Energy over view and wind power

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20150505

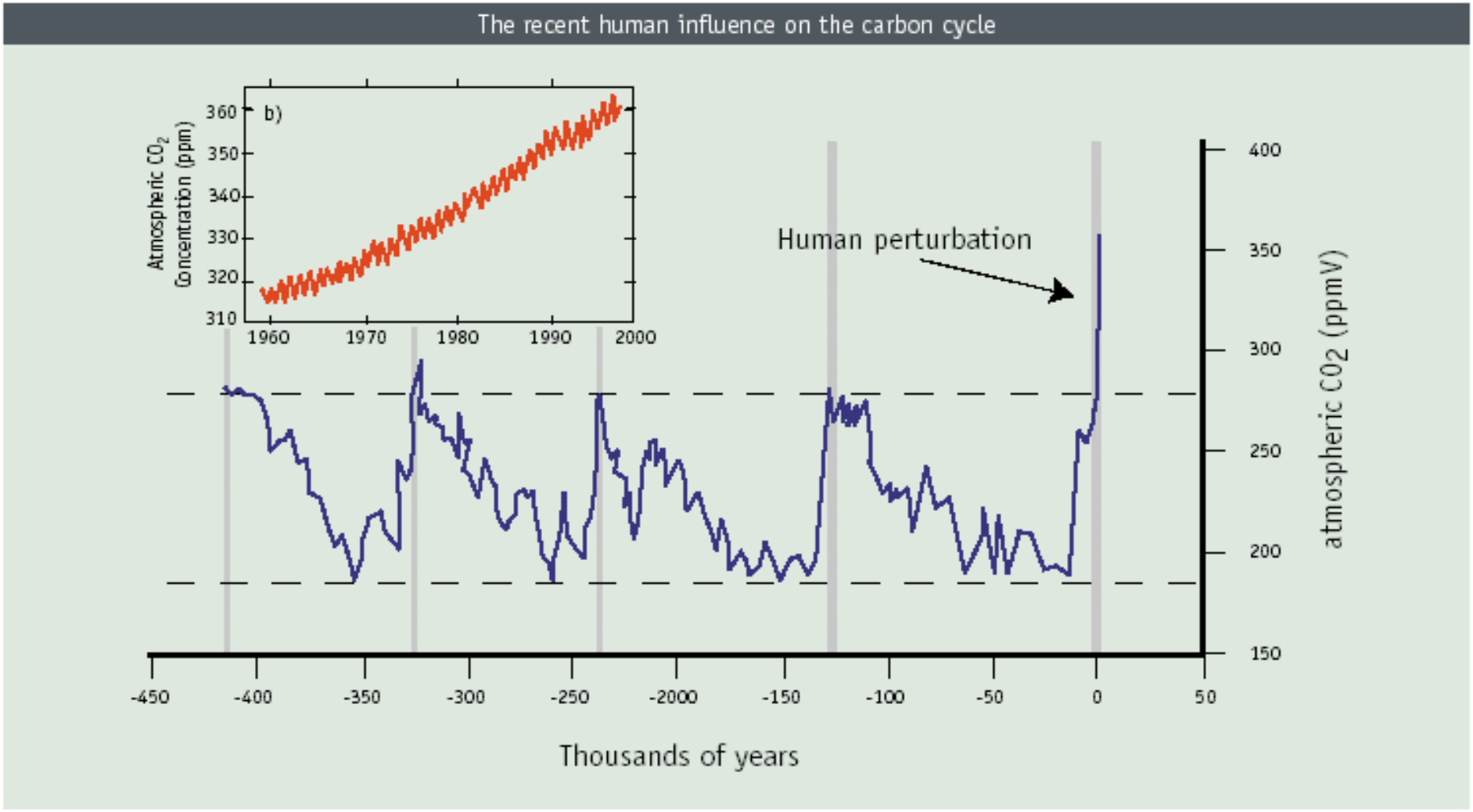
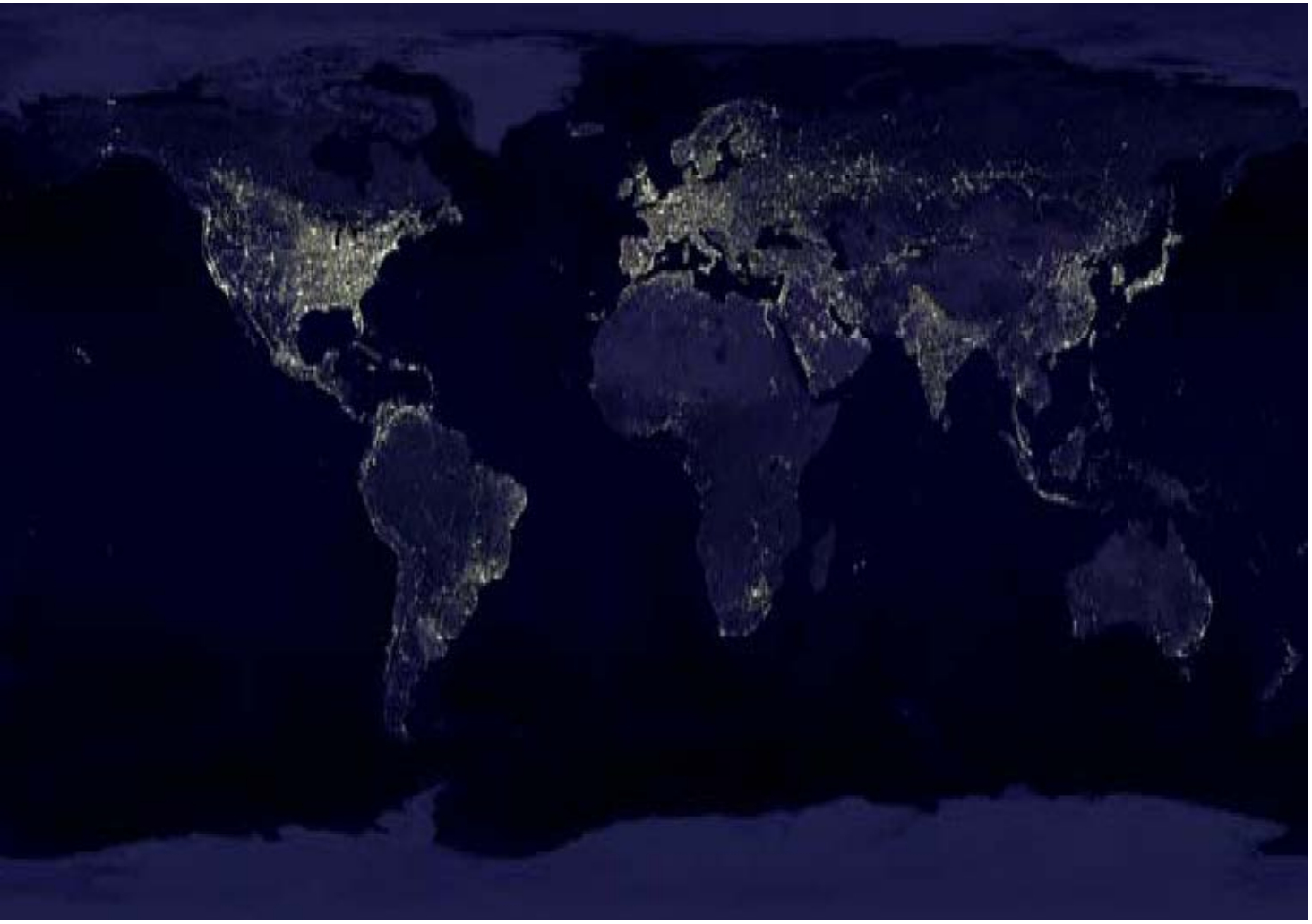


Figure 2 Atmospheric CO_2 concentration from the Vostok ice core record with the recent human perturbation superimposed. The inset shows the observed contemporary increase in atmospheric CO_2 concentration from the Mauna Loa (Hawaii) Observatory.

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

The world a dark night



1.6 billion persons without electric power

What is life without Electric Energy ?

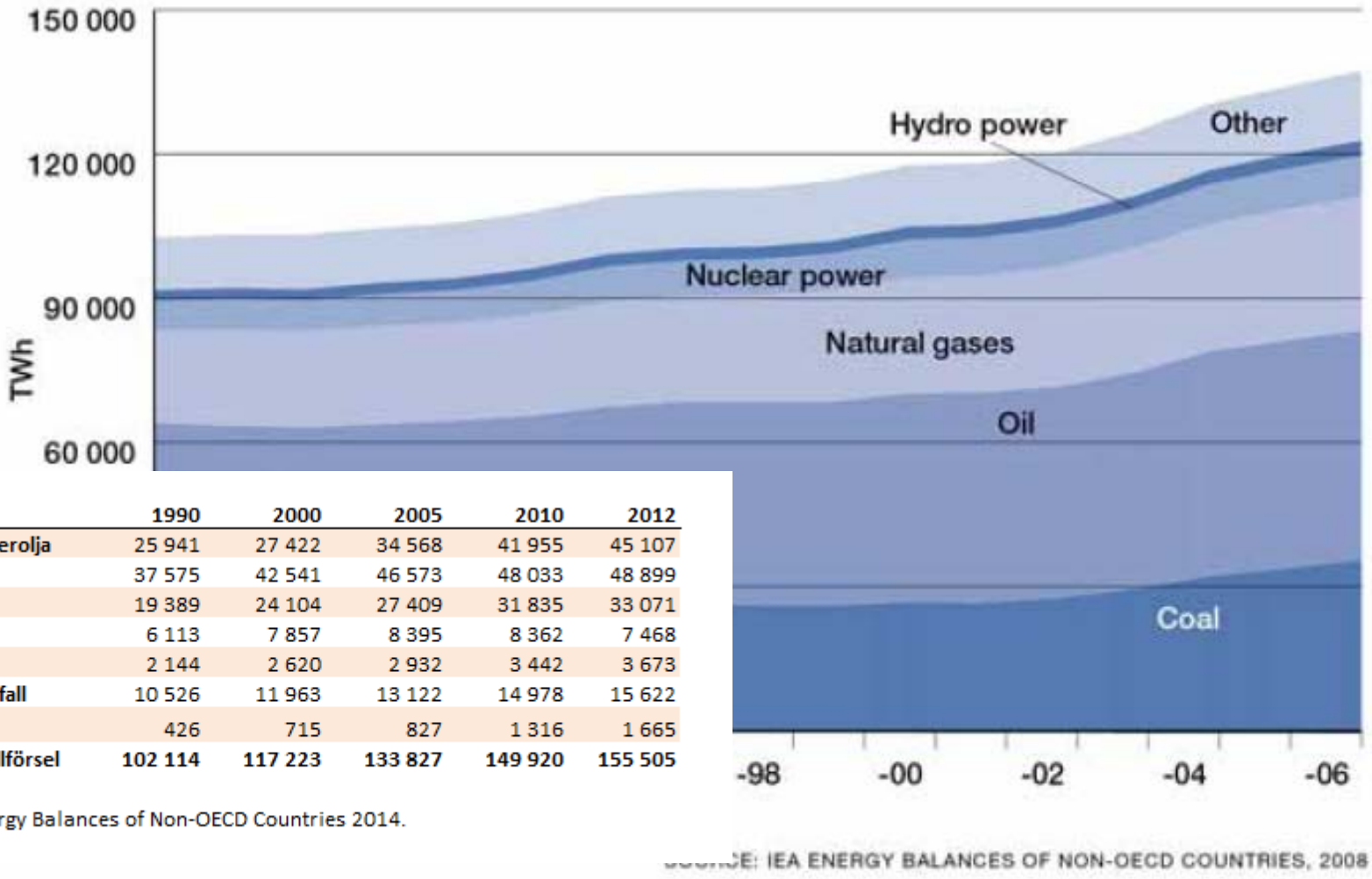
- No light
- No electric heat
- No electric motors
- No computers, phones, TV

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

Figure 49: Global primary energy supply, 1990–2006



Energislag	1990	2000	2005	2010	2012
Kol/torv/skifferolja	25 941	27 422	34 568	41 955	45 107
Olja	37 575	42 541	46 573	48 033	48 899
Naturgas	19 389	24 104	27 409	31 835	33 071
Kärnkraft	6 113	7 857	8 395	8 362	7 468
Vattenkraft	2 144	2 620	2 932	3 442	3 673
Biobränsle/avfall	10 526	11 963	13 122	14 978	15 622
Övrigt	426	715	827	1 316	1 665
Total energitillförsel	102 114	117 223	133 827	149 920	155 505

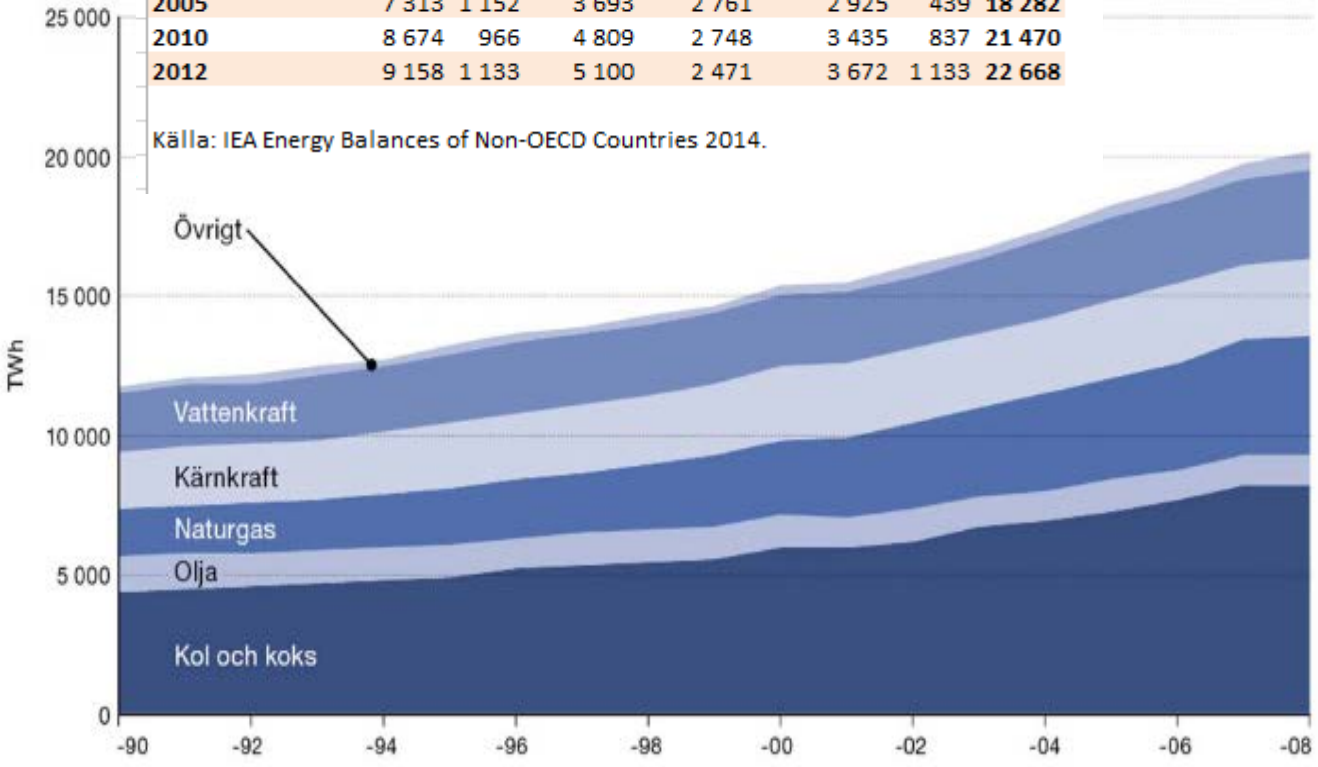
Källa: IEA Energy Balances of Non-OECD Countries 2014.

SOURCE: IEA ENERGY BALANCES OF NON-OECD COUNTRIES, 2008

Global electric power production

År	Kol, torv, skifferolja	Olja	Naturgas	Kärnkraft	Vattenkraft	Övrigt	Totalt
1990	4 423	1 313	1 762	2 010	2 140	177	**11 825**
2000	6 001	1 203	2 746	2 592	2 622	262	**15 426**
2005	7 313	1 152	3 693	2 761	2 925	439	**18 282**
2010	8 674	966	4 809	2 748	3 435	837	**21 470**
2012	9 158	1 133	5 100	2 471	3 672	1 133	**22 668**

Källa: IEA Energy Balances of Non-OECD Countries 2014.



