Wind power –
Green Revolution in Energy

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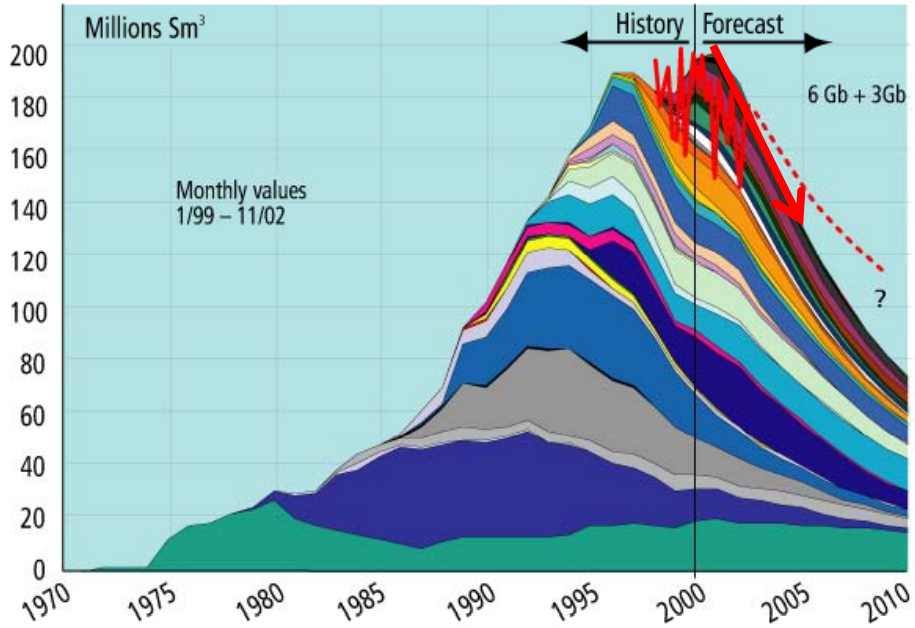
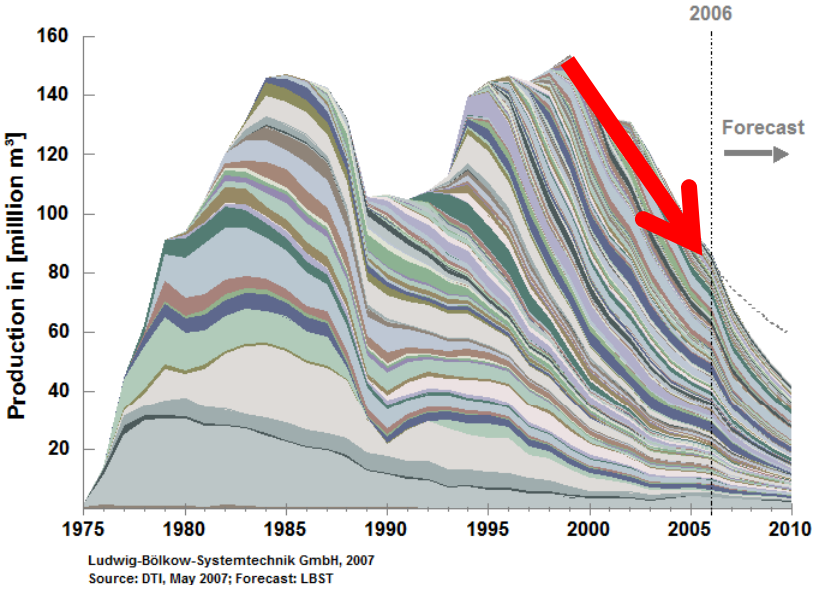
Member Swiss Parliament

Crude oil at a peak

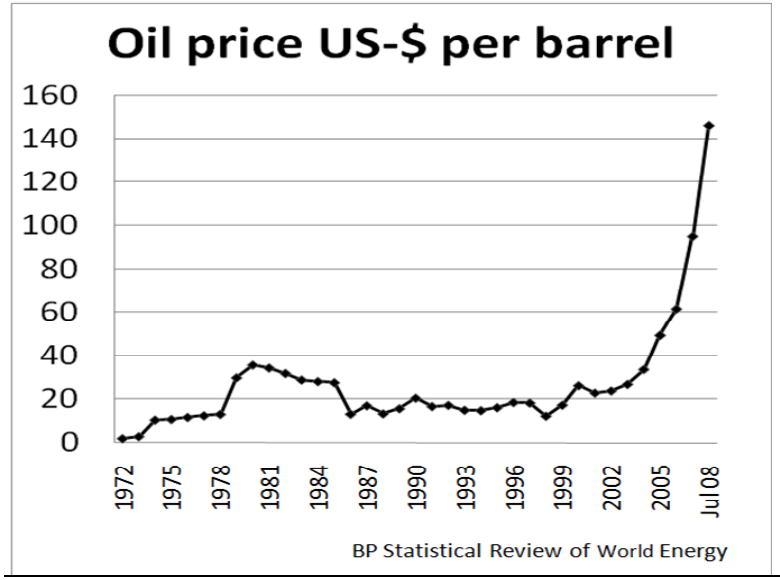
Norway Oil production profile minus 25 % since 2001 peak

