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Inteligentna elektryczność - efektywna energia dla zrównoważonego świata

AGH Akademia Górniczo-Hutnicza im. Stanisława Staszica w Krakowie

Wydział Elektrotechniki, Automatyki, Informatyki i Elektroniki

power and productivity for a better world™

Agenda

- Drivers and challenges
- How future electric systems must perform
- ABB's vision of smart grids
- ABB offerings
- Conclusions

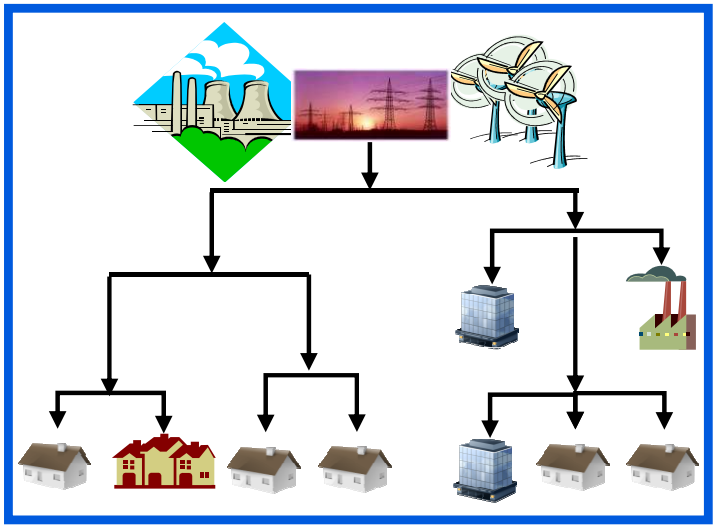
The evolution of electricity

- Electricity is the most versatile and widely used form of energy in the world, developed over one hundred years
- More than 5 billion people have access to electrical energy
- The electrical system ranges from power generation and transport to final consumption
- It’s evolution is ongoing but we urgently need to speed up the development
- The mitigation of global climate change requires fast changes in the electrical system
- We need a much better system

We need a smart grid

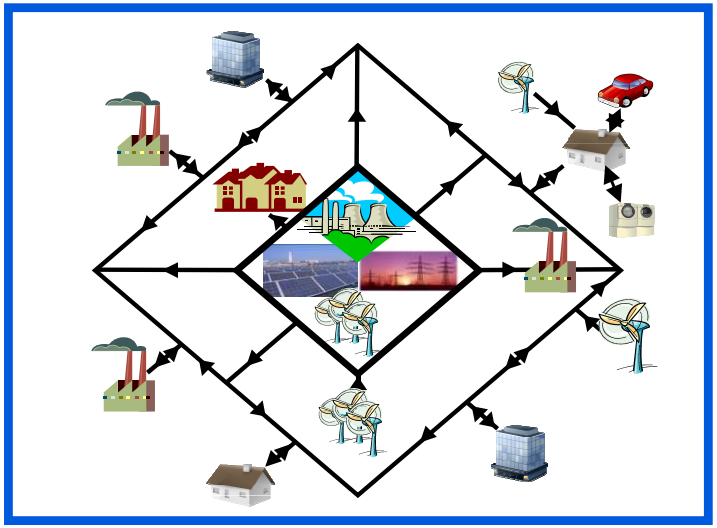
Evolution of grid design
From traditional to future grids

traditional grids



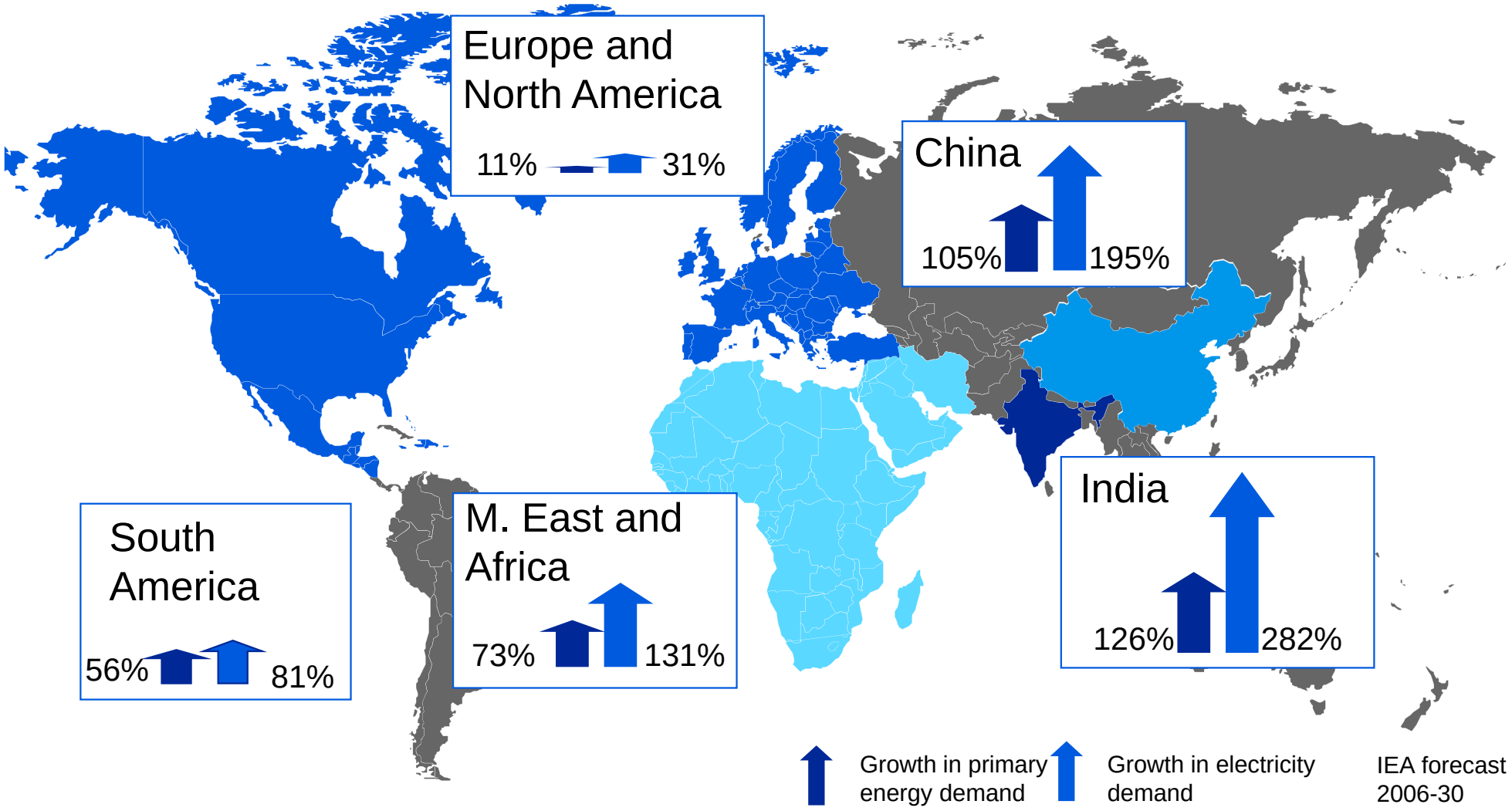
- Centralized power generation
- One-directional power flow
- Generation follows load
- Operation based on historical experience
- Limited grid accessibility for new producers

