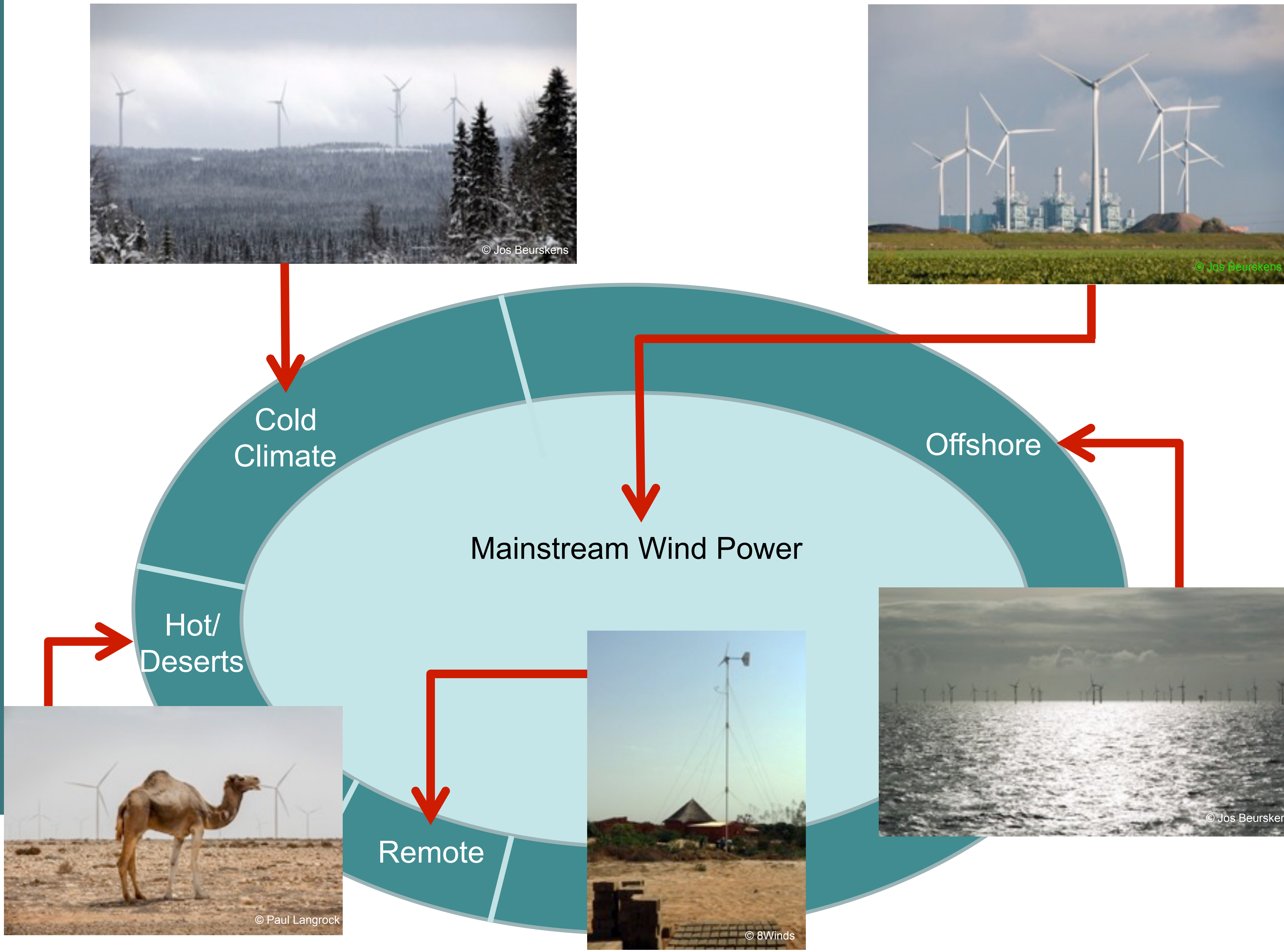
Wind Energy in Cold Climates, one of many niche markets requiring technical adaptations

Jos Beurskens
SET Analysis
(Former ECN)

Winterwind 2017
Skellefteå (S)
8 February 2017

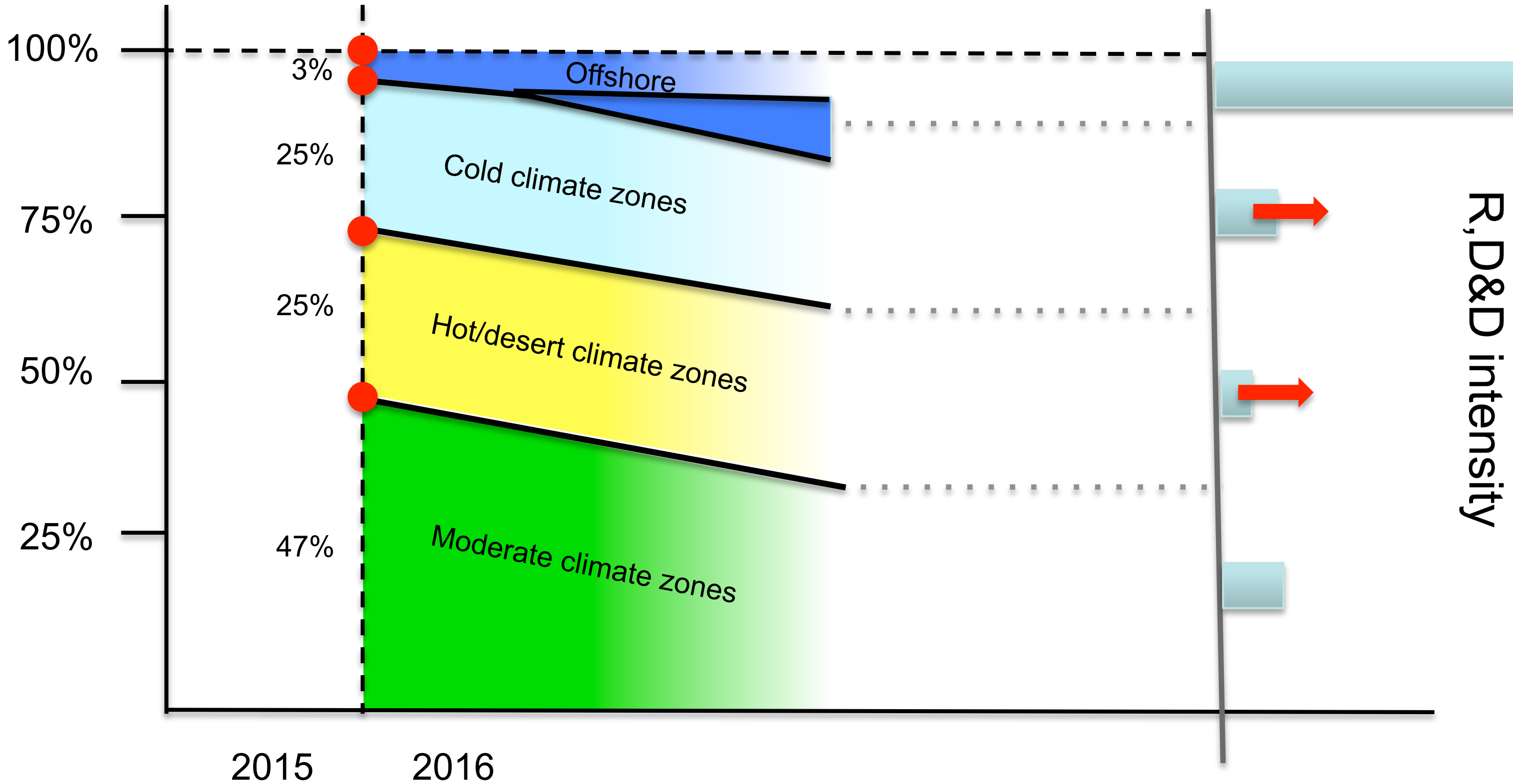

© Jos Beurskens
© Jos Beurskens
Cold
Climate
Offshore
Mainstream Wind Power
Hot/
Deserts
Remote
© Paul Langrock
© 8Winds
© Jos Beurskens

