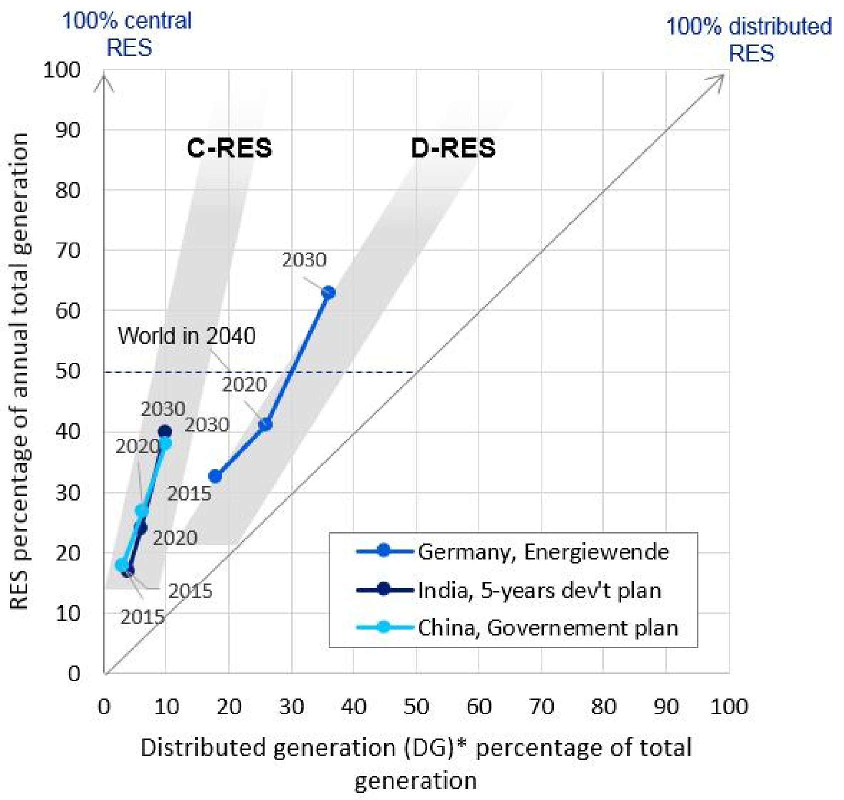
2016-05-12, Dr. Ernst Scholtz, Global R&D Strategy Manager IRENA Innovation Week, Bonn, Germany