Renewable

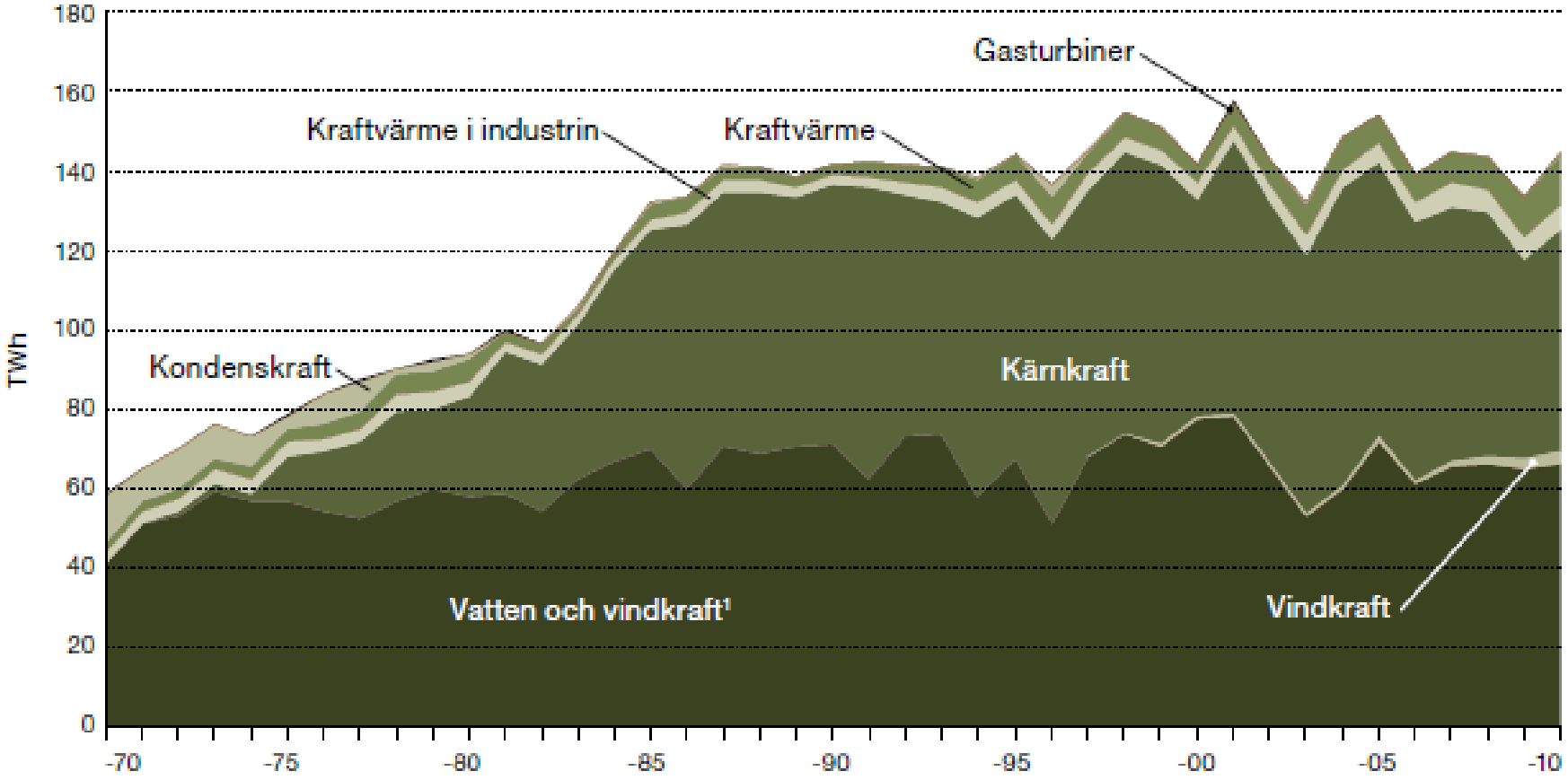
Nuclear

Fossil fuel

Sweden electrical production

		Energi	Maxeffekt
PRODUKTION		GWh	MW
Vindkraft	wind	11 592	4 663
Vattenkraft	hydro	64 820	13 265
Kärnkraft	nuclear	62 284	8 776
Gasturbin & dieselkraft		35	210
Övrig värmekraft	chp	6 714	1 991
Solel		12	12
Ospecificerad produktion		4	3
SUMMA PRODUKTION		145 461	25 417
Högsta produktionstimme (TT.DD.MM)			9
IMPORT/EXPORT			
Netto Import		340	2 749
Netto Export		-15 981	-6 809
Netto Import/Export		-15 641	

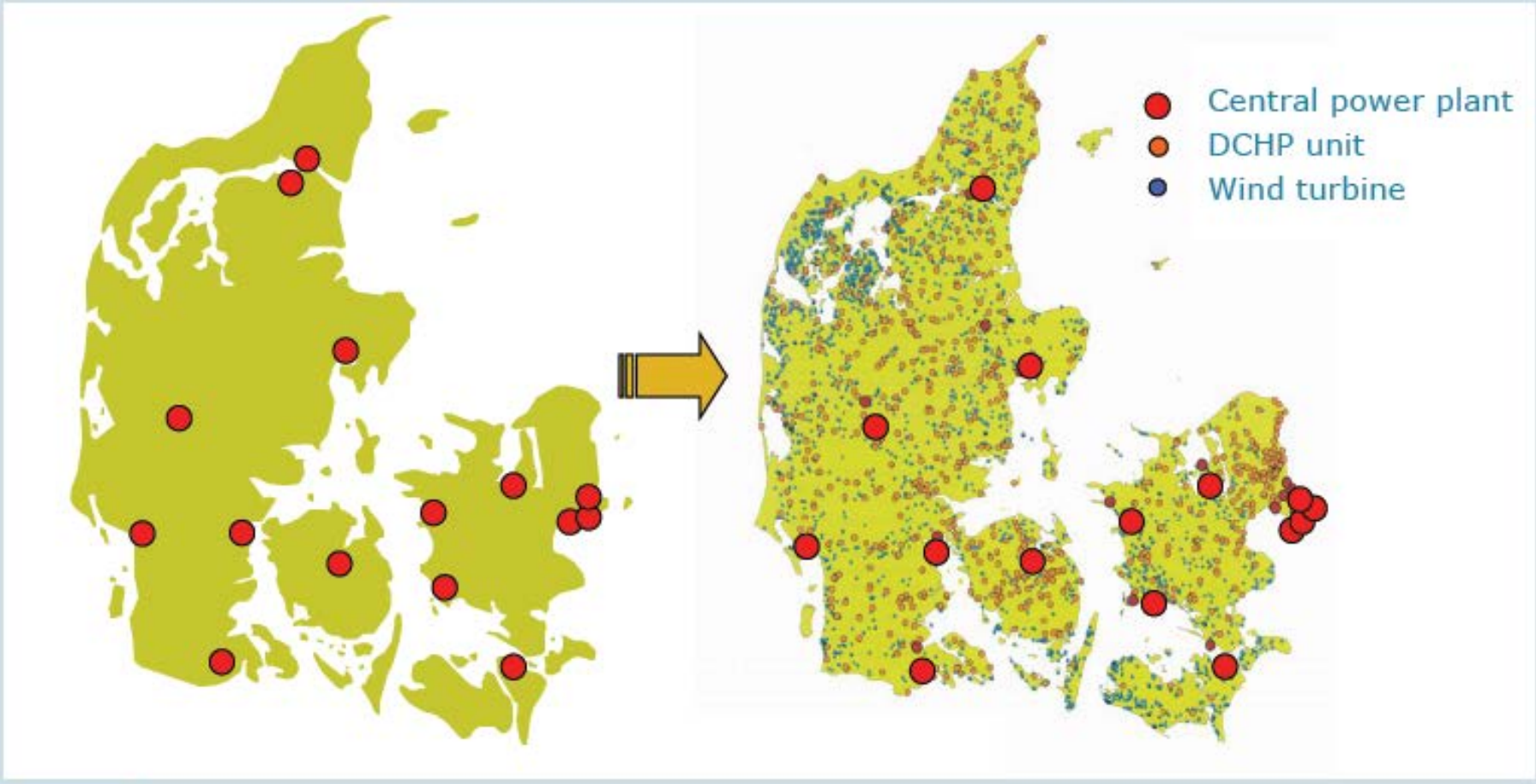
Figur 21 Sveriges elproduktion per kraftslag, 1970–2010, uttryckt i TWh



Källa: Energimyndigheten och SCB.
Anm. 1. Vattenkraft och vindkraft samredovisas till och med 1996, därefter särredovisas vindkraften i en egen serie.

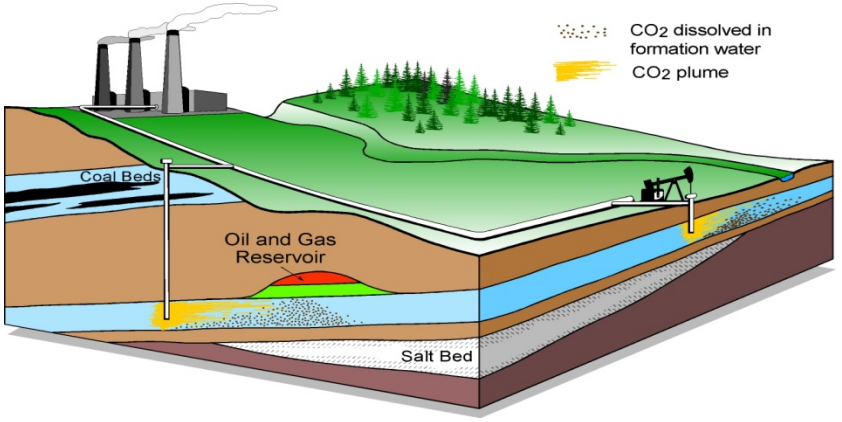
ENERGINET.DK

Development from the late 1980s to present

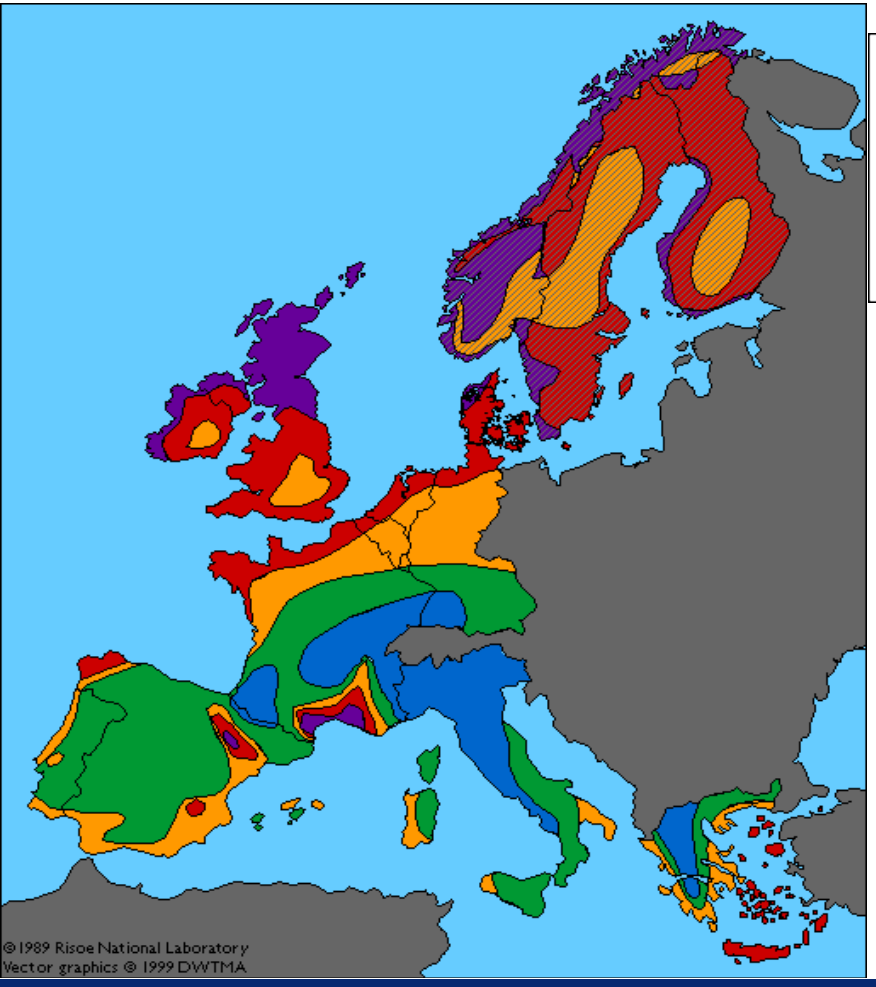


Renewables and new energy systems

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

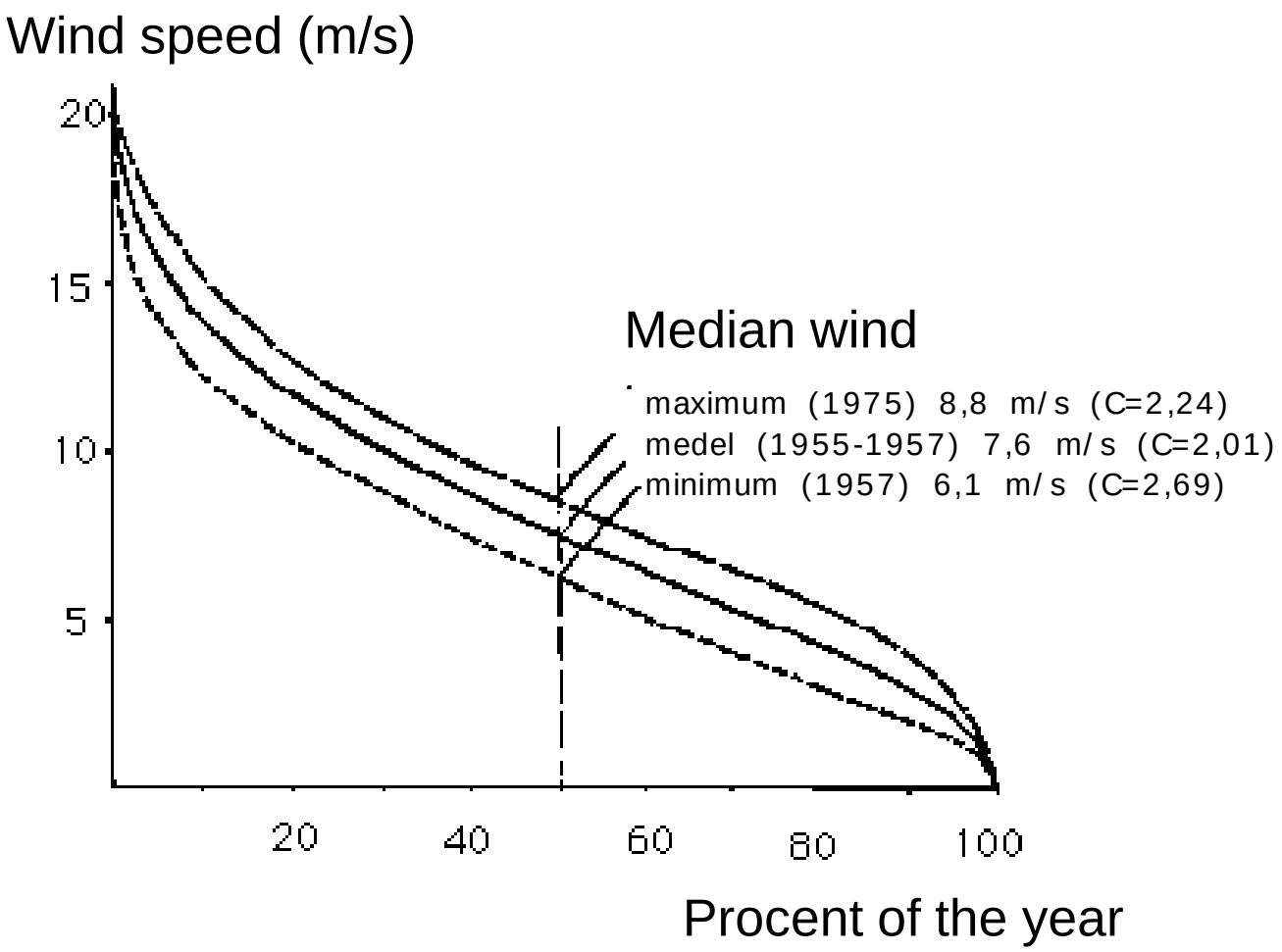


Wind conditions

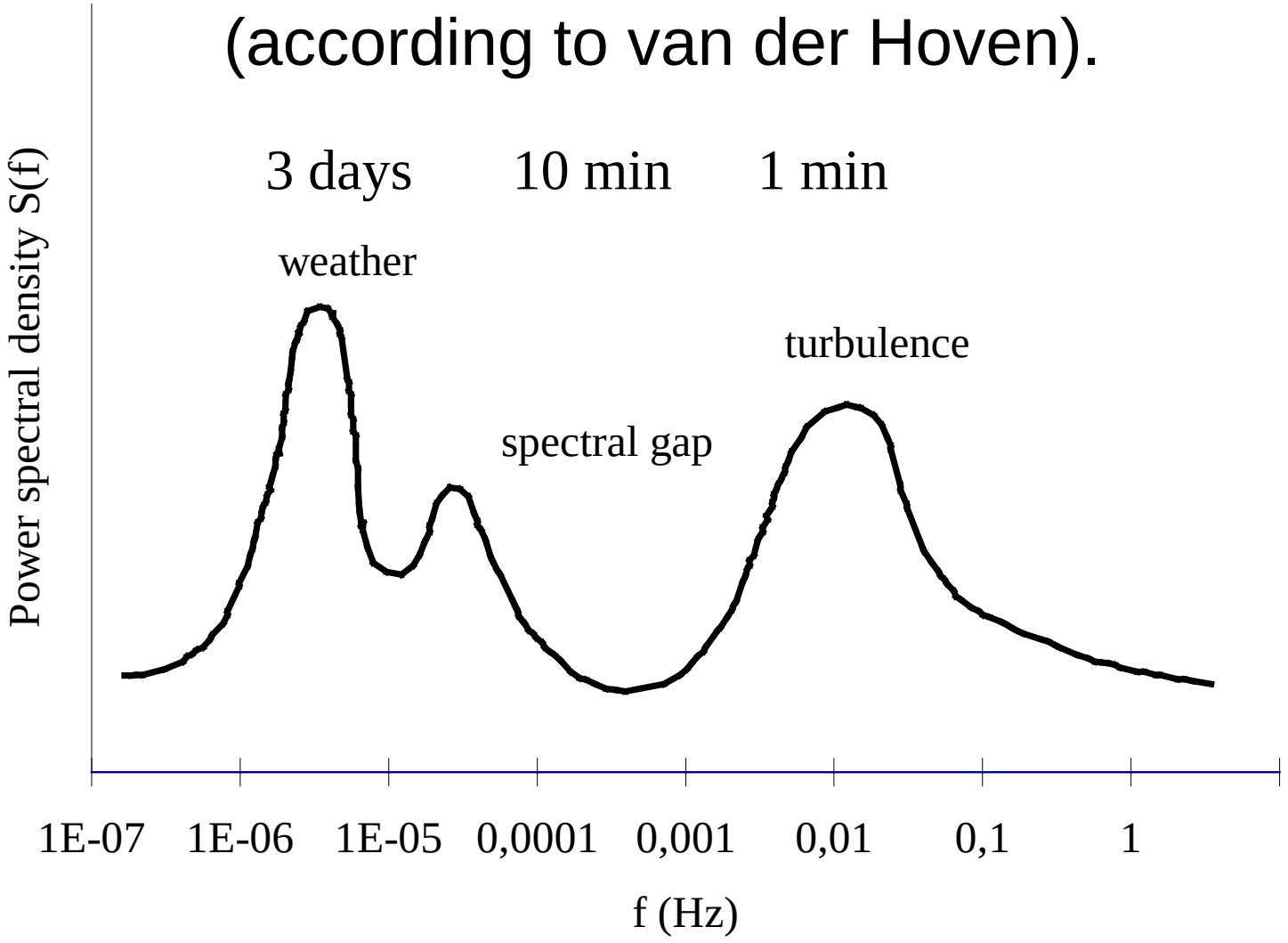


	m/s	W/m²	m/s	W/m²	m/s	W/m²	m/s	W/m²	m/s	W/m²
	>6.0	>250	>7.5	>500	>8.5	>700	>9.0	>800	>11.5	>1800
	5.0-6.0	150-250	6.5-7.5	300-500	7.0-8.5	400-700	8.0-9.0	600-800	10.0-11.5	1200-1800
	4.5-5.0	100-150	5.5-6.5	200-300	6.0-7.0	250-400	7.0-8.0	400-600	8.5-10.0	700-1200
	3.5-4.5	50-100	4.5-5.5	100-200	5.0-6.0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