Wind climate zones

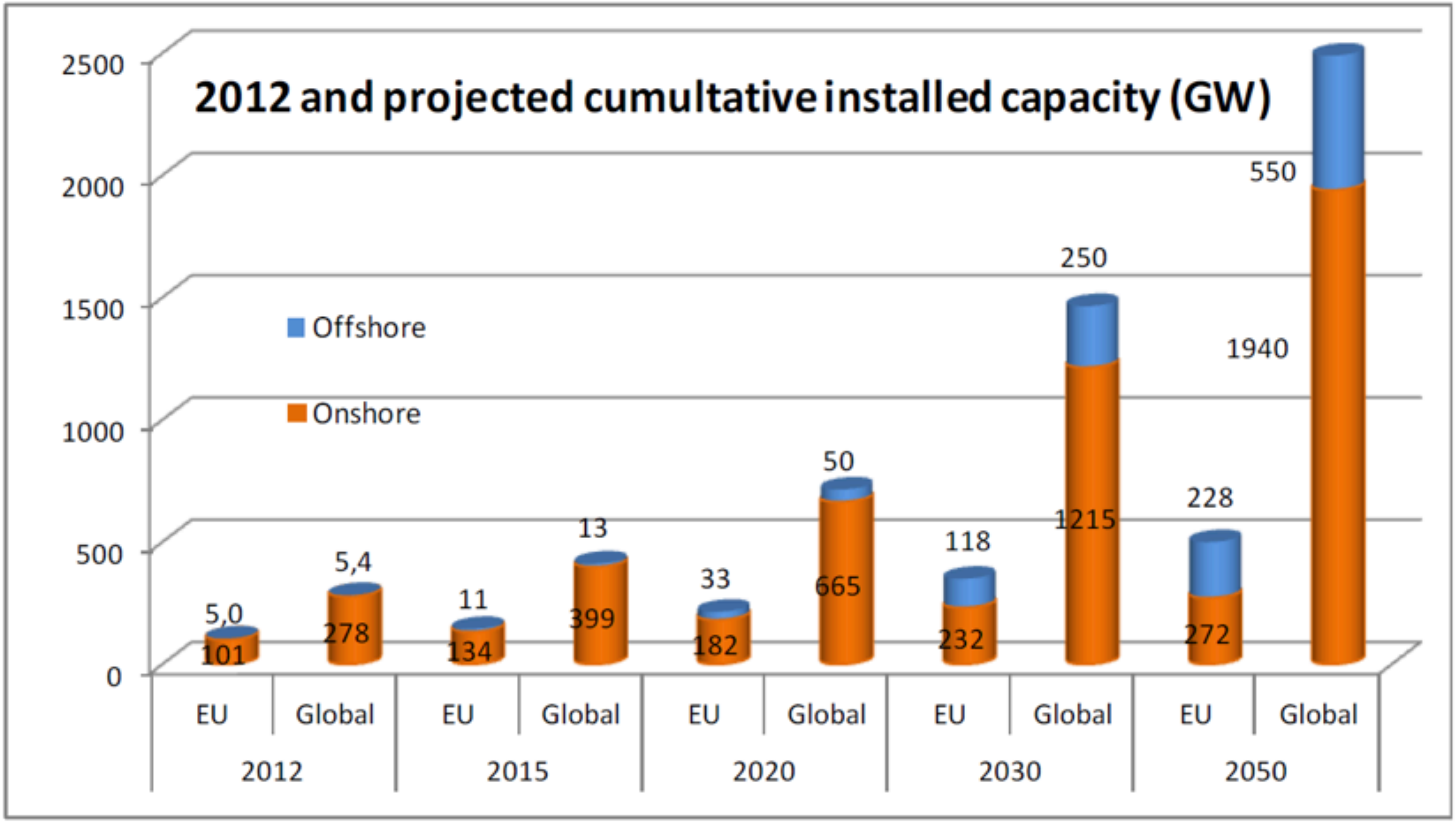
100% 2015: 420 GW
100% 2016: 497 GW
100% 2030: 1500 GW-2000GW
Cumm. growth rate 11%/year

Excluded:
appr. 1GW small wind turbines (on average 1kW/unit) *(GWEC)*
(Relevance to be expressed in number of families served and not in MWh's 1kW average(!) is 10 energy slaves)

Small turbine-systems will be installed in CC areas as well! (e.g. Alaska)



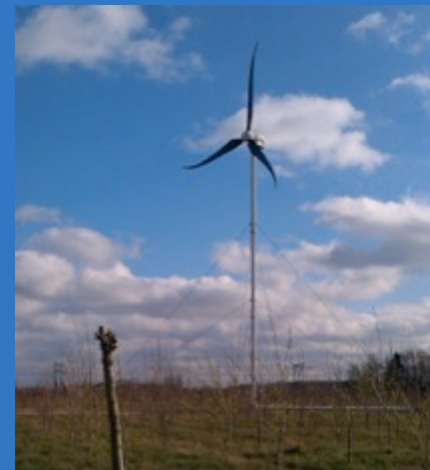
Forecast of wind energy byond 2017



Projected cumulative installed capacity (GW). Source: JRC

Wind climate zones

1991 Norgersund



Xant turbine for Alaska

EWT turbine Kotzebue (Alaska)

Kotzebue (Alaska)

Market state

Cold Climate wind energy about 25% of global wind power, but growth potential is similar to world growth rate:

