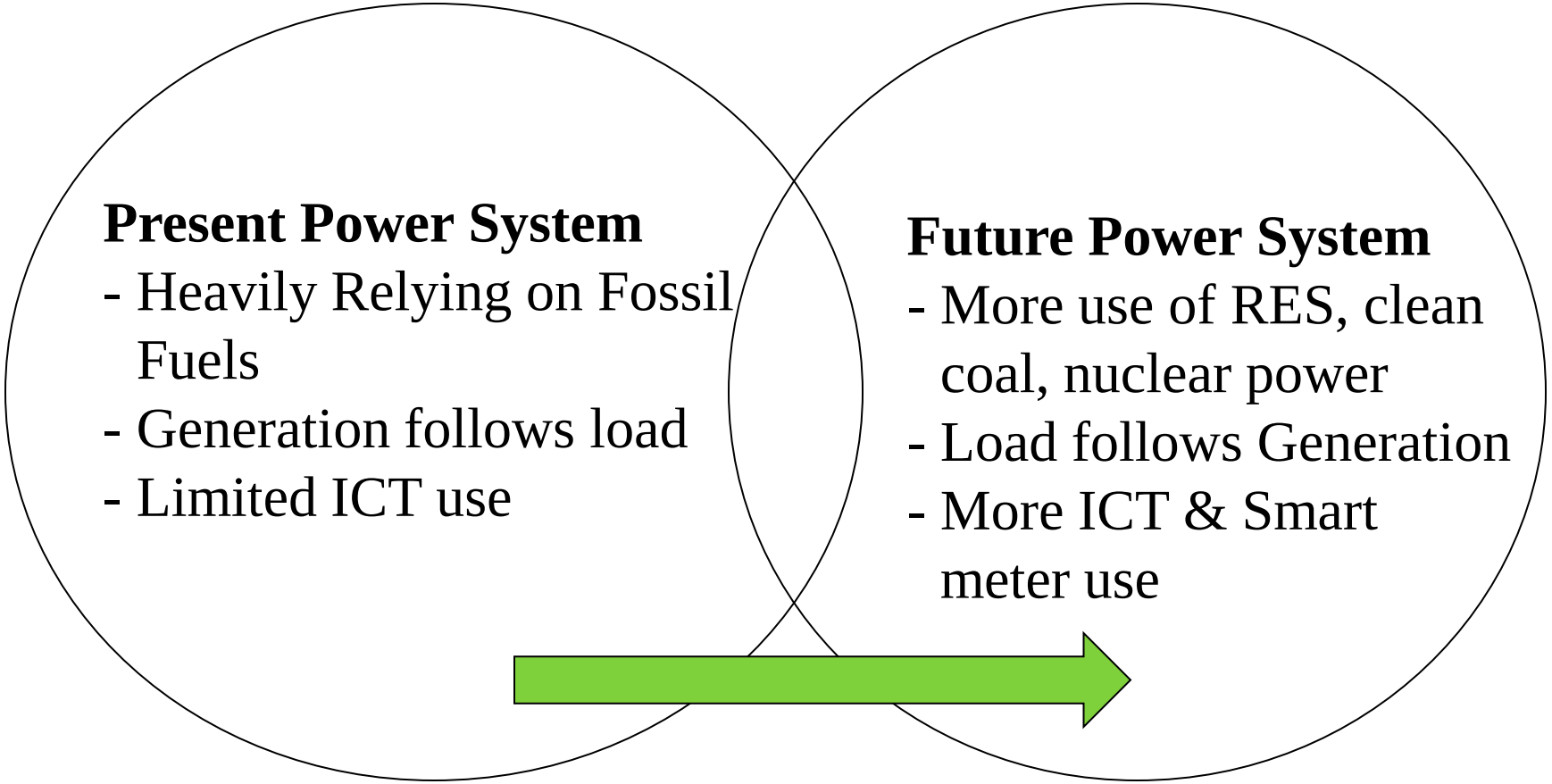
- Limited expansion of transmission network as compared to the generation addition.
  - Most of the generation, T&D systems have become old.
- Increased transmission and distribution losses.
- Lack of dynamic data for health monitoring and control.
- Increased concern towards vulnerability and resilience of the system under natural and man made disasters.
- Growing environmental concerns including the global warming.
- Poor power quality, limited customer focus and their participation in energy Management.
- Meeting the ever increasing electricity demand.

Key Drivers to Technological Changes in the Electricity Sector

- **Development of New Materials - Polymeric, Composite, Nano, Superconducting materials.**
- **Use of Alternate and Renewable Energy Sources to address Global Environmental Concerns**
- **Development of New Devices and Technologies**

