Energy over view and wind power

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20170502

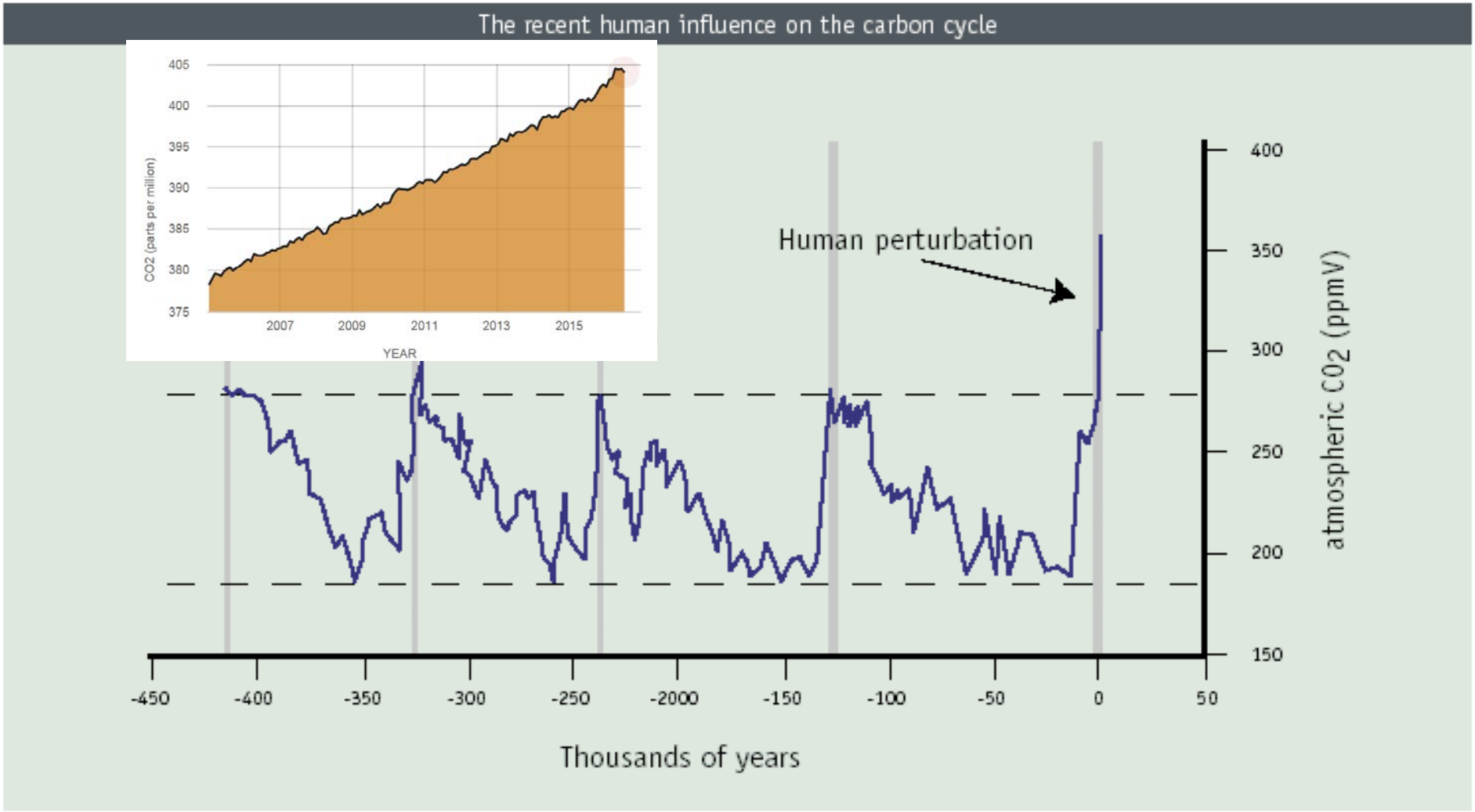
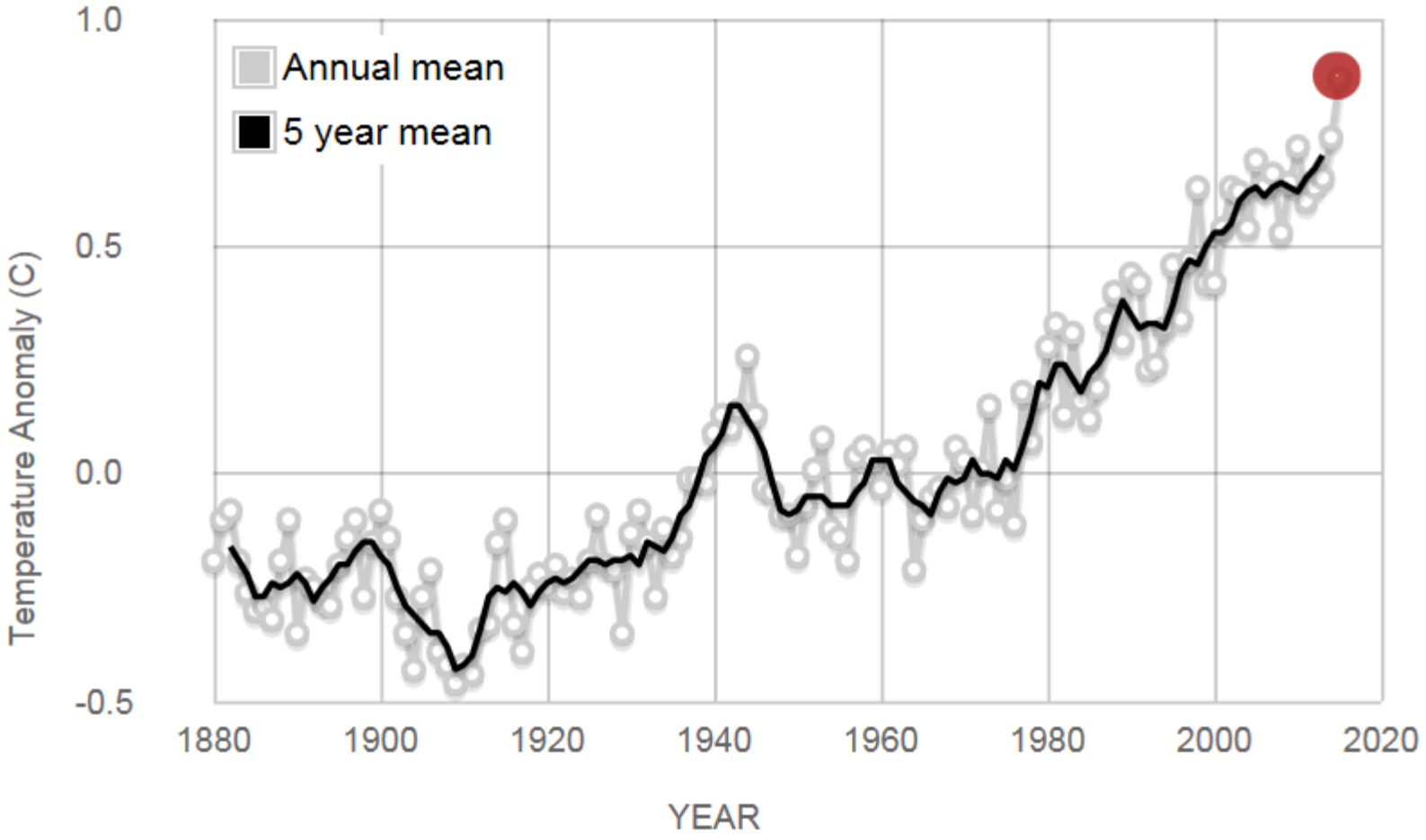
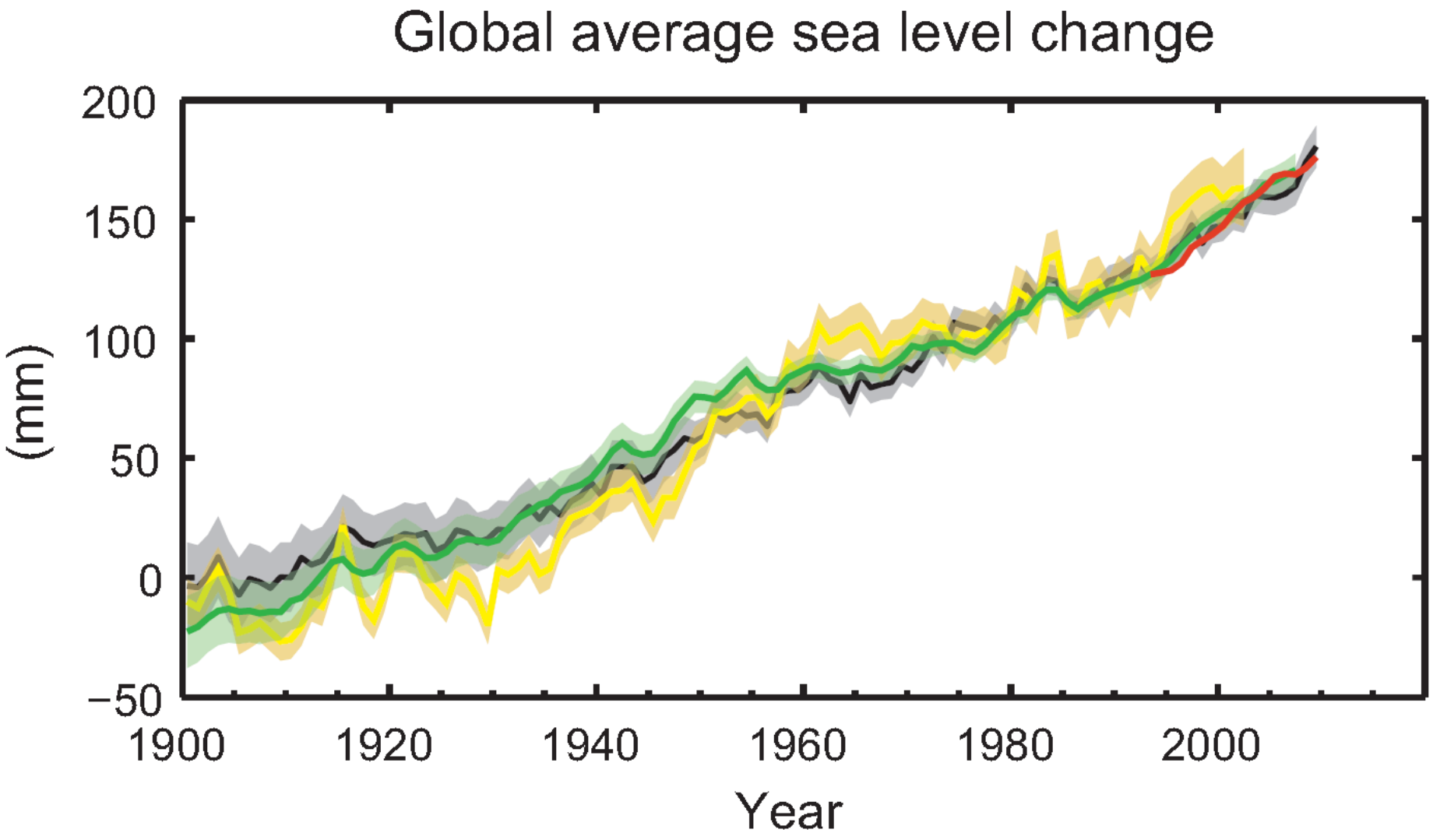


Figure 2 Atmospheric CO_2 concentration from the Vostok ice core record with the recent human perturbation superimposed. The inset shows the observed contemporary increase in atmospheric CO_2 concentration from the Mauna Loa (Hawaii) Observatory.

Sources: Petit et al. (1999) Nature 399, 429-436 and National Oceanic and Atmospheric Administration (NOAA), USA



This graph illustrates the change in global surface temperature relative to 1951-1980 average temperatures


Global average sea level change
200
150
100
50
0
−50
(mm)
1900
1920
1940
1960
1980
2000
Year

The world a dark night

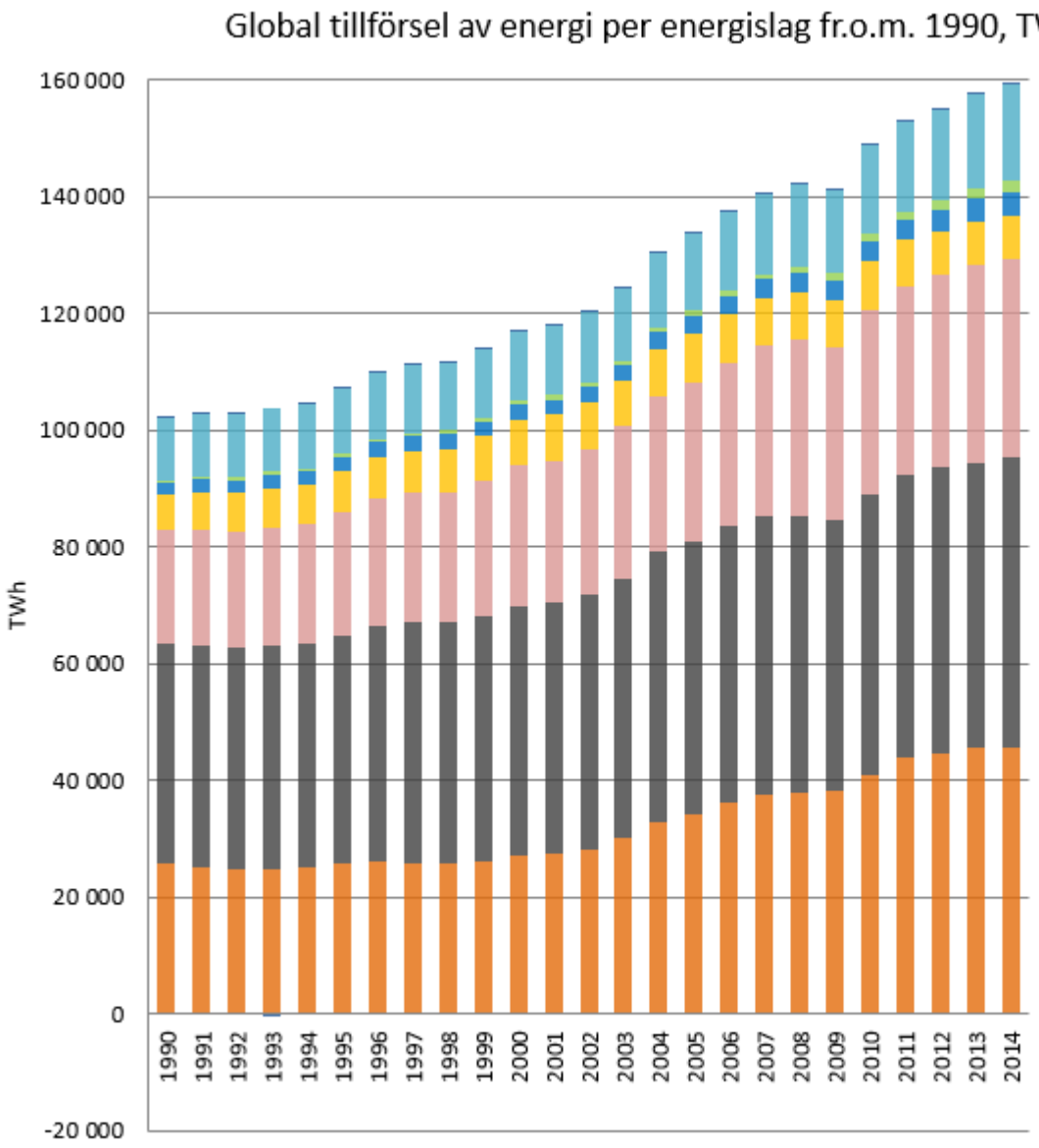
What is life without Electric Energy ?