Sufficient track records for investors

&

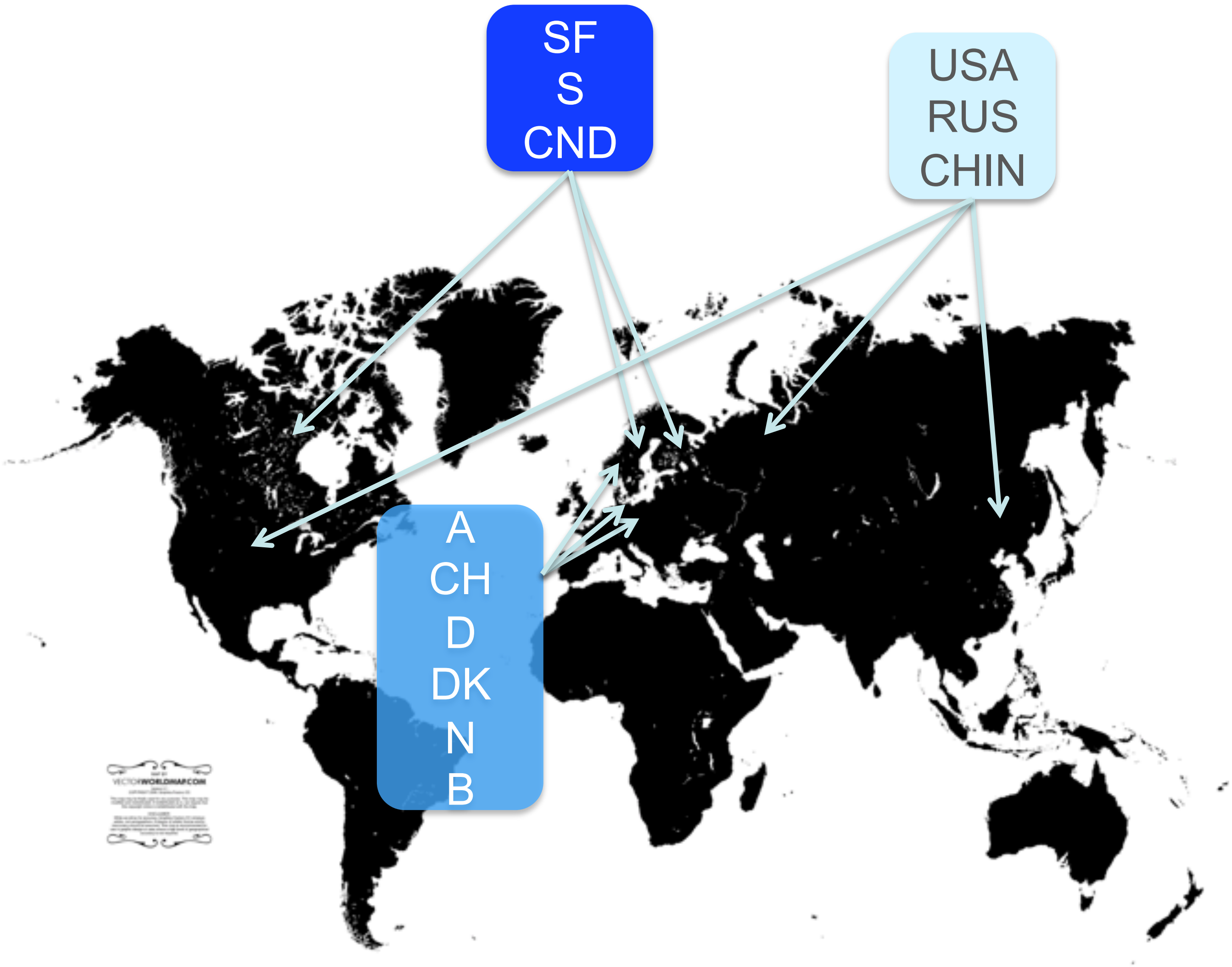
Enormous room for application of innovations for cost reduction

Cost reduction potential

Annual Energy production (P90)	100%
No operation during icing	72%
Maximum Icing protection	99%

VTT, Winterwind 2013

Where does R,D&D on CC issues take place ?

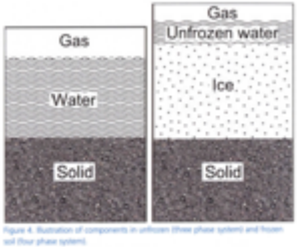


Technical adaptations

Wind resources
* Icing maps
* Met. Models of icing
* Ice detection
* Wind measurements
* Forecasting methods
* World resources in CC

Wind Turbine
* Design/engineering specs
* Use of materials
* Anti icing
* De-icing
* Control (for safety)
* Performance (output)
* Loads
* Overall design for CC

Environmental
* Safety (Ice throw & drop)
* Acoustic noise emission
* Risk analysis



Foundations
* 5 aggregation states

Installation O&M
* Access roads
* Size and weight limitations
* Lack of cranes

O Novel installation concepts

* Access

Grid Integration
O How to maximize CC wind electricity into the grid system?

