

Claudio Facchin, President Power Grids division, ABB – Cigré Keynote Address, Paris, August 21, 2016

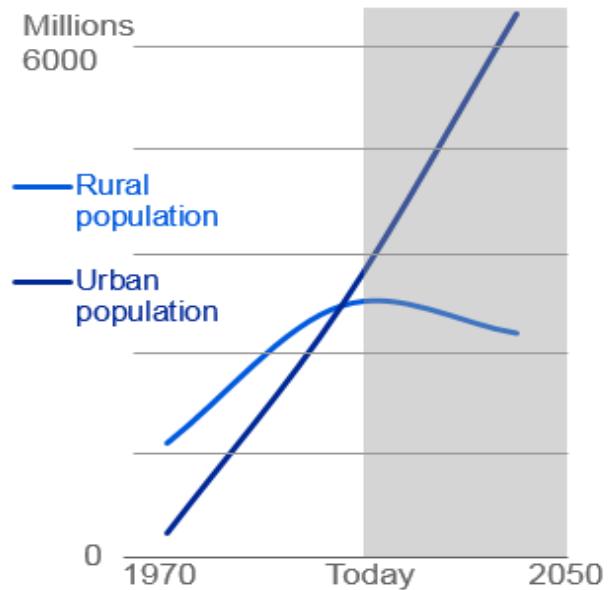
# Big shift in power

## Shaping power systems of the future

# Big shift in power

## Global challenges

### Population growth & urbanization



Source: UN World urbanization prospects: 2012 revision

### Paris climate agreement (COP 21)



Average global temperature increase  $<2^{\circ}\text{C}$



\$100 billion per annum to support developing countries



Emission peak soon, 2050 balance of emissions and capturing

**Manage economic growth and social challenges without consuming the earth**

# Big shift in power

## Changing power generation balance

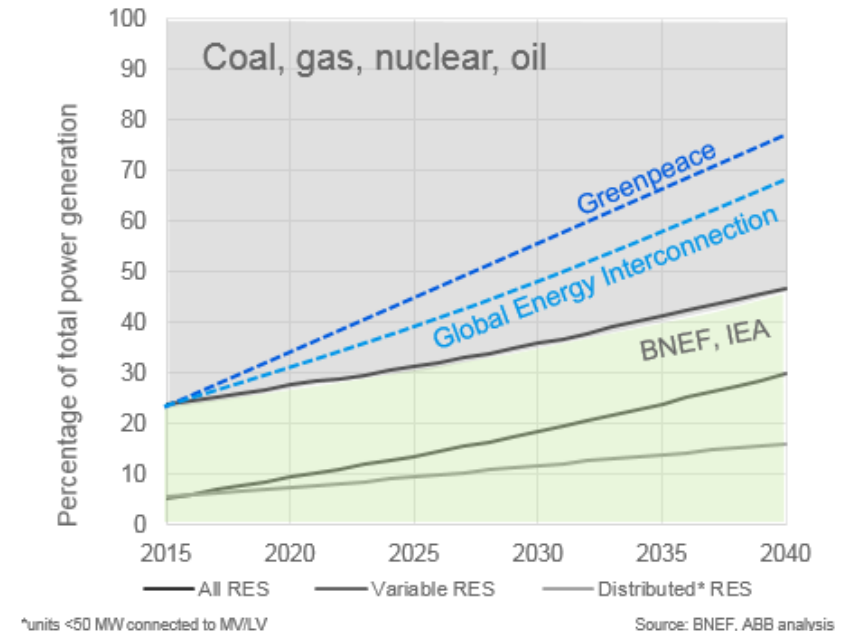
### Power generation

Power balance tipping irreversibly towards renewables, driven by policy & disruptive technology cost reduction