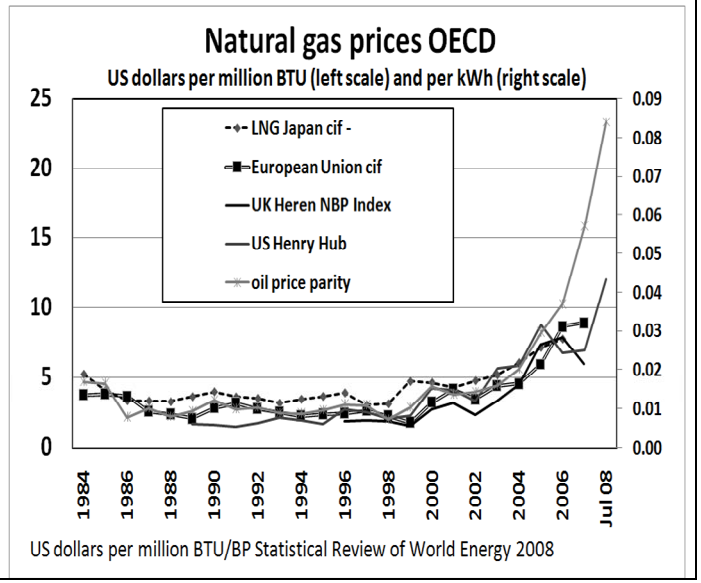


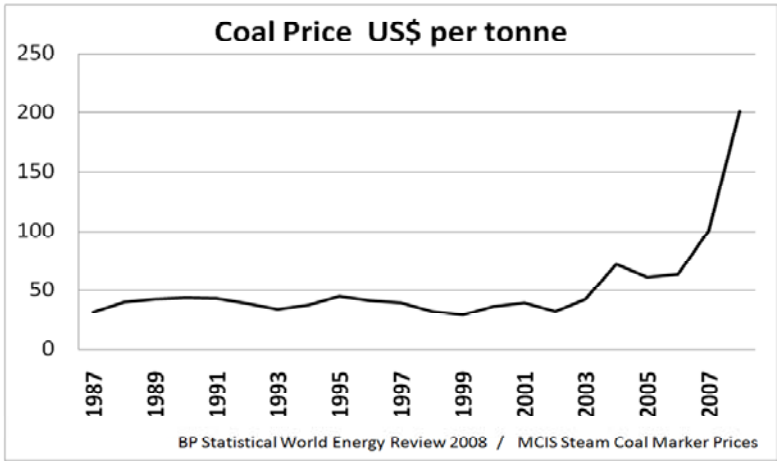
Britain: Oil production profile minus 44% since 1999 peak