* Distance wind resource to load centres
* System rating = offshore trend

* Field & laboratory testing & Operational experience

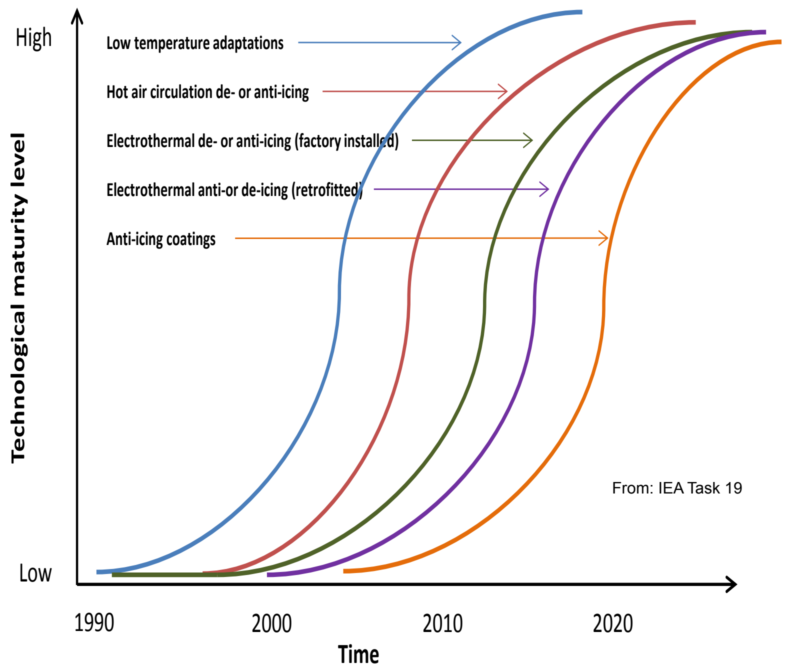
This presentation: O

Sources: IEA/Wind Task 19. Previous Winterwind conferences

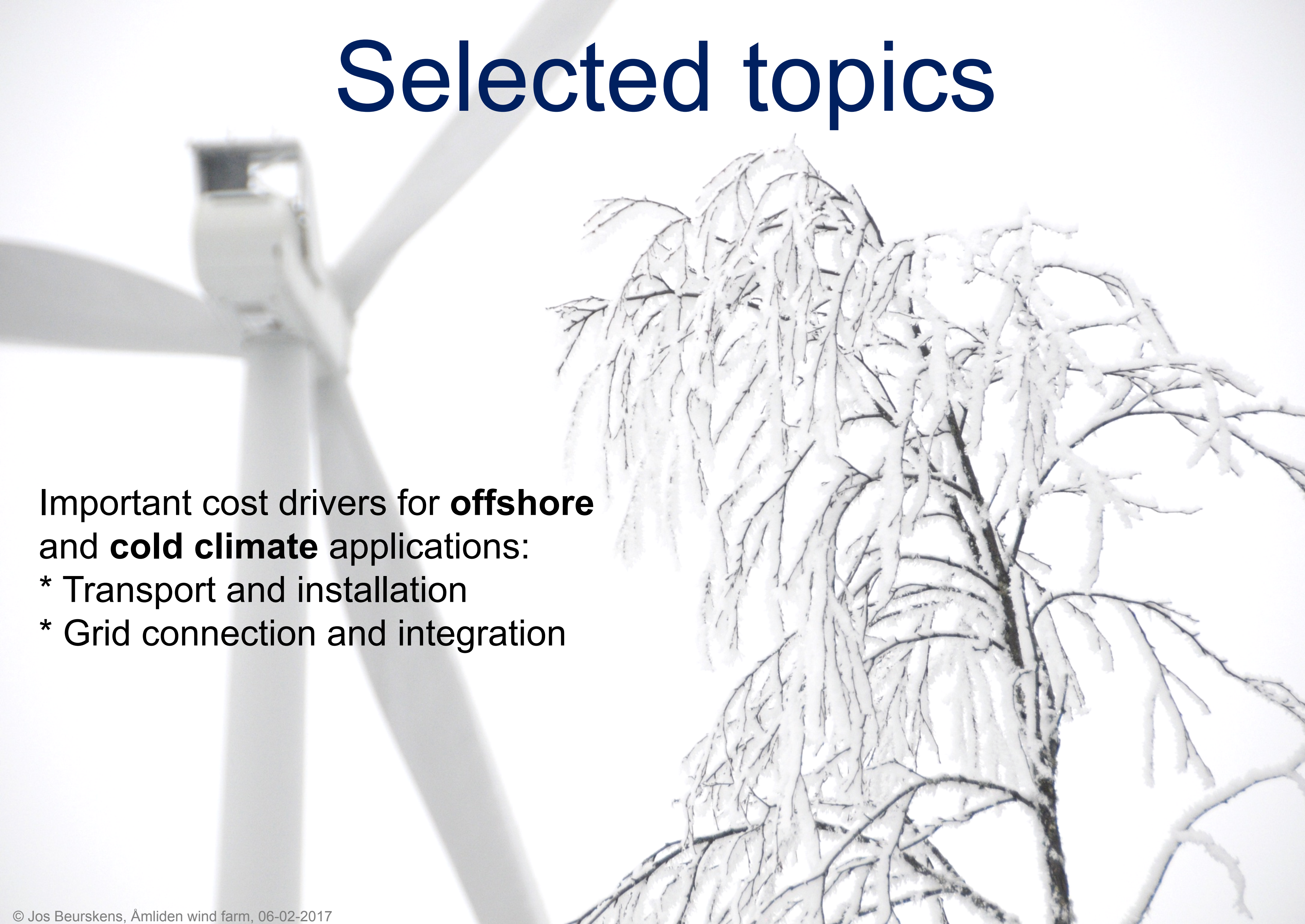
Technical adaptations, what happened?

Wind Turbine
* Design/engineering specs
* Use of materials
* Anti icing
* De-icing
* Control (for safety)
* Performance (output)
* Loads
* Overall design for CC

- Hydro(ice)fobic coatings
- Destruction molecular structure of ice crystals (by applying electric charge)
- Microwaves
- Plasma generators
- Vibrations



Selected topics



© Jos Beurskens, Åmliden wind farm, 06-02-2017

Important cost drivers for **offshore** and **cold climate** applications:
* Transport and installation
* Grid connection and integration

Novel installation concepts

Novel & re-invented installation concepts

Multi- rotor concept; its history

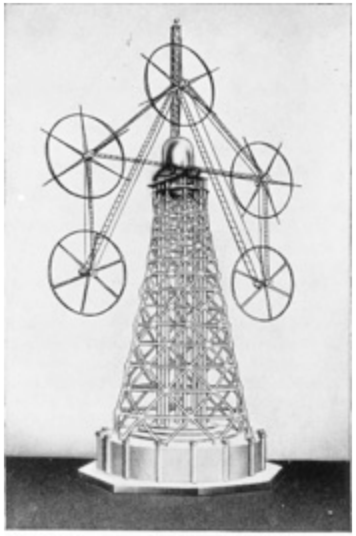
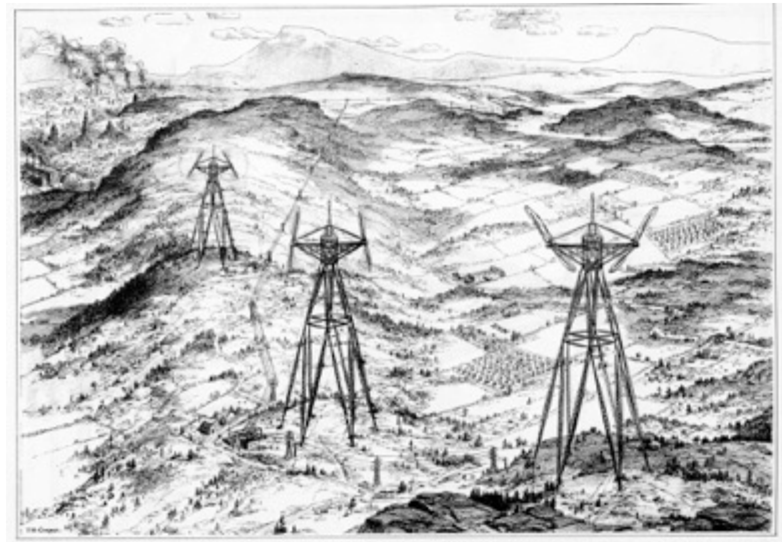
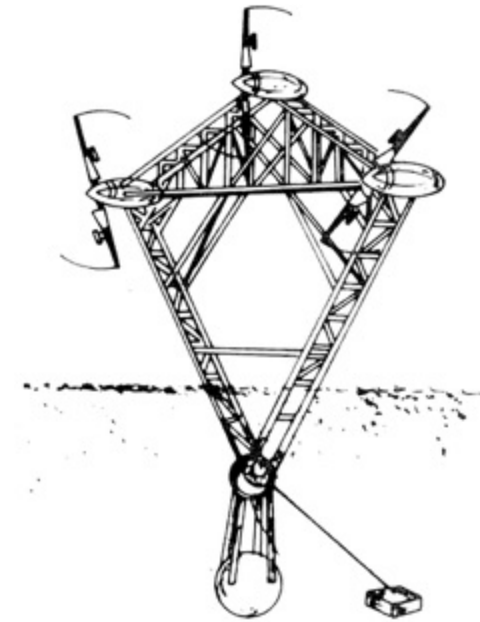
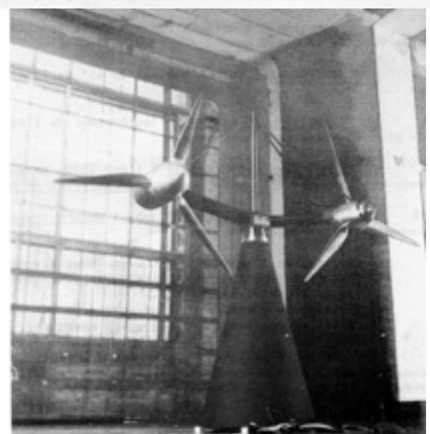


Fig. 64. Design proposed by Honnef of Berlin in 1933. This wind-turbine was to stand 1000 feet high and the inventor rated it at 50,000 kilowatts.