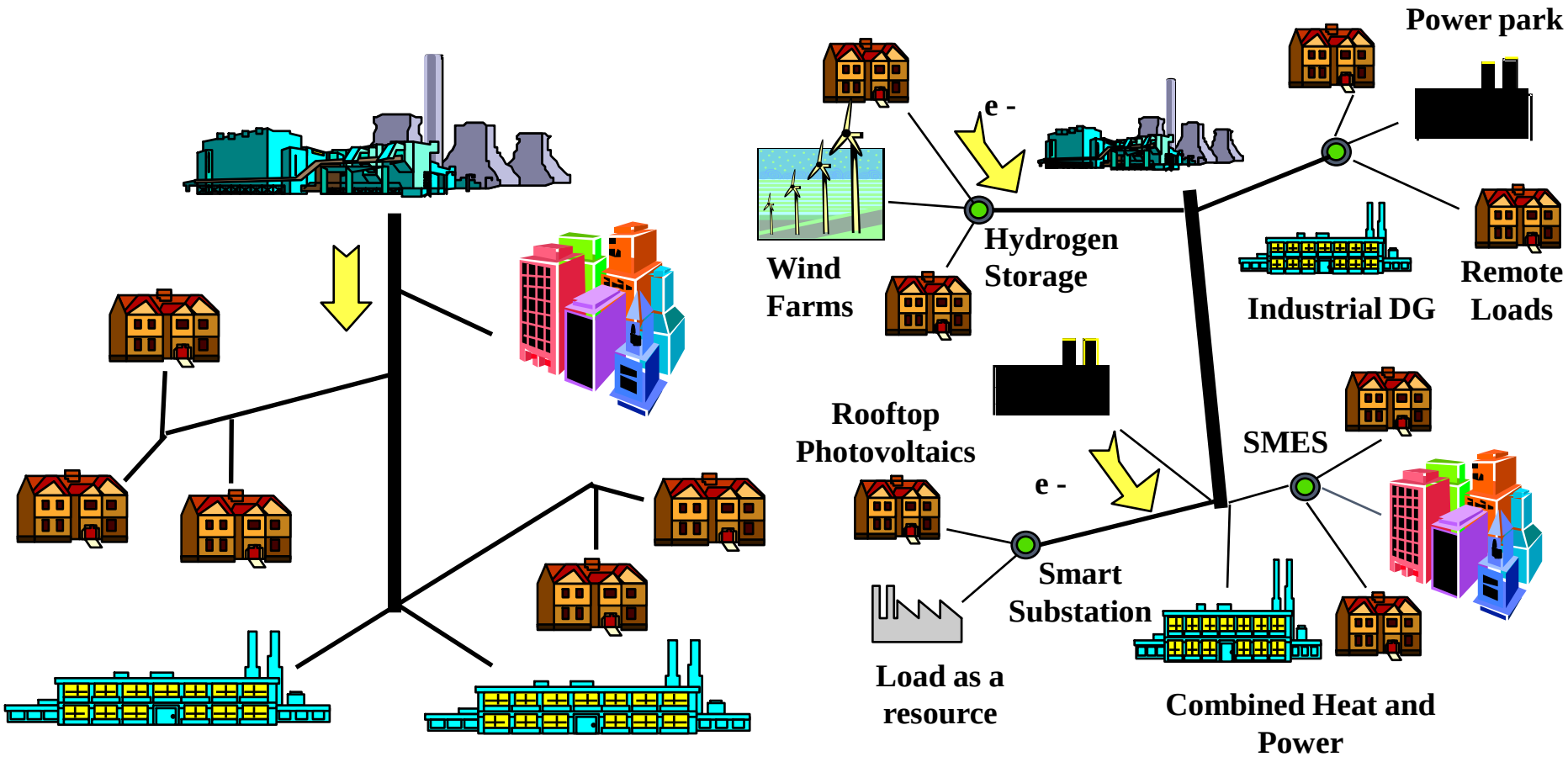
  - Power Electronic Devices, DSP, Sensors, Information & Communication Technology
- **Maintaining Security, Reliability and Resilience of Large Interconnected System**
- **Maintaining Quality of Supply and IT Enabled Services in Distribution Sector**
- **Regulatory Changes in the Electricity Sector**

Present and Future Power System



Today's Electricity …

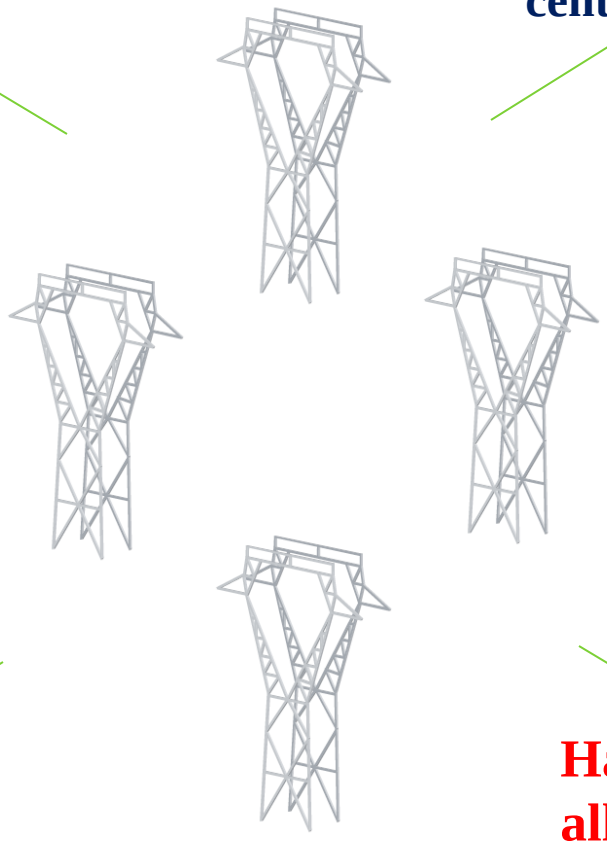
Tomorrow's Choices …



Future Grid – Smart(er) Grid

Wide area monitoring and control systems

Coordinated, full energy management and full integration of DG with large central power generation