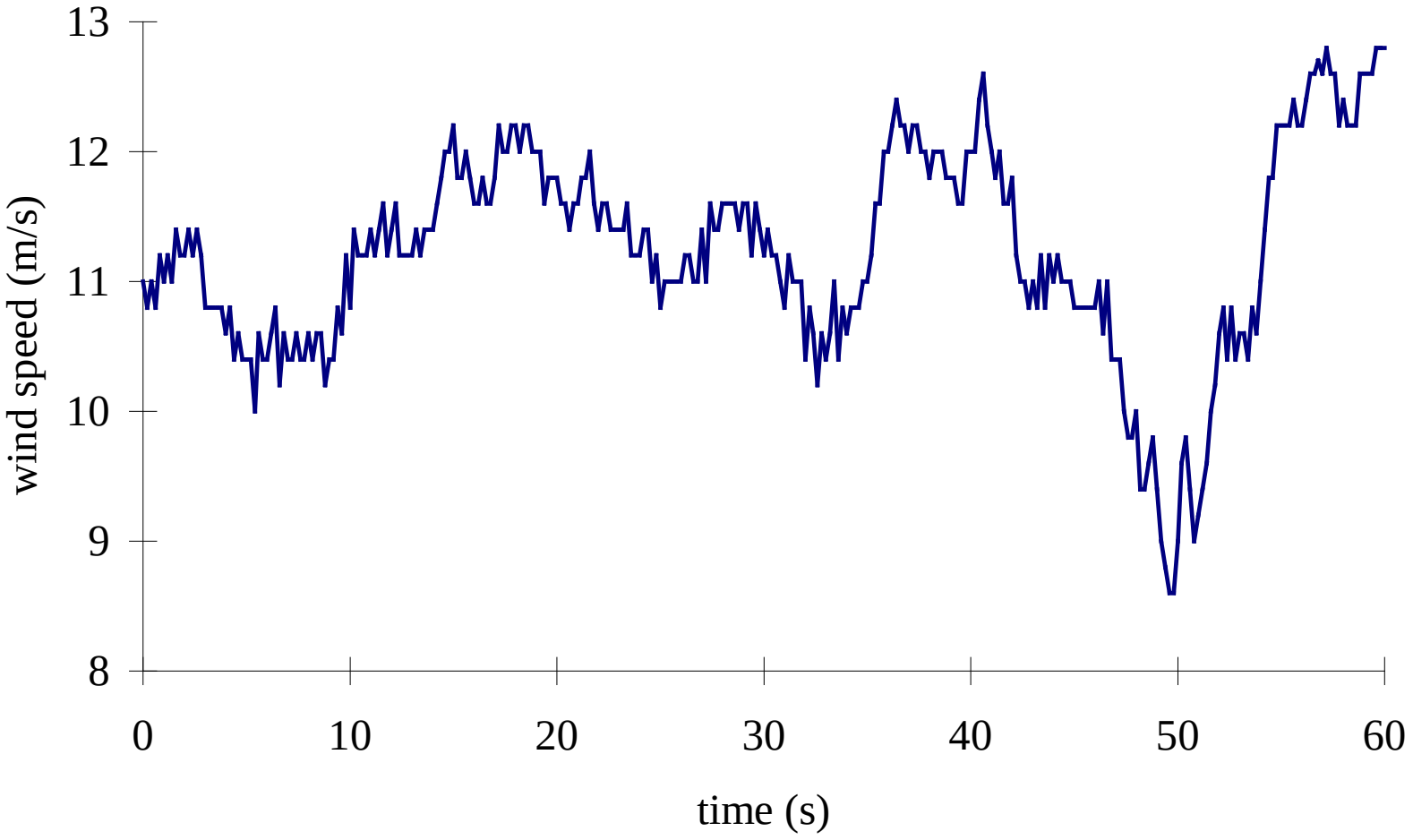
Weibull distribution



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



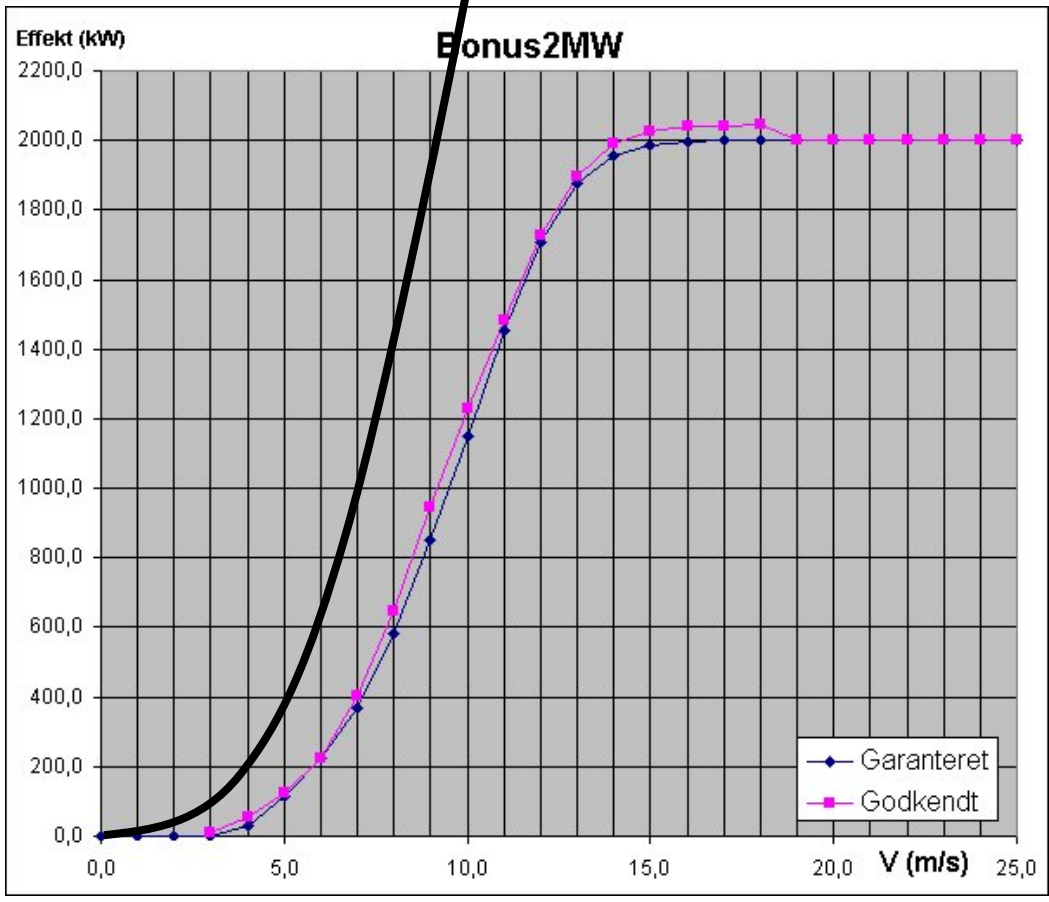
Wind speed measured at the harbour of Gothenburg, Sweden



Power from the wind turbine

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

Where Cp is power coefficient

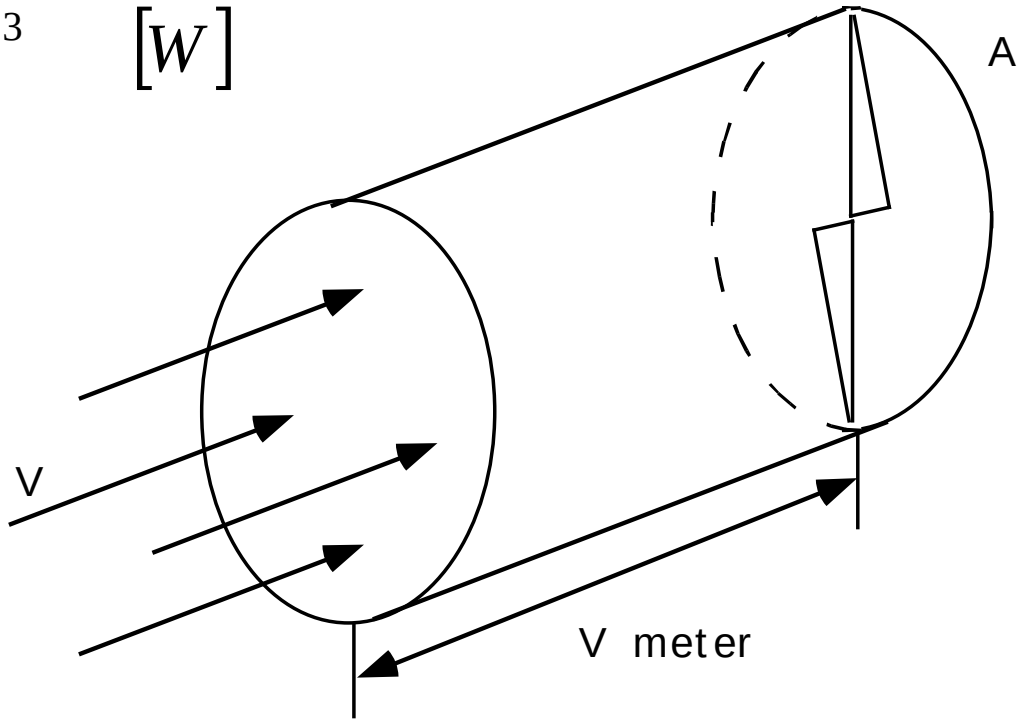


Power of the wind

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

Mass flow rate

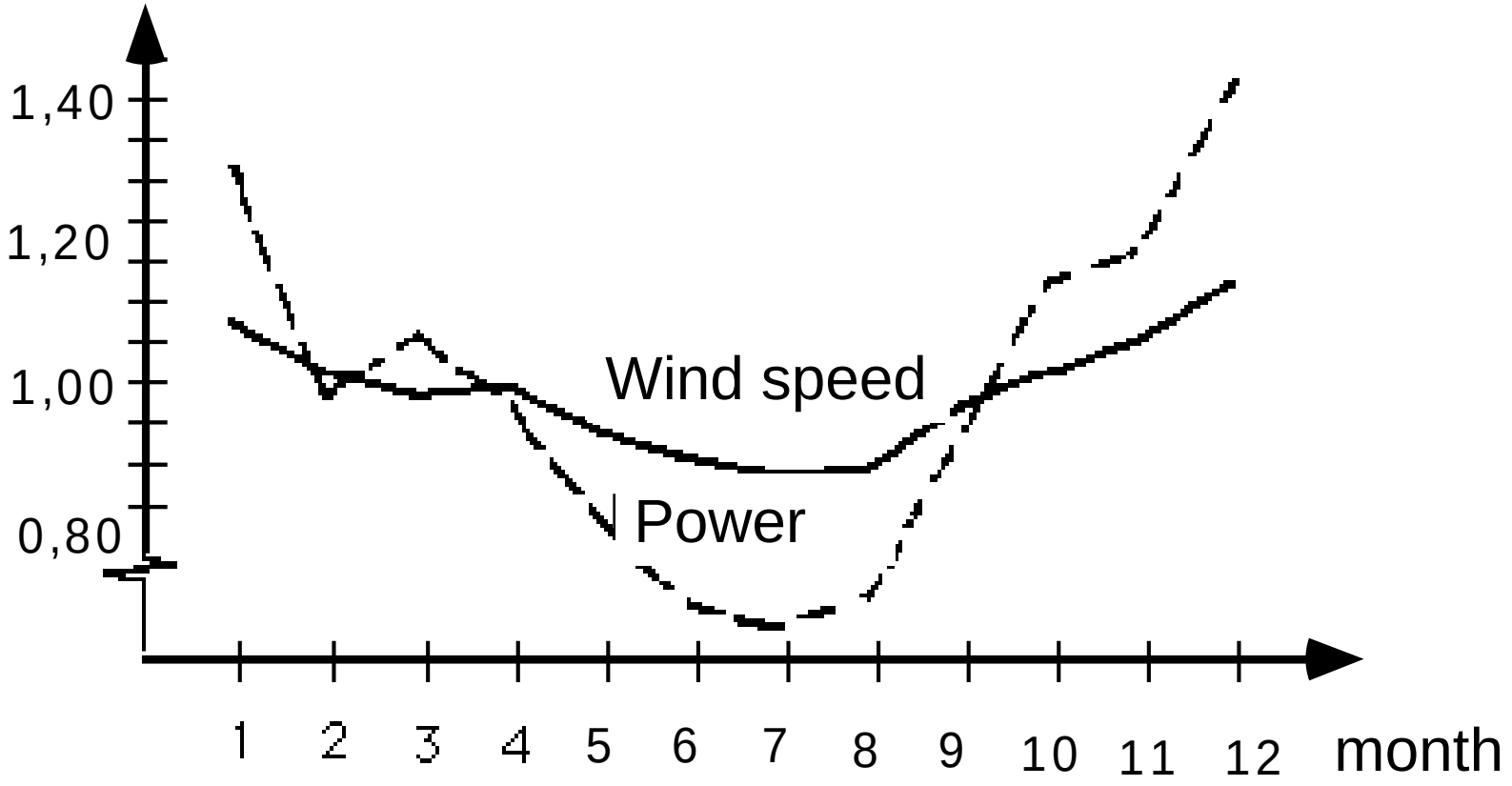
$$\dot{m} = \rho A V$$



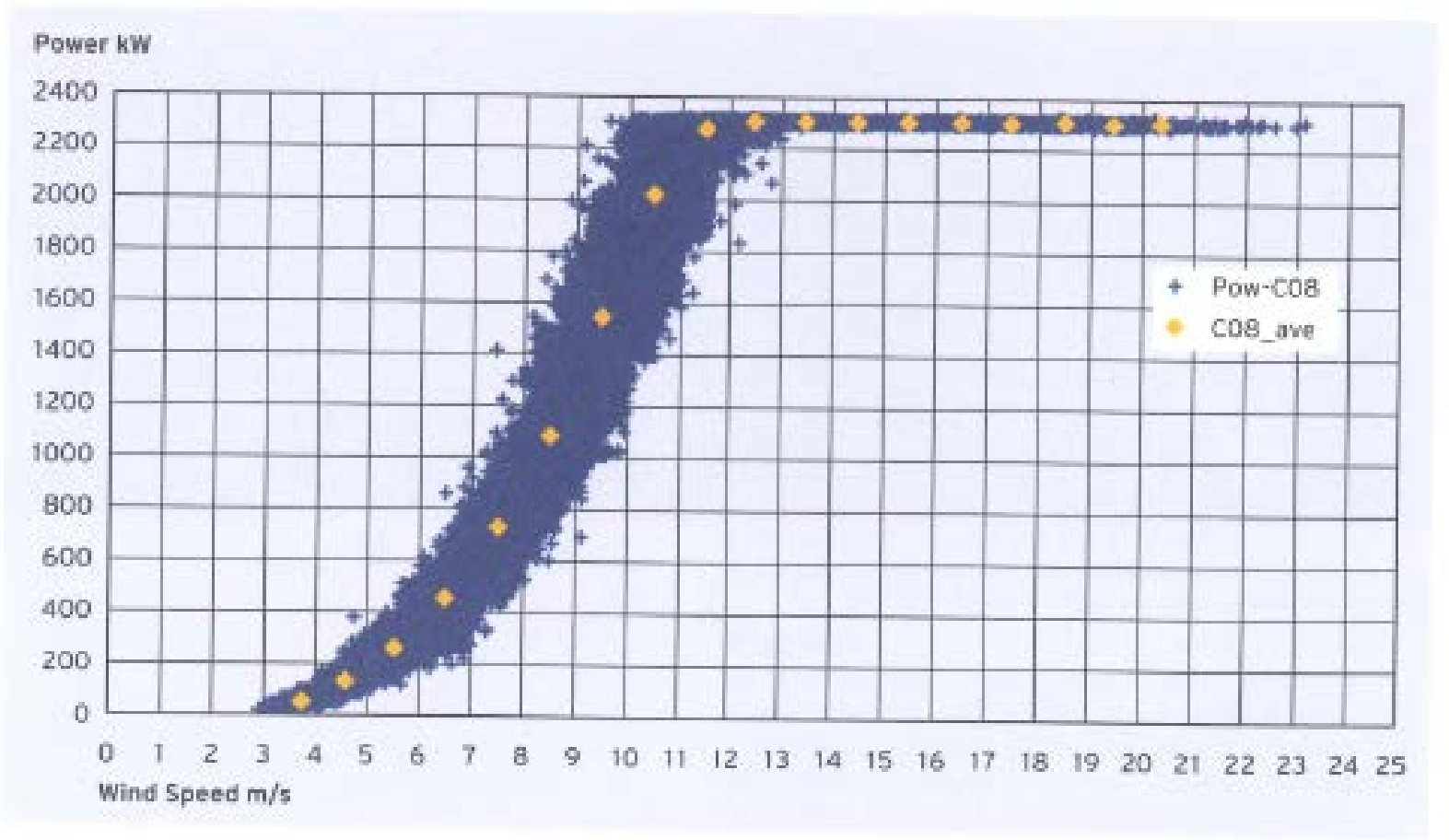
ρ = air density[kg/m^3]
V = air velocity[m/s]
A = rotor disk area[m^2]
m = mass of the air