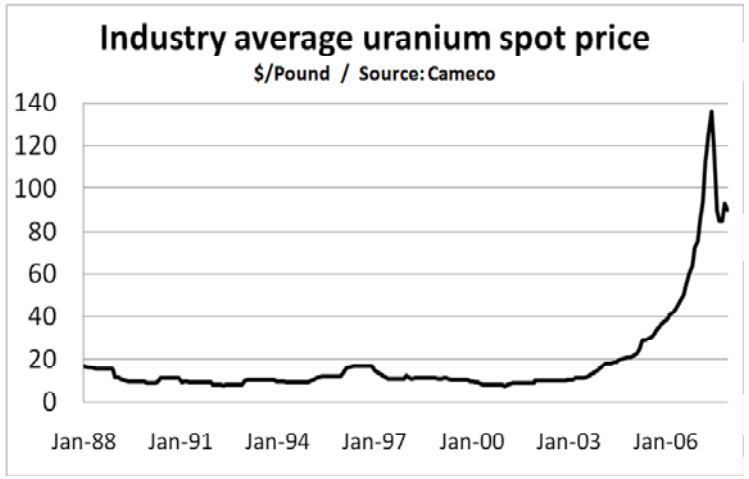


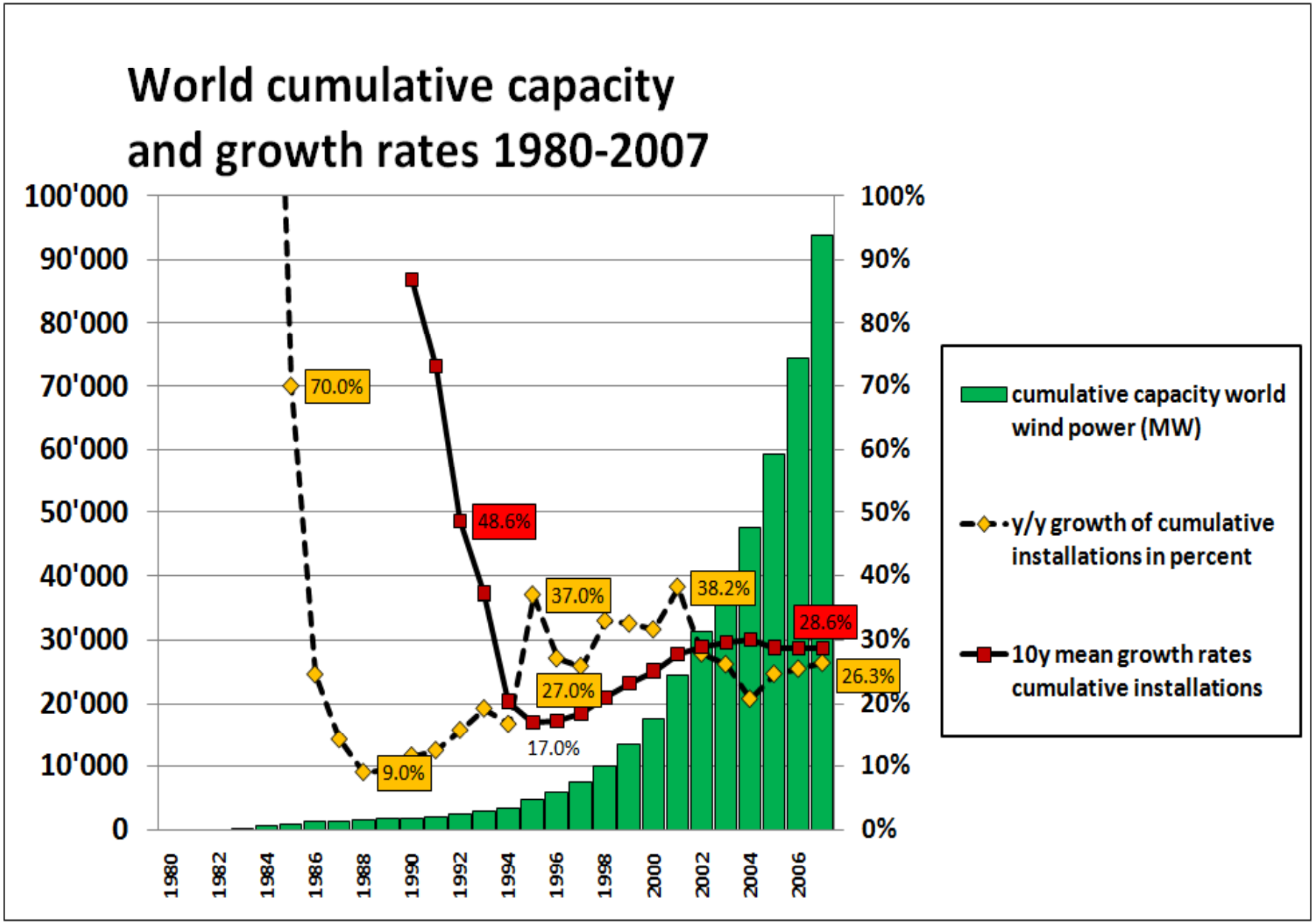
Oil, gas, coal, uranium prices + x-100%







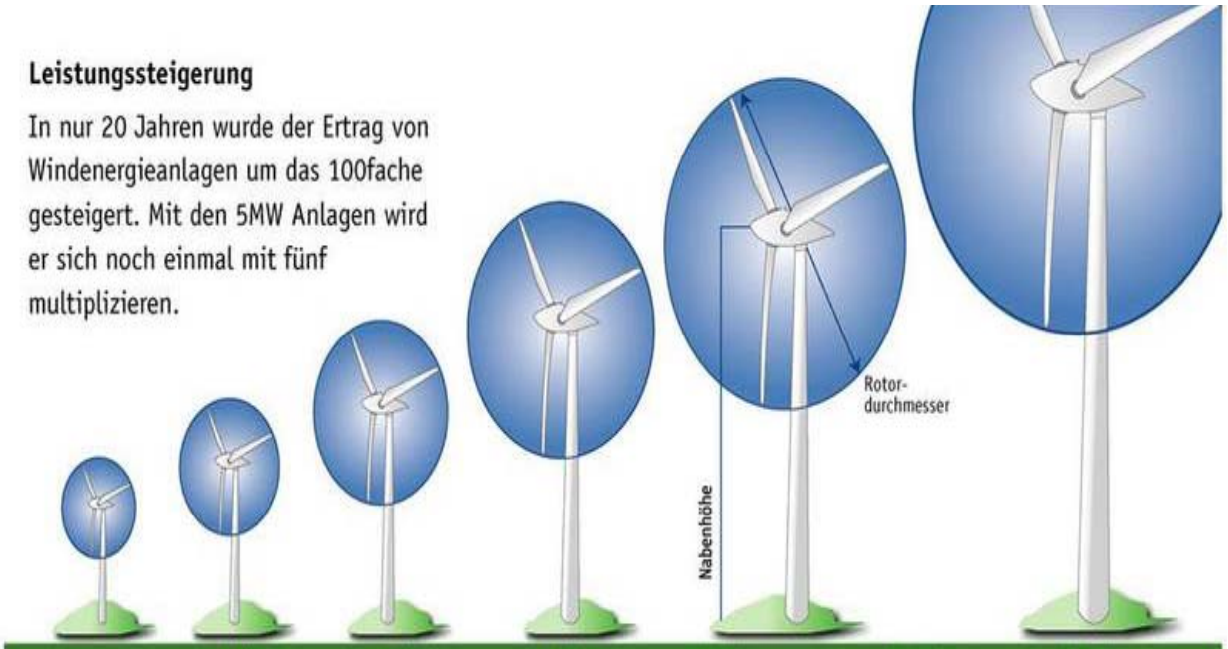



World cumulative capacity and growth rates 1980-2007
100'000
90'000
80'000
70'000
60'000
50'000
40'000
30'000
20'000
10'000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
70.0%
9.0%
48.6%
17.0%
37.0%
27.0%
38.2%
28.6%
26.3%
cumulative capacity world wind power (MW)
y/y growth of cumulative installations in percent
10y mean growth rates cumulative installations

Wind technology: bigger rotors = cheaper power
onshore 1500-3500 full-load hour per year
offshore: 3000-4500 full-load hour per year

Leistungssteigerung

In nur 20 Jahren wurde der Ertrag von Windenergieanlagen um das 100fache gesteigert. Mit den 5MW Anlagen wird er sich noch einmal mit fünf multiplizieren.