Extensive small, distributed generation close to end user

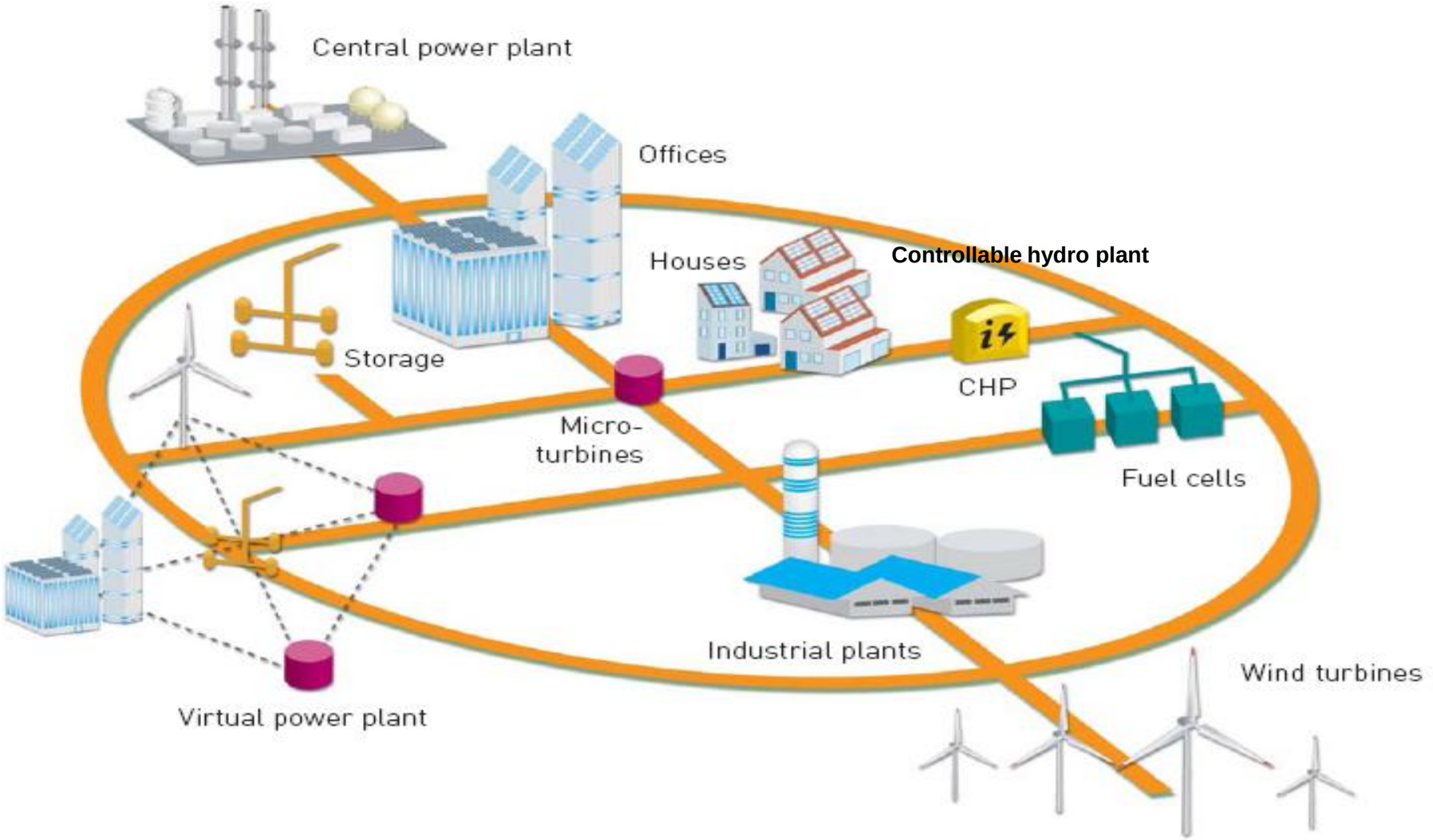
Secure, reliable and green power supply

Customer driven value added services

Harmonized legal framework allowing cross border power trading

What a Smart Grid would look like?