Average value

Power and wind speed during the year in Sweden



Power Curve from a 2.3 MW wind turbine at Lillgrund

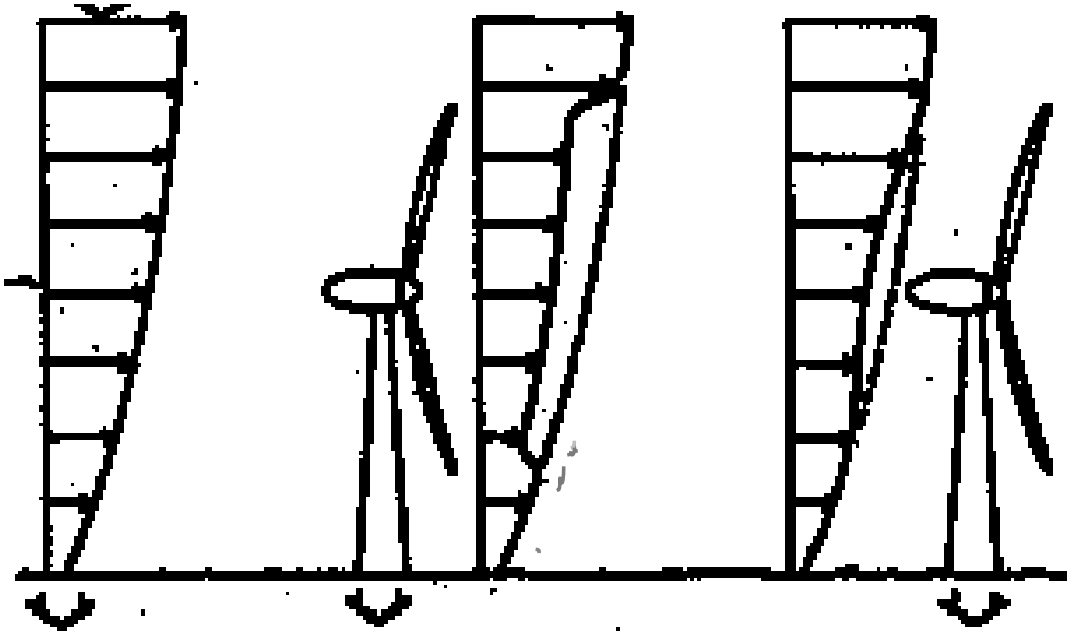


I grafen presenteras resultatet av vind-effektmätningen för vindkraftverk C-08. Medelvärdet (gul symbol) i varje fack...

Gradient of the wind

Wind decreases due to turbine

Wind reforms



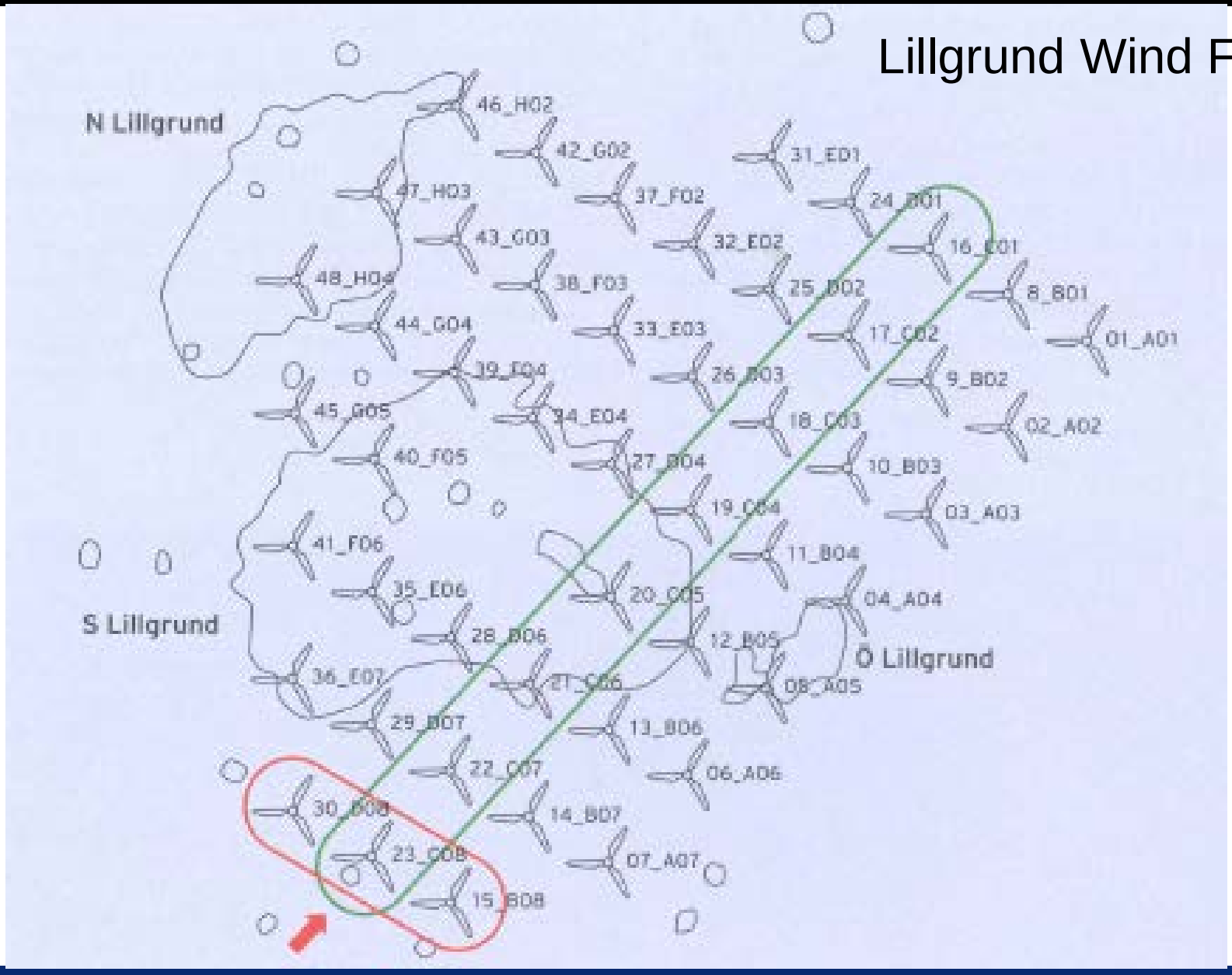
Energy decreases due to land friction

Energy to the grid

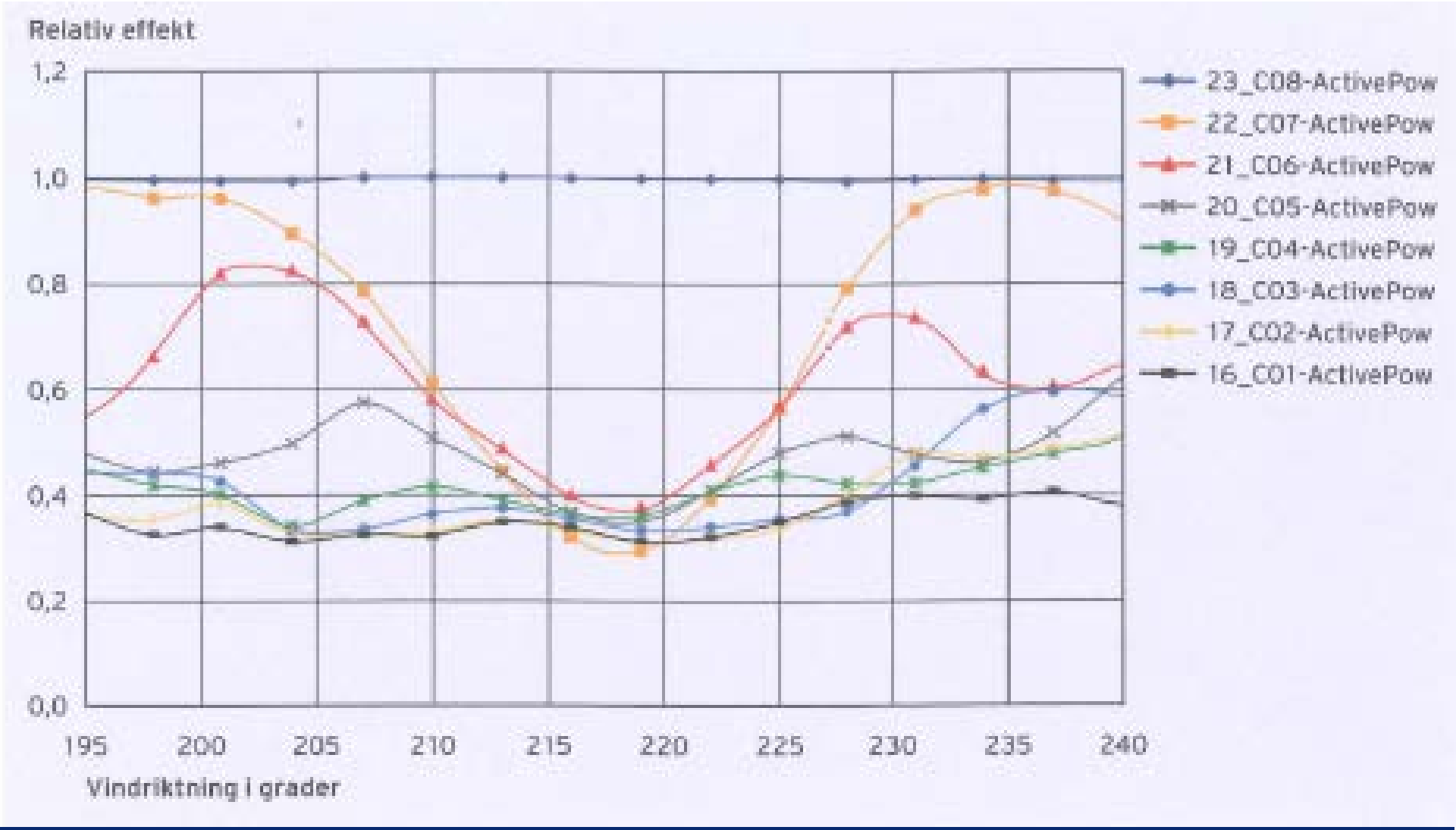
How much left?

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

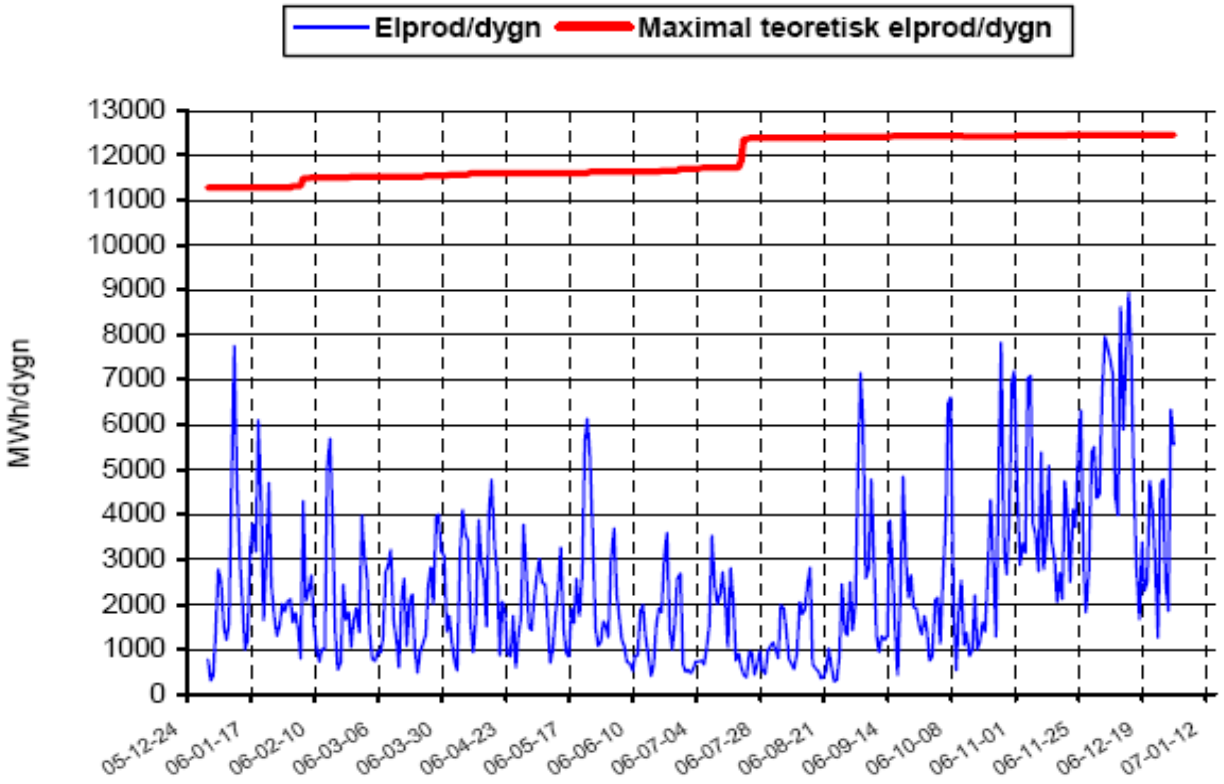
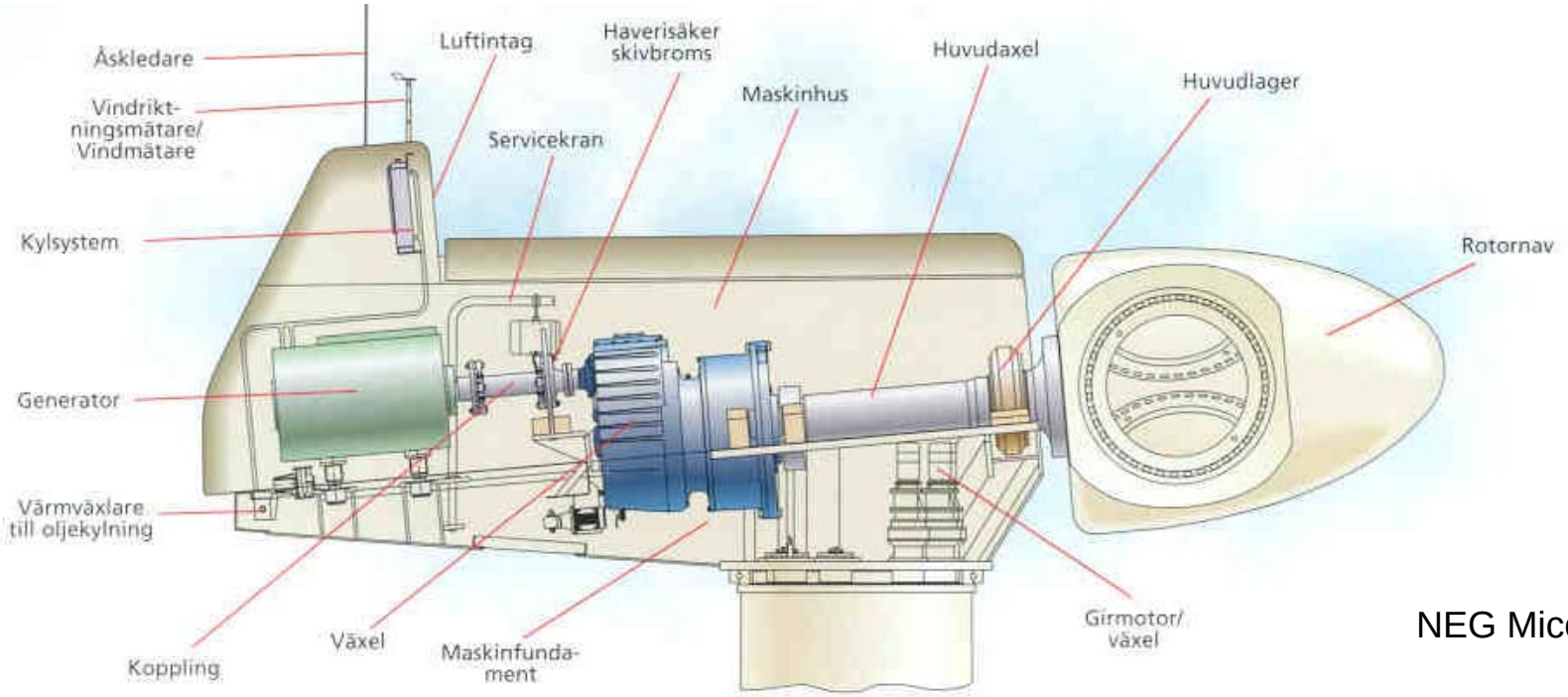