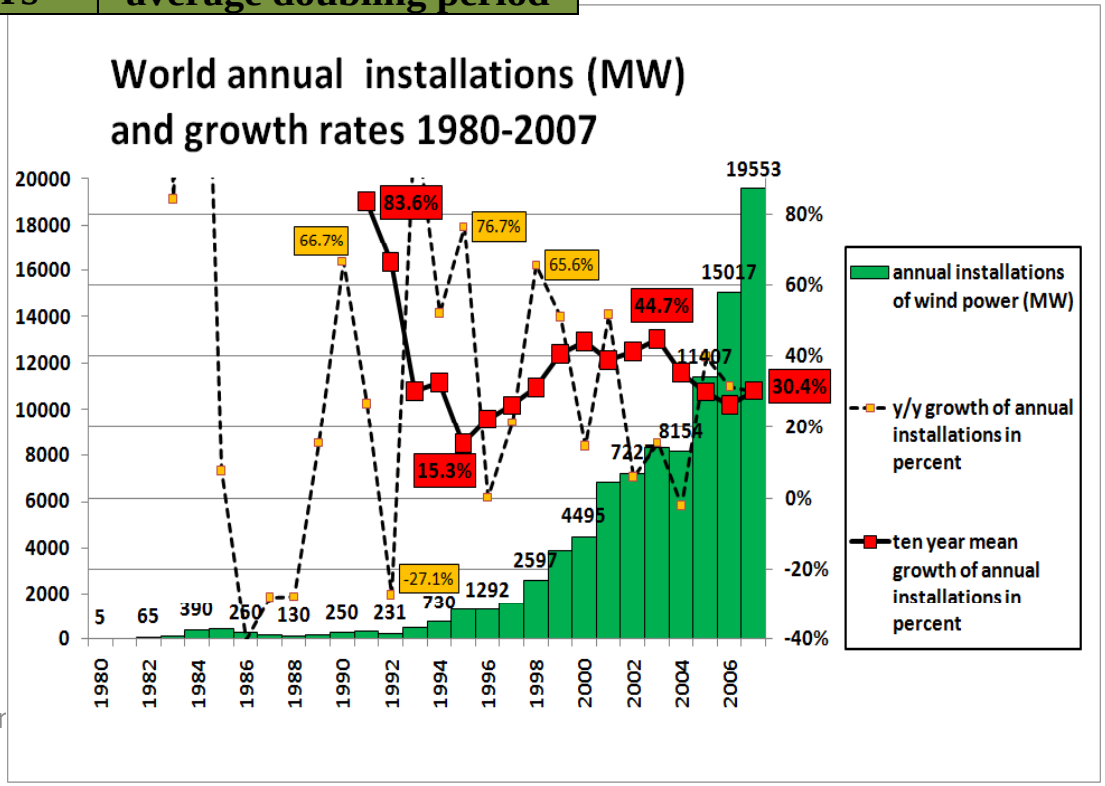


	1980	1985	1990	1995	2000	2005
Nennleistung :	30 kW	80 kW	250 kW	600 kW	1.500 kW	5.000 kW
Rotordurchmesser :	15 m	20 m	30 m	46 m	70 m	115 m
Nabenhöhe :	30 m	40 m	50 m	78 m	100 m	120 m
Jahresenergieertrag :	35.000 kWh	95.000 kWh	400.000 kWh	1.250.000 kWh	3.500.000 kWh	ca. 17.000.000 kWh

Annual additions doubling every 2½ years!

year	annual additions MW	years of doubling	2^n	n = (Number of doublings)
1990	250	Start	250	
1994	730	4	500	1
1995	1290	1	1000	2
1998	2597	3	2000	3
2000	4495	2	4000	4
2003	8344	3	8000	5
2007	19553	4	16000	6
		2.5years	average doubling period	

Annual additions of wind power

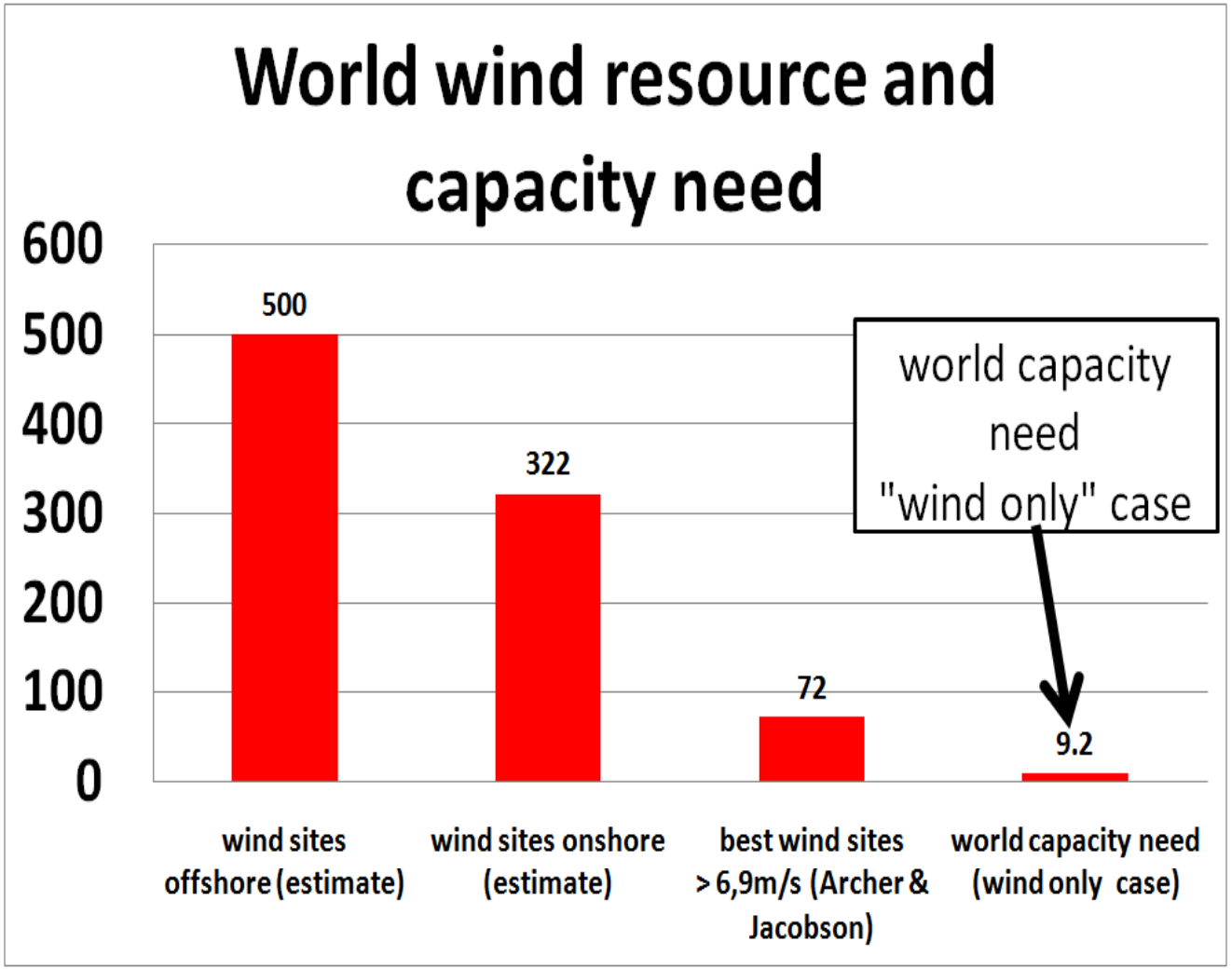


One dozen reasons of wind power's success

1. The primary energy (wind) is cost-free
2. The primary energy is renewable and never runs out
3. There is an abundant resource and stable life-cycle-costs of its use can be guaranteed
4. Wind power is competitive with other new power sources
5. There are no carbon emissions, no air pollution and no hazardous waste
6. No water for cooling is needed
7. short energy payback of energy invested, less than one year
8. global, easy access to wind technology, compared to nuclear
9. Short time to market, erection of wind farms within one year
10. Distances from good wind sites to consumers moderate (1-1000 miles) compared to oil, gas etc.
11. Fast innovation cycles, based on maturing know-how.
12. Still a young technology, allowing more cost reductions