future grids

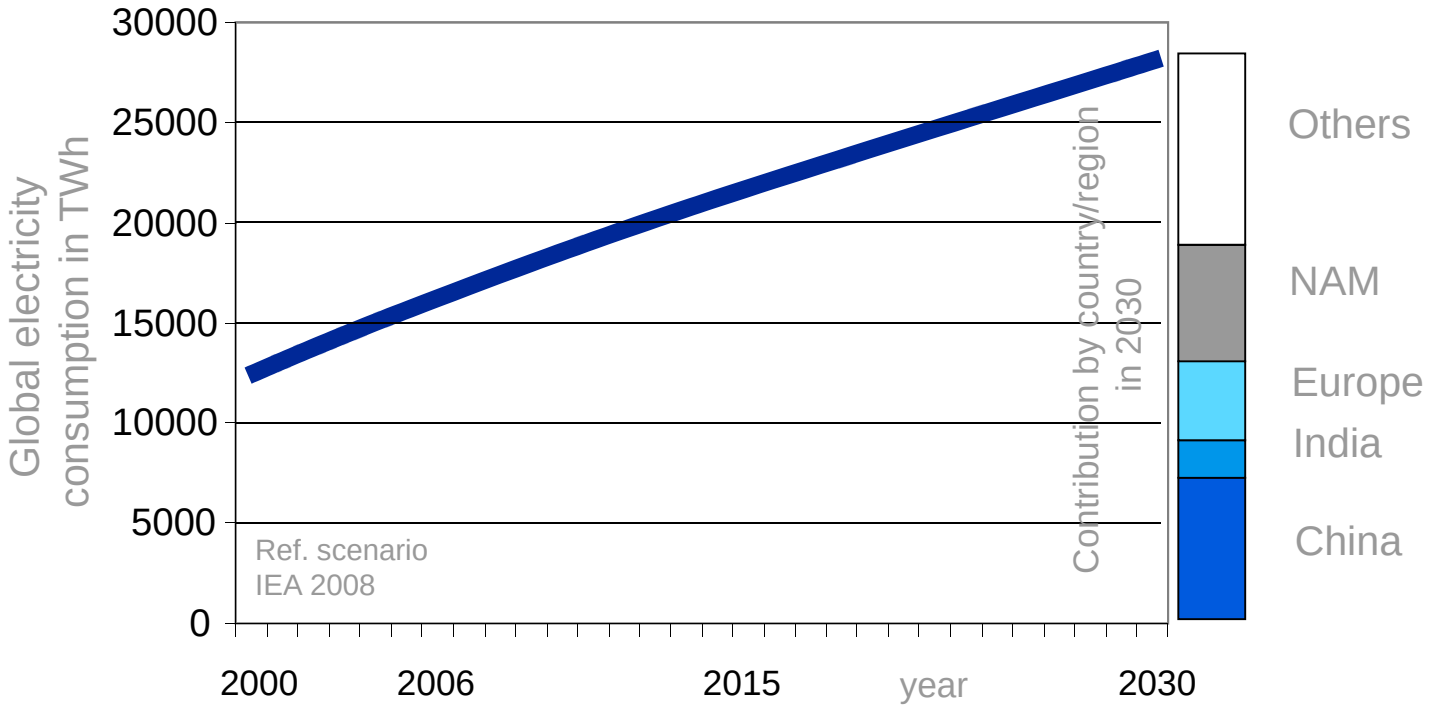


- Centralized and distributed power generation
- Intermittent renewable power generation
- Consumers become also producers
- Multi-directional power flow
- Load adapted to production
- Operation based more on real-time data

Today's energy challenge – growing demand
Electricity demand rising twice as fast

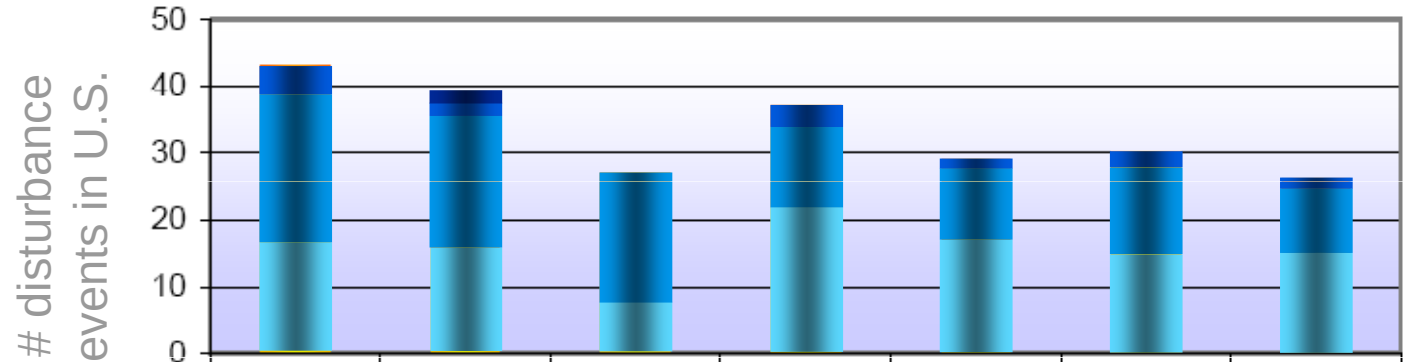


Electricity demand rising fast
Growth rates highest in Asia



Meeting the rise in demand will mean adding a 1 GW power plant and all related infrastructure every week for the next 20 years

Major challenge: improving reliability



	2002	2003	2004	2005	2006	2007	2008 (Jan-Jul)
Category 5	0	1	0	0	0	0	0
Category 4	4	2	0	3	1	2	1
Category 3	22	20	19	12	11	13	10
Category 2	17	16	8	22	17	15	15

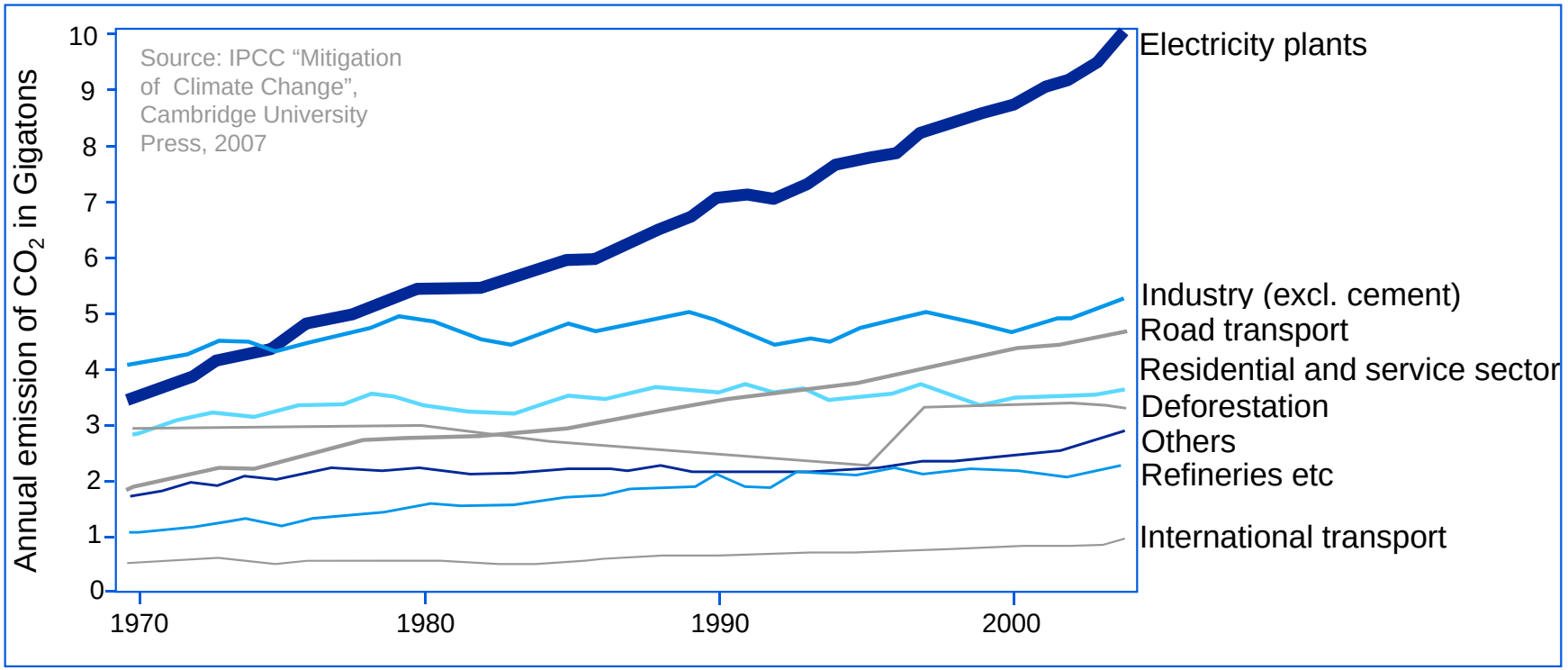
Source: FERC 2008

- In U.S. the annual cost of system disturbances is an estimated $ 80 billion*
- Commercial ($ 57 billion), industrial ($ 20 billion) and residential ($ 3 billion) sectors affected
- Most cost ($ 52 billion) due to short momentary interruptions

