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Interconnection enabling high shares of renewable energy

Latest achievements and findings

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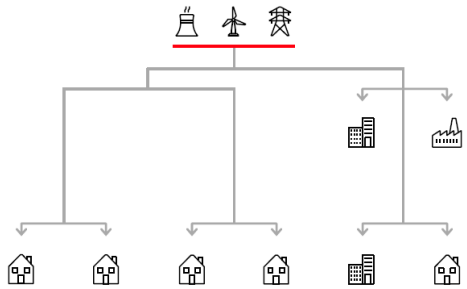
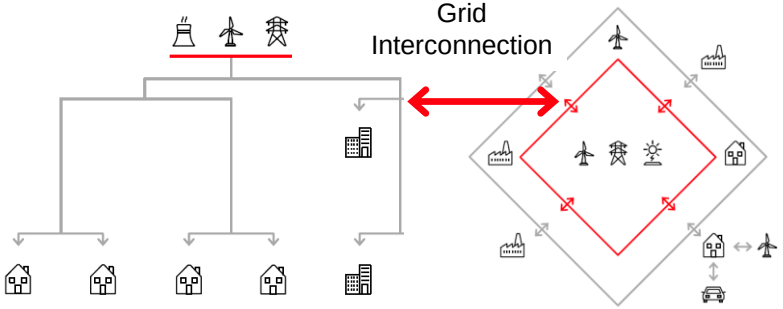
Power systems of the future

Grid evolution today and in the future

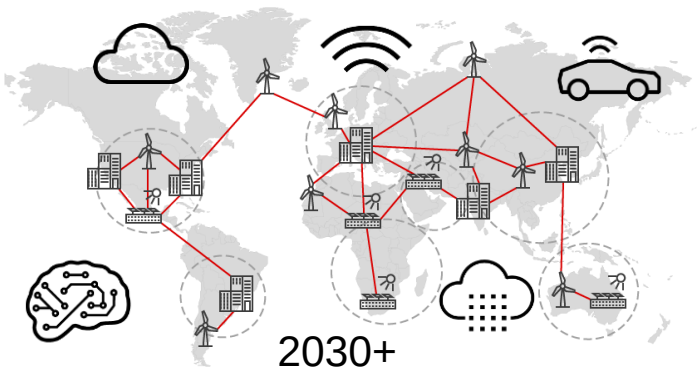
Yesterday



Today



Tomorrow



2000 — 2020 — 2030+

Factors:

- Global warming – ecological threats
- Stimulated, regional introduction of renewables
- Exponential reduction of photovoltaics & battery storage costs
- Consumer to Prosumer development
- Digitalization trend
- Interconnection technology development

Factors:

- Full scale deployment of renewables across all regions
- Increased share of energy by wire
- Massive introduction of grid connected Electrical Vehicles
- Utilities re-inventing themselves with new business models
- Fully flexible power exchange with related data transfer («Internet of Energy»)
- Artificial Intelligence enabling complex autonomous processes

