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Practical Experiences with Smart Grid Deployment

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CEER Workshop on Smart Grids
June 29, 2009 - Brussels

Draft 2009-06-18 V1.0

Balancing the magic triangles – for a sustainable energy system

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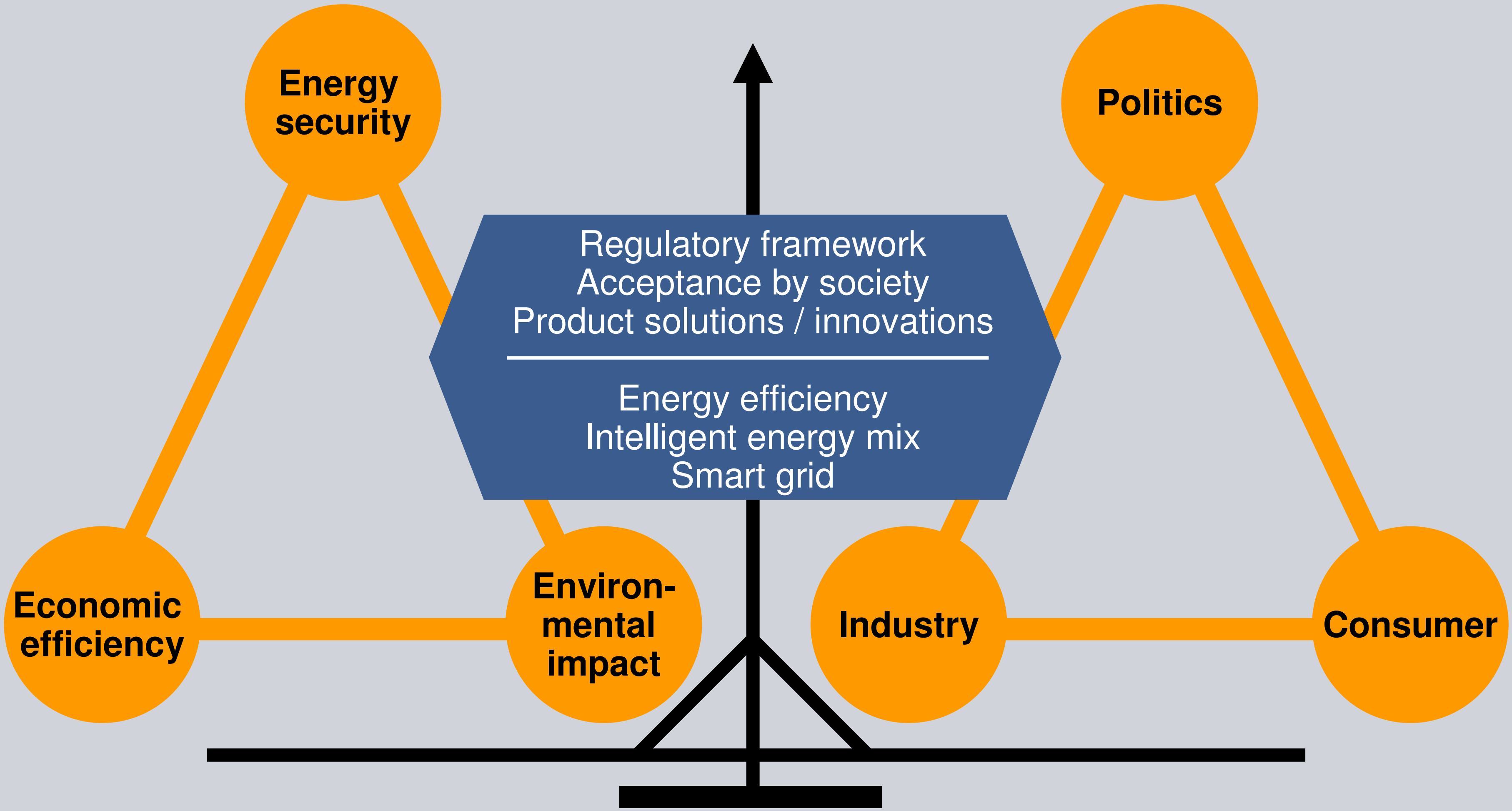
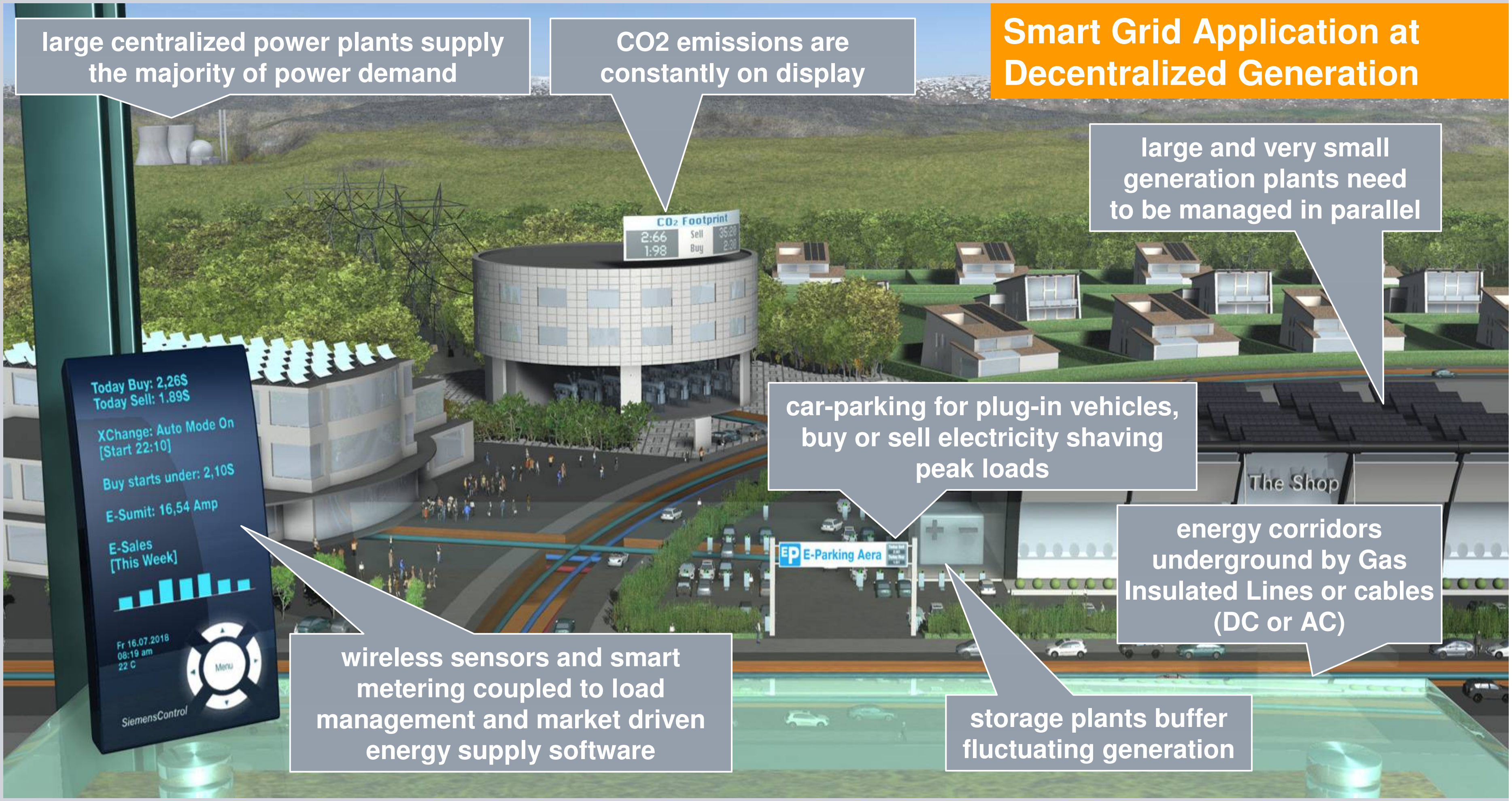


