VINDKRAFT
TEKNOLOGISKE OG ØKONOMISKE TRENDER

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Statkraft

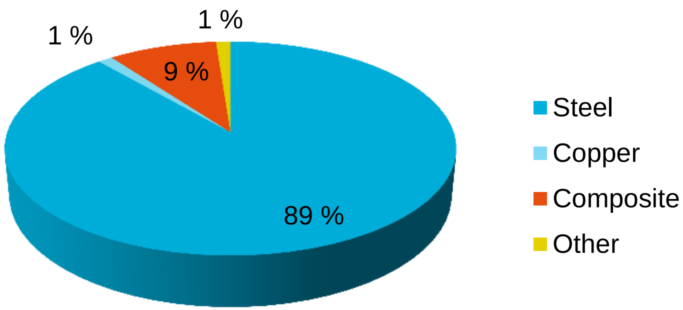
TEKNOLOGI OG TRENDER

Dagens vindturbiner

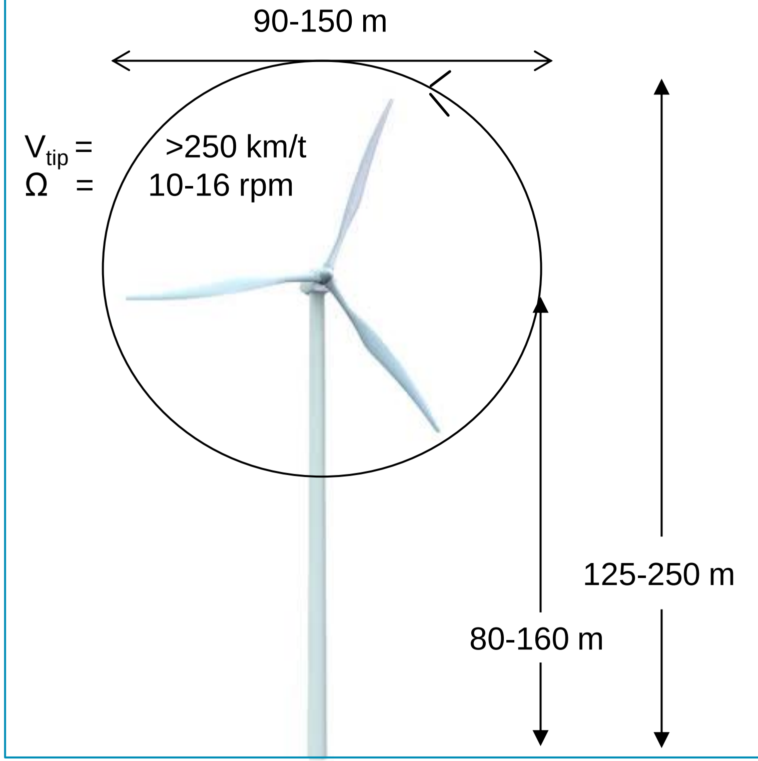
Generelt

- Turbinseffekt: **3-4 MW**
- Levetid: +/- **25 år**
- «Energy payback»: **3-6 måneder**
- Total vekt: **500 t**

- Vekt fordelt per material



Dimensjon



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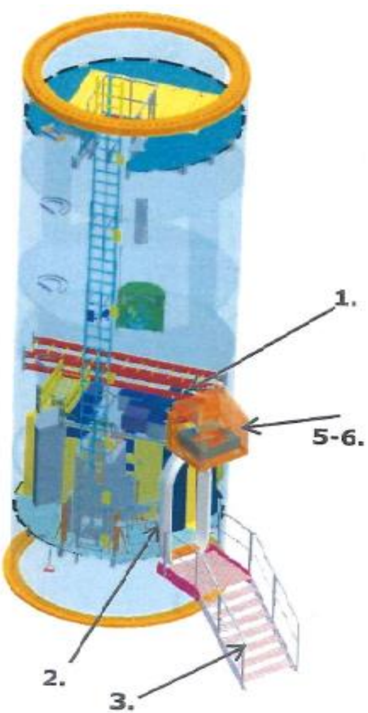
Hva som finnes i vindturbinen