Wind resource: could cover ~ 100 times global electricity demand

Source: Cristina Archer, Mark Jacobson/Stanford 2005



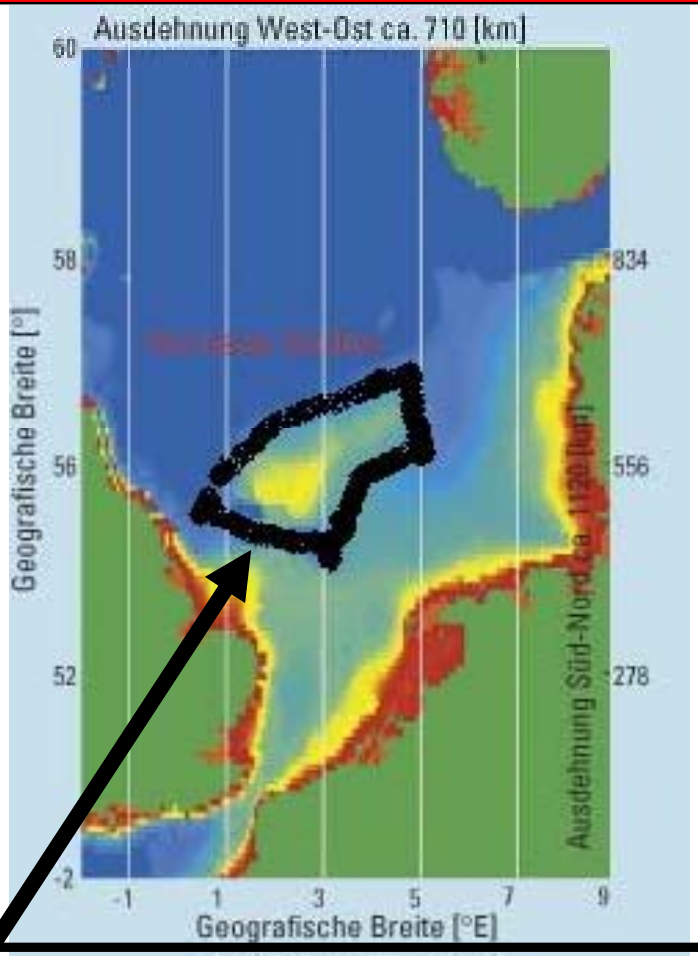

Gütsch, Switzerland

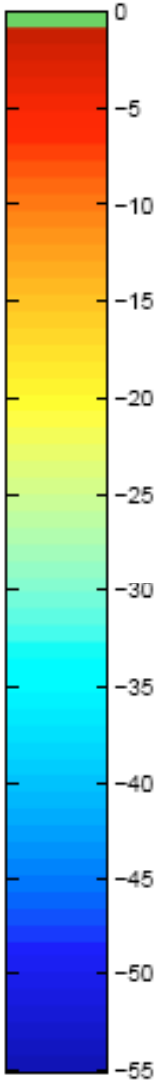

Utgrunden Schweden


US-Windfarm

Southern North sea:

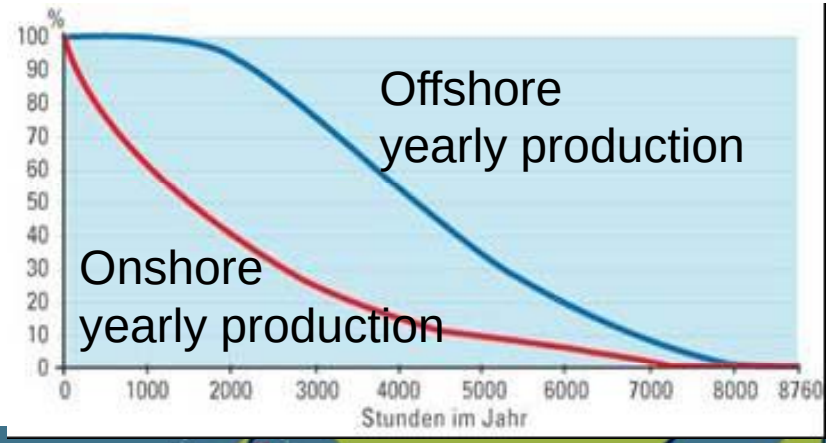
250‘000 km^2< 45m = ~ 13 Mbd = 7500 TWh

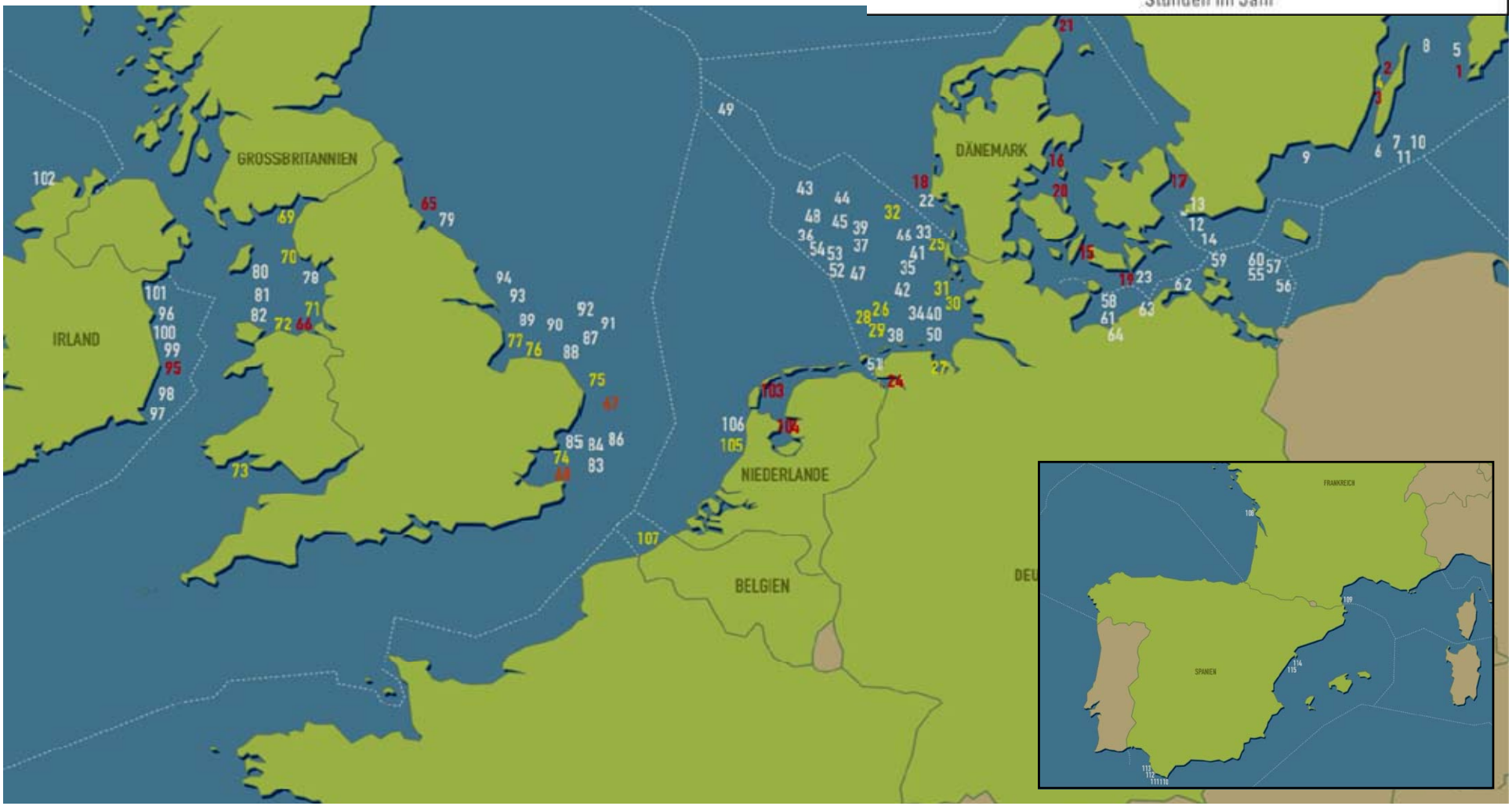


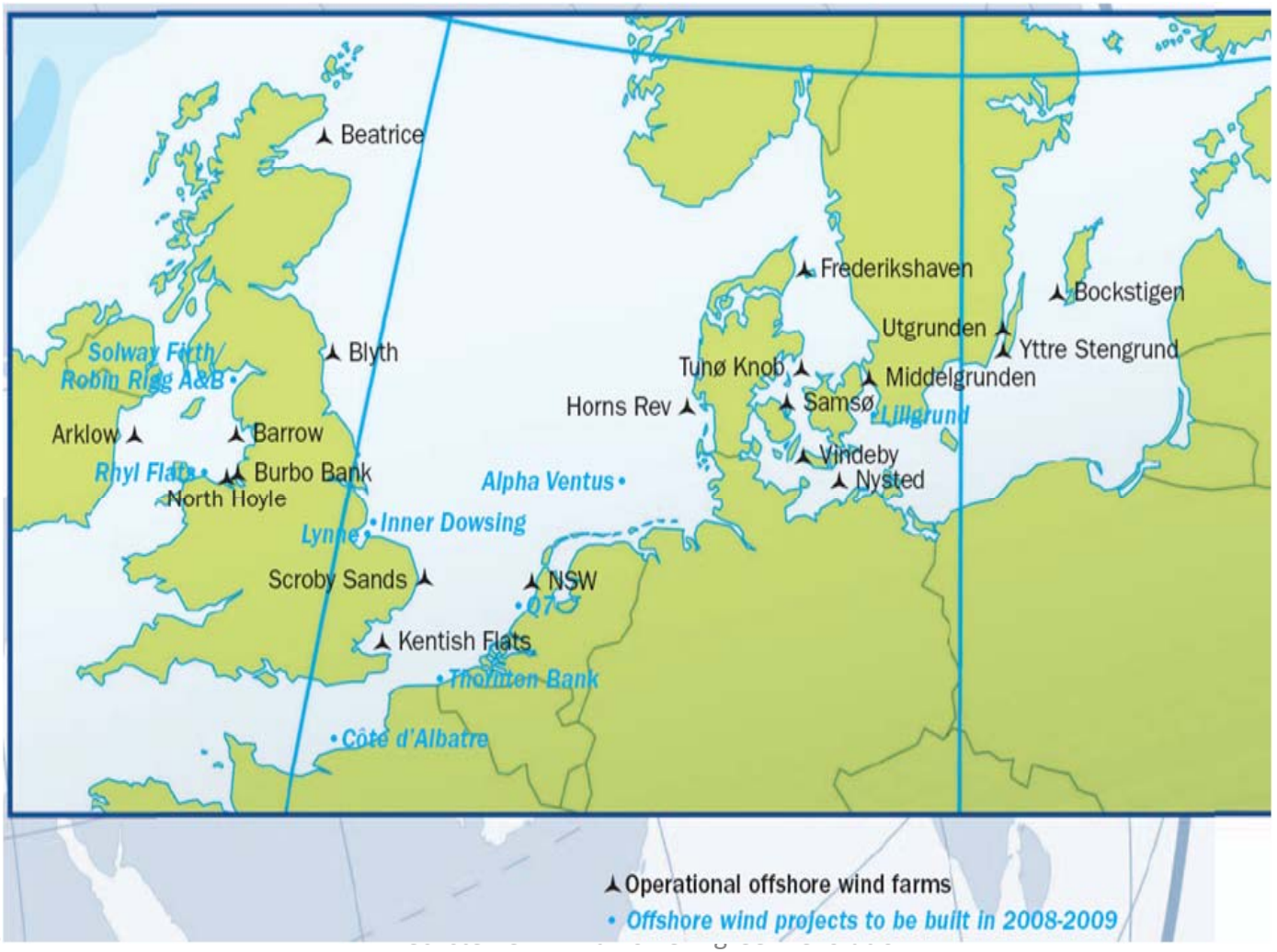


Polygon area can cover EU-electricity consumption
Two turbines / 10 MW per km^2

Offshore-projects in Europe






Beatrice
Blyth
Solway Firth
Robin Rigg A&B
Arklow
Barrow
Rhyl Flats
Burbo Bank
North Hoyle
Lynn
Inner Dowsing
Scroby Sands
Kentish Flats
Alpha Ventus
NSW
Q7
Thornton Bank
Côte d'Albatre
Horns Rev
Frederikshaven
Bockstigen
Utgrunden
Yttre Stengrund
Tunø Knob
Middelgrunden
Samsø
Lillgrund
Vindeby
Nysted
Operational offshore wind farms
Offshore wind projects to be built in 2008-2009

