Reducing Cost of Wind Energy

Opportunities to reduce the cost of wind energy

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Reducing cost of wind energy

- Levelized cost of energy to study the feasibility of subsidy-free wind energy
- LCOE reduction scenarios for onshore and offshore wind energy
- Topical aspects for turbine load design, site assessment, and farm design
- Summary and conclusions

Fantanele-Cogealac, Romania
240 GE 2.5 MW wind turbines; 600 MW farm power
Installation was completed in November 2012

Progress ratio vs. economies of scale

Progress ratio: cost reduction with doubling in cumulative volume

Learning rate = 1 – PR

Ex. 1: Unit #100 = 1500 \$/kW, turbine PR = 90%

=> Unit #200 = 1350 \$/kW

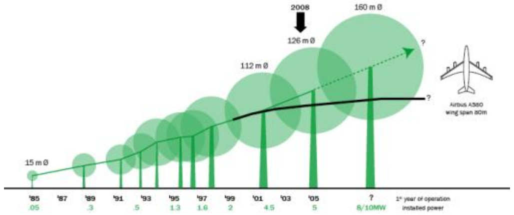
Progress ratio refers to cost reduction over time

Economies of scale: lower unit cost for a larger wind farm or turbine

Ex.: 10MW farm = 2000 \$/kW, EOS = 90% for doubling in size

=> 20MW farm = 1900 \$/kW

Economies of scale refers to cost reduction with size



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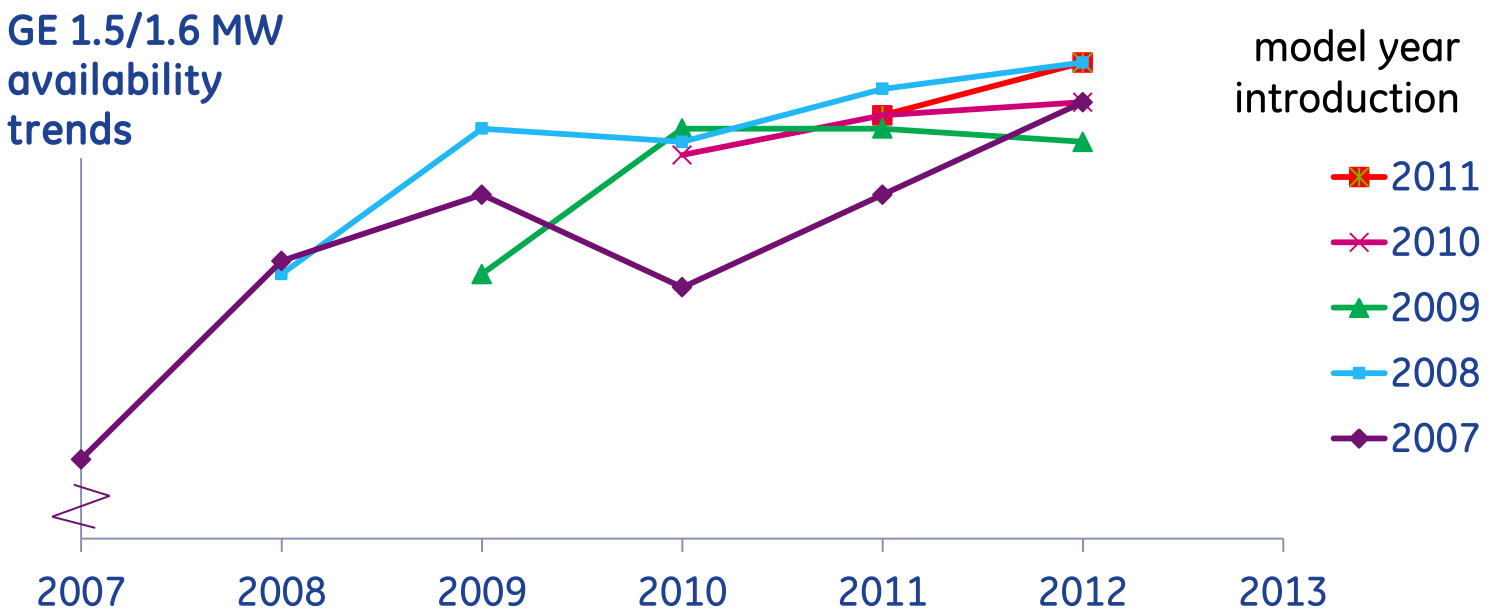
Progress ratio - turbine availability

- Upward trending improvement in turbine availability for consecutive model year introductions.
- Improved design. Improved services. Continuously resolving top issues.