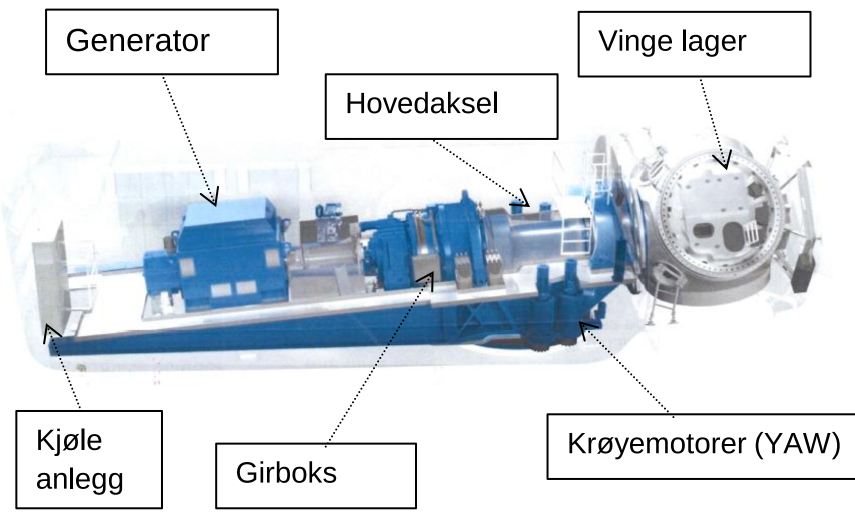
Tårn



1. Omformer (AC→DC→AC)
2. MV-bryter
3. Tilgang
4. Transformer (690V/23 kV)
5. Ventilasjon (luft-in)
6. Ventilasjon (luft-out)

Mer mer (heis, kabler)

Nacelle



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Bladene fanger vindenergien

- Vindkraft er kinetisk energi av luft i bevegelse:
  - $\mathbf{E} = \frac{1}{2}.m.V^2 = \frac{1}{2}.\rho.A.t.V^3$

- Effekten av turbinen:
  - $\mathbf{P} = \frac{\mathrm{E}}{\mathrm{t}} = \frac{1}{2}.\rho.A.V^3.Cp$

Effekt øker:

1. kubisk med vindhastighet ($v^3 = v \cdot v \cdot v$)
2. kvadratisk med radius ($A = \pi \cdot r \cdot r$)
3. lineært med ”Cp” (Power Coefficient) og lufttetthet (ρ)

<u>Bare Cp (=blad-profilen) endres under drift for å kontrollere effektopptak</u>

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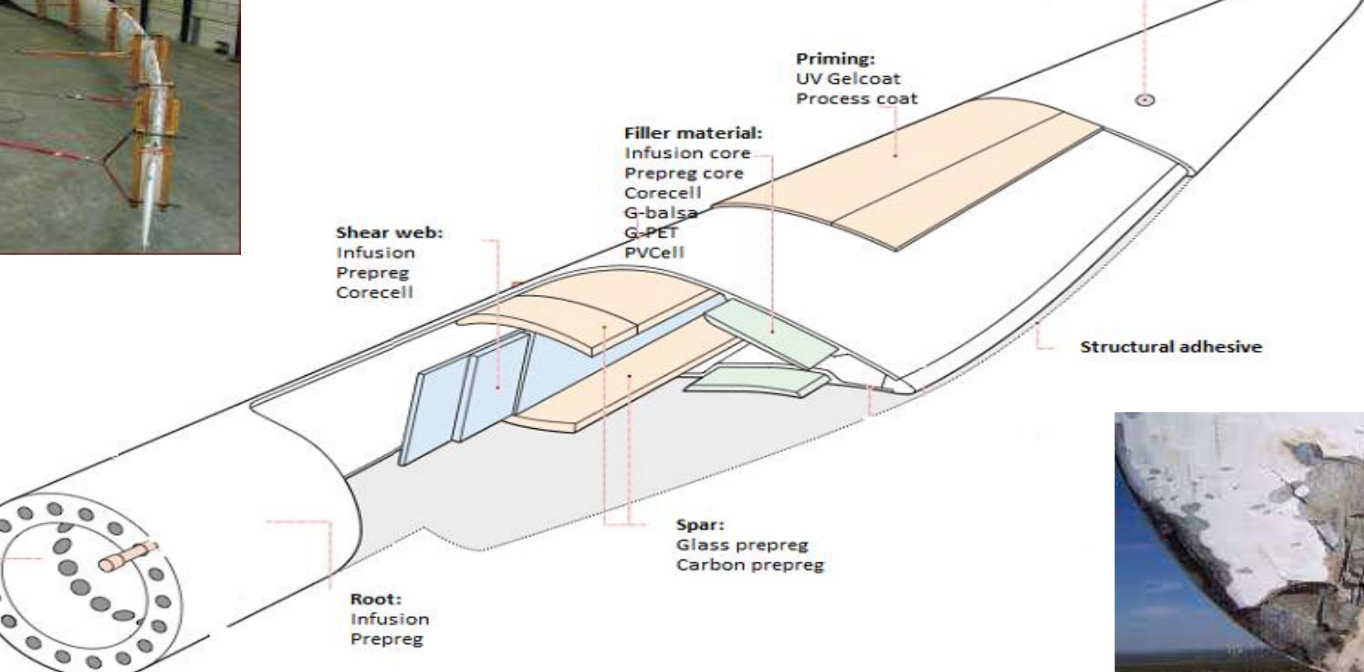
Et blad: et strukturelt og aerodynamisk objekt