- No light
- No electric heat
- No electric motors
- No computers, phones, TV

and

- Oil has reached its top production
- Gas soon on top production, but CO2
- Coal can be used for many years, but CO2

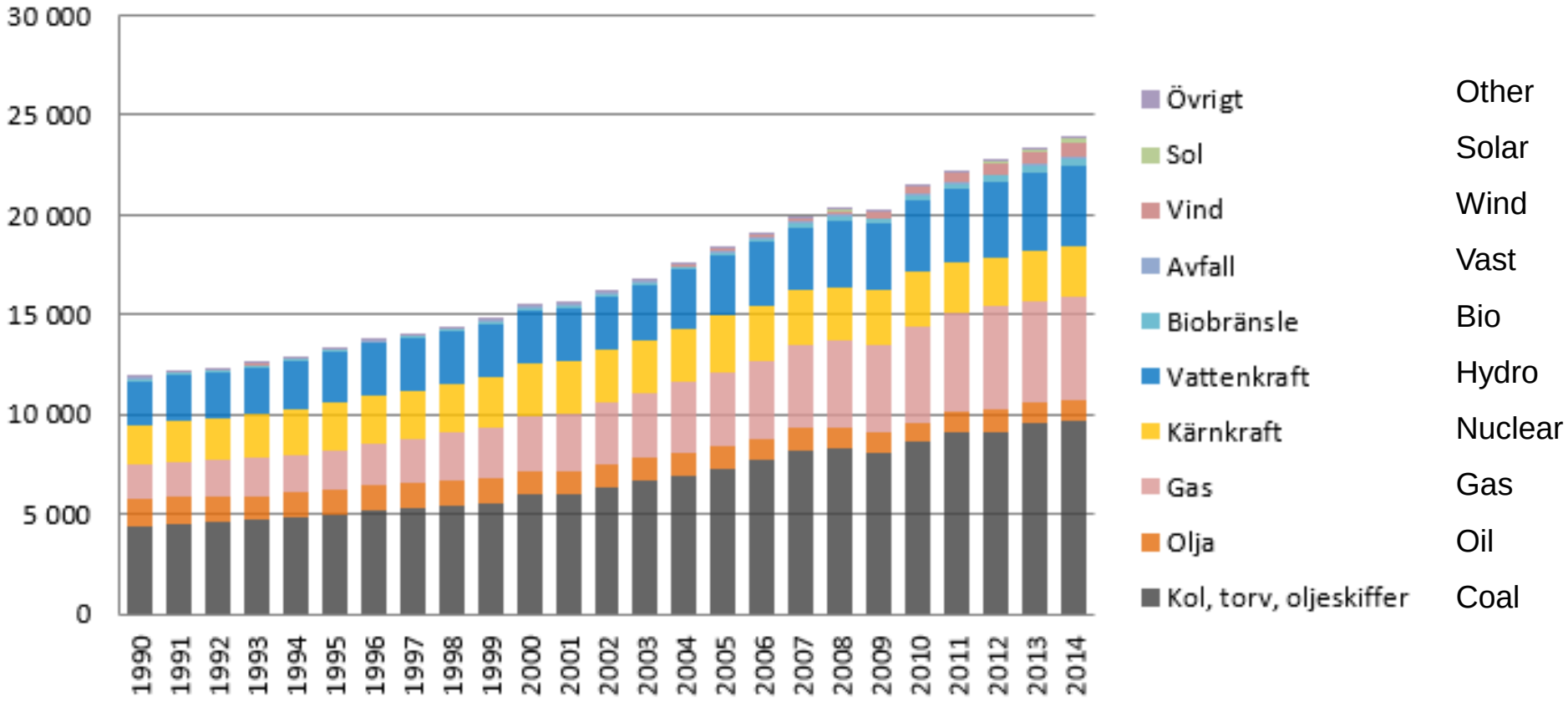
Needs for renewable electric power is great and there is a Need for Electric Power Engineers to develop the future



Global energy, TWh

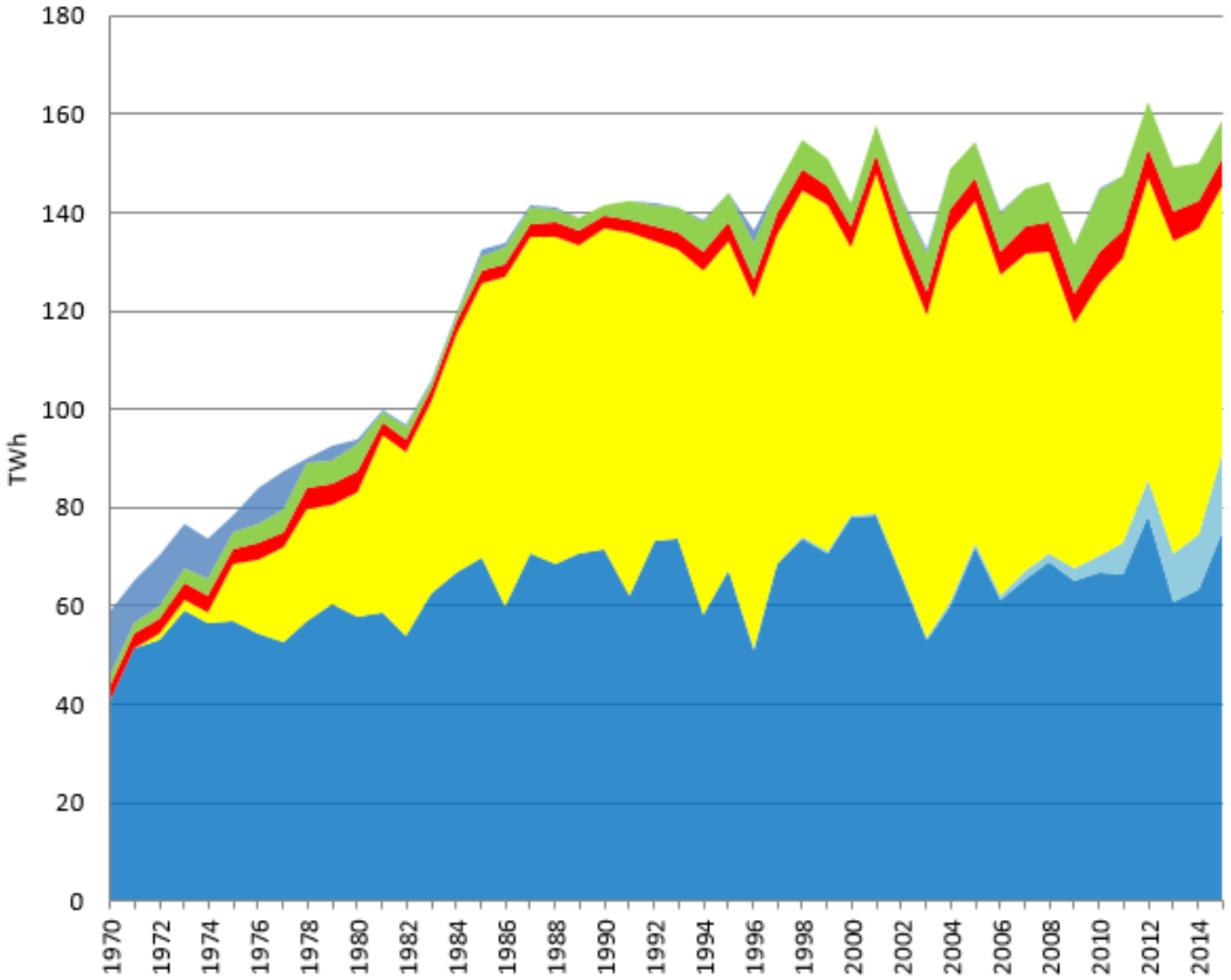
Övrigt	Other
Biobränsle och avfall	Bio and vast
Geotermisk, sol m.m.	
Vattenkraft	Hydro
Kärnkraft	Nuclear
Gas	Gas
Olja	Oil
	Coal

Global elproduktion per energikälla fr.o.m. 1990, TWh



Sweden

Elproduktion (netto) per kraftslag fr.o.m. 1970, TWh



Other

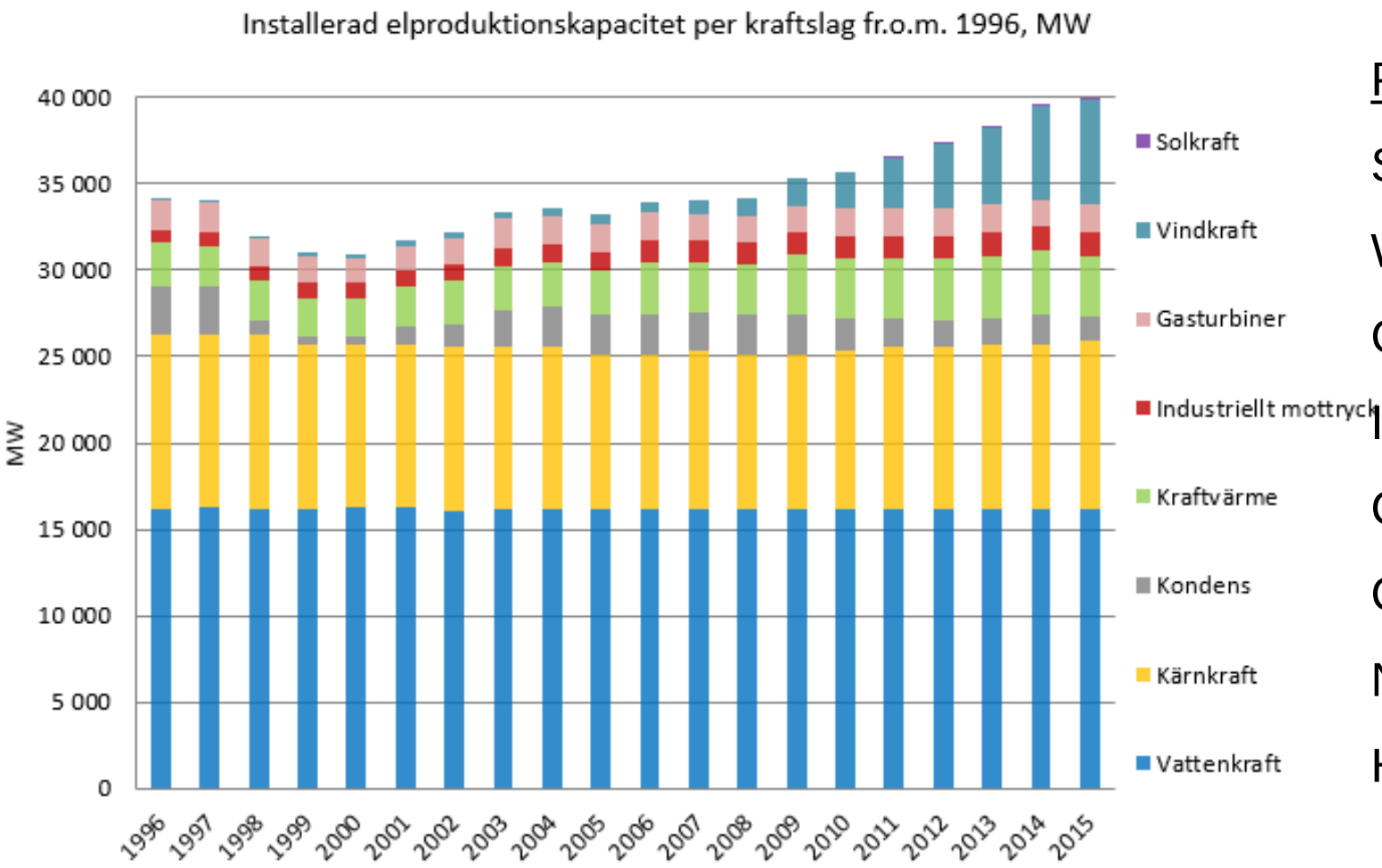
CHP

Ind CHP

Nuclear

Wind

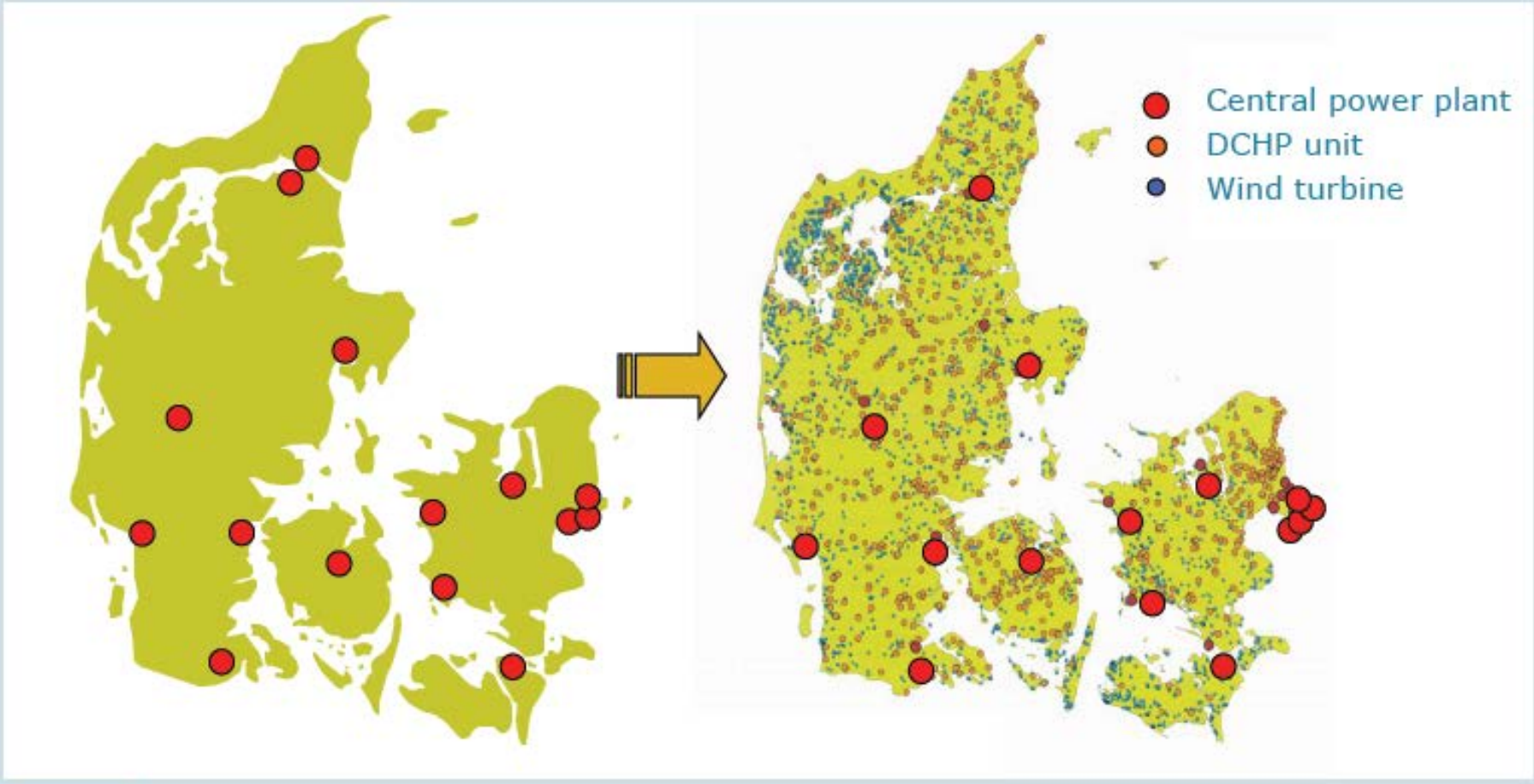
Hydro



Power	MW
Solar	104
Wind	6029
Gas	1606
Ind CHP	1376
CHP	3525
Condens	1413
Nuclear	9714
Hydro	16184