Main growth is foreseen in variable renewables such as wind and solar

Two growth paths: centralized and distributed renewables

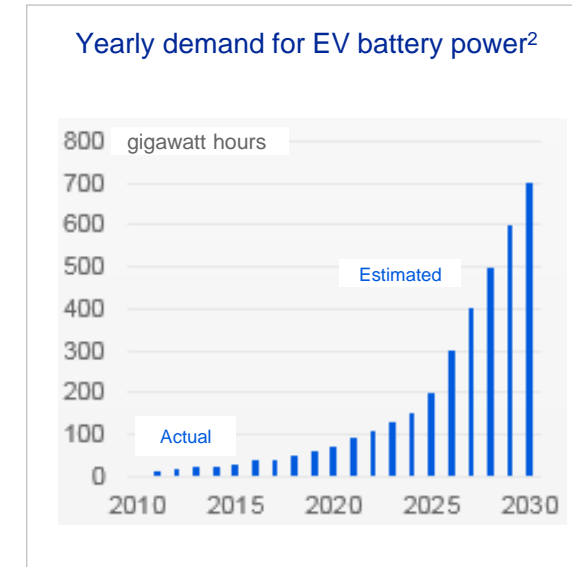
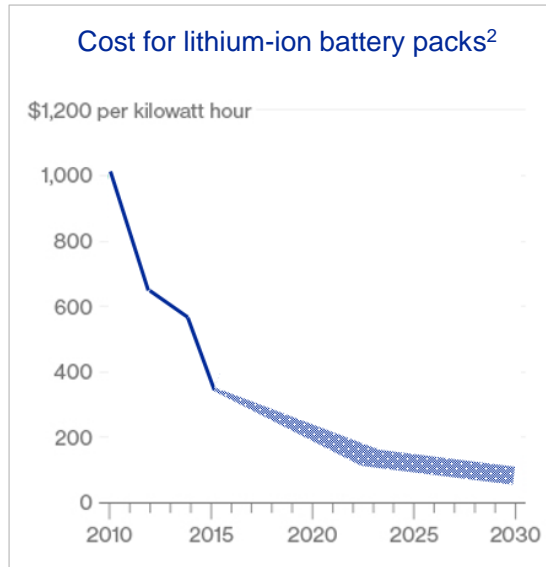
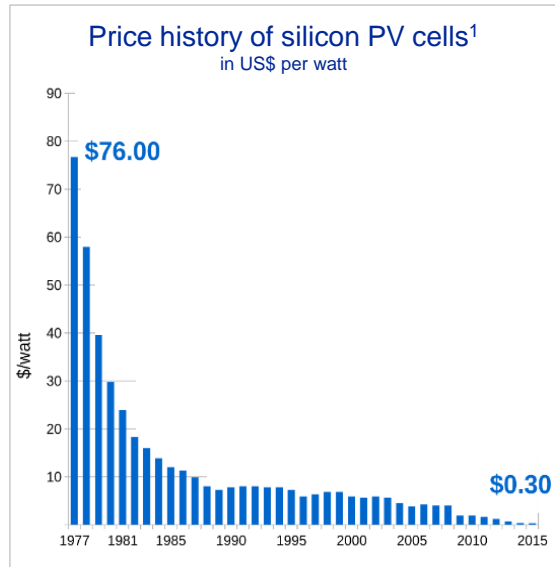
- Some countries / regions are more inclined towards distributed renewables
- Others are mainly on the centralized renewables path



**Renewables are expected to become the dominant source for electrical power generation**

# Big shift in power

## Disruptive developments driving key changes in future grids



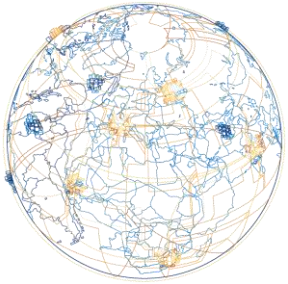
### Batteries & photovoltaic

- Dramatic cost reduction – to be continued
- Scalability of technologies
- Consumer investment across market segments accelerating developments