Dynamisk (eller «fatigue») test av blader

- https://www.youtube.com/watch?v=7Za21TfvKbE

Innovasjon og trender

Further utilise model prediction, high performance computing and big data to **support energy systems** dynamics.

Offer ancillary services by improving control and **optimal integration of storage** in wind power plants and wind turbines.

New technology materials such as radical weight reduction through Bionic design and Additive Manufacturing.

Exploit **Vestas' access to big data** for diagnostics, remaining useful life analysis, service and after sales optimisation.

Mobile factory reducing logistics challenges through portability and offering local labour creation at low investments.

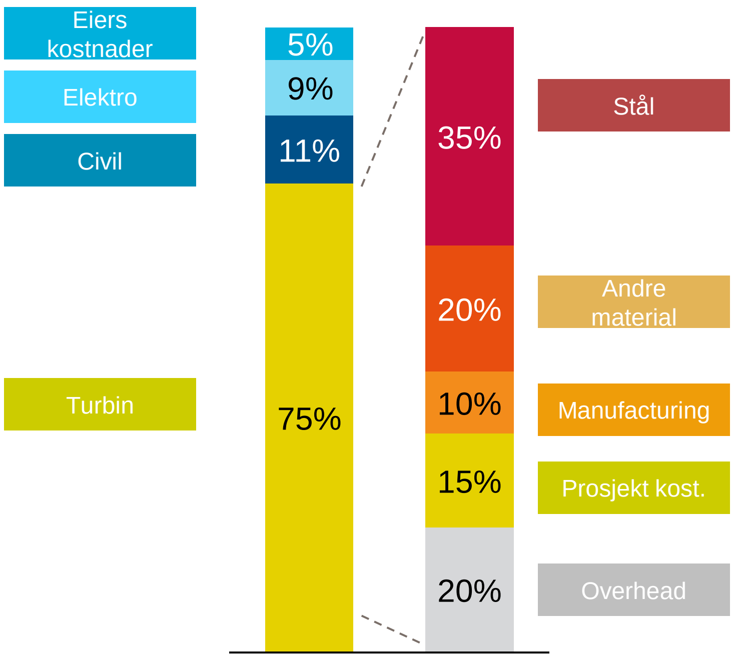
Turbine R&D, value chain simulation, O&M **performance and optimisation** all founded on high performance computing.

Source: Vestas

KOSTNADSREDUKSJON OG PROGNOSER

Turbinskostnader: ca. 3 M€
Prosjektinvestering: ca. 1 M€/MW

Nedbrytning



Hoveddrivere for prosjektskostnaden

Stål
- Hoveddelen av investering; prisnivået har vært historisk lavt det siste

35% (tårn, girbox etc)

Andre materialer
- Andre metaller følger stål-trender
- Mens GRP og CRP er ukorrelert

20% (vinge etc)

Lokaler kostnader
- Lokal produksjon i enkelte land
- Transport og aktiviteter på site

