



Renewable energy and electric grids

A holistic perspective on climate resilience RD&D strategies

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Agenda

- Observations on the climate resilience topic
- Various factors impacting the electricity system resilience
- How to anticipate resilience measures over time?
- Imagine the future e.g. 2050
- Conclusion
- Solution areas / RD&D focus



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This presentation is an invitation to look at the subject from an alternative / different perspective.



Observations on the climate resilience topic

Focus of actions and solution areas seems primarily driven **sector specific**

- Generation (thermal, nuclear, renewables)
- Transmission & Distribution
- Energy users
- Regulatory / Governmental
- Other (financial sector, insurance companies, mayors of large cities, etcetera)

Each within their sphere of influence

- In the “now situation”
- In their own geographic markets and systems
- And from **climate change** and **adaptation** perspective, not so much from a **resilience** perspective per se



...introducing the potential risk of overlooking aspects from an **electricity system resilience** and a **timing** perspective

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Various factors impacting resilience over time

- Fast changing playing field
- Technological developments
- Social developments
 - increasing dependency on power
 - ageing society & urbanization
- Centralization
- Decentralization



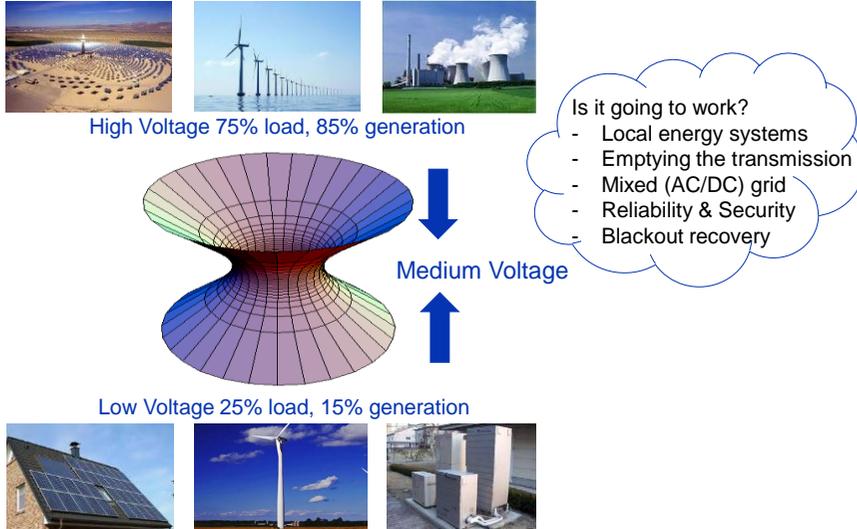
On top of this: climate change, extreme weather events

....and: interrelations between all these above

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At a crossroad: shift from Energy to Capacity



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How to anticipate resilience measures over time?



Compare it with simultaneously (and continuously) playing on multiple chess boards...in which the plays on the different boards influence each other...with different time horizons...with unexpected events...



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Imagine 2050...

- Electricity is the key energy carrier and you don't pay for the commodity (kWh's)
- Power generation comes mainly from renewable sources, thermal power generation has (nearly) phased out
- Transmission (all levels) is key
- More extreme weather conditions (fluctuations in solar, wind and hydro)
- Main issues in a capacity market:
 - Power System Stability
 - Voltage control / regulation
 - Information availability



Back to the future 3

Challenge: how to get the right amount of energy at the right place and time?

What does your organization do, in say 30-40 years from now, to increase resilience with the existing challenges and climate / weather change on top of those?

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Conclusion

- When planning and implementing resilience measures one must include technological, energy market and social trends as well as climate change
- To allow sound cost (risk-optimal) – benefit decisions to be taken
- Considering effectiveness and efficiency ... and lead times of implementations

Note: investments in resilience innovations, if not assessed holistically, could evolve into stranded assets



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Solution areas / RD&D focus

- Develop robust **integrated** plans with staged no-regret (risk-optimal) measures to be taken by different stakeholders in the energy market(s)
 - To realize resilience, and
 - To avoid stranded assets (and associated social costs)
- First steps for such plans:
 - Create and assess various multi-factor scenarios (climate / weather included, staged developments), and derive no-regret RD&D options
 - e.g. link centralization (super grids) and decentralization (smart grids) initiatives and approaches, pace of developments, power flows, power balance
 - e.g. suppose thermal generation is phased out, further increase of wind and solar
 - combinations of factors and developments
 - other...
 - Build timing-related investment models / decision and information support models for the stakeholders in the energy market(s)
- (thought)Leadership, communication, co-ordination and working together are key!



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DNV GL background information

With a global organization of 3000 energy experts, DNV GL has an unmatched combination of business and technical knowledge, offering tremendous value to our customers.

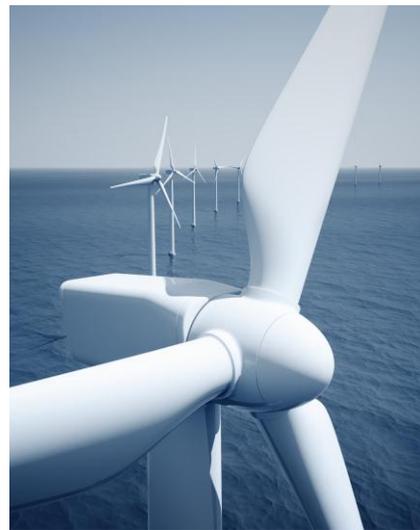
We have a unique combination of expertise in energy markets and policies, electrical transmission & distribution infrastructure, and in renewable and conventional energy generation. This gives us an edge in helping our clients in developing risk optimal strategies to manage energy system design, integration, transition and resilience challenges.

We are highly experienced in smart grids, super grids, and sustainable use. We are a world leader in renewable energy advisory services with over 800 experts offering services across the project lifecycle for offshore & onshore wind, solar and marine renewables.

With 10 energy-related labs, we have a very extensive suite, including the most powerful independent High Power lab and the largest High Voltage lab in the world. We are a leading certification body for renewable energy technology, setting the industry benchmark for 30 years with over 25 published guidelines and standards.

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