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LCOE = levelized cost of energy

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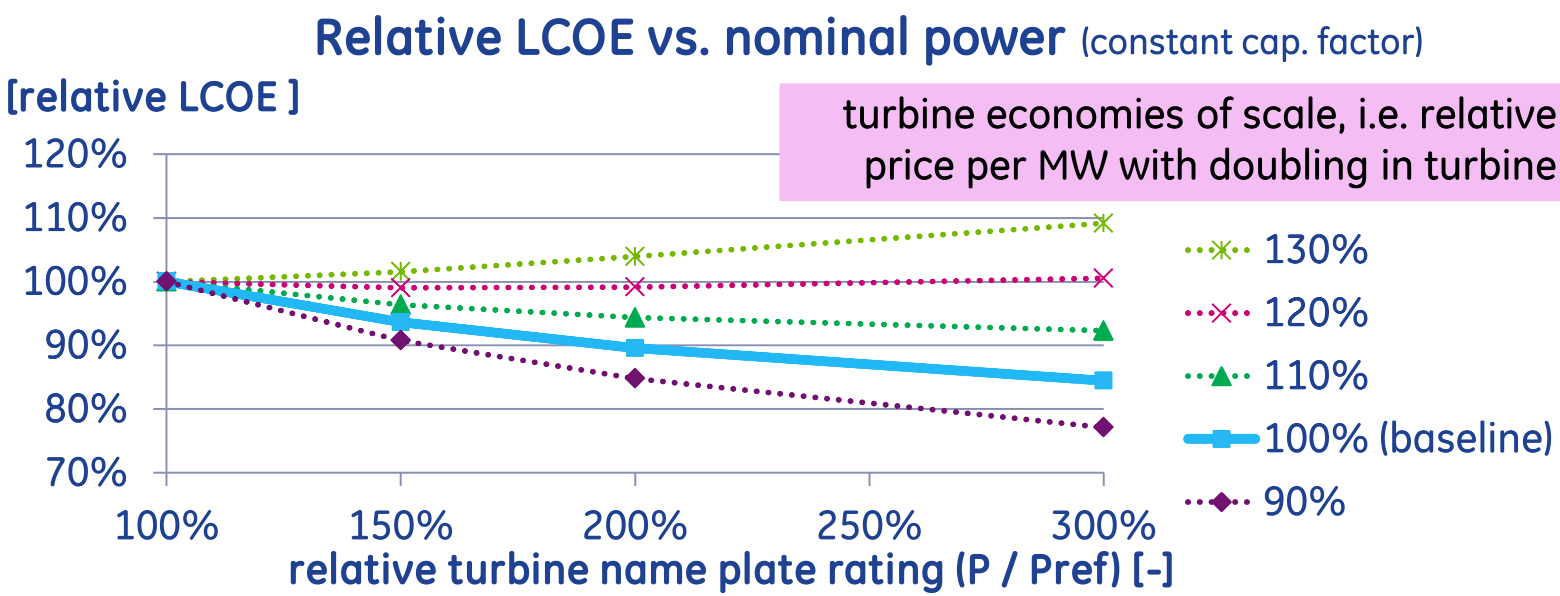
- LCOE reduction is importantly driven by economies of scale for BOP and O&M
- Turbine economies of scale doesn't work well because of square-cube law.

  New technologies and relative share of electrical cost can compensate this.