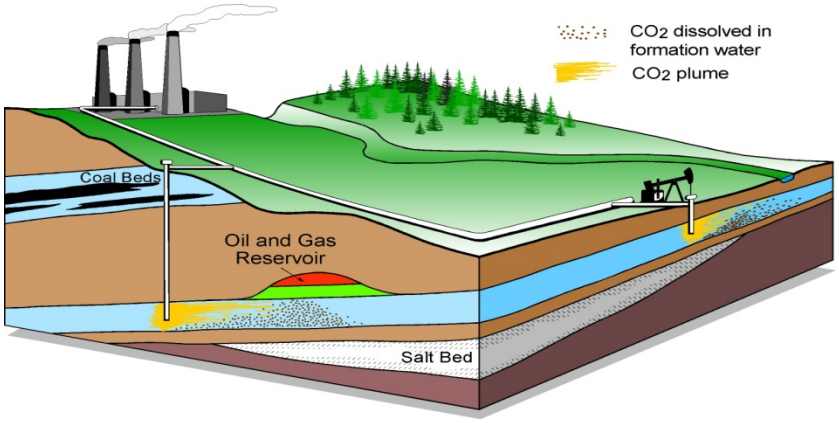
ENERGINET.DK

Development from the late 1980s to present

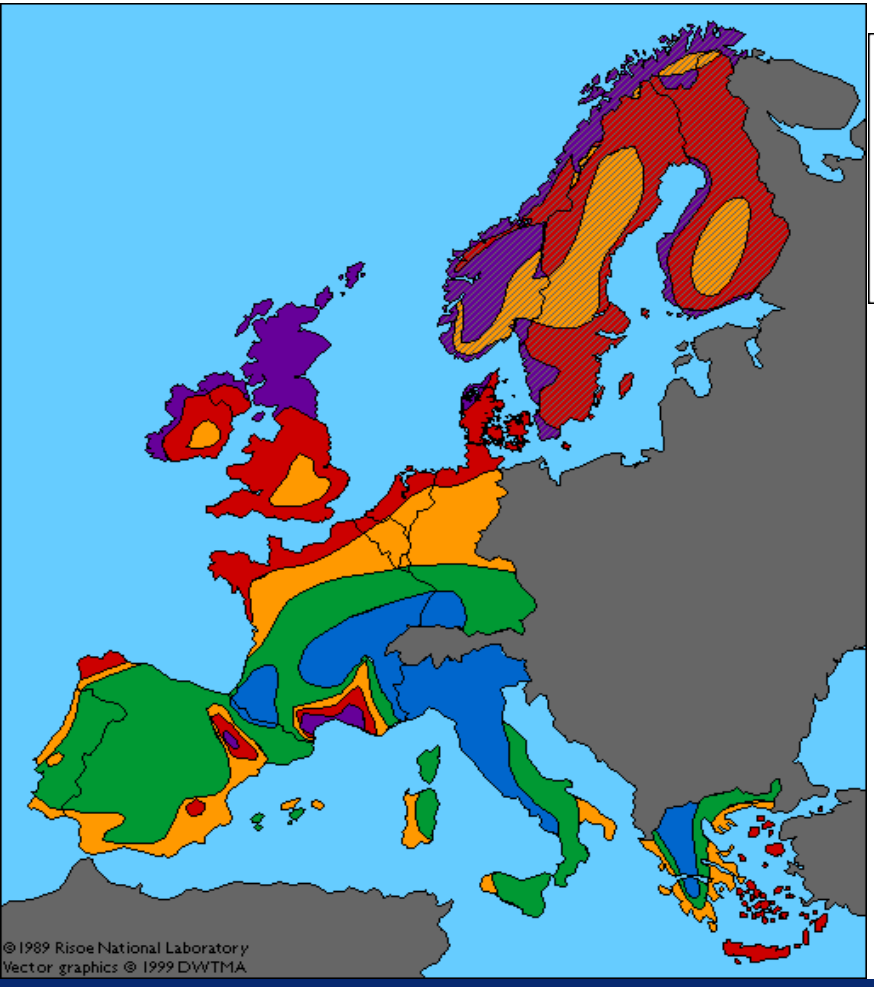


Renewables and new energy systems

- Hydro power
- Wind power
- Solar energy
- Wave Energy
- CO_2 separation and storage for converting natural gas to power
- Green certificates trading

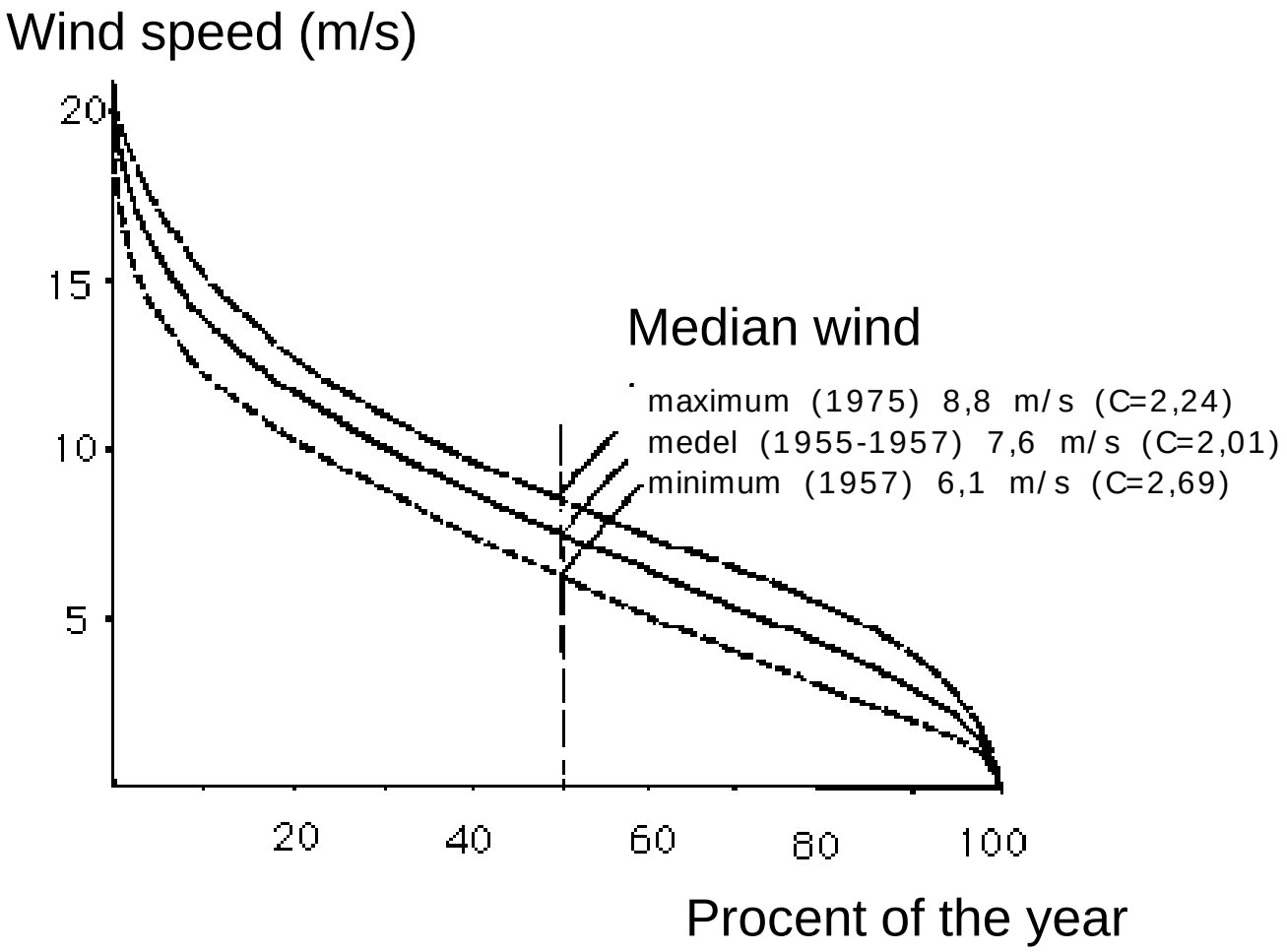


Wind conditions

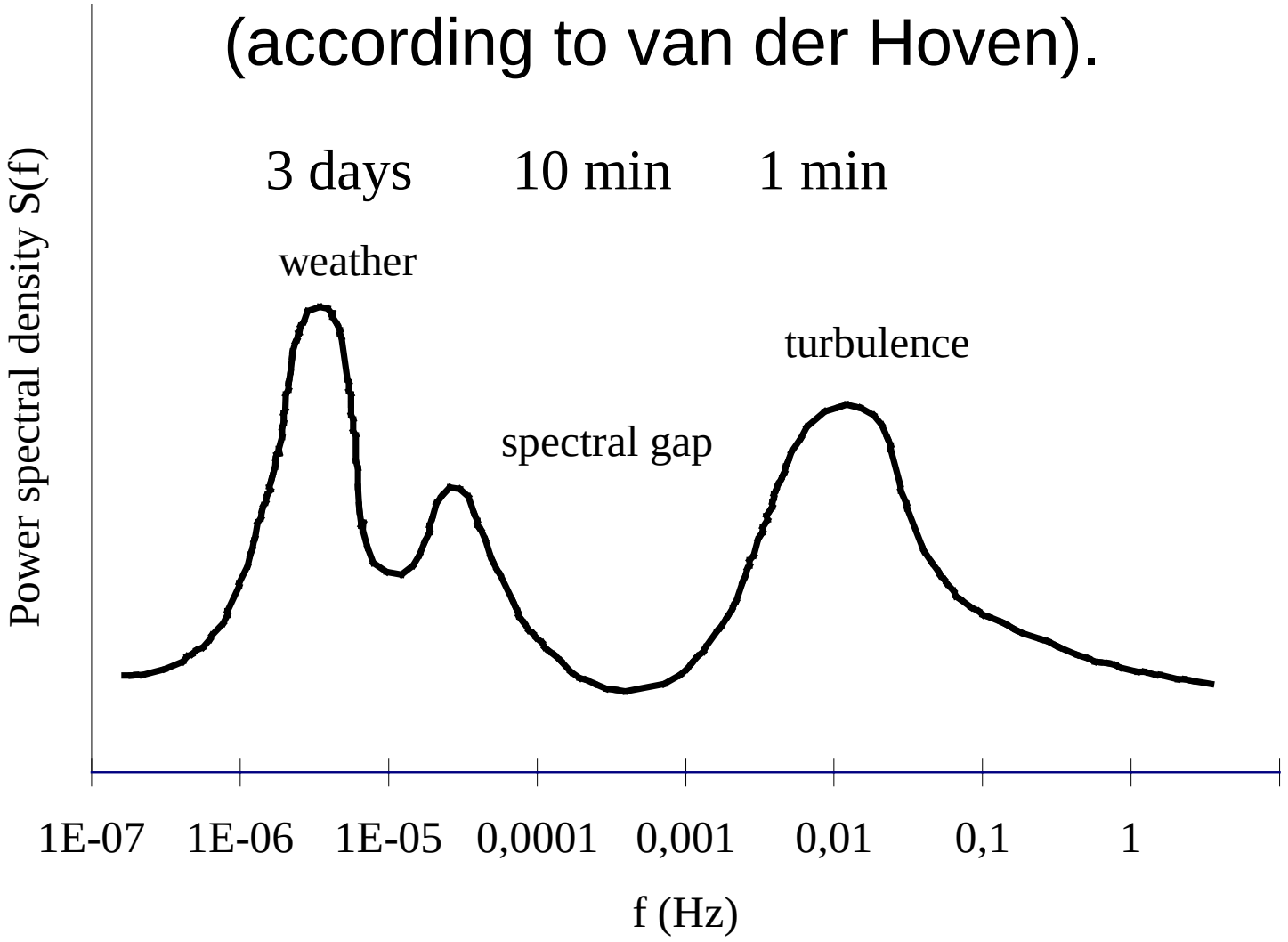


	m/s	W/m²	m/s	W/m²	m/s	W/m²	m/s	W/m²	m/s	W/m²
	>6.0	>250	>7.5	>500	>8.5	>700	>9.0	>800	>11.5	>1800
	5.0-6.0	150-250	6.5-7.5	300-500	7.0-8.5	400-700	8.0-9.0	600-800	10.0-11.5	1200-1800
	4.5-5.0	100-150	5.5-6.5	200-300	6.0-7.0	250-400	7.0-8.0	400-600	8.5-10.0	700-1200
	3.5-4.5	50-100	4.5-5.5	100-200	5.0-6.0	150-250	5.5-7.0	200-400	7.0-8.5	400-700
	<3.5	<50	<4.5	<100	<5.0	<150	<5.5	<200	<7.0	<400
			>7.5							
			5.5-7.5							
			<5.5							

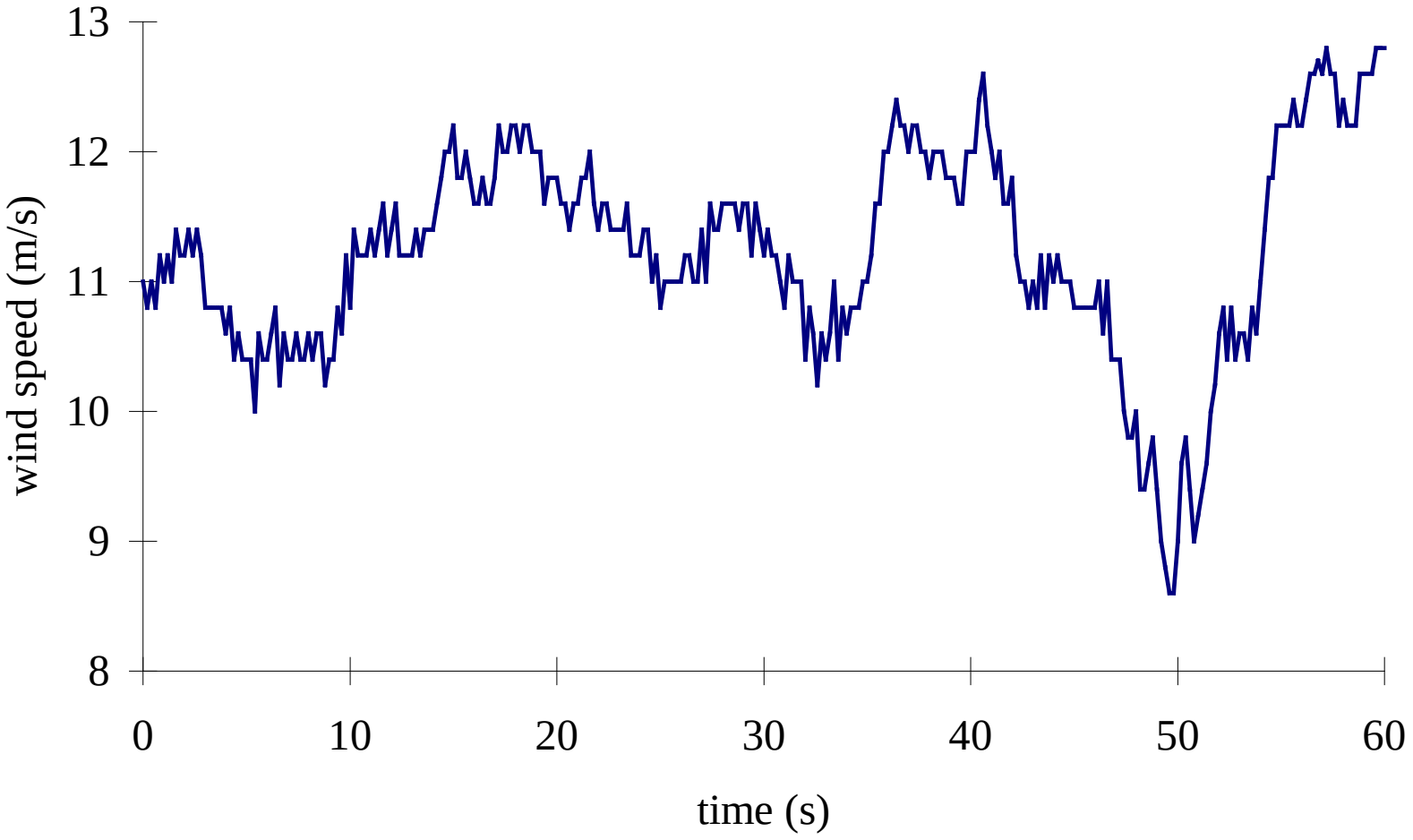
Weibull distribution



Schematic power spectrum of wind speed (according to van der Hoven).



