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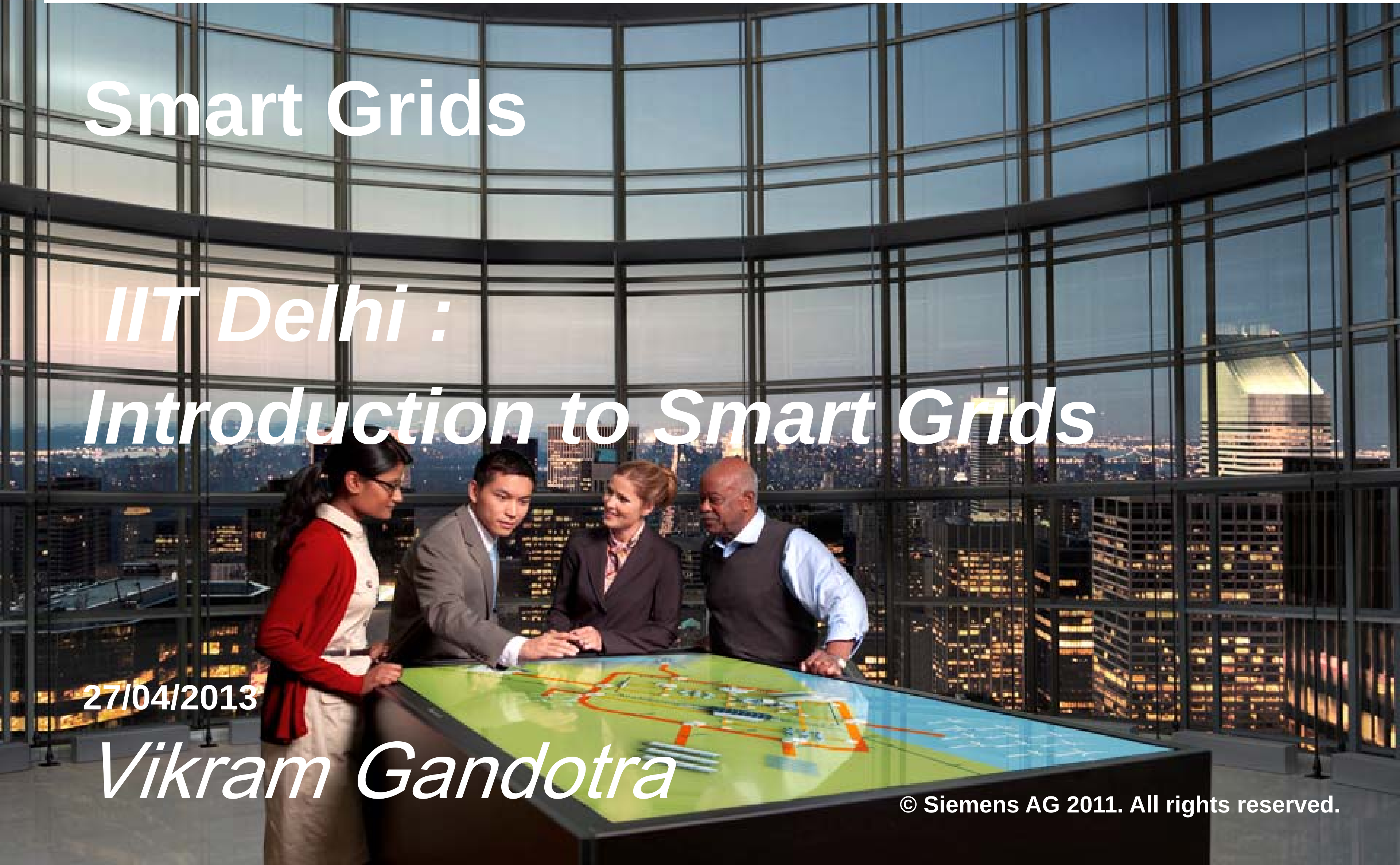
Smart Grids

IIT Delhi :

Introduction to Smart Grids



27/04/2013

Vikram Gandotra

Learning Objectives

This module will introduce the concepts and building blocks of Smart Grids

This module is intended to prepare the participants for accepting the changing and complex scenario where Smart Grid applications will play an important role.

- Introduction
  - Electricity System needs for Today and the Future
  - Why Smart Grids?
  - What are Smart Grids?
  - Basic Concepts for understanding Smart Grids
- Smart Grid Technologies in
  - Transmission
  - Distribution
  - Consumption
- Global Trends
- Cyber Security

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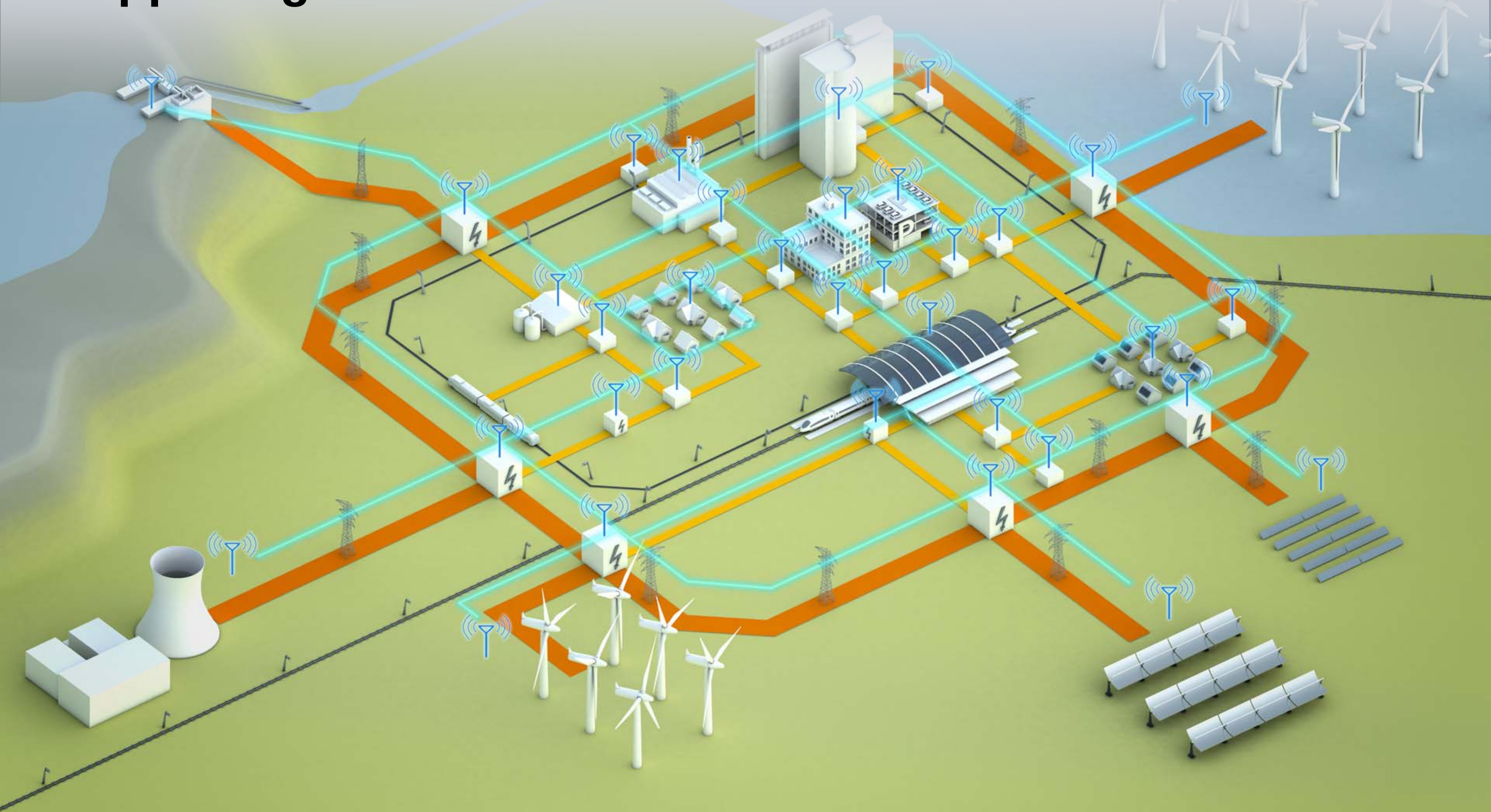
Power Grids exist since a long time, but new things are happening …



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Energy systems worldwide are changing…

Massive growth potential driven by urbanization
Urban Population is growing by 2 citizen per second

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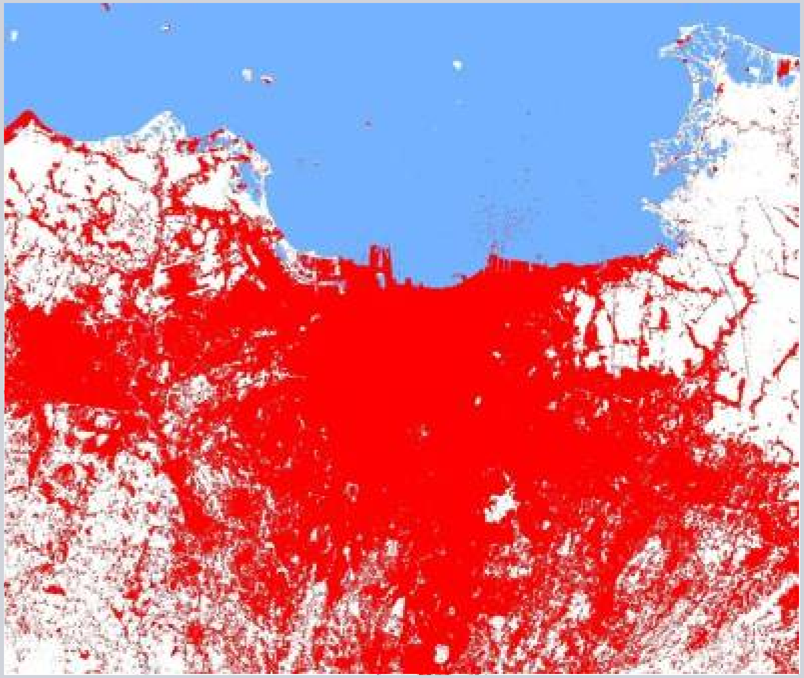
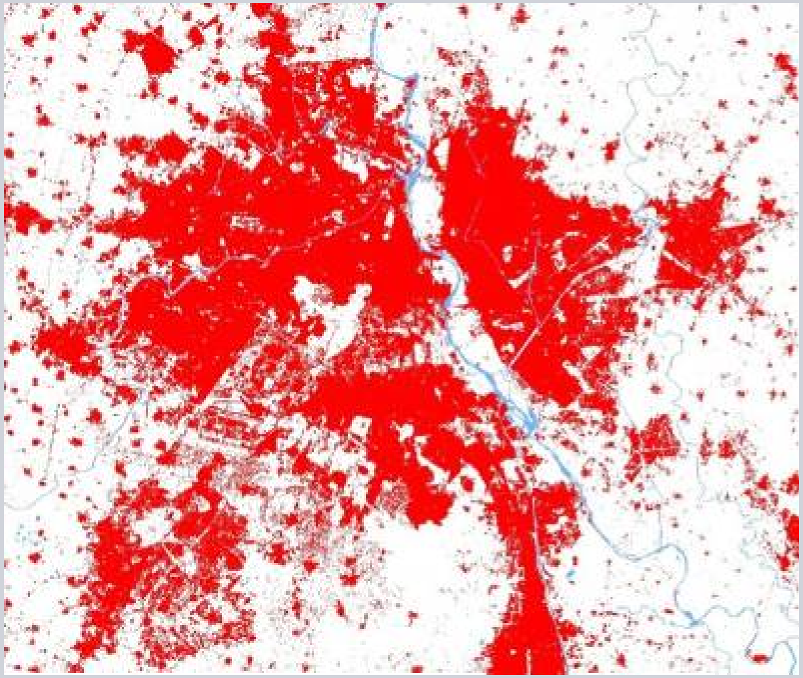
Jakarta 2010—9.2 Mio



Delhi 2010—22.2 Mio



Challenges to meet Demand

Source: Deutsches Zentrum für Luft- und Raumfahrt, UN World Urbanization Prospects: The 2009 Revision

Ageing distribution infrastructure is seriously endangering security of supply

Deployment of Variable Generation Technology - Solar power in various forms -a representative of worldwide push into renewables

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Changing infeed patterns challenge existing grid infrastructures

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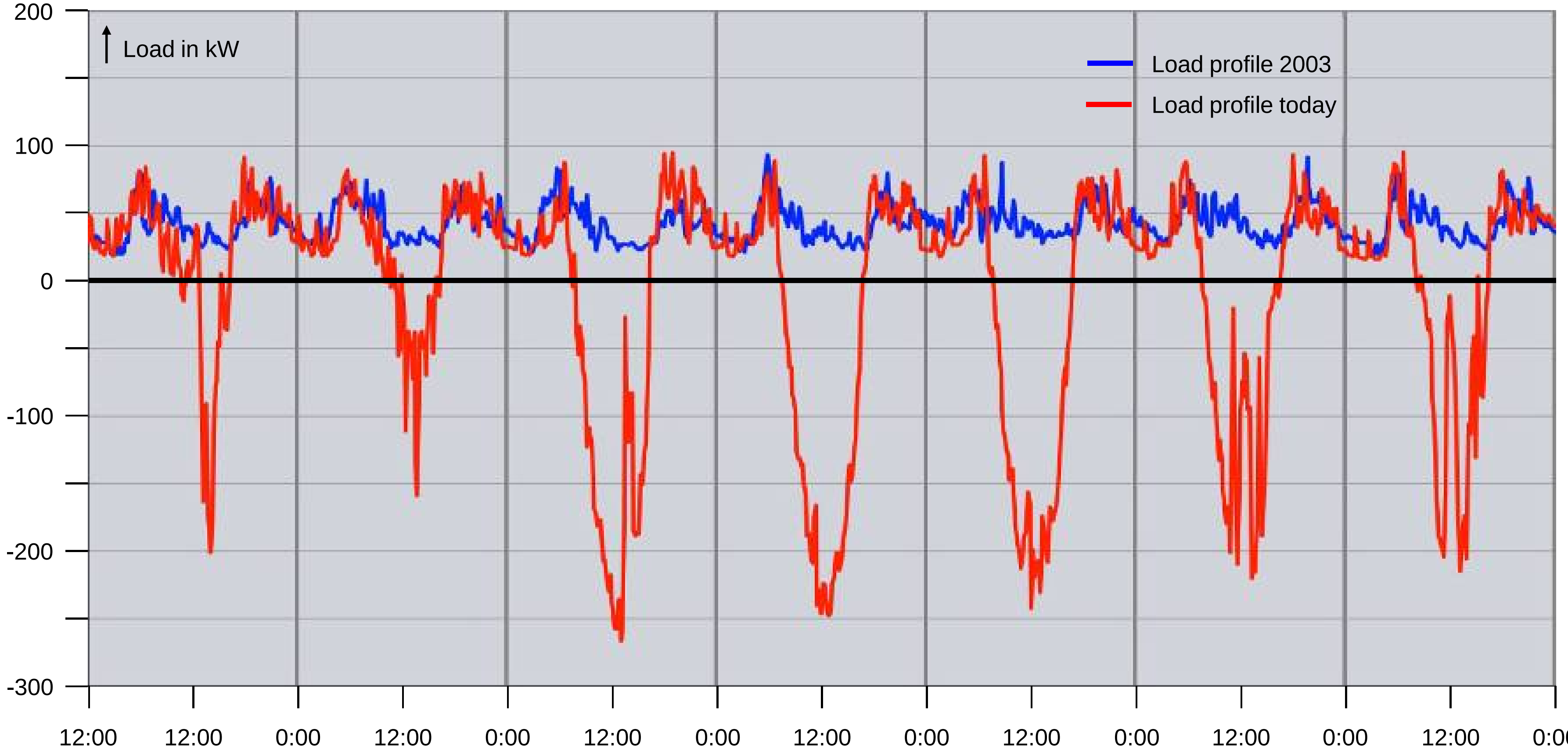
Weekly burden of a transformer station in the rural area the LEW-Verteilnetz GmbH – 2003 and today



Source: LEW

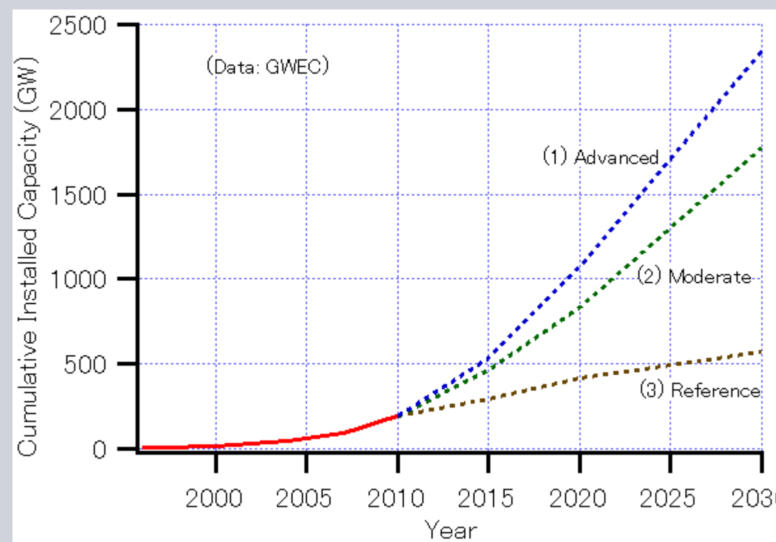
Renewable power is future but highly variable

News headline - Windmill Boom make Electricity Prices negative in Europe !!

Twice in 2010, Germany’s 21,000 Wind Turbines pumped out so much power that Utilities reduced customer bills for using electricity.

Wind Generation in Germany

Negative electricity prices happen when supply outstrips demand and we don’t know where to put it !



New Challenges due to Increasing Renewable Power in India

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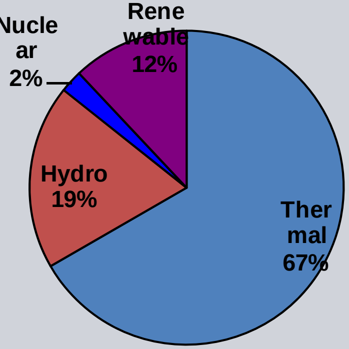
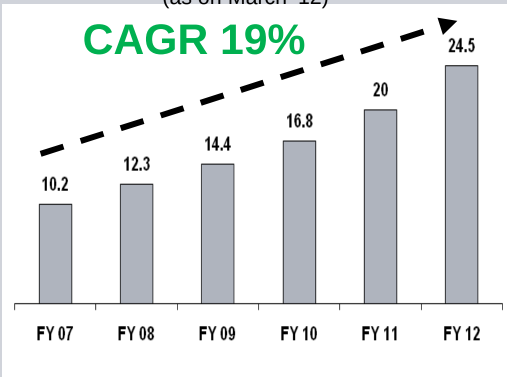
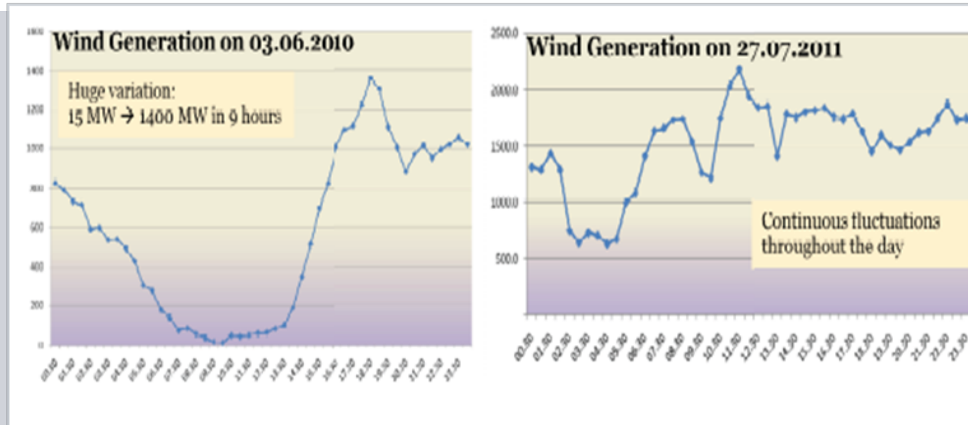
Break up of Installed Generation Capacity
(as on March '12)

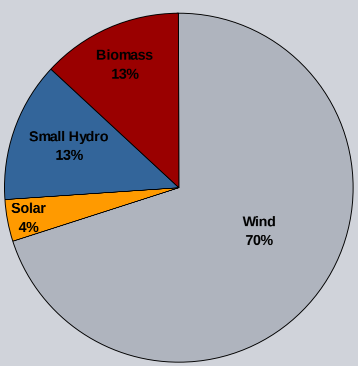


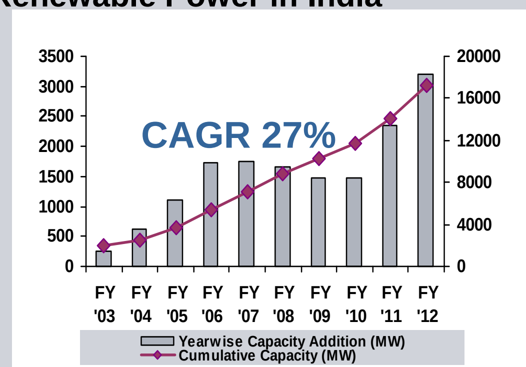


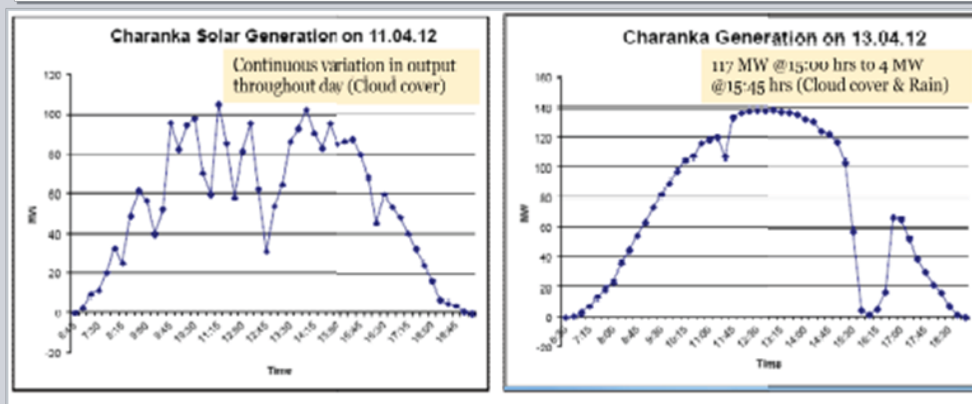


Source: Tamil Nadu SLDC

Renewable Power in India





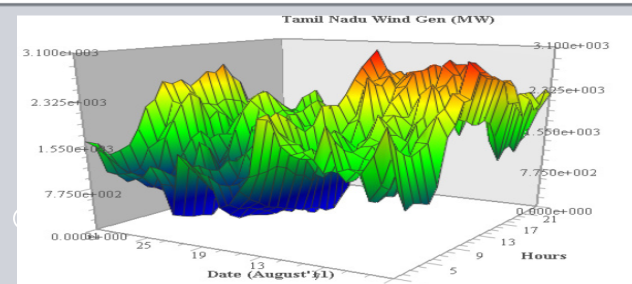


Source: Gujarat SLDC

Smart Grid Challenges

– to monitor & control the variable renewable energy resources

- Store renewable energy during low demand



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Powering the Automobiles

Global leaders are joining hands to develop infrastructure to meet committments of their Governments

Main Brazilian Distribution System Operators forfeit 5.8 % of the energy due to non technical losses

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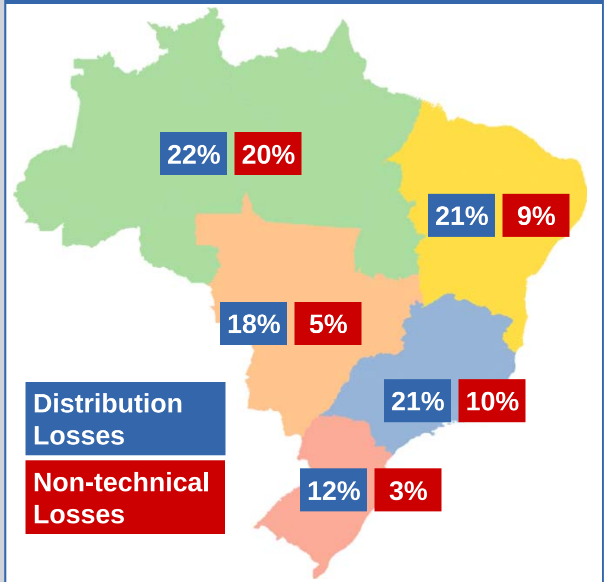
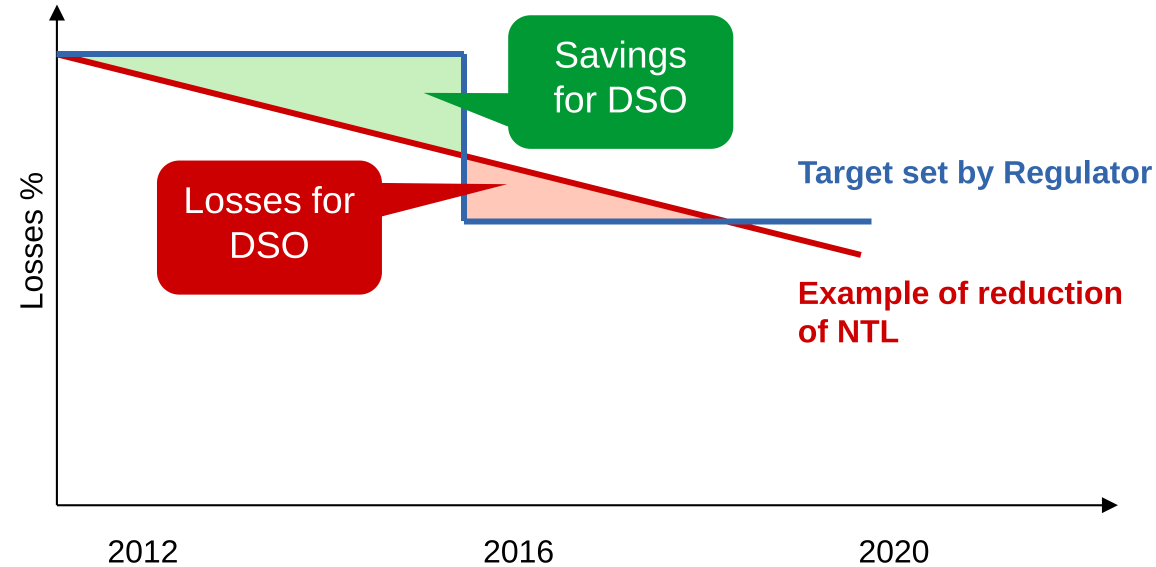
Network losses in % per region



The Non Technical Loss (NTL) business case for DSO is driven by regulation in Brazil



Brazilian Energy distribution network suffers non-technical losses (NTL) of 23 TWh p.a. (5.8 % of total generation)

€ 1" p.a. lost revenue to the DSOs accrues.

Regulator ANEEL established new regulation on network efficiency and demands 30% NTL reduction every 4 years.

AT&C loss in India at national level reduced from 38.86% in 2001-02 to 27.15% during 2009-10.

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Capacity problems are posing economic risks…

New equations with play of Regulators and Consumer Activism

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PROTESTS AGAINST ERRATIC POWER SUPPLY AT MANY PLACES

Delhi blows its fuse over power cuts

STREET ANGER Protesters pelt sub-stations with stones, cause massive traffic jams in city and NCR

electric shock

Delhi power price hiked 24% by DERC

HT Correspondents

NEW DELHI/GURGAON/NOIDA: Delhi and the National Capital Region (NCR) lost their patience on Tuesday with relentless daily power cuts ranging between 12 and 18 hours. In Gurgaon, Noida, angry residents blocked roads ... power sub-stations with stones ... decades and steeply rising power ... all the more unbearable.

Public anger could rise if the delayed monsoon doesn't arrive soon and dry farmlands start drawing more power from the little that is available.

"Burdened by 14-hour power cuts, our inverter batteries have gone dead," said Manoj Mishra, a resident of Shalimar Garden in Ghaziabad. "Last night I slept with my family in the car, keeping the engine and air-conditioning on."

Gurgaon, which is worst hit in NCR with outages as long as 18 hours, ... in the morning when ... formed mobs and took to the street, blocking traffic for five hours between 8 am and 1 pm on Delhi Road. Many office-goers reported late for work, while some companies were forced to shut offices ... Protesters threw stones at ... night on Monday, forcing ... selves inside.

Gujarat Congress President Arjun Modhwadia in a statement today protested the fresh hike in power tariff in Gujarat and said his party would give agitation programme against the tariff hike.

BJP PROTESTS POWER TARIFF HIKE IN NEW DELHI

...s block the old Delhi-Gurgaon road for more than five hours on Tuesday. Some companies were forced to shut offices before closing time. RAJESH KUMAR / HT PHOTO

inside P4

- Outages may continue
- Gurgaon residents fume
- Police security for power staff
- Sleepless in NCR
- Violence in Faridabad

TROUBLE BREWING

GURGAON	FARIDABAD	GHAZIABAD	NOIDA
Traffic blocked Delhi Road, Ardee City crossing, Gurgaon Expressway	**Traffic blocked** National Highway Number 2 (Mathura Road)	**Worst affected** 10-14 hours a day power cuts in areas such as Vaishali, Vasundhara and Indirapuram	**Worst affected** Sectors 19, 20, 22, 35, 53, 61, 71, 93 and 105
Sector 52 sub-station stoned	Sub-stations attacked at many places, police had to rush to the spots	Protests at sub-stations at many places	

Future Demand and Supply

Electricity is the fastest growing component of the total global energy demand.

India is projected to have the highest growth in electricity consumption

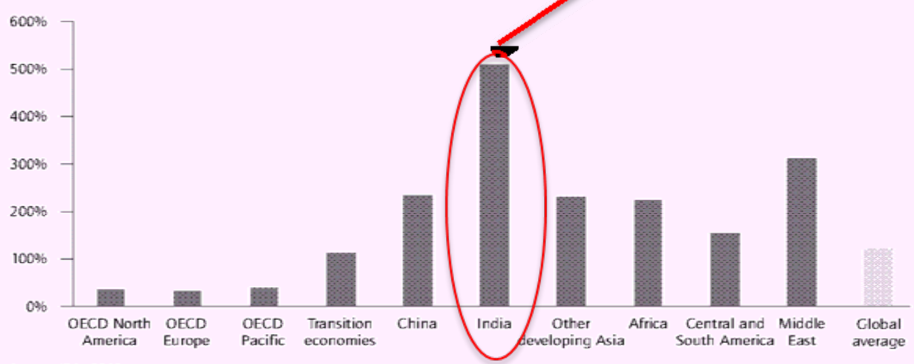

Figure 3. Electricity consumption growth 2007-50 (BLUE Map Scenario)

Source: IEA, 2010.