FEDERAL POWER COMMISSION
BATTERY of WIND TURBINES in An ELECTRIC POWER SYSTEM
Designed by Percy H. Thomas





Maquette d'ensemble de 2 machines de 2 MW
équipées d'hélices de 45 m
en cours d'essais en soufflerie
(Bréguet à Villacoublay)

Novel & re-invented installation concepts

Vestas

Novel installation concepts

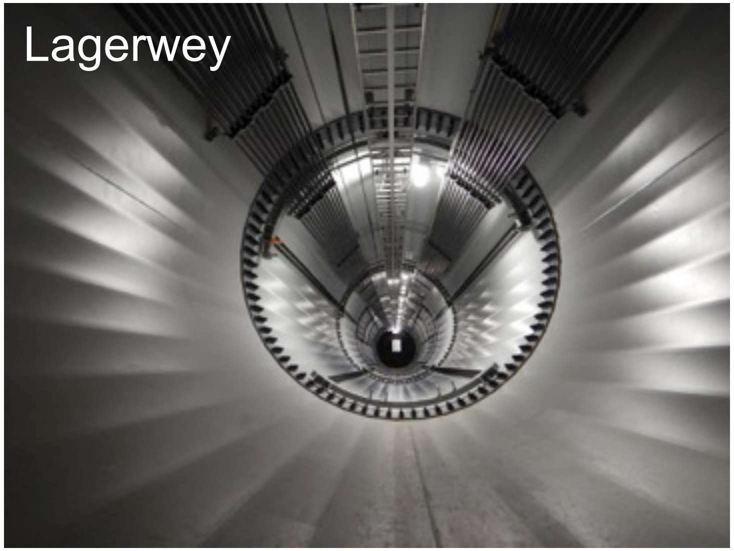
Transport limits dimensions of land based wind turbines

> 30 permits are required to transport
a wind turbine from the Netherlands to Finland