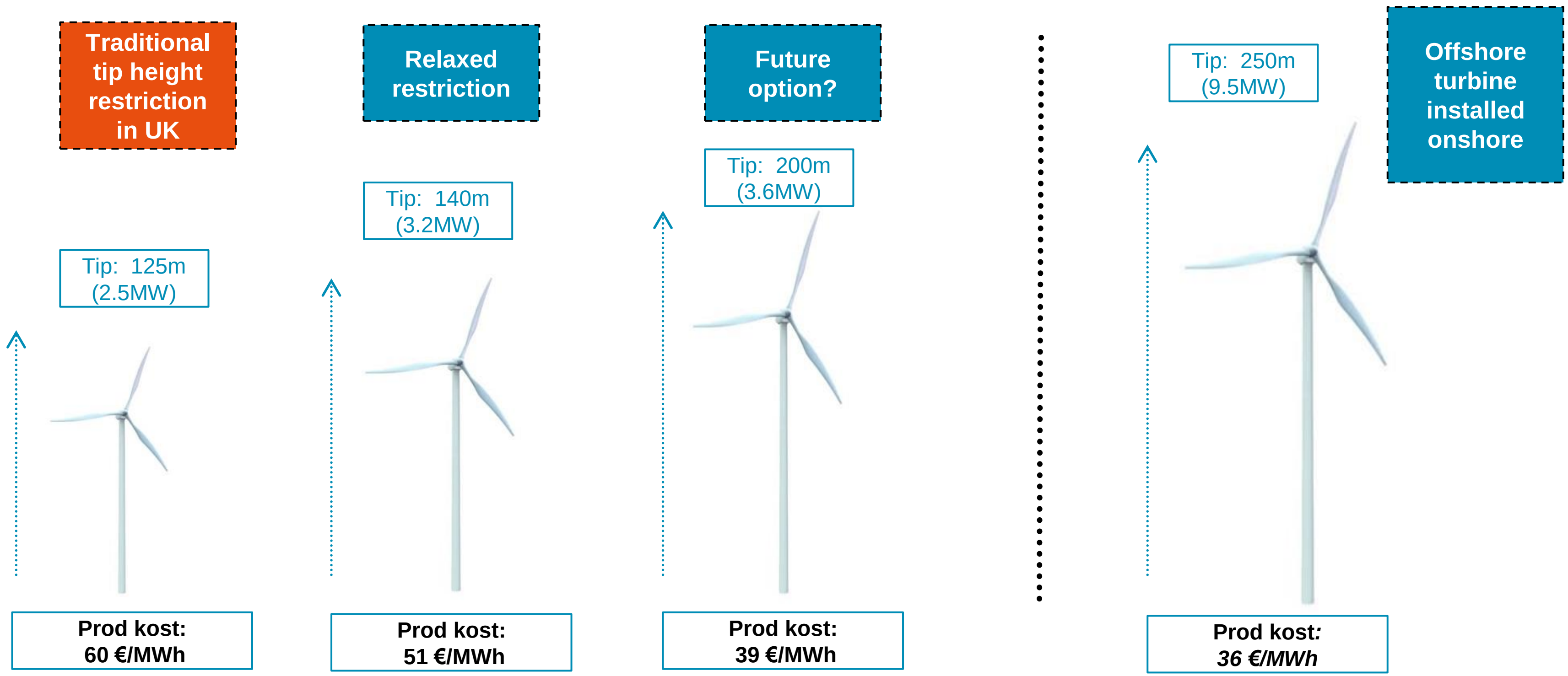
30-50 %

Ikke lokalt
- Shipping
- “Overhead” kostnad
- Engineering og consultancy i noen tilfeller