KEY POINT: Emerging economies will need to use smart grids to efficiently meet rapidly growing electricity demand.

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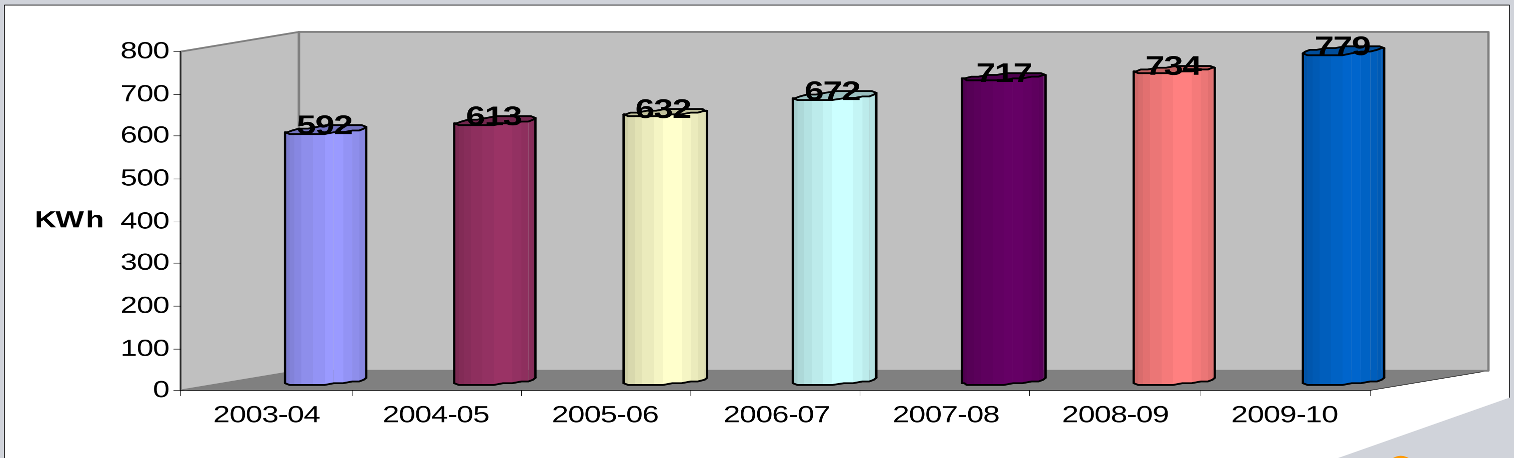
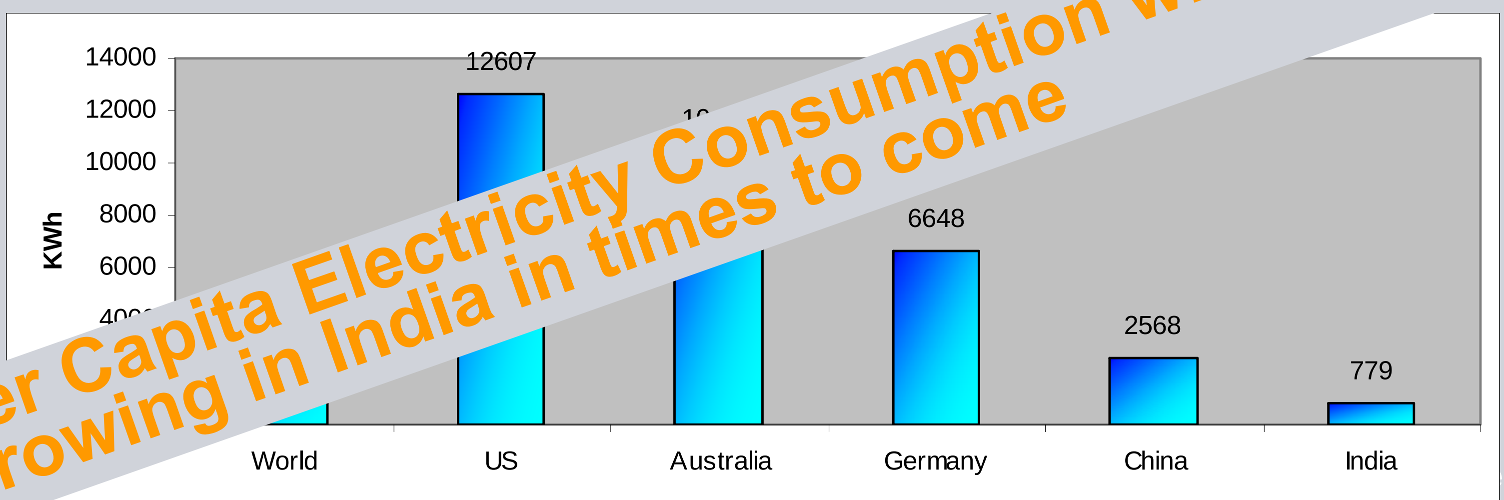
Energy Consumption - Scenario

Per Capita Electricity Consumption (KWh) in India



Per Capita Electricity Consumption (KWh)



Per Capita Electricity Consumption will keep growing in India in times to come

Source : IEA/CEA/CIA World Fact book 2010

A look at the Indian Loads
Flexibility of Energy Use : a key issue

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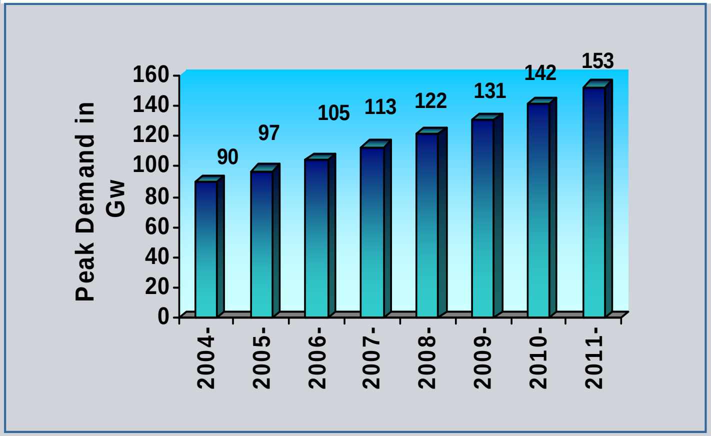
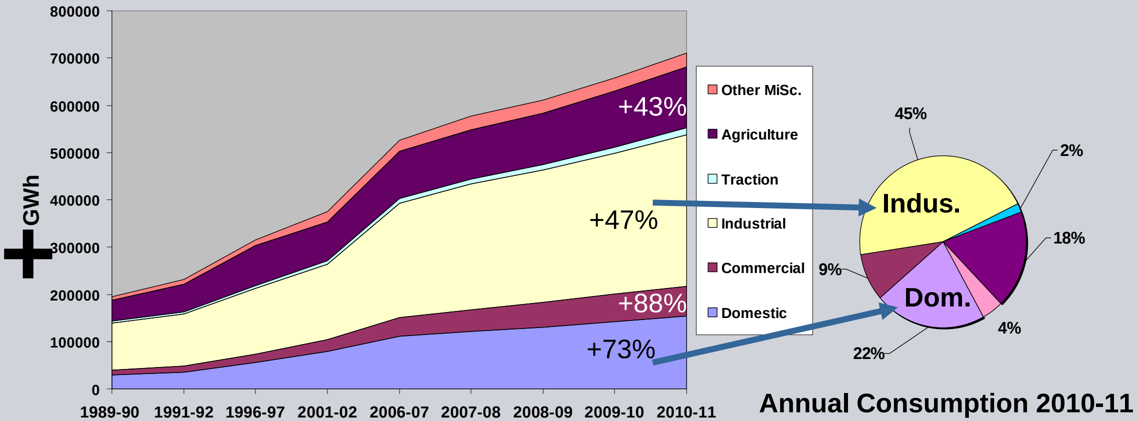


Increasing Consumption Peaks

+



Increasing Annual Consumption

Annual Consumption 2010-11

+

Increasing renewable generation

+

New Consumptions

↘ **Flexibility in generation**
↗ **Constraints in networks** } ↗ **Need for generalized intelligent & flexible consumption**
→ A major goal for Smart grids, smart homes, Smart Appliances, Smart Consumption

Why Smart Grids ?

As the world's electricity systems face a number of challenges such as

- New dynamics of future demand and supply
- Ageing infrastructure
- Complex interconnected grids
- integration of large number of renewable generation sources
- need to lower carbon emissions
- new type of loads such as Electric Vehicles
- Demands of Consumers and Regulators

Utilities must constantly evolve …

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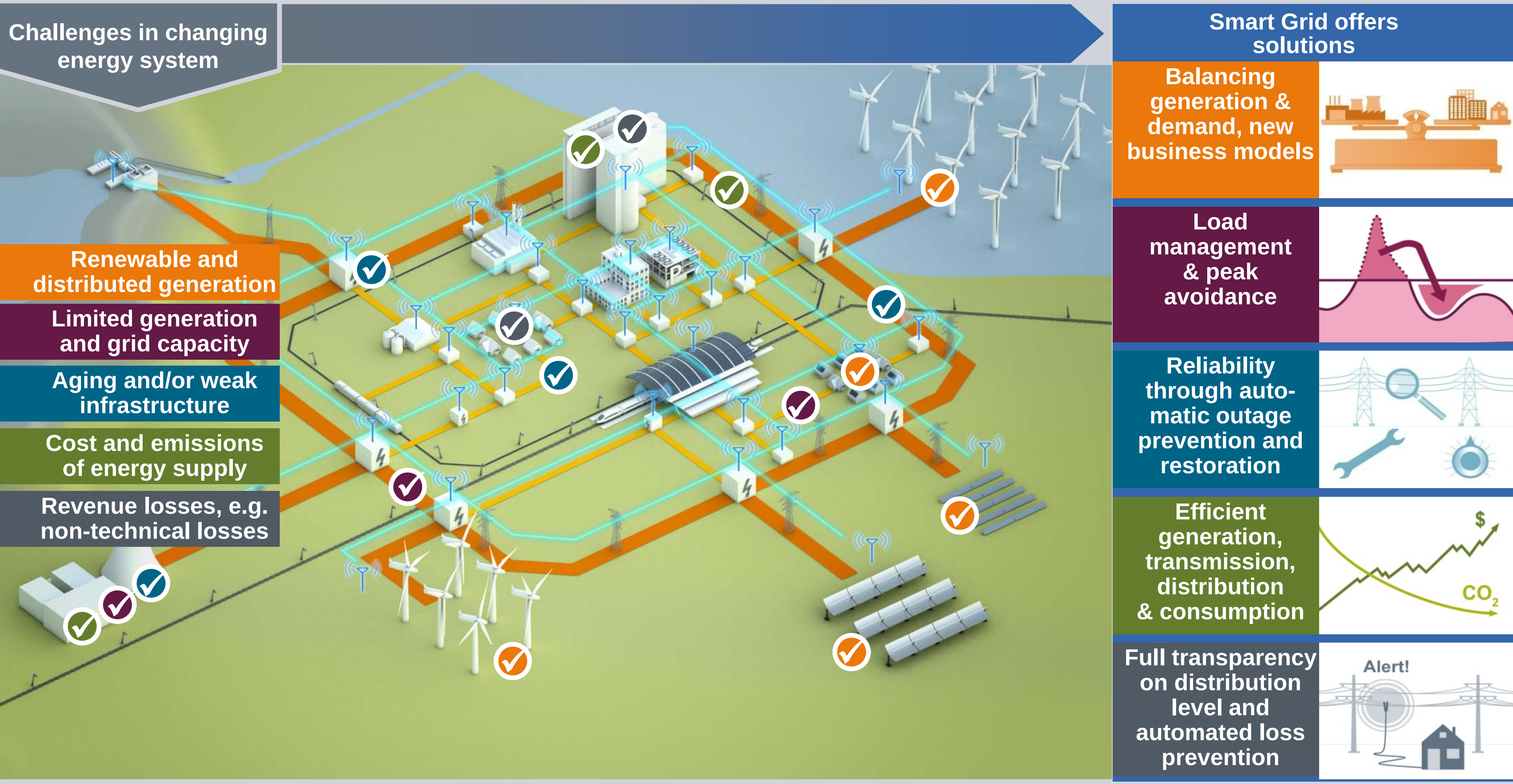
Secure and Reliable Power Supply for Everyone

Changing energy system requires new solutions



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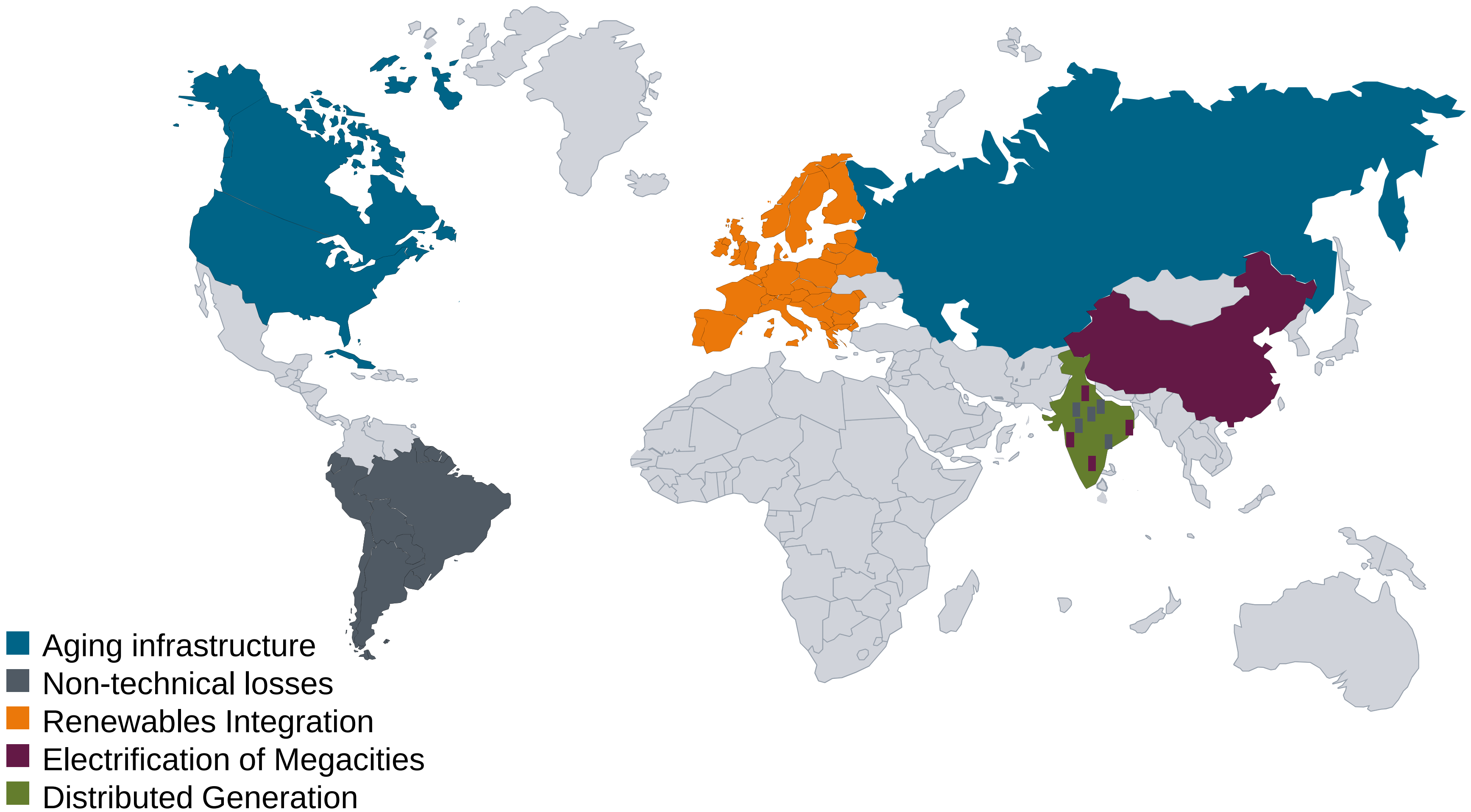
What are Smart Grids ?

A smart grid is an electricity network that uses digital and other advanced technologies to *monitor and manage* the transport of electricity from *all* generation sources to meet the varying electricity demands of end users.

Smart grids co-ordinate the needs and capabilities of all generators, grid operators, end-users and electricity market stakeholders to operate all parts of the system as *efficiently* as possible, *minimising costs and environmental* impacts while maximising *system reliability*, resilience and *stability*.

Smart grids are a *set of evolving technologies* that will be deployed at different rates in variety of settings depending on local conditions such as existing technologies, regulatory frameworks and investment framework.

There is not one global Smart Grid
Regional drivers are different: some examples



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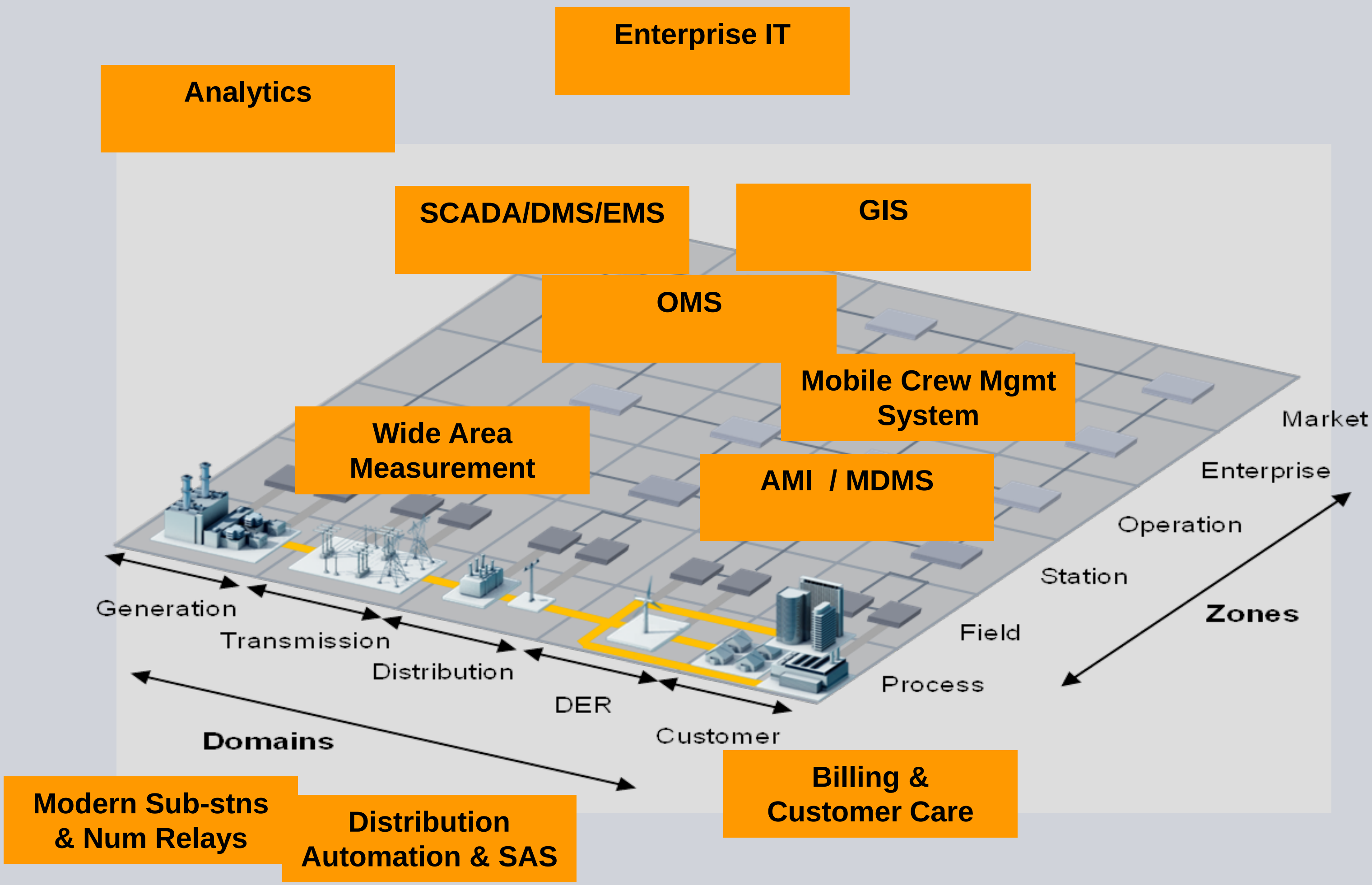
ICT envelops the Domains and Zones of Electric Value Chain

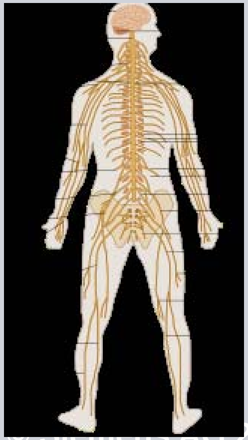


Basic Concepts to understand Smart Grid Technology

Analogy of Human Body with Electrical network

- The circulatory system carries blood in blood vessels (*power in electrical network, cables,etc*)

- The nervous system/brain monitors and controls (*automation & communication*)



Concept of Granularity

- Measurable and Controllable element
- Lower the level of the element - *Higher the measurability and controllability of the entire system*

Concept of OT/ IT

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Operational Technology

Necessary for Operations of network, e.g.

- Sub-station Automation
- Metering

Lowest level interventions
Highly accurate
Critical applications

Information Technology

ERP/ Billing
Top level view

Low criticality
Office related applications
Reports

Both are essential and must be strongly coupled for effective results

Concept of Hierarchy of Operations

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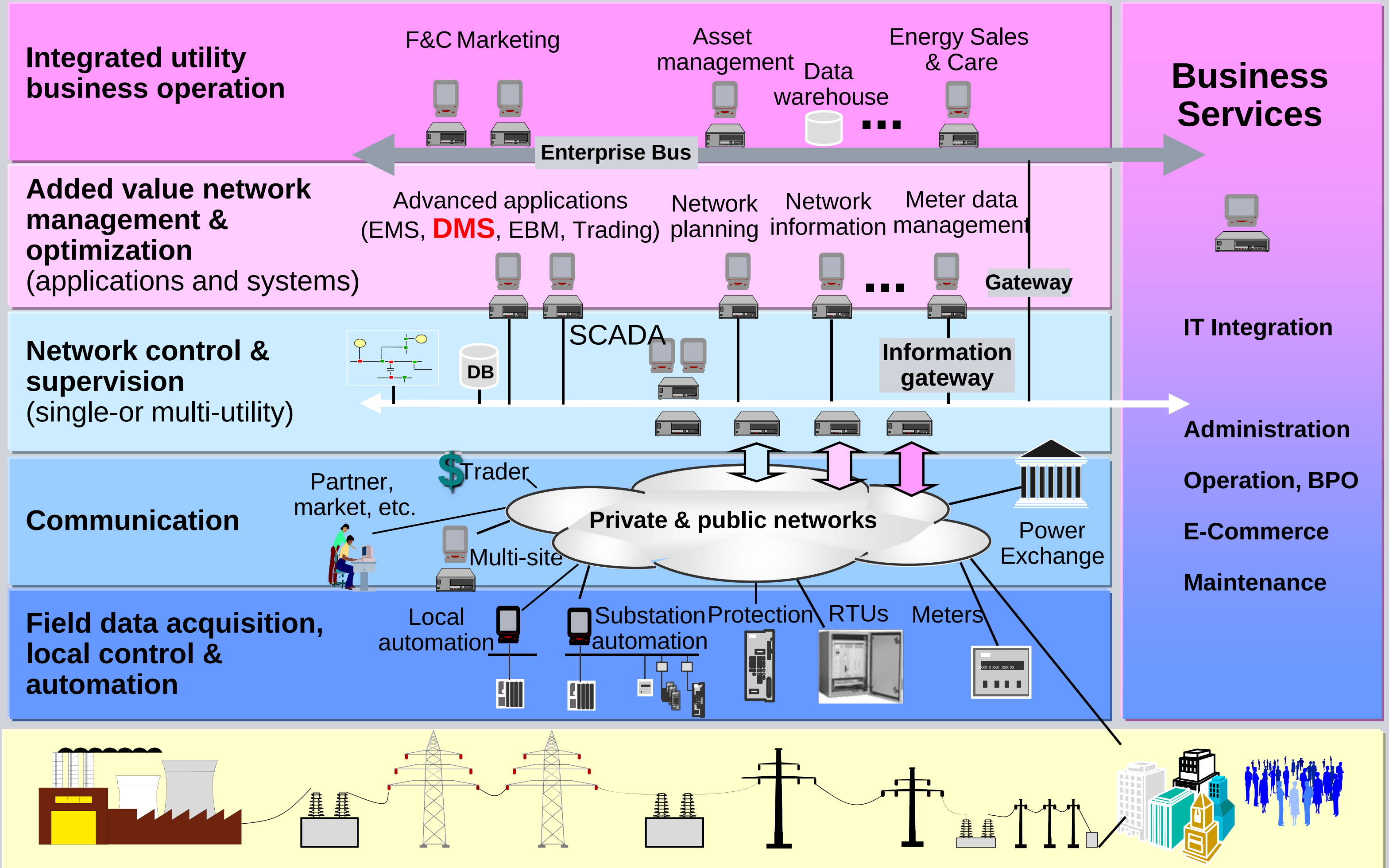

Concept of Balance of Generation and Consumption

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IT Systems
- Utility Operational IT
- Utility business systems
- Consumer energy management & monitoring systems

ensure balance between generation and consumption

Utility Infrastructure

Utilities / ISOs

- Generation
- Transmission
- Distribution

Smart Grid Applications

Generation | Consumption

End User Infrastructure

Industrial / Commercial / Residential

- Build. Autom.
- Indust. Autom.
- Smart Home
- Electric Vehicle

Generation follows load

Environmental awareness

Load follows generation with intelligent grids

Communications Technology
- Communications consulting & services
- Communications products & solutions

Transmission solutions
for secure, sustainable, and efficient power supply

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Smarten up Power Transmission

DEVELOPMENT OF POWER SYSTEMS

- **Extensions of Interconnected Systems**
- **Increased Power Exchange among the Interconnected Systems**
- **Transmission of large Power Blocks over long Distances * (Hydro Resources, Solar Energy)**

Development of AC Transmission

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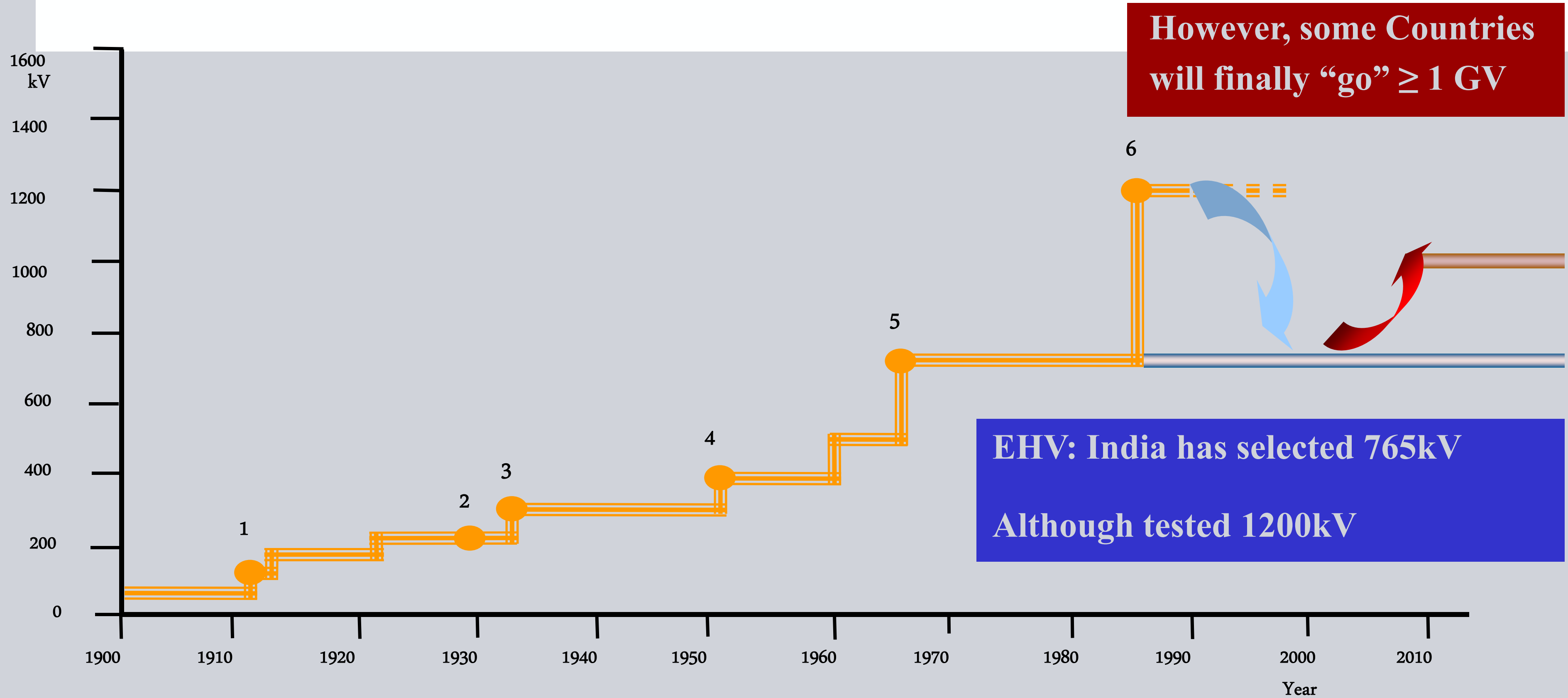

1. 110 kV Lauchhammer – Riesa / Germany (1911)
2. 220 kV Brauweiler – Hoheneck / Germany (1929)
3. 287 kV Boulder Dam – Los Angeles / USA (1932)
4. 380 kV Harspranget – Halsberg / Sweden (1952)
5. 735 kV Montreal – Manicouagan / Canada (1965)
6. 1200 kV Ekibastuz – Kokchetav / USSR (1985)

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HVDC and FACTS

From

Congestion, bottlenecks, and blackouts

To

Security, sustainability, and efficiency of power supply

What's necessary:

- Control of power flow
- Avoidance loop flows and overloads
- System interconnections with HVDC (Firewall)
- Use of integrated AC/DC systems with FACTS & HVDC
- Support of voltage recovery after system faults
- Reduction in Transmission losses (HVDC)
- Use of bulk power energy highways with HVDC & FACTS

Advantages with HVDC

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Why HVDC rather than HVAC?