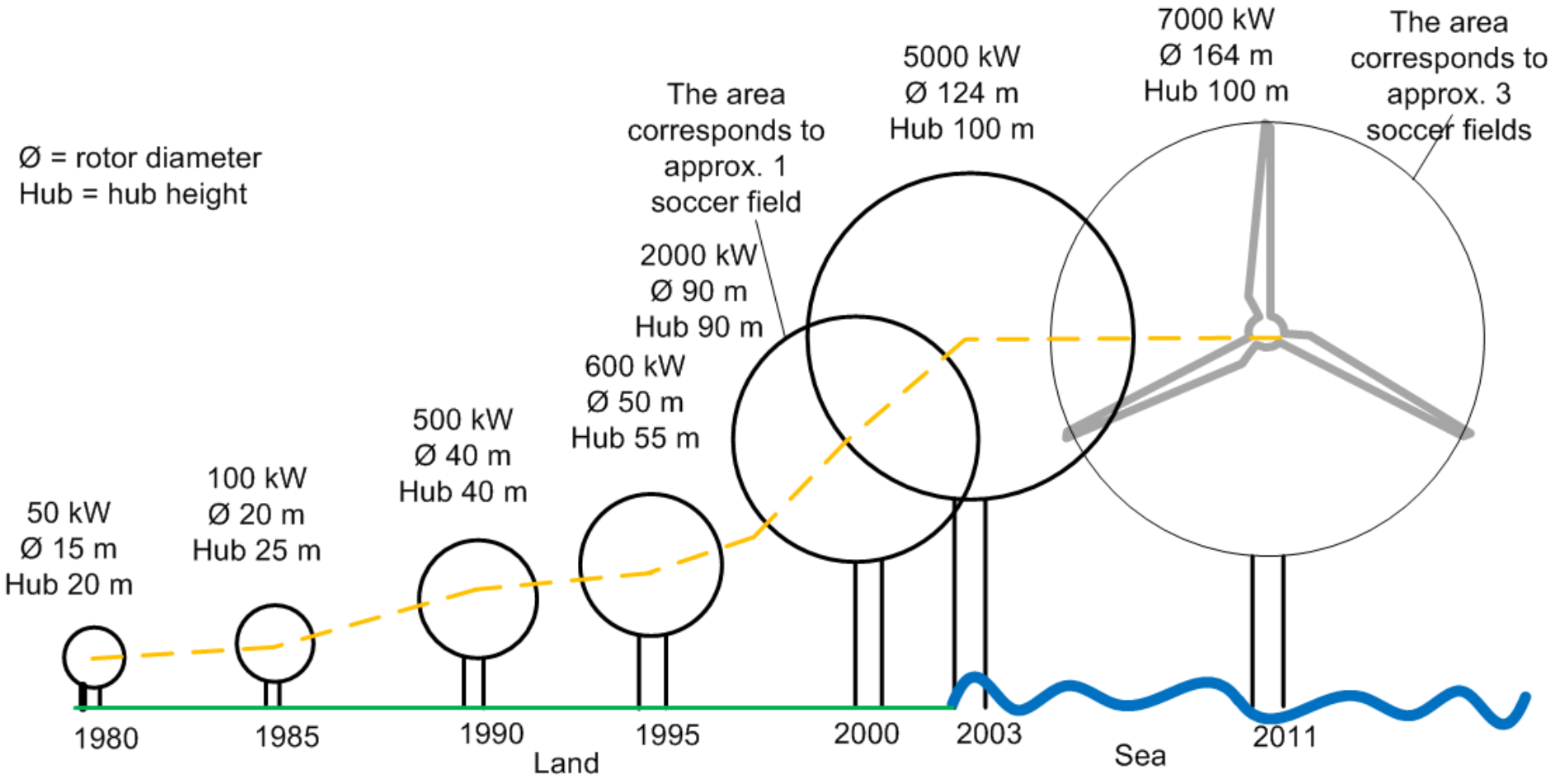
Diagram 3, verkens elproduktion per dygn över året.

Typical wind power nacelle



NEG Micon 750/48

Size Development of Wind Turbines

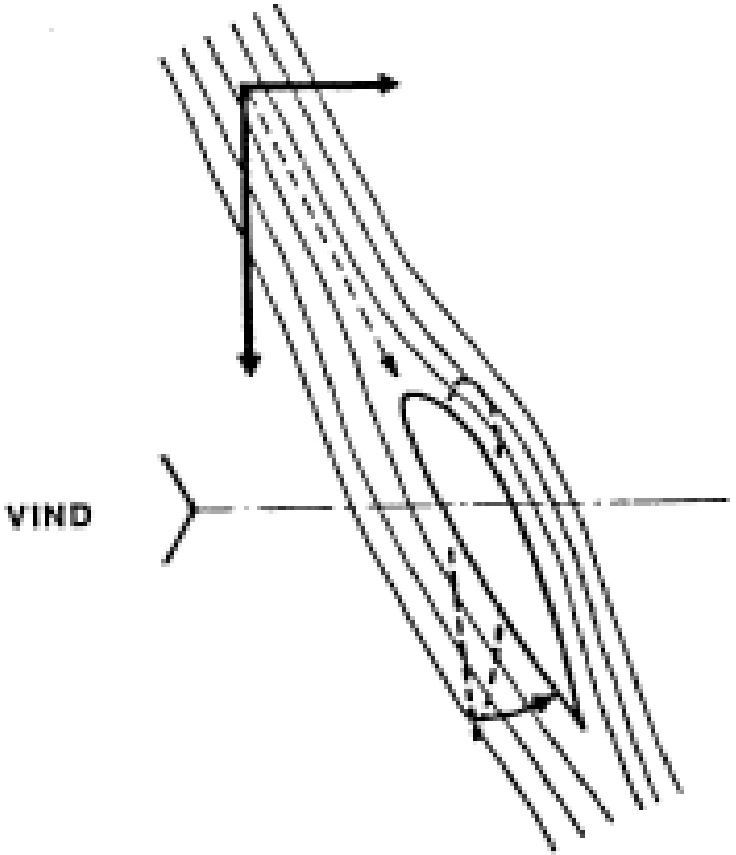


Limitations of wind power

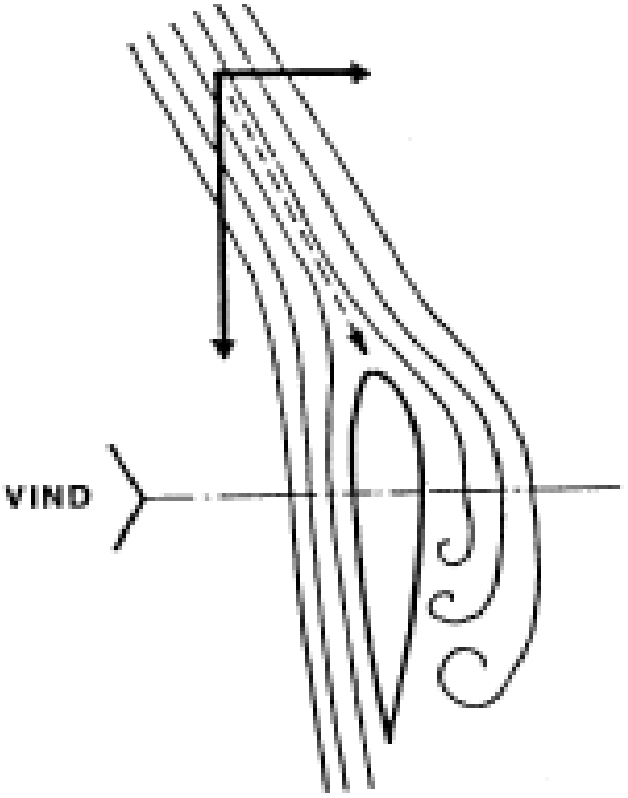
- Pitch control
  turn the blades
- Stall control
  Ridged blades, turbulence limit the power
- Active stall
  the pitch angle can be adjusted

- At emergency stop will the blades turn
- At emergency stop will the outer part of the blades turn
- At emergency stop will the blades turn

Pitch contol

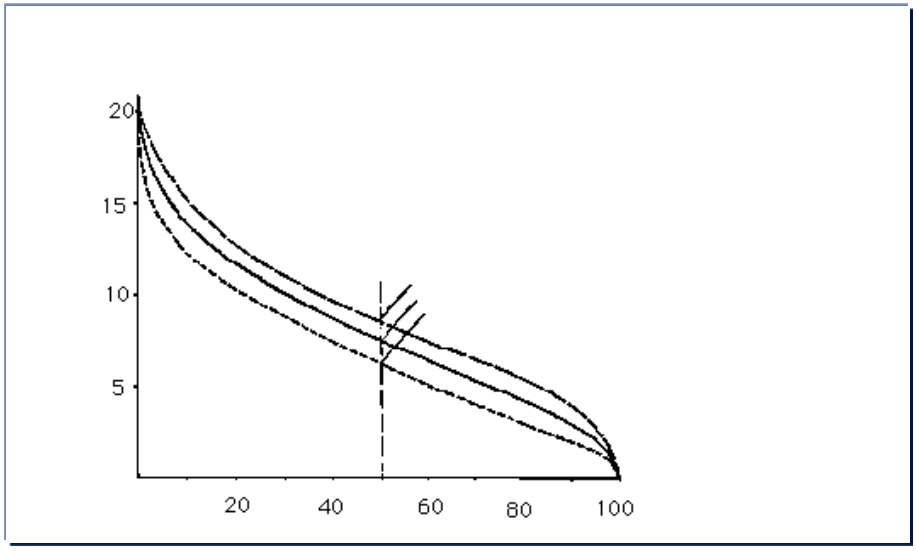


Stall control

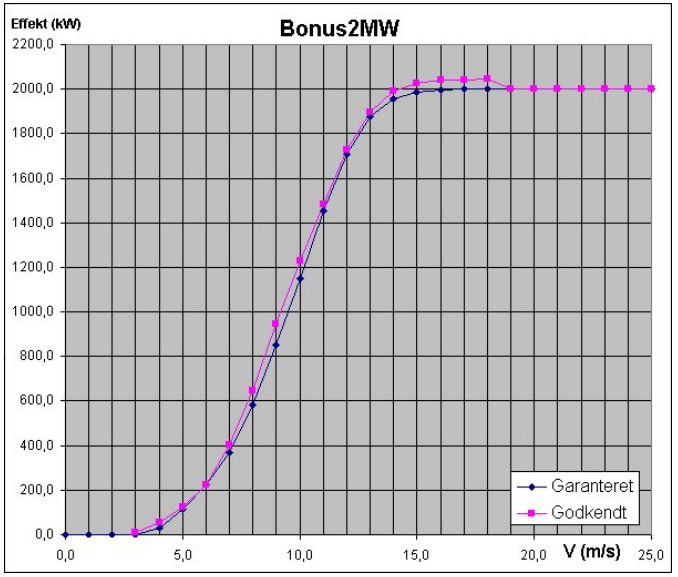


Energy from one year =

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 10-15 years to make a profit.

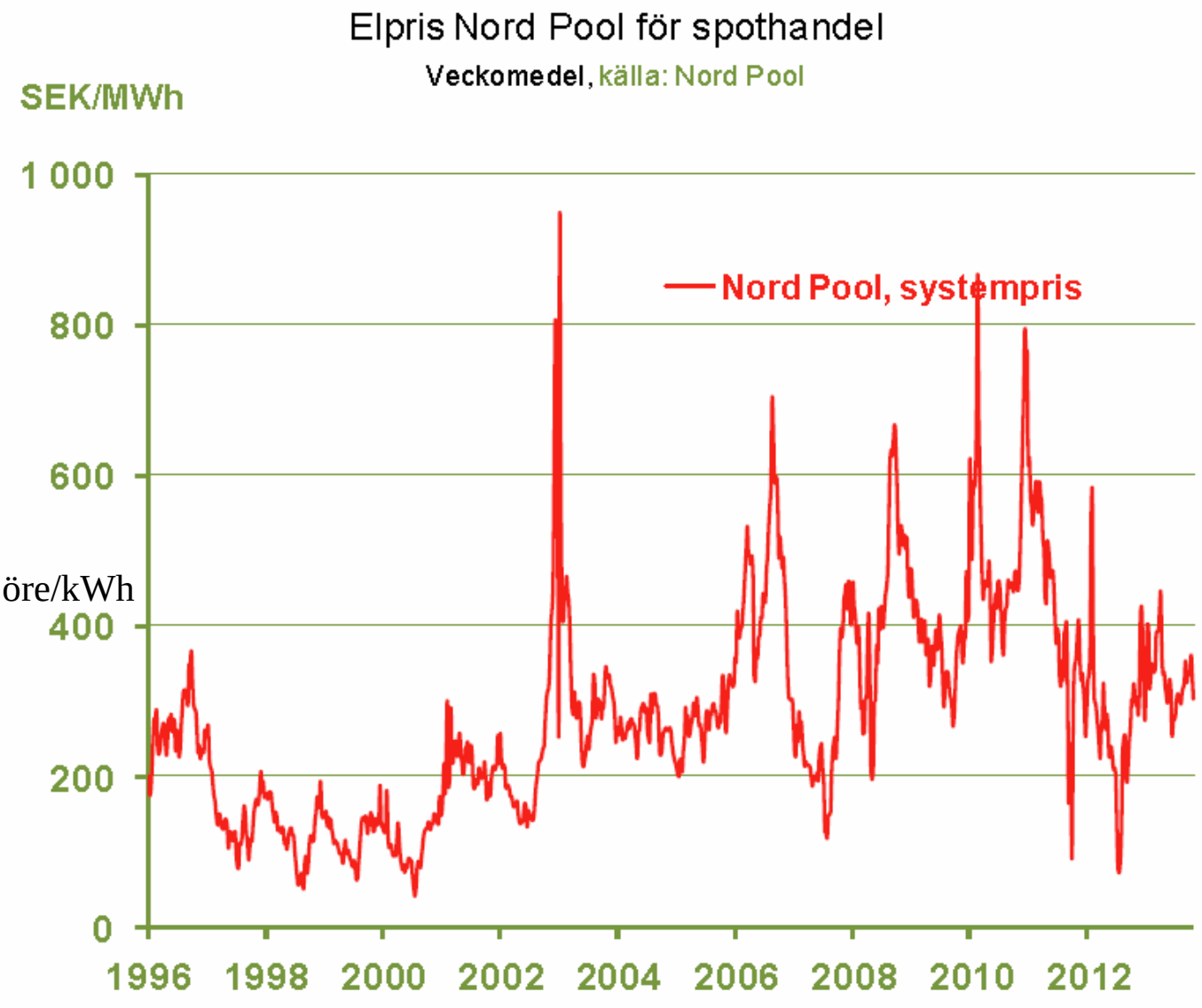
When the life time of the wind turbine is ended it is just to take down the turbine and use the land for something else