Distributed, Networked



Source: Wikipedia

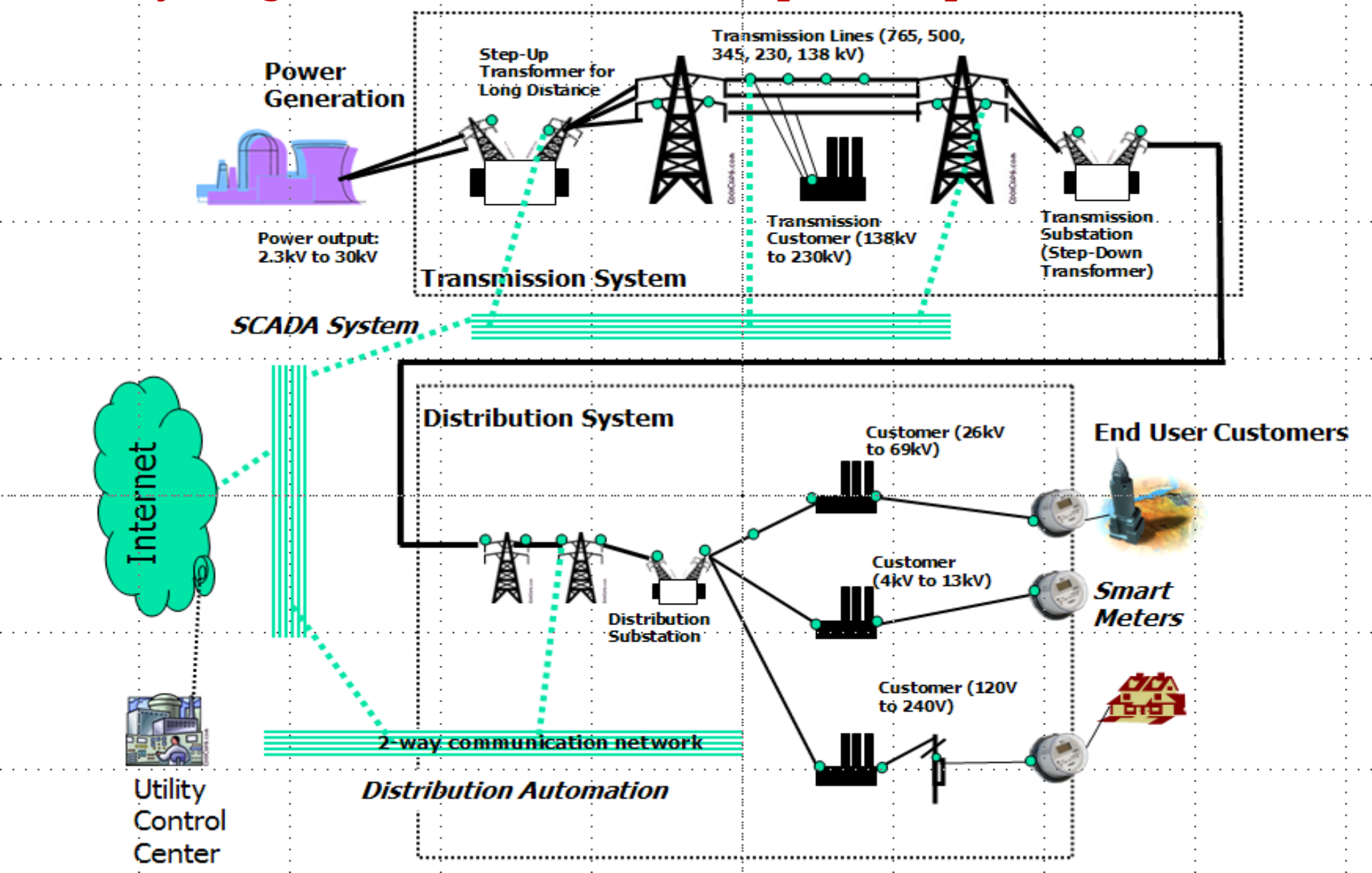
What a Smart Grid would look like?

Green, Environment friendly

Source: European Technology Platform SmartGrids

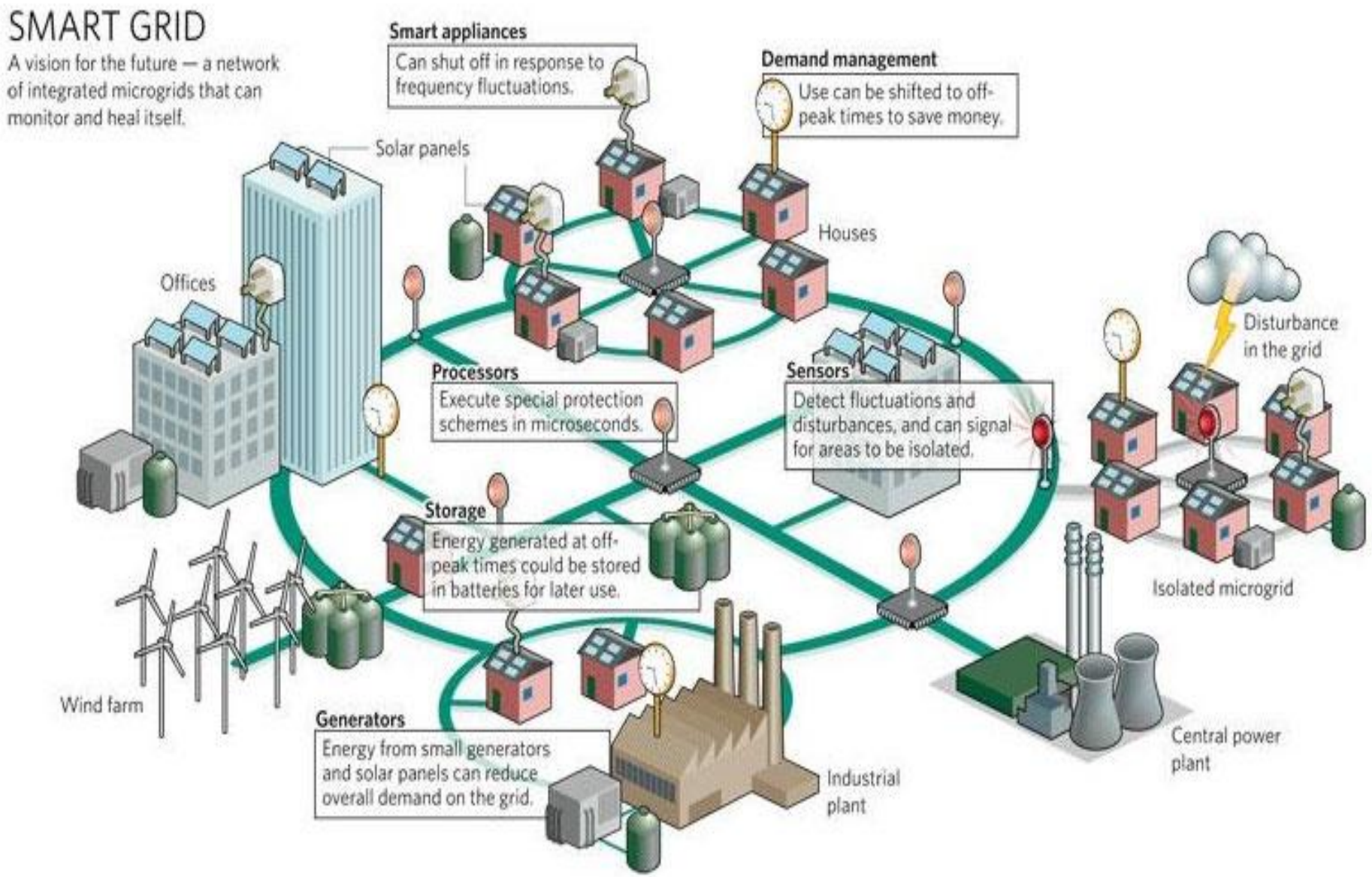
What a Smart Grid would look like?