Renewably-fueled Power Systems
Grid Innovations

Global observations
Changing power balance

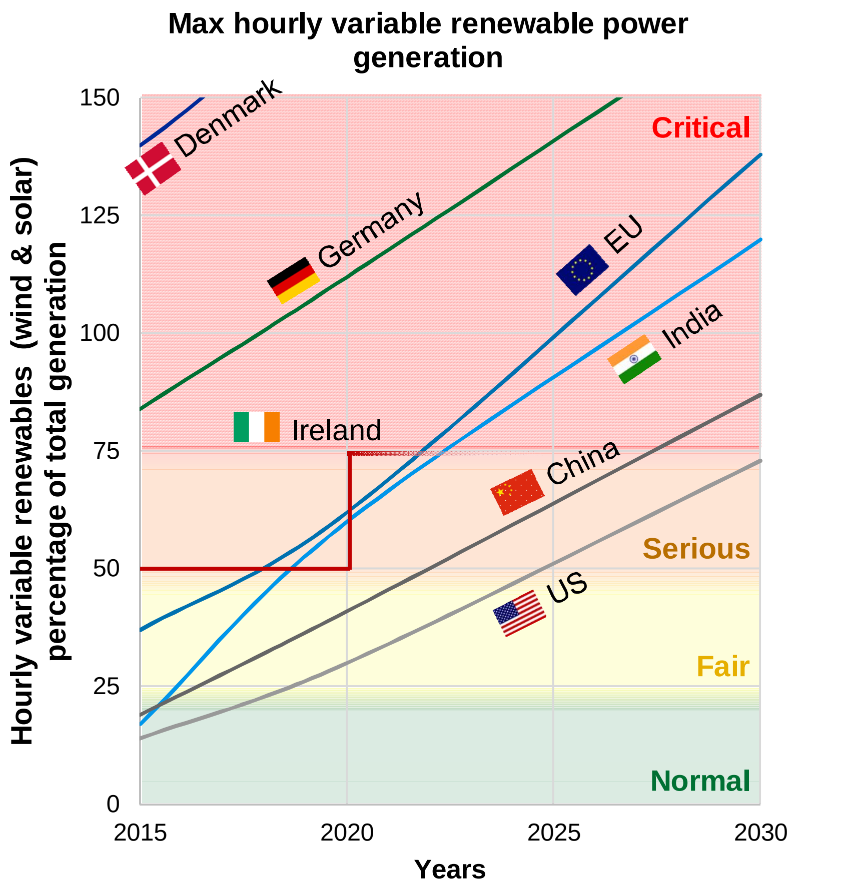


*units <50 MW connected to MV and LV distribution grids.

Source: Energiewende, China and India official plans, ABB analysis

- Balance tipping irreversibly towards renewables, driven by policy & technology cost reduction
- The growth has been and remains to be variable renewables (vRES, e.g. wind, solar)
- Centralized and distributed renewables are growing simultaneously
- Two paths: centralized and distributed*:
  - Most industrialized regions follows distributed
  - Fast-developing regions mainly follow centralized

Increasing Renewables
Technical barriers could limit adoption



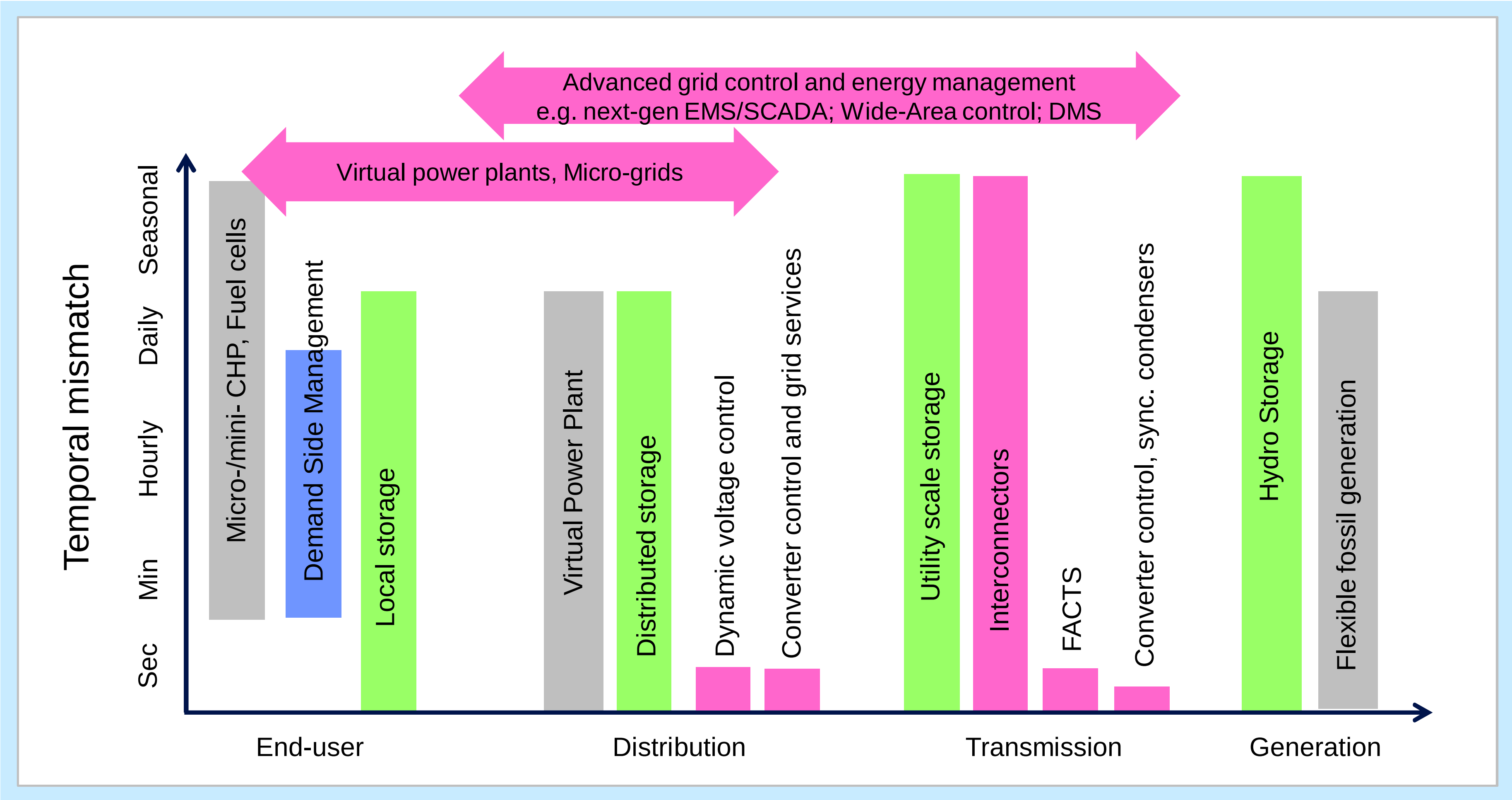
- The technical challenges for the maximum hourly variable RES penetration [%] are*:

