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Smart Grid – Integration of Distributed Generation

Role, Opportunities and Challenges in Future Power Generation Systems

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DISTRIBUTED GENERATION TECHNOLOGIES

- Wind Energy
- Solar Energy (photovoltaic & thermal)
- Bio-energy and Fuels
- Marine and Hydro Power
- Geothermal
- Fuel Cells
- Combined Heat & Power (CHP)

Vision for future energy distribution network

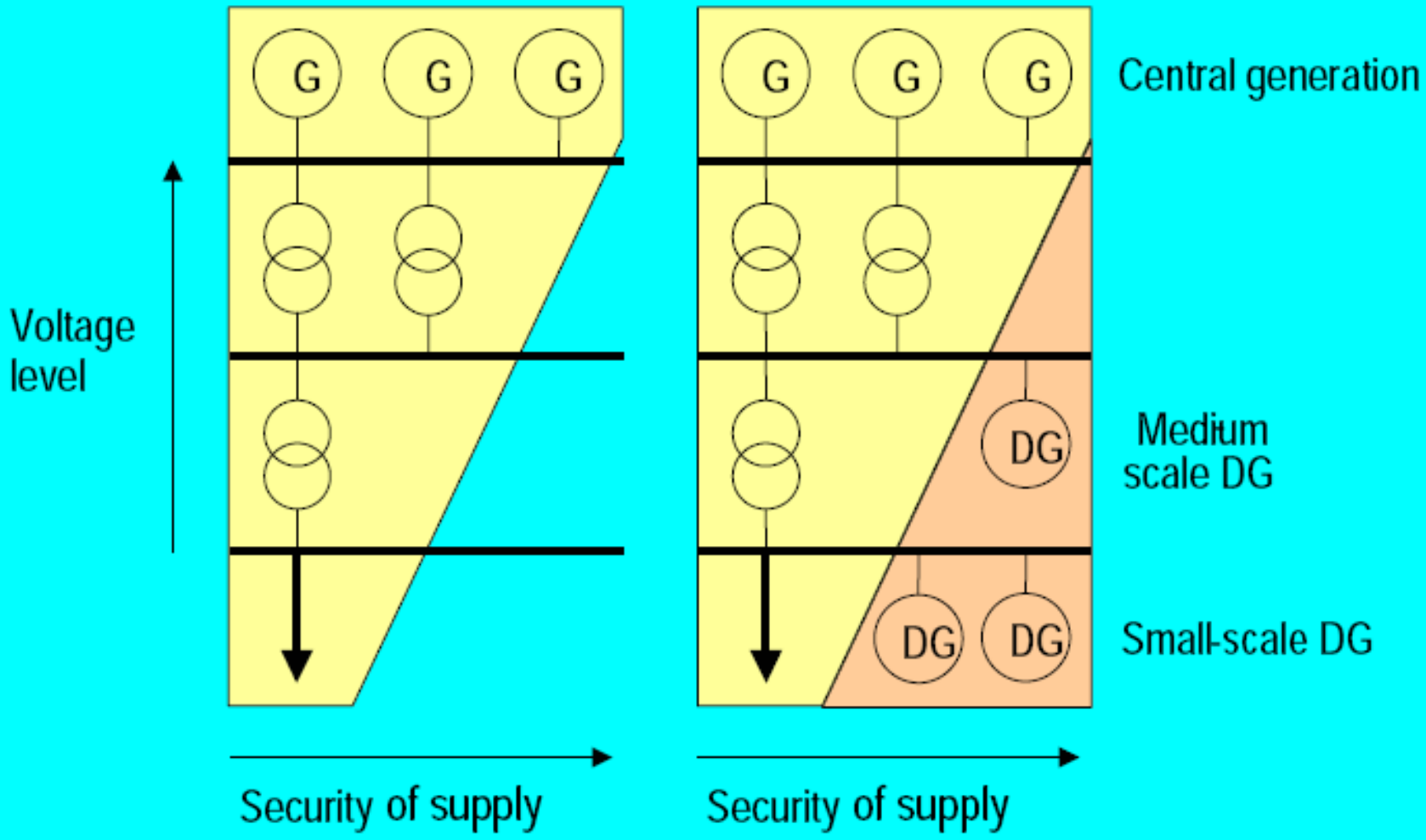
Source: EU communities 2006

Technical, Economic and Environmental Benefits of DG Integration in Smart Grid

- Transformation from a centralized, producer controlled network to one that is less centralized and more consumer interactive
- Smart Grid accommodate connection of widely distributed, renewable energy sources across the network
- Facilitate market interactions, providing customers access to products and services with choice, based on price and environmental concerns
- Improvement of energy system reliability and flexibility
- Energy efficiency
- Optimizing electricity infrastructure replacement investment