- **Long distances** make HVDC **cheaper**
- Improved link **stability**
- Fault isolation
- **Asynchronous** link
- **Right-of-way** for an AC Line designed to carry 2,000 MW is more than 70% wider than the right-of-way for a DC line of equivalent capacity
- Stabilize AC system frequencies and voltages, and help with unplanned outages
- HVDC links designed to carry a maximum load **cannot be overloaded by outage of parallel AC lines.**

Advantages with HVDC

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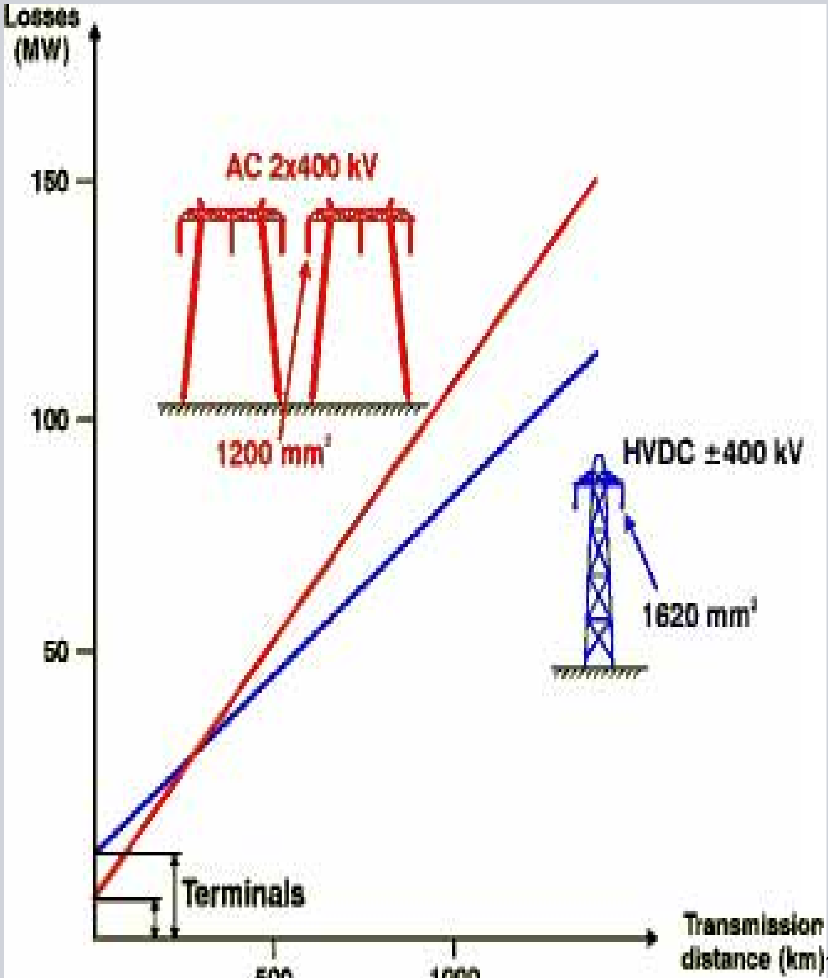
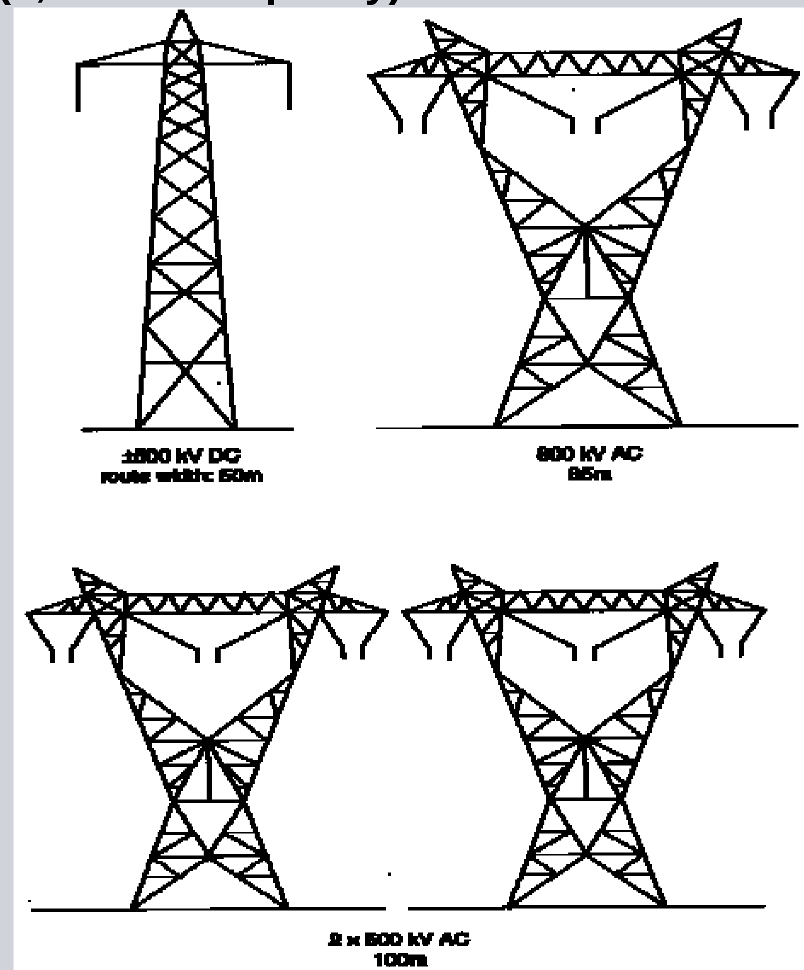
Example Losses on Optimized Systems for 1200 MW



Typical tower structures/ rights-of-way for alternative transmission systems (2,000 MW capacity)



300MW AC Offshore Grid Connection

designed by Siemens Transmission and Distribution Limited

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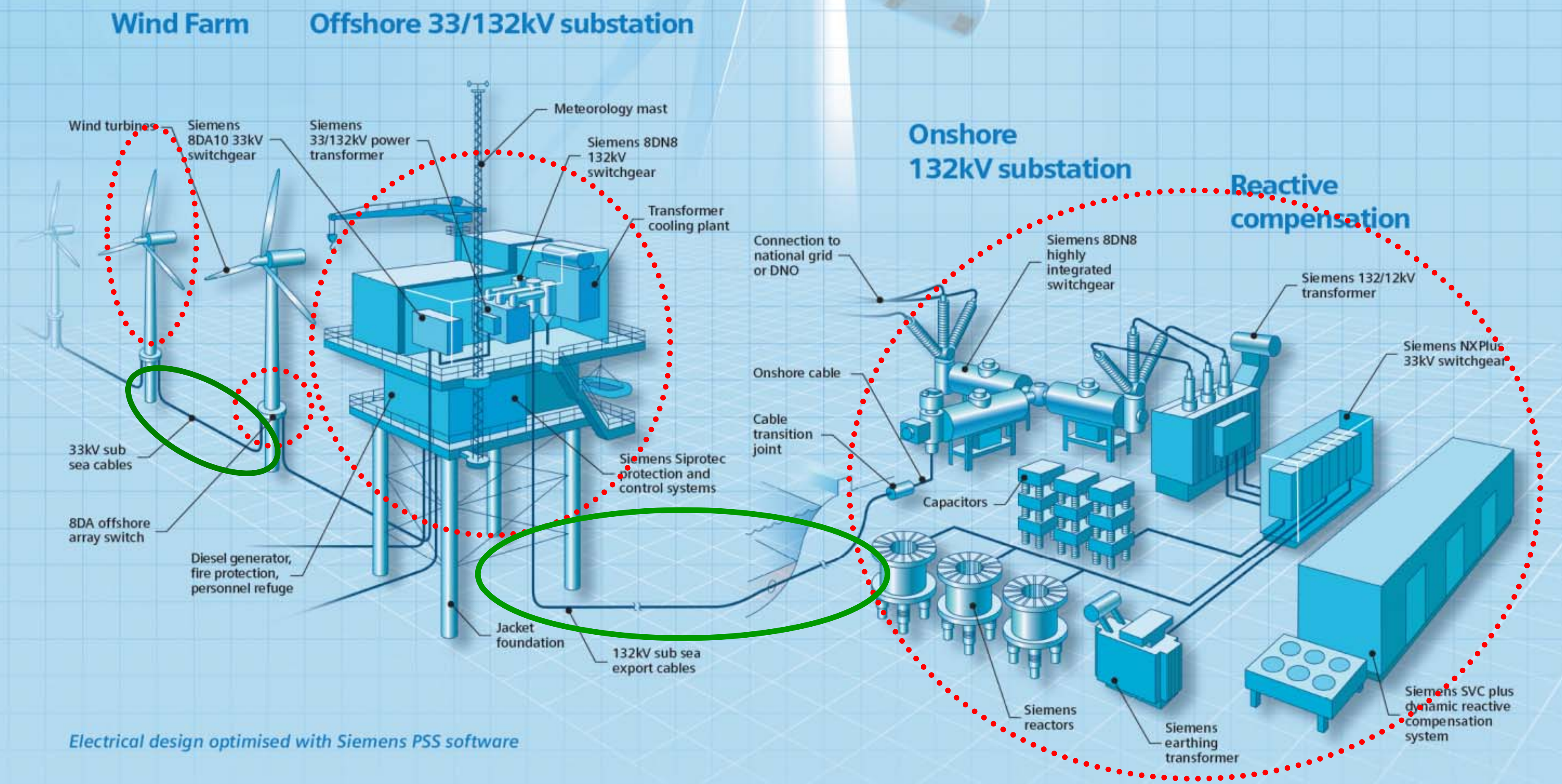


Electrical design optimised with Siemens PSS software

Grid connections for Wind Farms

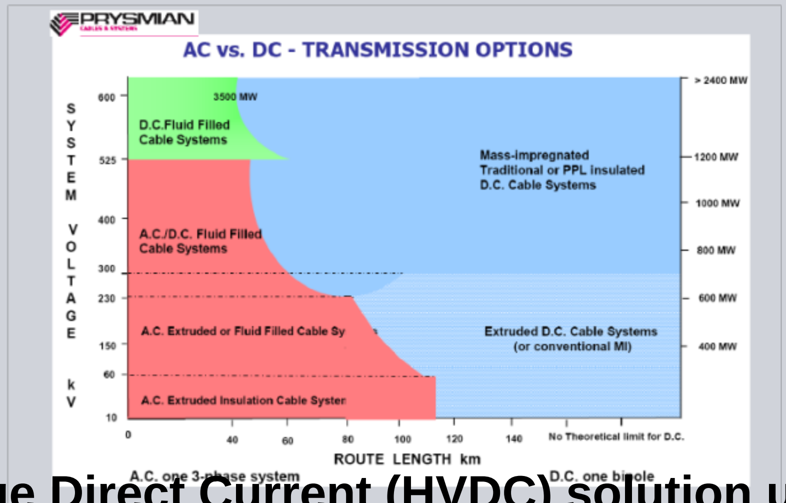
- The wind turbines used in offshore installations are separated by distances upto 500 meters or more.

- An underwater medium-voltage cable grid (often 24 or 36 kV AC) connects the turbines to each other and pools the power, which is then transmitted to a suitable connection point in the transmission grid on land.

- Depending on the size of the park and its distance from the shore, this connection can be made at a medium or high-voltage level using HVAC or HVDC techniques

Offshore Wind Parks -AC or DC Transmission?

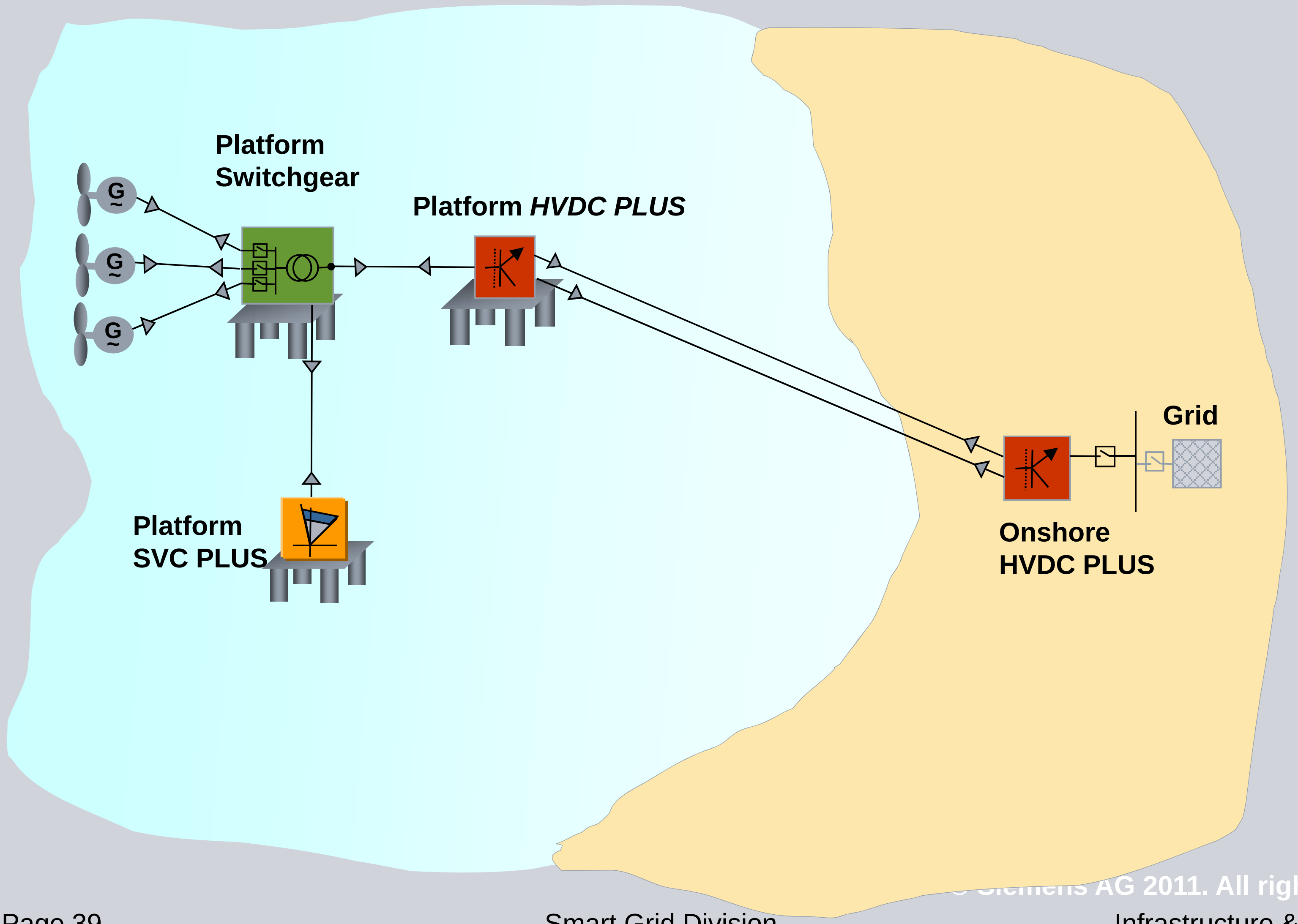
- AC transmission is not suitable for the transmission of power from large parks located **a significant distance** from the shore because of high cable capacitance which would lead to **high charging currents**.



- A **High-Voltage Direct Current (HVDC) solution utilising Siemens *HVDC Plus* system** can be used to overcome this problem.

- *HVDC Plus* is based on voltage source converter (VSC) technology, can be used for power transmission and reactive power compensation.

Examples for Grid Access Projects:
Typical DC-Transmission for Offshore Windpark



Trans bay cable project, USA: Security of power supply for San Francisco area with HVDC PLUS

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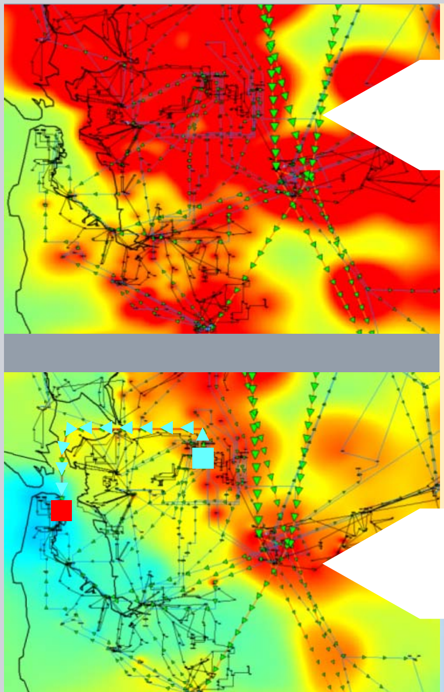

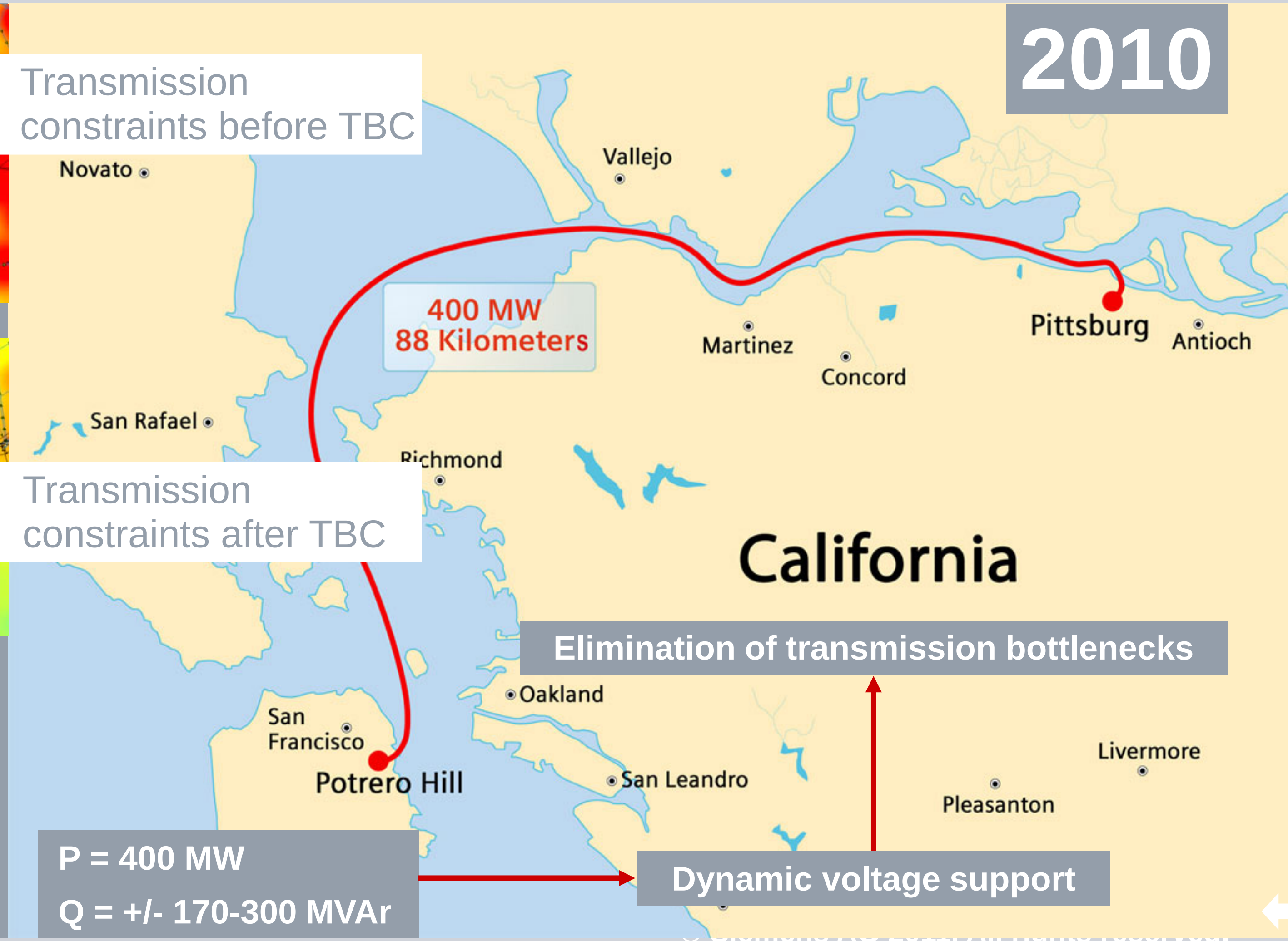

- Energy exchange by sea cable
- No increase in short-circuit power

Smart Power Transmission Systems

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FACTS - Flexible AC Transmission Systems: Support of Power Flow

- *Increased power flow capacity*
- *Increased stability*
- *Voltage quality*
- *Control of power flow*

SVC - Static Var Compensator (Standard for Parallel Compensation)
FSC - Fixed Series Compensation
TCSC - Thyristor Controlled Series Compensation
TPSC - Thyristor Protected Series Compensation

The benefits of HVDC and FACTS

- Reduction in transmission losses – increase in system security
- Reduction in CO_2 emissions through grid access of large wind, hydro, and solar power plants
- Bulk power transmission in the gigawatt range over distances of 1,000 kilometers and more
- Increase in power quality on the various voltage levels
- Increase in system stability

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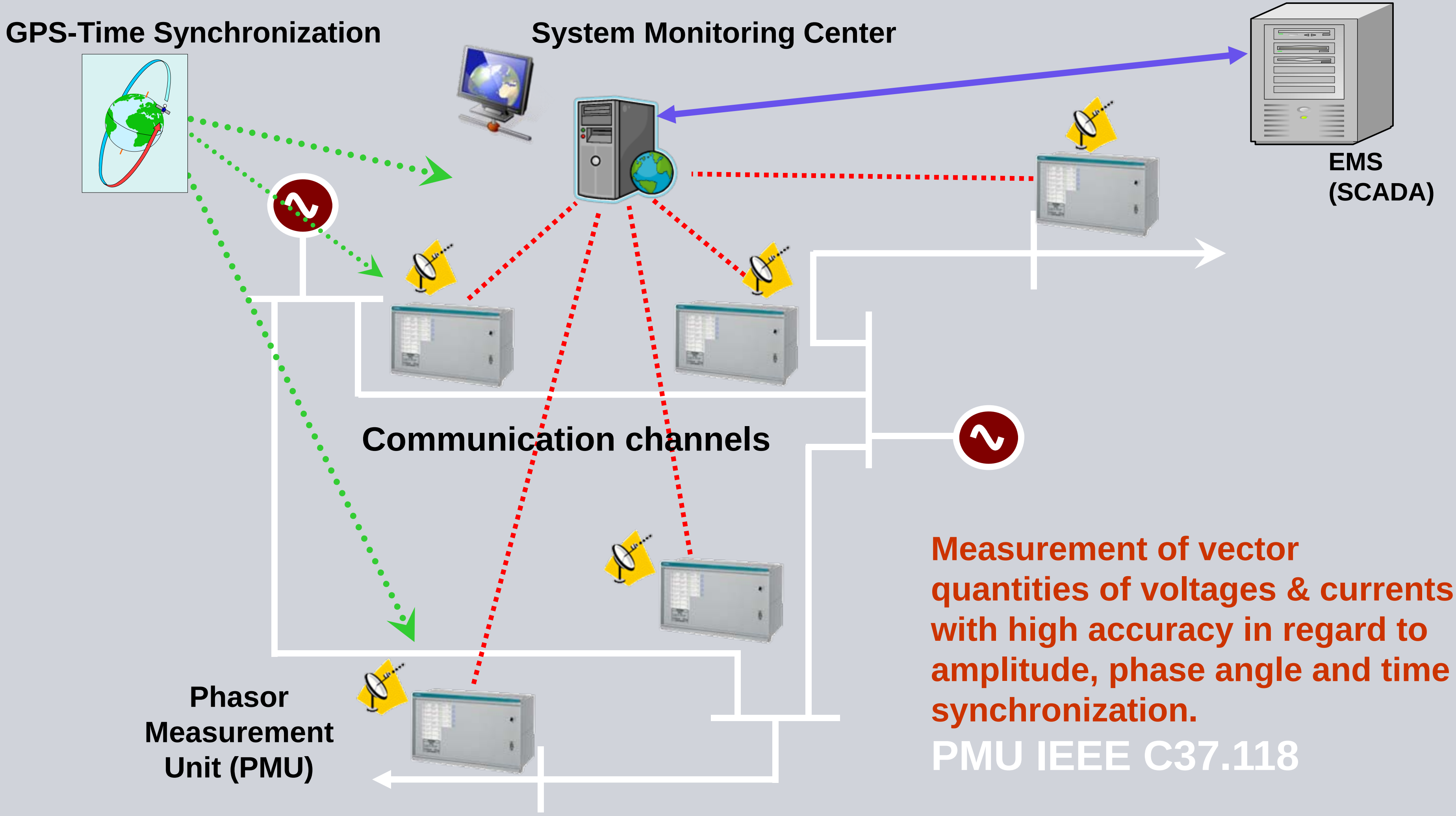
Phasor Measurement Units



Measurement of vector quantities of voltages & currents with high accuracy in regard to amplitude, phase angle and time synchronization.

PMU IEEE C37.118

SIGUARD Phasor Data Processing System Application

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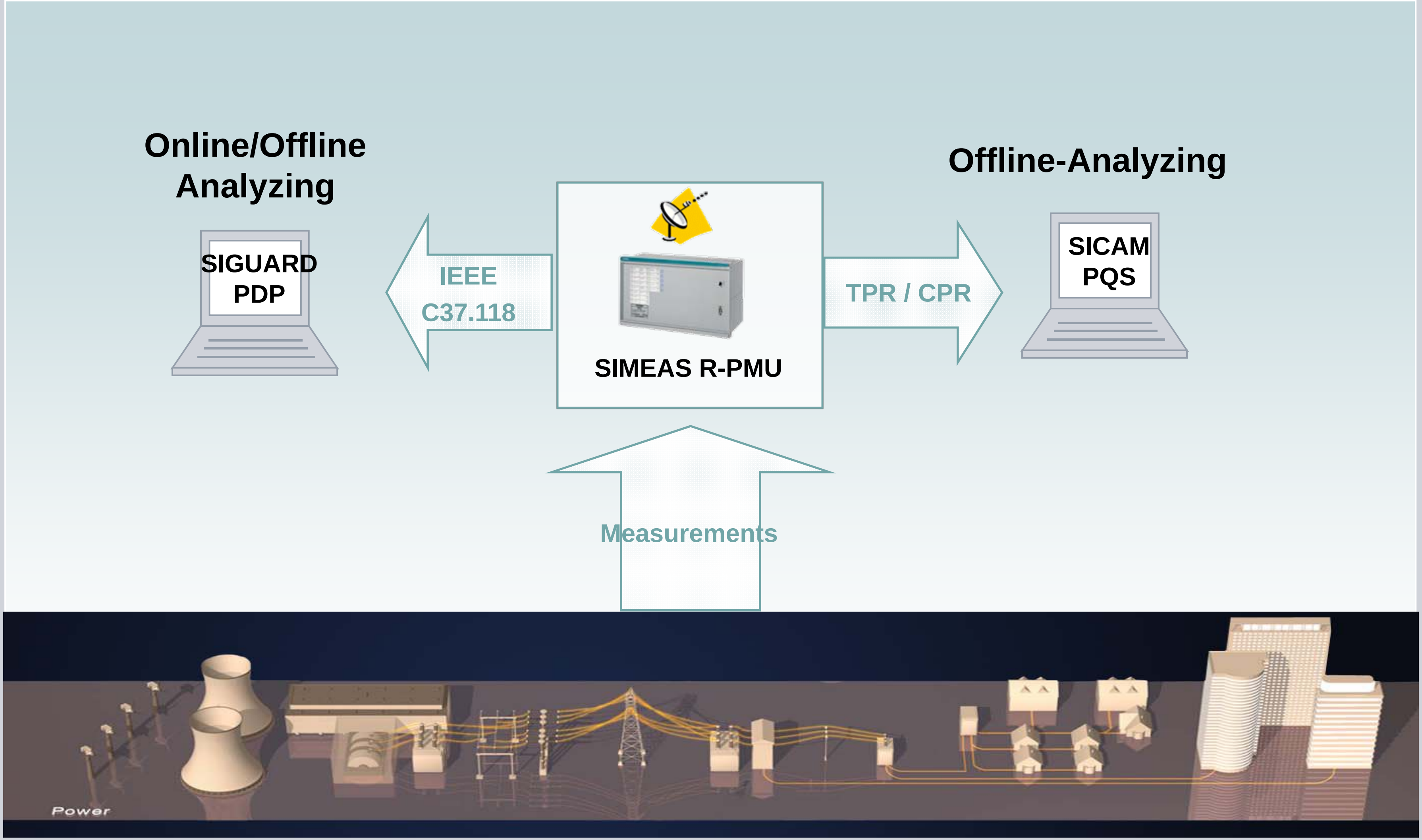
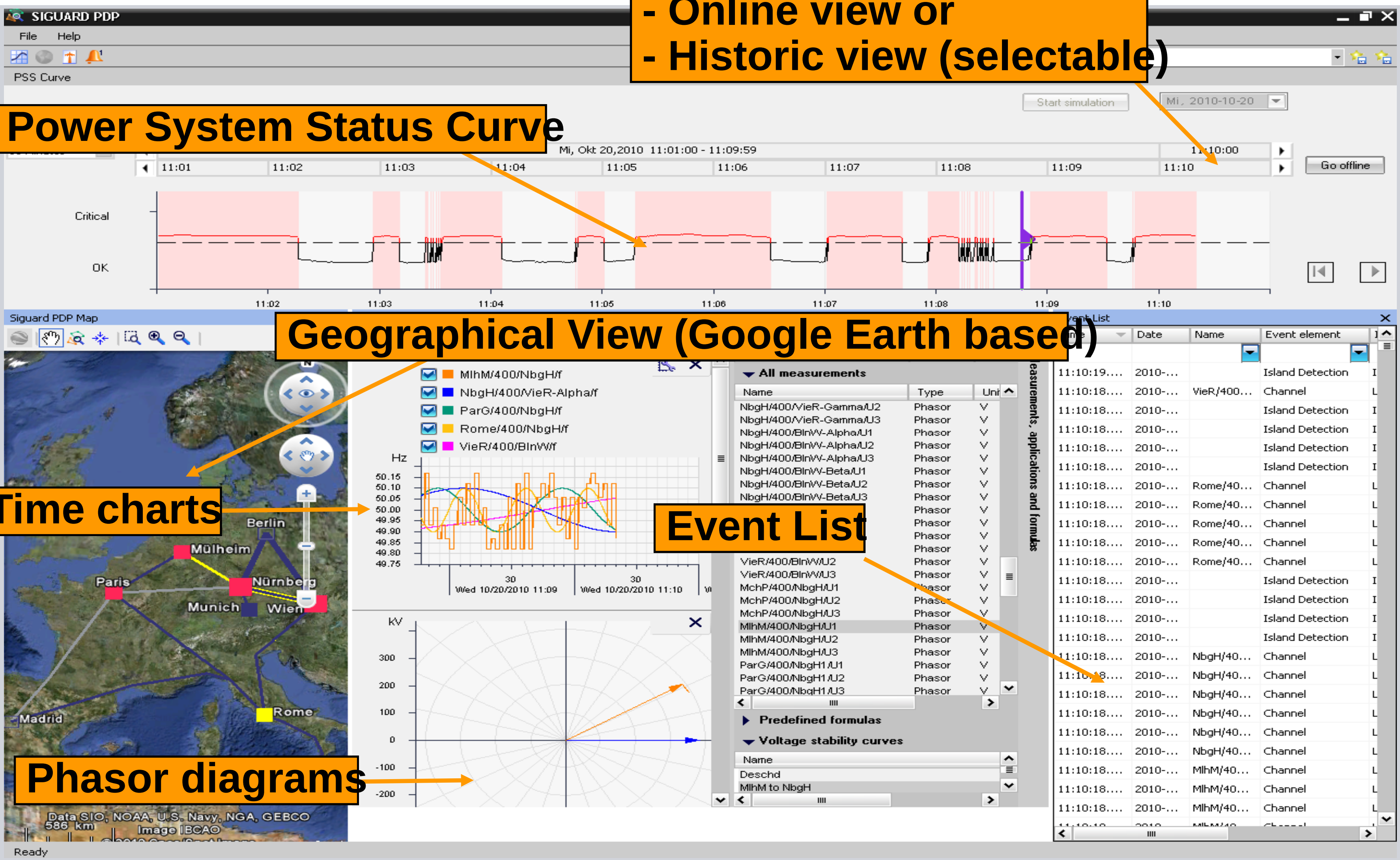


Userinterface



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Key advantages for Phasor deployment ...