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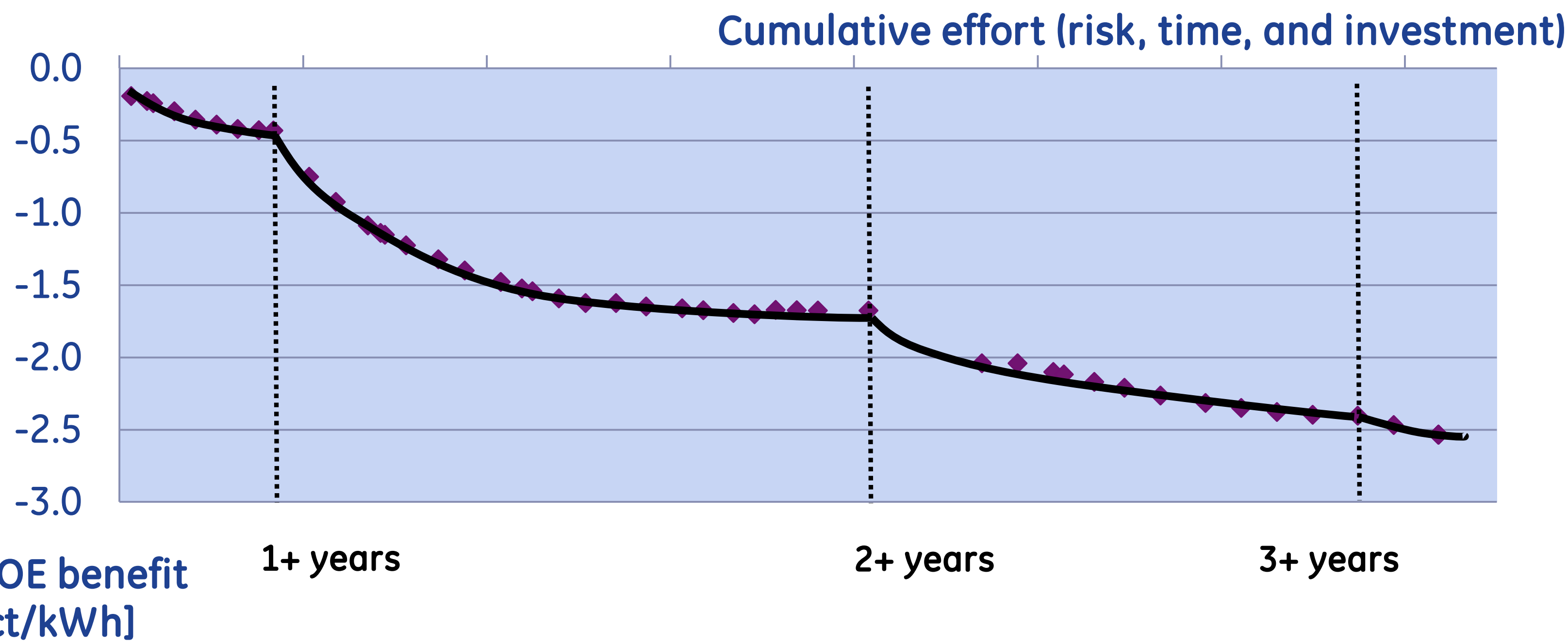
New technologies to drive down LCOE

Individual new technologies can importantly bring down LCOE, like more use of condition monitoring to reduce OPEX, distributed turbine control to improve farm AEP and design loads, or advanced aero to grow rotor size.



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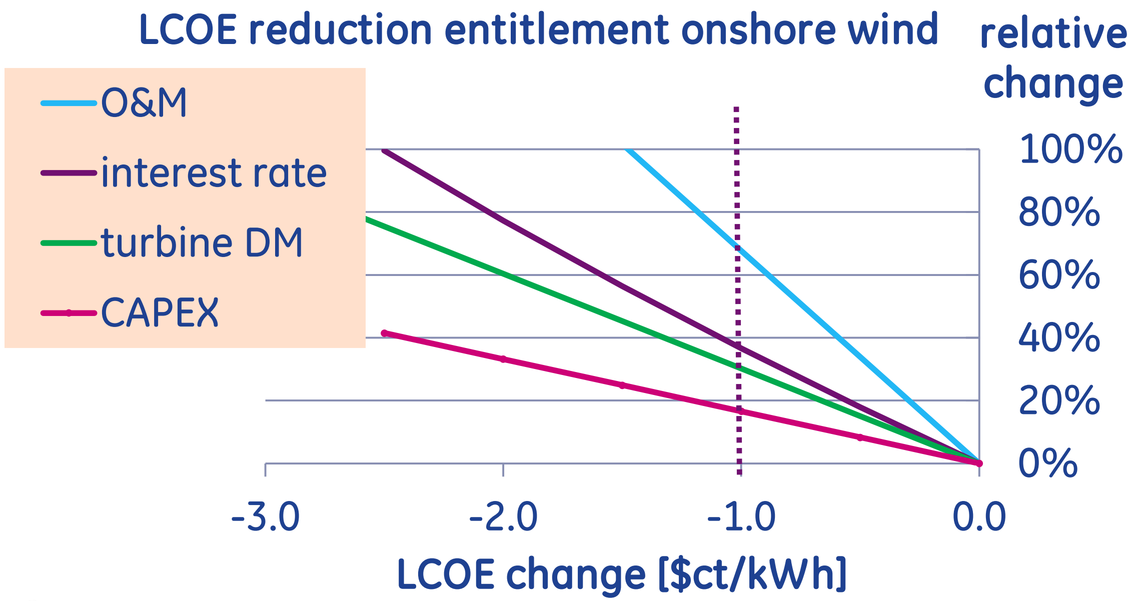
Onshore LCOE reduction scenario