Providing the building blocks

Latest achievement in UHVDC development

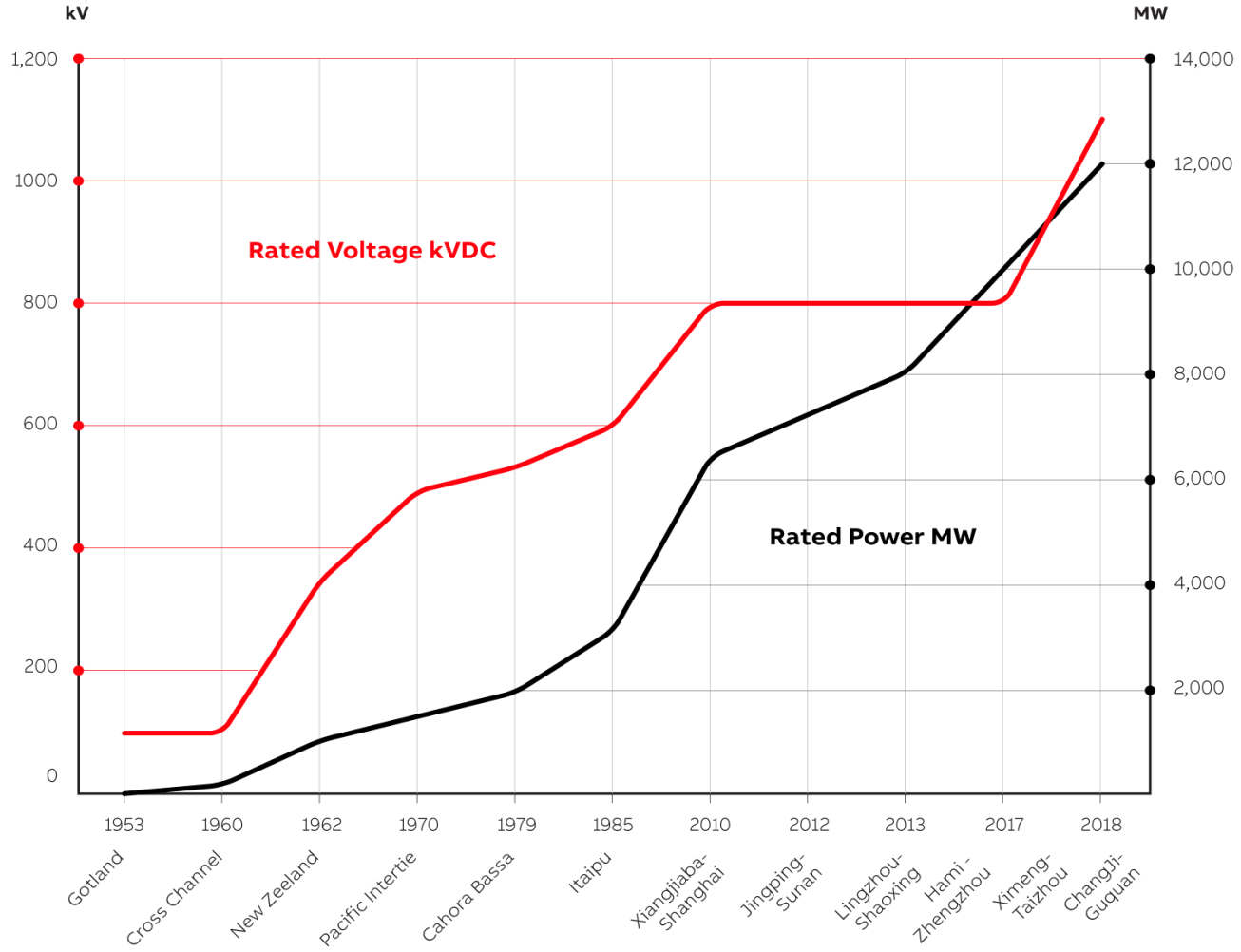
HVDC – taking new steps in technology

1954

Gotland HVDC transmission link, first commercial HVDC project, 20MW and 100kV DC

2018

Changji – Guquan +/- 1,100kV DC UHVDC transmission link, 12,000MW and 1,100kV DC



World’s most powerful 1,100 kV DC transformer successfully type tested

Changji-Guquan +/- 1,100 UHVDC Transmission project – setting new world records

November 2017 – successful type testing in Ludvika

- Weight >800 tons
- Length >30 meters
- Power rating >600 MVA
- Connected to 750kV AC on the line side

Historical breakthrough within HVDC high power long distance transmission

All planned schedules met – enabled by excellent SGCC – ABB collaboration

ABB deliveries for this record system:

- World’s most powerful converter transformer
- HVDC converters (receiving station)
- Wall bushings
- Neutral DC breakers

HVDC technology and applications – outlook

DC grids

- DC breaker
- System layout, protection & control

LCC – VSC mixed and embedded systems

- System upgrades
- Additional grid support functionalities
- Support of energy distribution in connection with cross-regional interconnectors