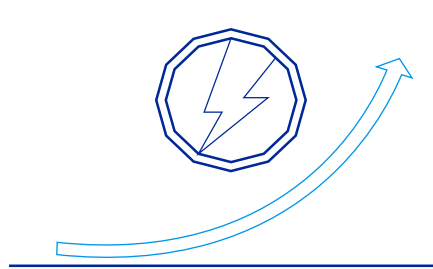
# Big shift in power

## Elements of the evolving grid

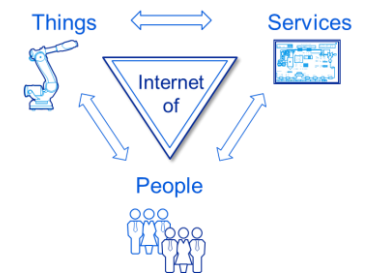
### Global super grids



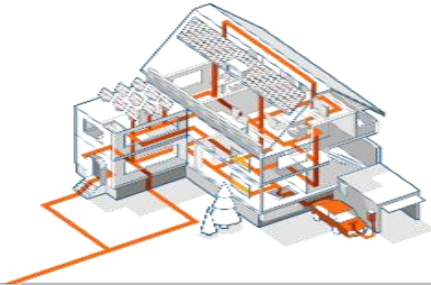
### Power quality & demand management



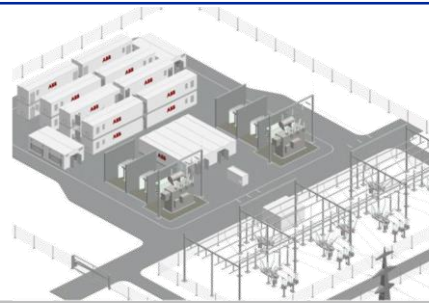
### Digitalization



### Residential roof top solar plus Micro- and Nano-grids



### Energy storage



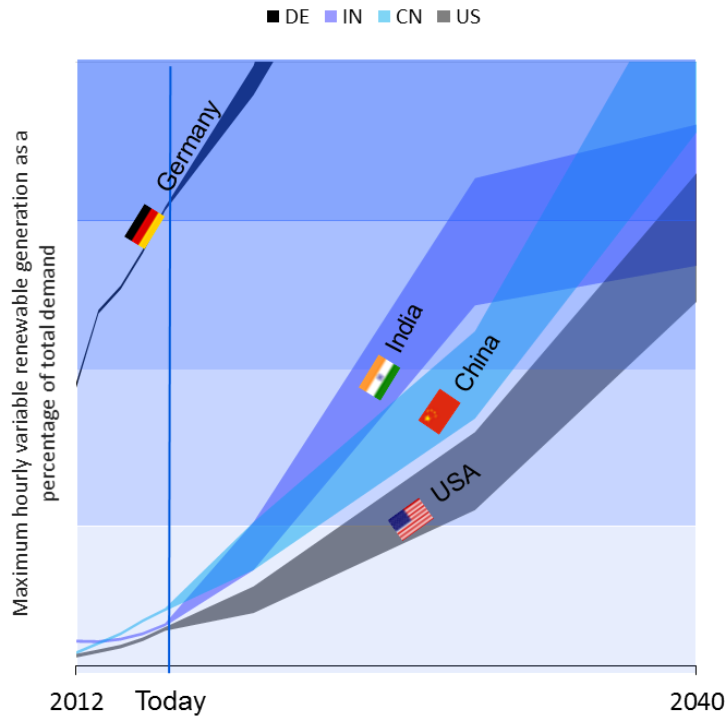
### New business models



NETFLIX

# Big shift in power

## Technical challenges of renewable energy grid integration



\*Source: ABB evaluation

### Technical challenges\*

Conventional operation

Grid capacity & reserve

+ system inertia & grid voltage

+ short circuit power & significant  
variable RES curtailment

\* Percentages are dependent on system characteristics

**Grid investments and technologies required to address above challenges**

# Power systems of the future

## Grid interconnection

### Opportunities

Renewable integration across regions

- Fluctuations during the day
- Seasonal variations

Optimal use of reserve and peaking capacities

Diversification of electricity supply

Reduction of wholesale electricity price volatility

Strengthening grid operation in case of fault conditions

Increase capacity utilization factor of conventional generation

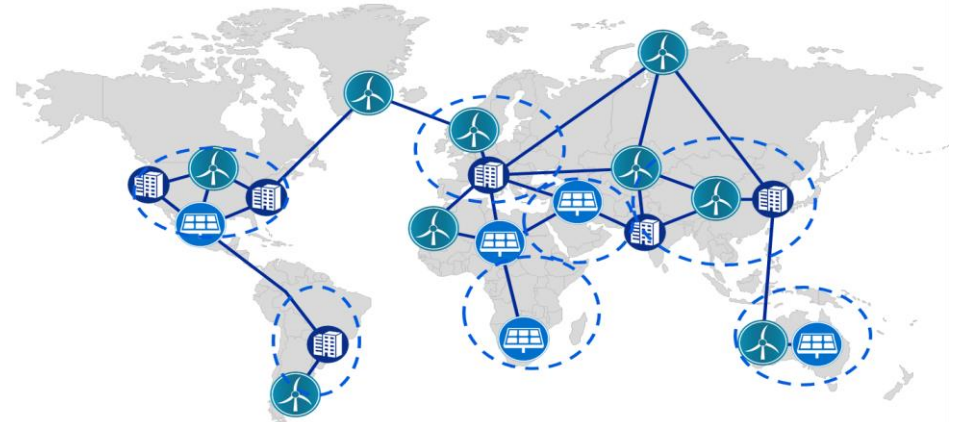
### Challenges

Political factors

Economic framework

Technological capabilities

Coordinated operation (global harmonization of standards, grid codes and operational practices)