0-25%	**safe operation**
25-50%	**grid capacity & reserve**
50-75%	**" + system inertia & grid voltage**
75-100%	**" + short circuit power**
>100%	**" + significant variable RES curtailment**

- DE and DK can operate in critical zone due to strong connections to the ENTSO-E grid
- Ireland limits an instantaneous percentage of wind power by 50%

* Percentages are dependent upon system characteristics

Breaking through technical barriers
Technology options*

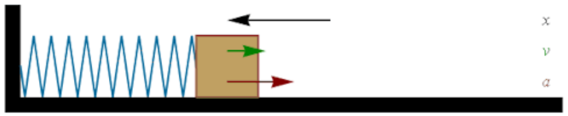


Flexible grid technologies
Flexible generation sources
Energy storage
Flexible demand

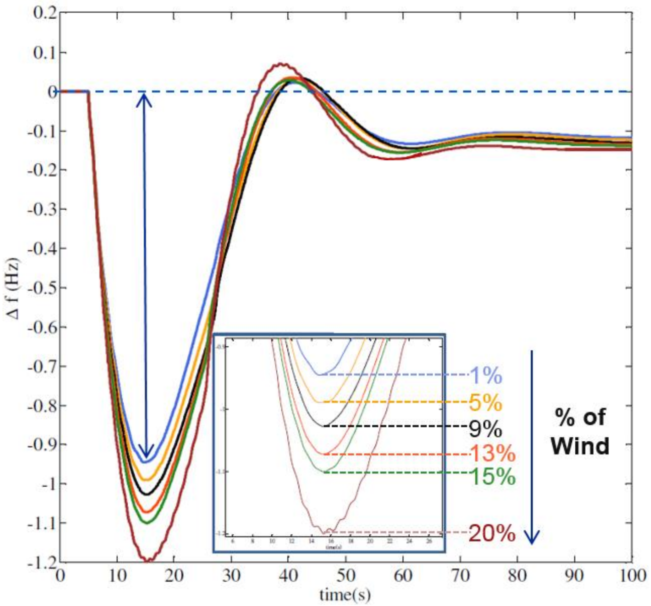
*(not exhaustive)

Technical barrier – limited inertia
Power swing (i.e., grid frequency) dynamics

Power swing dynamics



- Increasing penetration of vRES leads to larger system Frequency change after grid fault