30% reduction in onshore LCOE can be realized through a combination of:

- a 20% reduction in CAPEX, e.g. due to new technologies and economies of scale;
- a 10% higher capacity factor for the same CAPEX per kW;
- and 1pt lower real interest rate.



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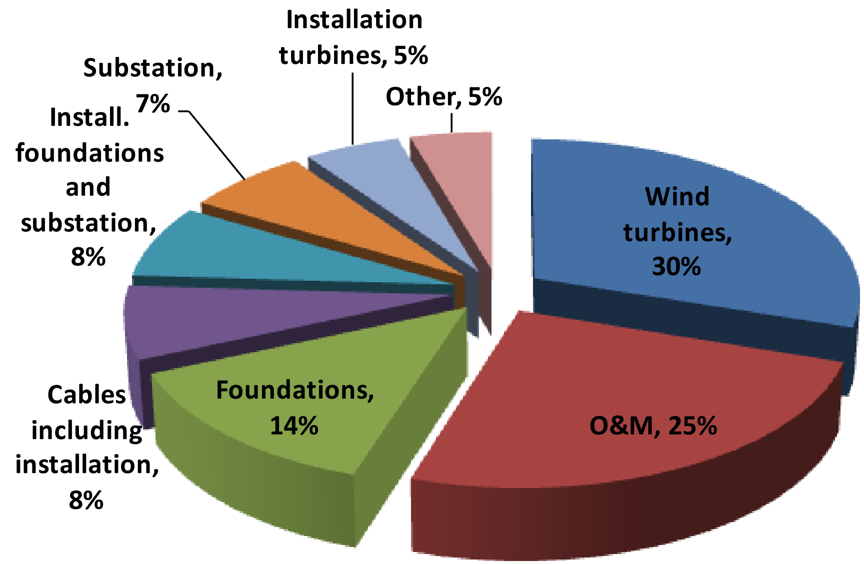
The offshore case