Distribution Grid enabling load side in-feed



Roadmap
for the Future Grids in Europe

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1	2	3	4

1. Ideas to support the European agenda
2. Potential solutions
3. Innovations & Technologies
4. Implementation & Facilitation processes

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for the Future Grids in Europe

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1. Ideas to support the European agenda

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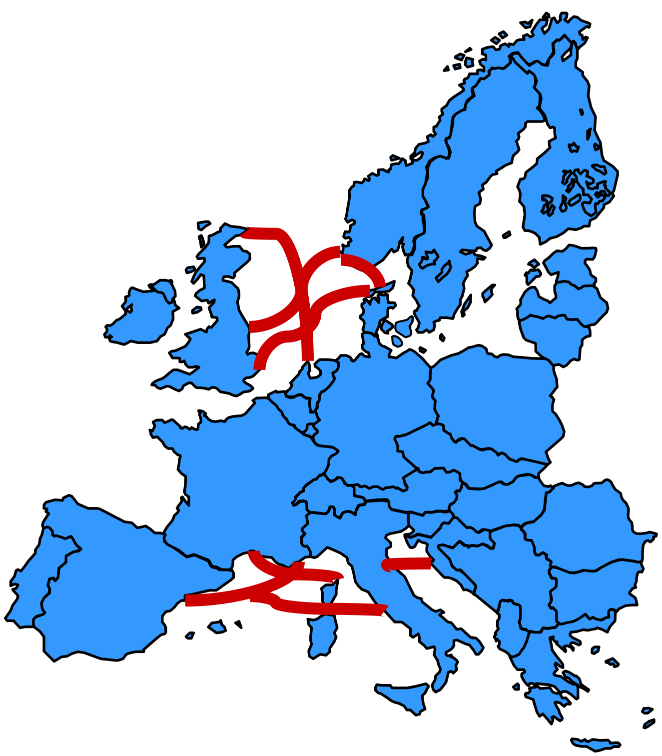
Preparing a Transmission Grid for Europe, to support the European political goal…

1 2 3 4

Connecting renewable & expanding to offshore grids



Including cross-borders power highways

Challenges in grid operation require new technological solutions

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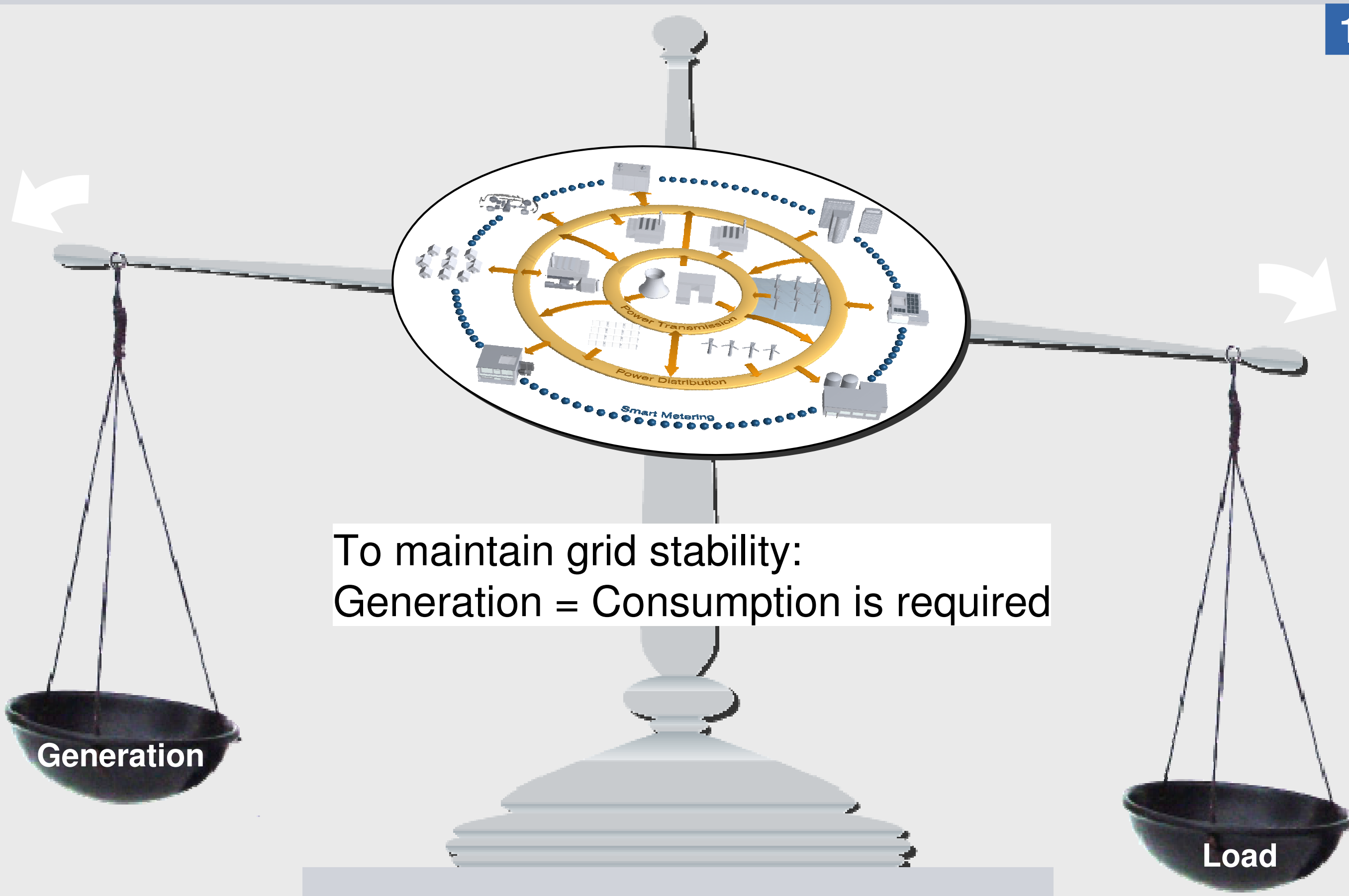