M

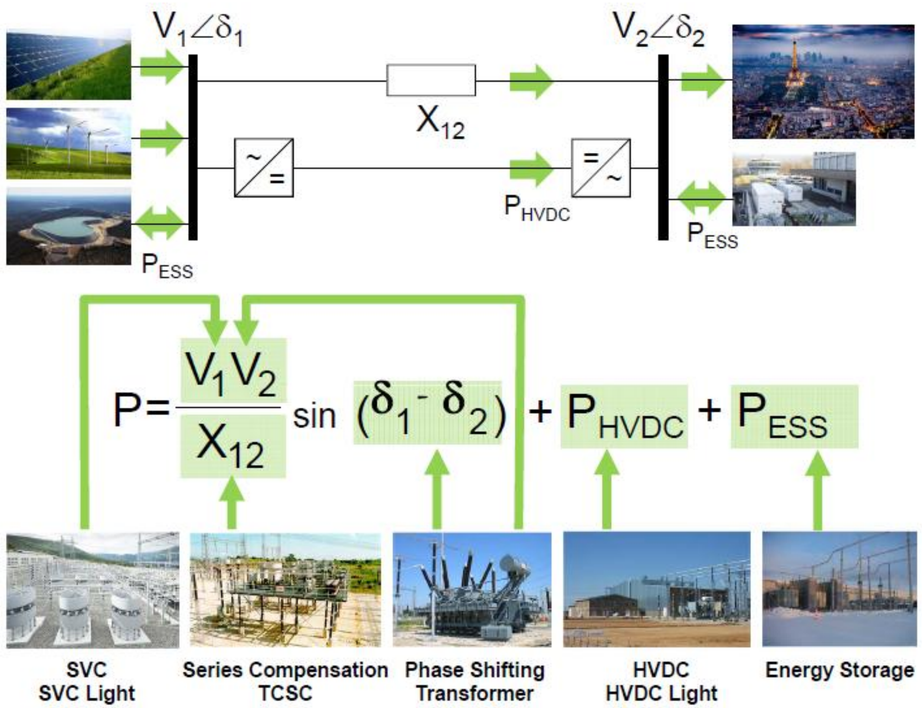
Σ m

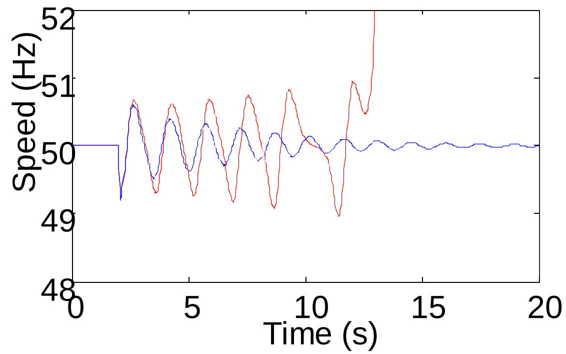
0

- Large generators (M) keep the frequency closer to 50 / 60 Hz (nominal frequency)
- M being replaced by generation with little to no inertia
- Deviating far from nominal triggers safeguards (e.g. generator protection), making the system prone to more oscillations / instability

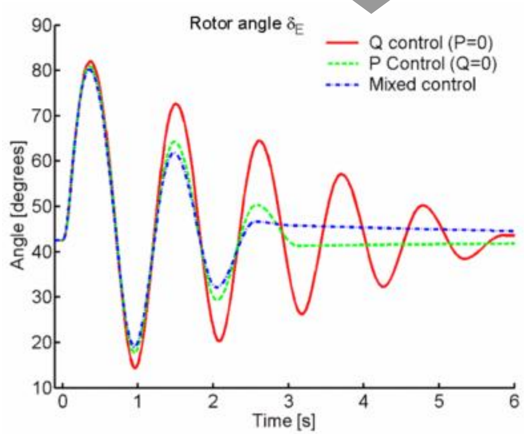
Increasing penetration of vRES increases magnitude of frequency events following a large disturbance

Controlling power swing dynamics
Options





Modulate P_{HVDC}



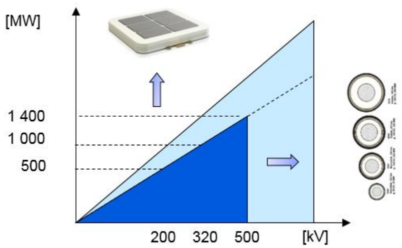
Beyond the power transport benefits of HVDC, it is also an effective actuator to damp power swings