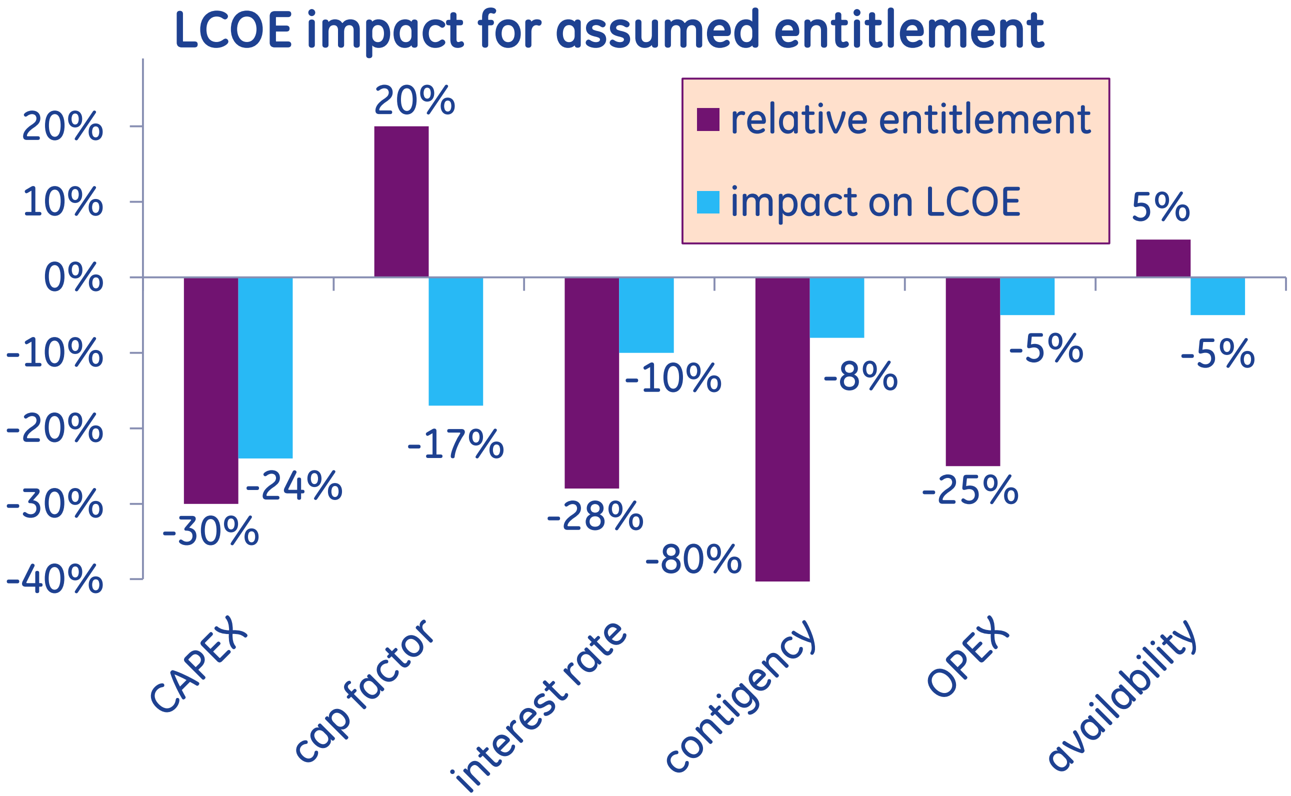
- Diverse site characteristics (water depth, facilities, distance to harbour and grid)
- Realization cost ($/kW) roughly twice as high as onshore.
- No visual impact.
- Important levers to reduce LCOE are:
  - Economies of scale (go bigger)
  - Progress ratio (do better)
  - Reduce DM cost (smarter design)
- Still, additional success criteria are:
  - Long-term government committment
  - Continuing research funds
  - Adequate service hubs and grid infrastructure
- Possible game changing concepts: VAWT or Kites.



Courtesy www.skysails.de

Offshore LCOE reduction entitlements

Maximum of ~50% reduction in offshore LCOE when grouping all entitlements.



GE 4.1MW in Gothenburg, Sweden

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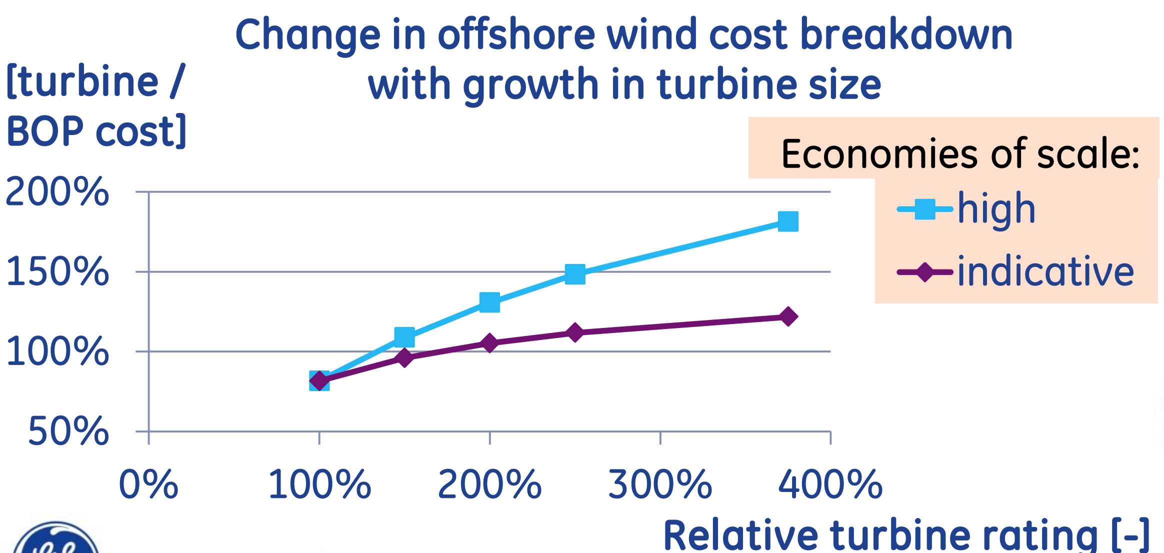
Offshore LCOE reduction scenario