To maintain grid stability:
Generation = Consumption is required

Stochastic Renewables | **Large number of Prosumers**

Smart Grids will ensure active load management and grid reliability

From traditional “Generation follows Load” to “Load follows Generation”

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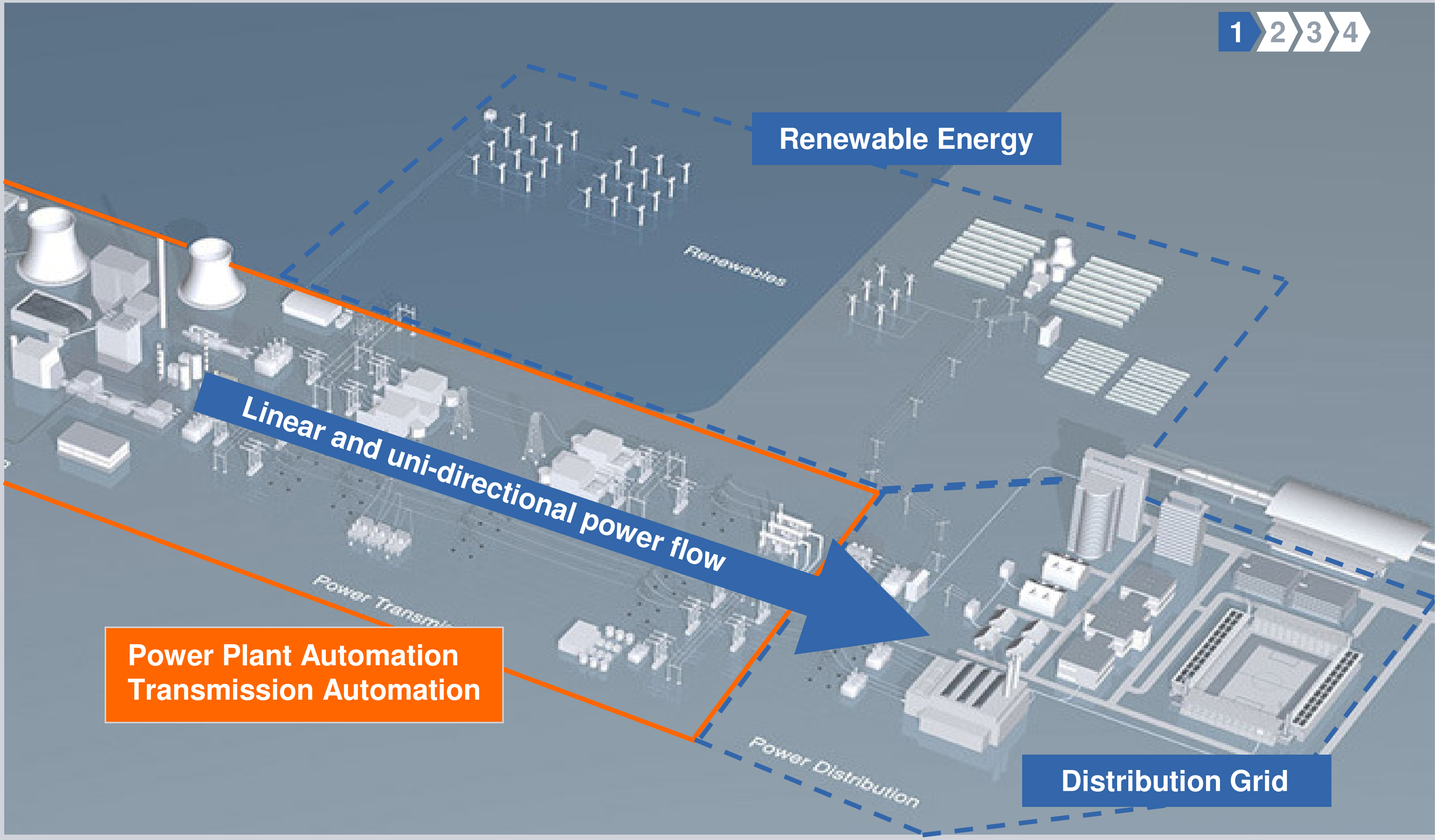