* Berkley National Laboratory 2005

Poor reliability is a huge economic disadvantage

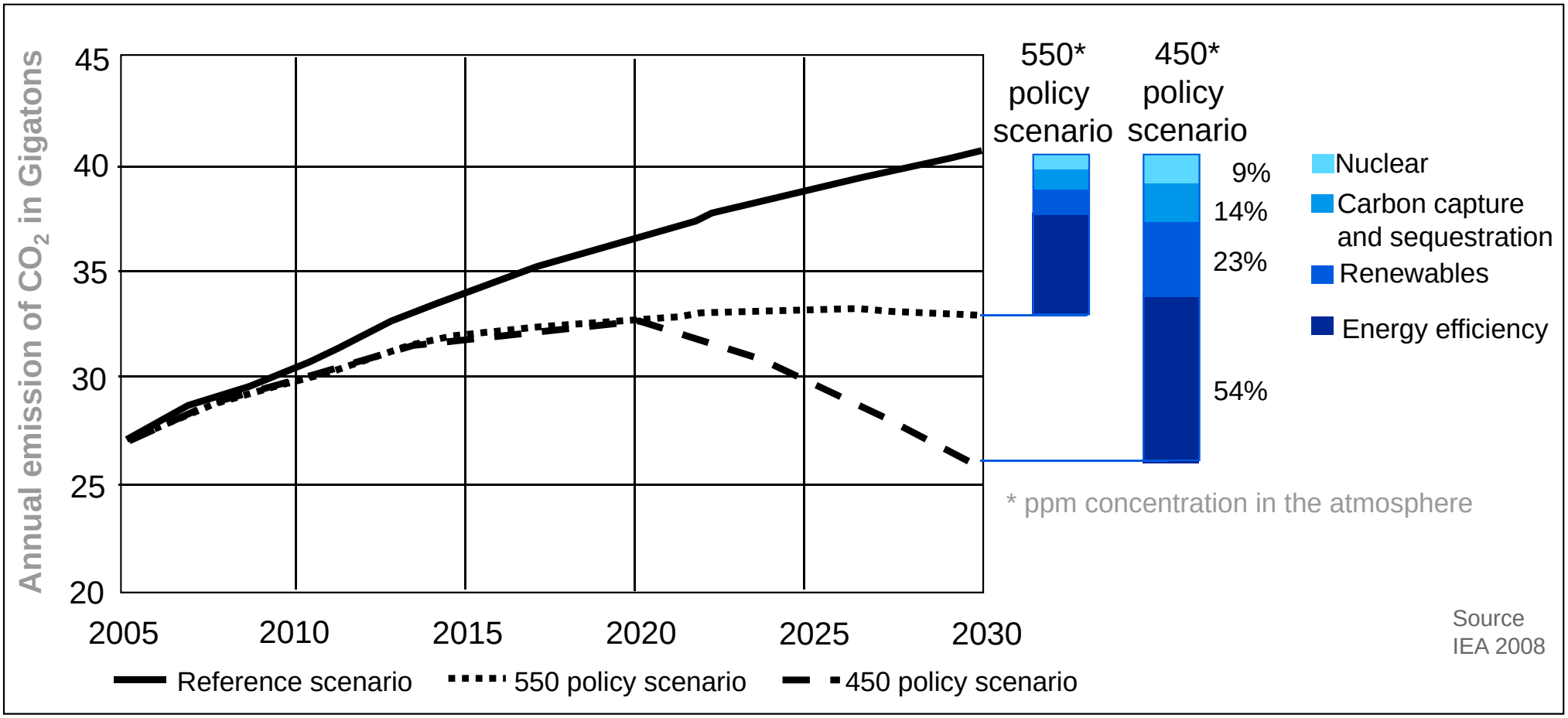
Major challenge: environmental concerns



- CO_2 is responsible for 80 percent of all greenhouse gas effects
- More than 40 percent of CO_2 is generated by traditional power plants

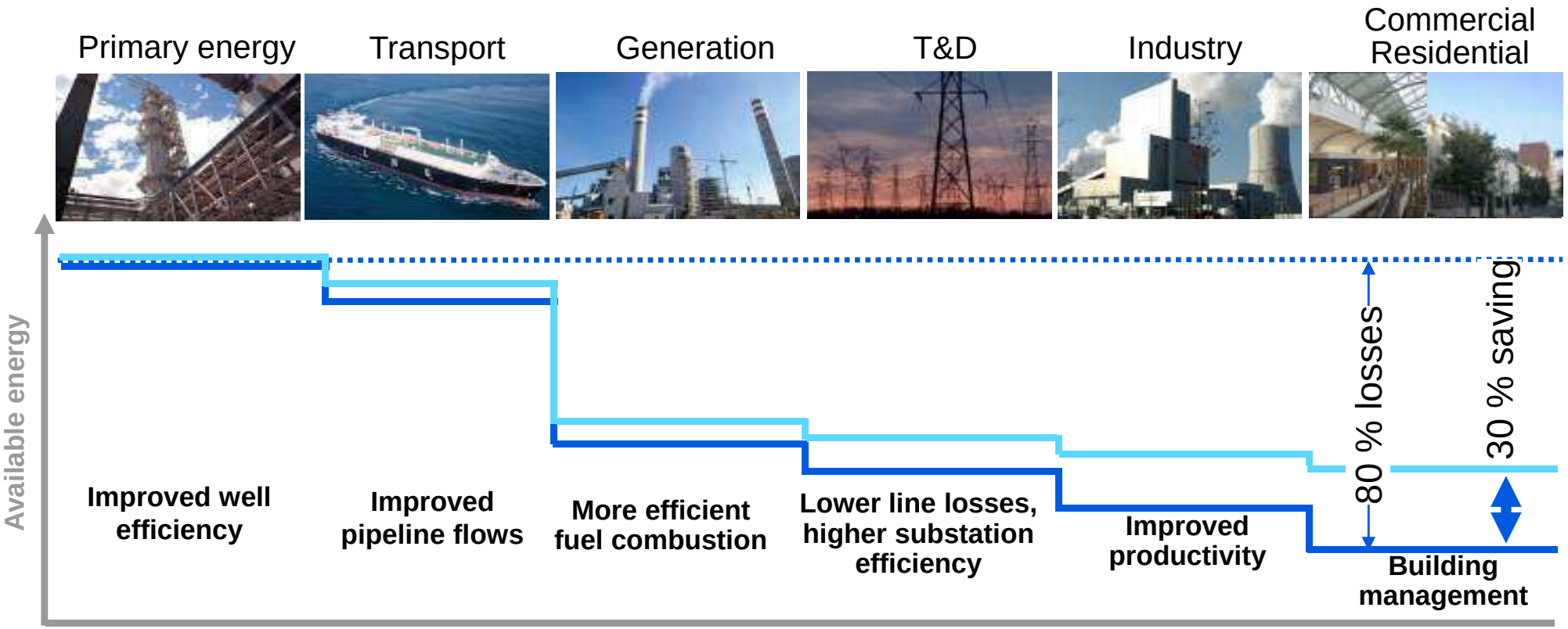
Electric power generation is the largest single source CO_2 emissions