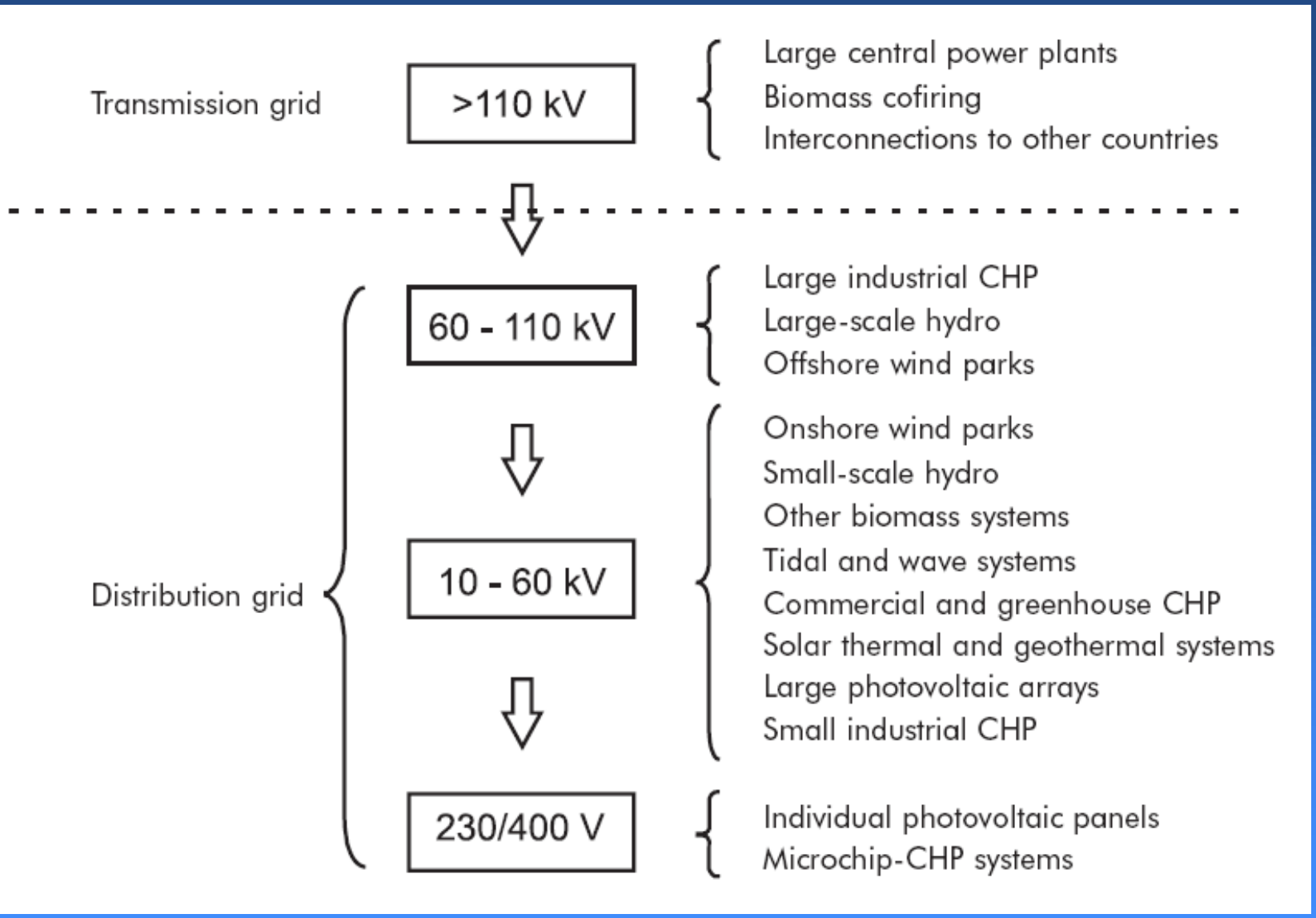
- The majority of renewable energy will be achieved by DG units connected to the LV or MV network. As a result, the distribution network operators will face a number of difficulties.