Costs for 25 TWh

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

A wind turbine installation 12-15 MSEK/MW

Elpris

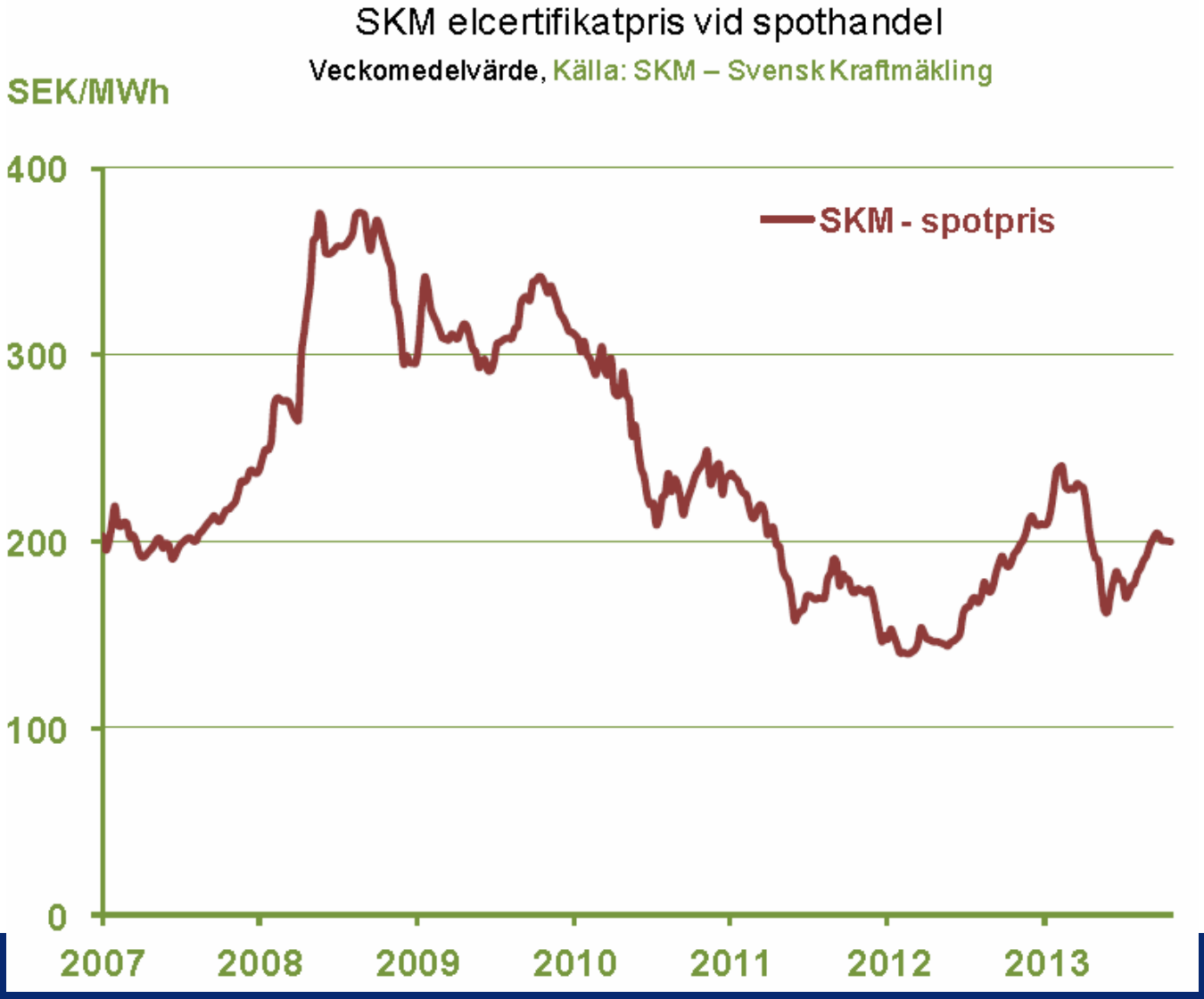


40 öre/kWh

Spotpris

Fleråriga avtal

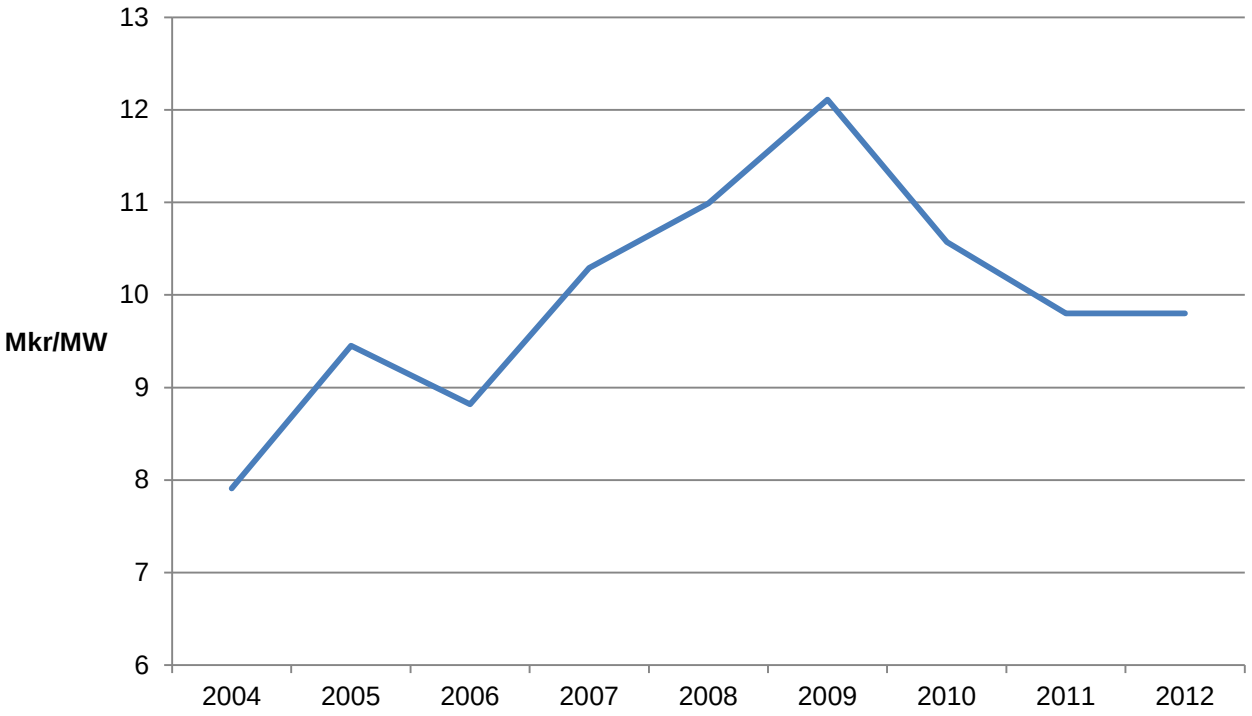
El certificate - Price development



Max: 380 kr/MWh
Min: 145 kr/MWh

Average price 2012:
181 kr/MWh eller
18,1 öre/kWh

Costs for a wind turbine



Källa: Renewable Energy Technologies: Cost analysis series, IRENA (International Renewable Energy Agency), juni 2012

Economic

Revenue	v 41 2012	v 13 2013	v 43 2013
Sales of el on Nord Pool	305 kr/MWh	391 kr/MWh	361 kr/MWh
Sales of elcertificate	189 kr/MWh	214 kr/MWh	200 kr/MWh
Total revenue :	49,4 öre/kWh	60,5 öre/kWh	56,1 öre/kWh

Costs
Total cost for a project: ca 27 miljon/wind turbine

Yearly production: 5 500 000 kWh
Revenue 1: 2 717 000 kr (5 500 000 kWh * 0,494 kr/kWh)
Revenue 2: 3 327 500 kr (5 500 000 kWh * 0,605 kr/kWh)
Revenue 3: 3 085 500 kr (5 500 000 kWh * 0,561 kr/kWh)

Profit after 9,9 year (27 000 000 / 2 717 000)
Profit after 8,1 year (27 000 000 / 3 327 500)
Profit after 8,8 year (27 000 000 / 3 085 500)

Key figures – kr/kWh år

$$\frac{Investment\ cost}{Yearly\ kilowatt\ hour} = 4{,}5kr/kWh$$

In this example 4,9 kr/kWh

Previous typical value 7 kr/kWh

Key figures – production cost

$$\frac{Production\ cost}{årsproduktion} = 58öre/kWh$$

El från nya anläggningar,
Elforsk, våren 2011

Production cost going down.
Close to 50 öre/kWh

Revenue: 56,1 öre/kWh

Onshore wind is now fully competitive but many other technologies continue to require incentives

Levelised cost estimates for new build in OECD countries (EUR/MWh 2010)

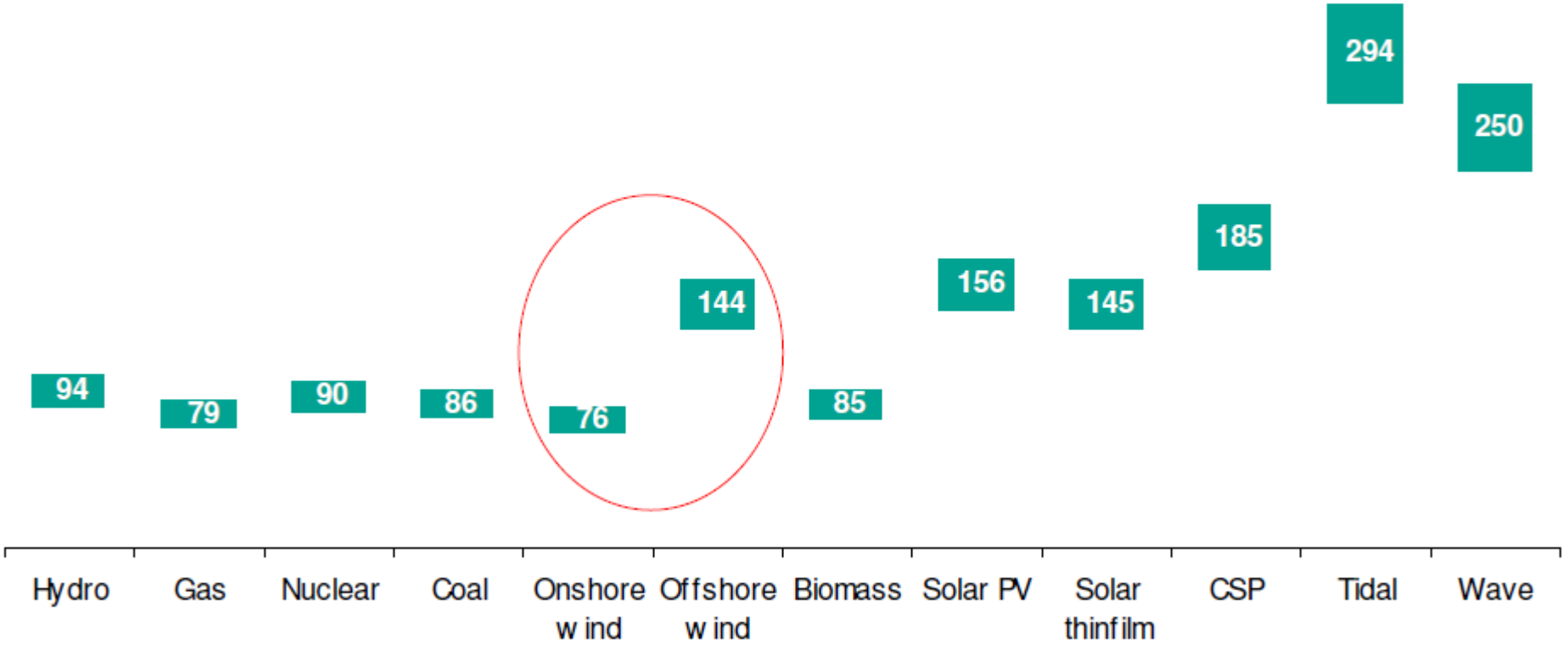


FIGURE 5: INSTALLED POWER GENERATING CAPACITY PER YEAR (MW) AND RENEWABLE SHARE (%)

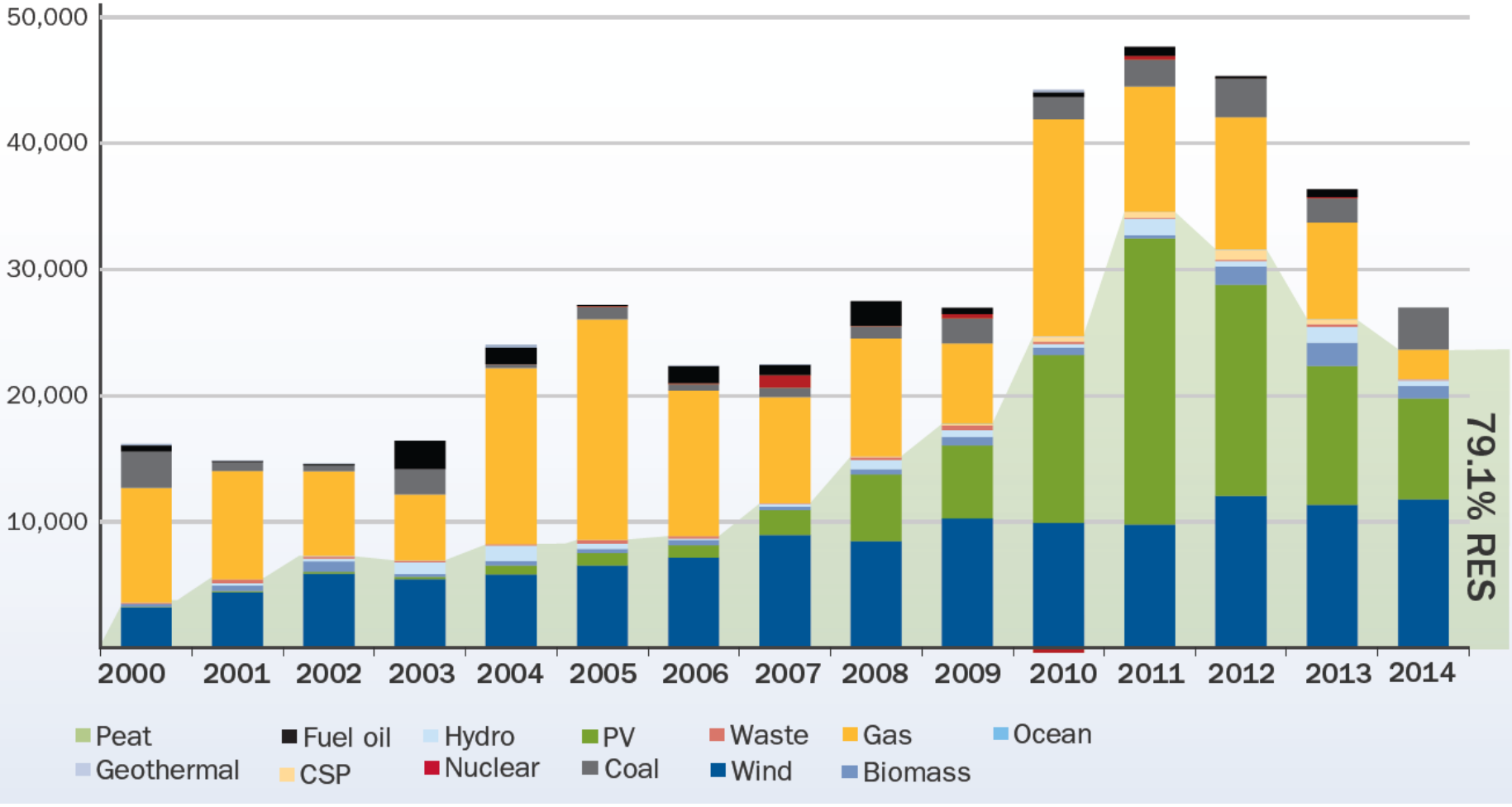


FIGURE 12: CUMULATIVE WIND POWER INSTALLATIONS IN THE EU (GW)

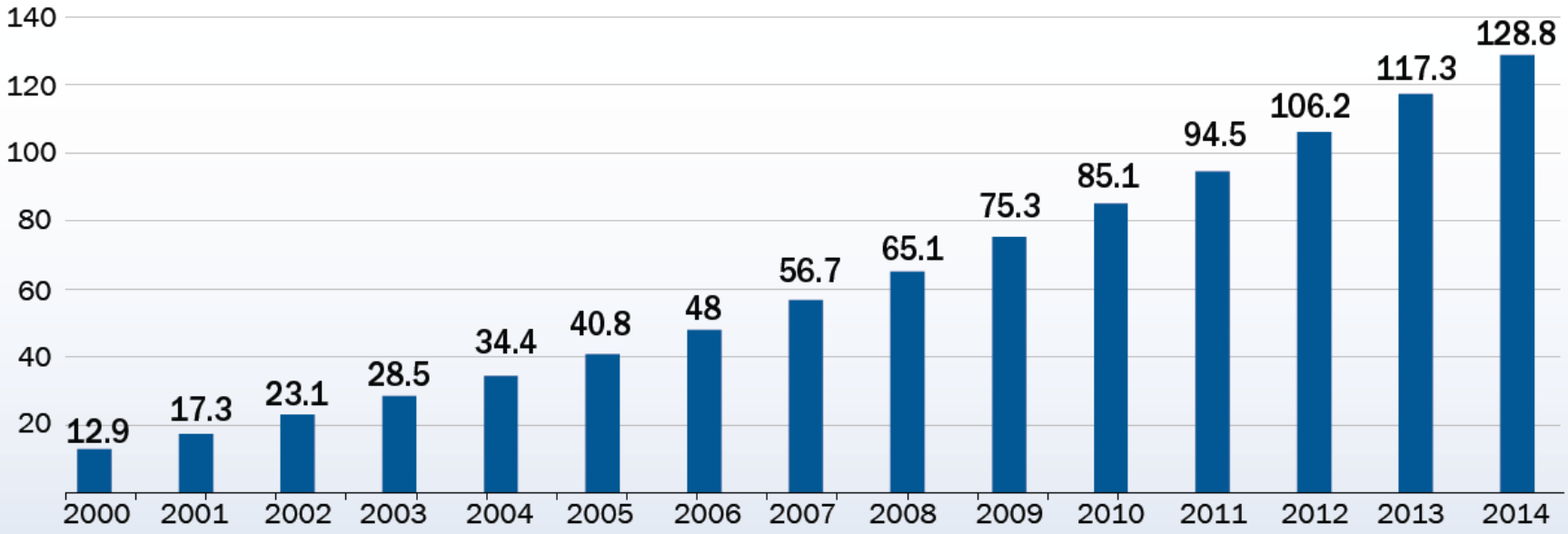
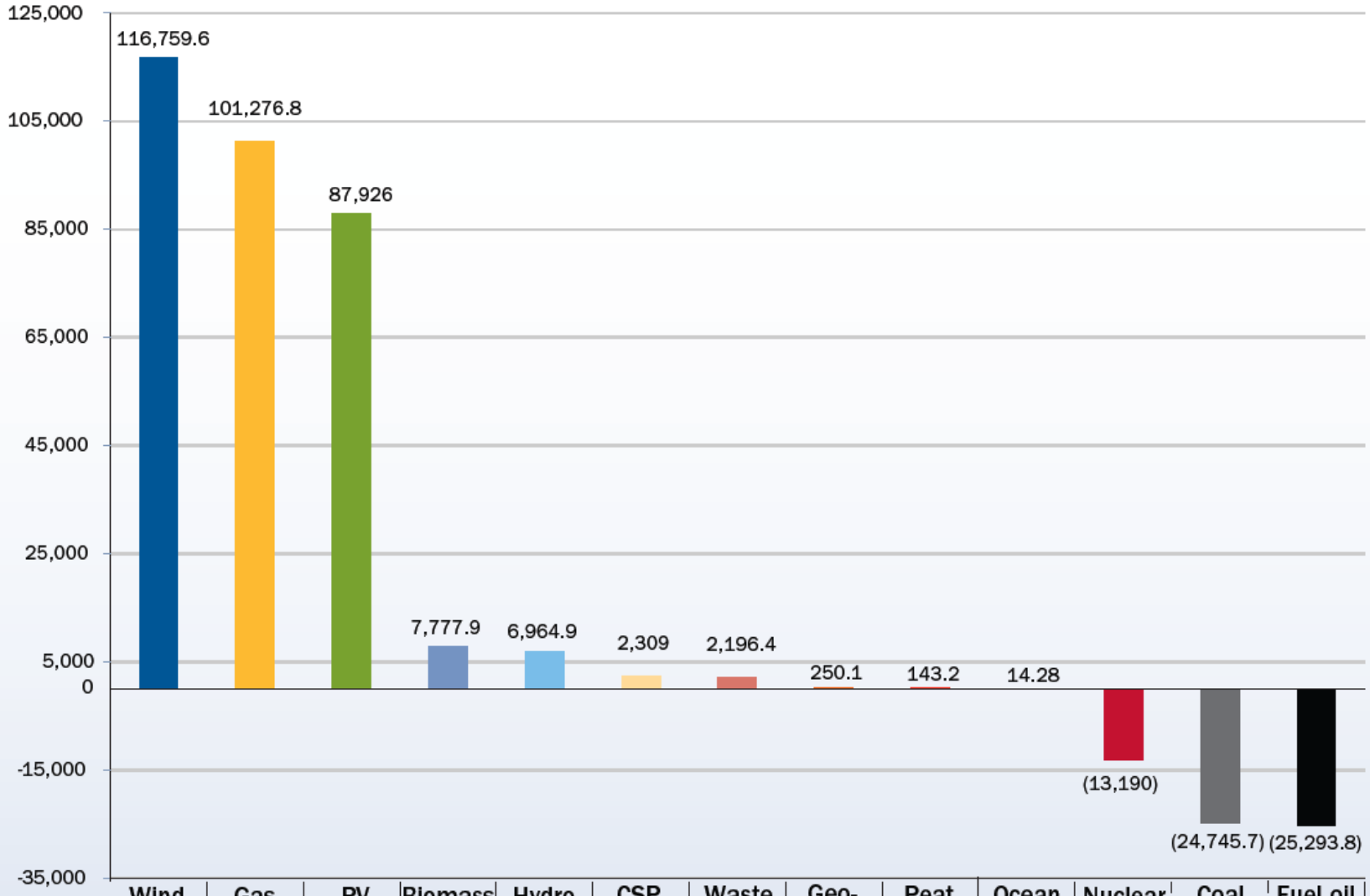