VSC functionalities and opportunities

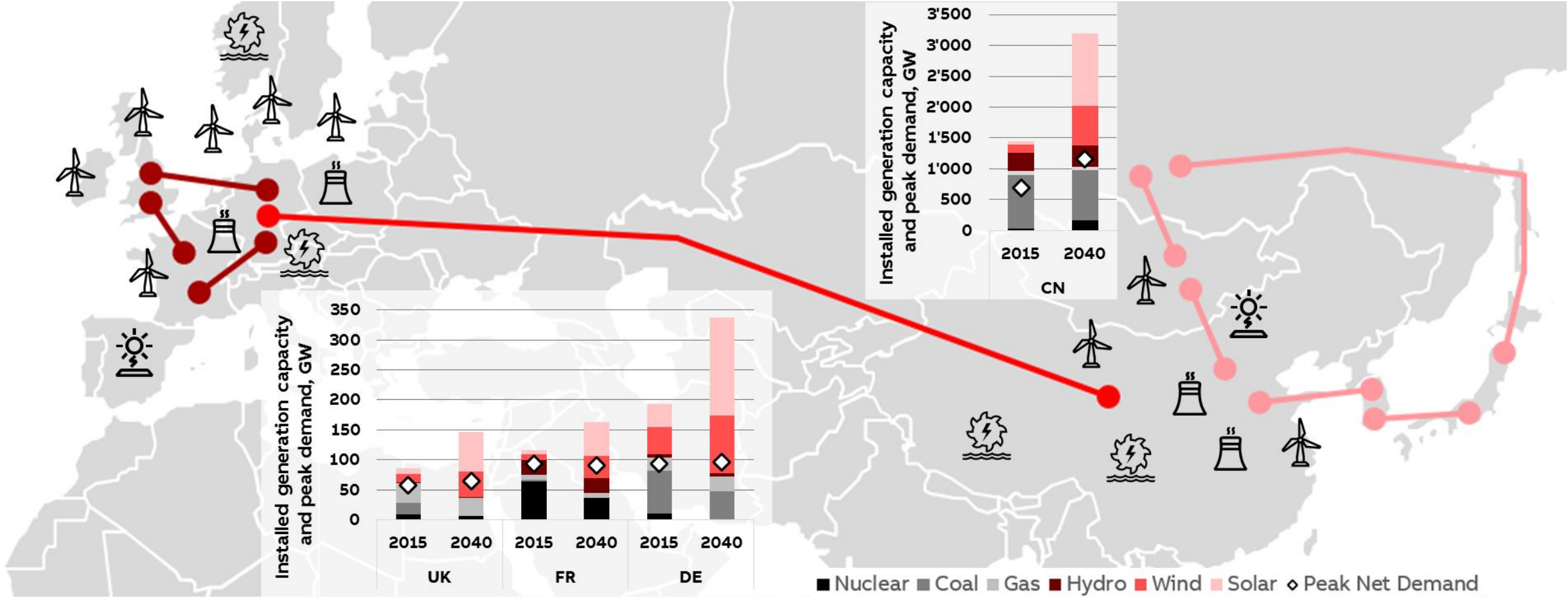
- Grid support functionalities
- Voltage & power rating increase
- Decreasing losses – compact arrangements
- High availability
- Black-start capabilities

How to accommodate high shares of RES?