Grid operations are also impacted by forecasted grid developments

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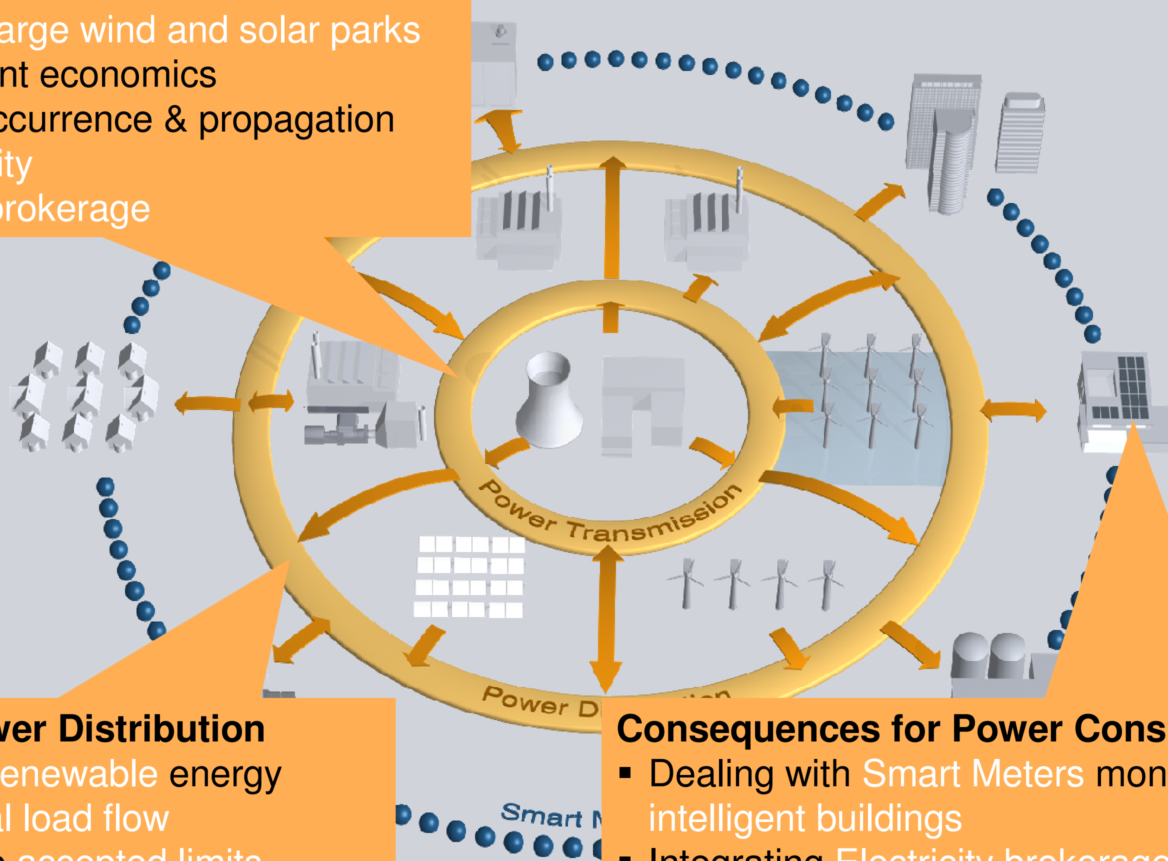
Consequences for Power Transmission
- Monitoring input from large wind and solar parks
- Efficiency in power plant economics
- Preventing Blackout occurrence & propagation
- Keeping system integrity
- Integrating Electricity brokerage



Consequences for Power Distribution
- Monitoring input from renewable energy
- Managing bi-directional load flow
- Driving networks to the accepted limits
- Adapting operation to serve stochastic loads

Consequences for Power Consumption
- Dealing with Smart Meters monitoring intelligent buildings
- Integrating Electricity brokerage down to the end consumer

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But also working on solving <u>present issues</u> ..

Some issues:

- Efficiency of electricity transmission & distribution
- Ageing assets
- Level of Short Circuit Current
- Stability of the combined European grids
- Environmentally friendly grid expansions
- Security of supply

Roadmap
for the Future Grids in Europe

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1. Ideas to support the European agenda
2. **Potential solutions**
3. Innovations & Technologies
4. Implementation & Facilitation processes

Key technologies are mostly available ...
... but radical innovation is needed in specific areas

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Super Grid

- HVDC from Point-to-Point connections to fully meshed DC networks
- UHV AC -systems
- Right of way optimization: upgrading existing lines, underground power carriers

Smart Grid

- Advanced Energy Management Systems - Substation automation - FACTS
- Blackout Prevention (phasor measurement, wide area monitoring, state estimator, ...)
- Last Mile Smart Metering - Meter Data Management
- Energy Marketplace - Building Automation

Living with ageing infrastructures

- Condition monitoring
- Life time extension and On-site repair and maintenance

Smart Cities and Smart Buildings

- Autonomous buildings and energy management
- Active building ('Prosumer')

Energy Storage

- large scale (Compressed Air (CAES), Hydrogen)
- medium size (SMES, Flywheels, heat pumps ...)
- small scale (Lithium-Ion battery, Redox-flow battery)