Two major ways to reduce greenhouse gas emissions



Energy efficiency and renewable power generation could provide almost 80 percent of the targeted reduction

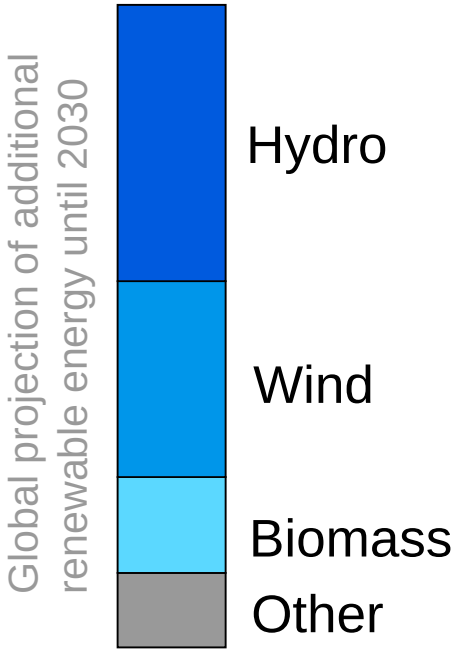
Efficient generation, transport and better utilization of electricity

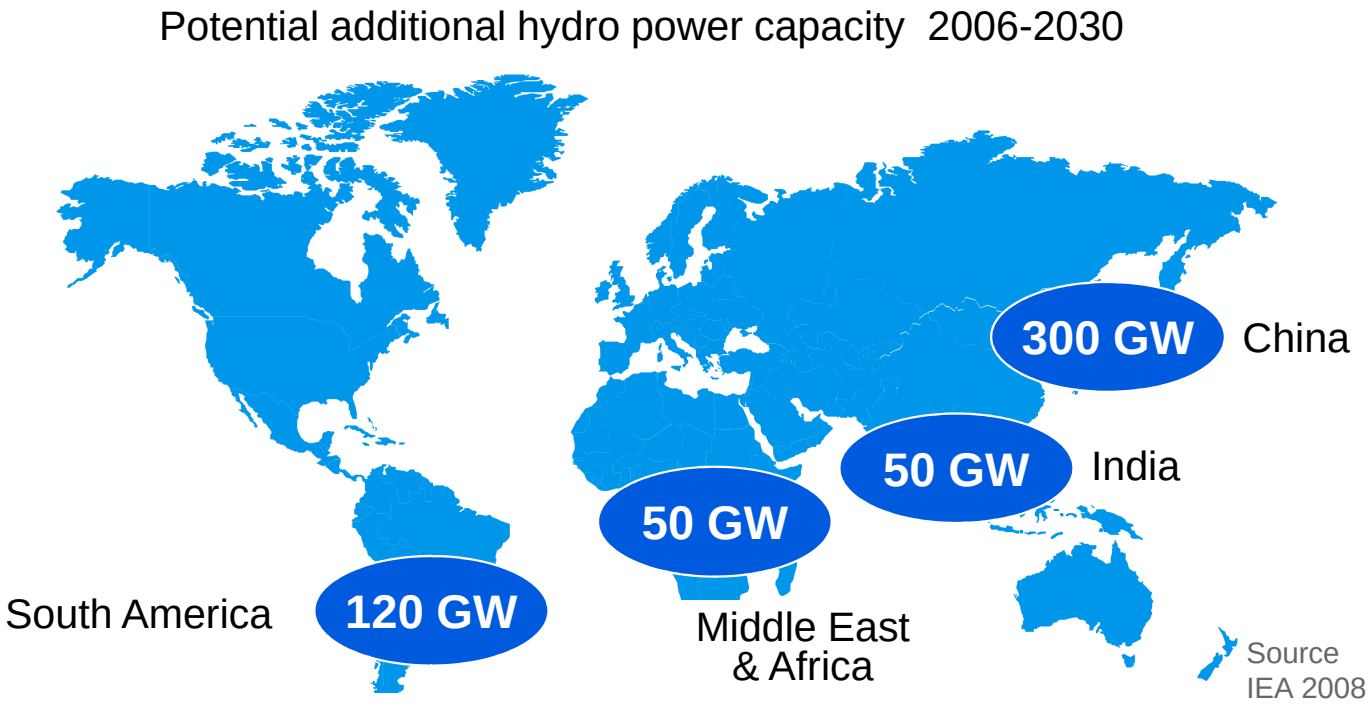


- Up to 80 percent losses along the energy value chain
- Some losses inherent to the generation of electricity

Energy efficiency along the value chain can reduce losses by 30 percent

Sustainable development with more renewable power generation

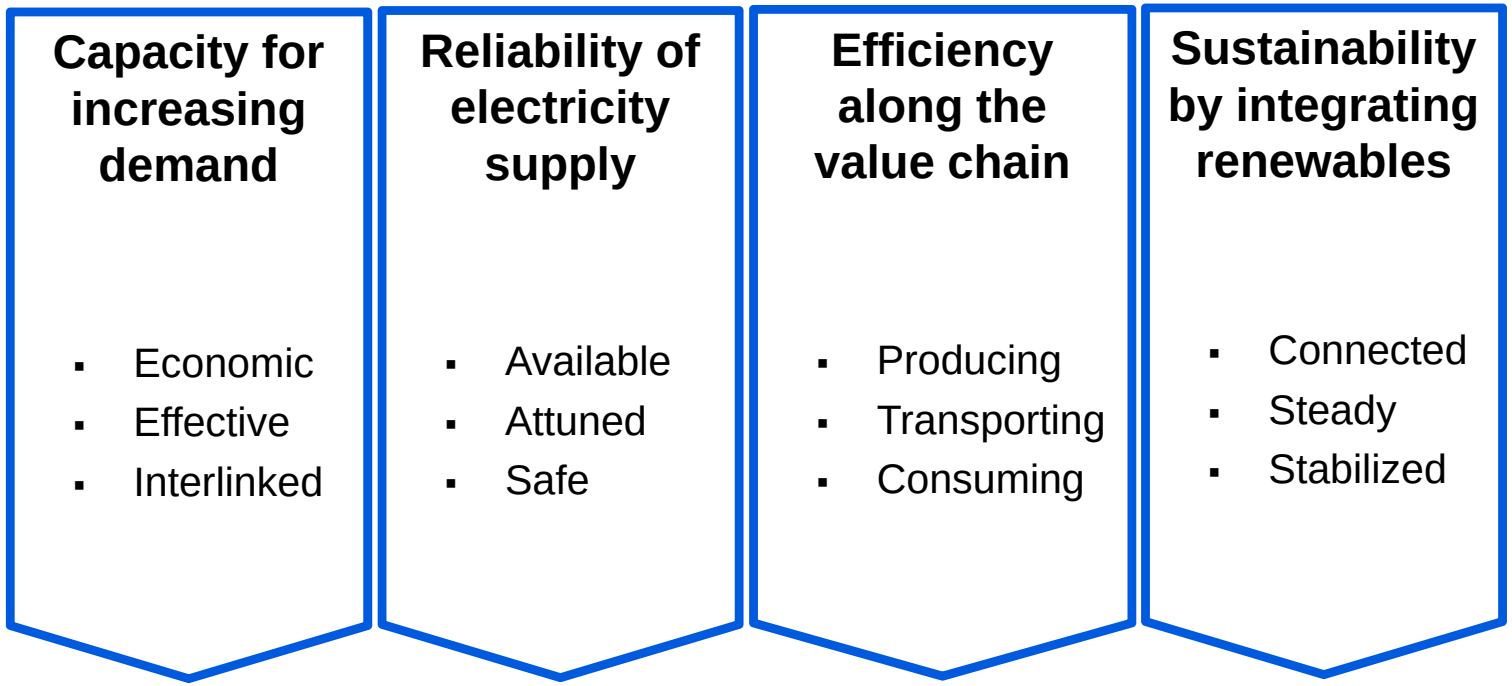




- Strong growth of renewable power generation
- In OECD countries wind power is dominating the growth
- Estimated global investment in renewables: $ 200 billion by 2030

Hydropower will remain the key global renewable energy source, followed by wind energy.