Two-way integrated communication, adaptive, responsive, wider control



What a Smart Grid would look like?

Sensors throughout, self healing & monitoring, remote check & test



Source: http://vtsenvirogroup.wordpress.com/2009/05/19/you-think-youre-so-smart-grid/

Features of a Smart Grid

Ref: DOE document at http://www.oe.energy.gov/smartgrid

Self-Healing to correct problems early

Interactive with consumers and markets

Optimized to make best use of resources

Predictive to prevent emergencies

Distributed assets and information

Integrated to merge all critical information

More Secure from threats from all hazards

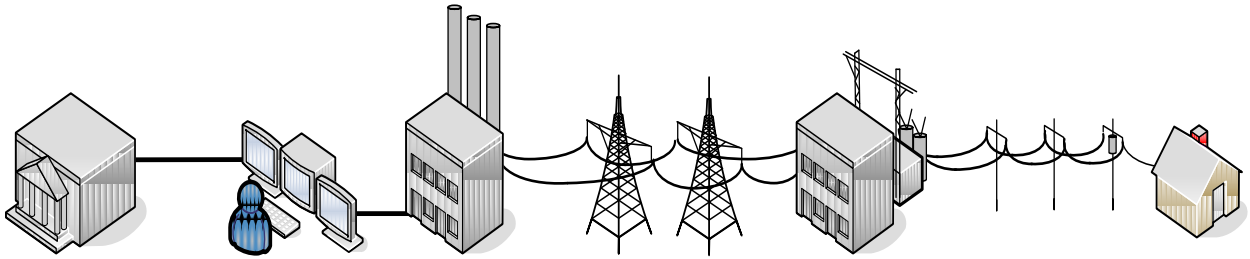
Existing Grid	Intelligent Grid
Centralized Generation	Distributed Generation
One-Way Communication	Two-Way Communication
Electromechanical	Digital
Hierarchical	Networked
Few Sensors	Sensors Throughout
Blind	Self-Monitoring
Manual Restoration	Self-Healing
Failures and Blackouts	Adaptive and Islanding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

Ref: Hassan Farhangi, "The Path of the Smart Grid", *IEEE Power and Energy Magazine*, Jan. 2010, pp.18-28