Trans-regional interconnection vs. storage

Benefit of interconnection: Example China <> Europe

Scenario description

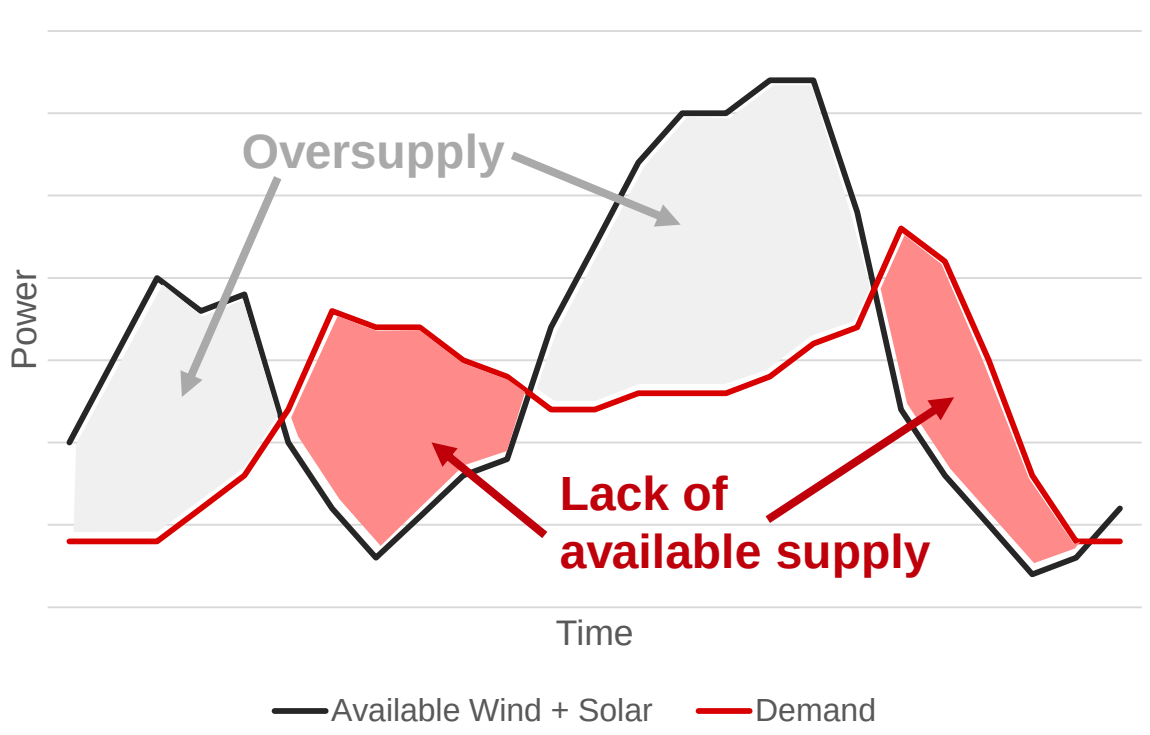


Source: ABB analysis, e-highway Slide 10 2050, Bloomberg New Energy Finance, IEA, IRENA

Interconnection vs. storage

Problem description

Challenge: continuously match supply and demand*

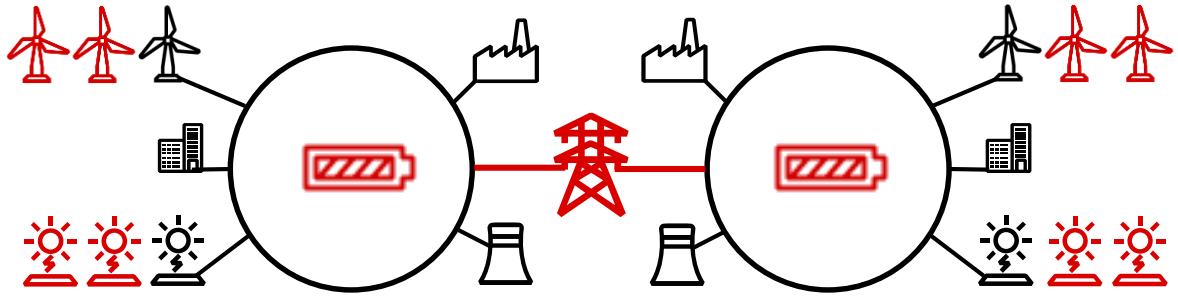


Key question

How much should we invest in new interconnection and/or energy storage capacity to accommodate very large amount of V-RES?

And even more general …

Is power supply based on 100% wind and solar techno-economically feasible? At what cost? How?



* in a system, which is energetically balanced on a yearly basis
V-RES = variable renewable energy sources, i.e. wind and solar

Economics of energy storage

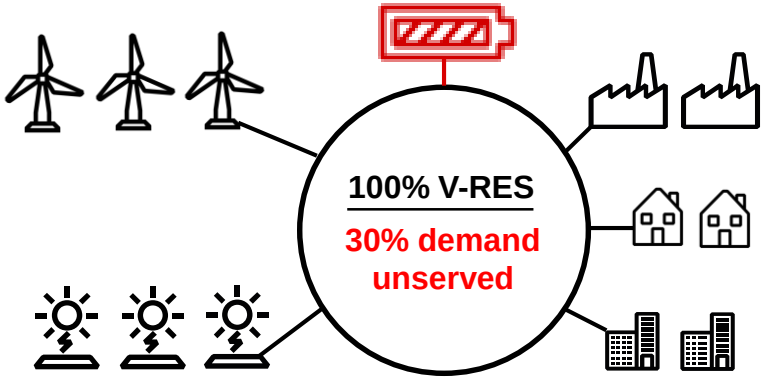
Minimum discharge time needs to achieve high local share of wind & solar generation