More realistically, 35% reduction in offshore LCOE is realized through a combination of:

- 20% reduction in CAPEX, e.g. through new technologies and economies of scale;
- No change in logistics cost per kW, improved turbine reliability: Availability up 3 pts;
- Net cap factor up by 7 pts, e.g. bigger rotor and less wake losses;
- 50% reduction in contingency and 15% reduction in O&M.



Arklow: 7 x GE 3.6 MW
World's first 3+ MW
offshore turbines
Since 2002

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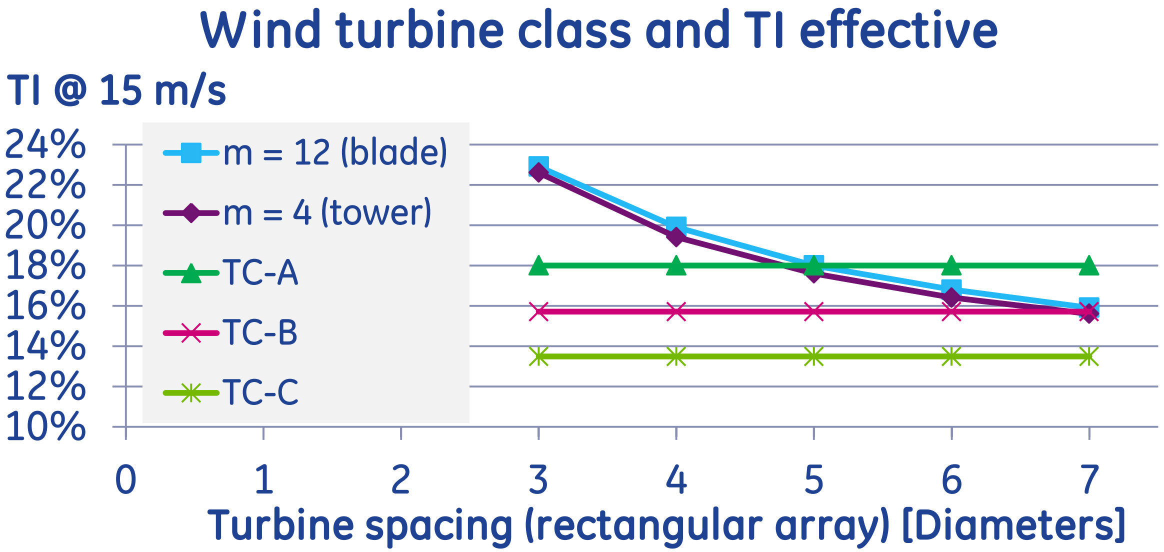
Topical aspects: turbine design loads

- There are many projects in Europe in area-constrained, complex terrains with a high design turbulence and challenging design load assessment.



Example:
Power density [MW/km^2] for a TC-A design relative to TC-B is equal to: $(7D / 5D)^2 \approx$ factor 2

- The global installed wind power, e.g. GE's 20,000+ unit fleet, offers valuable potential for experience-based loads analysis.