Innovations in Voltage-Sourced Converter HVDC

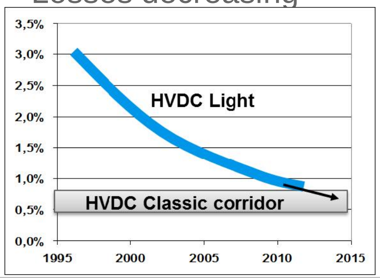
Increased power, lower losses and flexible to support AC grids

VSC Converters

Voltage up, Current up in R&D



Losses decreasing



Cables

2014: 525kV rated voltage, with 2.6GW capability

Cables + accessories for 2600 A

Control and Protection

1976: calculations took 15 ms

2015: 100 floating-point calculations / ns

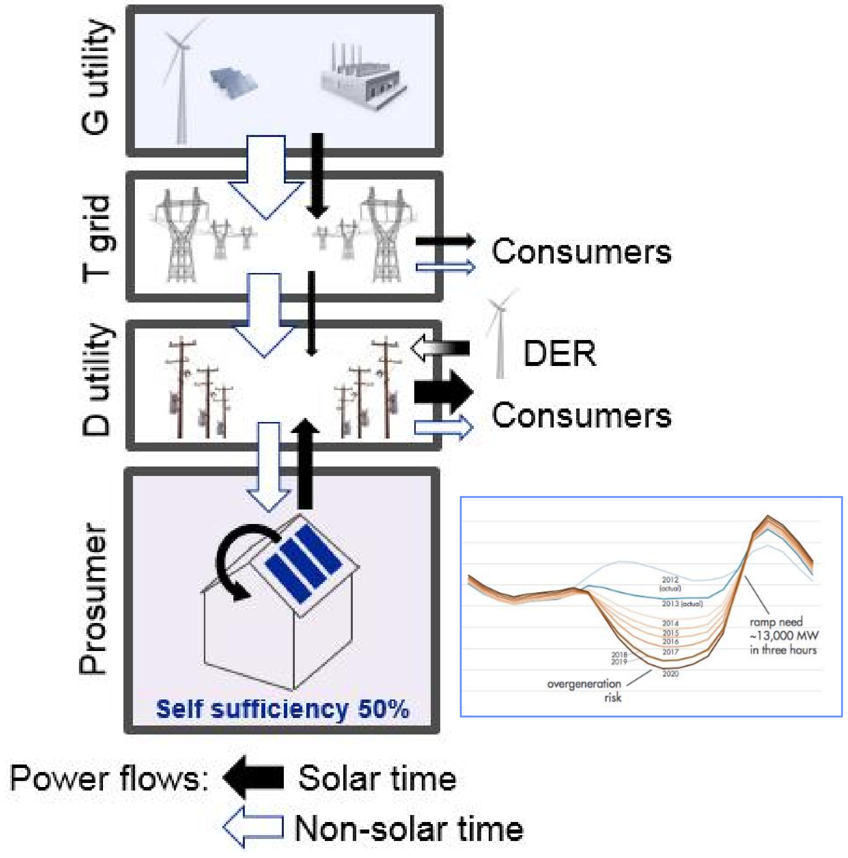
Notable points

Skagerrak 4: 500kV, 700MW

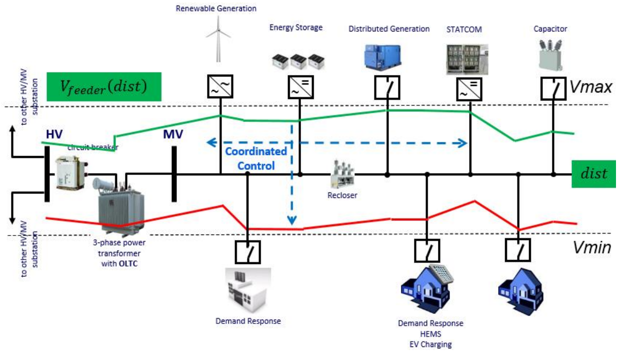
HVAC support via embedding of HVDC

Innovations around VSC-based HVDC continues to yield a capable actuator for Strong and Smart Grids of the future