Smart grid value proposition
Four main areas of emphasis



Large impact on the required performance of the grid

Future electrical systems will be different from those of the past

- **Open for all types and sizes of generation technologies**
- **Tuned to cope with environmental challenges**

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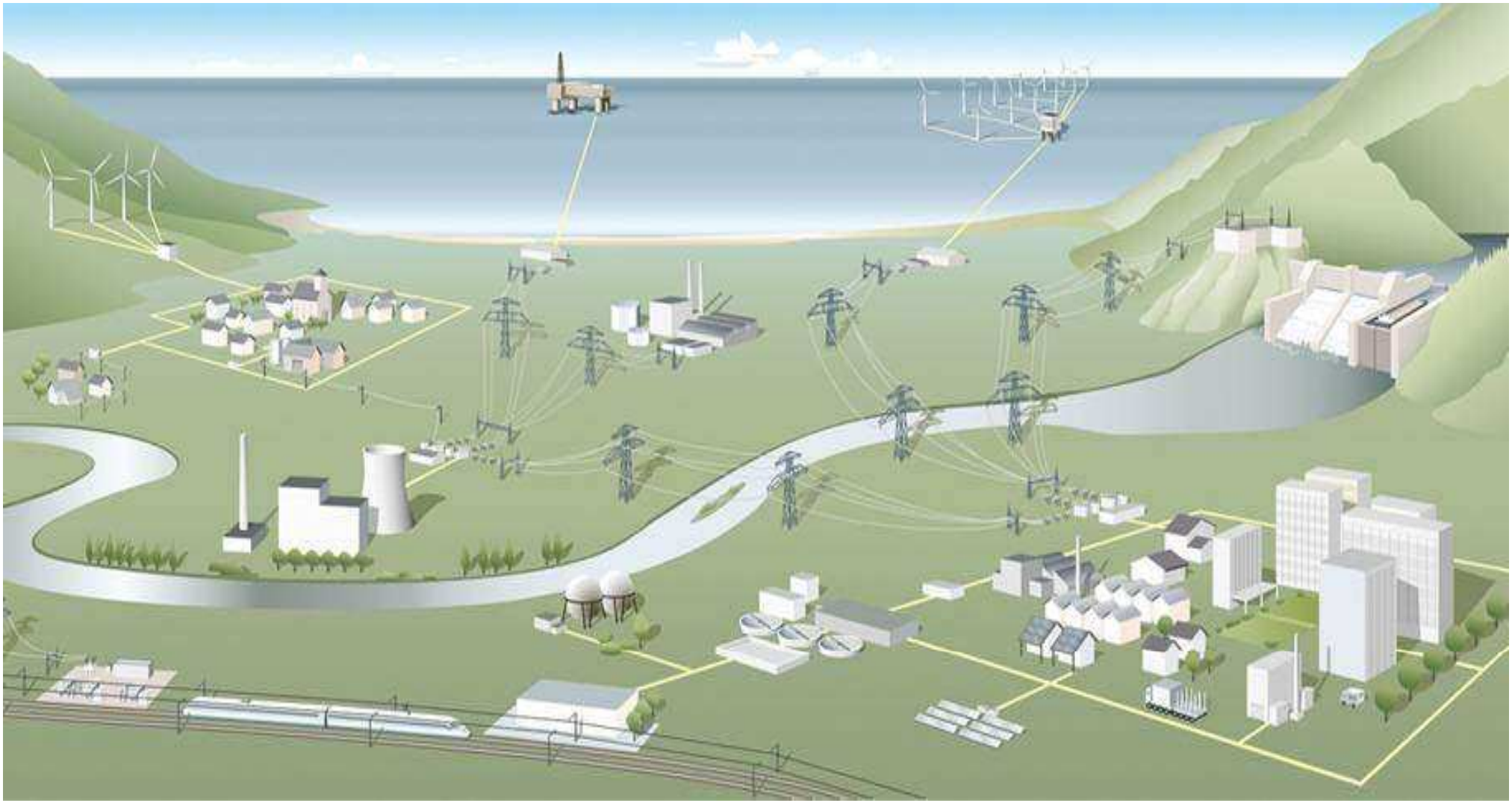
The electrical system handles production, transport and consumption of electrical energy



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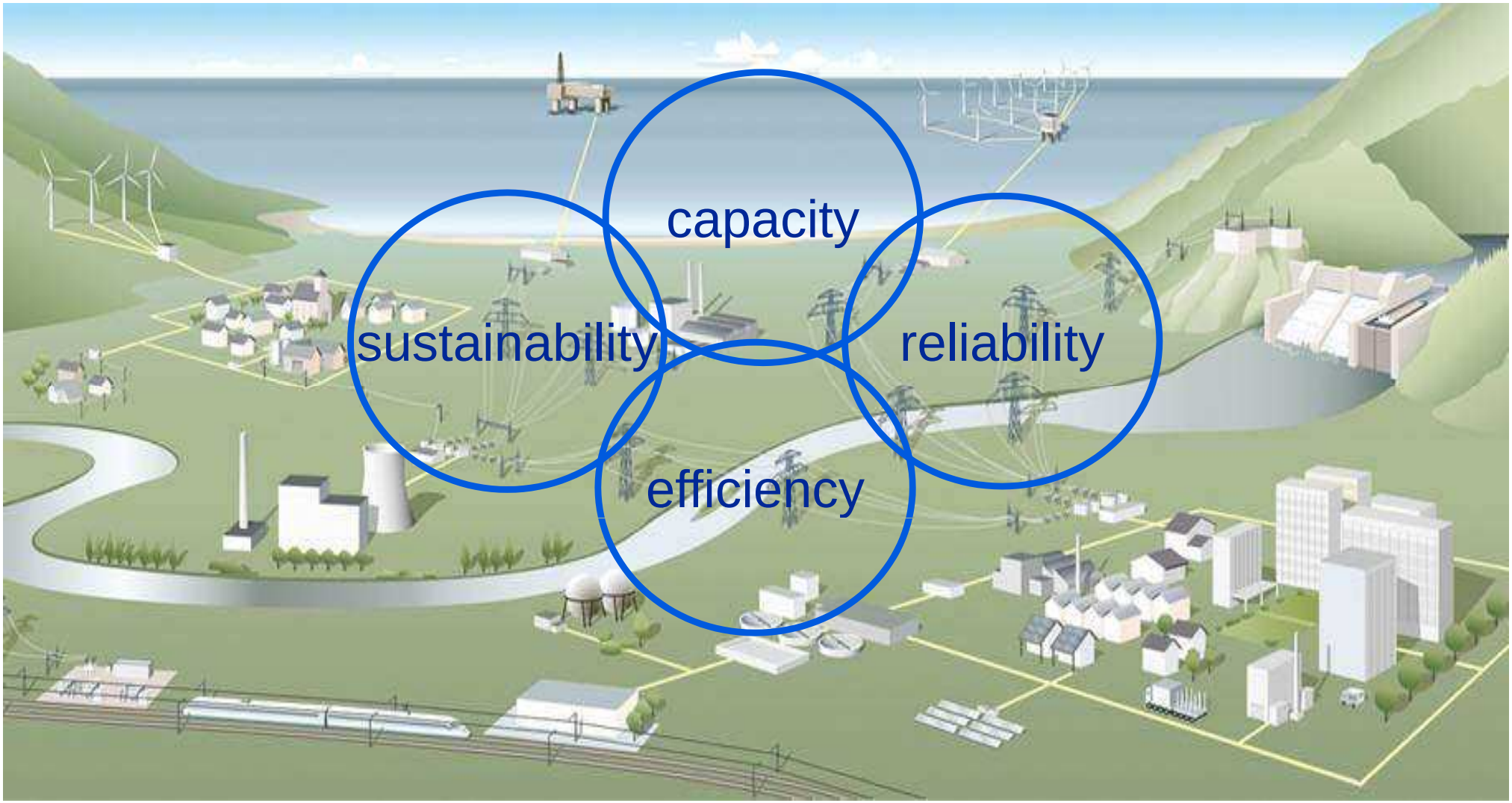