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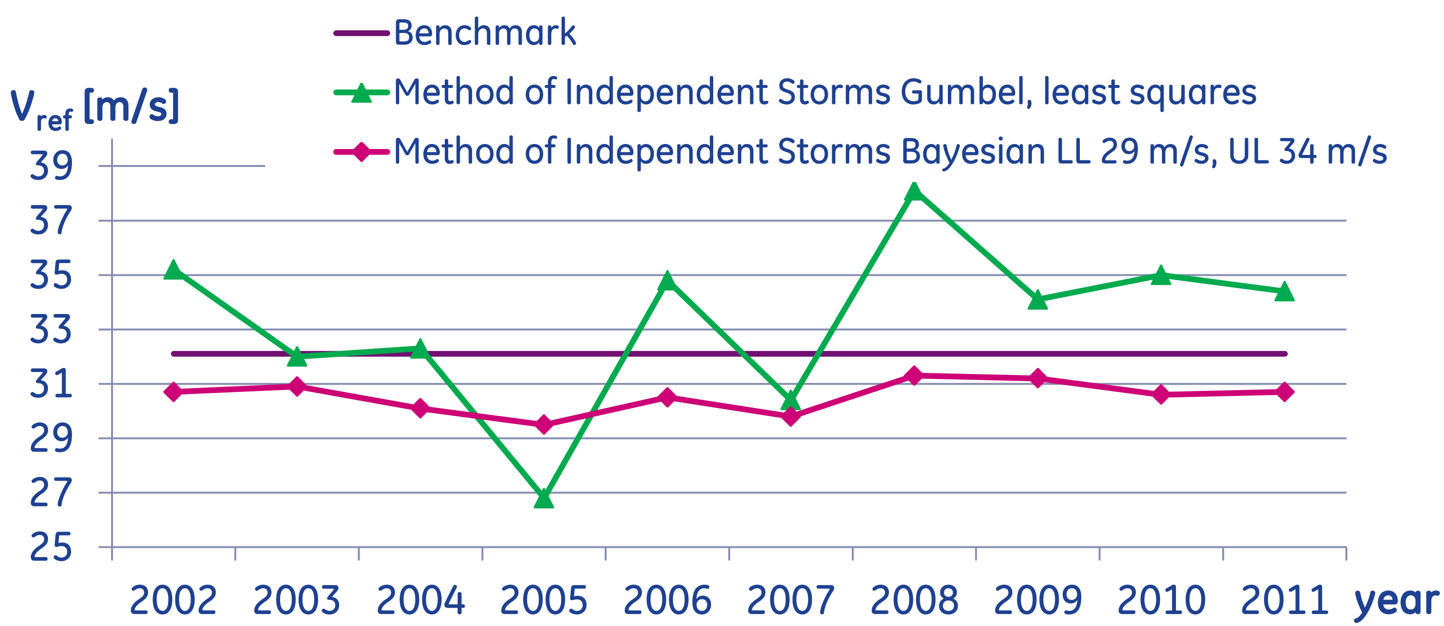
Topical aspects: site assessment

Accurate site design wind conditions are key for accurate load assessment.

For example, GE newly determines V_{ref} based on meso-scale data combined with site measurements combined with using Bayesian analysis.



Source: EWEA 2013 poster #490, author Joerg Winterfeldt et al., GE Power & Water.
Data by courtesy of Bonneville Power Administration (BPA)

Topical aspects: farms

- Curtailment losses on a regional scale can be significant,
  e.g. strong growth of installed wind base or delayed expansion of the grid.
- Industry is taken on a more wind power plant-centred perspective.
  Because only the OEM knows the turbine design limits and aero-elastic model, it has an essential role in minimizing the project-specific LCOE.

Turbine-centered view

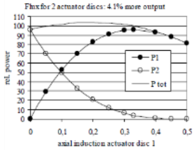
Designed as stand alone unit

Operated as single units in a wind farm

Accurate wind farm flow models

Holistic farm-level view

Better site lay out with diverse turbine options in a farm



Co-operative, ‘distributed’ farm control for max AEP

Summary

- Offshore wind energy LCOE will remain ~twice the value of onshore wind.
- Economic growth, investors, and green policy agenda like Europe's 'Horizon 2020' are essential for the expansion of wind energy.
- LCOE reduction is importantly driven by:
  - Up-scaling turbine and farm size to drive down BOP and O&M over AEP
  - Better design modelling to understand and deploy margins for more AEP
  - New technologies and operating methods for turbines and farms to:
    - Increase AEP and limit turbine cost per MW
    - Reach the goal of a purely fatigue-driven turbine: mitigate extreme loads and reduce blade static moment.

Thank You

GE 2.5-100

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