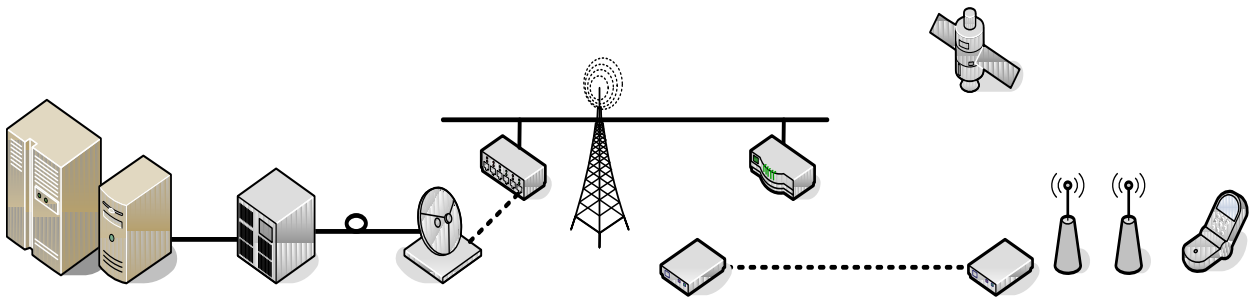
Merging Two Technologies

The integration of two infrastructures… securely…

Electrical Infrastructure



Information Infrastructure



***Source: EPRI® Intelligrid* at http://intelligrid.epri.com**

Smart Grid Advantages

Operational Efficiency

Reduced Onsite Premise Presence / Field Work Required

Shorter Outage Durations

Optimized Transformer Operation

Standards & Construction

Improved Network Operations

Reduce Integration & IT maintenance cost

Condition-based Asset Maintenance / Inspections

Energy Efficiency

Reduced Energy Losses

Active/Passive Demand-side Management

Smart Grid

Customer Satisfaction

Enable Customer Self-Service / Reduce Call Center Inquiries

Improved Revenue Collection

Environmental Impact

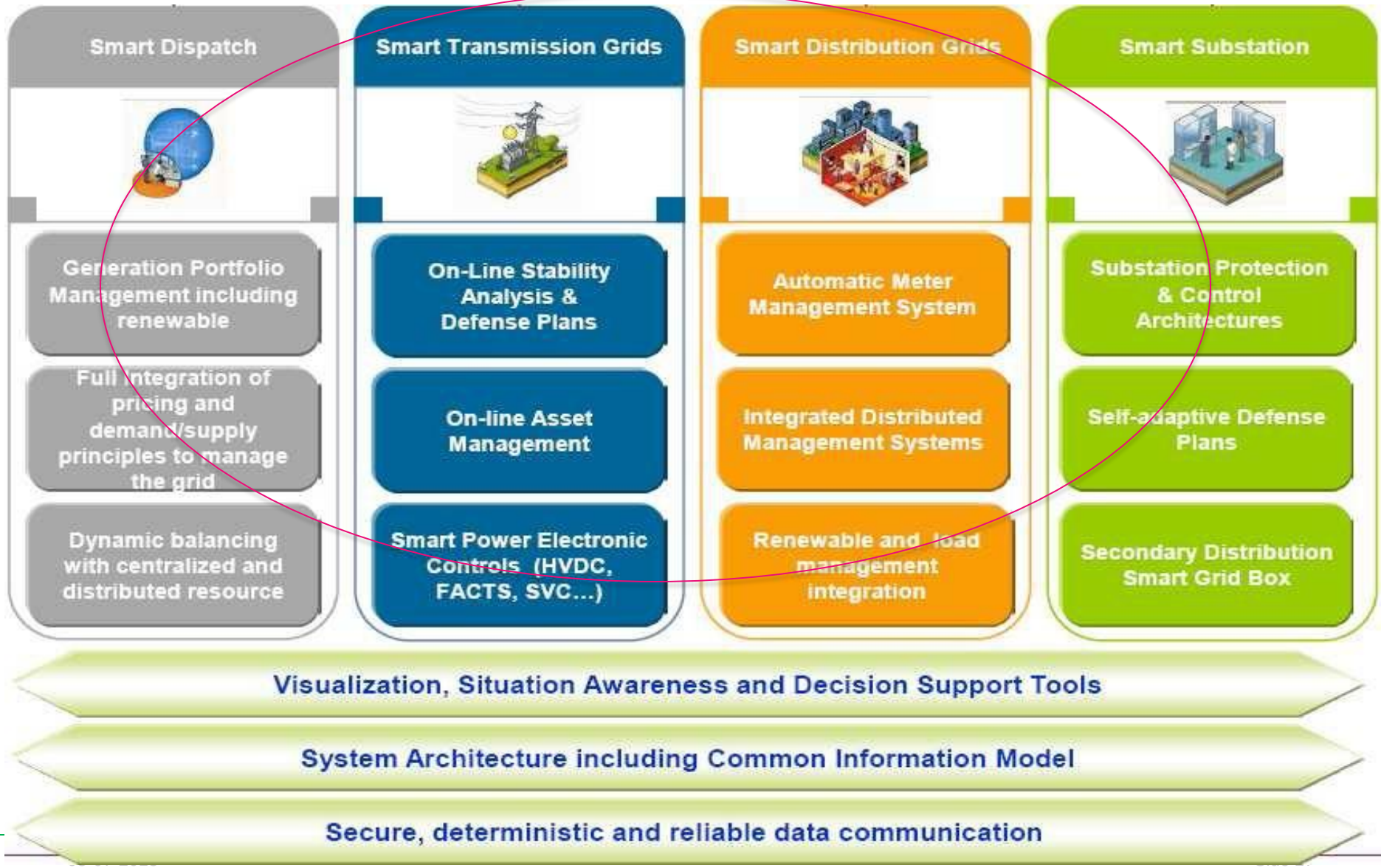
Reduced Greenhouse Gas Emissions

Delayed Generation & Transmission Capital Investments

Smart Grid : Building Blocks

- **Advanced Metering & Communication**
  - Smart Meters (single phase & polyphase), 2-way communication, interface to enterprise applications, Wide Area Monitoring System
- **Distribution Automation**
  - Fault Detection, Isolation, Restoration (FDIR), Integrated Volt/VAR management, including switched capacitors & voltage regulator
- **Substation Automation/M&D**
  - Substation controller and transformer monitoring and diagnostics
- **Distribution Operations**
  - DMS/OMS software and interface to existing applications, control center digitization, and enterprise integration
- **Utility Enterprise Applications**
  - Electric, Gas & Telecommunications utility geospatial based applications, DSM application, and advanced analytics & visualization
- **Systems Integration**
  - Enterprise Service Bus with adapters to all building blocks

Smart Grid Environment



Source: Generation Dispatch, AREVA – IEEE Smart Grid Conference January 2010.

Smart Grid Architecture

Utility Enterprise

Operations
OMS/DMS/DA
WAMS

Business Applications
GIS/Apps, CIS, ERP, Asset Mgmt.