back-up

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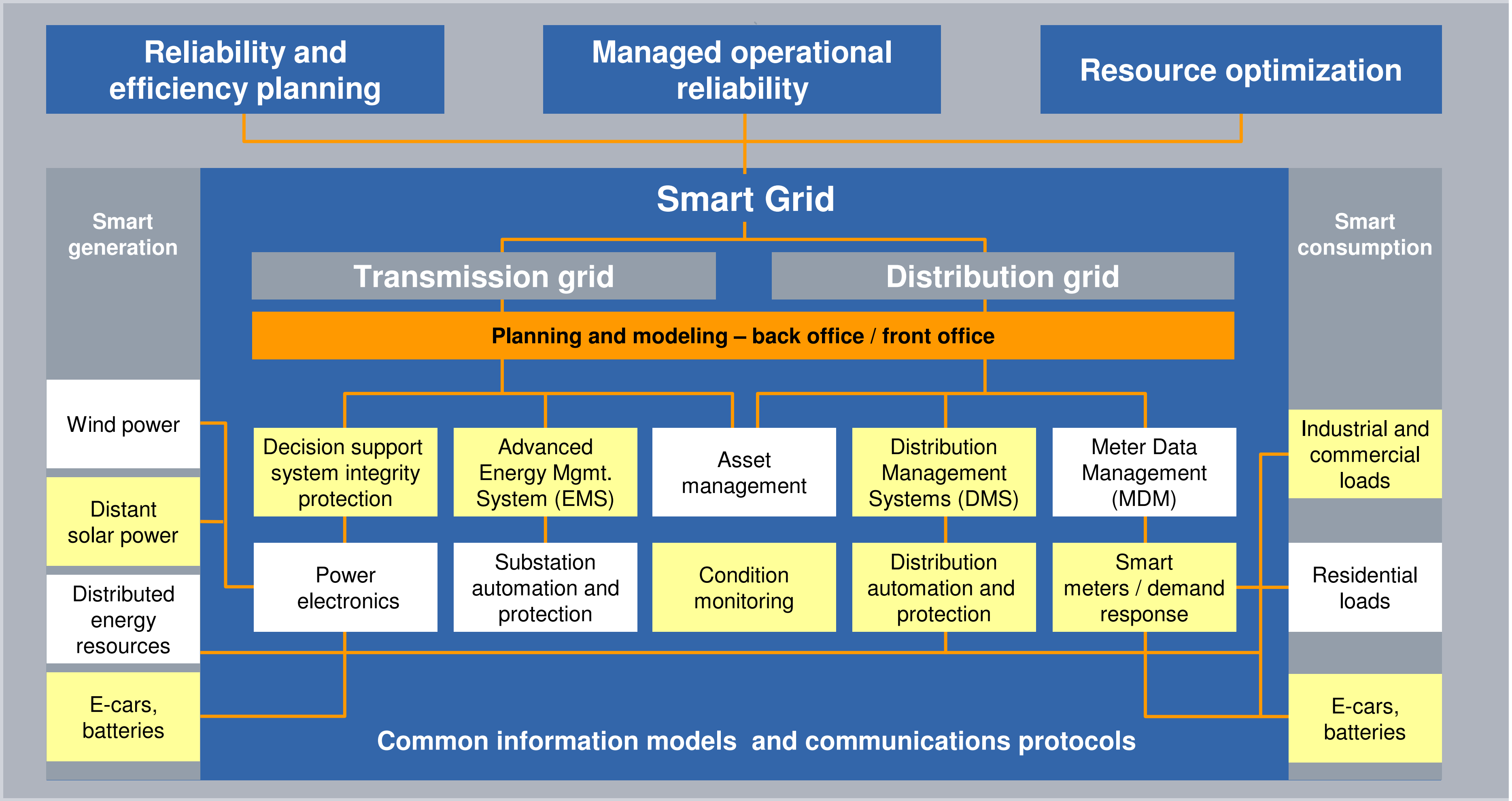
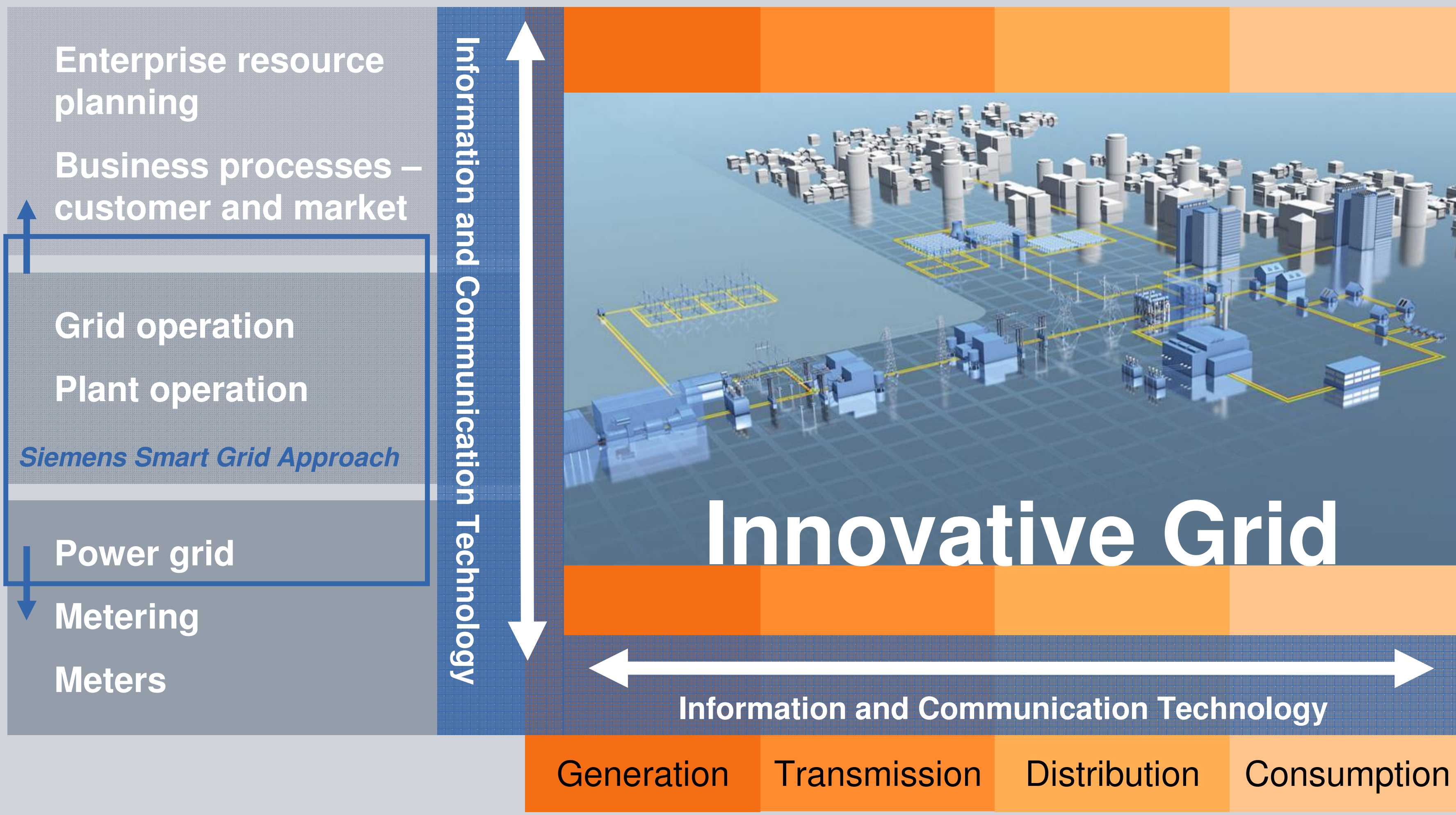
... and solutions should focus on Grid Intelligence ...

1 2 3 4



Need for grid operators' feedback

... very large and in-depth integration!



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1 → 2 → **3** → 4

1. Ideas to support the European agenda
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Transmission Grids developments to support the European agenda

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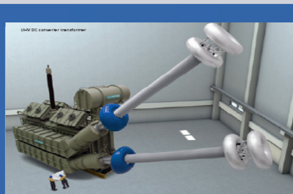
1 2 3 4

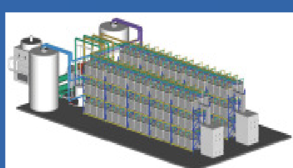


Connect load centers to far-away generation centers

Continuously assess grid stability

Overcome present bottlenecks

Optimize existing right-of-ways



Handle and balance stochastic in-feed and stochastic loads

- A super European UHV DC grid allowing inter-regional massive power transfers
- Complement existing grids with off-shore grid solutions to tap wind energy and facilitate power exchange
- Implementing a Higher Voltage level for the Transmission grid
- Designing higher Isc withstand specifications and Fault Current Limiters
- Re-use of existing right of ways and underground transmission solutions
- Storage as key element in the future infrastructure

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Example: a super grid (DC) roadmap

Embedded HVDC (Thyristors) HVDC PLUS (Transistors)

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- *Technology available*
- *References in Australia, China (800 kV), USA (New York & San Francisco), India*
- *Projects in the pipe line*

Multi terminal HVDC

☑

- *Technology under development*
- *New control algorithms and implementation*

Meshed DC grid

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- *Technology not available today*
- *DC Circuit Breakers*
- *Protection systems*
- *Power control centers*