©Jos Beurskens
Frankfurt 20-11-2013

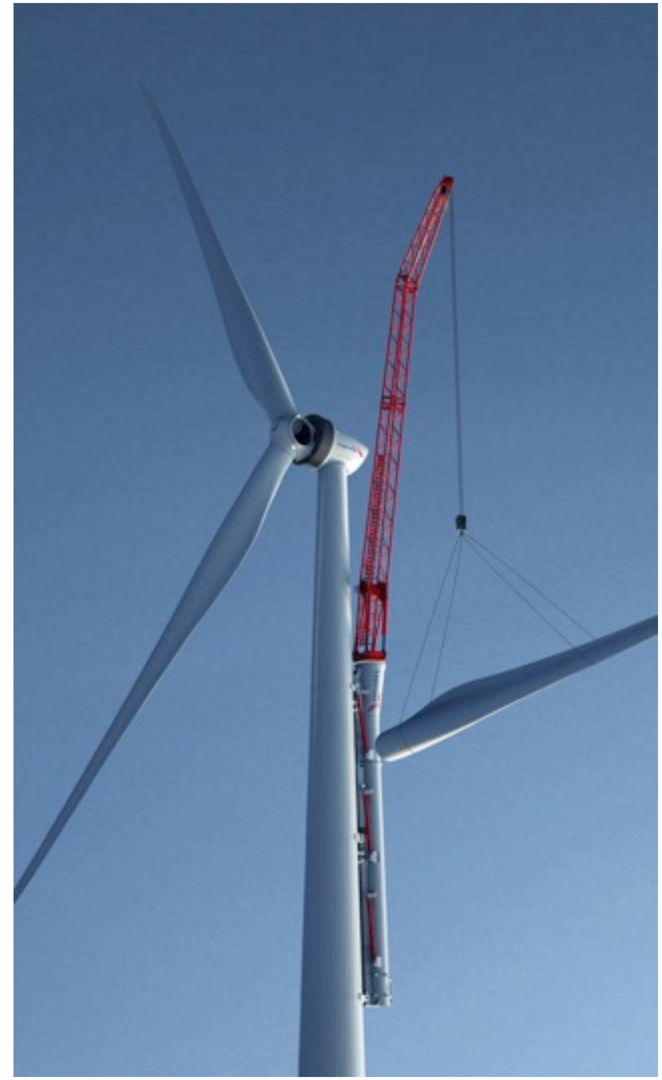
Novel installation concepts

Lagerwey



Novel installation concepts

Lagerwey



Novel installation concepts

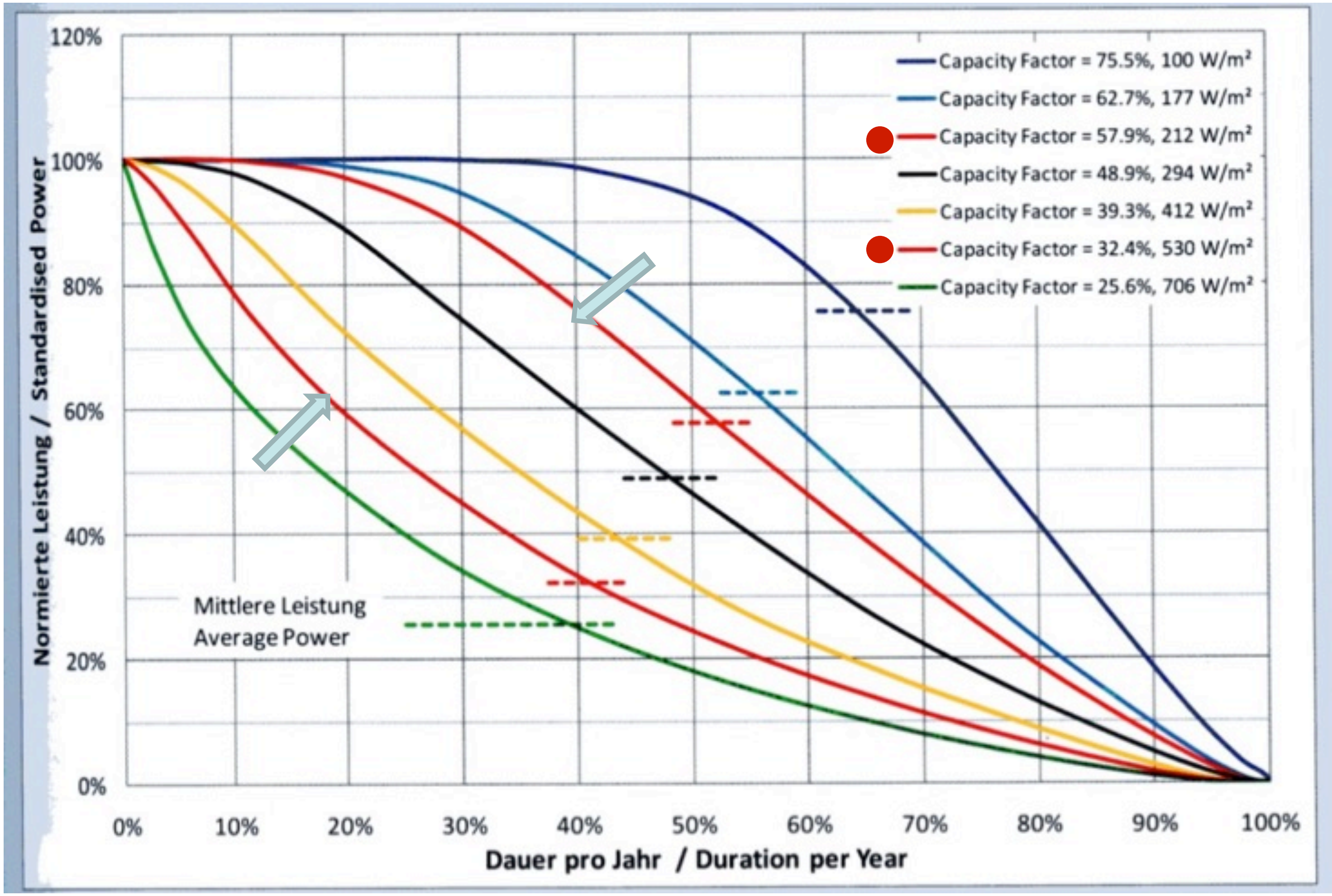
Lagerwey

Movie

https://www.youtube.com/watch?v=ZUzwk_Gr-rE

Facilitating Grid integration

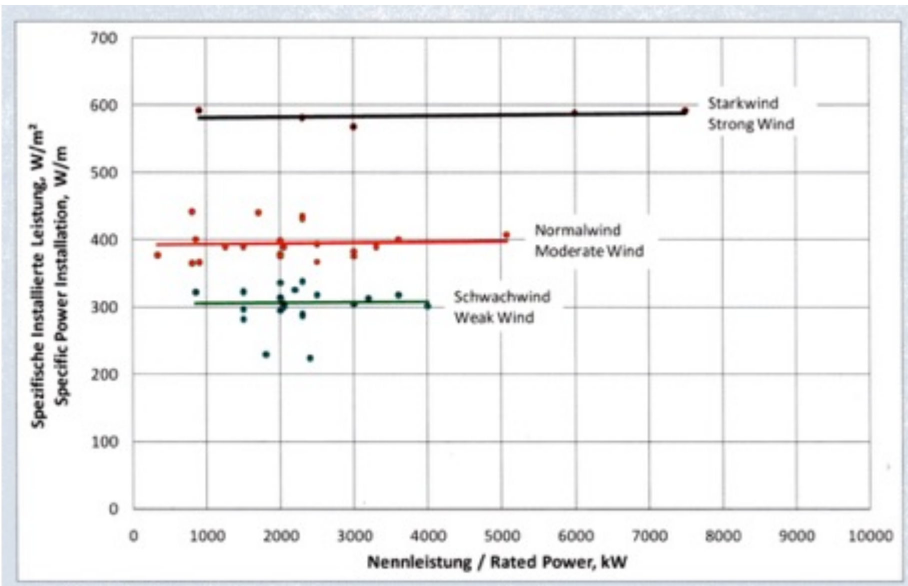
Wind turbine power rating and capacity factor