Integrated Network Manager

Communications Infrastructure

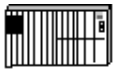
Distributed Generation (DG)

Smart grid devices

LTC

Voltage Regulator

Cap Bank

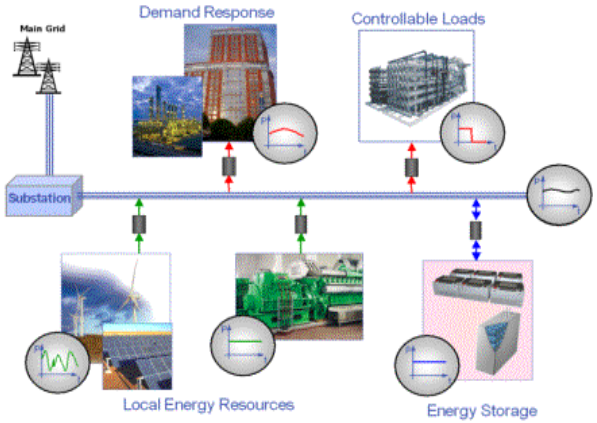


RTU

M&P Sensors

Relays & PMUs

WiMax / BPL /RF



Home area network
- ZigBee®/ HomePlug

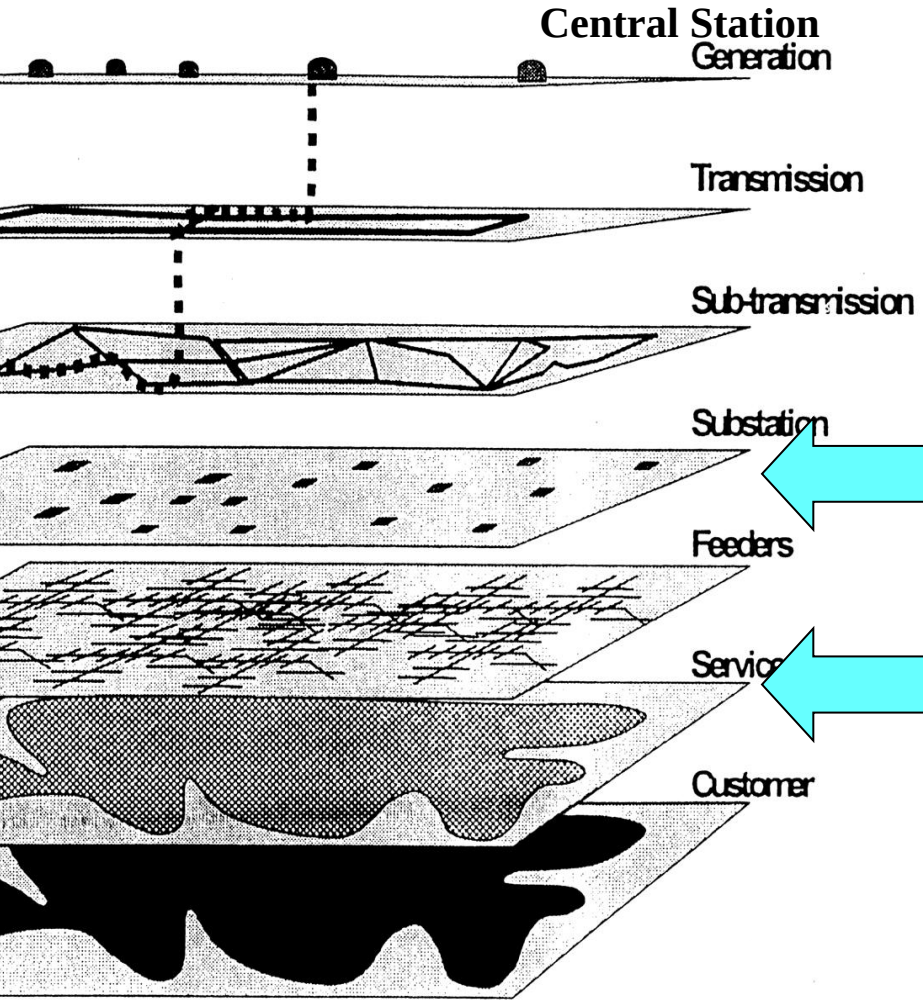
AMI, smart home & demand response

Interconnecting Distributed Power Systems

Wind Energy

Fuel Cells

Solar Energy



Combustion Engines

MicroTurbines

The overall power system is traditionally viewed in terms of 7 layers; each performing its function from central station generation supplying power out to customers.

Distributed Energy Resources

Fuel Cell

PV

Microturbine

Wind

Energy Storage

Generator

Modern Interconnection Technologies

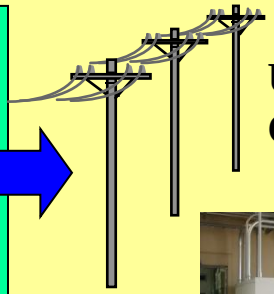
Inverter

Functions

- Power Conversion
- Power Conditioning (PQ)
- Protection
- DER and Load Control
- Ancillary Services
- Communications
- Metering