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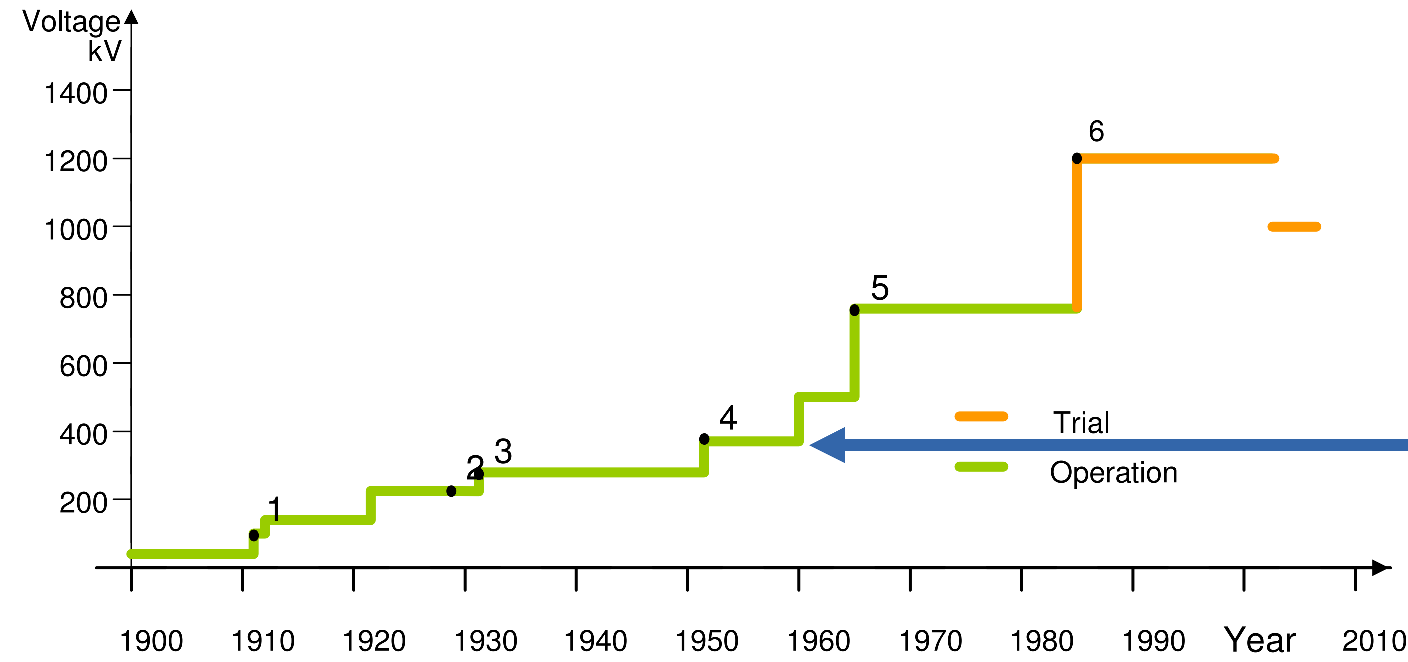
Example: development of higher AC voltage levels



50 MVA per System → 1 110 kV Lauchhammer - Riesa / Germany (1911)

2 220 kV Brauweiler - Hoheneck / Germany (1929)

3 287 kV Boulder Dam - Los Angeles / USA (1932)

1000 MVA per System → 4 380 kV Harspranget - Halsberg / Sweden (1952)

5 735 kV Montreal - Manicouagan / Canada (1965)

6 1200 kV Ekibastuz - Kokchetav / USSR (1985)

The European Transmission Grid concept – with a voltage level of 420kV – has proved extremely stable for the last 50 years!

Will it last another 50 years?

Shouldn't a higher voltage level, i.e. 550 or 750 kV be introduced?

back-up

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Example: right of ways optimization

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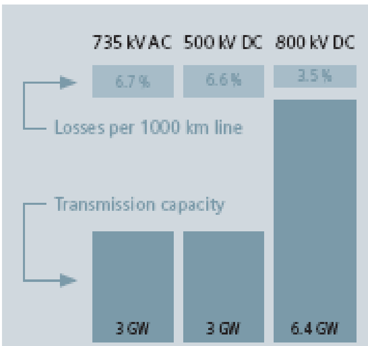
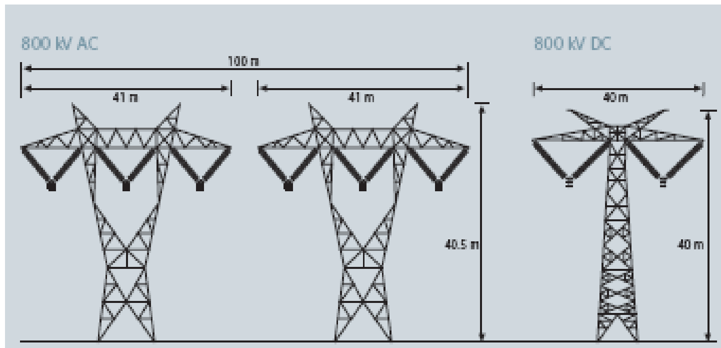
Transmitting 3 GW over long distances





- re-use of existing right-of ways by replacing AC overhead lines with DC systems.
- re-use of existing right of ways by combining AC & DC overhead lines on same towers
- for urban areas, natural parks or sensible places like airports, develop underground power carriers, like High Voltage cables or Gas Insulated Lines, either DC or AC, EHV or UHV.

back-up

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Example: Energy Storage roadmap

1 2 3 4

SMES

- *Cope with lack of primary reserve*
- *Time scale: from a second to some minutes*
- *Week spots on the grid*

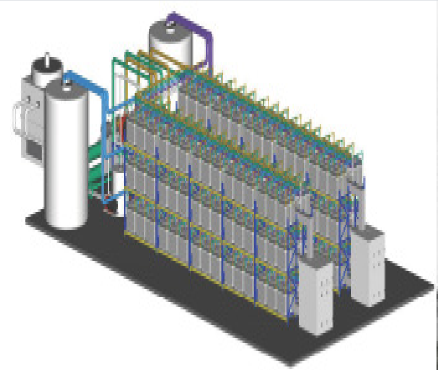
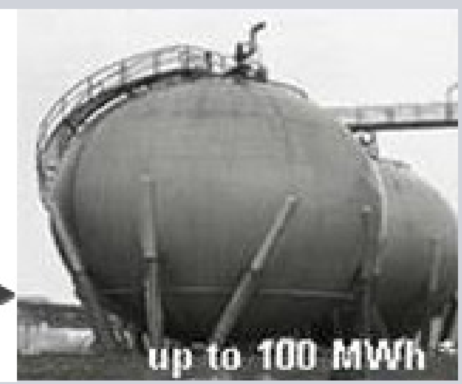
e-vehicles / batteries

- *Cope with stochastic in-feed from renewable*
- *Time scale: from few minutes to some hours*
- *Close to the loads*

Hydrogen

- *Cope with seasonal unbalance of renewable*
- *Time scale: from a day to some weeks*
- *Close to the generators*



Source: Institut NÉEL

Increase situational awareness and transparency of grid state

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1 2 3 4

From

Limited situational awareness

To

Full transparency of the entire system in real time including all (dynamic) phenomena

What's necessary?