✓Accurate phase angle measurements independent of frequency variations

✓Real time synchronized differences

✓Wide area protection

✓Improve grid stability/reliability

✓Minimize transmission congestion

✓Optimize transmission capacity

✓Forecasting grid instability and early warning to prevent blackouts and cascade collapse

Distribution solutions
for secure, sustainable, and efficient power supply

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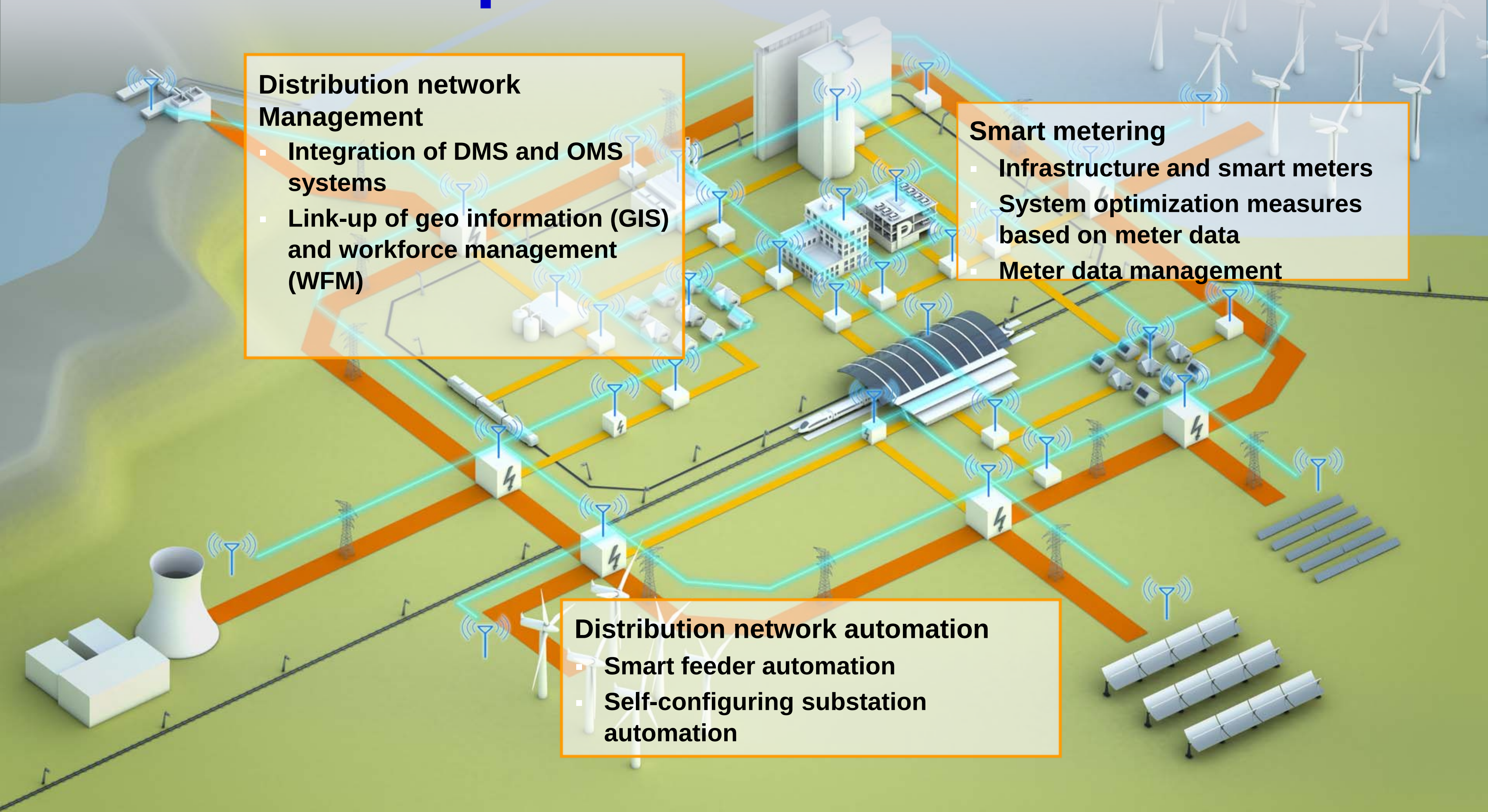
Smarten up Power Distribution



Infrastructure Age 50+
Down Times in MV Distribution Networks

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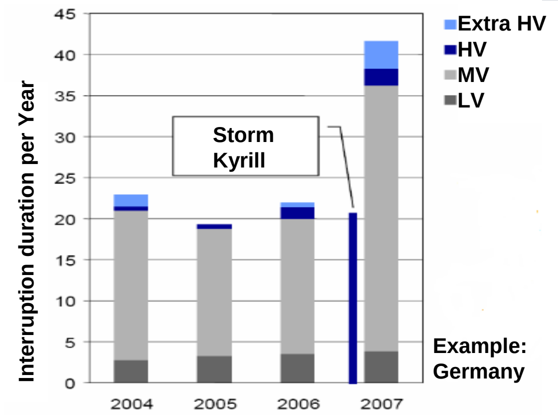
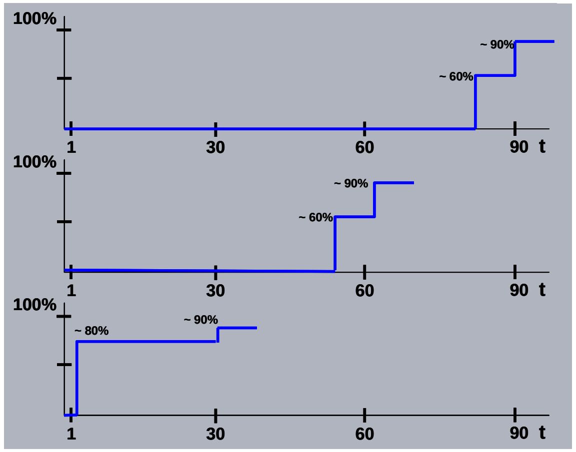
Many times, outages in the distribution automation are caused by components older than 50 years.



Interruption frequency ➔ **Modernization of the distribution network on the long run**

Interruption duration ➔ **Distribution Automation / Feeder Automation**



Typical distribution networ

- Loss of revenues
- Need of high personal resources
- High travel expenses

Fault indicators

- Reduced loss of revenues
- Reduced personal resources
- Medium travel expenses

Distribution Automation

Smart IED
SICAM 1703 emic

- Minimized loss of revenues
- Lowest need of resources
- High customer satisfaction
- Basis for further network optimizat on

Design of an Intelligent Transformer Substation Communication RTU – Control Level

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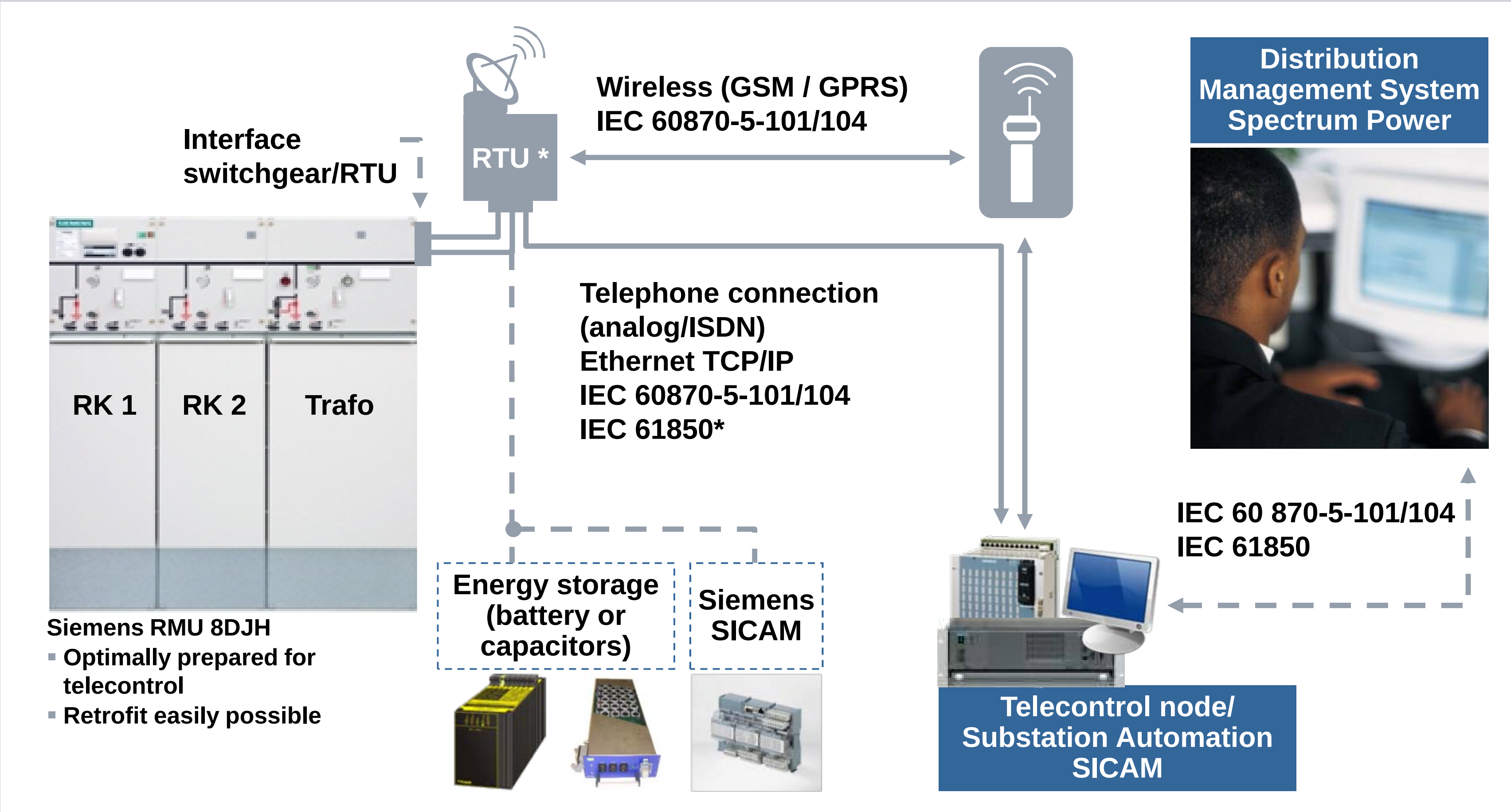
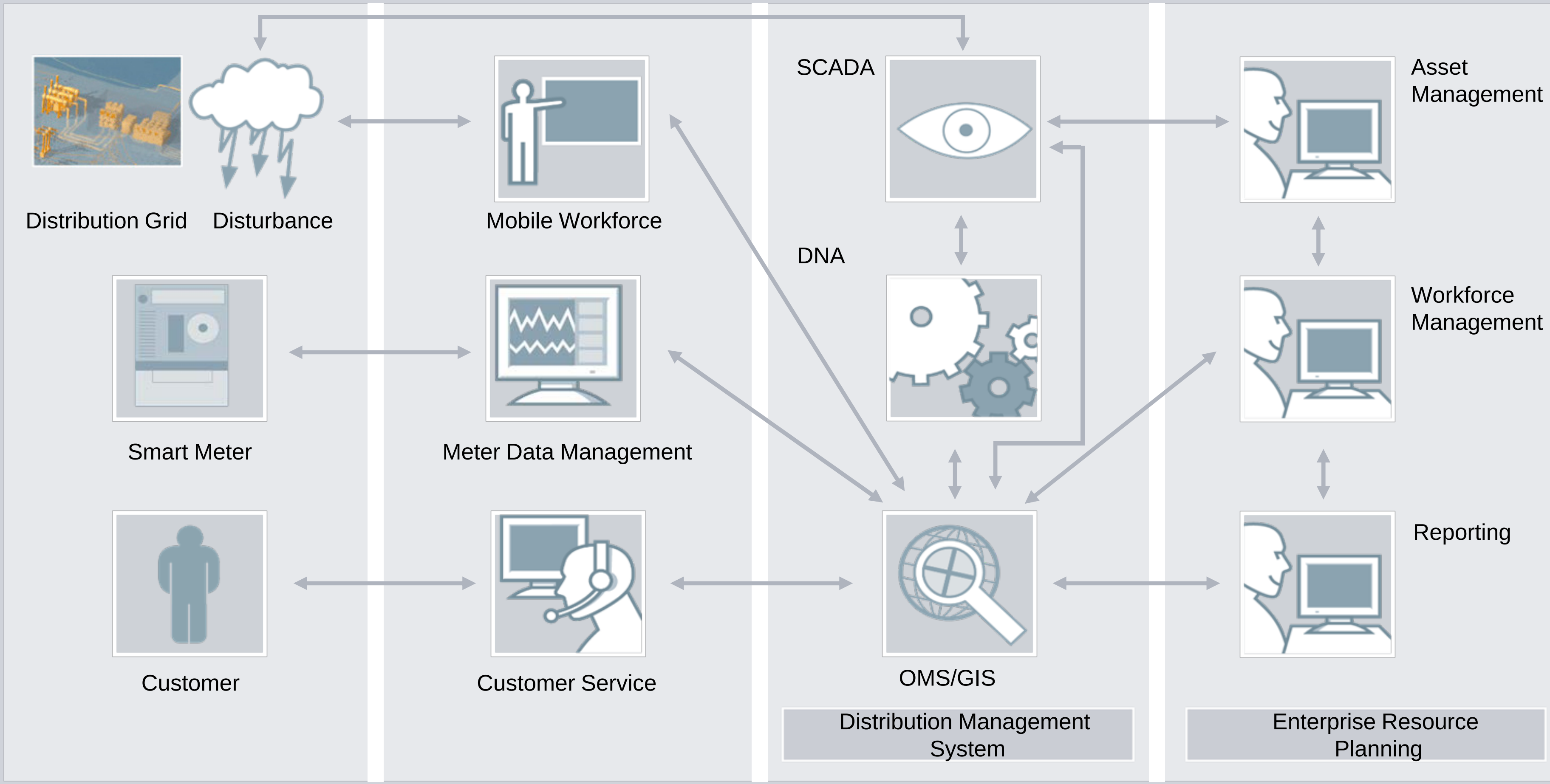
Possible customer strategies:
A) Only indications, for example, Short-circuit indicator
B) Indication + remote control
C) Indication + remote control + load management



Distribution Network Management System Solutions for distribution networks

Distribution Management System – typical operational process



Typical Medium-Voltage System of the Secondary Distribution Level with Decentralized Power-supply

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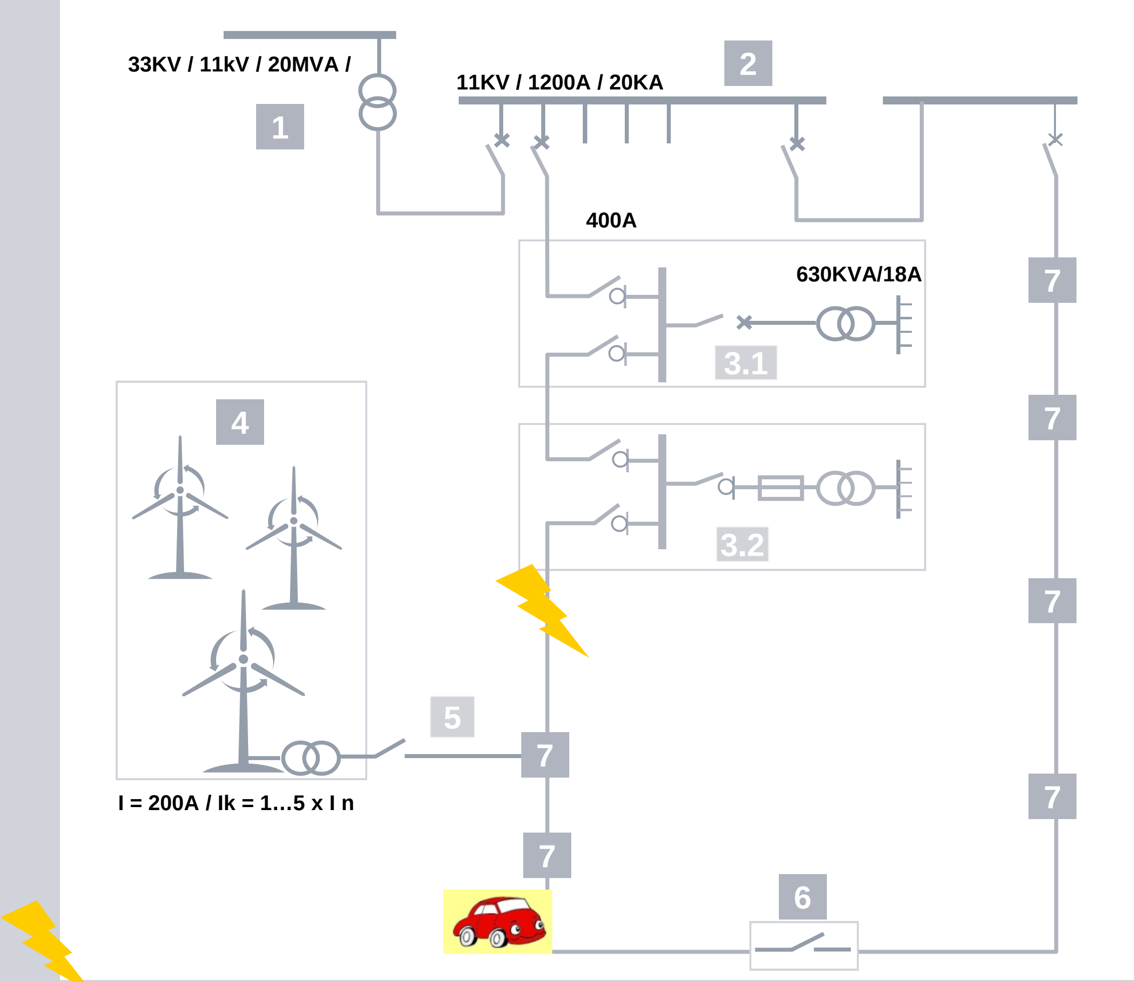

1. Power transformer
   - General data for Distribution-system
2. Circuit-breaker switchgear
   - Primary distribution level
   - Integration in substation automation system
3. Transformer substation with ring-main unit
   - Secondary distribution level
   - Today mostly without monitoring/control

   3.1 RMU with circuit breaker

   3.2 RMU with switch-disconnector/fuse combination

4/5 Decentralized Power-supply
   - Wind park, photovoltaic, biomass, etc.
   - Volatile direction of energy flow: Detection of short-circuit direction is necessary!
     Partly variable transformers required
   - Cable load
   - Increase of short-circuit capacity
   - Stipulations from renewable energies ACT (EEG)

6/7 Transformer substations

   6 RMU with open sectionalizing point (operation like radial system)

Fault location by driving along the distribution line or Remote indication and control – Distribution Automation

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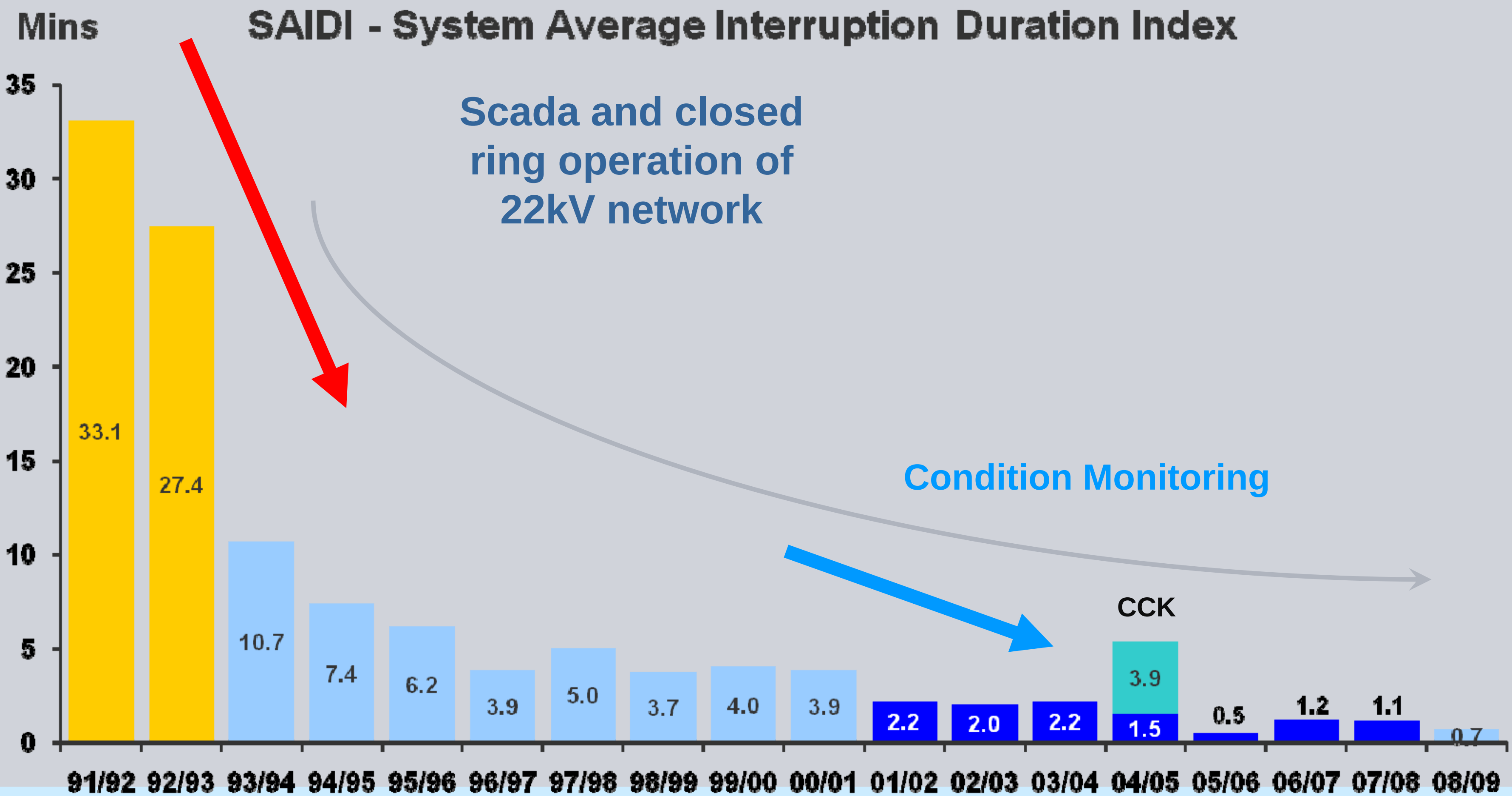
Singapore’s Network Performance



Continual Improvement in SAIDI

For more details :- yvonnelee@singaporepower.com.sg

SP GLOBAL SOLUTIONS
A member of Singapore Power Group

Voltage Problems at LV Distribution Infeed by Decentralized Power Producers

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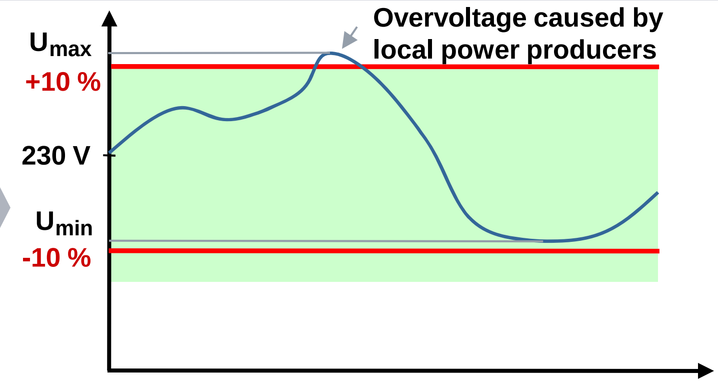
Voltage increase due to direct power infeed



Smart IED
SICAM 1703 emic

Smart IEDs are monitoring the voltage level and will control the distribution transformer accordingly

➔ Keeping the voltage within the limits given by the norm

Dynamic parameters
- Unsynchronized load
- Decentralized infeed

Static parameters
- Network impedance
- EN50160

Power quality?!