Switchgear, Relays, & Controls

Electric Power Systems



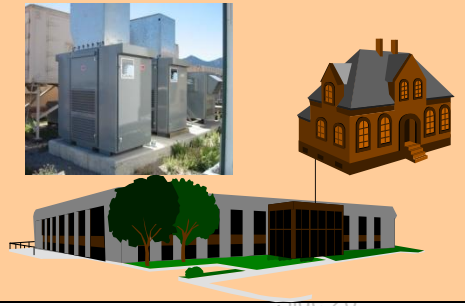
Utility Grid

Utility Grid Simulator
Micro Grids

Loads

Local Loads

Load Simulators



Solar Initiative- launched in India

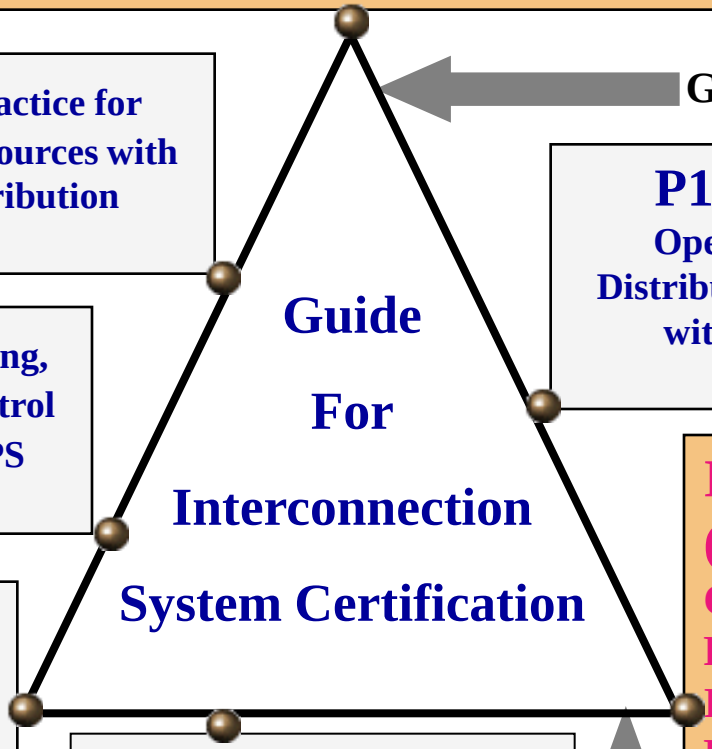
11 MW solar thermal plant in Spain (Tower almost of 40 storey height, 600 mirror reflectors, enough power for 6000 homes)

Renewable: Wind and Solar Power Plants (Source: Google Images)

Sahara / Concentrating Solar Power

Source: ABB

IEEE Std 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems



P1547.6 Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks

P1547.3 Guide for Monitoring, Information Exchange and Control of DR Interconnected with EPS

P1547.2 Application Guide for IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems

P1547.5 Technical Guidelines for Interconnection of Electric Power Sources Greater Than 10 MVA to the Power Transmission Grid

Guide for Impacts

P1547.4 Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems

IEEE Std 1547.1™ (2005) Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems

DP Specifications & Performance (includes modeling)

Solar Energy Policy in India

- **National Action Plan on Climate Change**
  - **–Prime Minister's Office; 30th June 2008**
- **Ministry of New and Renewable Energy (MNRE)**
  - **– http://mnes.nic.in/**
- **Support for research in solar energy harnessing**
  - **– Department of Science and Technology**
- **Promotion of use of solar energy**
- **Support at the central and state government levels**

National Action Plan on Climate Change

Announced by Prime Minister on 30th June, 2008

- National Solar Mission
- National Mission for Enhanced Efficiency
- National Mission on Sustainable Habitat
- National Water Mission
- National Mission for Sustaining the Himalayan Ecosystem
- National Mission for a "Green India"
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge for Climate Change

National Solar Mission

Announced by Minister of New and Renewable Energy on 23rd November, 2009

S. No.	Application segment	Target for Phase I (2010-13)	Target for Phase 2 (2013-17)	Target for Phase 3 (2017-22)
1.	Solar collectors	7 million sq meters	15 million sq meters	20 million sq meters
2.	Off grid solar applications	200 MW	1000 MW	2000 MW
3.	Utility grid power, including roof top	1,000-2000 MW	4000-10,000 MW	20000 MW

http://mnre.gov.in/pdf/mission-document-JNNSM.pdf

Electricity Generation Cost (Per kWh)

Energy Source	Cost
Combined cycle gas turbine	3 ¢ -5 ¢ (Rs.1.20-Rs.2.00)
Wind	4 ¢ -7 ¢ (Rs.1.60-Rs.2.80)
Biomass gasification	7 ¢ -9 ¢ (Rs.2.80-Rs.3.60)
Remote diesel generation	20 ¢ -40 ¢ (Rs.8.00-Rs.16.00)
Solar PV central station	20 ¢ -30 ¢ (Rs.8.00-Rs.12.00)
Solar PV Distributed	20 ¢ -50 ¢ (Rs.8.00-Rs.20.00)

http://www.solarbuzz.com/StatsCosts.htm (accessed 14.11.2010)

Smart Grid Initiatives

- **US Dept. of Energy**
  - **GridWise & GridWorks**
- **Modern Grid Initiative (NETL: National Energy Technology Lab)**
- **GridWise Alliance (US industry group)**
- **IntelliGrid (EPRI)**
- **CERTS – Consortium for Electric Reliability Technology Solutions (USA)**
- **SmartGrids (European Union)**
- **Integration of Decentralized Energy Resources Program (NRCan Canada)**
- **NIST Special Publication 1108, NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0 , January 2010**
- **Smart Grid Forum launched in India on 27 May 2010.**
- **The Smart Grid Vision for India's Power Sector: A White Paper, under USAID DRUM project, prepared by PA Government Services, Inc., India**

Pike Research* Report (2009)
(* A Cleantech Market Intelligence company)

- **Smart Grid investment to total $ 200B worldwide by 2015**

- **Utility companies around the world will spend $ 21B by 2015 to improve cyber security of the world's electrical (smart) grid.**

- **Smart Grid cyber security is a fast developing field**

Conclusions

- Smart Grid will be characterized by two way flow of electrical power and communication.
- It will require large deployment of DERs, microgrids, WAMS in a distributed and networked manner.
- Modular integration approach, open protocol and common information (CIM) system need to be developed and deployed.
- Operation and Control of Smart Grid will be far more complex.
- There will be enormous Research Development and Demonstration (RD&D) efforts required by stakeholders from all disciplines: academia, industries, government and utilities together.

THANKS FOR YOUR ATTENTION ?