Analysis

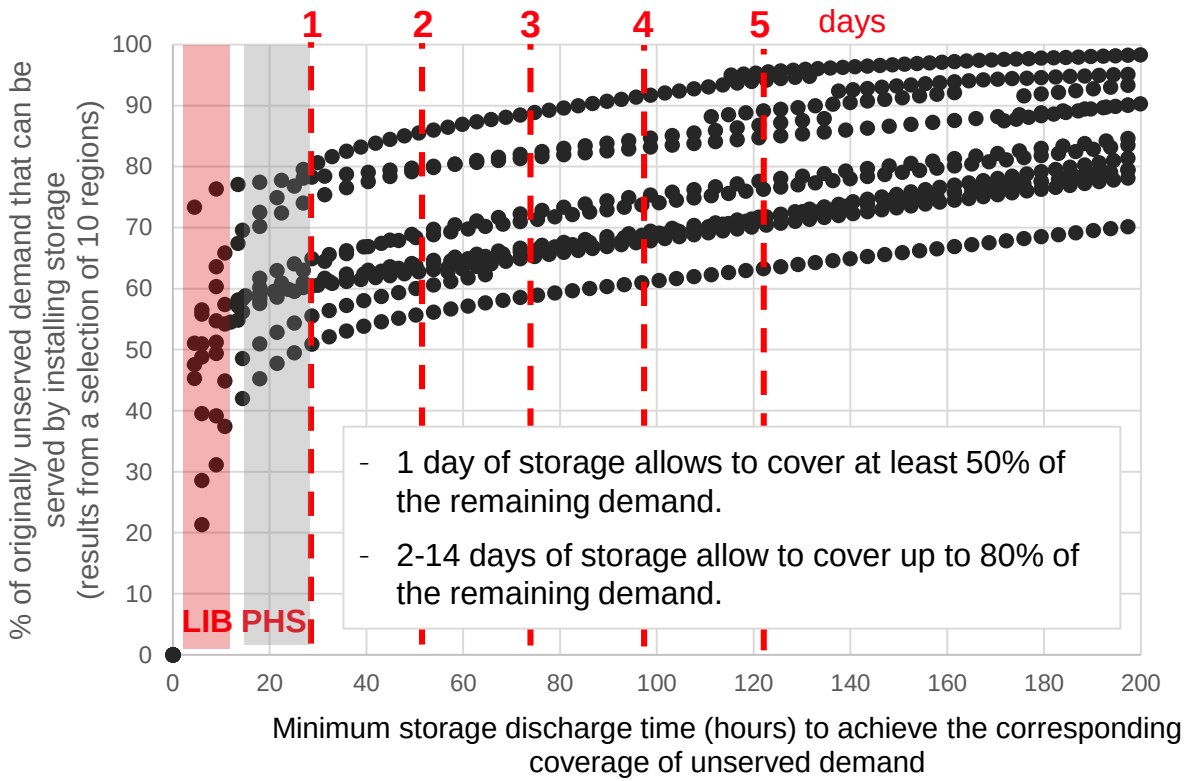
Based on hourly resolution time-series, from a variety of locations globally, of:

- electricity demand (industrial, commercial & residential)
- wind speed & solar irradiance (converted to available power)

Objective: identify amount of storage required to cover electricity demand exclusively by wind & solar.