5-20 %

Generic split shown – differs across country and exact project specifications

Større turbiner = mer vind = lavere produksjonskostnader

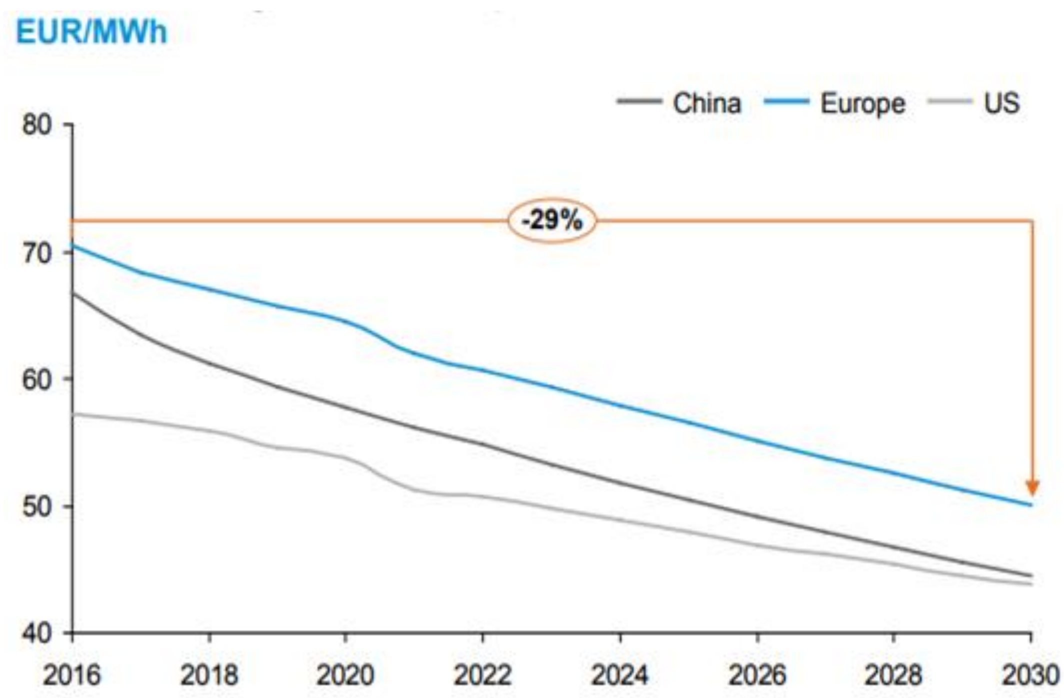


Mer fleksible regler i UK kan medføre til en nedgang i produksjonskostnader på minst 30 %, idag !

LCOE assumptions: WACC: 5.5% and 25 yrs lifetime

Fremtidig kostnadsreduksjon for onshore vindkraft

Produksjonskostnader



1. Investments
2. Innovation
3. Modularisation
4. Optimisation
5. Partnership

Source: BNEF NEO 2016

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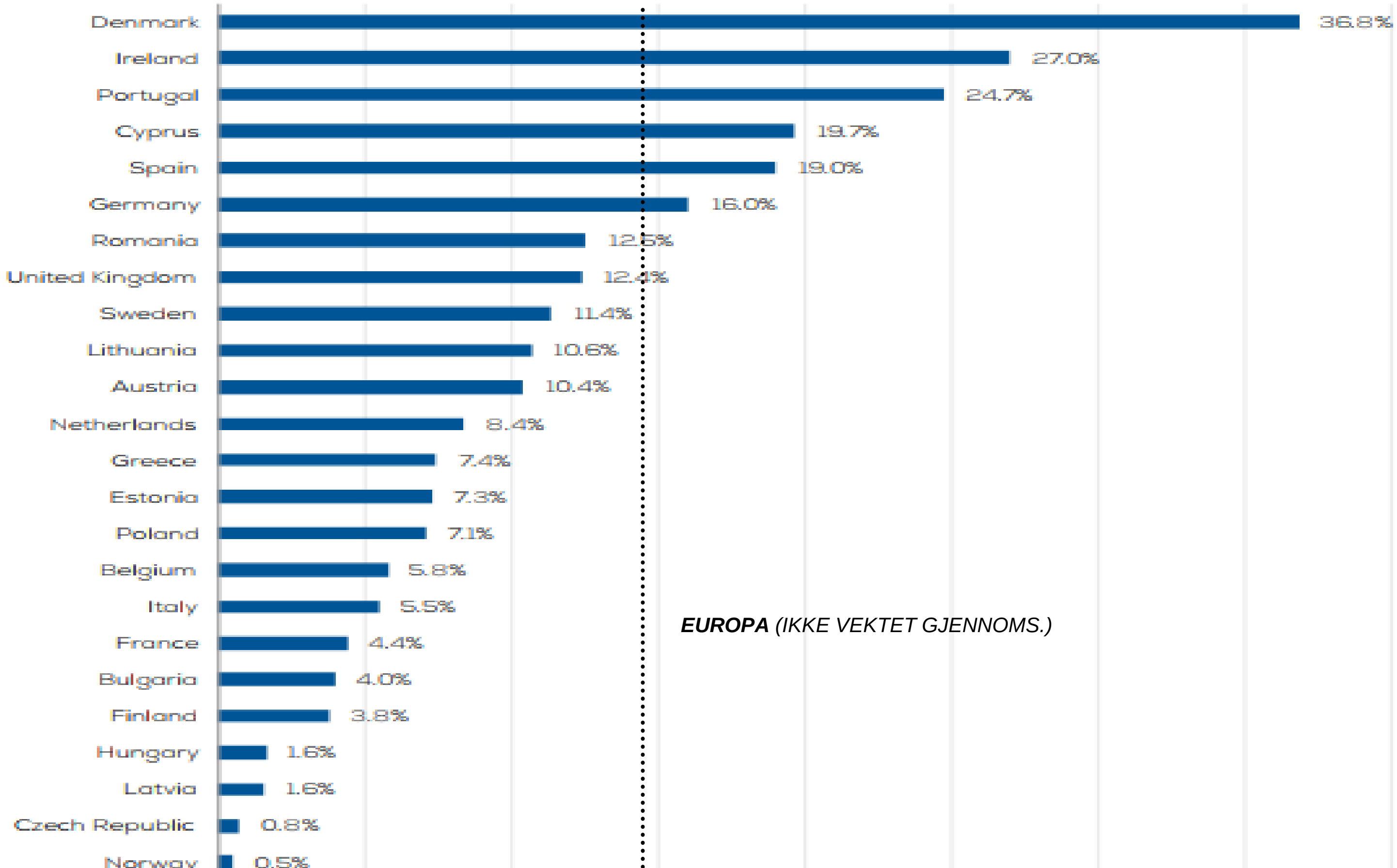
Andel av vindkraftproduksjon i Europa