Wind speed measured at the harbour of Gothenburg, Sweden

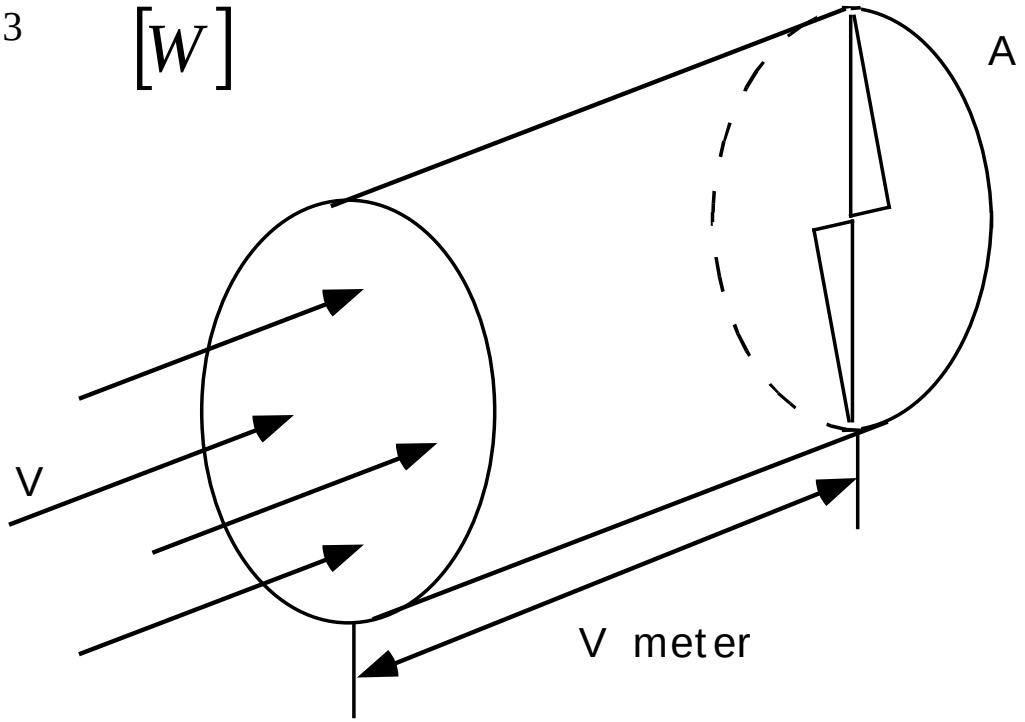


Power of the wind

$$P_{kin} = \frac{1}{2}(\rho A V)V^2 = \frac{1}{2}\rho A V^3 \qquad [W]$$

Mass flow rate

$$\dot{m} = \rho A V$$

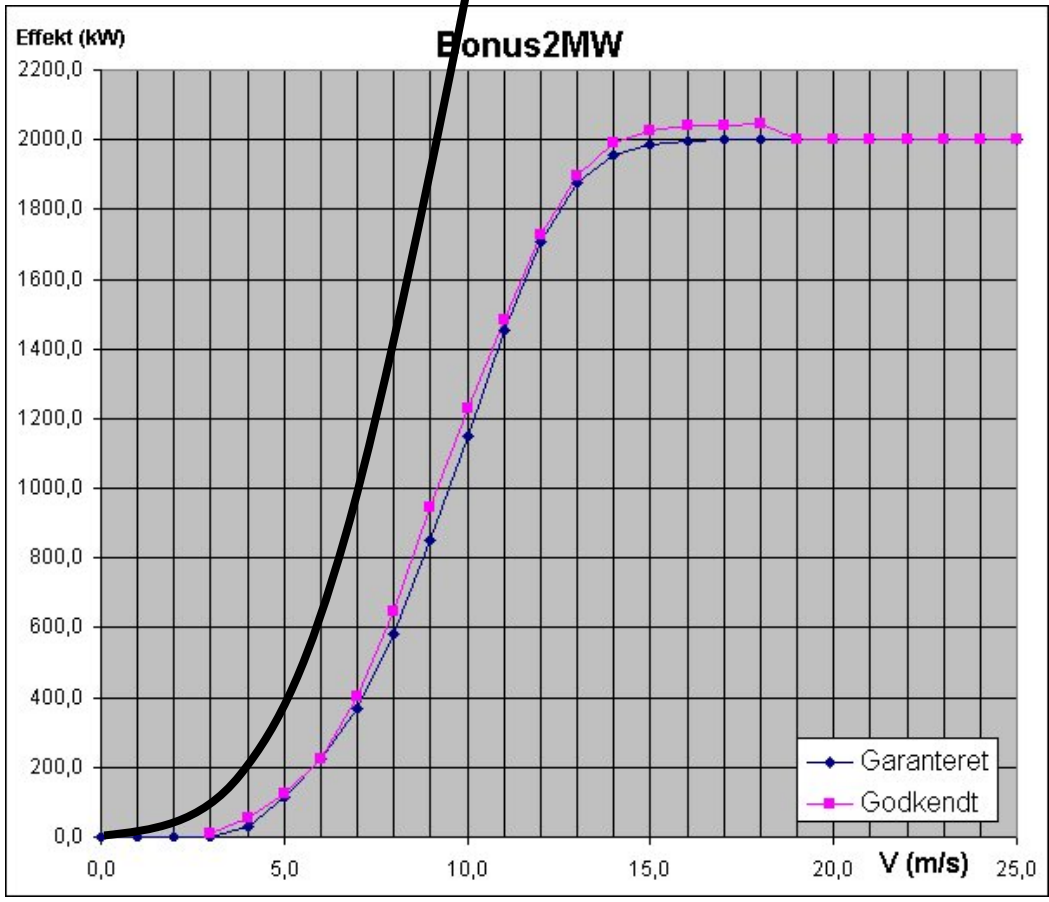


ρ = air density[kg/m^3]
V = air velocity[m/s]
A = rotor disk area[m^2]
m = mass of the air

Power from the wind turbine

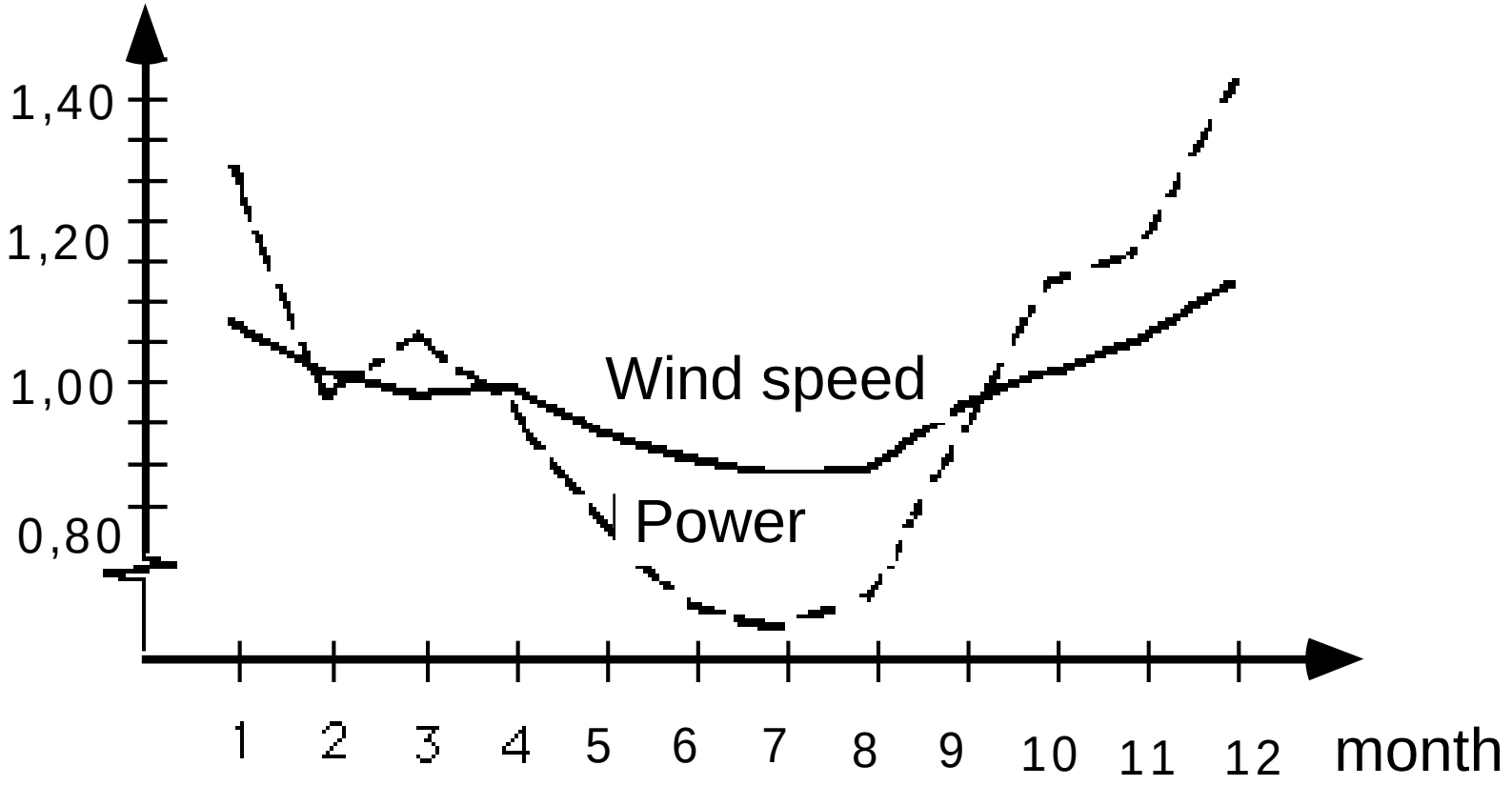
$$P = \frac{1}{2}\rho A C_p V^3$$

Where Cp is power coefficient

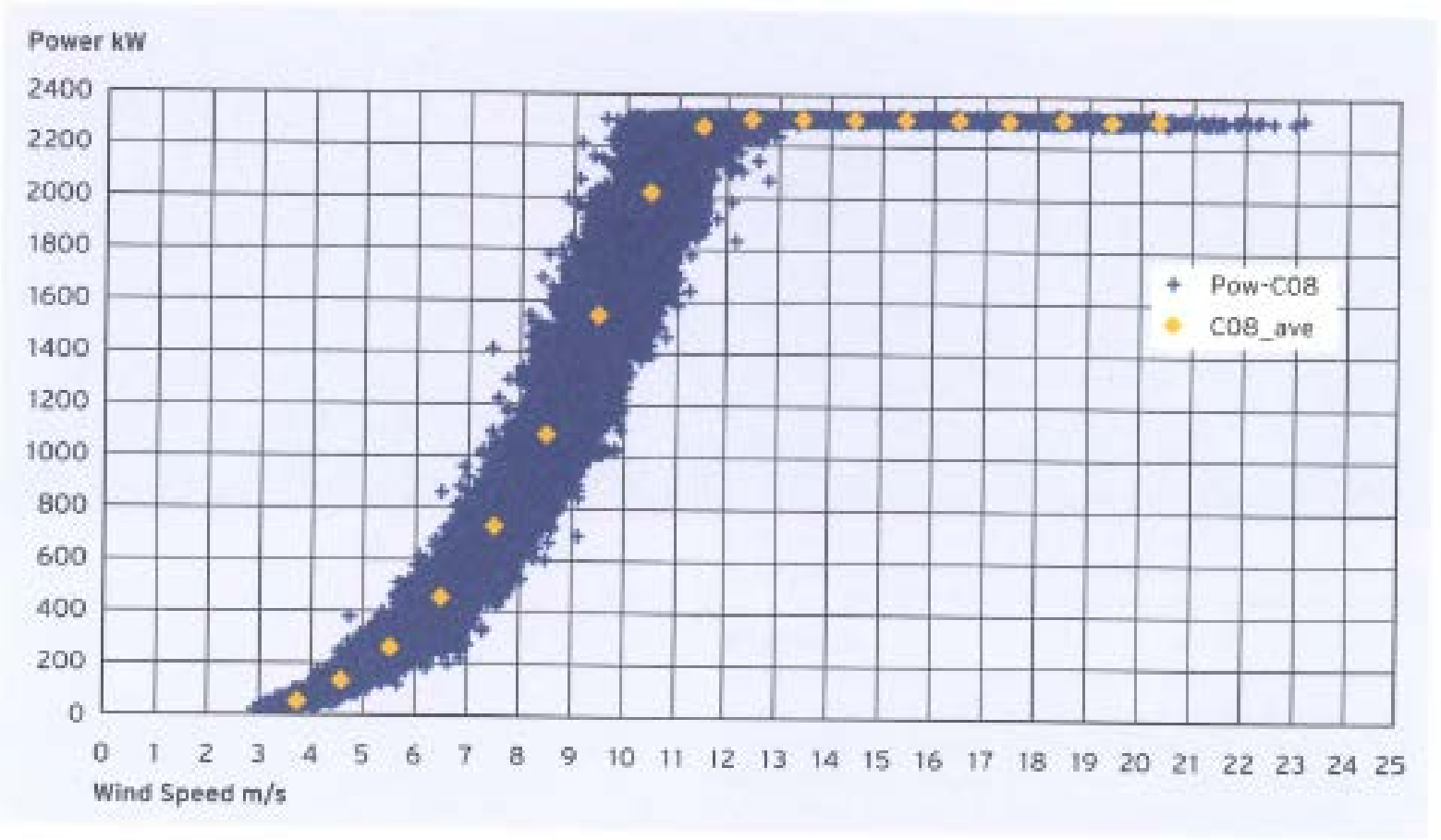


Average value

Power and wind speed during the year in Sweden



Power Curve from a 2.3 MW wind turbine at Lillgrund

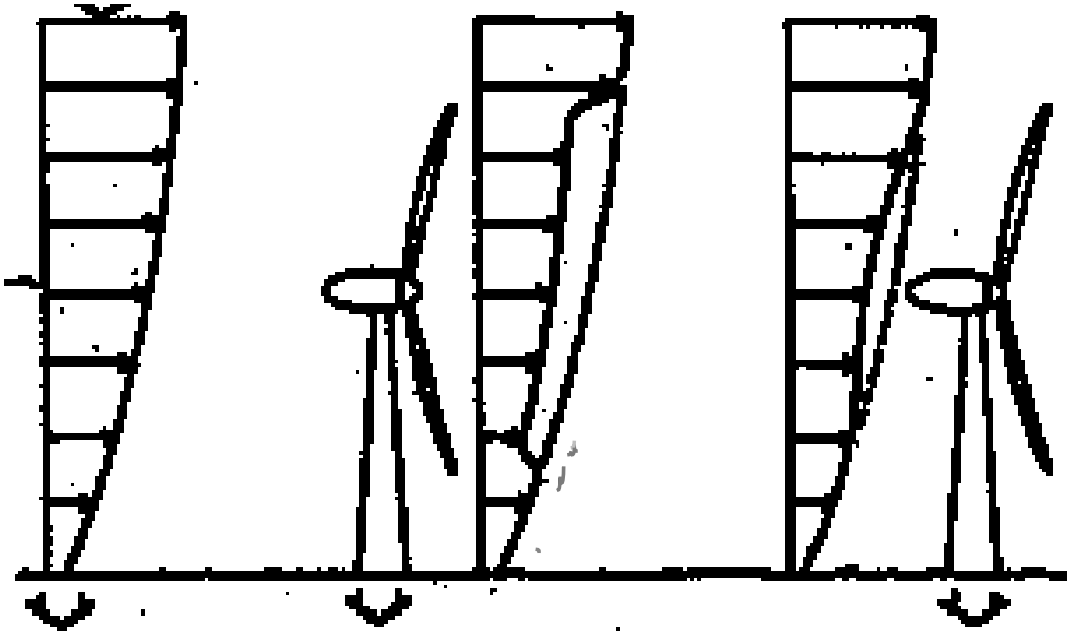


I grafen presenteras resultatet av vind-effektmätningen för vindkraftverk C-08. Medelvärdet (gul symbol) i varje fack...