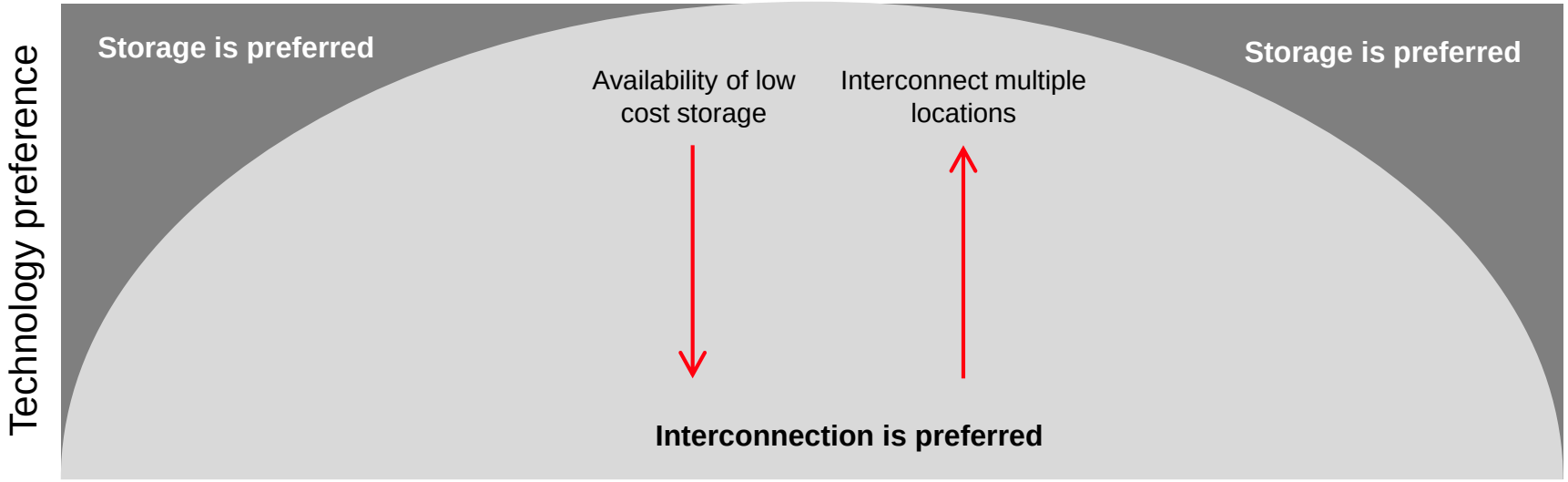


Conclusions (required storage capacities)

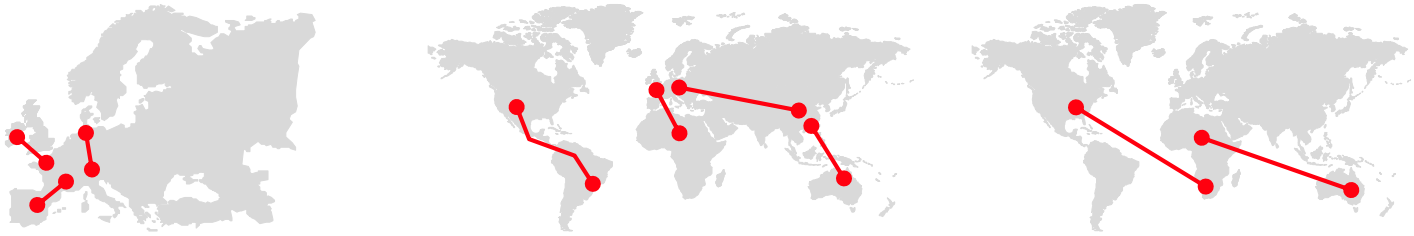


Interconnection vs. storage

Flexible grid evolution – large scale energy storage and grid interconnection



Transmission distances



 Source: ABB analysis

Impact of energy storage cost ($/kWh)

How much should the energy capacity cost be to make storage a competitive option?*