# Power systems of the future

## Grid interconnection: Ultra High Voltage

### World's most powerful UHVDC link

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Chiangji-Guquan, China

1100kV DC

12000MW

>3000km



### World's first multi-terminal UHVDC link

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North-East Agra, India

800kV DC

6000MW

>1700km



### UHVAC transmission

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Bina Substation, India

1200kV Circuit breaker &  
transformer



# Power systems of the future

## Microgrids and integration of renewables

### Resilient and cost-effective technology

Grid code compliant integration of wind & solar

Stabilizing weak grids

Microgrids acting as one controllable generator or load

Access to power in remote locations

### Marble Bar, Australia

- PV\* (300 kW)
- Diesel (1280 kW)
- Flywheel (500 kW)



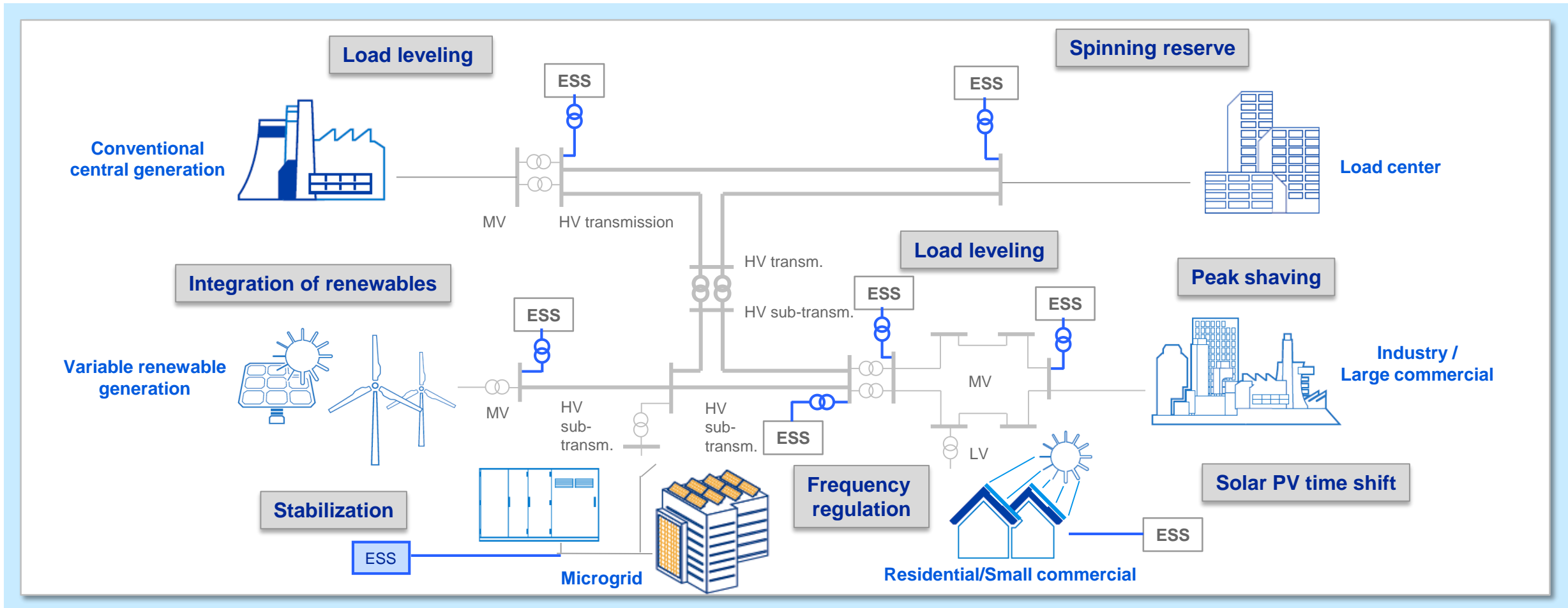
### Johannesburg, South Africa

- PV\* (750 kW)
- Diesel (2x600 kW)
- Battery (1 MVA/380 kWh)