Economic build up of capacity

Capacity
Reliability
Efficiency
Sustainability

- Investment in global grid infrastructure is estimated to total $ 6 trillion by 2030[1]
- Present grids can be refurbished to operate at full capacity without compromising safety: an economic alternative to new installations
- New installations must provide maximum flow of energy to any location in the grid

The future electrical system must be used at its full capacity

[1]Source: IEA

New challenges require additional capacity

- **Capacity**
- Reliability
- Efficiency
- Renewables

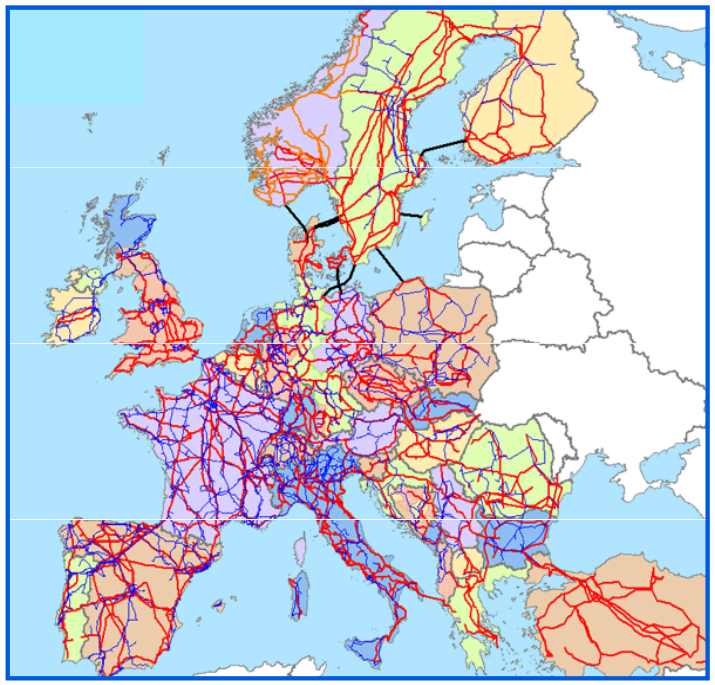
[1] Sources: CS Investment Bank, Boston Consulting, Renault-Nissan, Roland Berger

- In 2020 the fleet of electric cars could reach 40 million world wide[1]
- The infrastructure for charging has to be built
- Required fast charging options cannot be provided by the present grid infrastructure

The future electrical system must be able to cope with new challenges

Electrical energy at any time and any place
Transmission systems

Capacity
Reliability
Efficiency
Sustainability



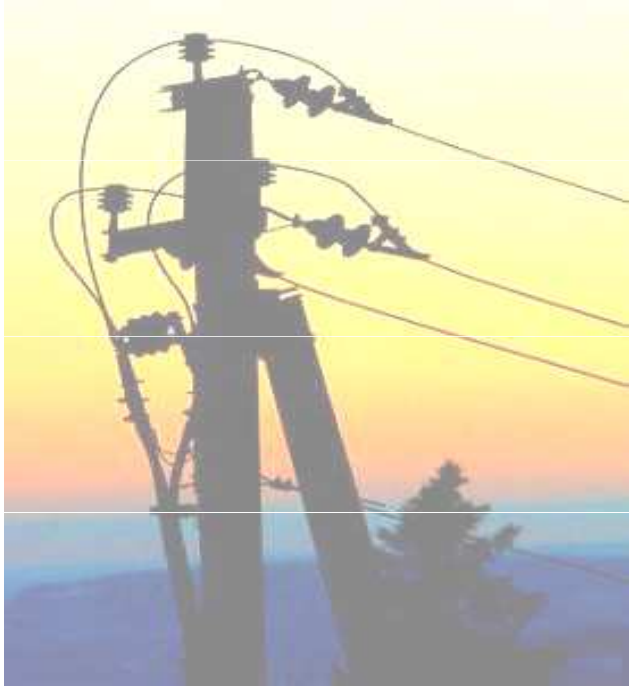
The European grid covers the whole continent

- Safe operation with minimum reserves is the most economic and environmental friendly way to operate the electrical system
- Systems must be designed for utmost reliability and maximum power quality
- Impact of unavoidable faults must be limited to local areas
- Immediate restoring of full performance is a must

The future electrical system must provide a fully reliable energy supply without interruptions

Electrical energy at any time and any place
Distribution systems

Capacity
Reliability
Efficiency
Sustainability



- Distribution grids are awaiting massive roll out of technologies to support
  - remote monitoring and control
  - automated switching
  - fast fault location
- Resulting in
  - reduced outage time
  - increased power quality
  - improved maintenance

Reliability of power distribution is a focus area of the future electrical systems

Saving potential in transmission and distribution

Capacity
Reliability
Efficiency
Sustainability

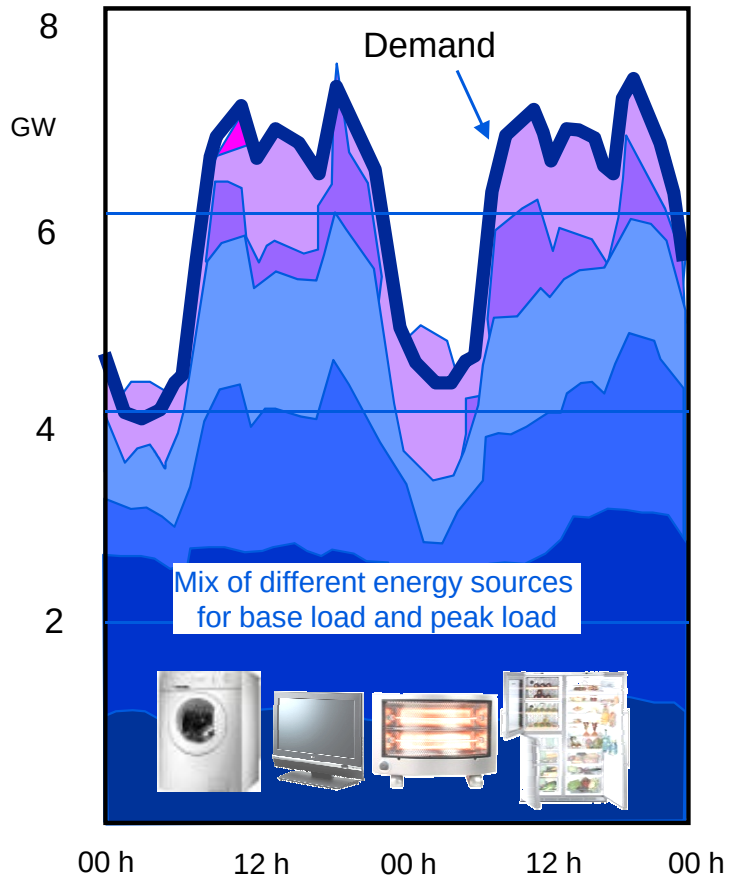
- Losses of electrical energy in the grid can reach 6-10 percent
- Aging equipment with lower efficiency and thermal losses in conductors are the main reasons
- Inefficient distribution transformers account for about 30 percent of losses
- Network losses in EU are an estimated 50 TWh, the annual consumption of 13 million households[1]

[1] Source: European Commission

In future electrical systems losses must be reduced significantly

Supply-demand optimization
Adjusting the energy mix

Capacity
Reliability
Efficiency
Sustainability



- Power consumption varies over the year and during day and night
- To satisfy the demand at any time reserve capacities are required which might not be optimal for environmental reasons
- The challenge grows with more intermittent renewable energy
- A wide range of electrical storage technologies could mitigate the problem