LV Network

Reduction of side effects due to improved power quality

Improved power efficiency for decentralized infeed

Distribution solutions
for secure, sustainable, and efficient power supply

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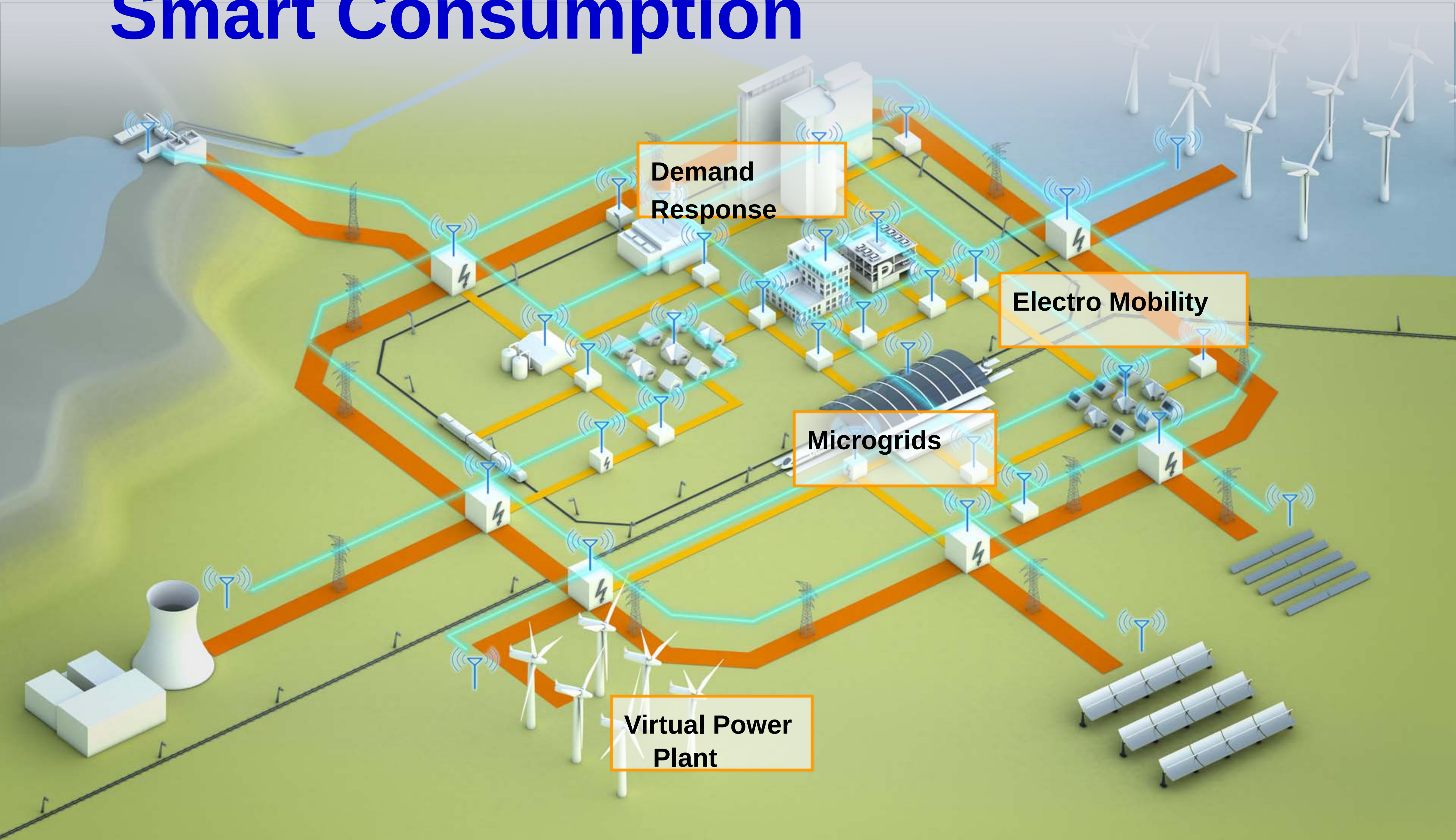
Smart Consumption



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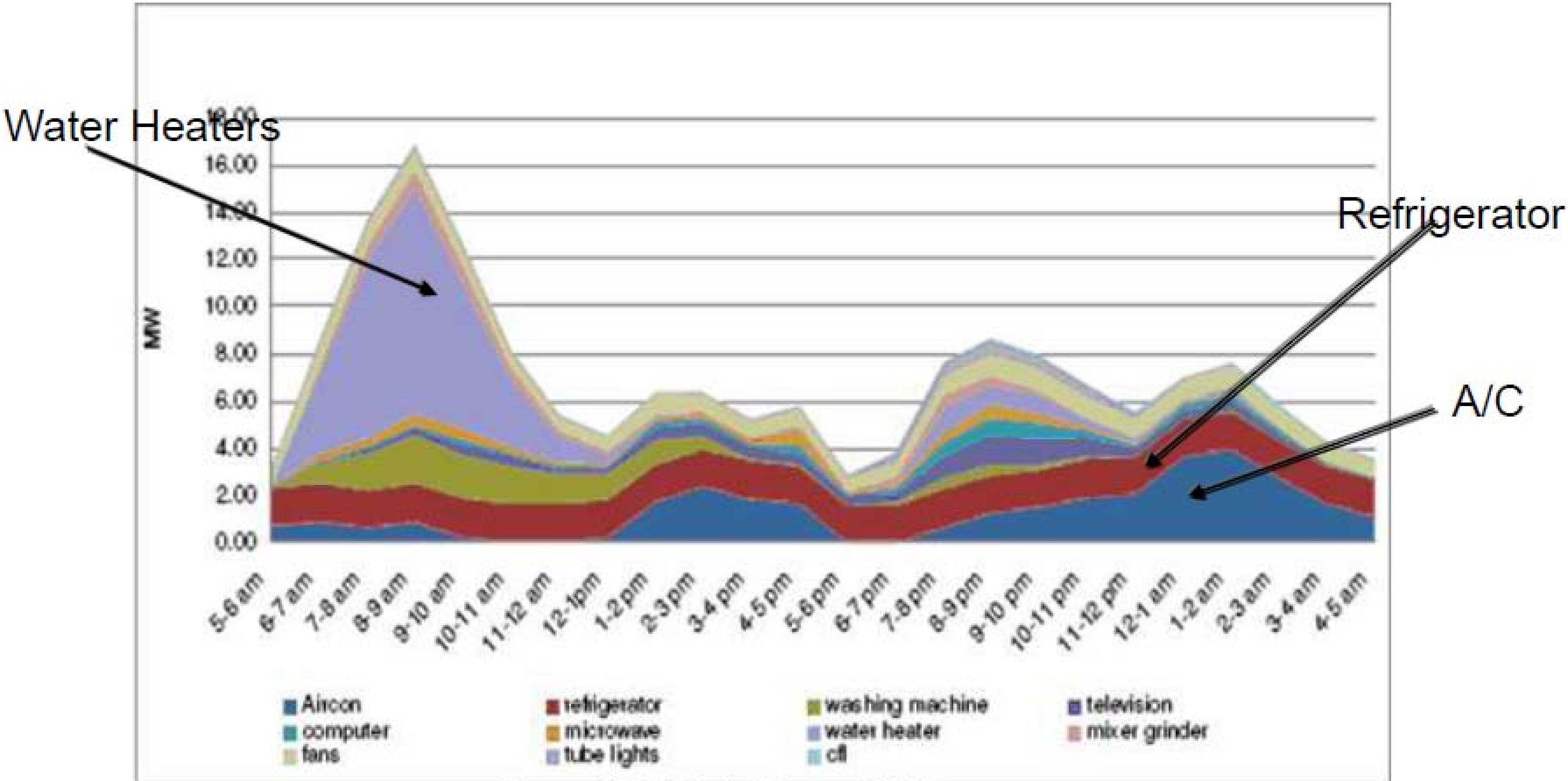
Heaters and Airconditioner load causes Residential peaks



Source: UCC Market Survey-2009

Source :- Bhise, Tata Power, ISGF July 2012

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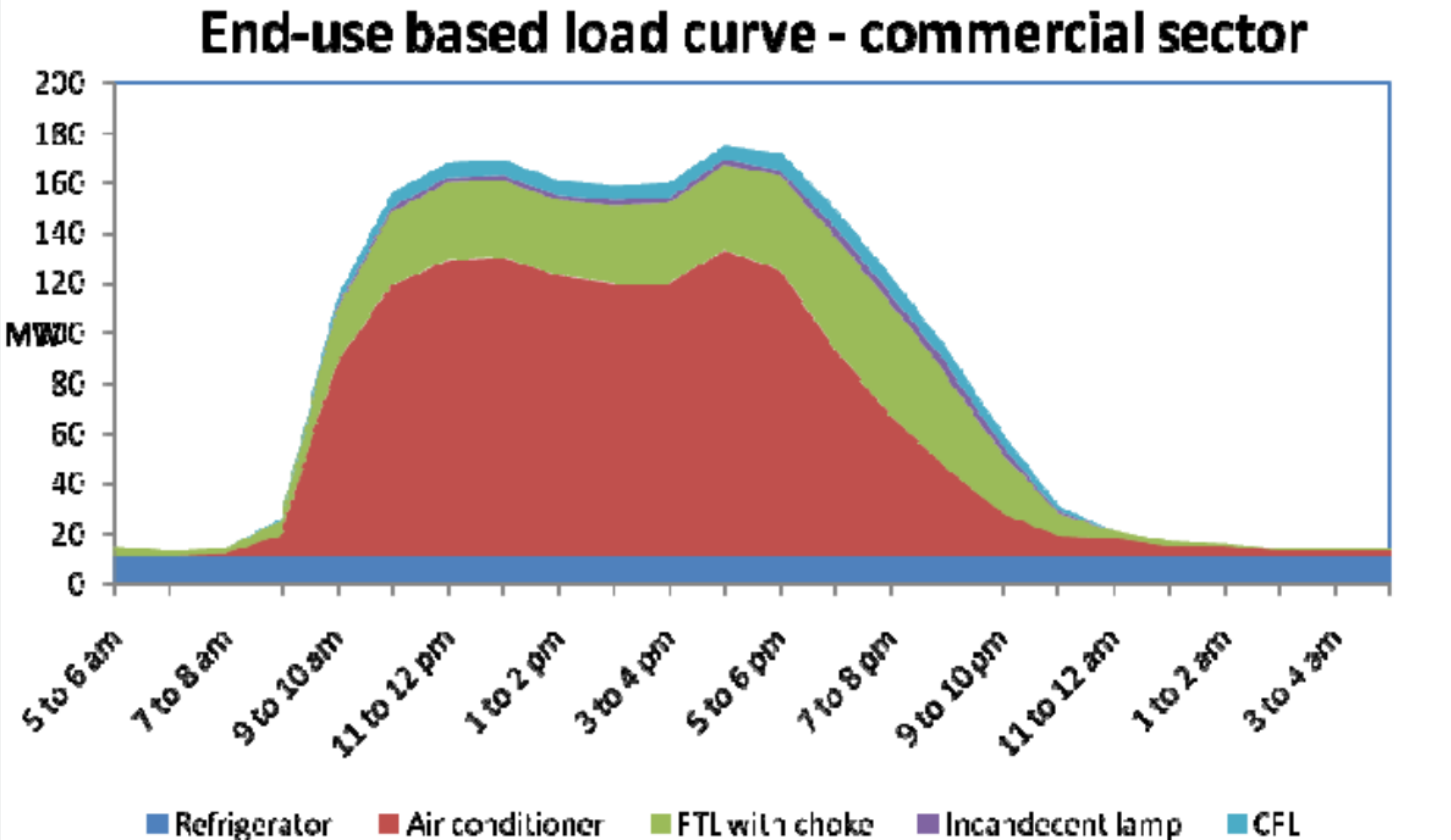
Typical Load Curves – Commercial Sector



Source: MERC website

•Fully airconditioned commercial complexes are the norm today
•Large scope of proper management of Central Airconditioning
•Old commercial establishments have inefficient airconditioning
•SMEs reluctant to invest in new technologies

If you can‘t use Less Energy, Use it at Different Times

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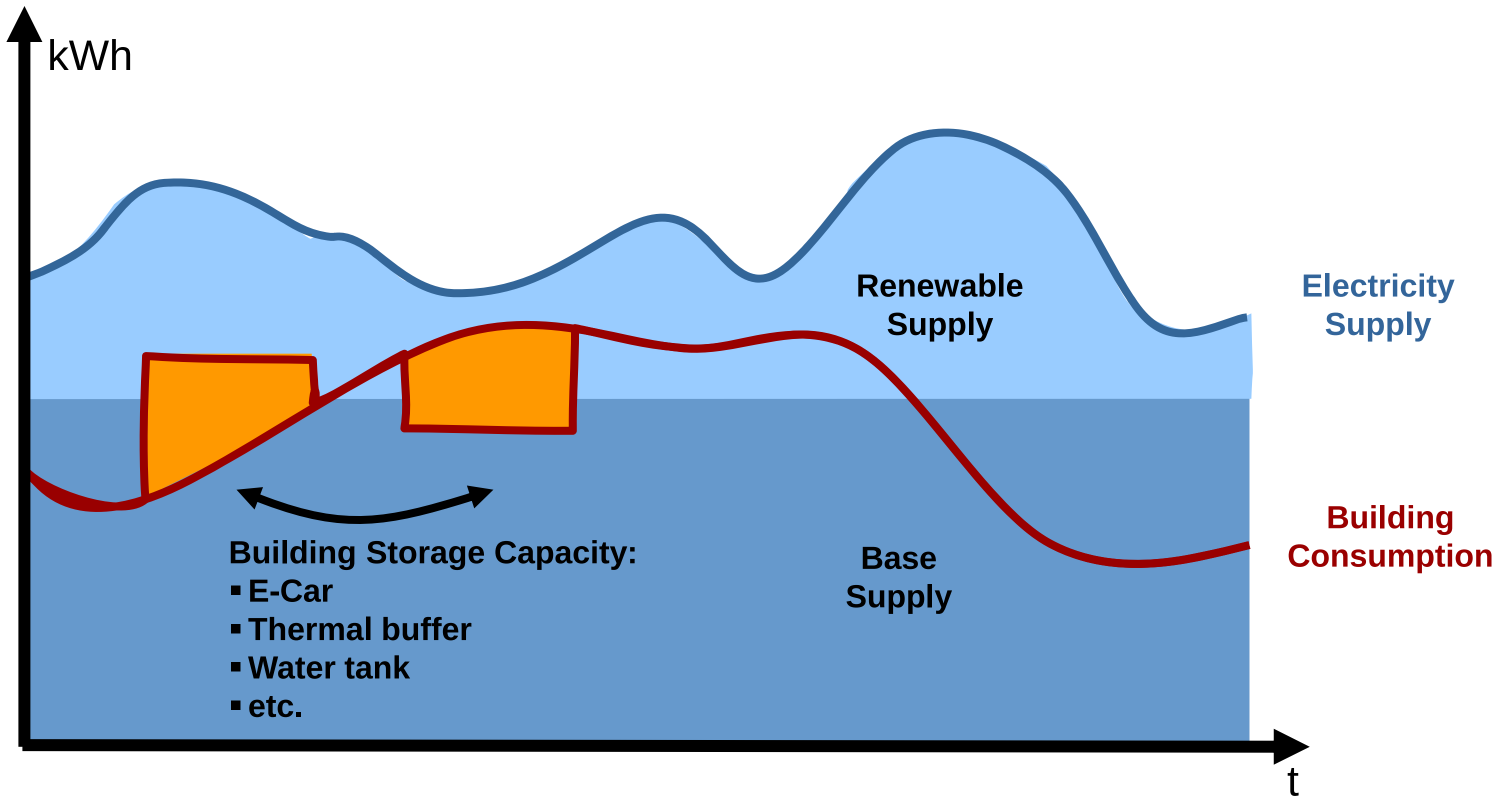

Goals of DR program

Demand Reduction

Peak Load Shifting

Improve Asset Utilization

Reduce Spinning Reserve

DR Motivation and Criteria

Trigger Criteria		Motivation Method: Load Response	Motivation Method: Price Response
	Reliability	▪Direct Load Control ▪Curtailable Load ▪Interruptible Load	▪**Critical Peak Pricing** ▪**Demand Bidding**
	Economic	▪Direct Load Control ▪Curtailable Load	▪**Time-of-Use Pricing** ▪**Critical Peak Pricing** ▪**Real-time Pricing** ▪**Demand Bidding**

Source: V. S. K. Murthy Balijepalli, Vedanta Pradhan, S. A. Khaparde, Review of Demand Response under Smart Grid Paradigm, 2011 IEEE PES Innovative Smart Grid Technologies – India, 2011

Demand response
Business models in relation to market players

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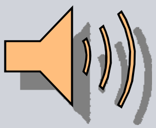
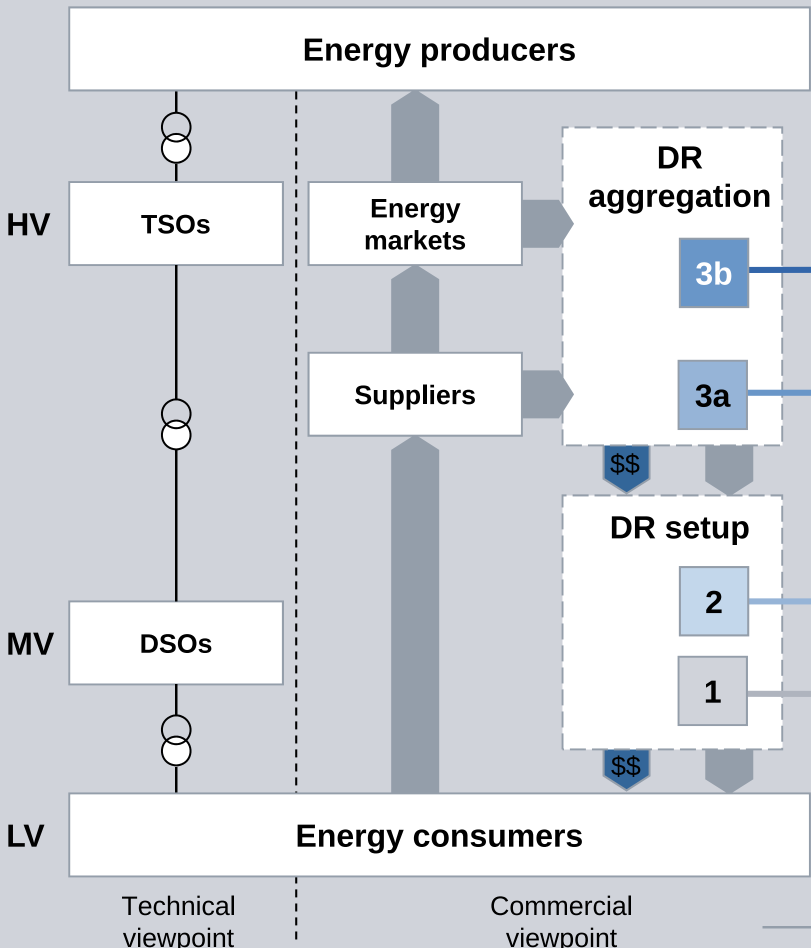
Trigger



Unusual high energy demand



Market player aggregator
Markets "**Nega-Watts**" capacity on the open energy market; has user under contract, enrolls and enables them on own cost
➔ **paid for capacity trade on open energy markets**

Bilateral aggregator
Has bilateral agreement with utility; has users under contract, enrolls and enables them on own costs;
➔ **paid by utility per MW of curtailable load provided**

DR service company
Provides DR value adding services such as DR marketing support, user enrolment, site enablement and operations;
➔ **paid for services and SW licenses**

Technology provider
Offer DRMS; optionally site gateways / thermostats and IT integration services;
➔ **paid for SW licenses**

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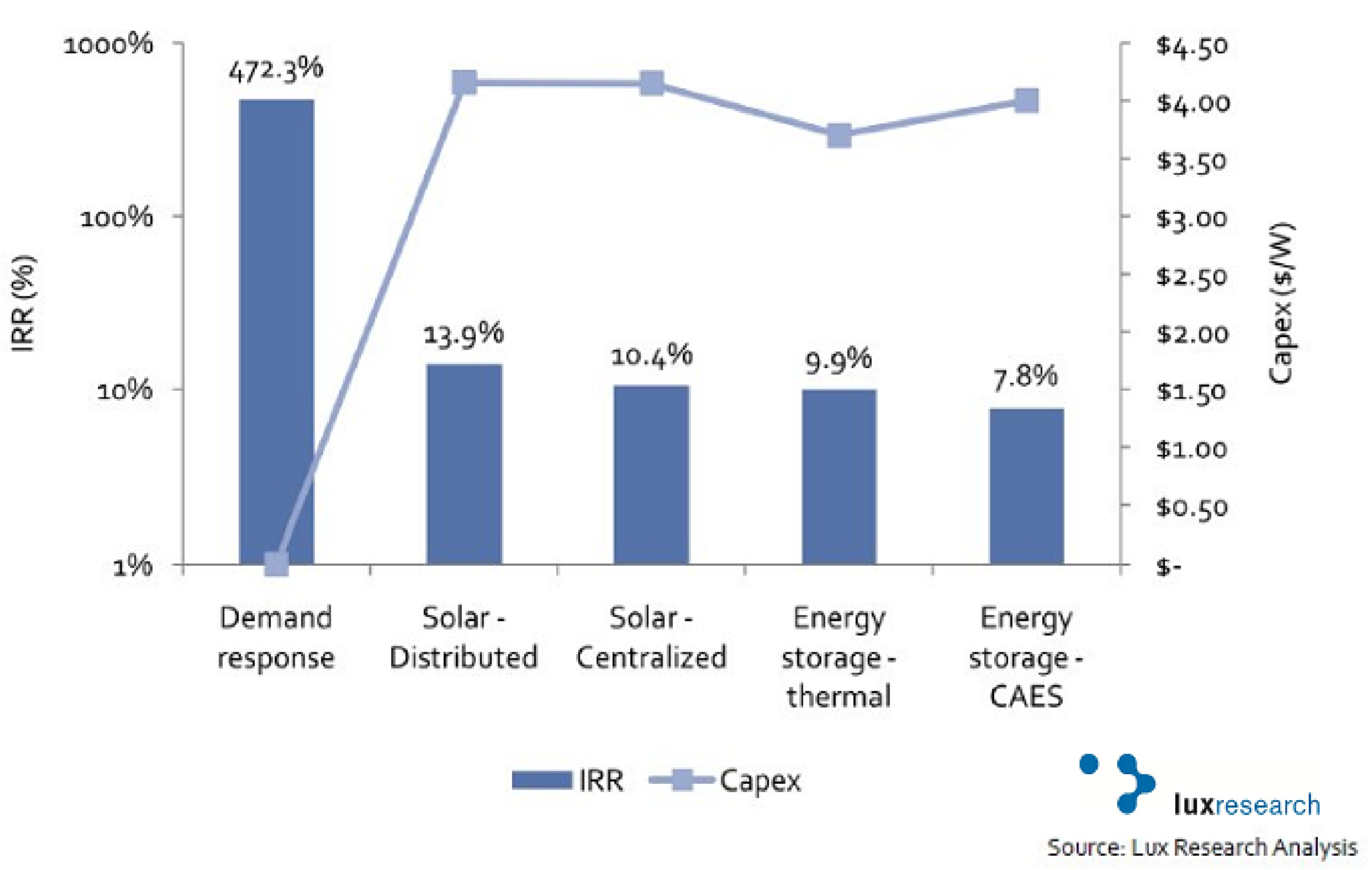
Capex & IRR capability of DR



Source: Brian Warshay, Highlighting Energy Storage as DR Resources, Lux Research, Inc. Grid Connectivity Week 2012, May 2012

Sample Demand Management System Architecture

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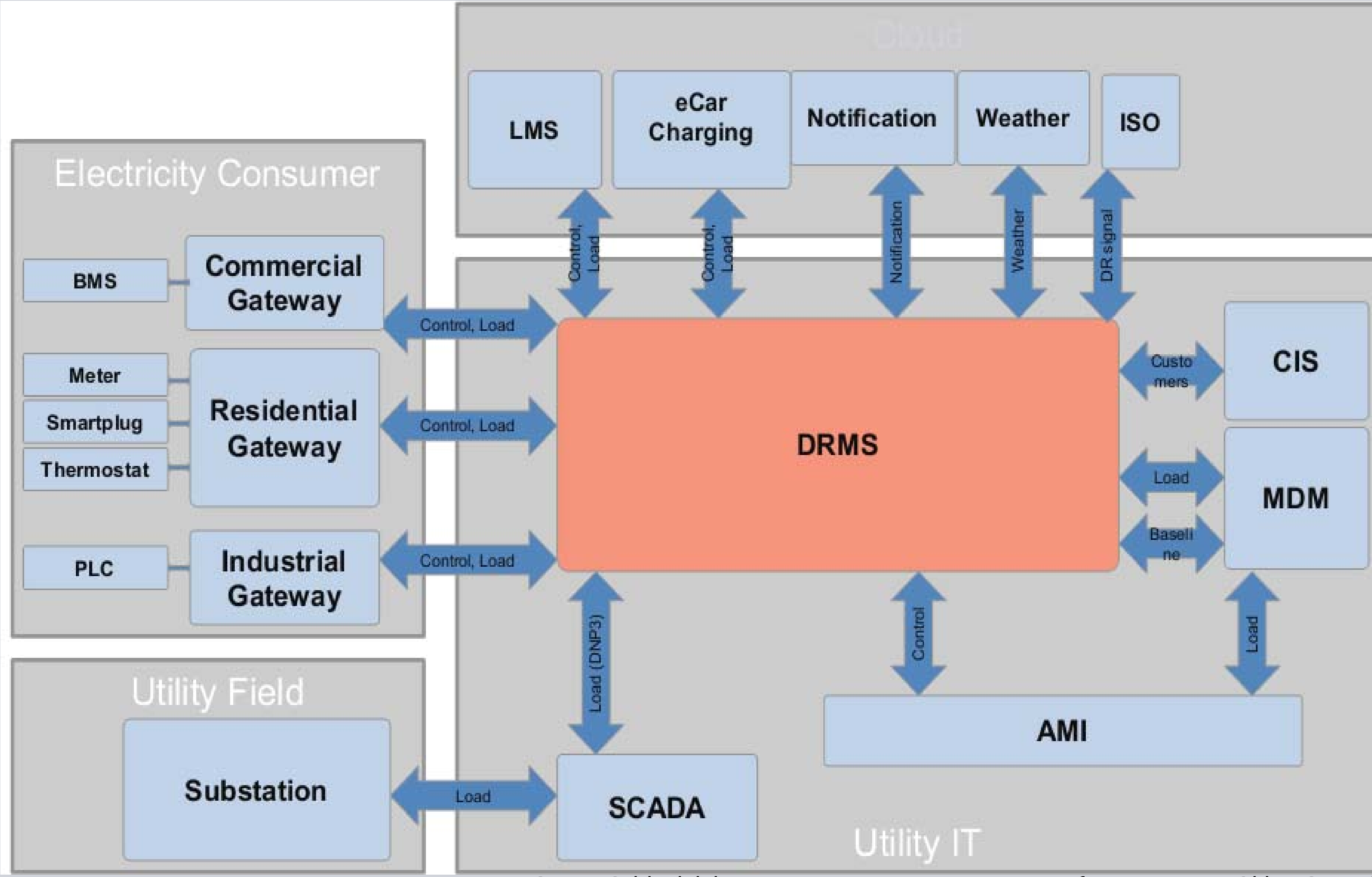

Mumbai DR success story

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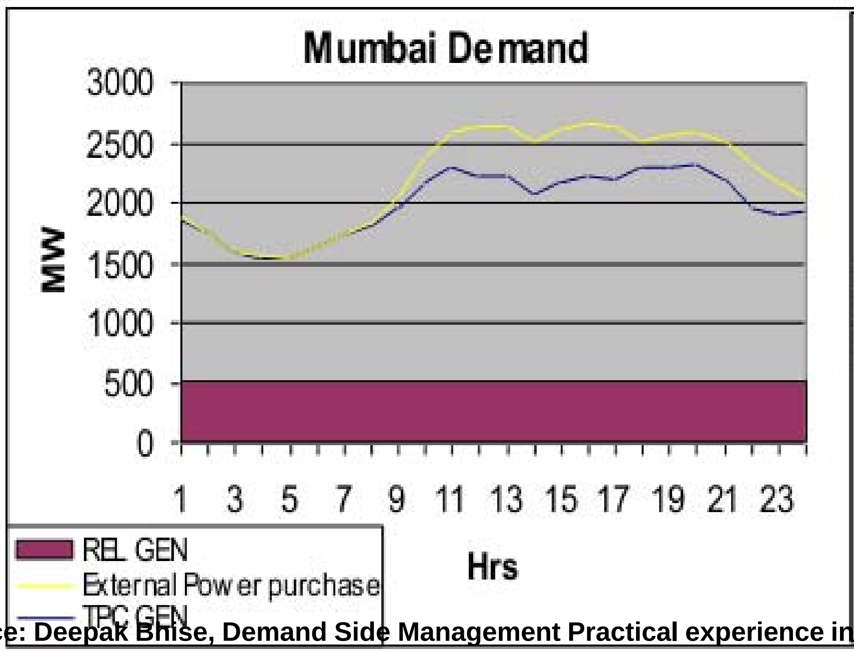
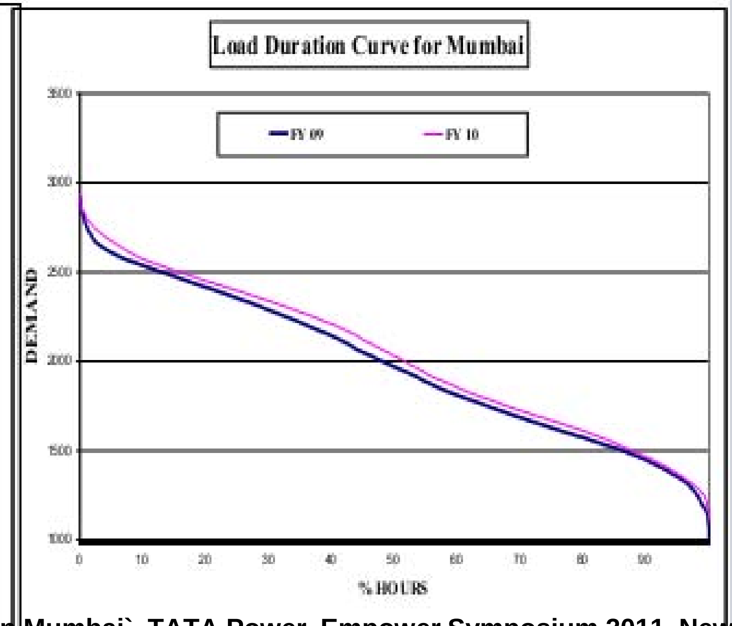
Demand Side Management : Utility Perspective

TATA

Mumbai Power Scenario :

- Needs purchase of 600 to 800 MW power in day time peak
- Load duration curve shows large distortion in peak and off peak power requirement.