- How much DG can be tolerated on each voltage level of a network and concerns about stability and intermittency are among the issues to be analyzed?


G
G
G
G
G
G
Central generation
Voltage level
DG
Medium scale DG
DG
DG
Small-scale DG
Security of supply
Security of supply

Conceptual Design for Distributed Generation

- Energy management at the distributed power system.
- Management of power flow constraints, voltage & frequency.
- Device & interface response and intelligence requirements.
- Protection options for networks of variable configurations.
- Standardization of technical and commercial protocols and hardware.


Transmission grid
>110 kV
Large central power plants
Biomass cofiring
Interconnections to other countries
60 - 110 kV
Large industrial CHP
Large-scale hydro
Offshore wind parks
Distribution grid
10 - 60 kV
Onshore wind parks
Small-scale hydro
Other biomass systems
Tidal and wave systems
Commercial and greenhouse CHP
Solar thermal and geothermal systems
Large photovoltaic arrays
Small industrial CHP
230/400 V
Individual photovoltaic panels
Microchip-CHP systems

Future Distributed Electricity Network

Reliable, Flexible, Accessible and Cost-effective

- Creating a **toolbox of proven technical solutions that can be deployed rapidly and cost-effectively,** enabling existing grids to accept power injections from all energy resources.

- **Harmonising regulatory and commercial frameworks to facilitate trading**, ensuring that they will accommodate a wide range of operating situations.

- Inadequacy of existing dynamic simulation / analytical tools to study planning and development of networks taking into account the stochastic nature of DG, both in steady state and under dynamic conditions.

- Differentiated definitions of grid connection requirements for the various types of generators are needed because of their different nature.

- Establishing **shared technical standards and protocols that will ensure open access, enabling** the deployment of equipment from any chosen manufacturer.
- Developing **information, computing & telecommunication systems** to utilise innovative service arrangements to improve energy efficiency, control, management and trading.
- Ensuring the successful **interfacing of new and old designs of grid equipment to ensure interoperability** of automation and control arrangements.