The future electrical system must provide optimal solutions

Supply-demand optimization
The role of the consumer

Capacity
Reliability
Efficiency
Sustainability

- Today consumers determine when and how much energy they want to use irrespective of the actual supply situation
- Power producers plan the supply and deliver without knowing the detailed projected consumption
- Effective information exchange and automation of appropriate actions of both parties can optimize the demand supply equation
- For US a 20% reduction potential in peak demand after full deployment of demand response is estimated[1]

[1] FERC 2009

The future electrical system must facilitate an effective dialog

Integrating renewable power
Bridging long distances

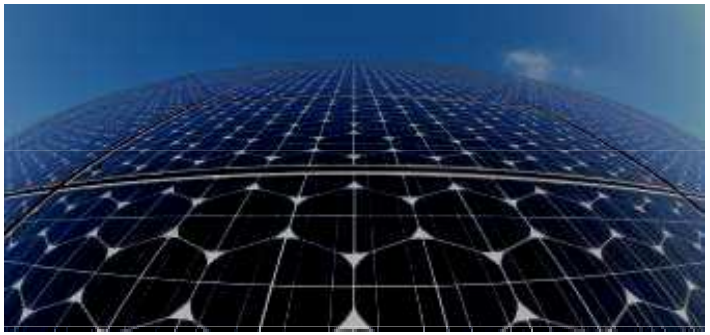
Capacity
Reliability
Efficiency
Sustainability

- Large hydropower plants present the biggest contribution to renewable energy over the next 20 years
- Several Gigawatts of power must be transported over thousands of kilometers to the centers of consumption
- Technologies for economic and reliable transport are required

The future electrical system must provide viable solutions

Integrating renewable power
Intermittent power generation

Capacity
Reliability
Efficiency
Sustainability



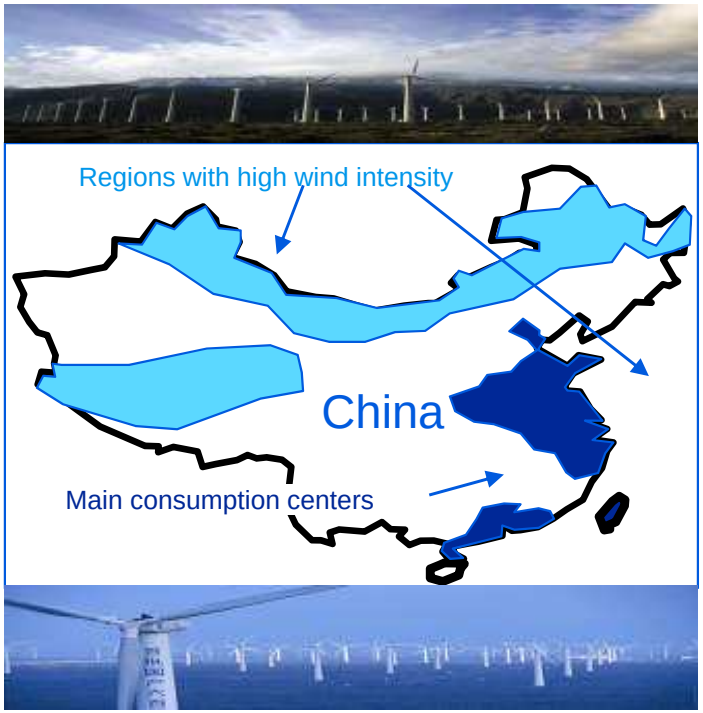
- Electricity from wind and solar plants is intermittent
- Spinning reserves between 5 and 18 percent of installed wind energy are required[1]
- Plant interconnections and a wide range of storage technologies could reduce the need for reserves
- ABB´s answer: SVC Light with Energy Storage

[1] Wind impact on power system, Bremen 2009

The future electrical system must be able to cope with these challenges

Integrating renewable power
Challenging locations

Capacity
Reliability
Efficiency
Sustainability



- Wind farms are built where wind availability is highest
- For energy transport, AC technology with FACTS is often the optimum choice
- Often remote and deserted or off shore
- For offshore installations cables are the only option for energy transport
- For long subsea distances DC technology is the optimal choice
- For medium and short subsea distances AC technology with FACTS is the optimum choice

The future electrical system must offer economic and reliable solutions

The visionary smart grid
Summing up the major requirements

Capacity	Upgrade/install capacity economically Provide additional infrastructure (e-cars)
Reliability	Stabilize the system and avoid outages Provide high quality power at any time
Efficiency	Improve efficiency of power generation Reduce losses in transport and consumption
Sustainability	Connect renewable energy to the grid Manage intermittent generation

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Smart electricity – efficient power for a sustainable world

A smart grid is the evolved system

that manages the electricity demand

in a

sustainable, reliable and economic manner

built on

advanced infrastructure

and tuned to facilitate

the integration of behavior of all involved

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Agenda

Capacity
Reliability
Efficiency
Sustainability

- ABB offerings
  - How to extend reliable capacity
  - How to make the system more efficient
  - How to optimize supply and demand
  - How to integrate renewable energy sources

Effective extension of capacity with proven technology

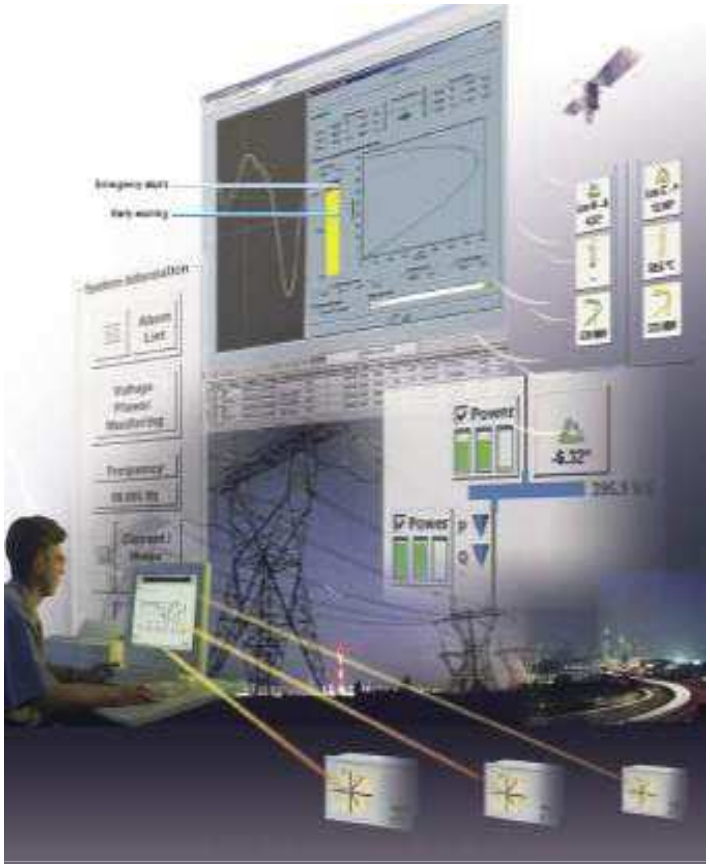
Capacity
Reliability
Efficiency
Sustainability

- Wide area monitoring and control systems for very large scale stability (WAMS)
- Supervisory control and data acquisition systems for large networks (SCADA)
- Flexible AC transmission systems (FACTS) for improved power transfer and stability
- High voltage DC systems to connect different grids, provide stability and transport power from challenging locations (HVDC)
- Substation automation for instantaneous fault detection and system restoring
- High quality products (transformers, etc)

Required systems to unfold the full potential of the grid

Proven technology for wide area monitoring

Capacity
Reliability
Efficiency
Sustainability



- Wide area monitoring systems (WAMS) collect grid conditions in real time at selected relevant locations
- Accurate time stamps are taken from GPS satellites
- Enhanced network analysis of PMU data for estimation of instability development
- ABB's WAMS technology has been recognized by the Massachusetts Institute of Technology (MIT) in 2003 as one of the 10 technologies that can change the world