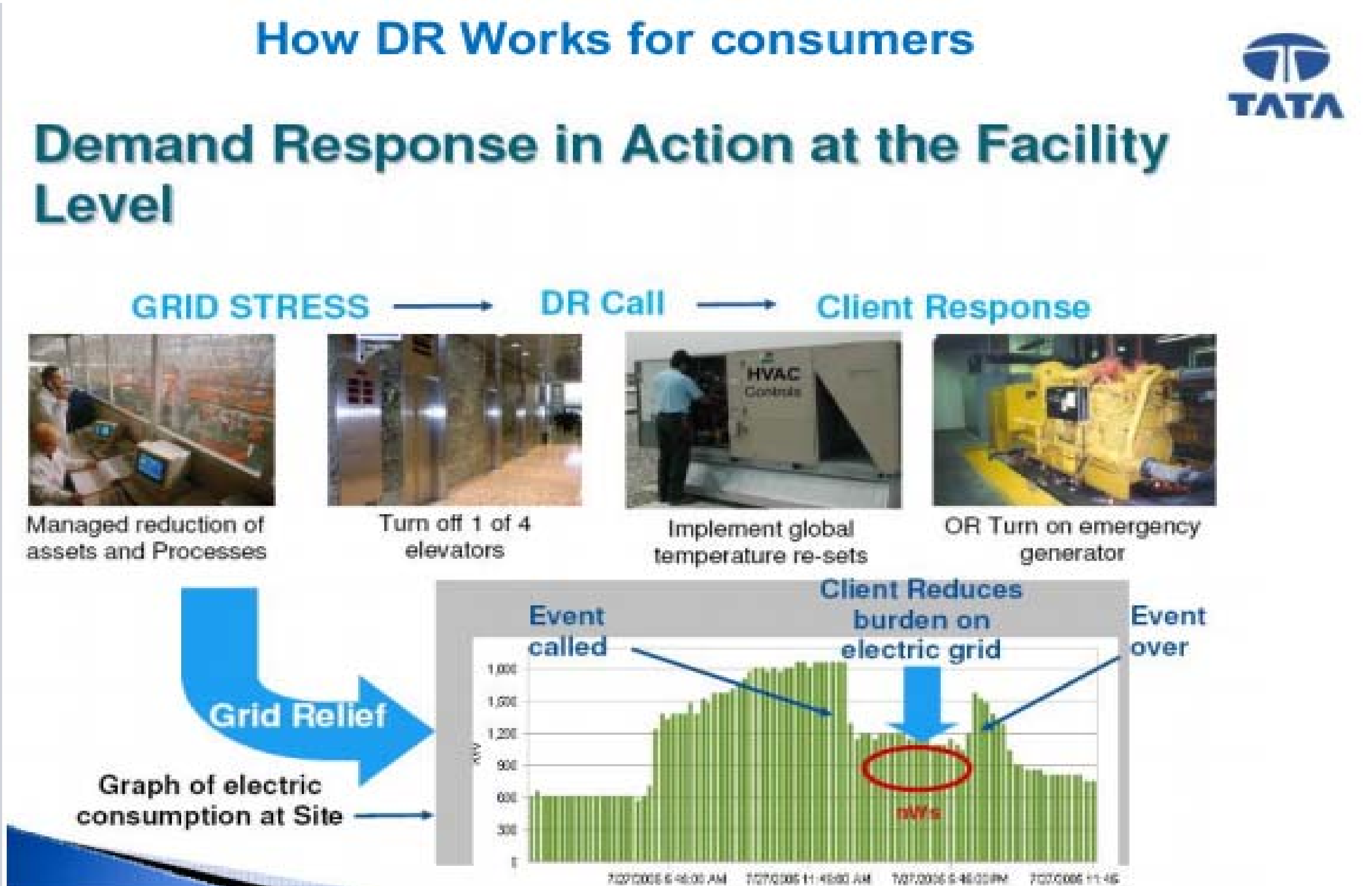




Source: Deepak Bhise, Demand Side Management Practical experience in Mumbai`, TATA Power, Empower Symposium 2011, New Delhi, Oct 2011

Mumbai DR success story

SIEMENS



Source: Deepak Bhise, Demand Side Management Practical experience in Mumbai`, TATA Power, Empower Symposium 2011, New Delhi, Oct 2011

Load Shifting Strategies

Thermal Storage program

- 40% of Mumbai load is of Central Air Conditioning
- Thermal Storage system runs Chillers in night and stores energy in ice tanks.
- Customers shifts load to night and gets benefit of TOD tariff.
- Saves on Maximum Demand Charges
- Tata Power motivates customers with rebate for using thermal storage

Source :- Bhise, Tata Power, ISGF July 2012

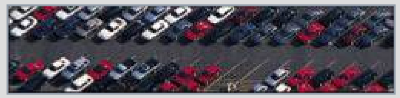
Siemens Electromobility infrastructure has different layers

Siemens Electromobility infrastructure portfolio overview

Solution and system integration = **Services and operation center** + **EV interface: charging infra-structure**

Services and operation center

Fleet management



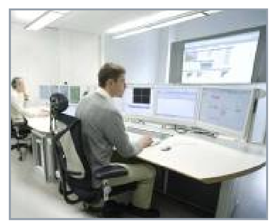
Customer portal

Energy management

Installation and maintenance

EV interface: charging infra-structure

EM software platform



- Operation and monitoring of hardware
- IT-solutions for service applications

Charging hardware

- AC, DC, inductive charging, and swapping hardware to charge BEVs and PHEVs

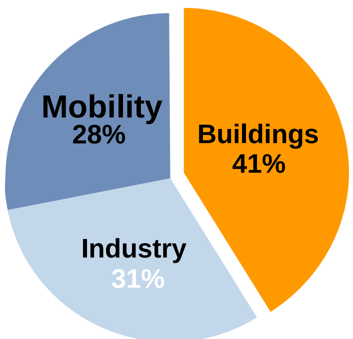
EM: Electromobility BEV: Battery Electric Vehicle PHEV: Plug-in Hybrid Electric Vehicle

Source: SGA-EM Sales Setup

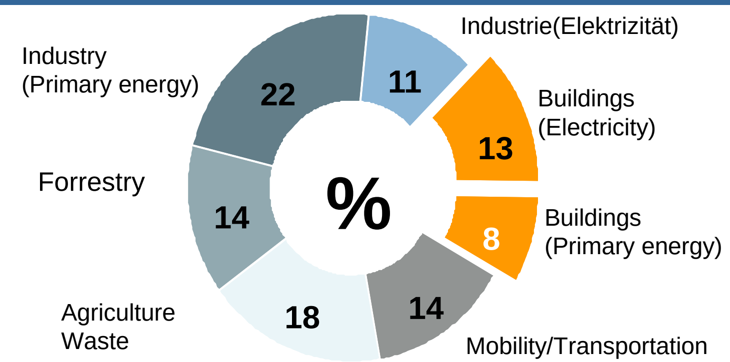
Buildings are the major energy consumer over their entire life cycle

SIEMENS

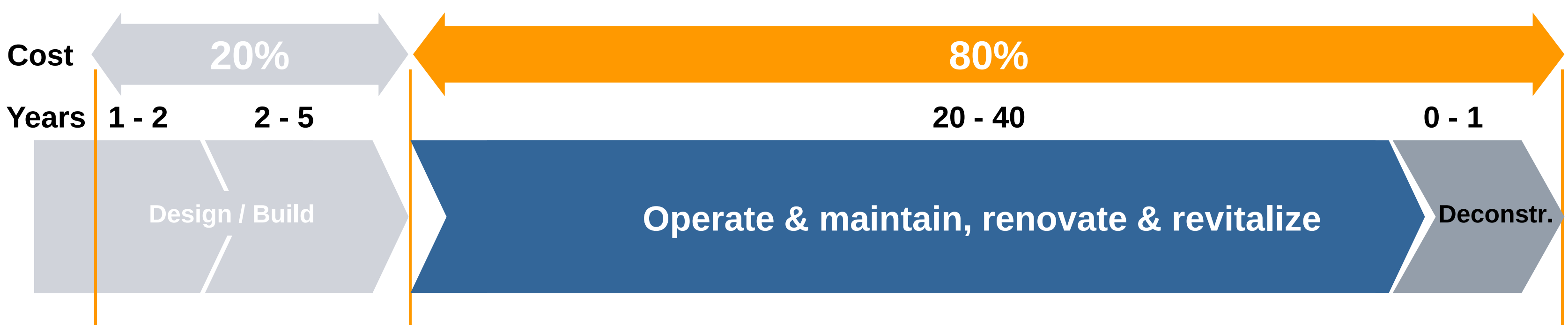
40% of the world energy consumption*



21% of the global green house gas emissions***

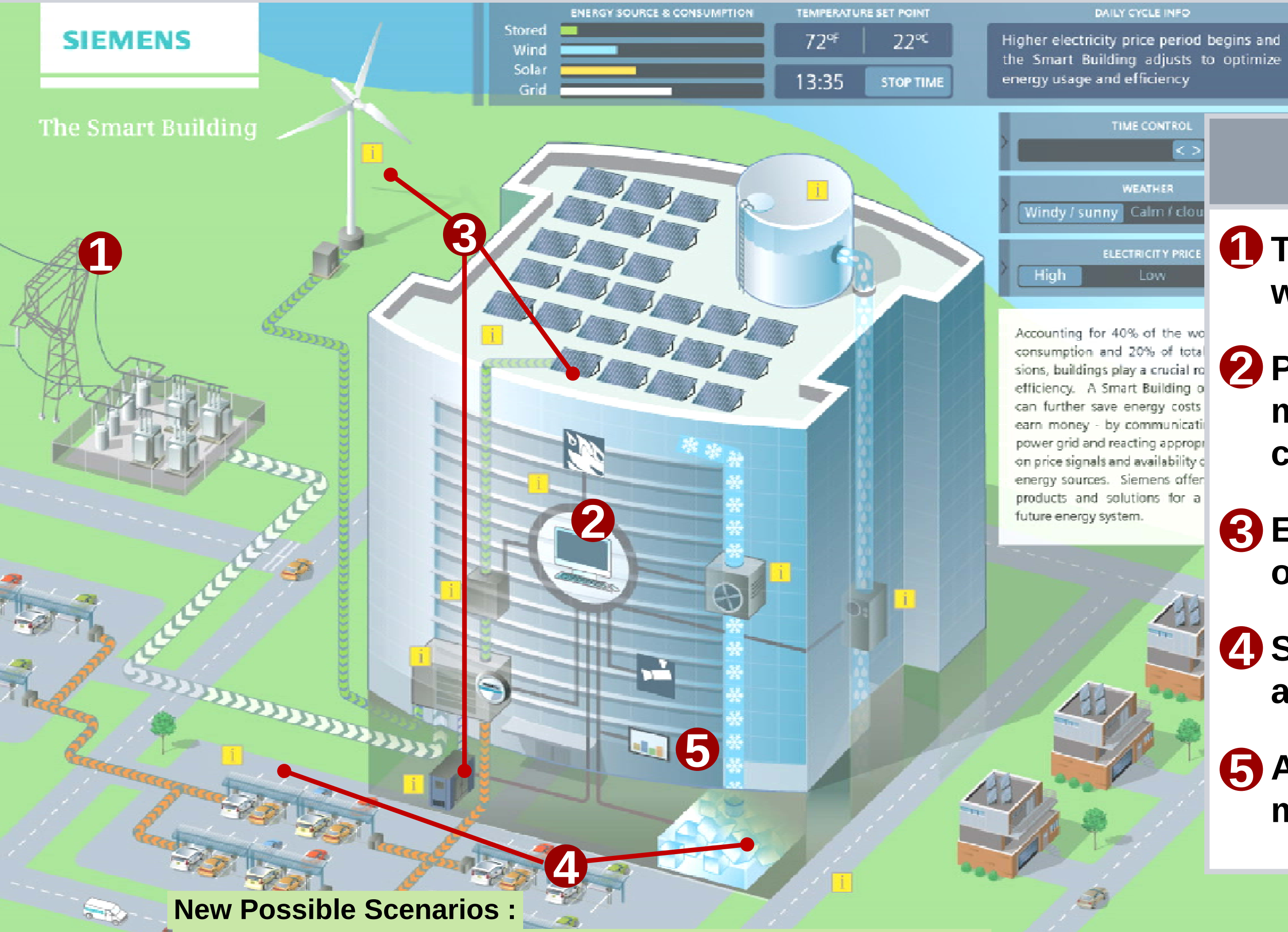


Energy accounts for 40% of the building operation cost**



*International Energy Association, auf weltweiter Basis, im Jahr 2002 / ** Dena Congress, Berlin, 2008 / *** „Global Mapping of Greenhouse Gas Abatement Opportunities up to 2030",
Building Sector deep dive, June 2007, Vattenfall AB, basiert auf Information von IEA, 2002, % der weltweiten Treibhausgasemissionen; Total 40 Gt CO2e

Smart Building



Applications

1. Two-way communication with utilities
2. Proactive energy management / smart consumption
3. Energy sources with onsite generation assets
4. Storage capacity for added flexibility
5. Active carbon management

New Possible Scenarios :

Low Energy Tariff: Building consumes energy from the Grid

High Energy Tariff : Building delivers energy to Grid

Smart Building: Infrastructure

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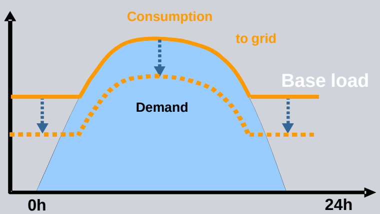
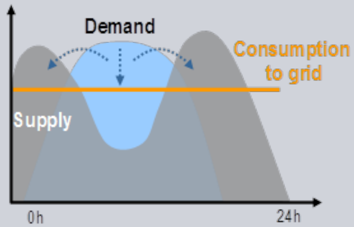
Smart Building

Smart grid infrastructure

Control strategies

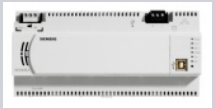




Onsite generation

Storage

Smart consumption infrastructure



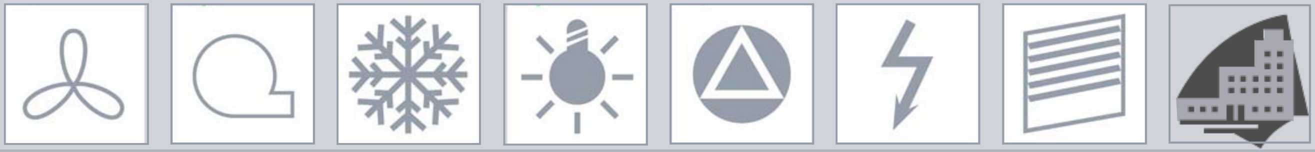
OpenADR
ZigBee
BACnet

APOGEE ANYWHERE

Energy management applications

Transparency infrastructure

Efficiency built into building systems and integration into the Building Automation System



Microgrid Solutions overview

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Description:

- Large industry customers, which have own energy production for electricity and heat / power process
- Energy Management System, which balances own production with demand
- Forecasting and market interface

Benefit:

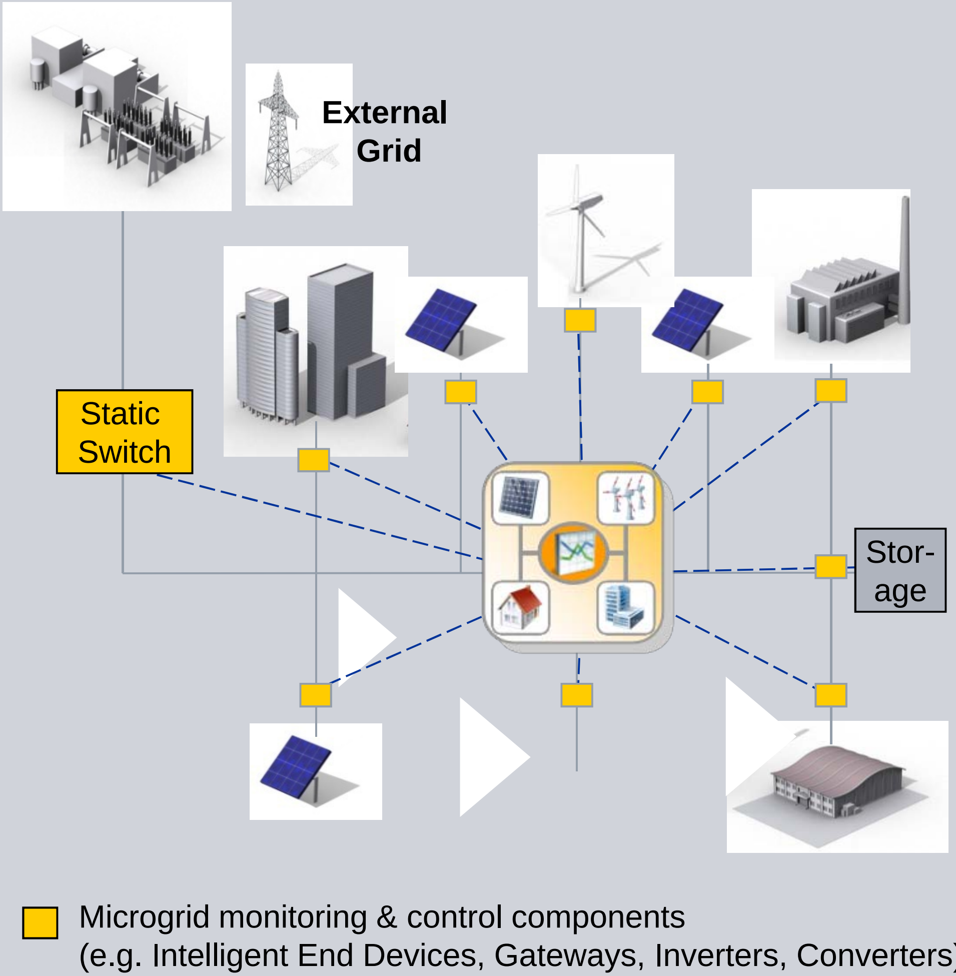
- Reduction of energy costs of roughly 5% by intelligent forecasting and load prediction
- Island mode operations possible

Potential customers:

- All energy intensive industries (e.g. pulp & paper, metals, chemical, cement)
- Airport, harbours

Solution components:

- DEMS system
- Metering infrastructure including energy data management



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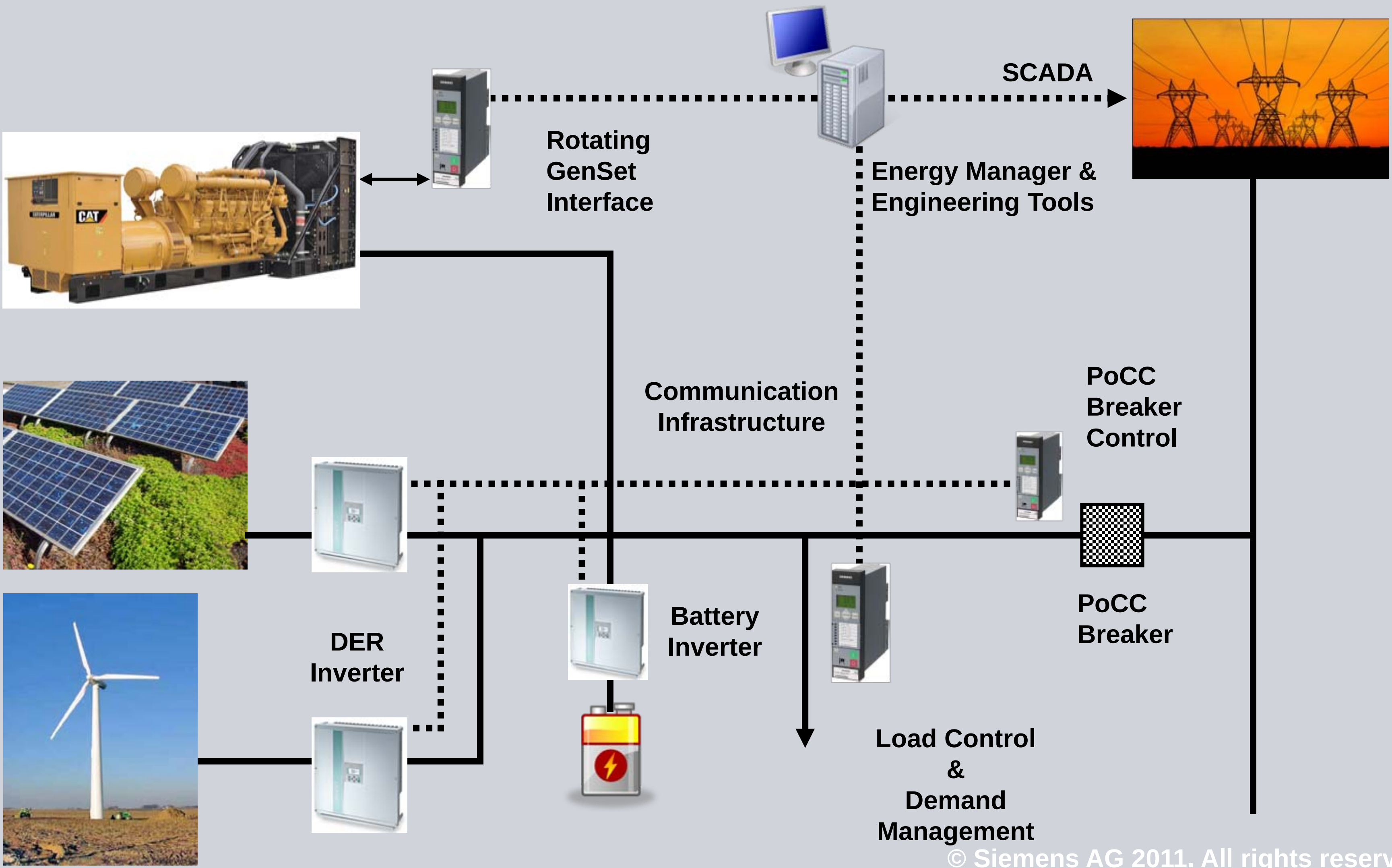
Microgrid components for integration & control



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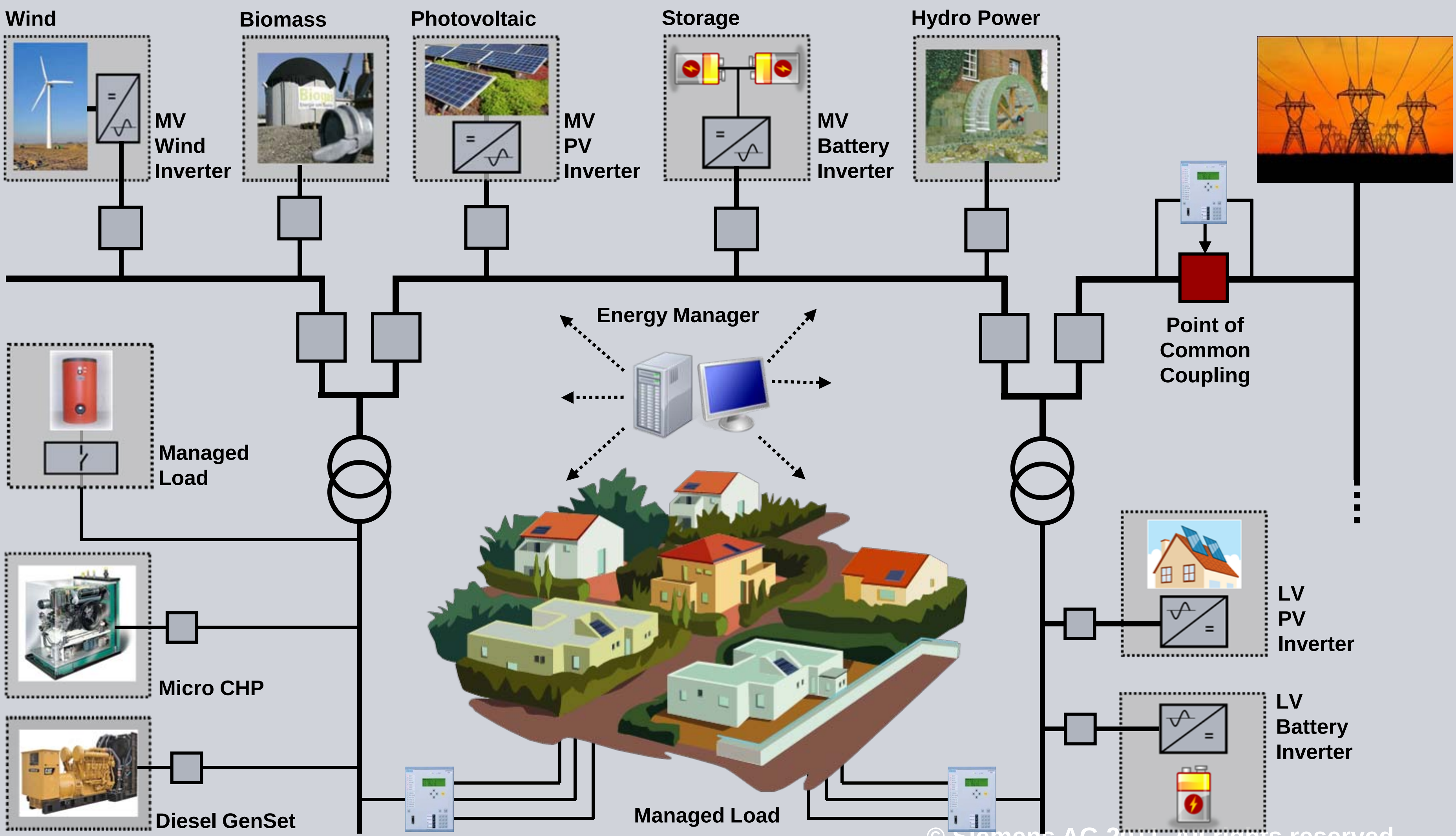
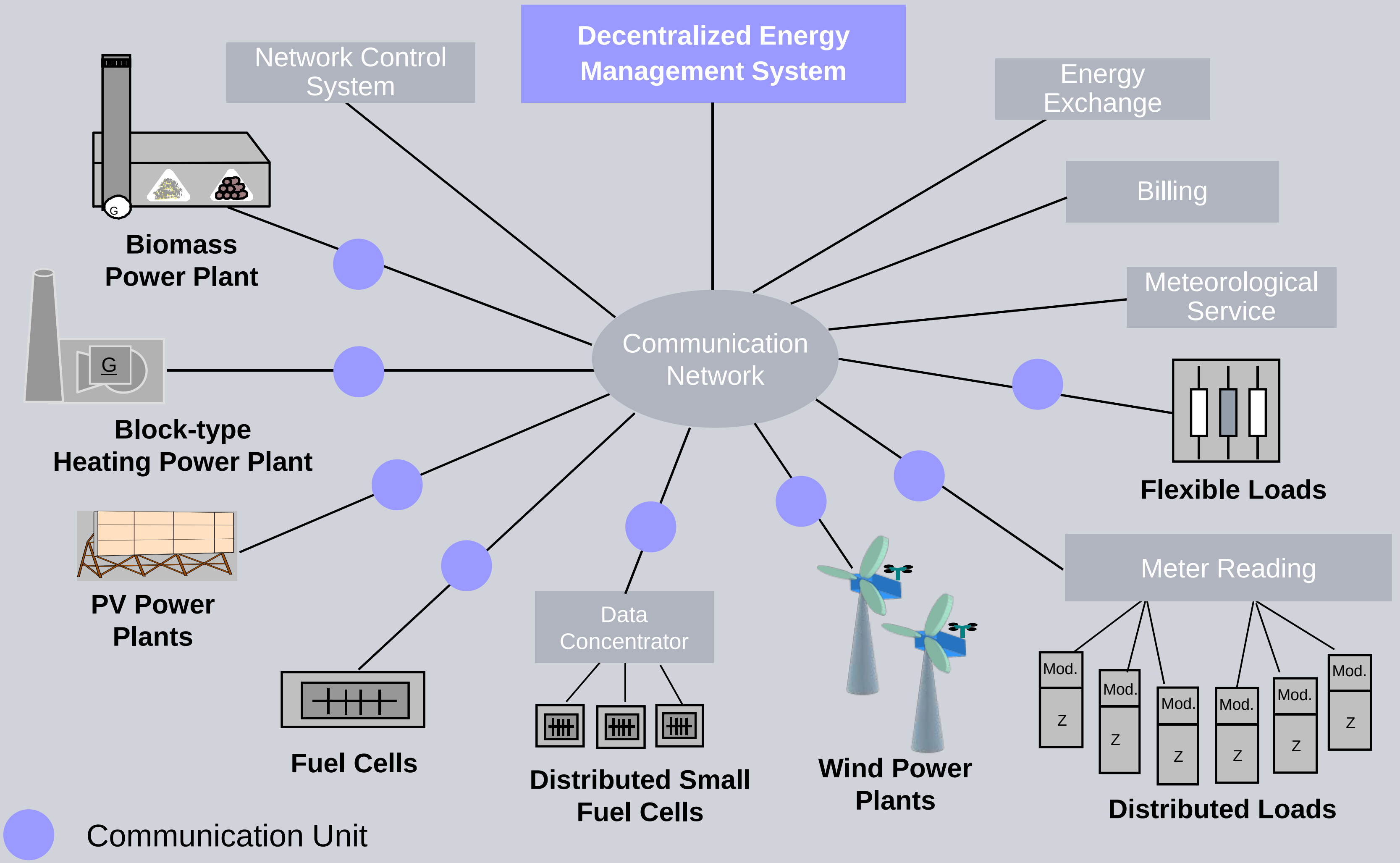
Microgrid with Generation & Load Management



Virtual power plant – the control of distributed energy resources

SIEMENS



Some International Smart Grid initiatives

Integration of Renewables
Project IRENE

Challenges in 2020

Distributed renewable energy generation

High density of electric vehicles

Extension of distribution grid

The Project IRENE

Approach

- Real-word realization of 2020 extension status for renewable generation and eCar-density
- Installation of a **measurement and control system** in a municipality with high degree of PV-installation
- Coordination and active control of energy generation and charge management of **electric vehicles**
- Active- and Reactive power control of **PV-plants**
- Storage of solar energy in stationary **Batteries**, as well as in electric vehicles during generation peaks
- Introduction of **switchable** transformers (tap-changers) for **voltage control**

Project E-DeMa – Basic Concept

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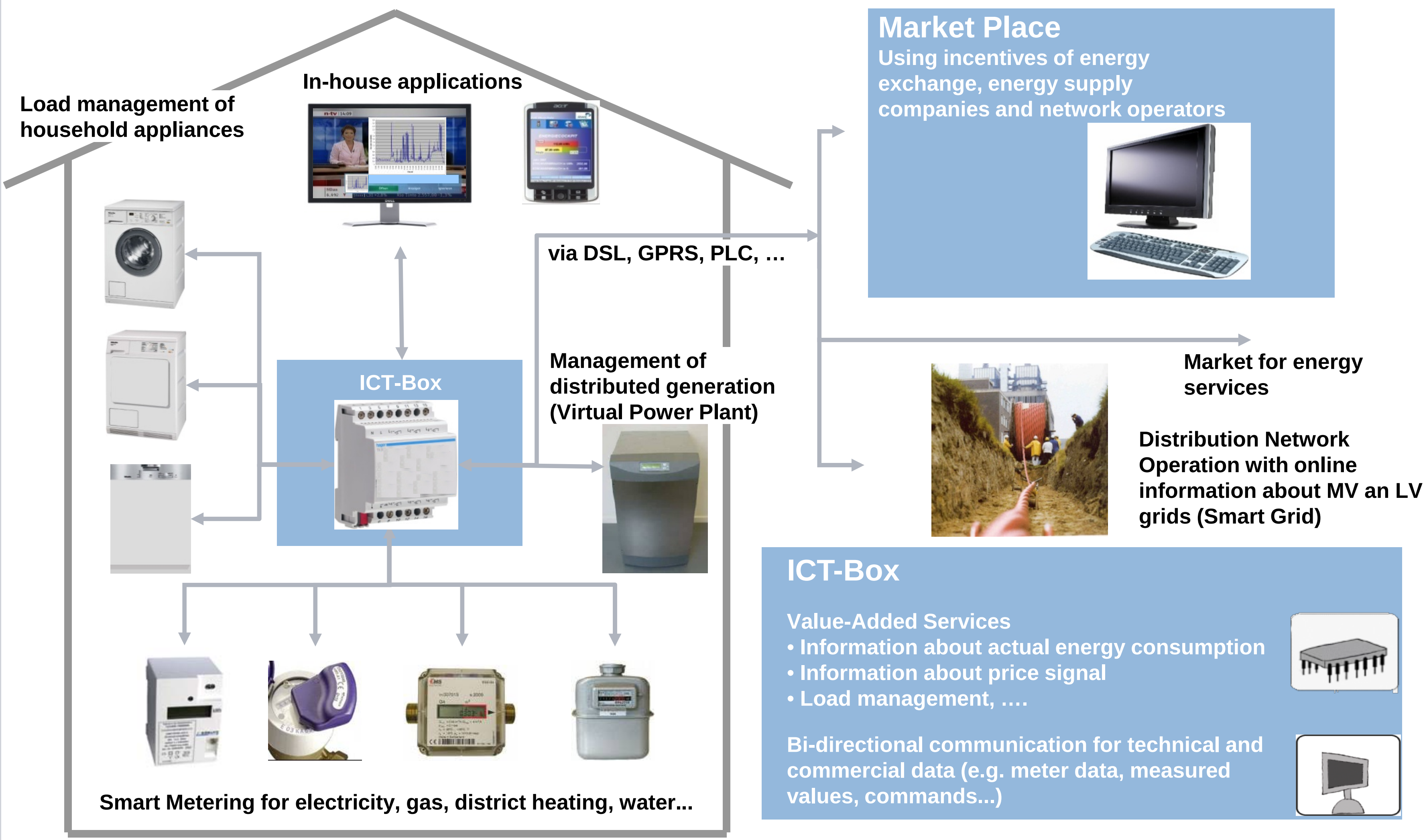

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RWE Wind Heating Pilot project – Overview

Project Objective

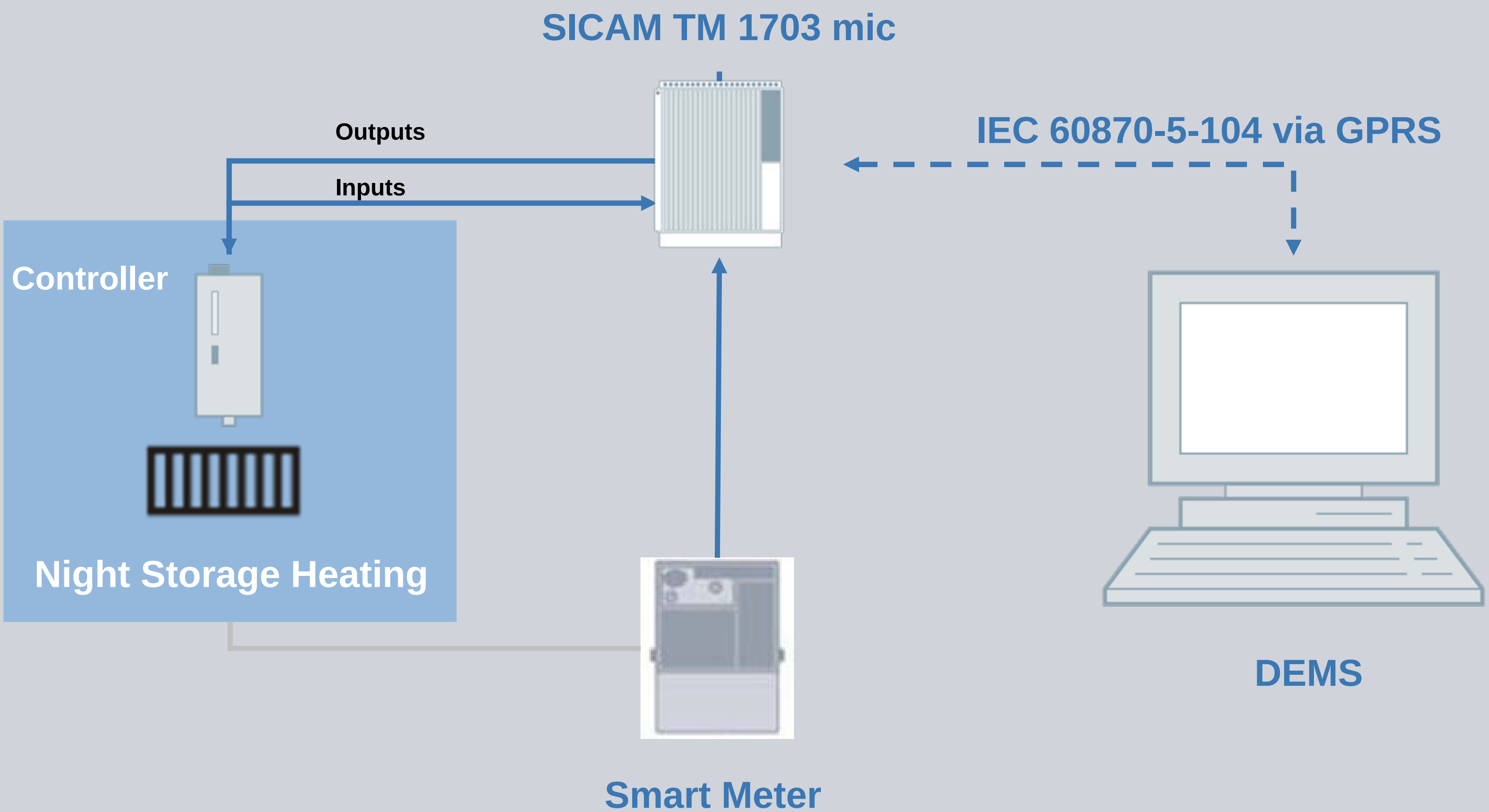
- RWE uses the research project to identify **potential business cases for using the storage capacity of night storage heating systems in different energy markets, e.g market for minute reserve**
- 50 Households have been equipped with the DER-Controller and an adpated controller unit
- Research project shall deliver the data for assessing the technical and econimcal benefits.