FIGURE 6: NET ELECTRICITY GENERATING INSTALLATIONS IN THE EU 2000-2014 (MW)



Källa EWEA

FIGURE 7: EU POWER MIX 2000 (MW)

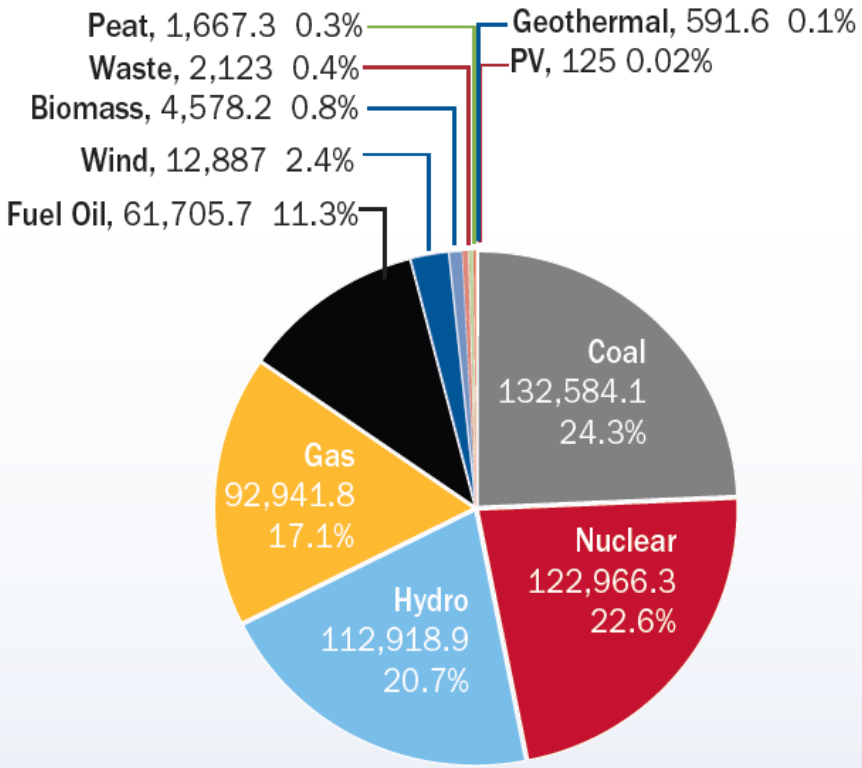
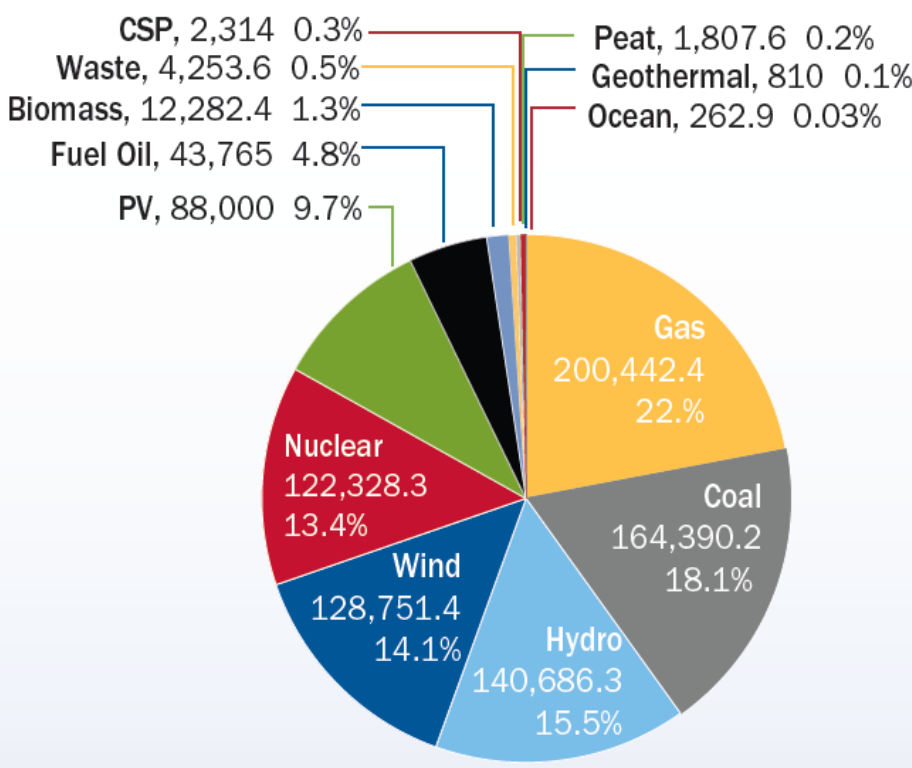
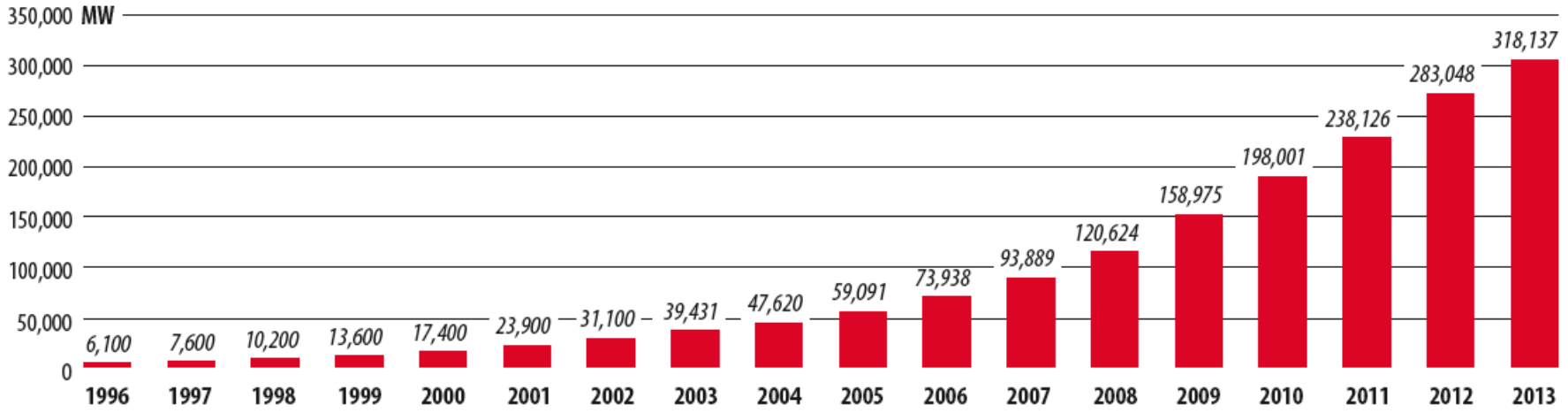


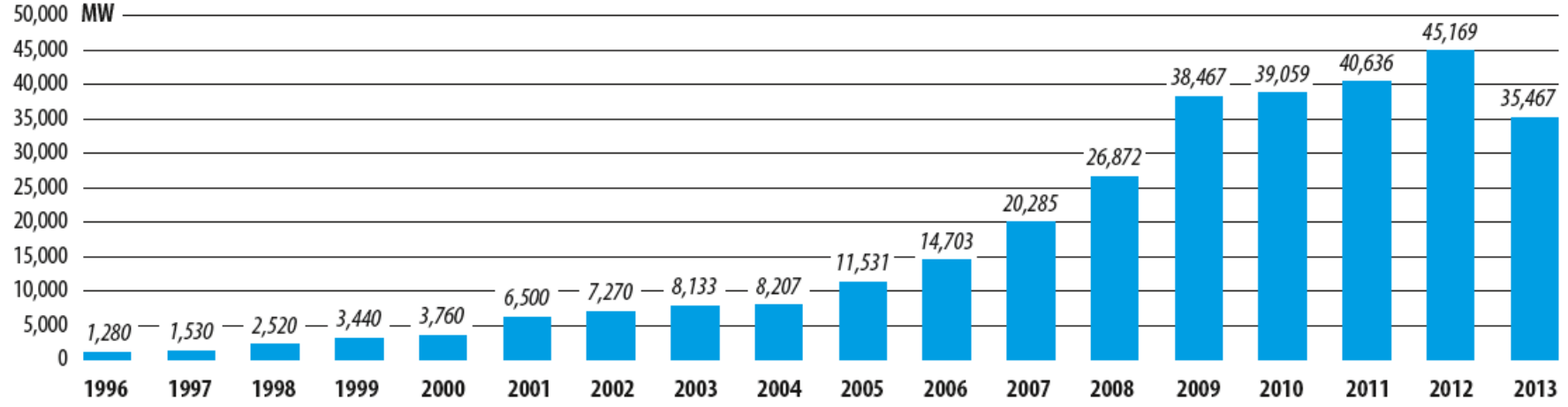
FIGURE 8: EU POWER MIX 2014 (MW)



GLOBAL CUMULATIVE INSTALLED WIND CAPACITY 1996-2013



GLOBAL ANNUAL INSTALLED WIND CAPACITY 1996-2013



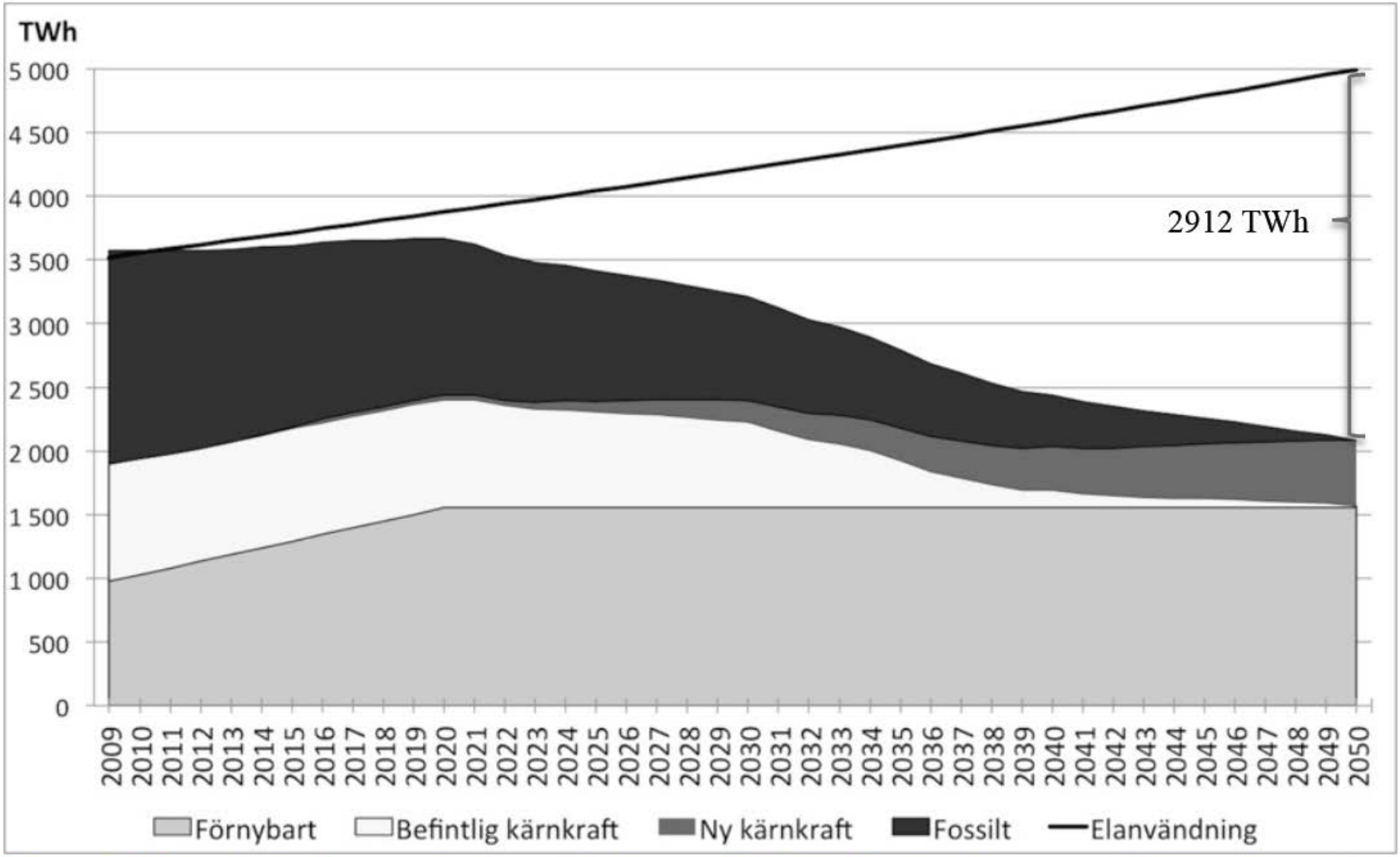
Källa ovanstående bild

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



Figur 5. Elanvändningen och elproduktionen i EU, inklusive Norge och Schweiz, med antagande om livslängd på 50 år för kärnkraftverken.