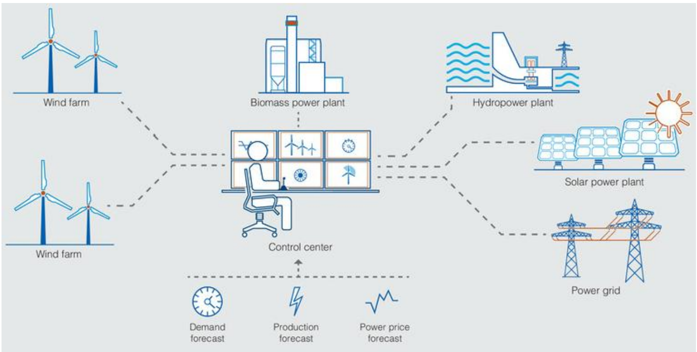
Grid innovations close to end consumer
Increasing observability and controllability



- Distribution grid observability (e.g. digital s/s) and controllability (e.g. PV converters, DMS) improving



- Aggregators improving observability and controllability of modern end-users

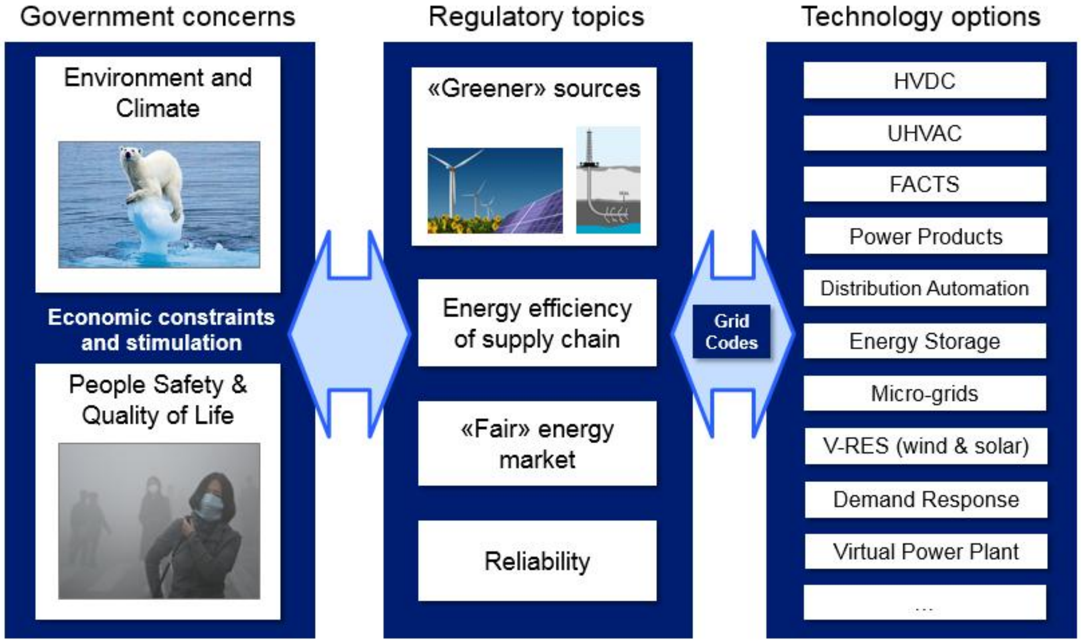


Closing remarks
Regulation stimulates technology innovation

Some technologies to watch

- Ultrahigh Voltage DC (> 1’100kV for > 5’000km)
- Battery energy storage
- Digital Substations
- Advanced Transmission Energy Mgmnt (e.g. using PMUs)
- Next-generation ICT (5G) applied in Power Systems
- Scalable aggregation platforms interfacing w/ TSO/DSO
- Inertia control and protection

- Policy and regulation set targets, devise remuneration schemes and create market rules
- This affects the feasibility of using various technologies, influencing the innovation speed for technology options.



Grids of the future will leverage more ICT, Power Electronics, and Control

Power and productivity
for a better world™

ABB