Early detection and prevention of potential instabilities avoids black-outs

Controlling power flow through transmission lines

Capacity
Reliability
Efficiency
Sustainability

The world's largest SVC
with 500kV, -145 /+575 MVAr
at Allegheny Power/US delivered by ABB

- FACTS devices compensate the inductance of the lines for maximum power transfer (series compensation)
- They also mitigate disturbances and stabilize the grid (dynamic shunt compensation)
- In some cases power system transmission capacity can be up to doubled

ABB has installed over 700 systems, more than 50 percent of all installations world wide

Connecting and stabilizing grids with HVDC

Capacity
Reliability
Efficiency
Sustainability

World's longest sub sea cable from ABB

- HVDC systems convert AC from power generation to DC for transport and reconvert DC to the consumer-required AC
- Grids running at different frequencies (50 Hz or 60 Hz) can thus be coupled
- Instabilities in one part of the grid are decoupled from the other
- Long sub sea connections are only possible with HVDC (DC cables)

ABB is market and technology leader since more than 50 years in HVDC technology

Automated detection and prevention of faults

Capacity
Reliability
Efficiency
Sustainability

ABB has installed one of the world's largest substation automation systems with 482 data points in Moscow

- Substation automation is a key component in ABB's offering
- Compliant with the IEC 61850 standard it performs
  - Fault evaluation
  - Remote communication for telecontrol and supervision
  - Protection
  - Data acquisition

ABB has sold more than 700 of substation automation systems compliant to IEC 61850 standard

Agenda

Capacity
Reliability
Efficiency
Sustainability

- ABB offerings
  - How to extend reliable capacity
  - How to make the system more efficient
  - How to optimize supply and demand
  - How to integrate renewable energy sources

Improved process control in power generation

Capacity
Reliability
Efficiency
Sustainability

- Optimization of auxiliary systems in power plants offers significant savings
- Up to 8 percent of produced energy is consumed in auxiliary systems
- Additional savings from process improvement for
  - combustion systems
  - start up time for boilers
- Analysis of overall system optimization

Savings in both thermal and electrical energy can be achieved today by using existing technologies

Reduced losses with HVDC

Capacity
Reliability
Efficiency
Sustainability

- HVDC is especially beneficial for long distance transmission with low losses
- Lower cost for infrastructure (fewer and smaller pylons, fewer lines) compensate higher investment in converter stations
- ABB will save 30 percent transmission losses by installing an ultra-high voltage direct current (UHVDC) connection more than 2,000 km long in China
- One of the world's longest and powerful transmission systems from ABB operates at ± 800 kV, transporting 6,400 MW

ABB has delivered most of the world's installed HVDC systems

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Capacity
Reliability
Efficiency
Sustainability

- ABB offerings
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Building control for optimal performance

Capacity
Reliability
Efficiency
Sustainability

ABB Comfort panel

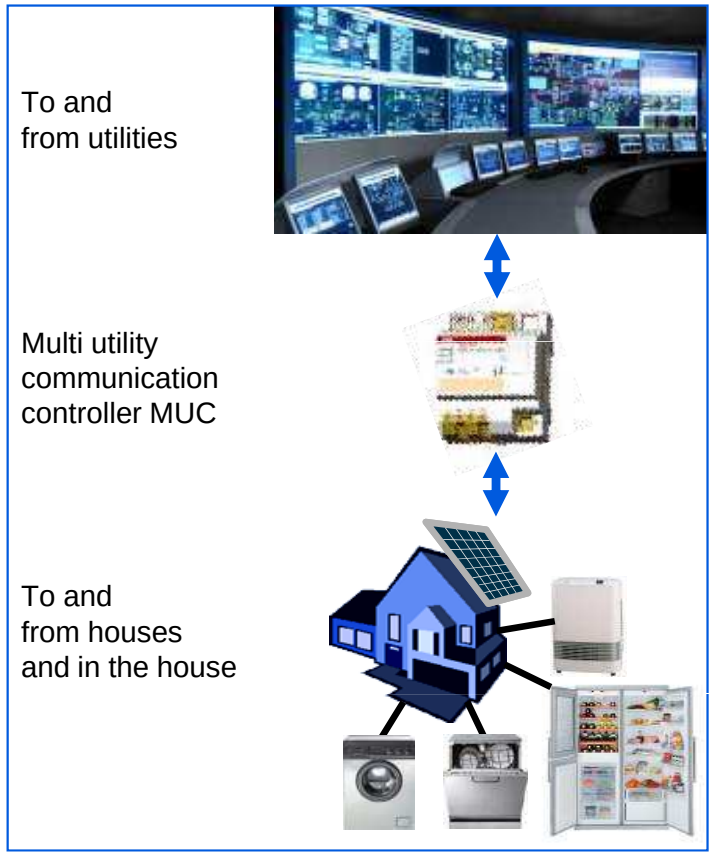
- Building automation can save up to 60 percent of energy[1]
- ABB control systems allow the individual adjustment of rooms and appliances to the most efficient energy consumption
- Up to 30 percent energy savings could be achieved in several large buildings in Singapore with ABB i-bus KNX systems
- ABB i-bus technology is used world-wide in hotels, airports, shopping centers and houses

[1] estimates of WBCS

Broad application of building control could reduce global energy consumption by 10 percent[1]

ABB offers a wide range of communication options

Capacity
Reliability
Efficiency
Sustainability



- Full two-way communication via different channels [1]
- Remote energy shut downs possible
- Energy import and export measurements
- Visualization, control and configuration
- Electronic meters for monitoring serve all customer needs
- Multi-tariff options, load profiles, real time or monthly reading

[1] Communication via GSM (GPRS); Internet (WAN, LAN, DSL, ISDN); PLC; M Bus over TP, Ethernet or GSM/GPRS, LonWorks PLC or EIB/KNX

Customized solutions for information exchange and demand response

Agenda

- ABB offerings
  - How to extend reliable capacity
  - How to make the system more efficient
  - How to optimize supply and demand
  - How to integrate renewable energy sources

Solar and hydro power

Capacity
Reliability
Efficiency
Sustainability

- ABB supplies power plant control for hydro, wind and solar plants and tailor-made long distance connections
- ABB has delivered the automation systems and electrical equipment to Europe's first large-scale 100 MW solar plant in Spain (Andasol)
- ABB provides the complete balance of plant for the world's first integrated solar combined cycle plant in Algeria (175 MW)

ABB has connected 230 GW of renewable energy to the grid

Huge wind farms far out in the sea

Capacity
Reliability
Efficiency
Sustainability

- ABB supplies complete electrical systems for wind generation and the subsea connections to the shore
- ABB is the world's biggest supplier of electrical equipment and services to the wind industry
- HVDC Light with oil-free cables and compact converter stations will connect one of the world's largest wind parks (400 MW) at Borkum/Germany to the mainland.

ABB is a leading supplier of electrical systems for wind energy

Energy storage to bridge outage periods

Capacity
Reliability
Efficiency
Sustainability

BESS installation in Fairbanks, Alaska

- Balancing power is a major issue for utilities and especially critical with large amounts of intermittent wind and solar energy in the supply mix
- Storage of electrical energy helps to bridge the time of reduced or missing power to activate reserves

ABB equipped the world's largest battery storage system, which can supply 26 MW for 15 minutes

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Smart grids will significantly contribute to mitigate climate change

Today	With smart grids
▪ <13% variable renewables penetration	▪ >30% variable renewables penetration
▪ 5% demand response systems	▪ 15% demand response systems
▪ >1% consumer generation used on the grid	▪ 10% consumer generation used on the grid
▪ 47% generation asset utilization	▪ 90% generation asset utilization
▪ 50% transmission asset utilization	▪ 80% transmission asset utilization
▪ 30% distribution asset utilization	▪ 80% distribution asset utilization

Source: DOE and NETL

Strong support of all involved is required

- Everyone has to reconsider the individual energy consumption behavior
- Politicians must set up incentives to save energy commit to global CO_2 reductions
- Energy markets with active participation of all involved must be installed

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