Gradient of the wind

Wind decreases due to turbine

Wind reforms



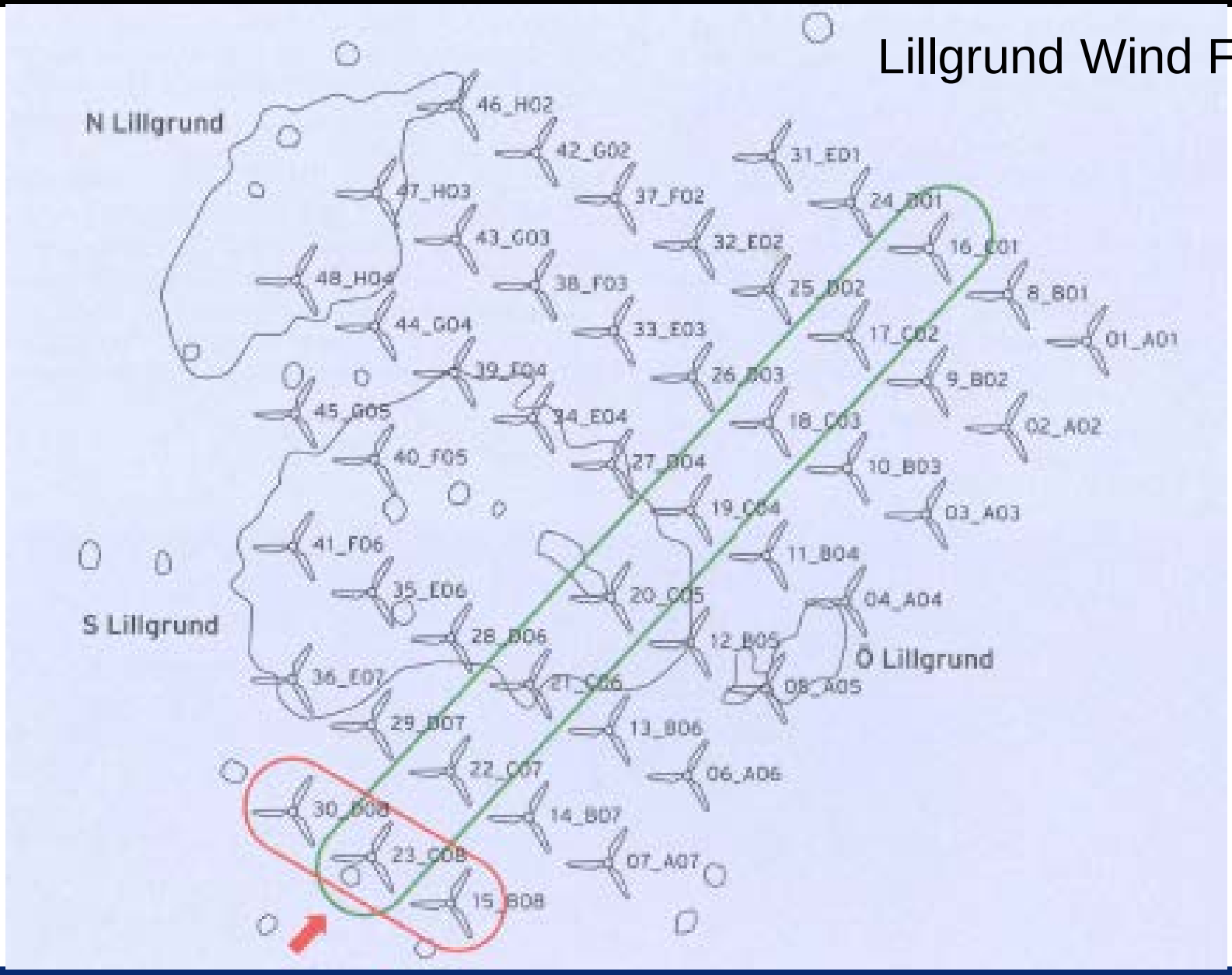
Energy decreases due to land friction

Energy to the grid

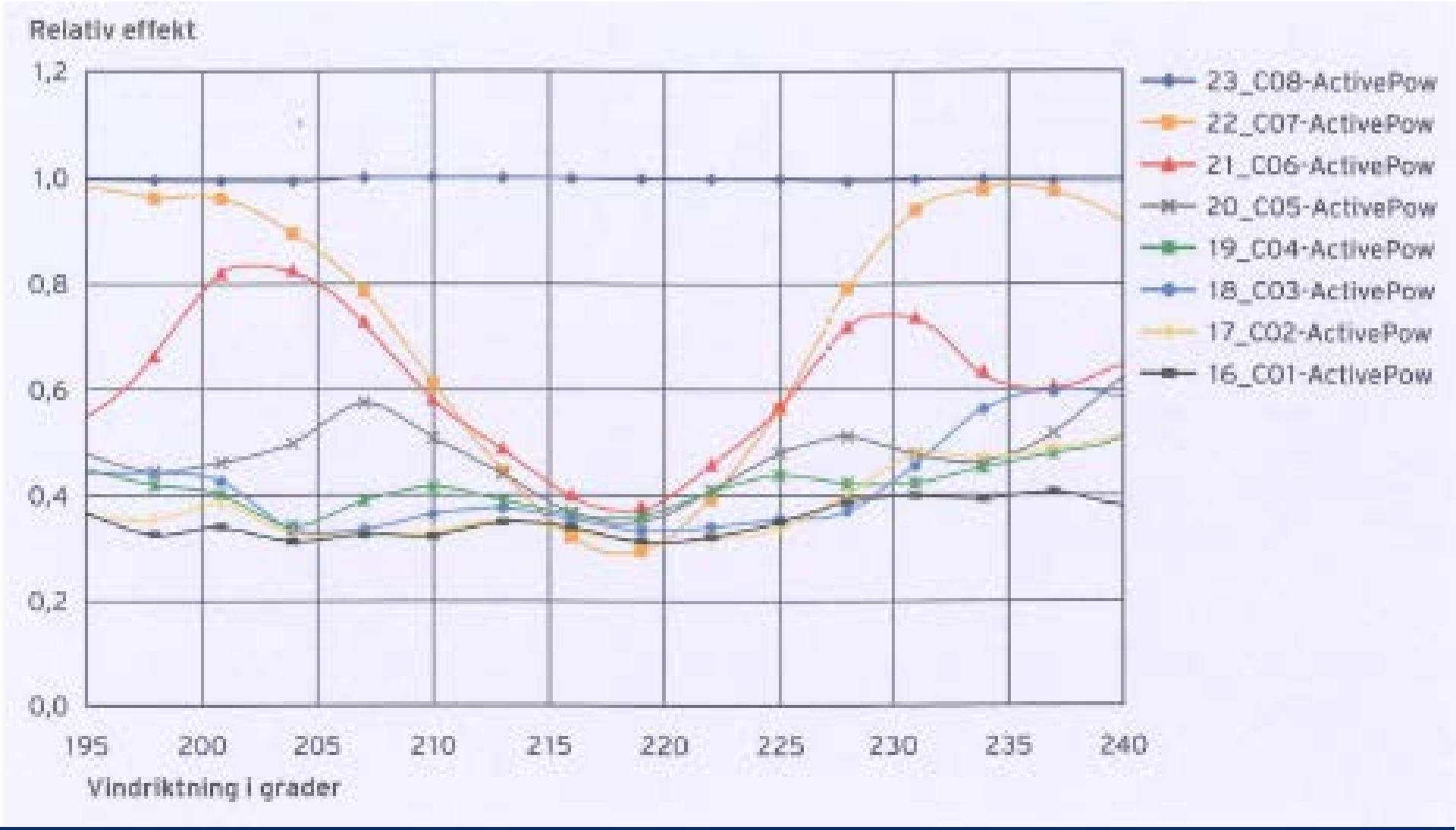
How much left?

5 to 10 rotor diameters

Lillgrund Wind Farm



Relativ Power from wind turbines in the wind farm



Electric power from Swedish wind turbines per day

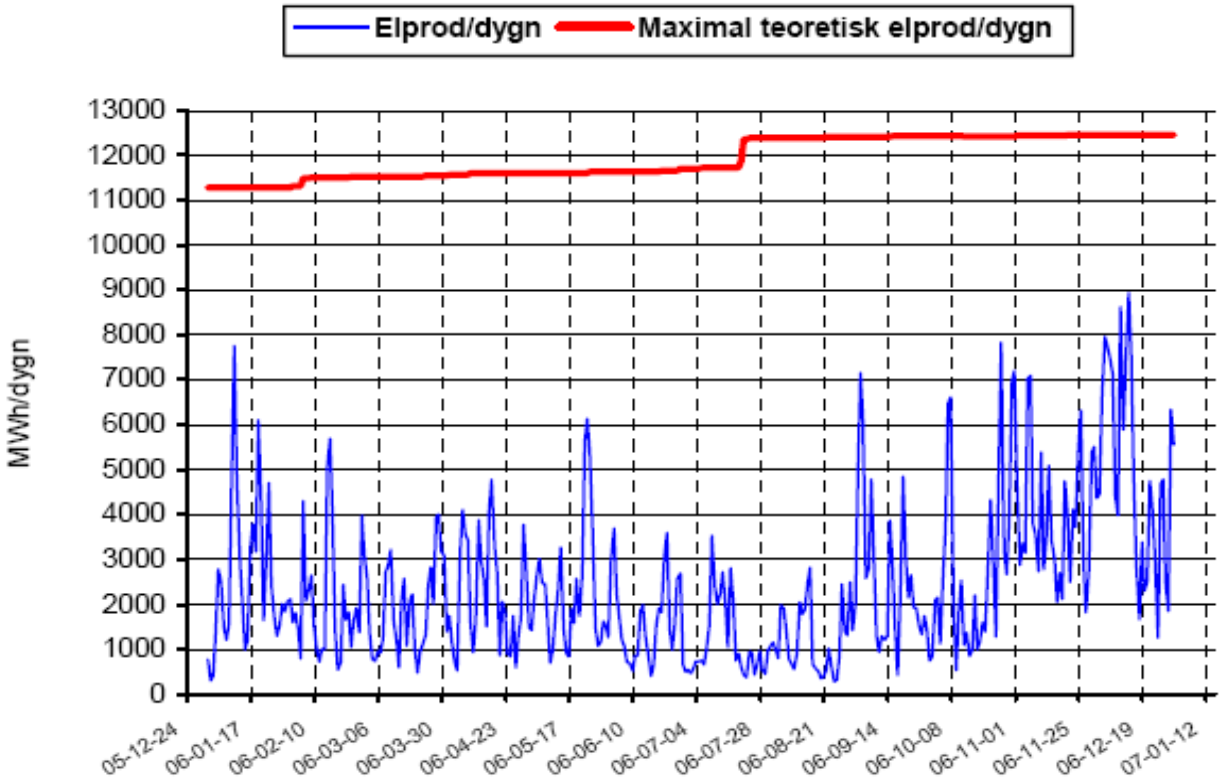
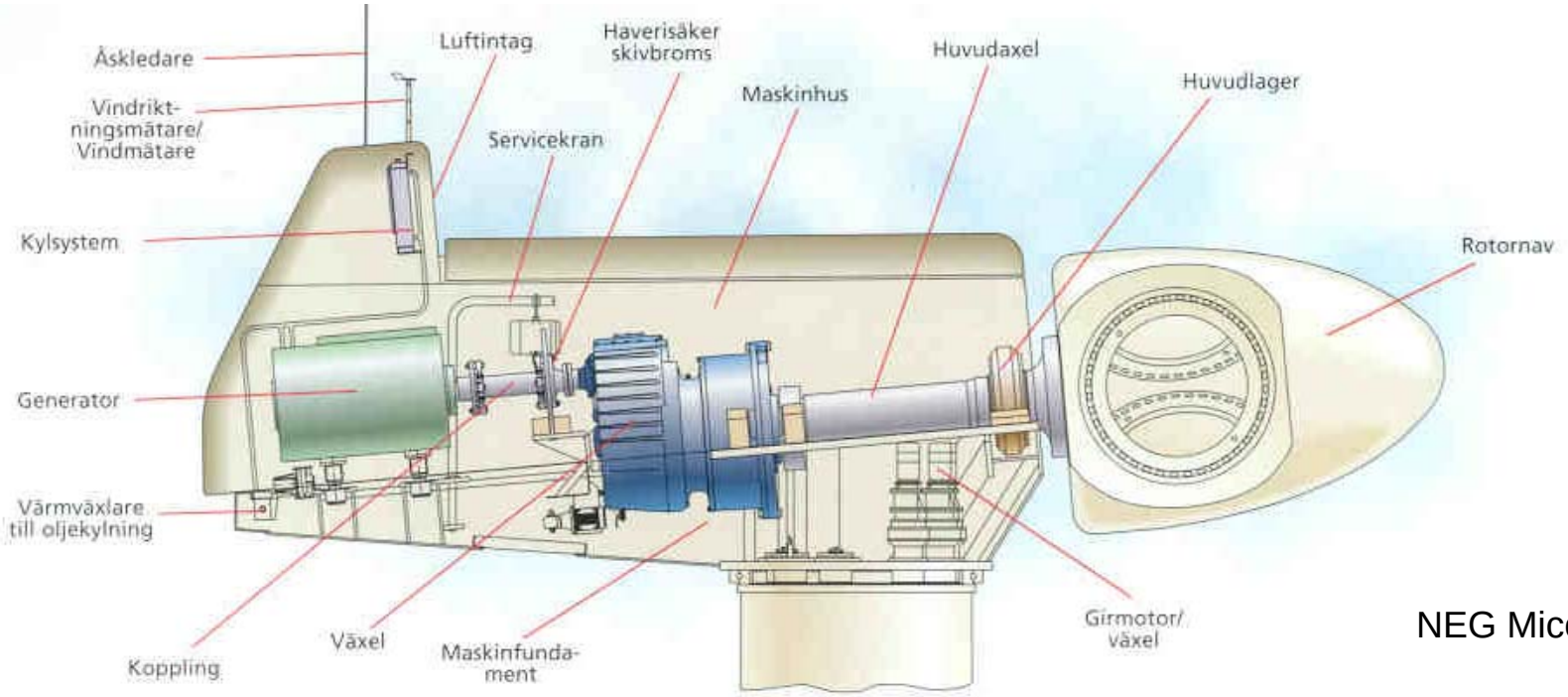


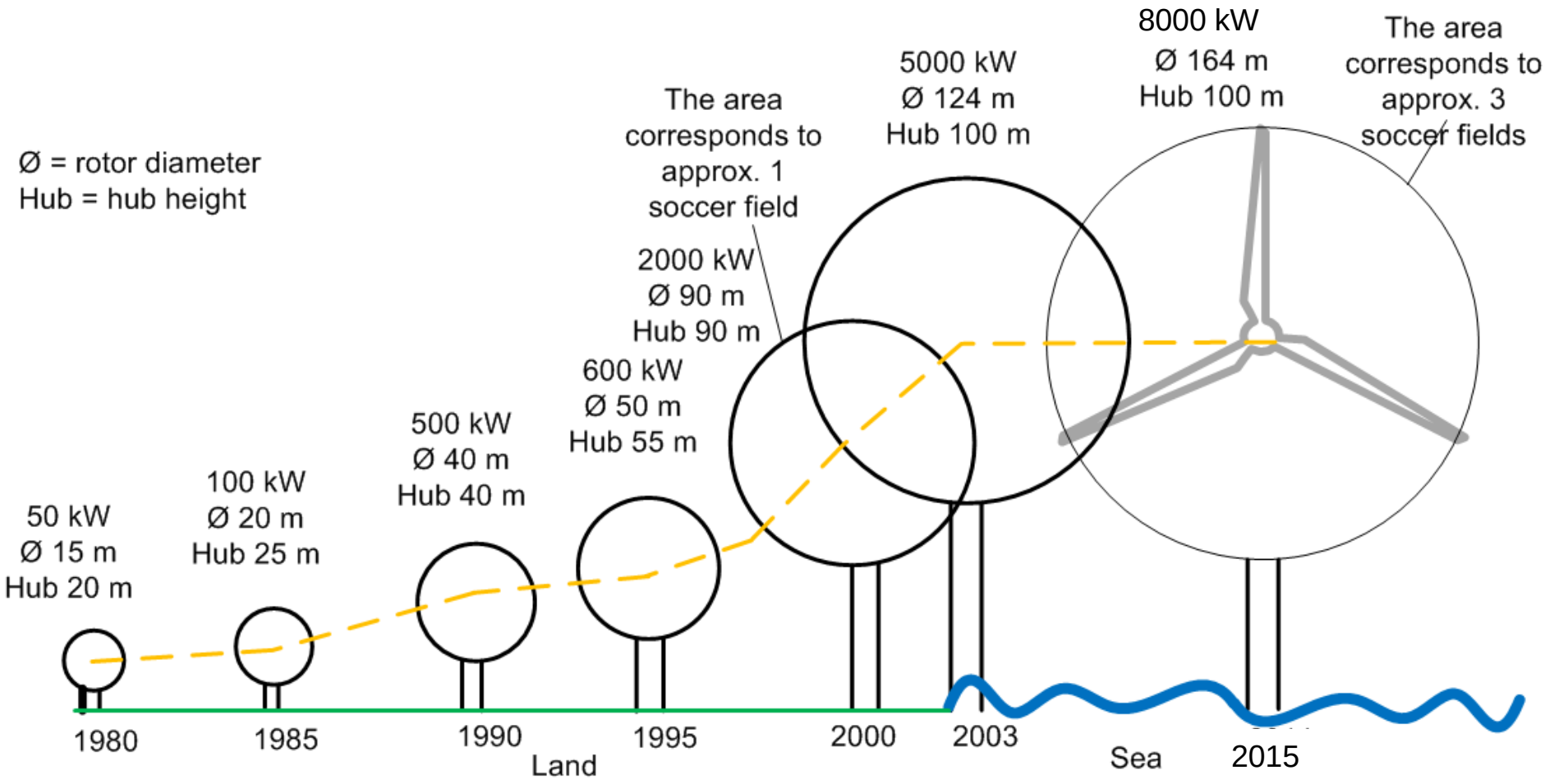
Diagram 3, verkens elproduktion per dygn över året.