 Source: WindEurope 2016

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Statkraft today

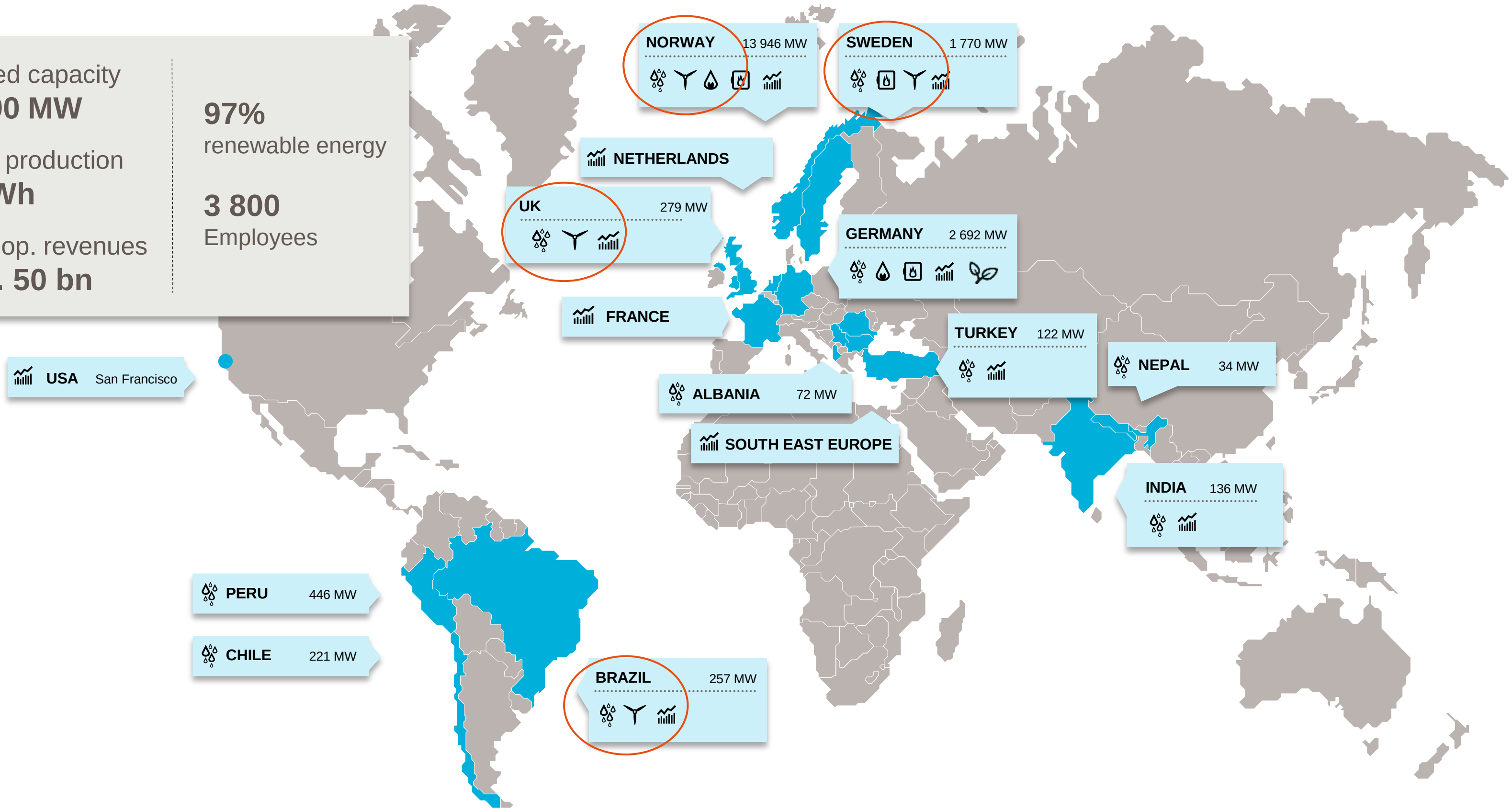
Installed capacity
19 290 MW

Power production
66 TWh

Gross op. revenues
Aprx. 50 bn

97%
renewable energy

3 800
Employees