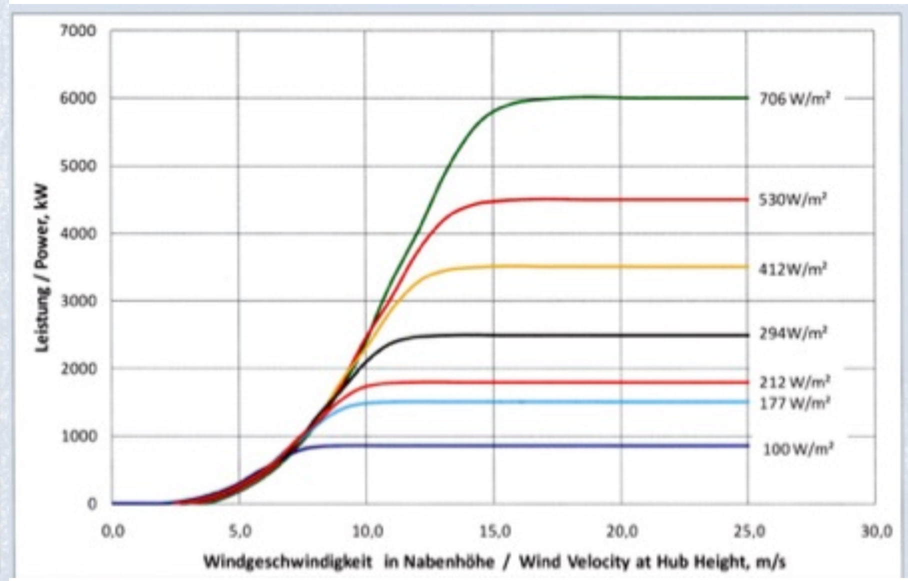


Source: J.P. Molly, DEWI

Facilitating Grid integration

Lower specific power rating of wind turbines



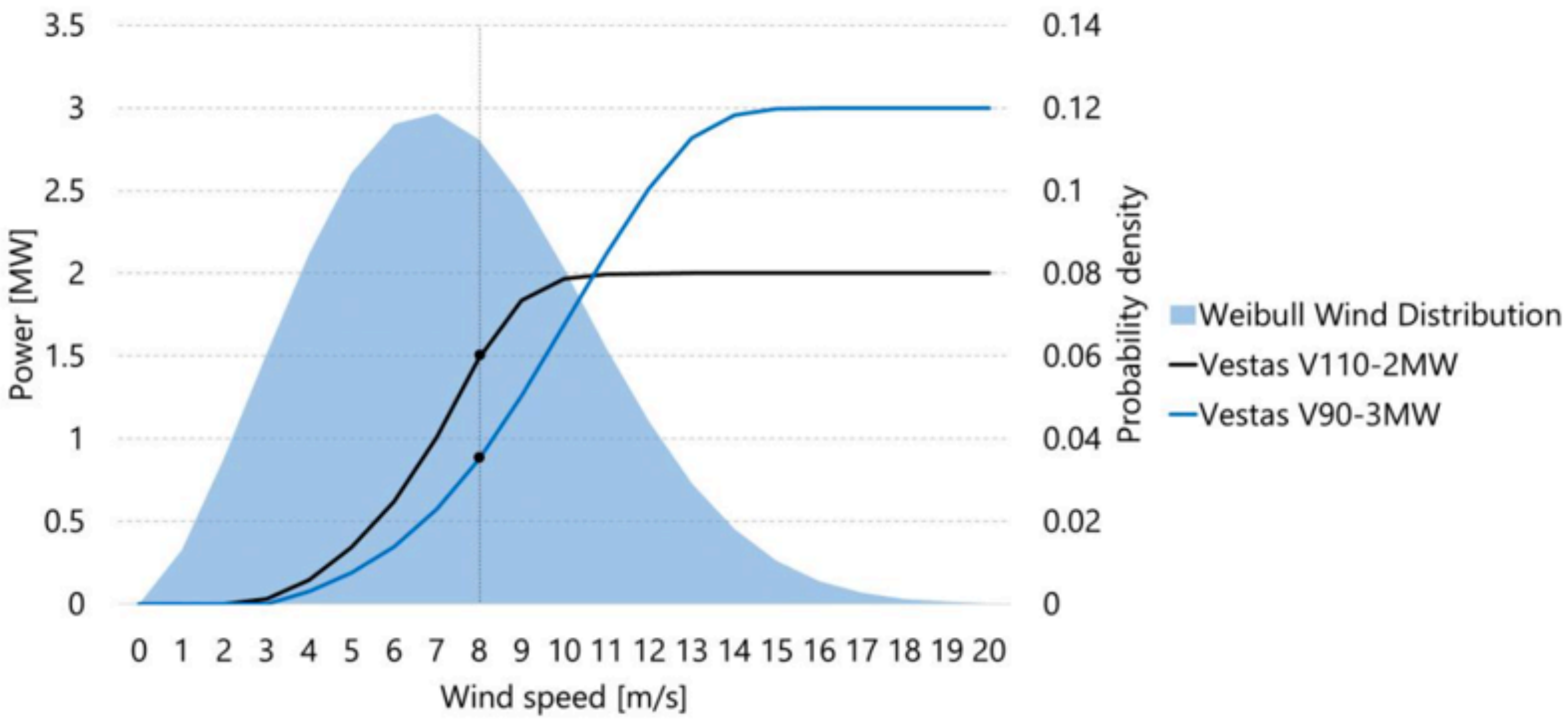


Source: J.P. Molly, DEWI

Wind turbine power rating

$$p = \frac{P_R}{A_{rotor}} \quad [W/m^2]$$

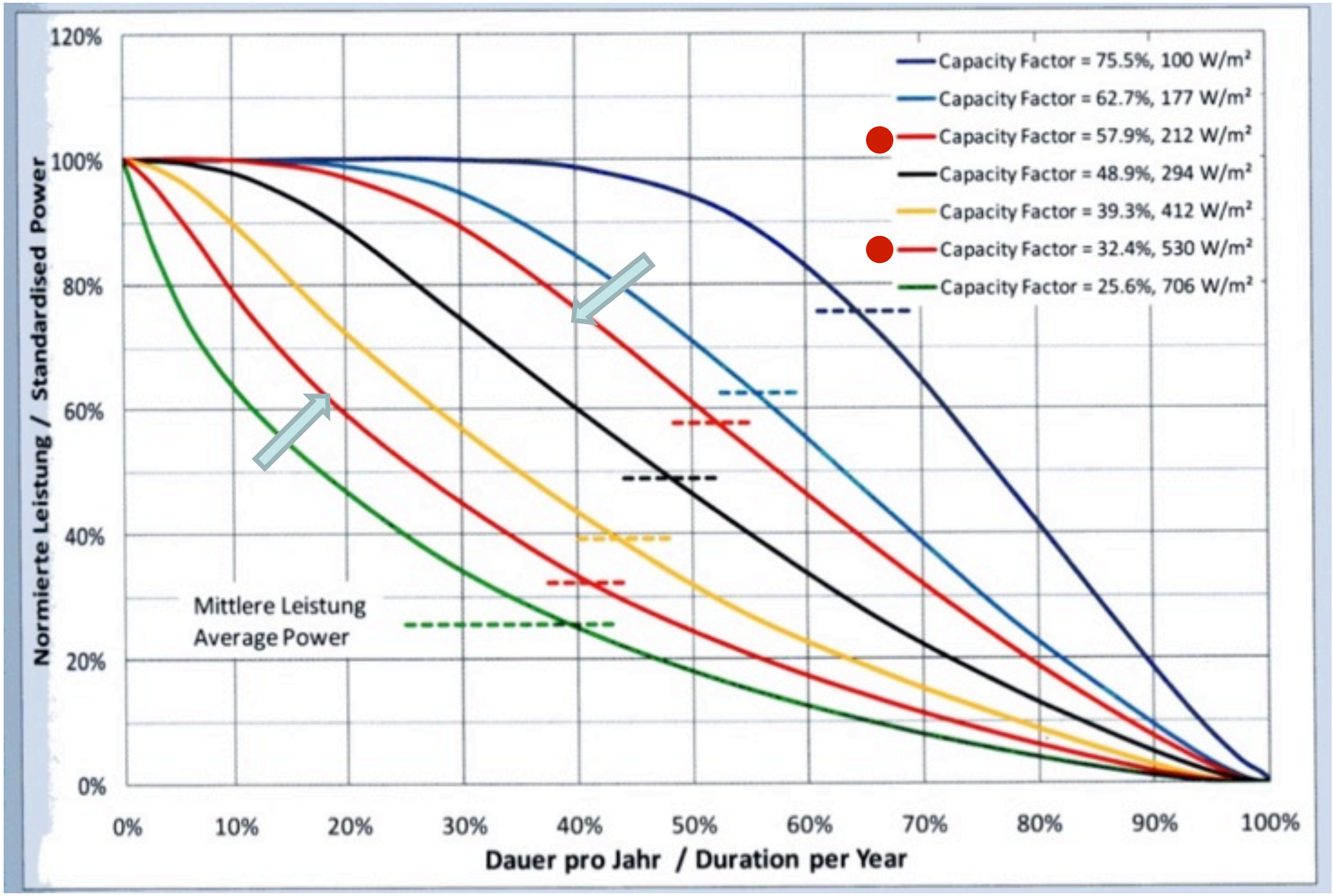
Advantages of low value of p, or high capacity factor