Smart Distribution Infrastructure

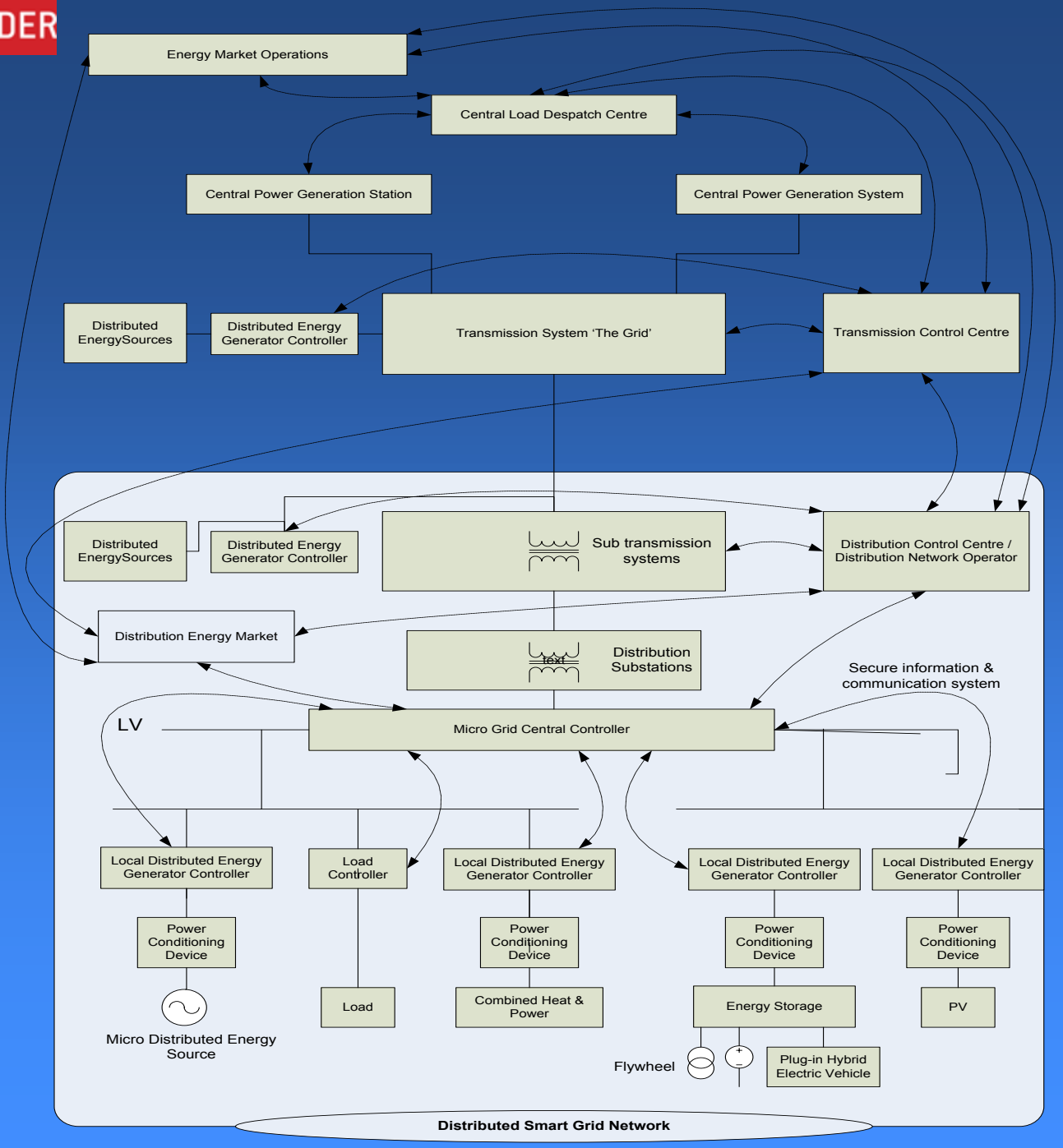
- New architectures for system design, new concepts to study DG integration, advanced forecasting techniques, customer participation
- Innovative energy management strategies for large DG penetration, storage and demand response
- Effective distribution control for the benefit of power quality and reliability enhancement at the connection point (active and reactive power)
- A system engineering approach to study the operational integration of distributed generation & active customers

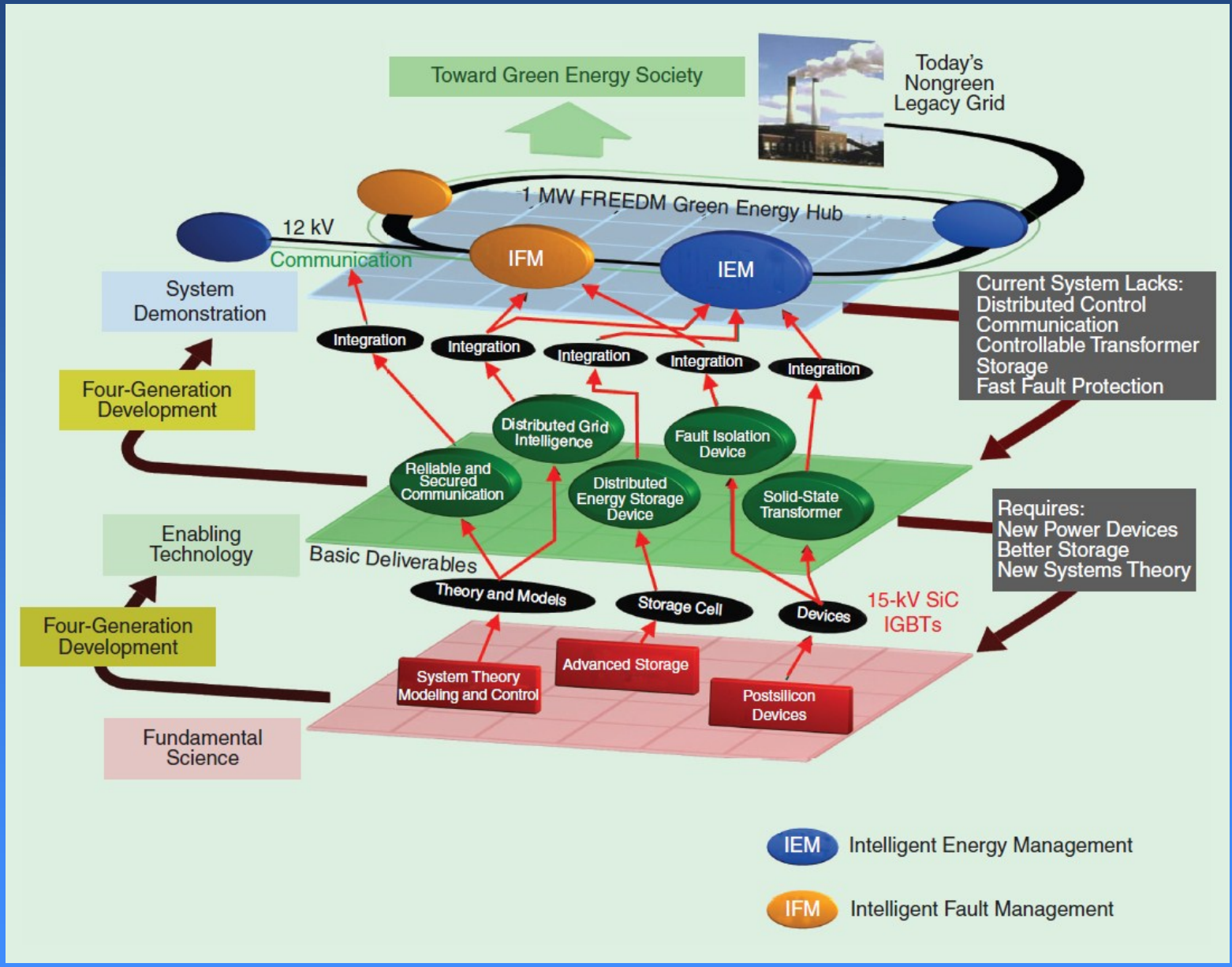
Interoperability of DG (T&D)