Floating turbines – a new world of renewable power

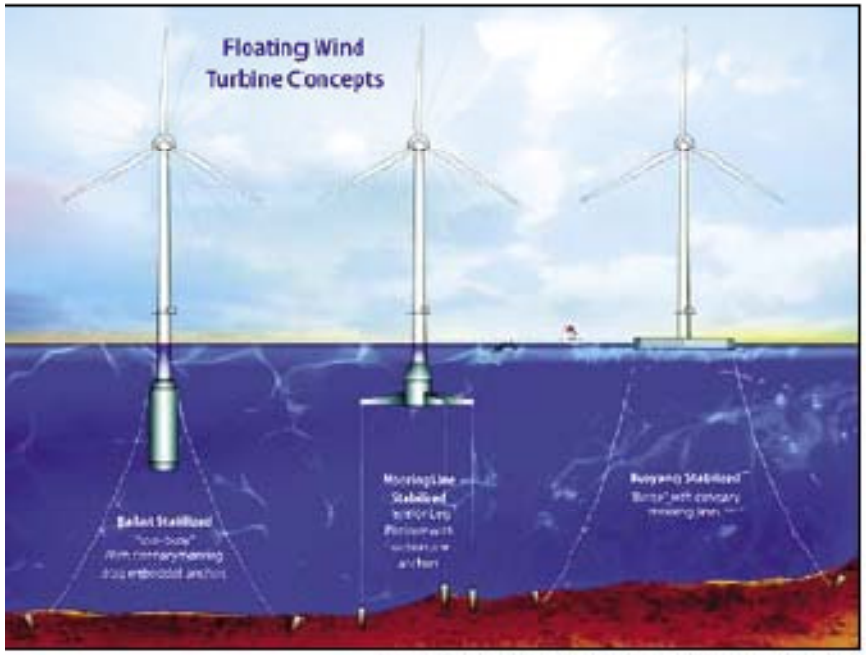


FIGURE COURTESY / NATIONAL RENEWABLE ENERGY LABORATORY

“Deep-sea oil rigs inspire MIT designs for giant wind turbines”

Norsk hydro: first prototype announced for 2007

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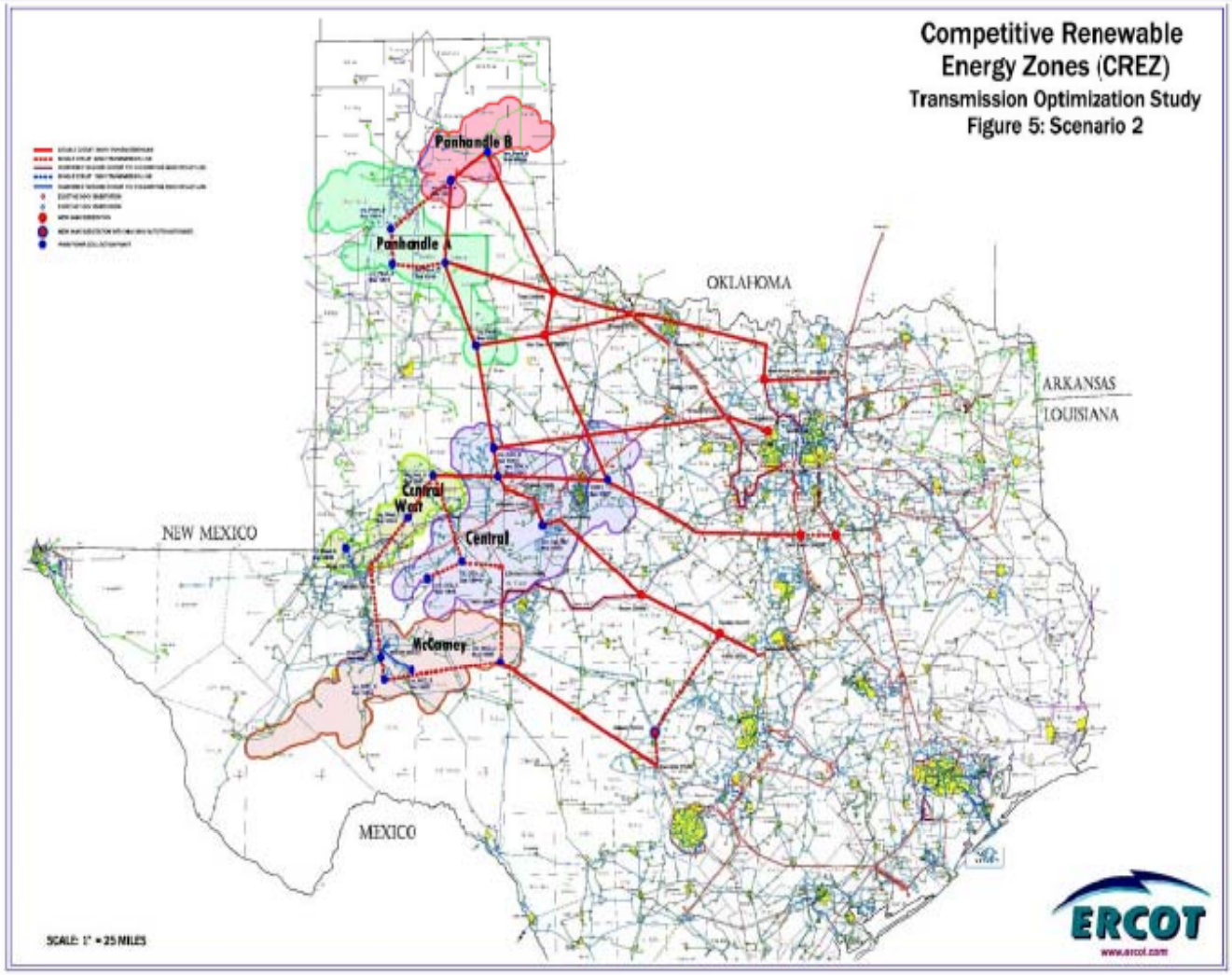
12. Still a young technology, allowing more cost reductions