Source: János Hethey, Ea

Facilitating Grid integration

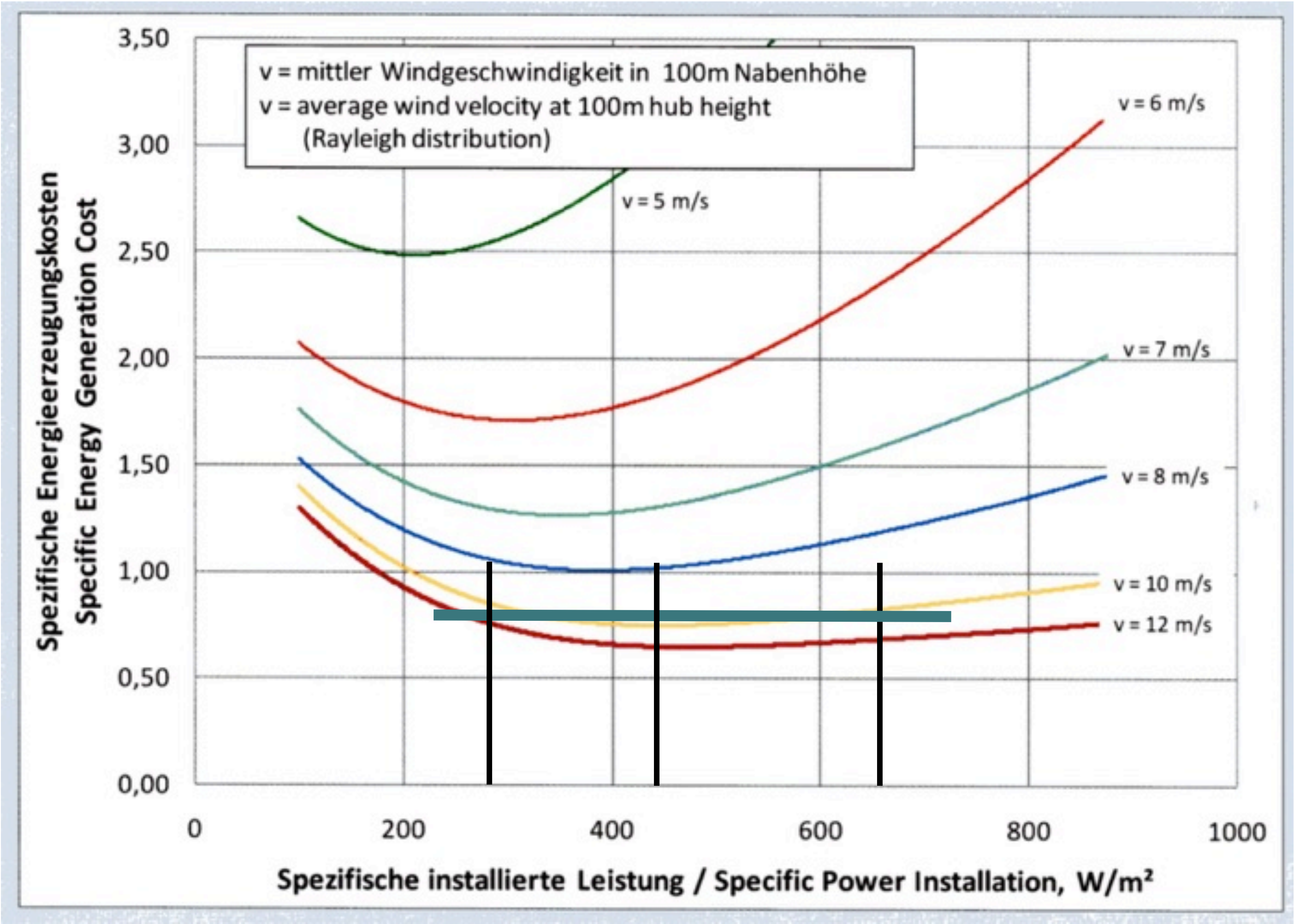
Wind turbine power rating and capacity factor



Source: J.P. Molly, DEWI

Facilitating Grid integration

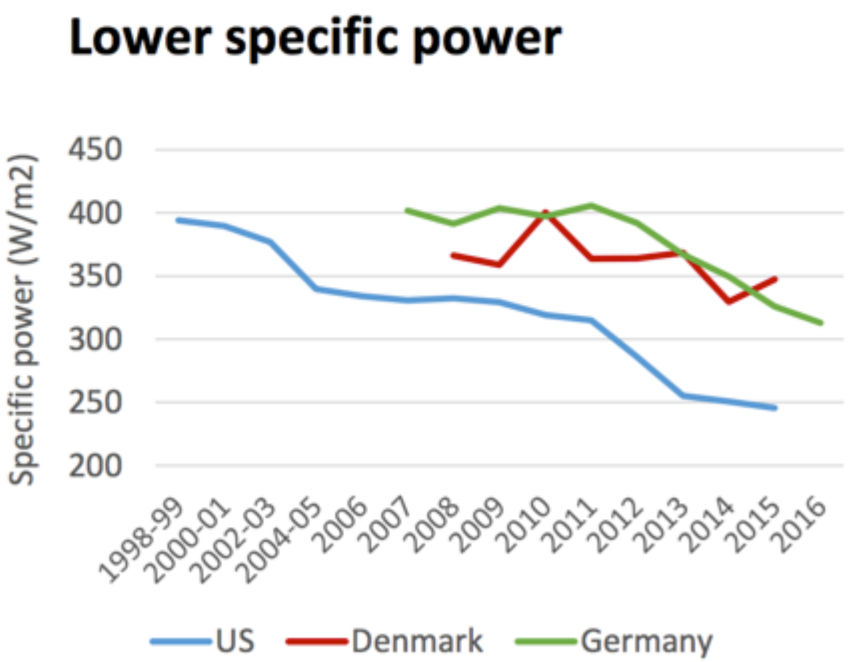
Cost of de-rating wind turbines

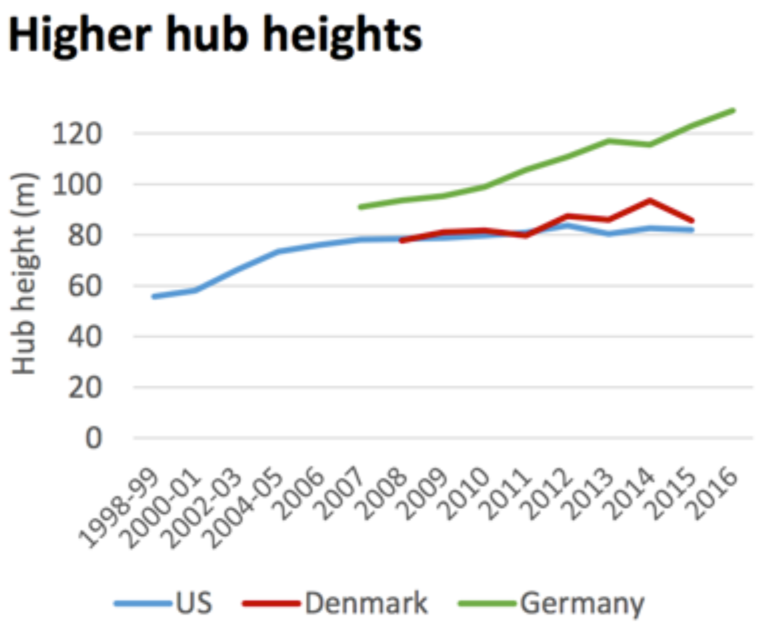


Source: J.P. Molly, DEWI

System rating: Low wind regime rating
Mechanical design: High wind speed regime

Advantages of low value of p, or high capacity factor





Source: János Hethey, Ea

Advantages of low value of p leading to high capacity factor

- Cost reduction of all electrical components, which outweighs the slight reduction of output per m² swept rotor area.
- Higher penetration degree of WE, lower use of coal, oil & gas
- Improved output predictability of wind farm output (< 24 hours ahead)
- Lower balancing cost
- Reduced need for curtailment of Wind power
- Lower storage cost

Conclusions

- Increase budgets for CC R&D considerably
- The future potential of CC remains considerable
- Introduce CC adapted wind turbine transport and installation concepts
- Develop low-p [W/m²] wind turbines for better grid integration


Thank you for your attention !