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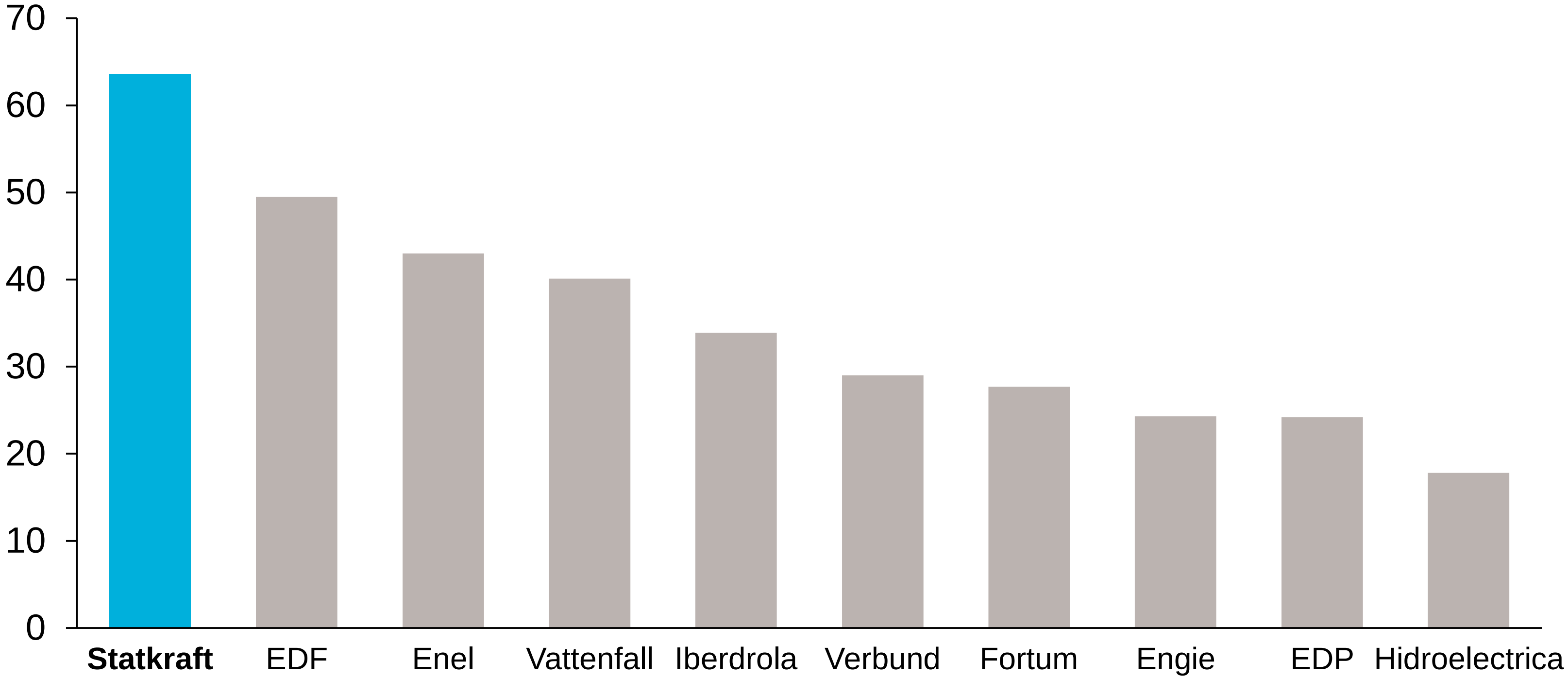
Statkraft er Europas største produsent av fornybar elektrisitet

Fornybar kraftproduksjon 3-år gjennomsnitt (TWh)



Source: PWC: "The largest renewable power producers in Europe 2016"