Time Period

Since 2011

RWE

RWE Wind Heating – Technical Solution



Japan - Smart Community Projects
– Four large scale pilot projects started in 2010 –

SIEMENS

Yokohama City	**Tokyo Electric Power et al. plan to begin testing demand response in the spring of 2013, with the ultimate goal of expanding targeted households to 4,000 homes. It plans to use data from the test in its evaluations of dynamic pricing and other flexible pricing options for its service area.**
Toyota City	**Toyota and Chubu Electric Power have been testing demand response since December 2011.**
Keihanna District	**Beginning in the summer of 2012, Kansai Electric Power et al. will be testing demand response in 900 households.**
Kitakyushu City	**In April 2012, the City of Kitakyushu, Nippon Steel et al. plan to test a** "real time pricing" **system, which changes electricity prices on any given day in response to supply and demand. This test, the first such attempt in the world, will involve 230 households and 50 factories and other industrial establishments. The findings from this test will be provided to Kyushu Electric Power.**

PC 118: DR Use cases proposed by Japan National Committee

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No.	Name	No.	Name
1	Control energy consumption with smart appliances by Energy Provider	7	Peak Shift Contribution by Battery Aggregation (Virtual Energy Storage)
2	Control energy consumption with smart appliances by Building Energy Management System (BEMS)	8	Control of Smart home appliances based on price information by time slot
3	Control energy consumption with smart appliances by Community Energy Management System	9	Control of Smart home appliances in response to power saving request from Electric power supplier
4	Control energy consumption via Home Energy Management System (HEMS) with smart appliances	10	Control of Smart home appliance before power cut
5	Control Battery via Home Energy Management System (HEMS)	11	Control of Smart home Appliances in case of natural disaster
6	Control Distributed Energy Resources (DER) via Home Energy Management System (HEMS)		

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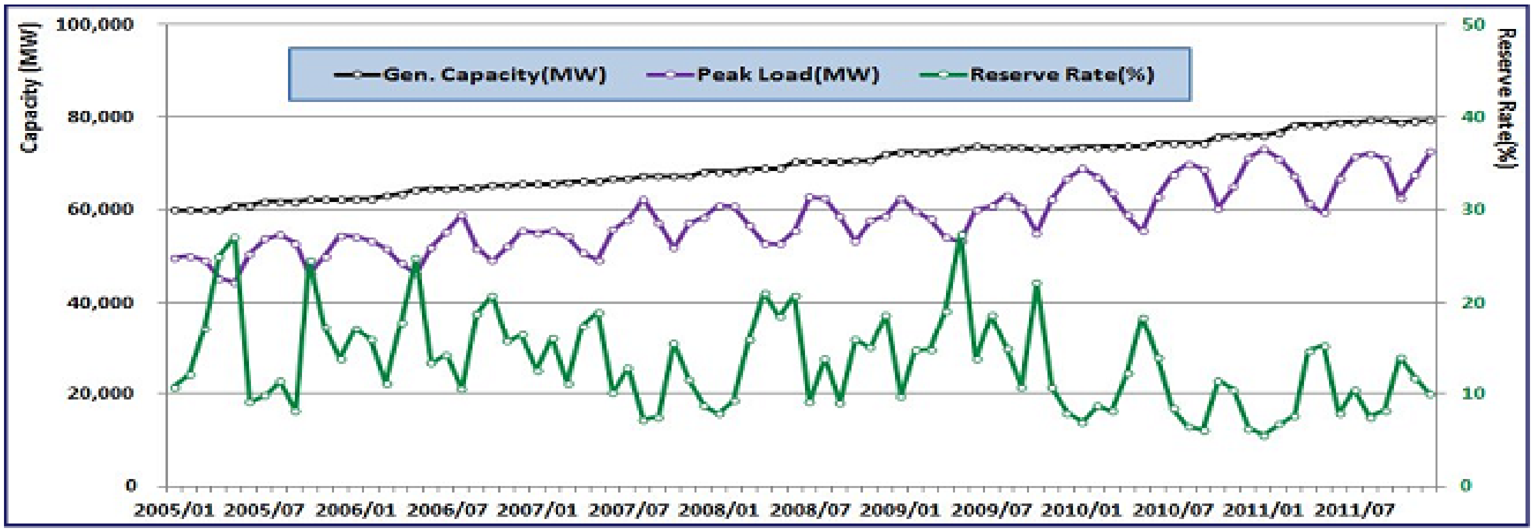
South Korea

Generation capacity and Peak Demand



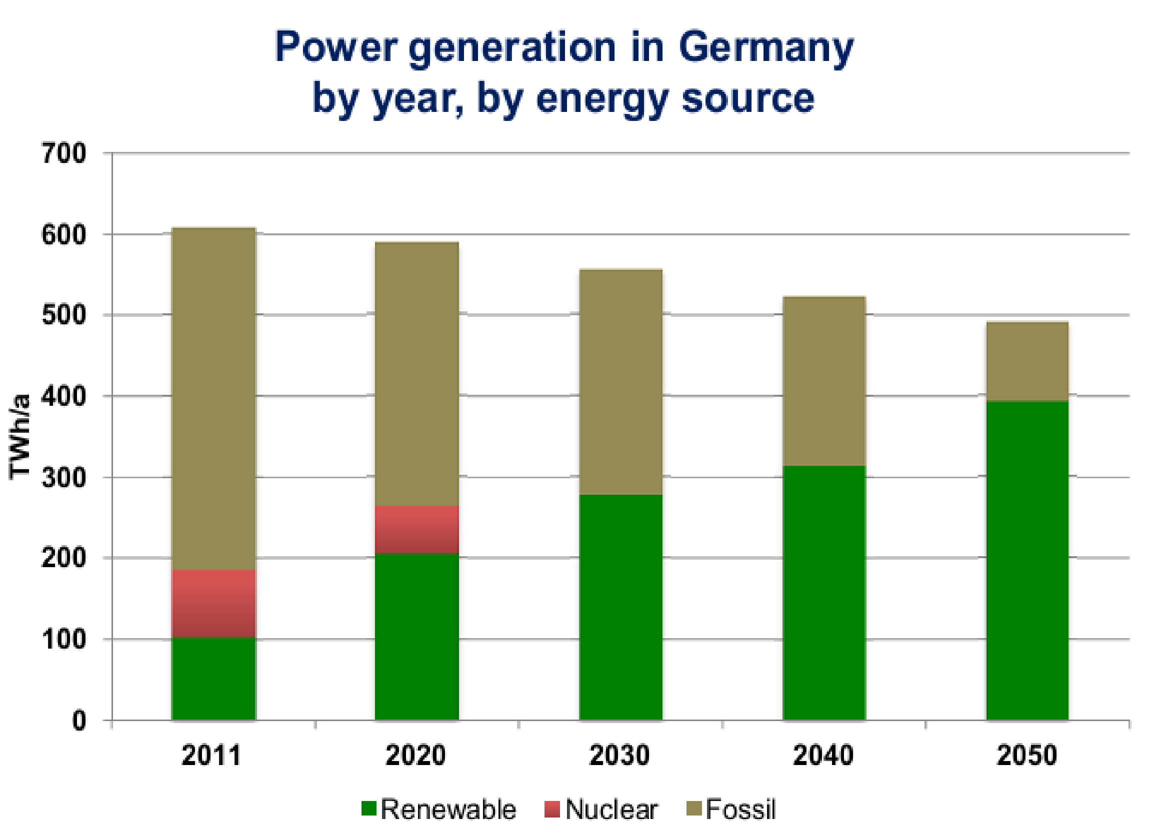
	2005	2006	2007	2008	2009	2010	2011
Gen. Capacity (MW)	61,740	64,780	67,200	70,350	73,310	76,080	79,342
Peak Load (MW)	54,630	58,990	62,290	62,790	66,800	71,310	73,140
Annual Growth (%)	6.6%	8.0%	5.6%	0.8%	6.4%	6.3%	2.6%

Trend of reducing Reserve Rate calls for effective Demand Management programs

Source: Chang Ho Re, DR Program Development in Korea, Grid Connectivity Week 2012, May 2012

Germany

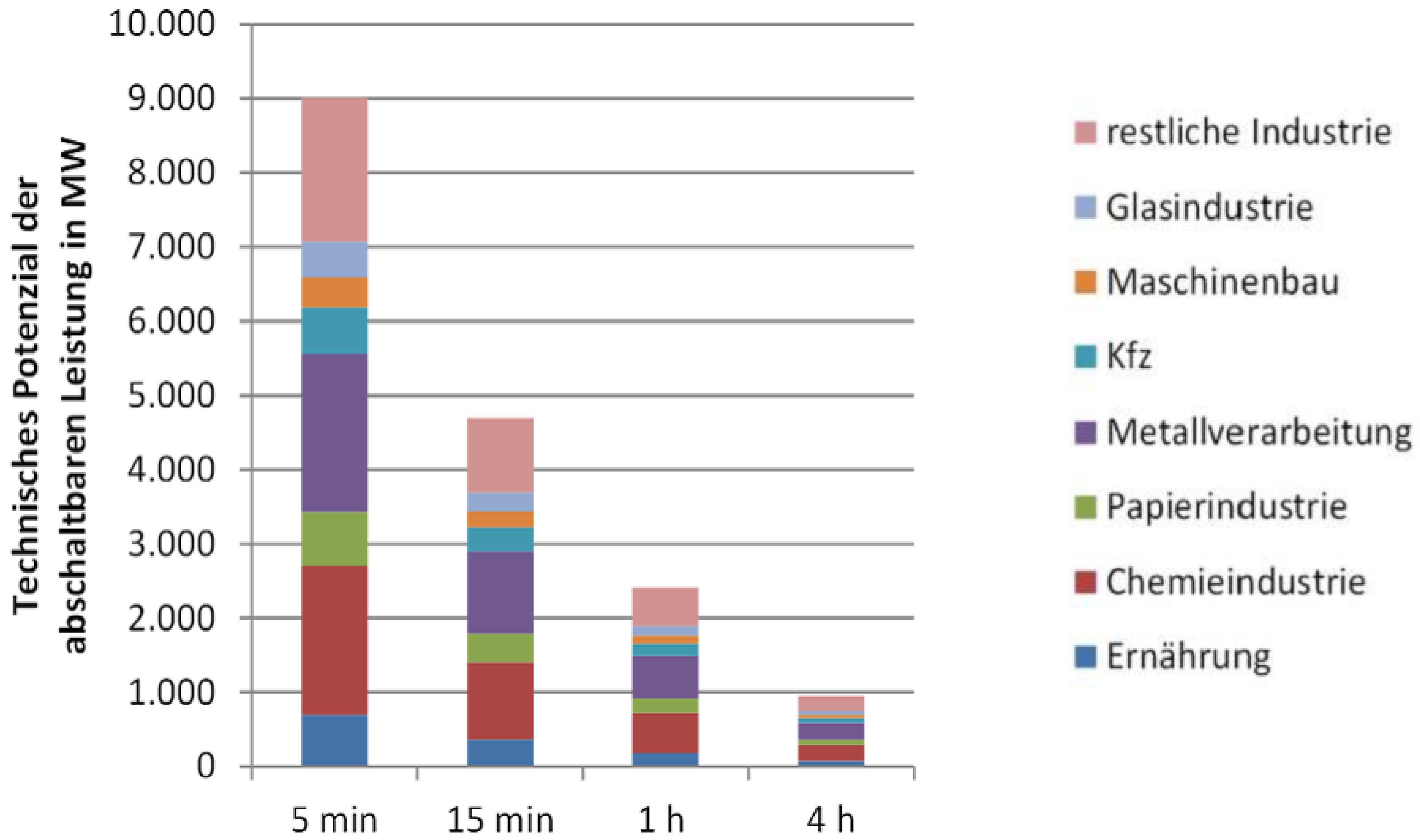
Germany’s energy turnaround based on energy efficiency, renewables and phasing out of nuclear power



Source: Industrial / Commercial Demand Response as a Business Model - A practical view - EnInnov2012 at Technical University Graz

DR in Germany

DR Potential by Industry (9 GW in 5 min)



Source: FfE, München

Standard to be developed: US Perspective

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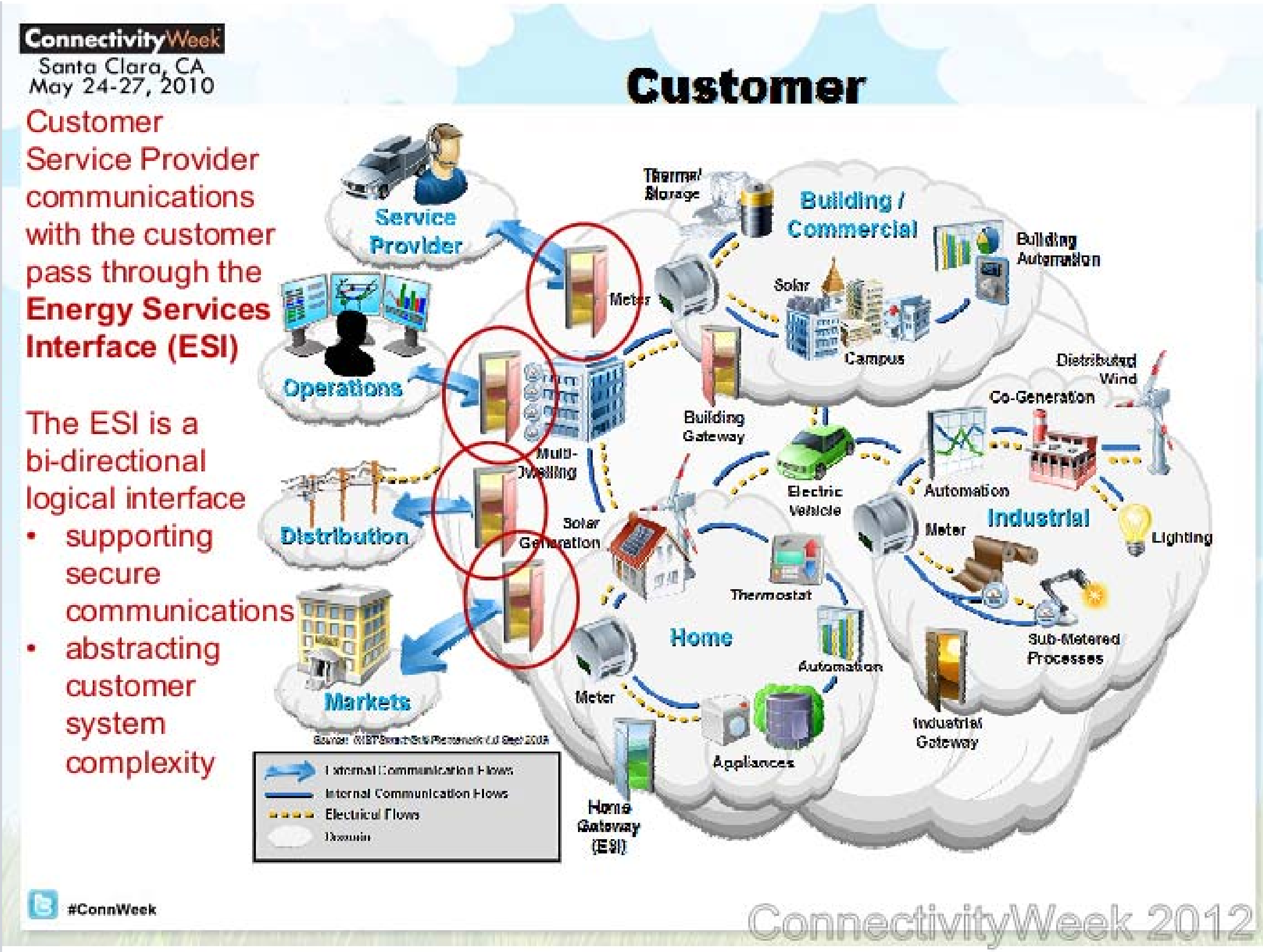

Energy Services Interface

External Service Providers *

- Wholesale Markets
- Retail Service Provider
- Curtailment Specialist
- Distribution System Operator
- Micro-Grid

Facility Service Consumers *

Facility service gateway

- Residential gateway, EMS
- C&I EMS or other business system

Facility device information model

Loads:
- Systems
- Equipment
- Appliances
- Devices
- Electric Vehicles

Storage:
- Active
- Passive

Generators:
- Variable
- Non-variable

Meter [3]

[1] DR event notification, start time, duration, shed level/ price, bid acceptance

[2] Energy usage, per NAESB ESPI standard provides validated meter data from utility back end.

[3] The meter shown here in the facility domain is a sub-meter. The utility revenue meter may also provide data to the facility owner using the facility meter data model.

*The service providers and consumers listed here are given as examples and not meant to be comprehensive.

Standards to be developed:
Proposed by Chinese National Committee in PC 118

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standard1 : Standard for DR term, DR capability, DR signal model

standard2 : standard for requirement of DR-ready appliance and customer EMS

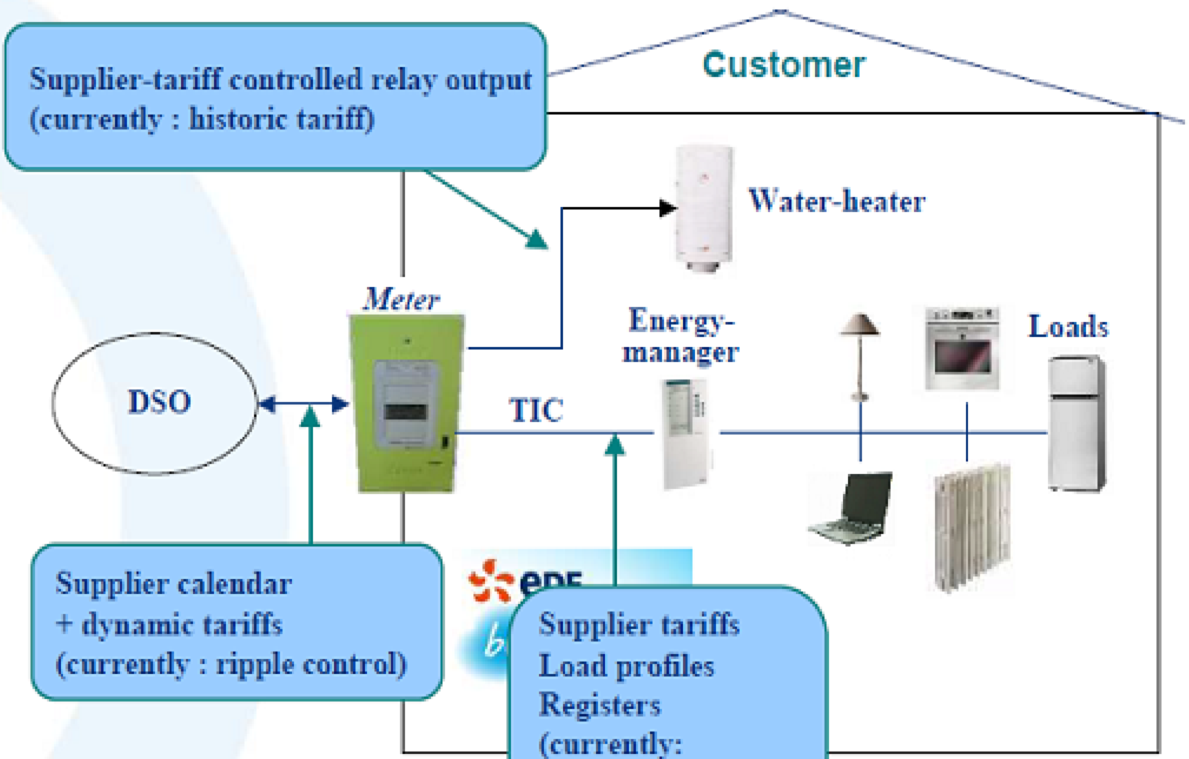
standard3 : standard for communication interface between grid system and smart appliance

standard4 : Standard for communication interface and information exchange between grid system and EMS

standard5 : standard for measurement and verification of DR program

DR in France Perspective

- Smart meter + customer without e-box (post-AMM situation in France)



TIC = customer digital output bus (HN 44-S-81)

Similar architectures

Similar to Enel's architecture but offers additional digital output bus

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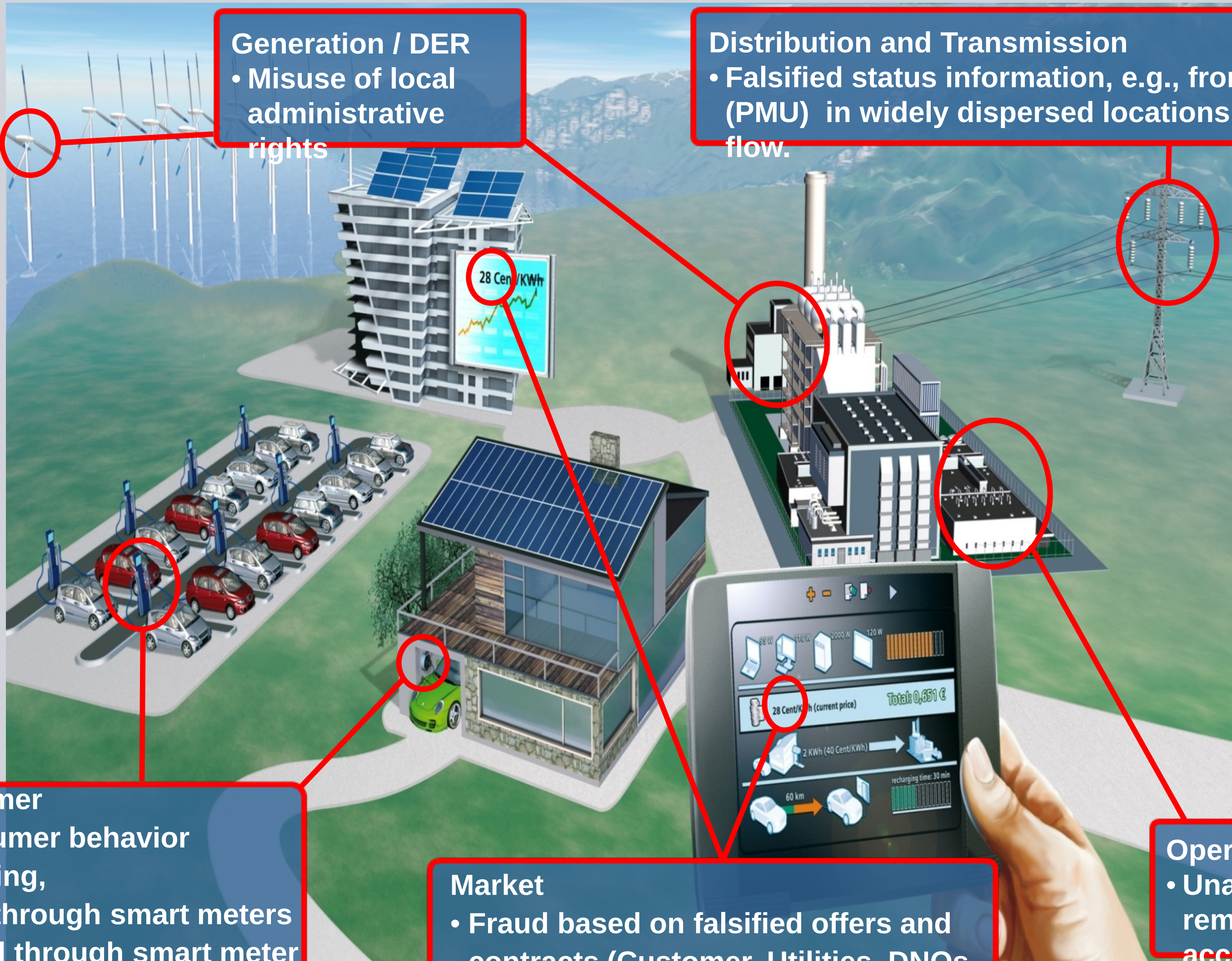
Security Requirements for Smart Grid Applications from a Variety of Potential Attacks (Examples)



Generation / DER
- Misuse of local administrative rights

Distribution and Transmission
- Falsified status information, e.g., from synchrophasors (PMU) in widely dispersed locations may limit the power flow.

Customer
- Prosumer behavior tracking, e.g., through smart meters
- Fraud through smart meter manipulation

Market
- Fraud based on falsified offers and contracts (Customer, Utilities, DNOs, …)

Operation
- Unauthorized remote service access

Priorities in IT Security

SIEMENS

Availability / Protection – **Integrity** – **Confidentiality**

Switch-Off is seen as one of the biggest risk in the context of cyber security !