- Advanced forecasting techniques for sustainable operations and power supply
- Advanced operation of the high voltage system – seamless smart grids
- Pre-standardisation research
- Long distance energy supply
- Storage and its strategic impact on grids

Mechanisms by which DGs can participate

- Trading.
- Tariff.
- Real Time Control.
- Automatic Control


Energy Market Operations
Central Load Despatch Centre
Central Power Generation Station
Central Power Generation System
Distributed EnergySources
Distributed Energy Generator Controller
Transmission System 'The Grid'
Transmission Control Centre
Distributed EnergySources
Distributed Energy Generator Controller
Sub transmission systems
Distribution Control Centre / Distribution Network Operator
Distribution Energy Market
Distribution Substations
Secure information & communication system
LV
Micro Grid Central Controller
Local Distributed Energy Generator Controller
Load Controller
Local Distributed Energy Generator Controller
Local Distributed Energy Generator Controller
Local Distributed Energy Generator Controller
Power Conditioning Device
Power Conditioning Device
Power Conditioning Device
Power Conditioning Device
Micro Distributed Energy Source
Load
Combined Heat & Power
Energy Storage
PV
Flywheel
Plug-in Hybrid Electric Vehicle
Distributed Smart Grid Network



Source: IEEE Industrial Electronics Magazine, June 2009.

Role of a cell (MGCC)

- To enable decentralized active network control using local DERs
- To enhance reliability and power quality of supply locally
- To promote autonomy for local system management including capability of islanded operation and synchronization to the main grid
- To enhance energy efficiency by coordinating consumption of energy (heat, power)
- To provide a test system for future technologies
- VPP to enable efficient participation in energy market

Functionality of Controller in Each Area

- Maintaining voltage, power flows and frequency within the limits
- Optimizing generator schedules and controllable loads
- Forecasting energy demand, availability from renewables
- Optimizing control of network switching to minimize interruptions
- Managing restoration process
- Maintaining power (active & reactive) / energy balance

- Voltage control and balance during normal operation
- Stability in case of incidents on power lines or generation units, power quality issues
- Network protection issues
- Communications & integrity of remote control signals, technical standards
- Use of plug-in hybrid and all electric vehicles
- New Design for information sharing and transacting in an energy exchange system
- Regulatory framework, business models in the new energy enterprise,

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Thank you