# Power systems of the future

## Energy storage – a key element across the power value chain



# Power systems of the future

## Power quality & demand management

### Distributed renewables

Line voltage regulator  
On-load tap-changers for distribution transformers  
Extended control algorithms

Line voltage regulator  
for medium voltage  
grids with RESIBLOC®  
technology



### Bulk renewables

Extremoz substation (BR): Static Var Compensator to connect wind energy (>1000 MW) to 230kV level



### Demand response management

Frequency regulation through short term balancing of supply and demand  
Smart home and building management  
Electric vehicle (charging) infrastructure



# Power systems of the future

## Digitalization trend – Internet of Things, Services & People

### Design and build

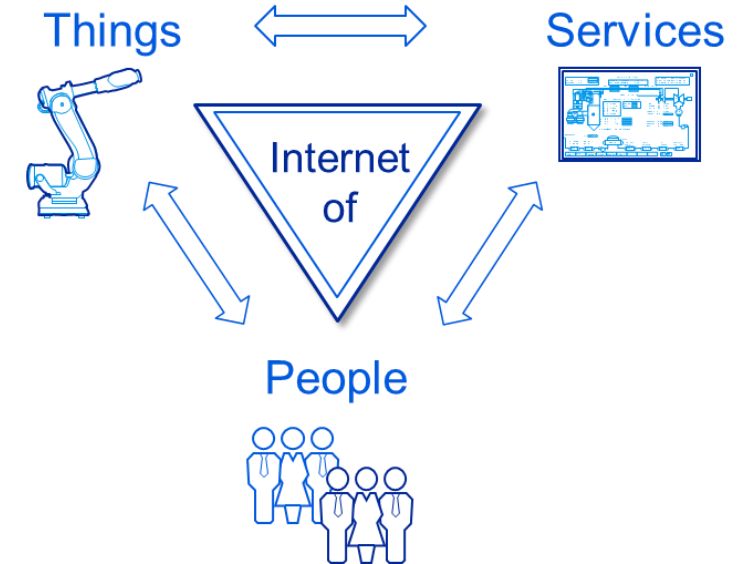
- Optimized design through simulation
- Faster configuration process
- Lower lead times and higher quality manufacturing & assembly processes
- Reduced on-site installation & commissioning

### Operate

- Virtual power plants
- Power generation forecasting & scheduling
- Electricity market management
- Ownership of assets and business model

### Maintain

- (Big) Data analysis – continuous learning
- Remote access – communication
- Monitoring, asset management & service aligned with expert knowledge
- Workforce management



# Power systems of the future

## Evolution from a conventional to a digital substation

### Fit for future grid requirements

Standardized digital signal transfer

- Compatibility & interchangeability
- Signal supervision
- Fast communication
- Data acquisition for monitoring

Reduced cabling

Reduced footprint (AIS)

Safety

Reduced installation times

Flexibility for changes

### Queensland, Australia

275kV digital substation including NCIT<sup>1</sup> & 61850 process bus communication in operation since 2011