The New York Times

26th July 2012:

America preparedness for a large scale cyber attack is ‘3’ on a scale of 1 to 10

Core Standards for Smart Grid
IEC TC57 Reference Architecture

SIEMENS

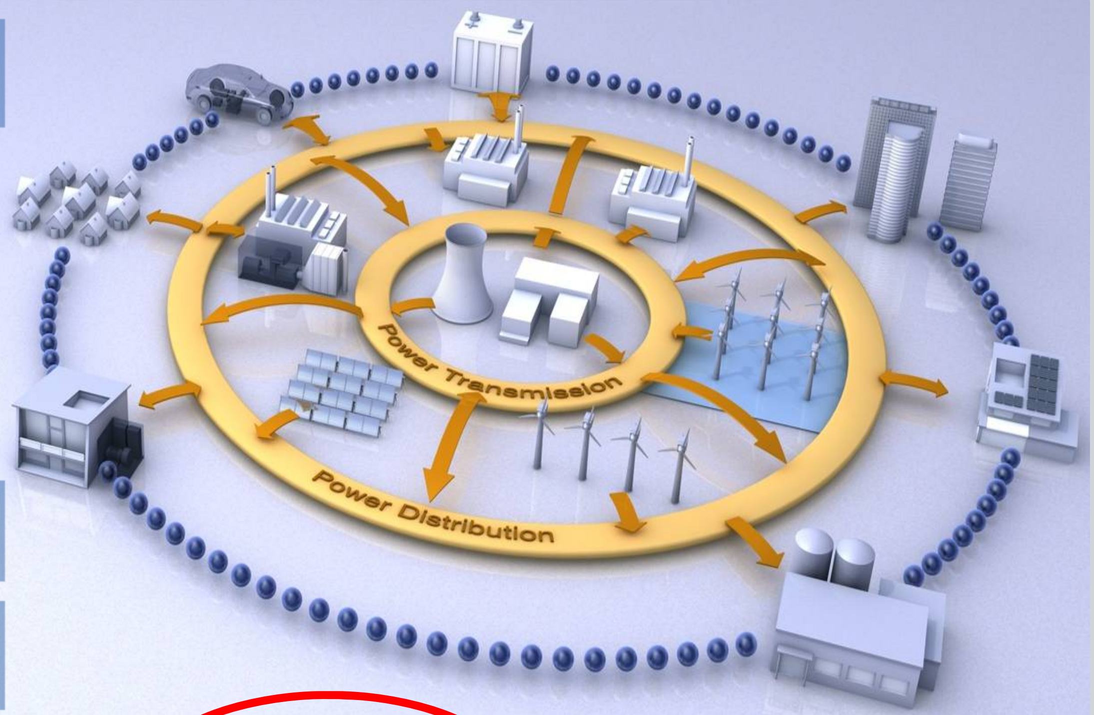
Common Information Model
IEC 61970 / 61968

Market Communication
IEC 62325

Substation Automation
Distribution Automation
DER Automation
IEC 61850

Tele-control Protocols
IEC 60870

Smart Metering
IEC 61334 DLMS, IEC 62056 COSEM



Cyber Security
IEC 62351

NIST Interop Report

IEC Roadmap

EU Mandate Report

DKE Roadmap

IEC 62351 produced by IEC TC57 WG15 – Enables secure modern Energy Control Networks

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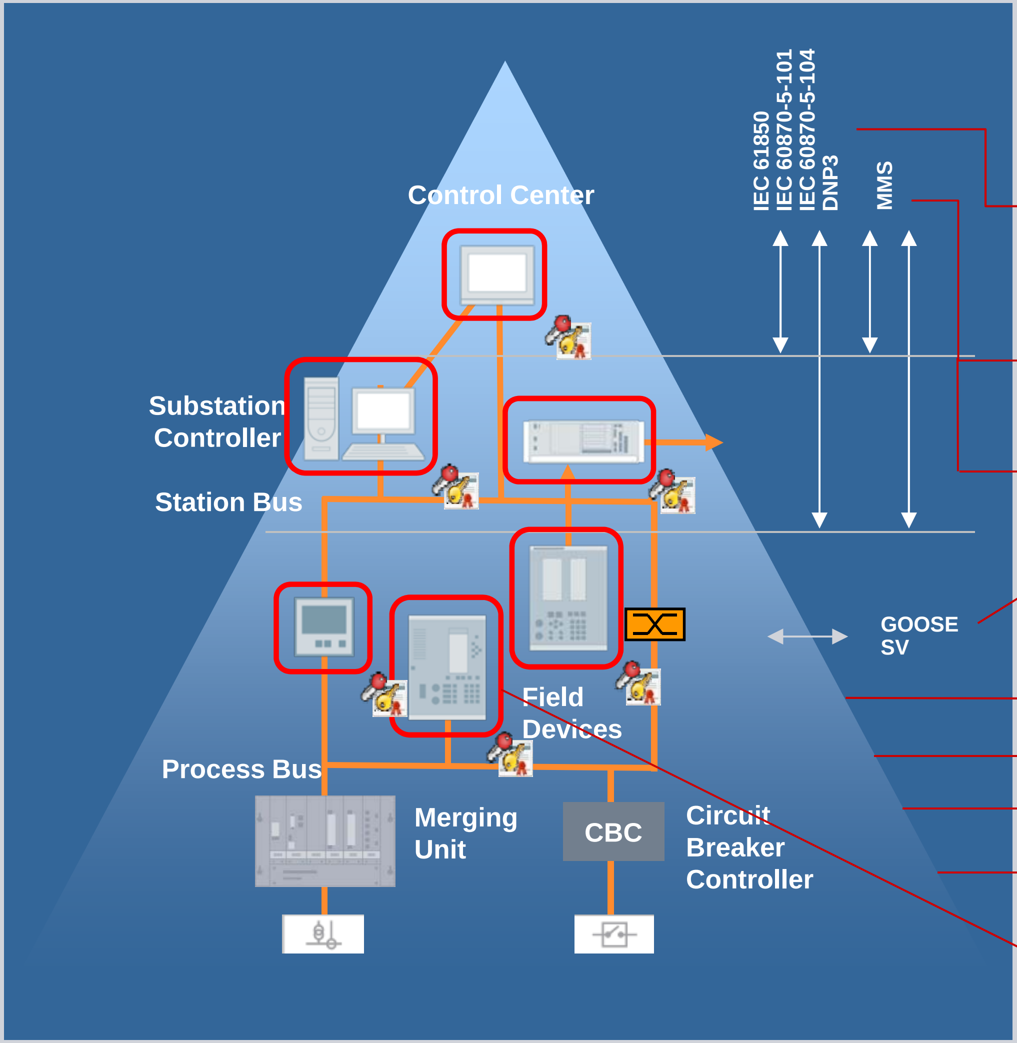

- Integrity protection and encryption of control data
- Part 1: Introduction
- Part 2: Glossary
- Part 3: Profiles including TCP/IP (cover those profiles used by ICCP, IEC 60870-5 Part 104, DNP 3 over TCP/IP, and IEC 61850 over TCP/IP)
- Part 4: Profiles including MMS (cover those profiles used by ICCP and IEC 61850)
- Part 5: Security for IEC 60870-5 and derivatives (covers both serial and networked profiles)
- Part 6: Security for IEC 61850 Peer-to-Peer Profiles (profiles that are not based on TCP/IP)
- Part 7: Network and System Management
- Part 8: Role Based Access Control
- Part 9: Key Management
- Part 10: Technical Report regarding Security Architecture Guidelines for TC 57 Systems
- Part 11: Security for XML Files

"If Alexander Graham Bell were somehow transported to the 21st century, he would **not begin to recognize** the components of modern telephony – cell phones,texting, cell towers, PDAs, etc. – while Thomas Edison,one of the grid's key early architects, would **be quite familiar** with the grid"

Thank you for your attention

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Questions ??

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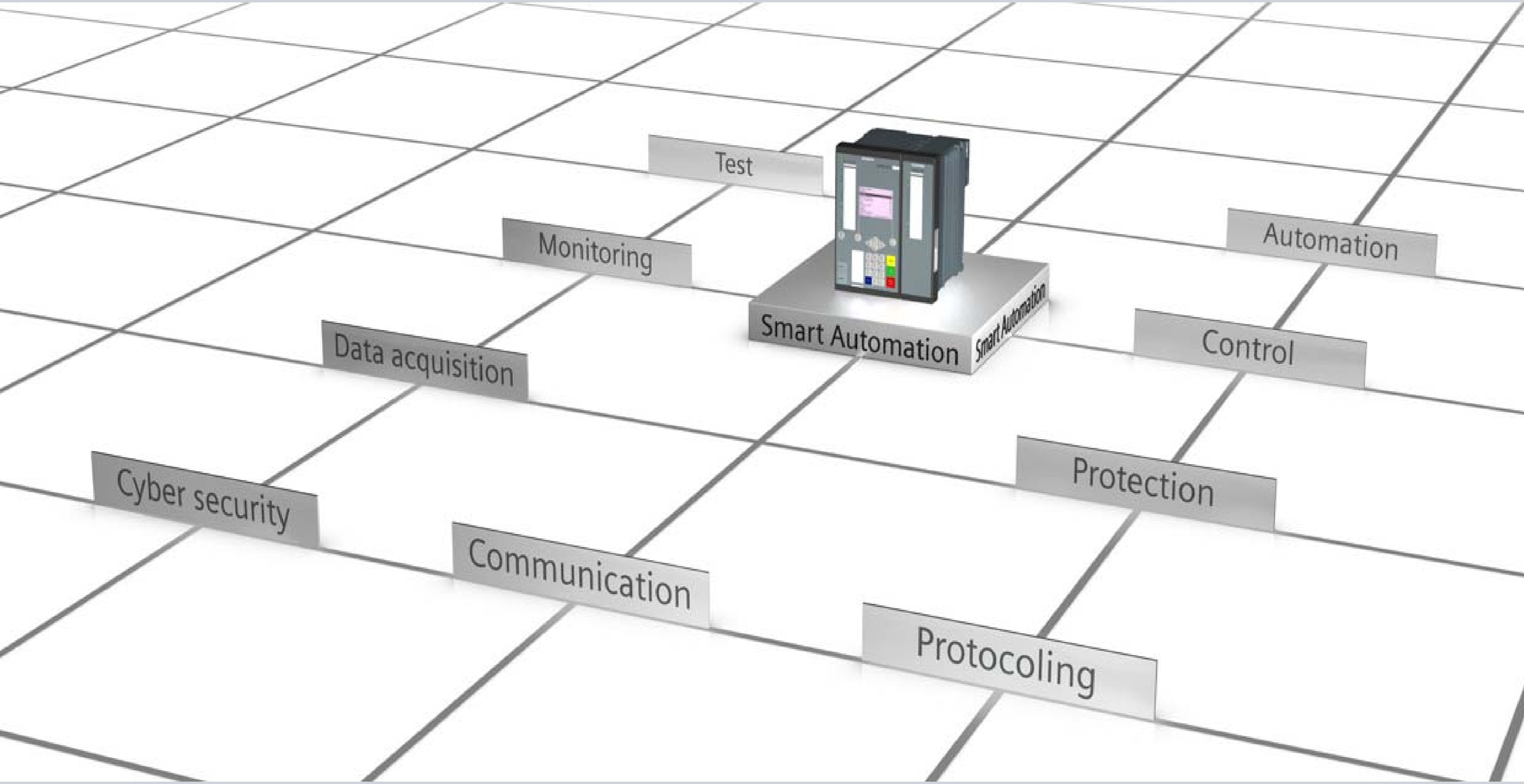
Functional Integration



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Flexibility of Domestic Consumption

	A/c / Heating	Water Pump	Lighting	Entertainment	Cooking Ovens/ Microwaves	Washing Machine	Heating Water - Geysers	Others
Prospect for ‘Time Shift’		☺				☺	☺	
Prospect for ‘Reduced power’ operation	☺	☺	☺		☺	☺	☺	☺
Possibility for Energy storage	☺						☺	

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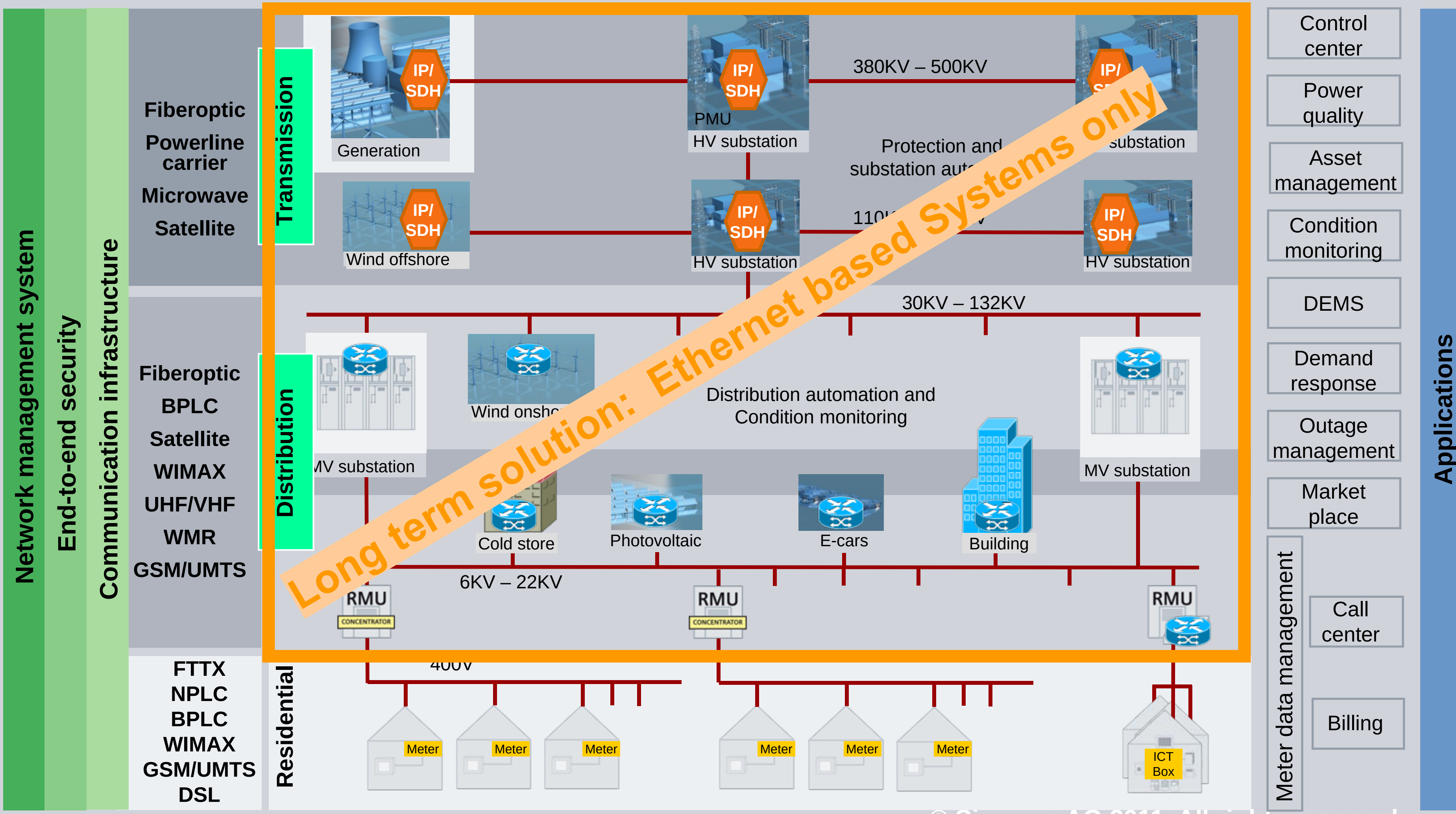
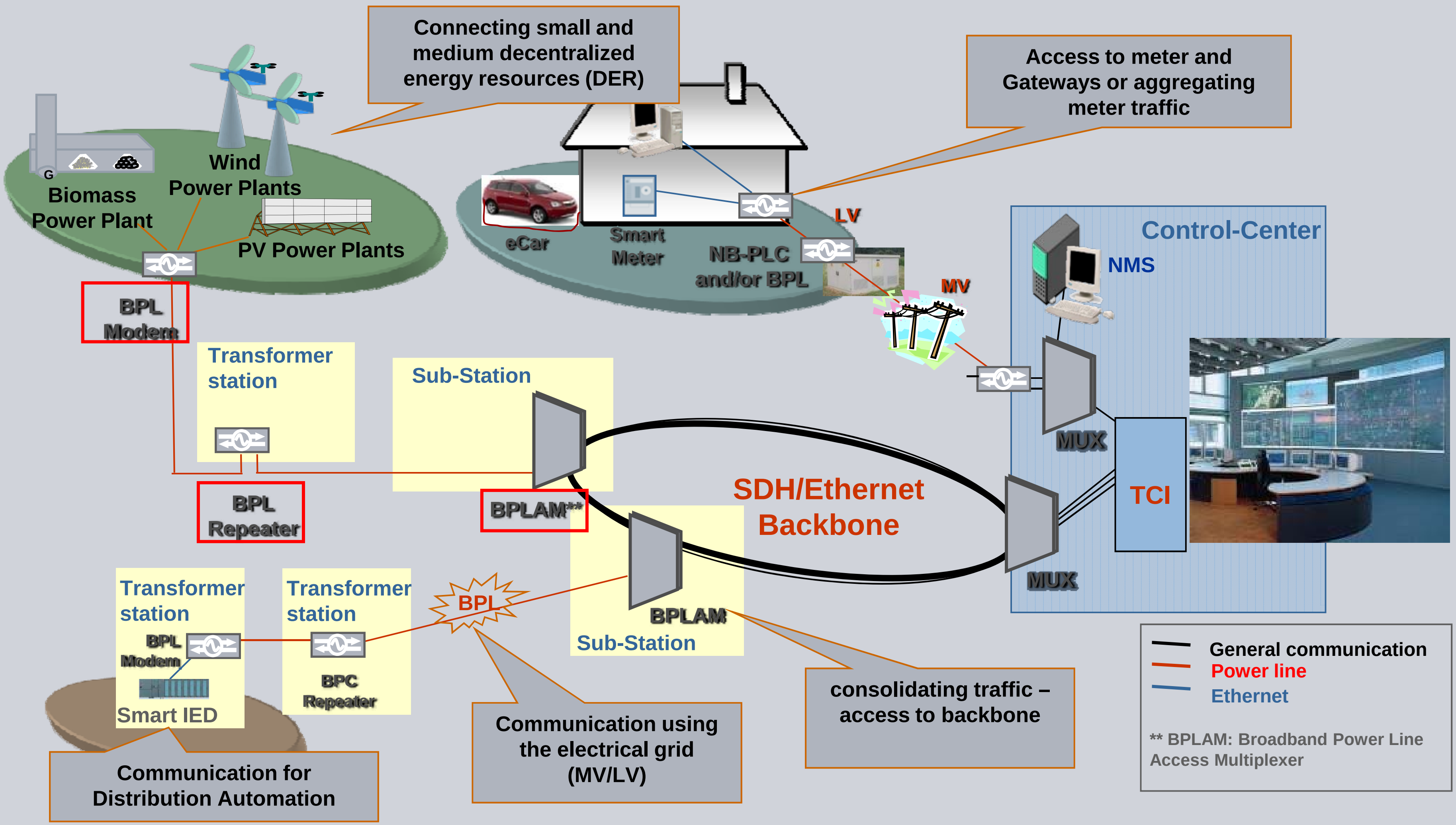
Communication development

- Communication is the Key Enabler
- The need for communication solutions is constantly increasing
- Demand for bandwidth increases due to new applications being introduced (PQ, AMR, DR, DER, Distribution Automation)
- Modern communication networks can fulfill this requirements easily
- Utility communication networks are penetrating towards medium- and low voltage domain for consumers to take advantage out of a flexible, intelligent energy network
- Today‘s heterogeneous networks will migrate to a homogenous IP network in the future
- Utilities communication network need a solution approach, requiring a competent one stop solution provider

Communication Solutions for Smart Grids



Communication Elements including BPL Topology



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Choice of telecommunication - Utilities Owned vs. Telcos

Utility Owned

- means to an end
- CAPEX is relevant
- OPEX for communication
- Infrastructure of low importance
- Lifetime > 15 years
- stringent requirements regarding reliability; availability, real time

Telco

- reason for existence
- Telco network is the basis for business (main asset)
- very competitive market
- OPEX is important
- Lifetime < 10 years
- quality of service and reliability is a matter of price

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eCar Infrastructures

Integrated charging, energy supply and parking, solutions for home, public and semi-public use

Wall box

Energy Management Grid and Buildings

Car park systems

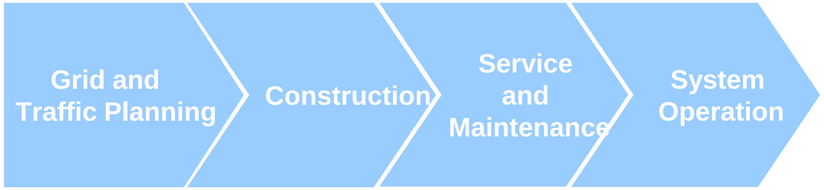
Charging pole AC/DC

LV and MV distribution

Multi space parking meters

Integrated solutions for the management of charging infrastructures, energy demand, traffic and fleets

Project phases



Integrated eCar Infrastructure Solutions and Services

- Charging infrastructure Management
- Smart Grid Integration
- Billing systems
- Service Desks / Back Office Systems
- Traffic Management
- Fleet Management & Navigation
- Security and Access Management
- Value Added Services Platform
- Communication Solutions
- Service and Maintenance
- System Operation

Intelligent Consumption - Efforts needed for every consumer segment

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Agricultural –

- Awareness that “Electricity costs money !”
- Replacement of inefficient pumpsets/foot valve – Ag. Demand Side Management

Industry –

- Optimise Manufacturing Processes
- Microgrid operation for intelligent load management
- BEE inititiative for individual components replacement of inefficient machinery

Commercial –

- Green Architecture
- Intelligent Building Management Systems
- Thermal Storage

Domestic –

- Engage with TV, white good manufacturers
- DSM initiatives by Discoms

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DSM - Three pronged approach

- EFFICIENCY : Consumption appliances to be Efficient
  - BEE labeling in India
  - Efficient Technology – CFL, LEDs, VFD A/cs
- LOAD MANAGEMENT : Consumption to be Smart and Flexible
  - Regulator interventions - Time of Use incentives
  - Active Consumer intervention – Automatic Demand Response
- SUBSTITUTION : Alternate energy source
  - LPG Water heater

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Smart Home / Smart Power / Smart Communication

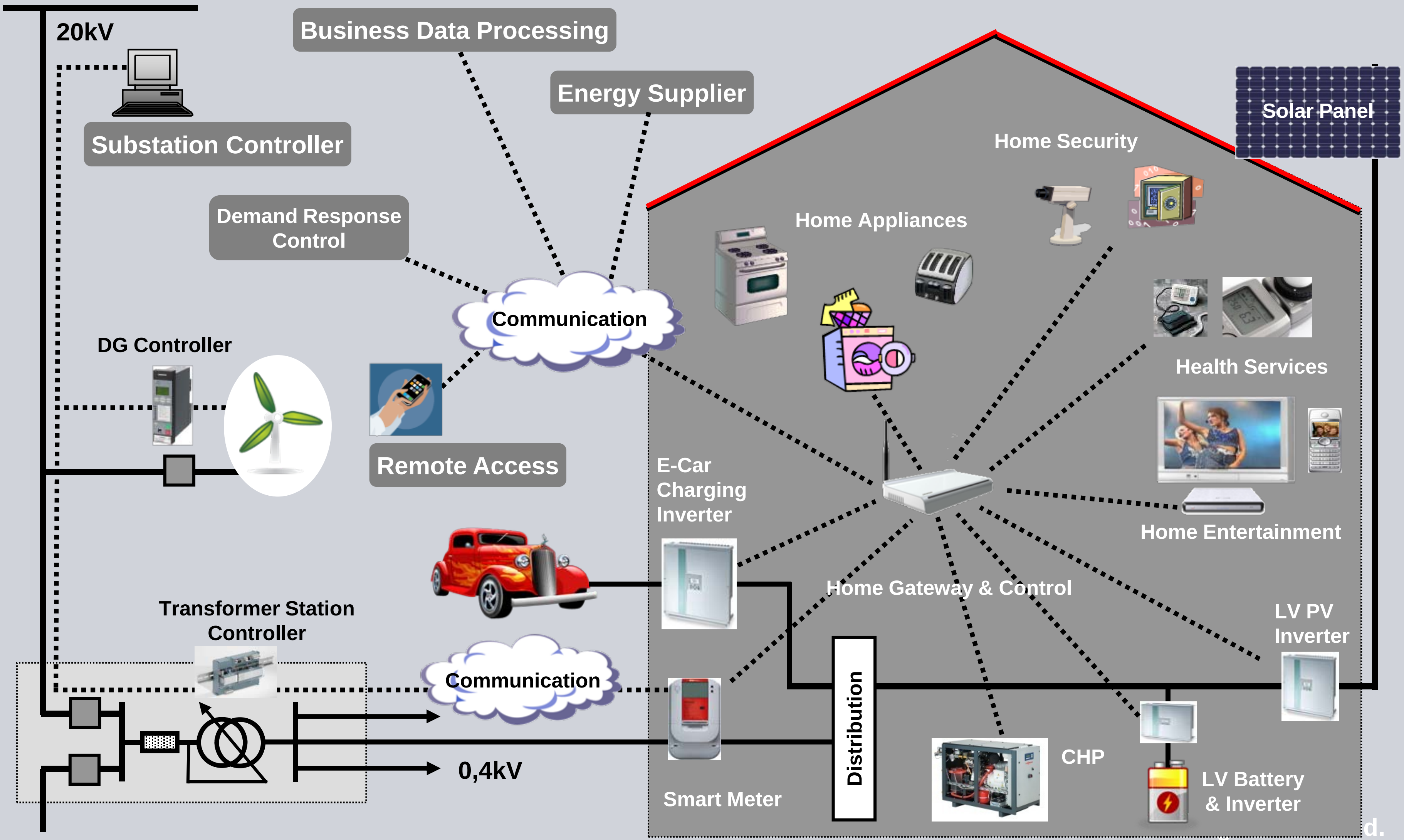

Table 3. Smart grid technologies

Technology area	Hardware	Systems and software
Wide-area monitoring and control	Phasor measurement units (PMU) and other sensor equipment	Supervisory control and data acquisition (SCADA), wide-area monitoring systems (WAMS), wide-area adaptive protection, control and automation (WAAPCA), wide-area situational awareness (WASA)
Information and communication technology integration	Communication equipment (Power line carrier, WIMAX, LTE, RF mesh network, cellular), routers, relays, switches, gateway, computers (servers)	Enterprise resource planning software (ERP), customer information system (CIS)
Renewable and distributed generation integration	Power conditioning equipment for bulk power and grid support, communication and control hardware for generation and enabling storage technology	Energy management system (EMS), distribution management system (DMS), SCADA, geographic Information system (GIS)
Transmission enhancement	Superconductors, FACTS, HVDC	Network stability analysis, automatic recovery systems
Distribution grid management	Automated re-closers, switches and capacitors, remote controlled distributed generation and storage, transformer sensors, wire and cable sensors	Geographic information system (GIS), distribution management system (DMS), outage management system (OMS), workforce management system (WMS)
Advanced metering infrastructure	Smart meter, in-home displays, servers, relays	Meter data management system (MDMS)
Electric vehicle charging infrastructure	Charging infrastructure, batteries, inverters	Energy billing, smart grid-to-vehicle charging (G2V) and discharging vehicle-to-grid (V2G) methodologies
Customer-side systems	Smart appliances, routers, in-home display, building automation systems, thermal accumulators, smart thermostat	Energy dashboards, energy management systems, energy applications for smart phones and tablets

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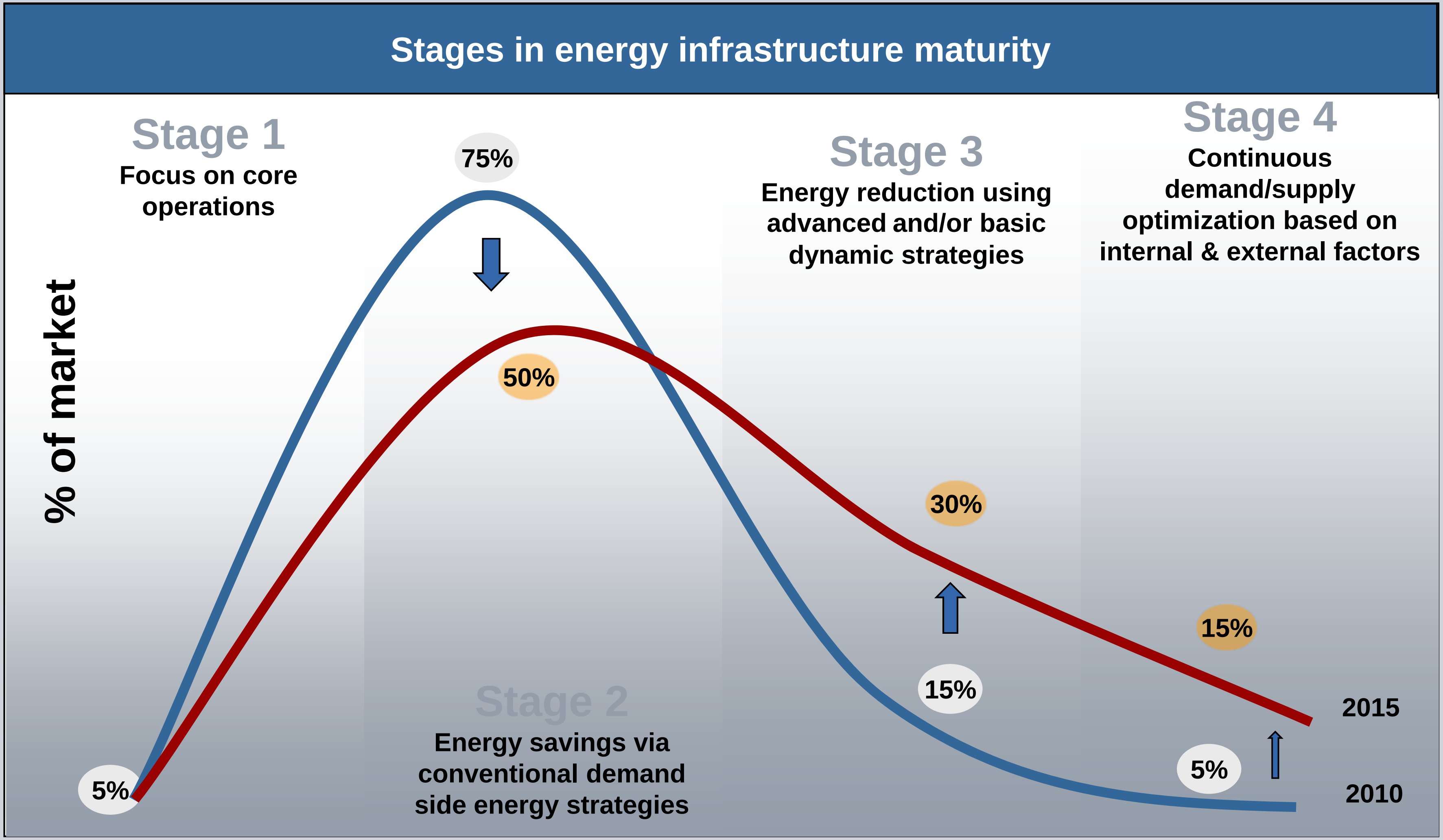
Table 4. Maturity levels and development trends of smart grid technologies

Technology area	*Maturity level*	*Development trend*
Wide-area monitoring and control	Developing	Fast
Information and communications technology integration	Mature	Fast
Renewable and distributed generation integration*	Developing	Fast
Transmission enhancement applications**	Mature	Moderate
Distribution management	Developing	Moderate
Advanced metering infrastructure	Mature	Fast
Electric vehicle charging infrastructure	Developing	Fast
Customer-side systems	Developing	Fast

* Battery storage technologies are less mature than other distributed energy technologies.

** High Temperature Superconducting technology is still in the developing stage of maturity.

Large campus customers are seeking advanced solutions



Source: Customer interviews, Smart Consumption – large commercial team