- Phasor Measurement Units and Wide Area Measurement may allow on-line detection of swing phenomena and the introduction of a system level protection scheme
- New visualization concepts

➔ Better understanding of system dynamics
➔ Implementation of automated counter measures

Smart Buildings as a "prosumer" - a new active element within Smart Grids

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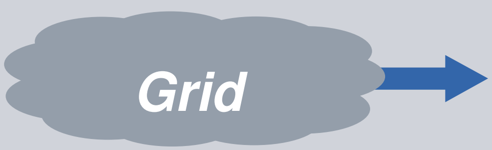
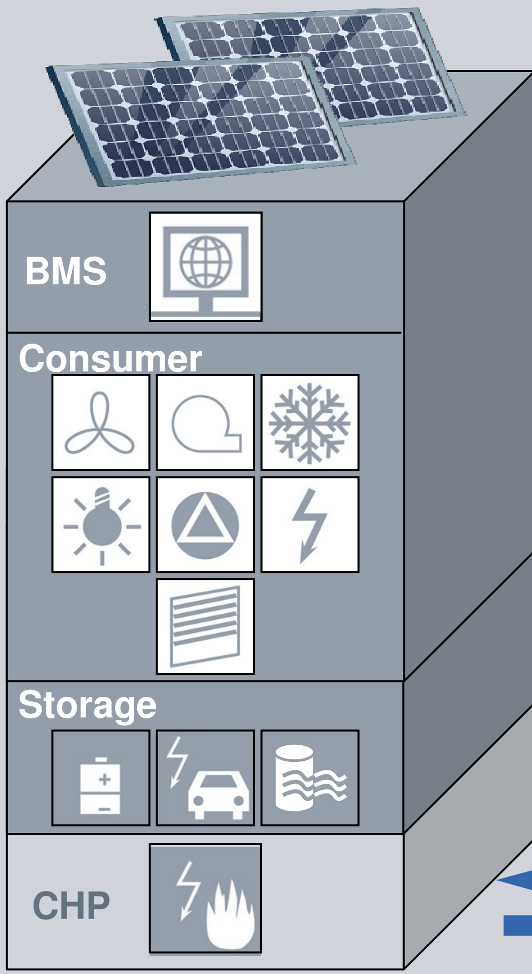
1 2 3 4

Low energy tariffs

- Intelligent filling of storage capacities, e.g.:
  - Load e-car
  - Load thermal storage (boiler, ice, building structure, indoor air)
- Minimal use of CHP
- Use comfort band to build reserves

Building is energy consumer to grid





High energy tariffs

- Use energy from storage, e.g.:
  - Use reserves in e-car
  - Empty thermal storages
- Maximum use of CHP
- Minimize el. consumption within comfort band
- Use or sell self produced energy (PV, wind, CHP…)
- Switch to oil or gas

Building may even deliver energy to grid

CHP : Combined Heat & Power

BMS : Building Management System

PV : Photo Voltaic

back-up

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Example: building automation roadmap

1 2 **3** 4

Building Automation

- *Local control of sensors and actuators*
- *optimization of energy consumption*
- *Building as a drain for energy*

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Autonomous Buildings

- *Energy consumption optimization*
- *Managed load*
- *Virtual Power Plant (Decentralized Energy Management DEMS)*

☑

Building to Grid Integration

- *Co- generation*
- *Integrated load forecast*
- *Floating tariffs*
- *End-to-end communication*
- *Building as a source or storage*
- *New operation models*

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Smart metering:
Reference example Europe

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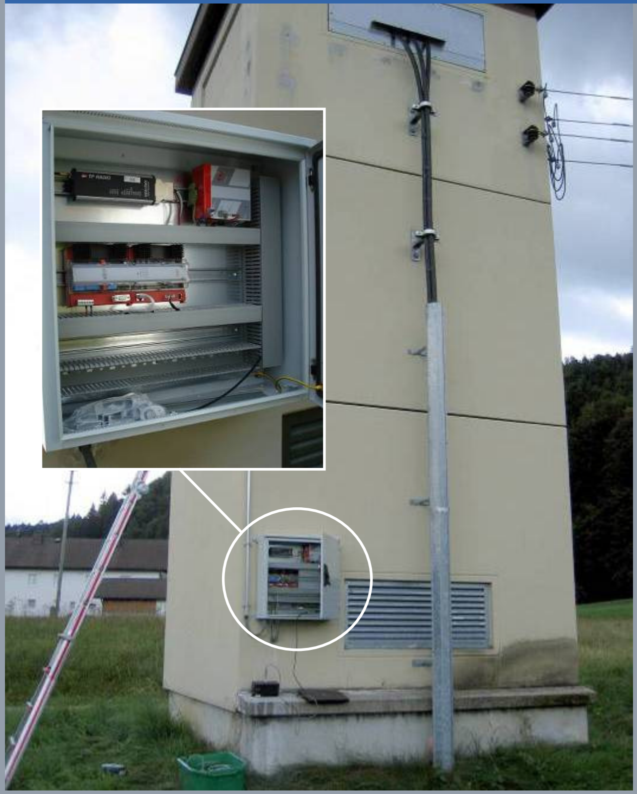
1 2 3 4

Reference project for Energie AG Oberösterreich, Austria:
The most important reasons for the implementation of an AMIS system are



- Automated metering processes (meter reading, blocking of customer installations, billing, prepayment services, etc.)
- Significant improvement of customer processes
- Implementation of various tariffs
- Quality improvement of consumption data due to monthly meter reading
- Replacement of ripple control
- Recording of customer supply
- Automation of the transformer stations
- Support of Energie AG's energy efficiency program

Smart metering: Reference example Asia / Pacific

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Transitioning 800,000 retail customers in New Zealand to smart metering: Meter data management solution (EnergyIP) provides

- High volume meter data management for gas and electricity
- Time-of-use-based billing
- Residential load management
- Exception reporting and integration of field workforce
- Automated commissioning of each meter installation
- Detailed reporting for retail and distribution applications
- Web-based energy Information portal
- Integrated wireless in-home display
- Fully managed smart service

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Example: smart metering roadmap