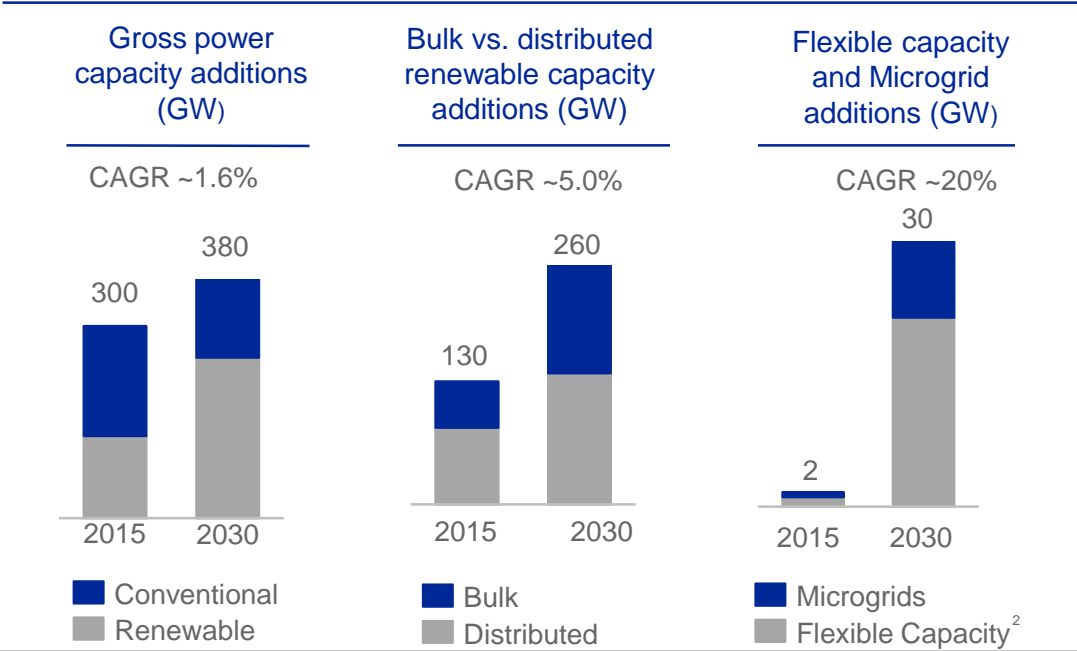


**Relevant for new and existing substations**

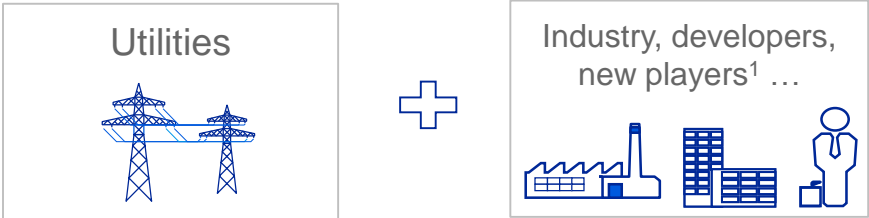
# Market undergoing significant change

## Demand drivers remain attractive

### Shift in growth of electricity sources



### Customers & consumers: more diverse, more grid feed-in & take-out points



### Suppliers: shift in differentiation

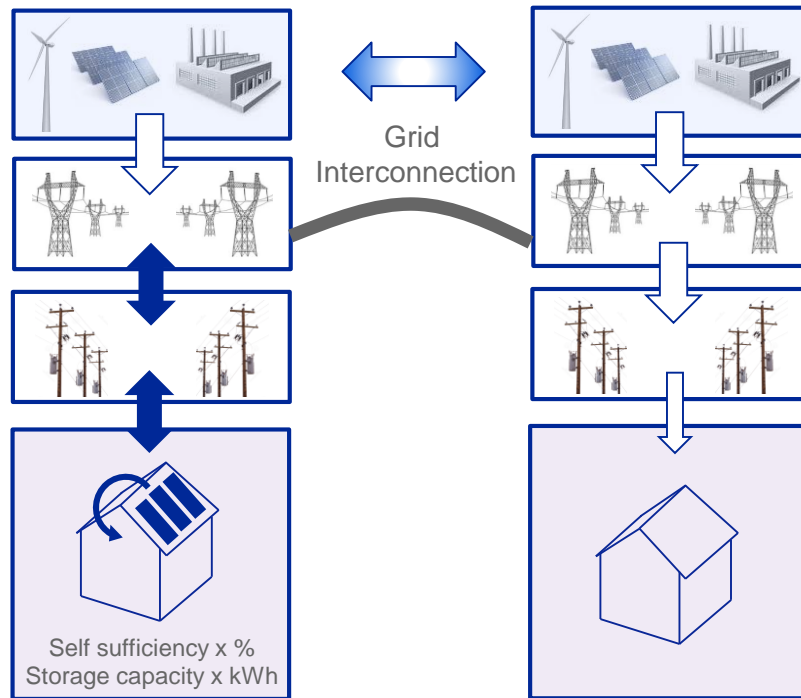


**Shift in generation mix, customer diversification and supplier differentiation**

<sup>1</sup>E.g. Virtual Power Plants, local consumers, ...;  
<sup>2</sup>Flexible capacity includes Virtual Power Plants and battery storage capacity.  
Source: Bloomberg New Energy Finance

# Power systems of the future – an evolutionary vision

Interconnected system of regional grids with fluctuating demand and generation patterns



Renewables will take major share in electrical power generation

- Disruptive elements
  - Photovoltaics
  - Batteries
  - Digitalization
- Distributed generation with changing consumer & producer patterns
- Distribution grid role changing
- Transmission backbone essential
- New business & operational models

**New opportunities & challenges require new ideas – evolutionary & revolutionary**

# Thank you