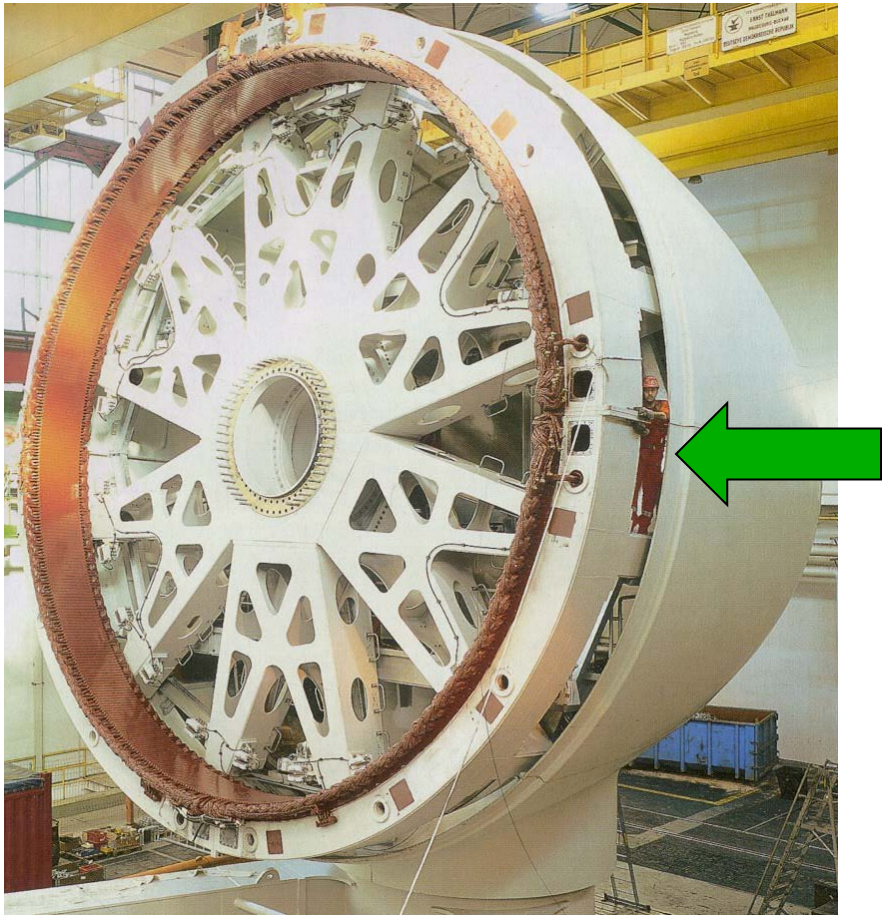
Vestas

- 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

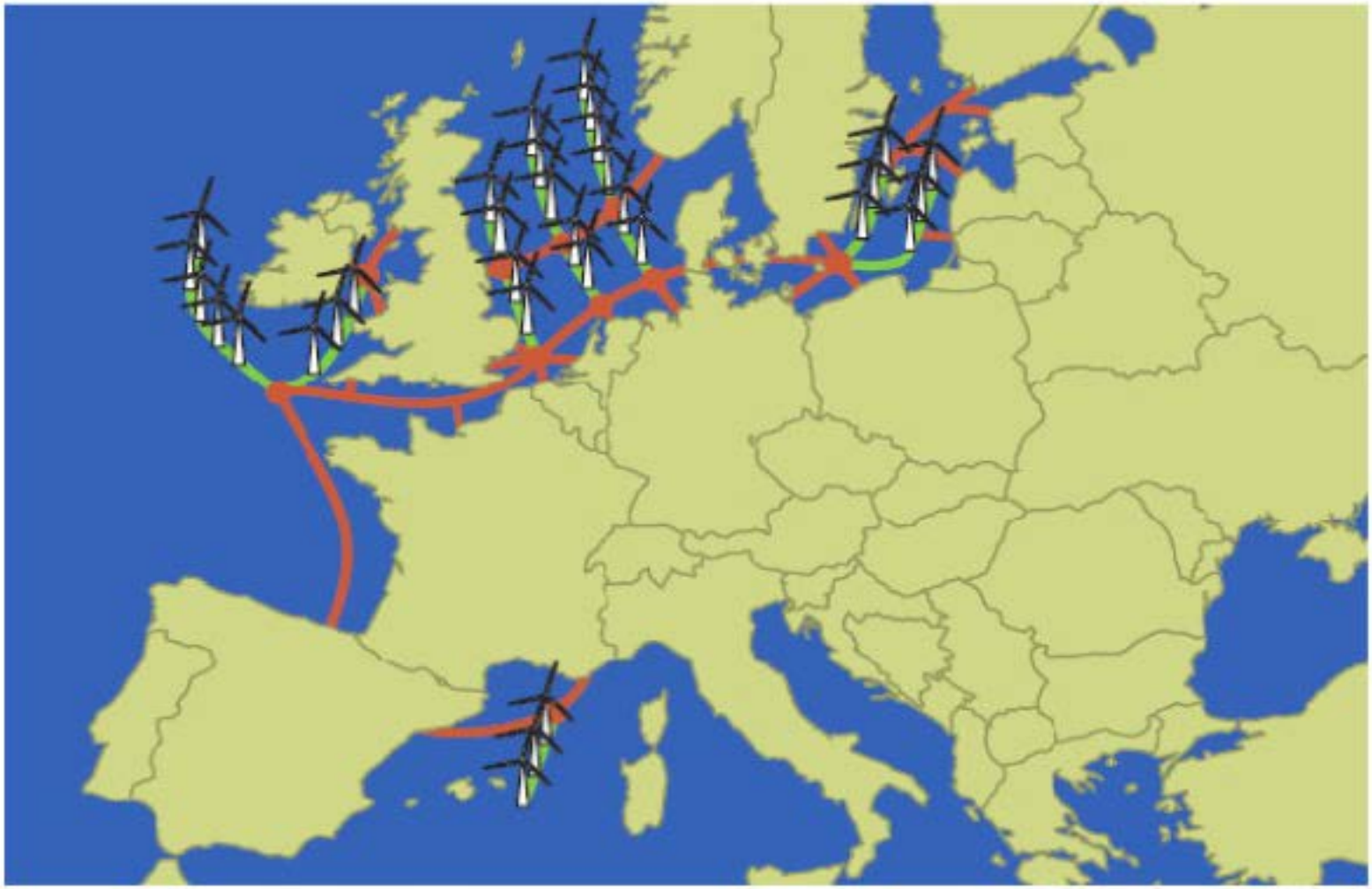
2 MW, 78-100 m

Repower

6,12 MW, 126 m

Offshore GE-wind turbines outside Kalmar, Utgrunden

1.5 MW

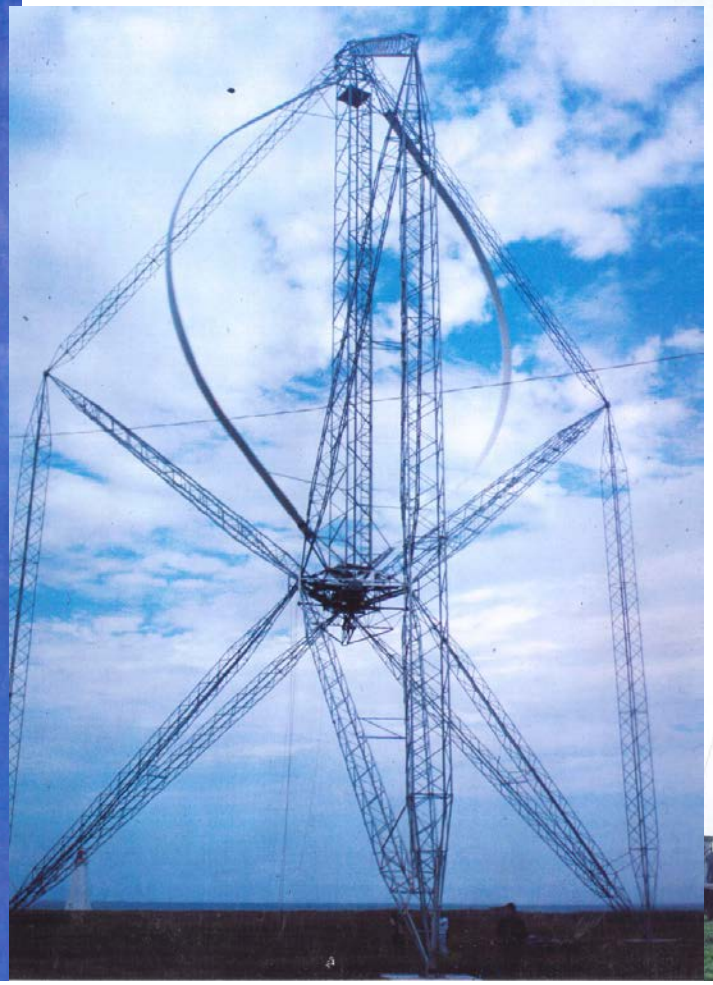


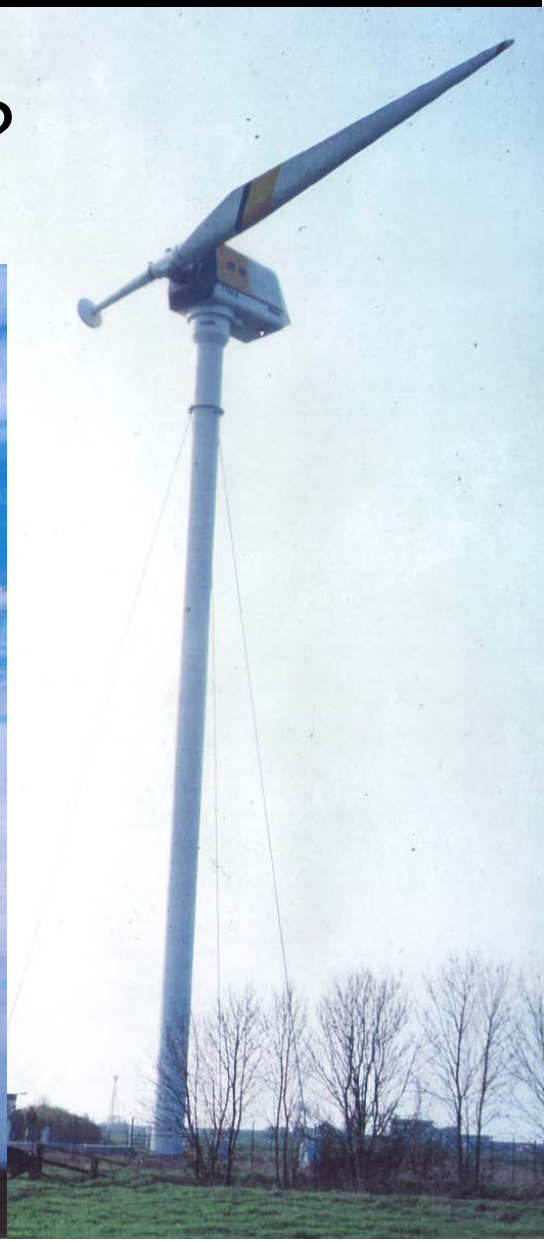
The European Offshore Supergrid

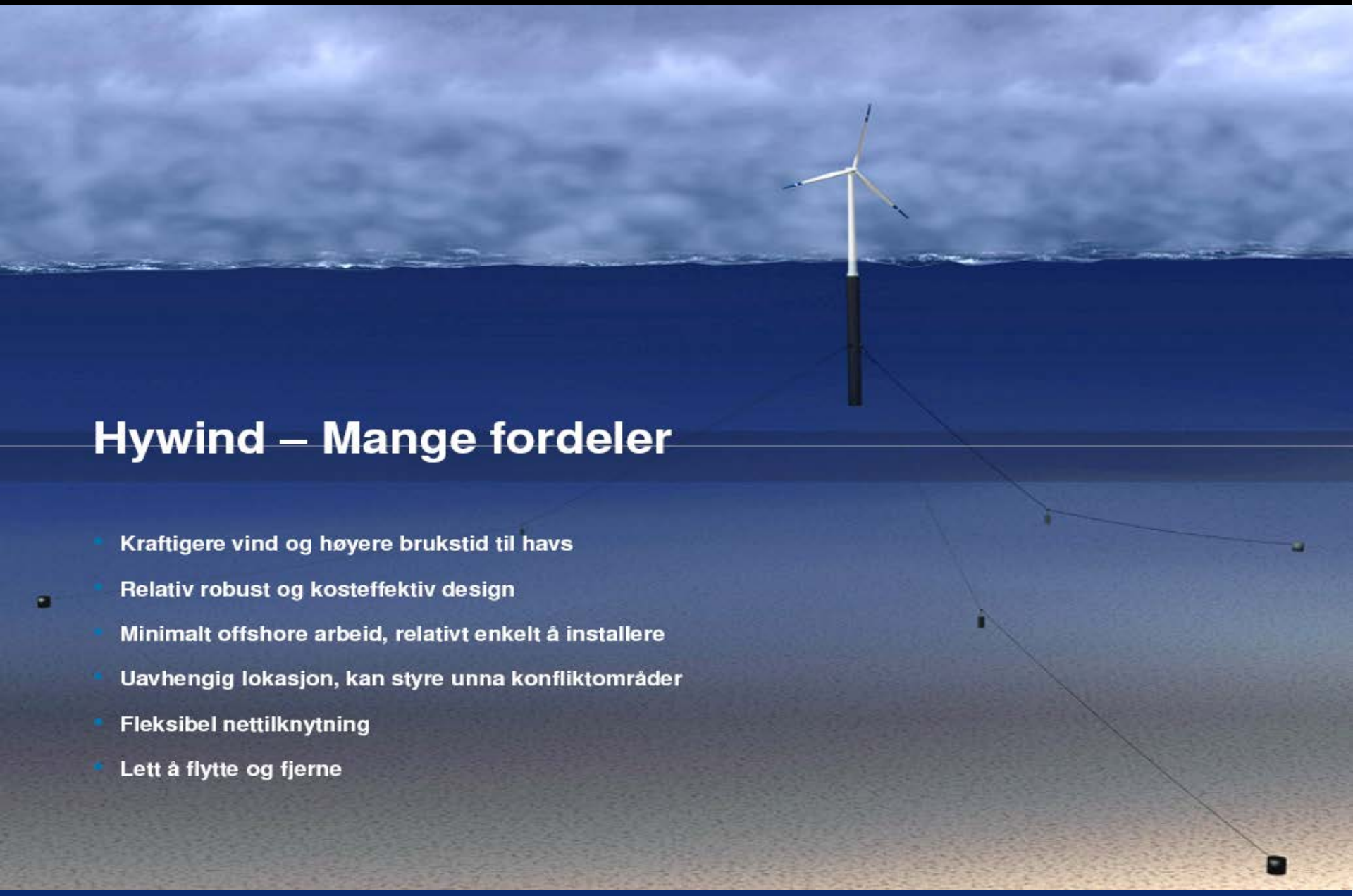
Lillgrund vindkraftpark – Tekniska data

- 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

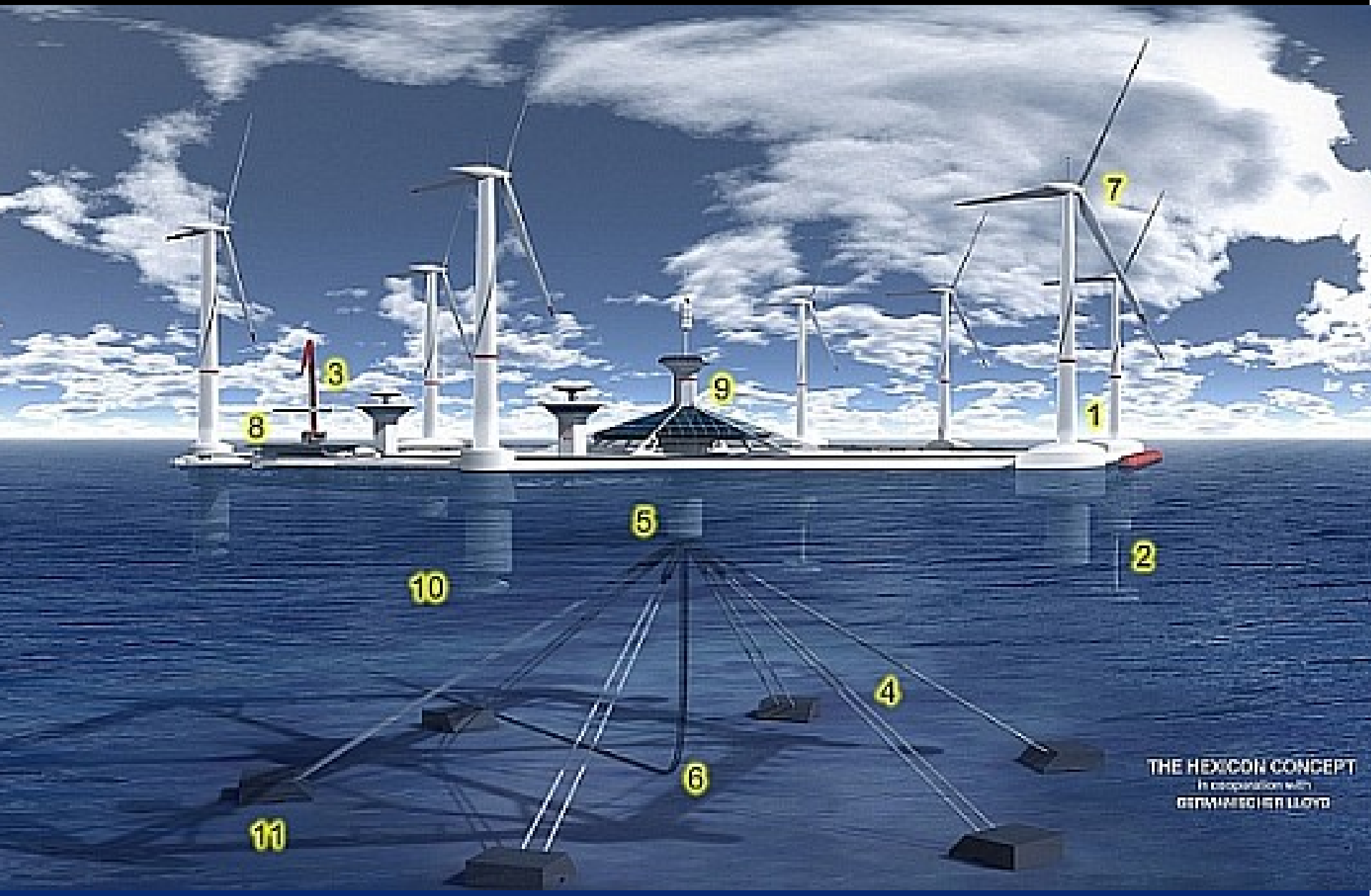
- Kraftigere vind og høyere brukstid til havs
- Relativ robust og kosteffektiv design
- Minimalt offshore arbeid, relativt enkelt å installere
- Uavhengig lokasjon, kan styre unna konfliktområder
- Fleksibel nettilknytning
- Lett å flytte og fjerne

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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