Typical wind power nacelle



NEG Micon 750/48

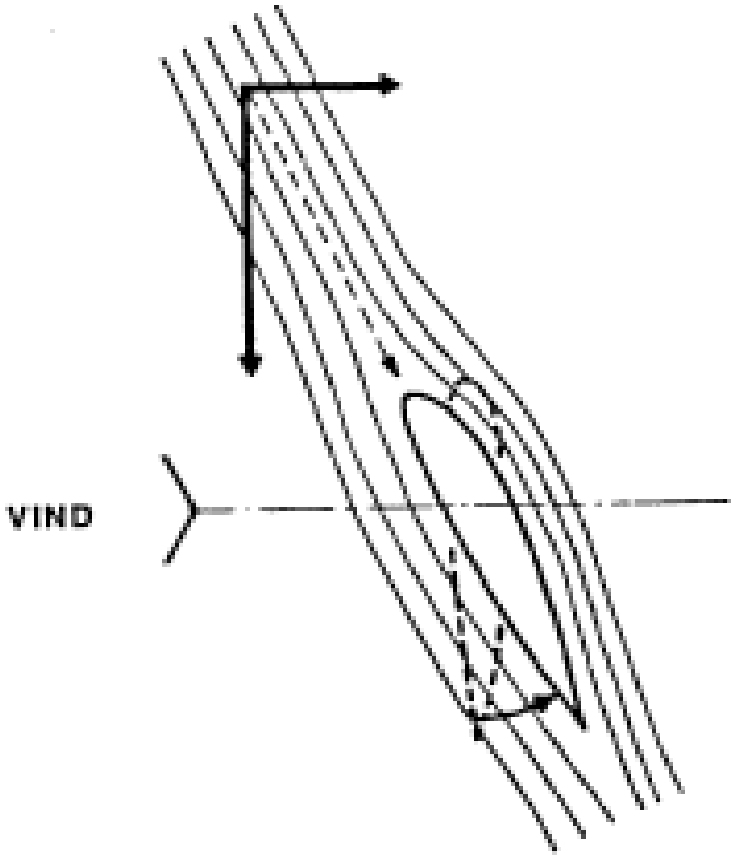
Size Development of Wind Turbines



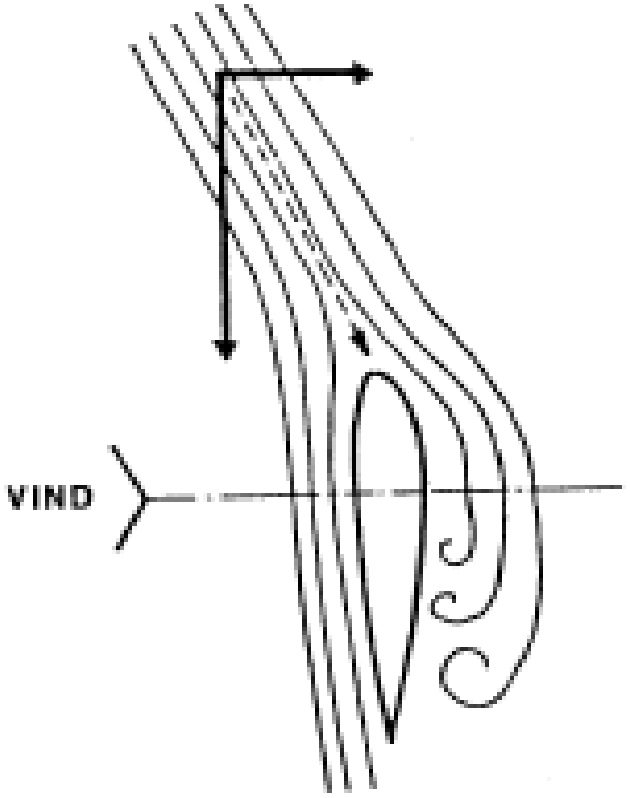
Limitations of wind power

- Pitch control
  turn the blades
- At emergency stop will the blades turn
- Stall control
  Ridged blades, turbulence limit the power
- At emergency stop will the outer part of the blades turn
- Active stall
  the pitch angle can be adjusted
- At emergency stop will the blades turn

Pitch contol

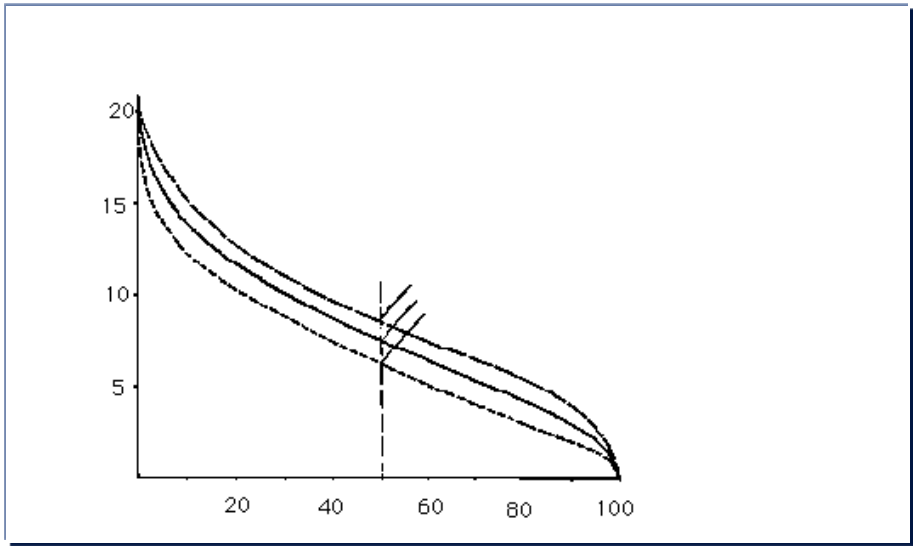


Stall control

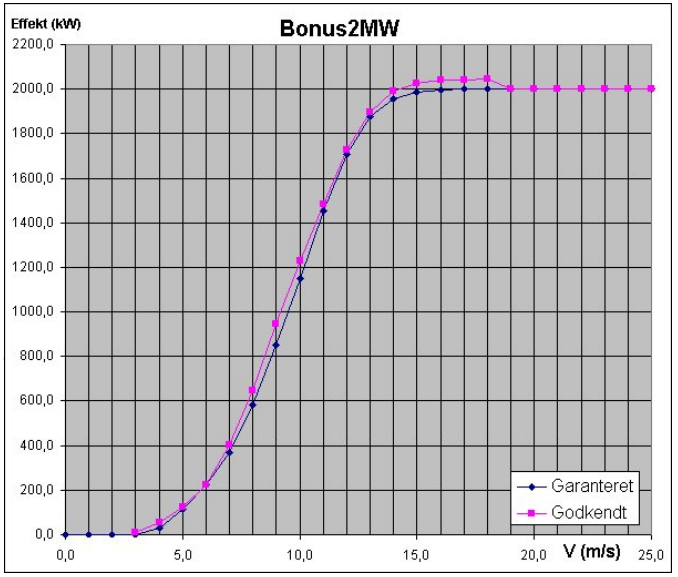


Energy from one year =

Weibull distribution x Wind-power-curve



x



=…+tid(5-6 m/s) x effekt(5-6 m/s) + tid(6-7 m/s) x effekt(6-7 m/s) + ….

=….+0.08*190kW + 0.08*290kW

Energy from a wind turbine

4 kW wind turbine	600 kW wind turbine	3.000 kW wind turbine
gives 10 MWh/year	gives 1300 MWh/year	gives 8900 MWh/year
10 m high,	40 m high, 42 m	80 m high
5 m diameter	diameter	90 m diameter
0.5 house / turbine	65 house / turbine	445 house / turbine

Electric heaten house 20 MWh/year

Wind turbine pays back

A wind turbine in a windy place has after
4 to 6 months produced, as much energy as was needed for the production of the wind turbine

There after will the turbine be in operation 20-25 years

But it takes 15-25 years to make a profit in Sweden, dependent on electricity price.

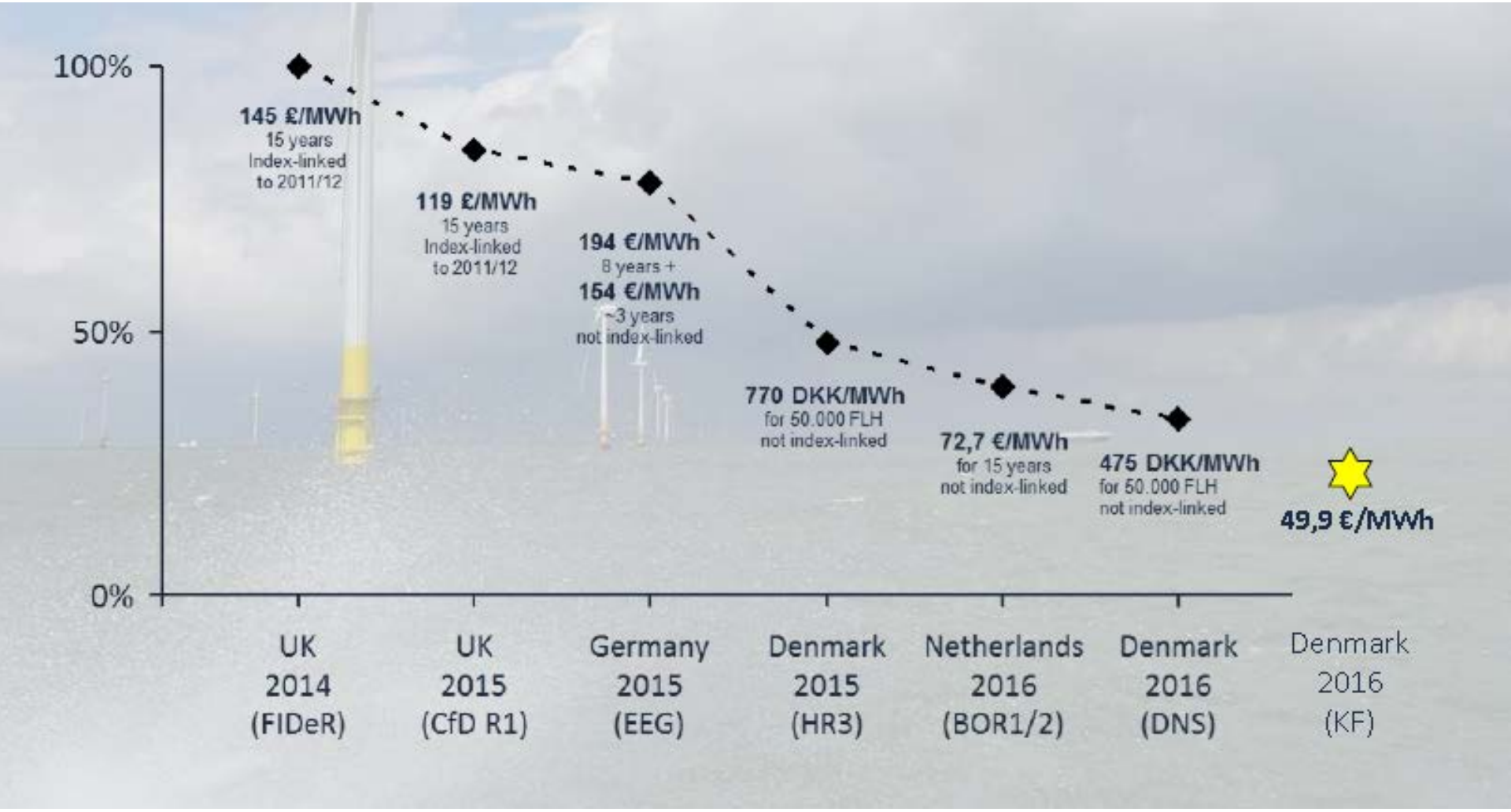
When the life time of the wind turbine is ended it is just to take down the turbine and use the land for something else

Costs for 25 TWh

Sweden plans for 25 TWh wind power, today 11 TWh
The investment will be10-15 billion Euro

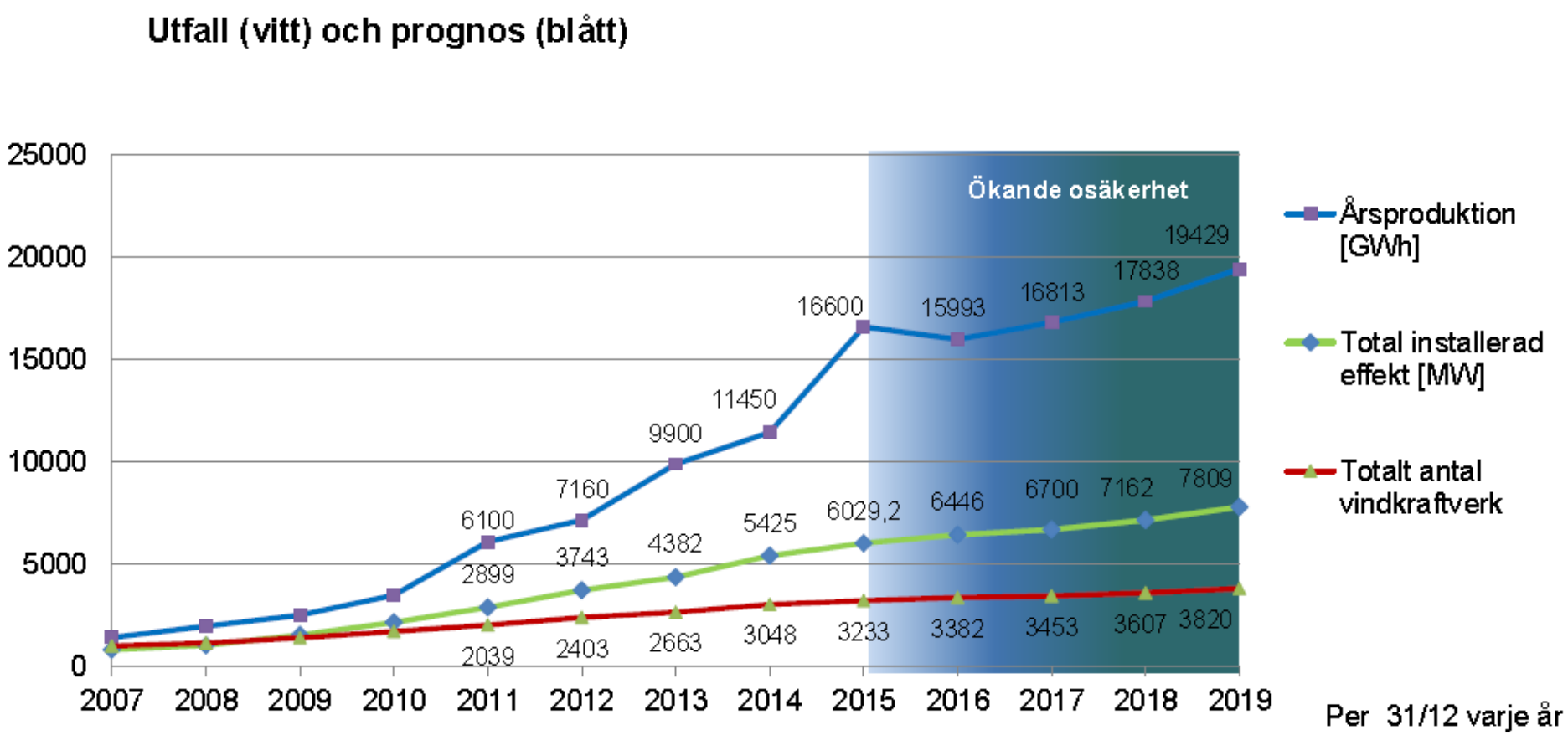
A wind turbine installation 12-15 MSEK/MW

Price development offshore wind



Basscenariot – Svensk Vindenergis prognos

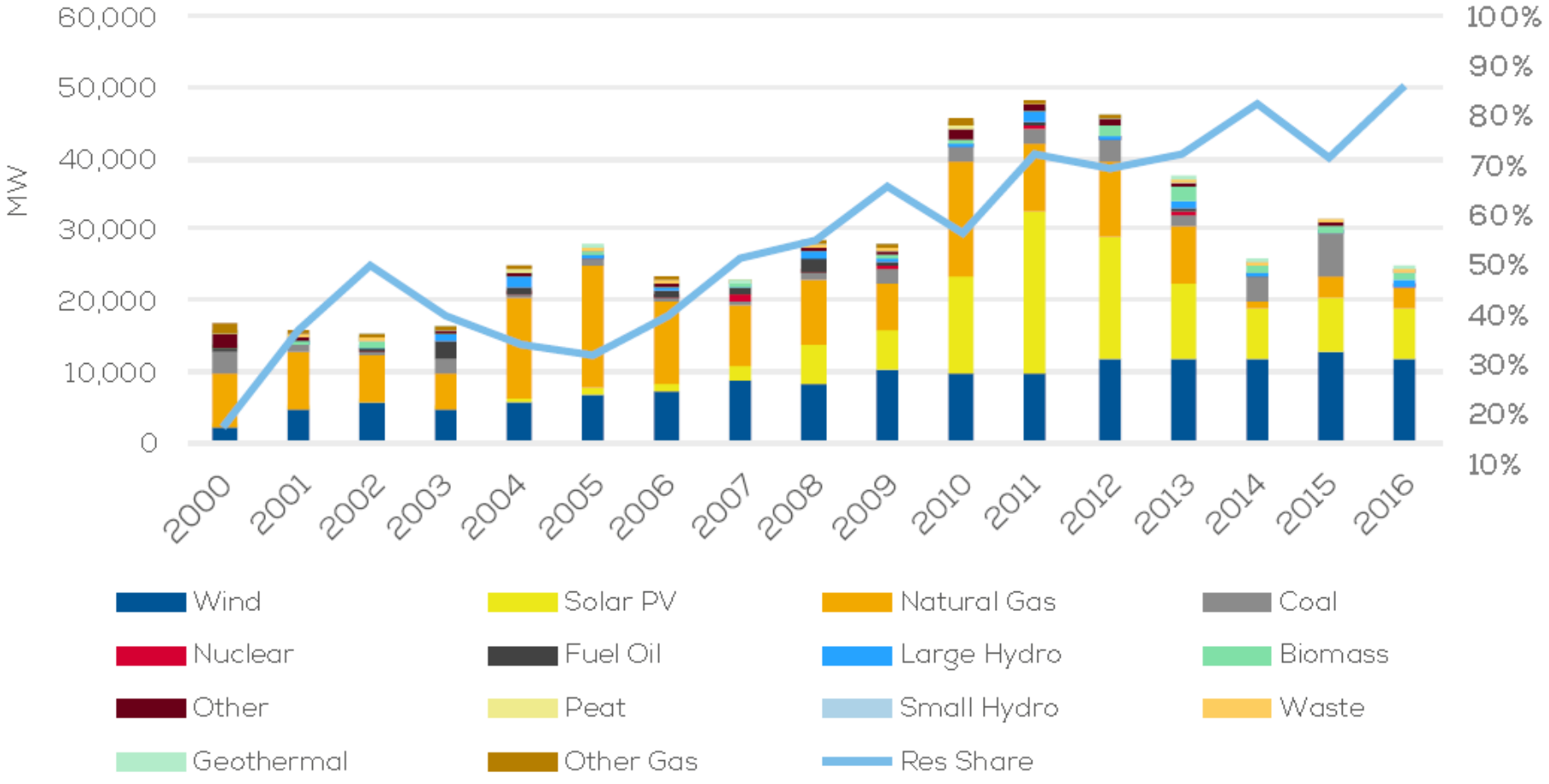
Detta scenario av vindkraftsutvecklingen är det mest troliga och utgör Svensk Vindenergis prognos



Basscenariot avspeglar en tänkbar utveckling med hänsyn till vilka projekt som kan förväntas realiseras utifrån en bedömning av nuvarande och framtida marknadsläge. I modellen antas 10 procent av projekten försenas in på nästa år.