What did we

We assume energy storage technology w/

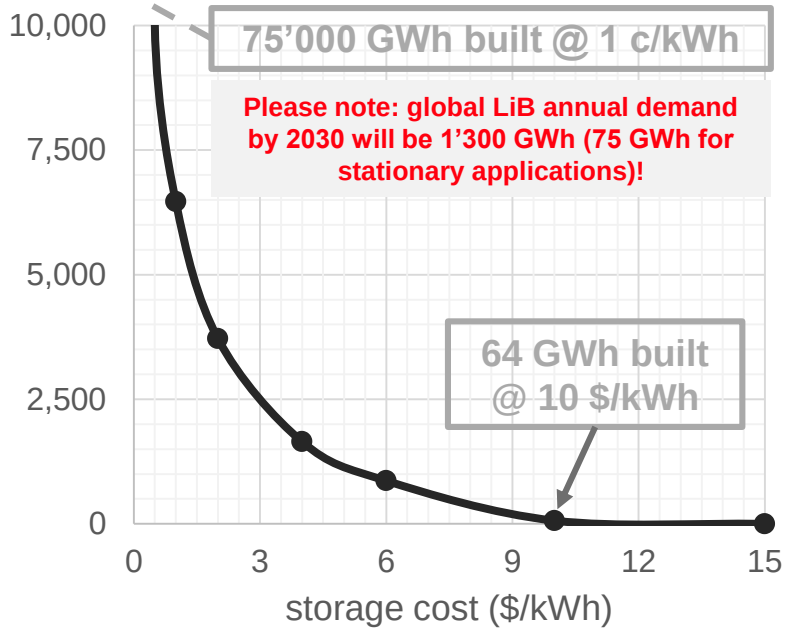
- Power capacity cost = 90 $/kW , lifetime = 20 years
- Energy capacity lifetime = 10 years

We keep the power & energy capacity costs constant over the 40 years period

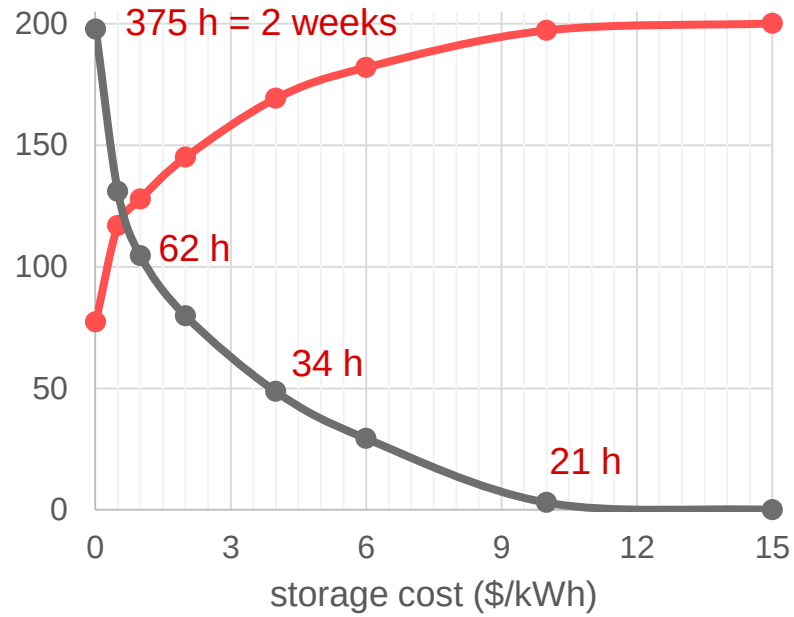
We solve the problem with different values of the energy capacity cost ($/kWh)

We DO NOT allow any new PHS to be built

Built storage capacity (GWh)



Built interconnectors (GW) and storage power capacity (GW)



Storage cost needs to approach the value of 10 $/kWh to make a 10-year lifetime technology competitive. Even with very low (0.5 – 1 $/kWh) storage cost, interconnectors are still worth the investment.

* European case: 60% of V-RES scenario.
BESS cost used up to now in this study: 150 $/kWh in 2015, dropping to 30 $/kWh in 2050.

Conclusions

Interconnection as enabler for high shares of renewable energy

Conclusions

In general

- Power system are undergoing a fundamental transformation
- Renewable energy at the core of this transformation for political as well as economical reasons
- International cooperation will enable the transition to a sustainable energy system

Current achievements and findings

- Trans-regional interconnection allows high shares[1] of variable renewable energy with limited energy storage
  - By exploiting locations with best capacity factors
  - By benefiting from source complementarity
- Technology for bulk long-distance transmission has been rapidly evolving over the past two decades
- Still a number of open topics, such as building and operating DC grid

[1] Implies coverage of 50% - 80% of annual demand. Support of hydro generation is instrumental towards reaching 100% RES.


ABB