1 2 **3** 4

Meters

- *No communication*
- *Manual reading*
- *Very limited tariff options*

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Smart Metering

- *Variable tariffs*
- *Monthly billing*
- *Reduction of no technical losses*

☑

Smart Metering as Gateway for "Prosumer"

- *Integration of generation and load information*
- *Enhanced load management*

☐

Easy integration of engineering, IT security and end-to end communication

Engineering

Harmonized tools and optimal coordination

- Workflow optimization at operators's plant
- Easy to use
- Reusable assets

IT Security

Integrated IT security across the entire automation chain

- Hardened products and secure solutions
- Standardized mechanisms and functions
- Integrated security processes and guidelines

Communication

Harmonized interfaces and interoperability

- Standard protocols, data models based on IEC 61850/ IEC 61970
- A platform for vertical and horizontal integration

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3 key forces for developing the future sustainable energy system

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Climate-compatible energy technologies
Efficiency increase, CO_2 sequestration, wind, solar thermal …

1 Technology push

- R&D funding for key technologies
- Funding for full-scale demo projects
- Fair risk sharing between suppliers, operators and the public

2 Market pull

- Reliable long-term investment incentives
- Global perspectives for equipment suppliers

3 Legal basis and acceptance

- Public relations in an open dialogue
- Cooperation of politics, industry, NGOs

If politics, utilities and supply industry join their forces sustainable energy systems can become reality.

back-up

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Make it happen: joint efforts

1 2 3 4

Pre-requisites to implement innovative solutions

- Approvability (reliability references, regulation compliance, failure redundancy)
- Feasibility (engineered solution to be disclosed to authorities and regulator)
- Public acceptance (sustainability value, right of way)
- Economic value (business plan, stable planning conditions, financing)

Developing applications and field experience:

- Mixed R&D -Teams and R&D co-financing
- Standardization and specification harmonization committees
- Develop pilot projects and business models

Communication:

- Long term policy deployment - addressing all stakeholders (including regulators)
- Cooperation T&D Europe, ESMIG - ENTSO-E, "ENDSO-E" - ACER - CENELEC, DG-TREN
- Communication for public acceptance

Siemens view
Key messages for grid regulators

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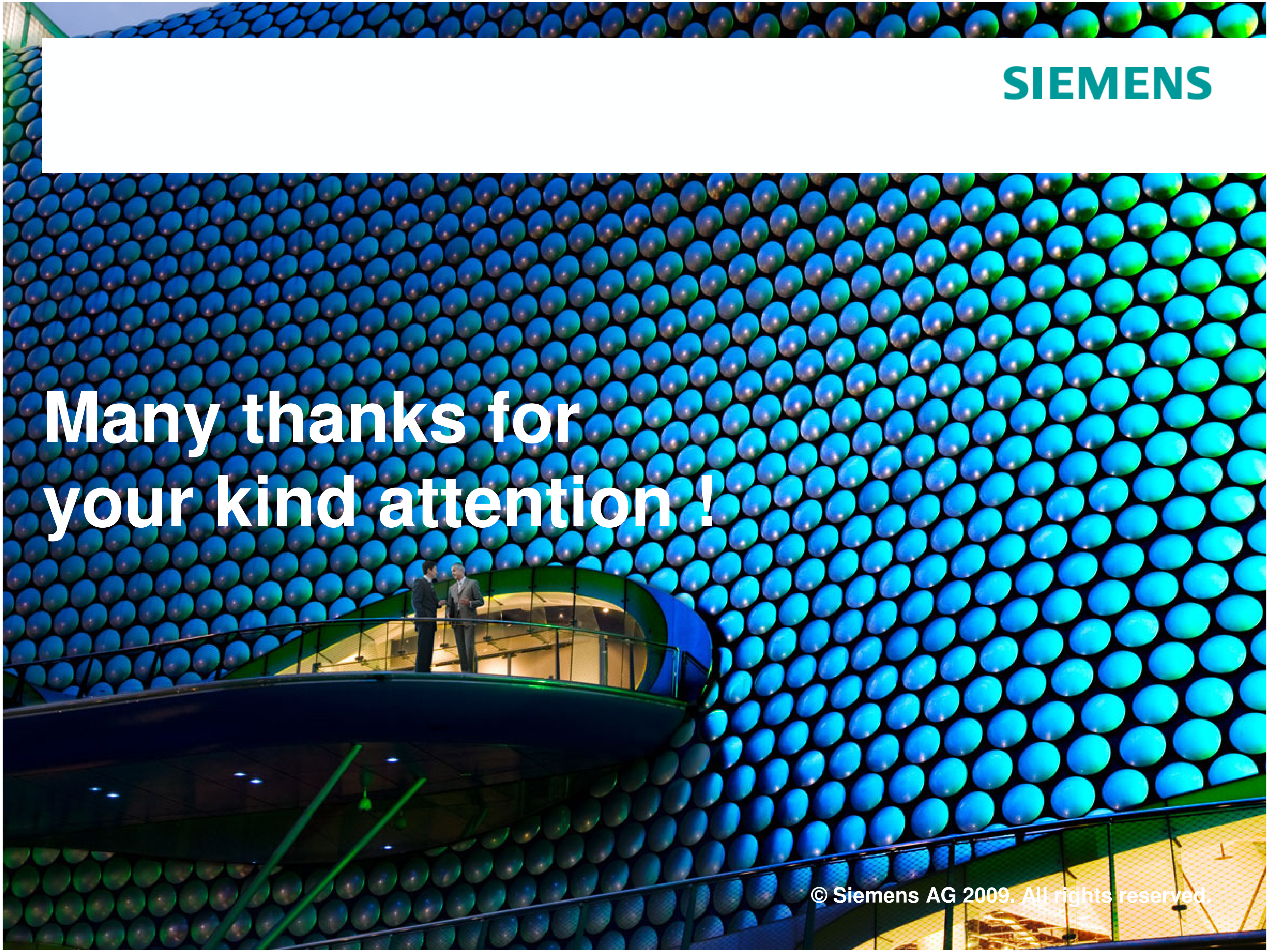
1	Common goal	▪ Industry (system operators, utilities and manufacturers) fully supports the European agenda fighting climate change
2	Supergrid	▪ Technology roadmap exists, limited risk foreseen in development ▪ Main hurdle lies in right-of-way optimization
3	Smart Grid	▪ Building blocks are identified, technology roadmaps available ▪ Main hurdle: value proposition not fully shared by stakeholders
4	Initiatives	▪ Commitment to push for demonstrator- and pilot projects ▪ Standardization of functionalities´ description



Many thanks for your kind attention !

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