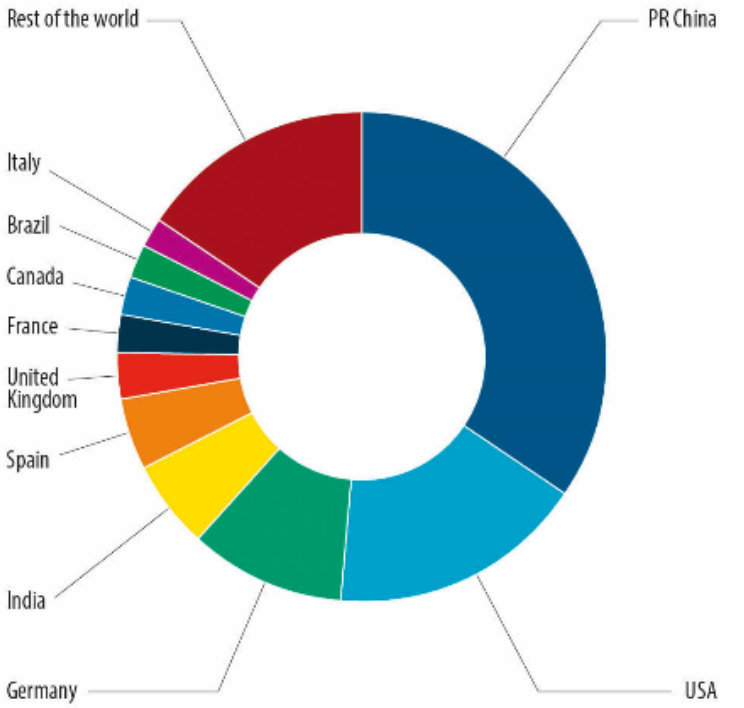
Svensk Vindenergi

Annual installed capacity and renewable share



Source: WindEurope

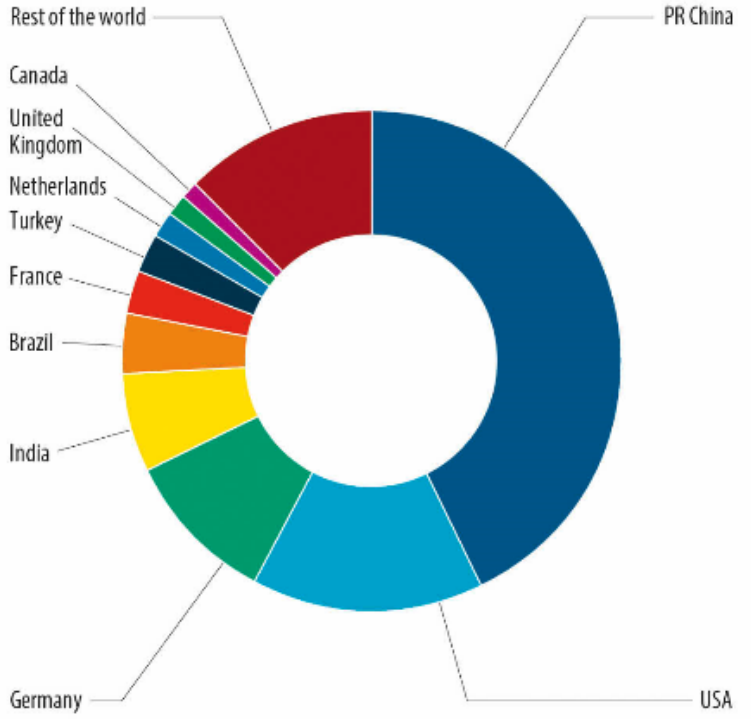
TOP 10 CUMULATIVE CAPACITY DEC 2016



Country	MW	% Share
PR China	168,732	34.7
USA	82,184	16.9
Germany	50,018	10.3
India	28,700	5.9
Spain	23,074	4.7
United Kingdom	14,543	3.0
France	12,066	2.5
Canada	11,900	2.4
Brazil*	10,740	2.2
Italy	9,257	1.9
Rest of the world	75,576	15.5
Total TOP 10	**411,214**	**84**
World Total	**486,790**	**100**

Source: GWEC

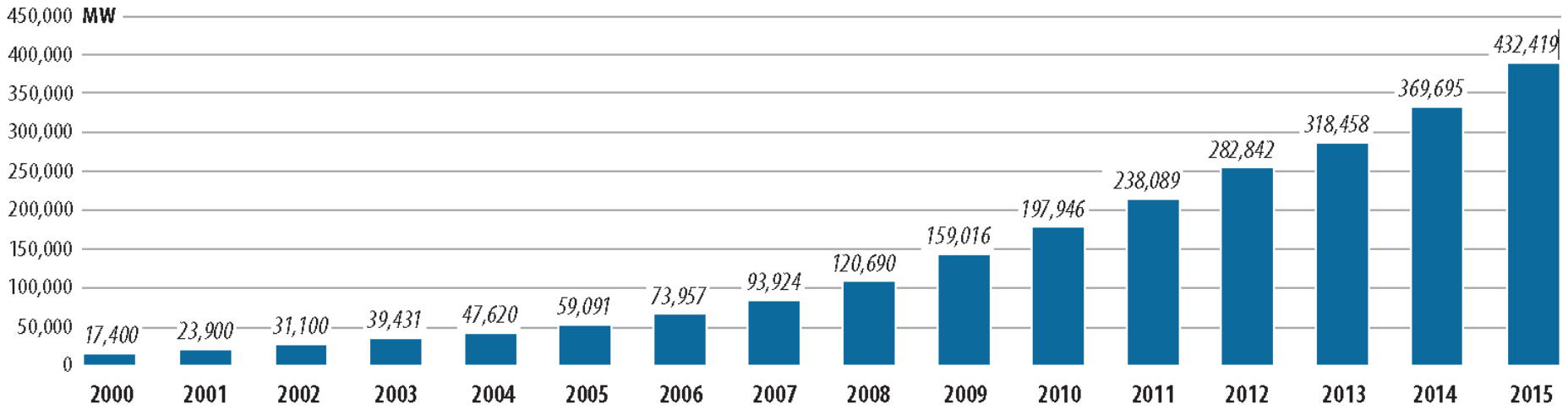
TOP 10 NEW INSTALLED CAPACITY JAN-DEC 2016



Country	MW	% Share
PR China	23,370	42.8
USA	8,203	15.0
Germany	5,443	10.0
India	3,612	6.6
Brazil*	2,014	3.7
France	1,561	2.9
Turkey	1,387	2.5
Netherlands	887	1.6
United Kingdom	736	1.3
Canada	702	1.3
Rest of the world	6,727	12.3
Total TOP 10	**47,915**	**88**
World Total	**54,642**	**100**

Source: GWEC

GLOBAL CUMULATIVE INSTALLED WIND CAPACITY 2000-2015



Source: GWEC

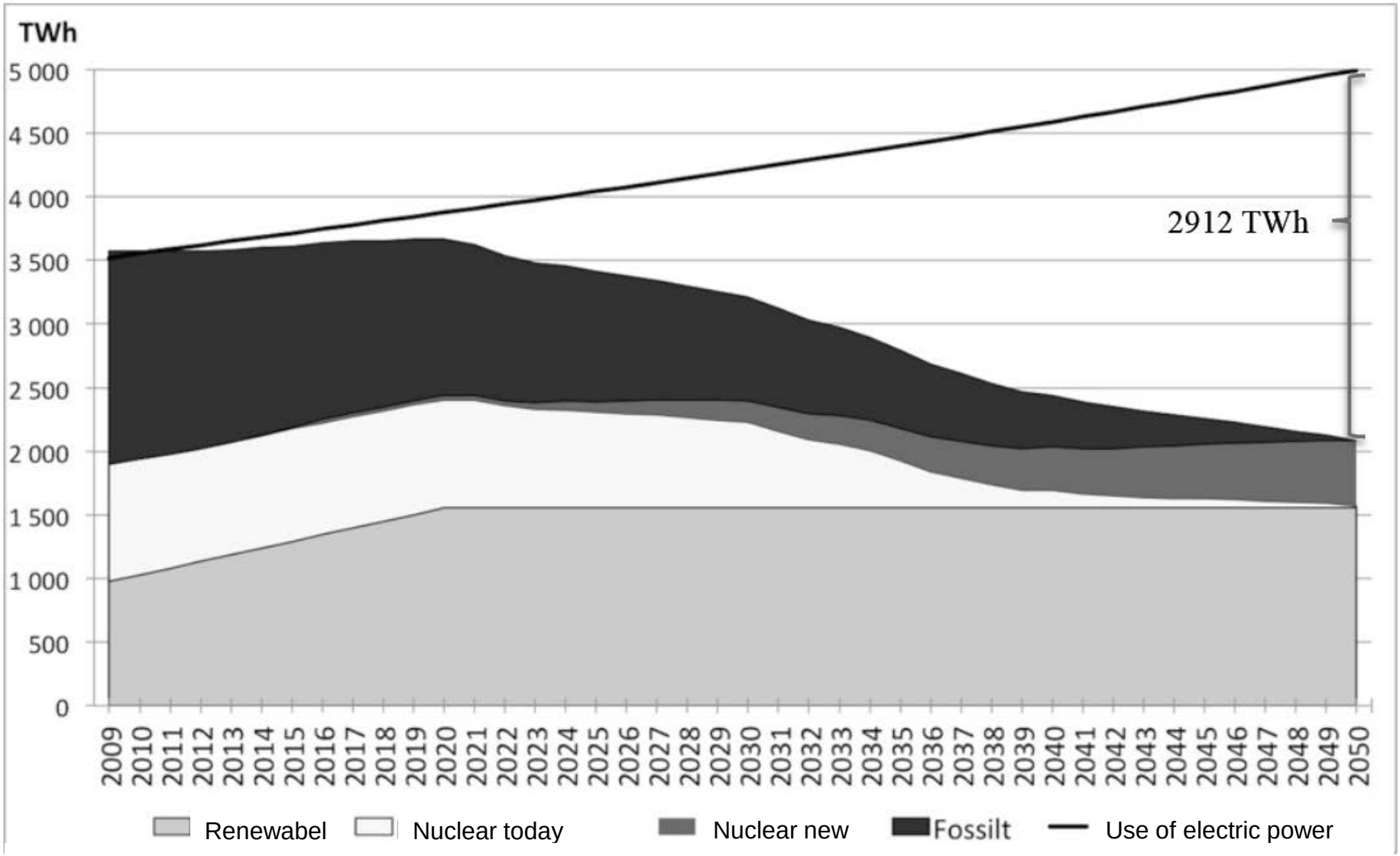
Källa ovanstående bild

Bidrag till en handlingsplan för havsbaserad vindkraft i Sverige

För säkrad eltillförsel, stabilt klimat och industriell utveckling

Staffan Jacobsson
Fredrik Dolff
Kersti Karltorp

Institutionen för energi och miljö
Avdelningen för miljösystemanalys
CHALMERS Tekniska högskola
Göteborg, Sverige, 2013
Rapport Nr. 2013:11



El use and production in EU, with expected lifetime of 50 year for nuclear

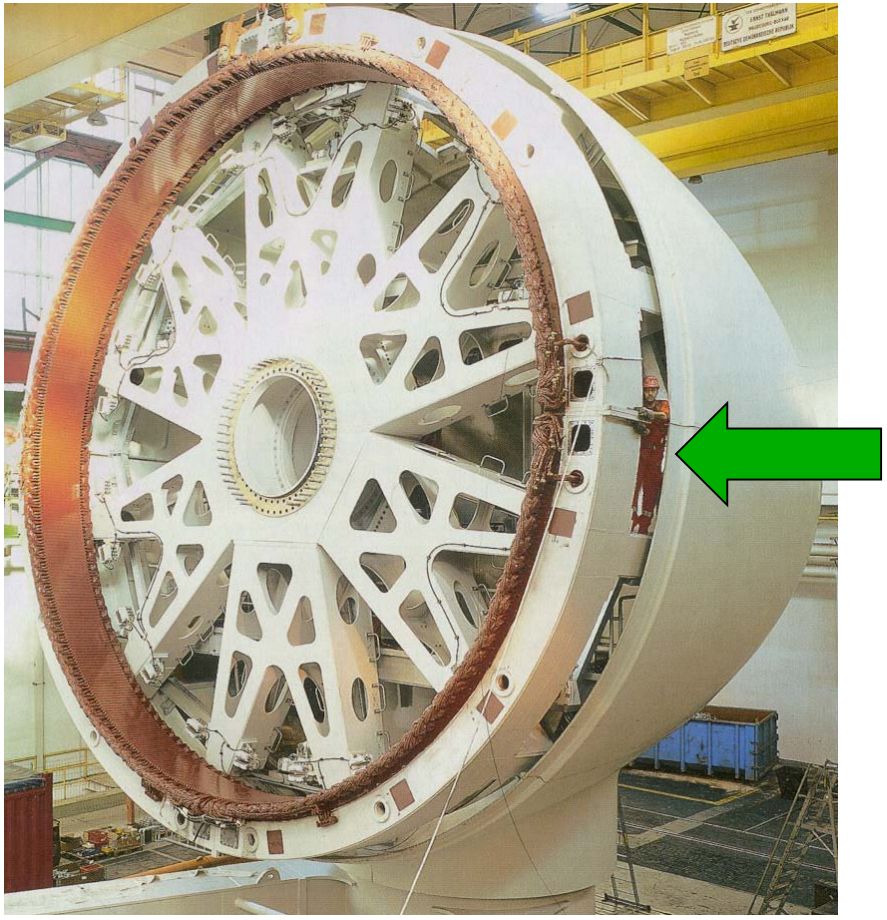
Vestas

- 3 MW,
- Diameter 90 m

Direct driven generator– Enercon

- Extreme high weight due to small air gap
- Generator weight 220 ton

  (4,5 MW)
- Look at the man!



Enercon

- 2,0 MW
- Diameter 82m
- Navhöjd 58-113 m

WinWinD WWD-1, WWD-3

- Finish manufacture
- 1MW and 3MW
- Compact design with 1-step planetary gerabox
- Permanent magnet synchronous low speed generator

You need a reliable wind turbine. We kan supply one.