THANK YOU

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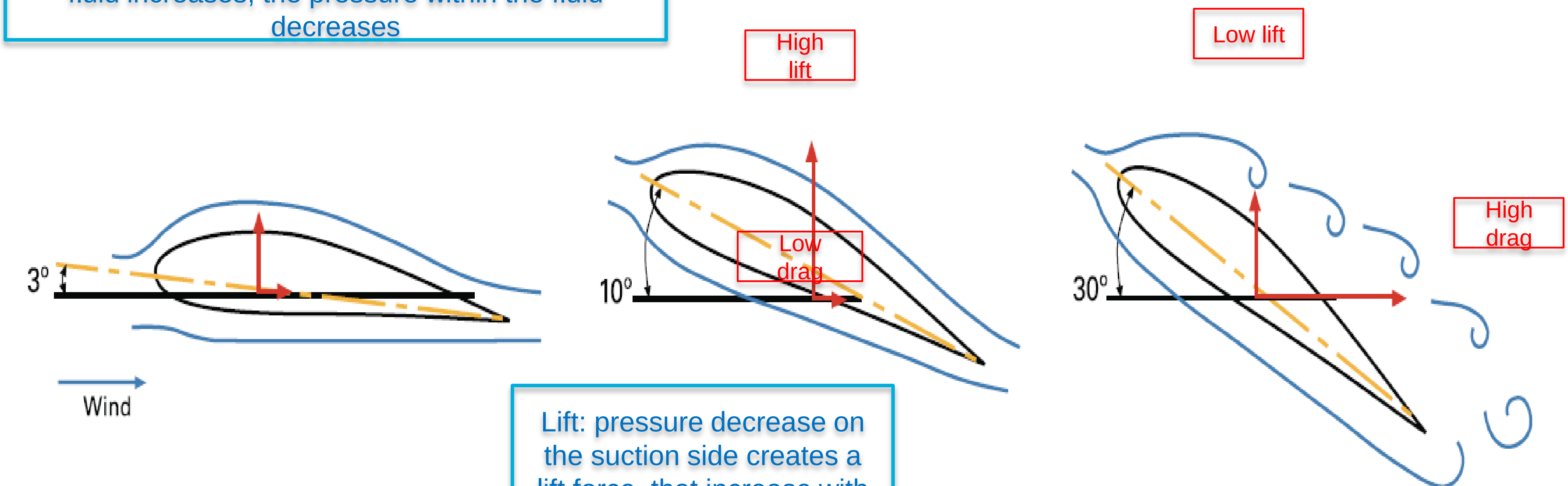
PURE ENERGY

Aerodynamic basics

Bernouilli's principle: as the speed of a moving fluid increases, the pressure within the fluid decreases



Lift: pressure decrease on the suction side creates a lift force, that increase with the angle of attack

Stall: flow distachement due to too high angle of attack. Lift is then reduced

Fremtidig kostnadsreduksjon for onshore vindkraft

Innen 2040 kan kostnaden til onshore vindkraft reduseres til 30-40% i USA

1. Investments
2. Innovation
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4. Optimisation
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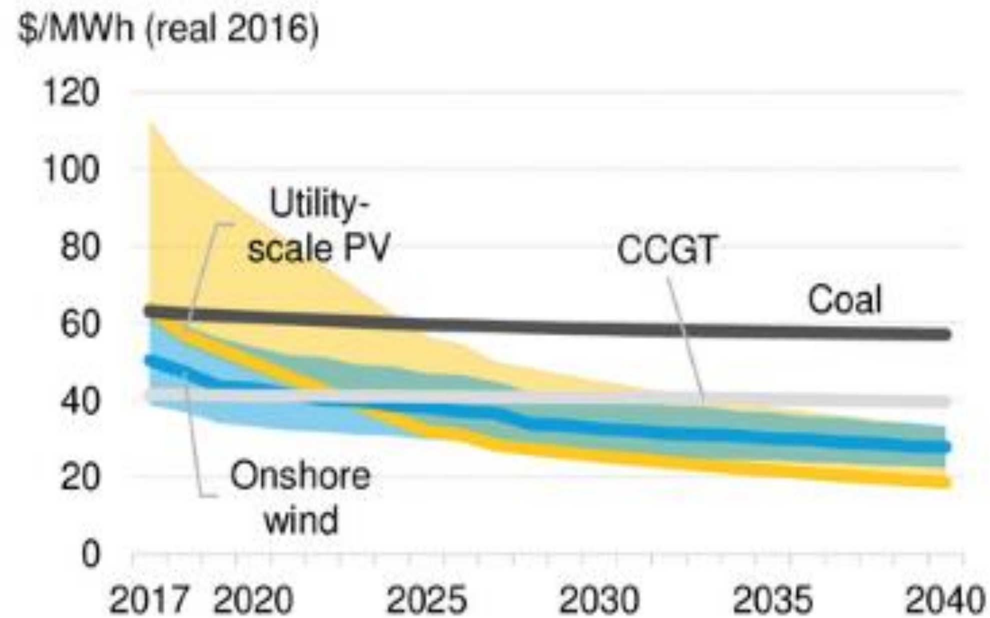

Source: BNEF, NEO 2017

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