Wind turbines between the buildings

- Bahrein World Trade Center, in operation 2006
- 240 m high buildings
- 3 x 22 kW wind turbines
- Designer – Danish Ramboll and Norwin

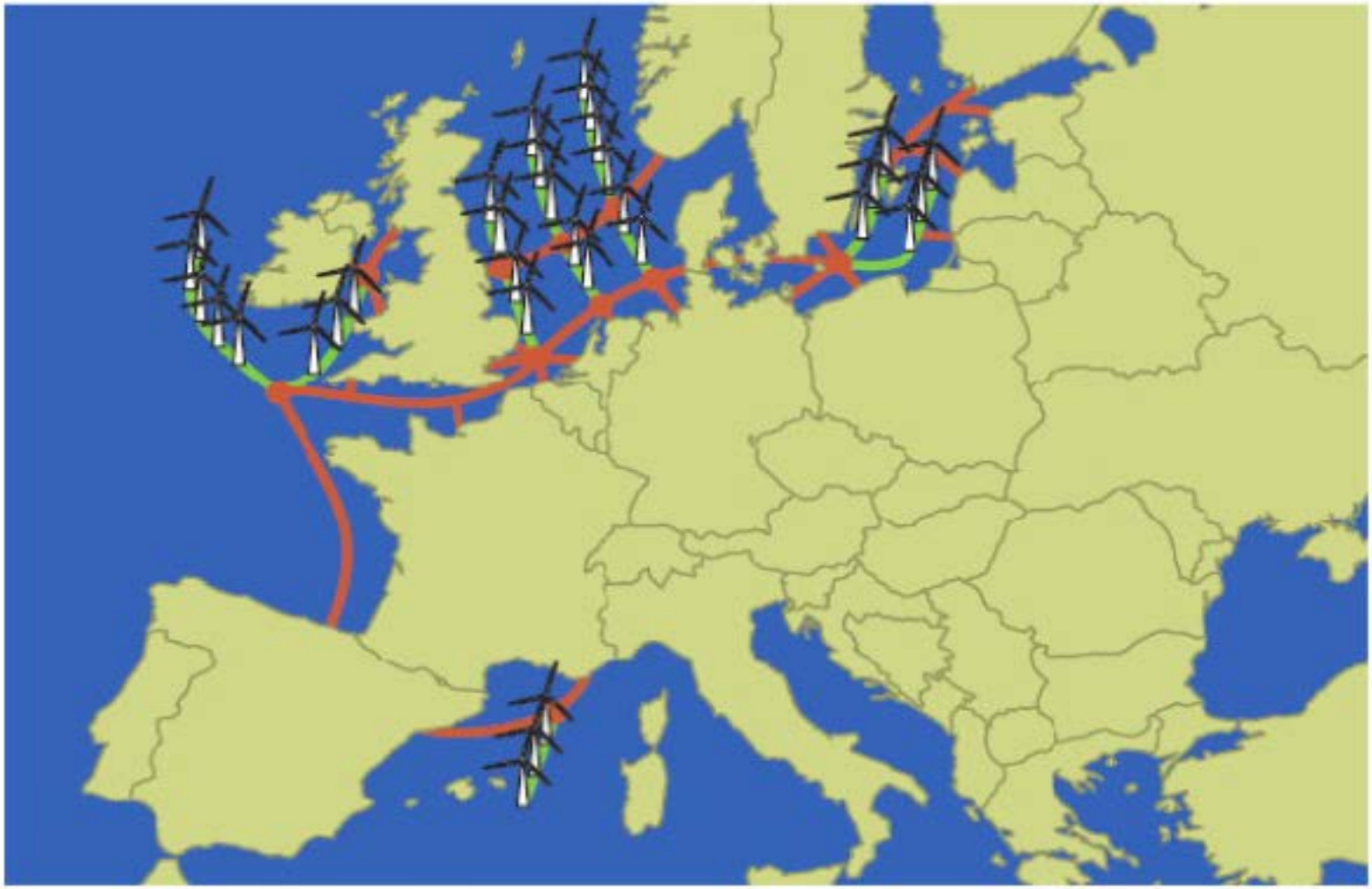
2 MW, 78-100 m

Repower

6,12 MW, 126 m

Offshore GE-wind turbines outside Kalmar, Utgrunden

1.5 MW

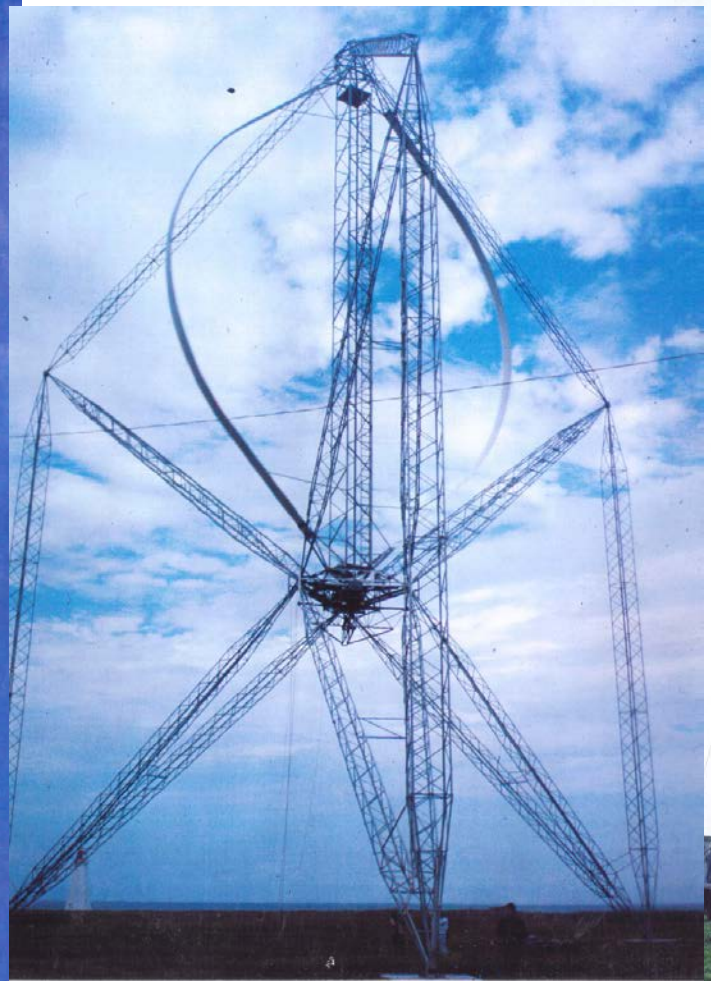


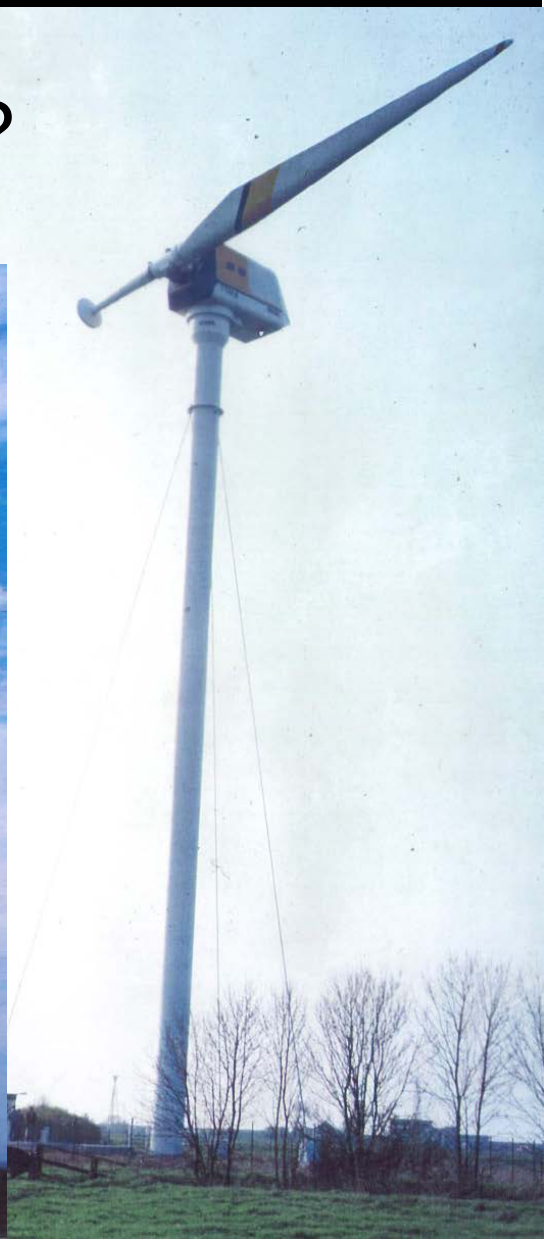
The European Offshore Supergrid

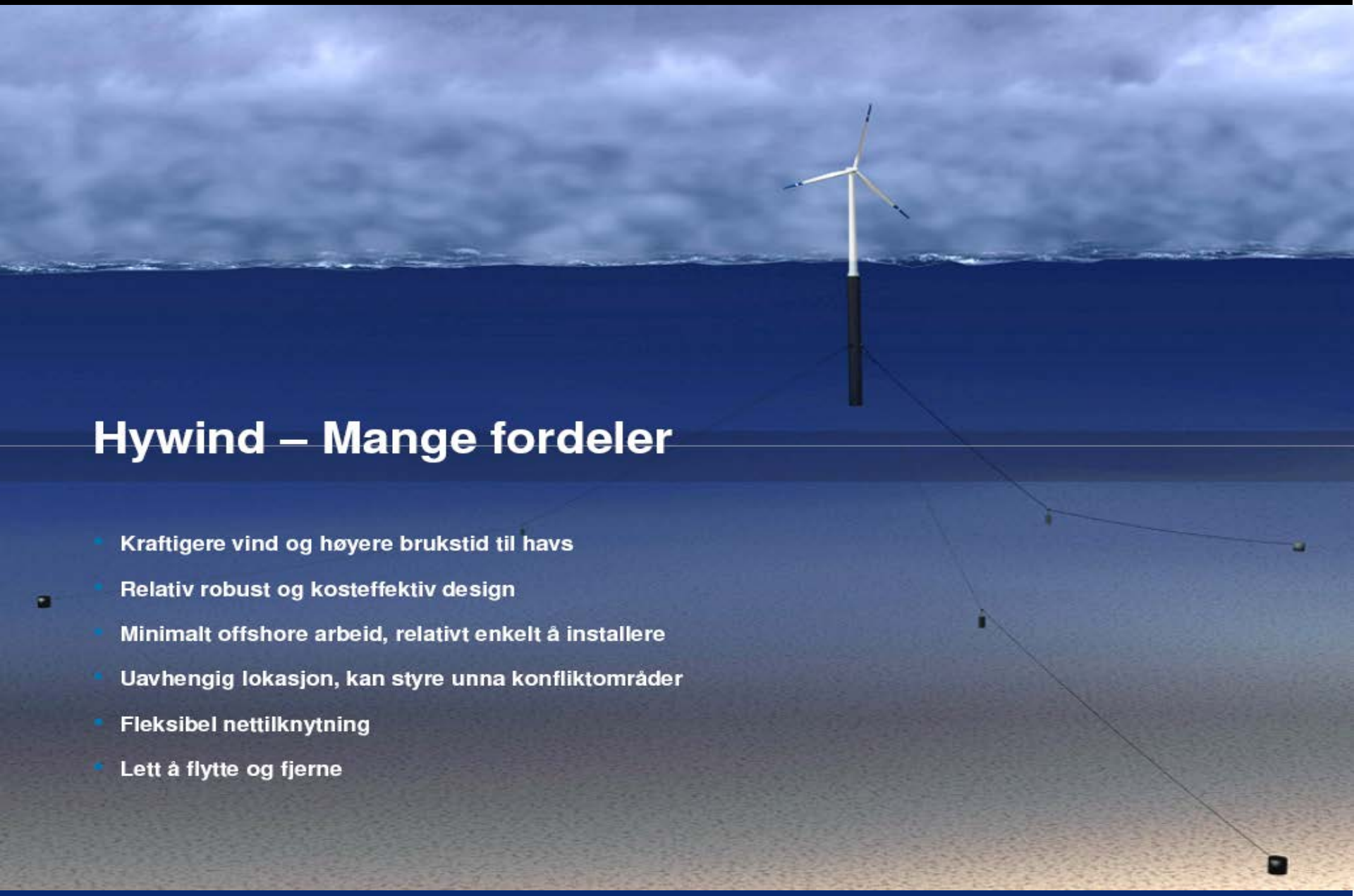
Lillgrund vindkraftpark – Tekniska data

- 48 vindkraftverk
- >2 MW/st
- Transformatorplattform 30/130 kV
- ca 330 GWh medelårsproduktion
- Medelvindhastighet ca 8.5 m/s (65m)
- Höjd: 60-65 meter
- Höjd inkl rotor: drygt 100 meter
- Rotordiameter: 70-80 meter

Success ??????







Hywind – Mange fordeler

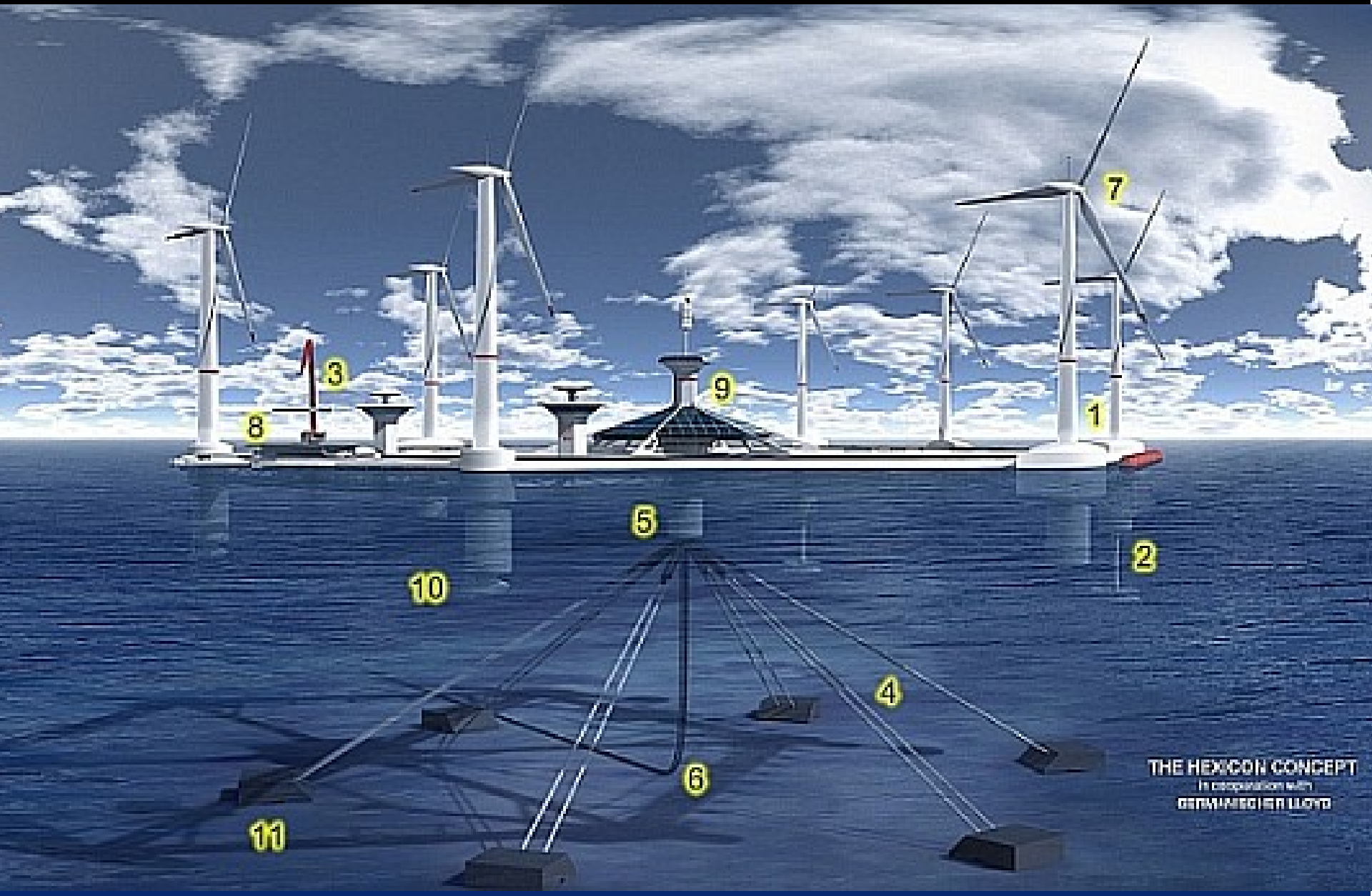
- Kraftigere vind og høyere brukstid til havs
- Relativ robust og kosteffektiv design
- Minimalt offshore arbeid, relativt enkelt å installere
- Uavhengig lokasjon, kan styre unna konfliktområder
- Fleksibel nettilknytning
- Lett å flytte og fjerne

Hywind – konseptet

- Betong eller stålsylinder med ballast
- 120 m draft (base case)
- Oppankret med tre anker liner
- Egnet for vanndyp mellom 100 – 700 m
- Ståltårn festet til understellet 12 meters under vannlinjen
- 80 m opp til nacellen
- Rotordiameter inntil 120 meter
- Effekt 3 - 5 MW
- Displacement: 6500 tonn
- Diameter understell: 8 m

Future?

▲ Mounted on semi-submersible platforms, the floating wind turbines being developed by Principle Power can be built in shipyards and towed into place.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THE HEXICON CONCEPT
In cooperation with
GERMANISCHER LLOYD

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