Texas: 5 billion $ interconnection

45 billion $ private investments in turbines

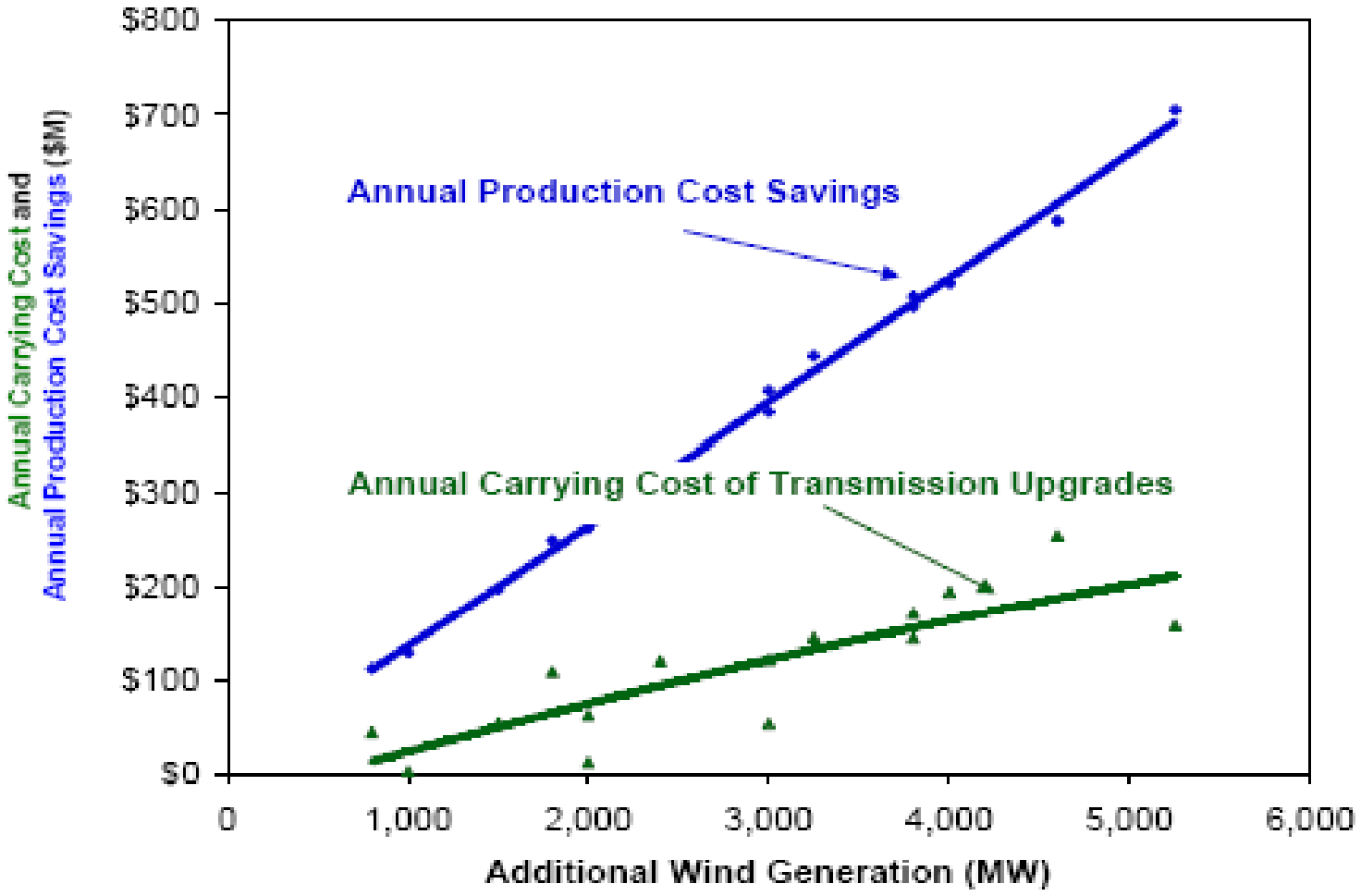
Texas PUC decision July 2008



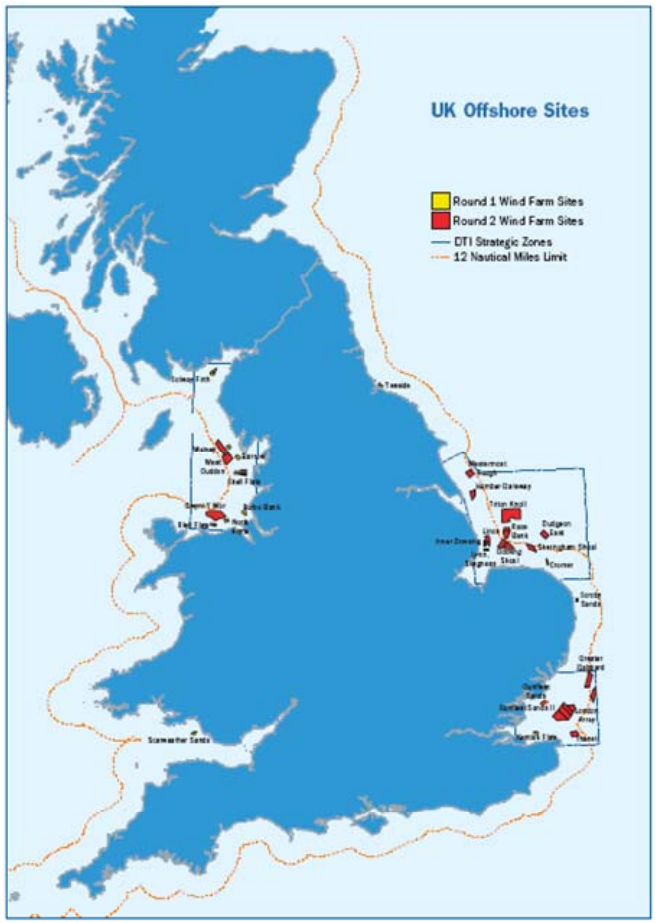
T. Boone Pickens
Texas oil billionaire
Investing 10 billion $
in Texas wind energy

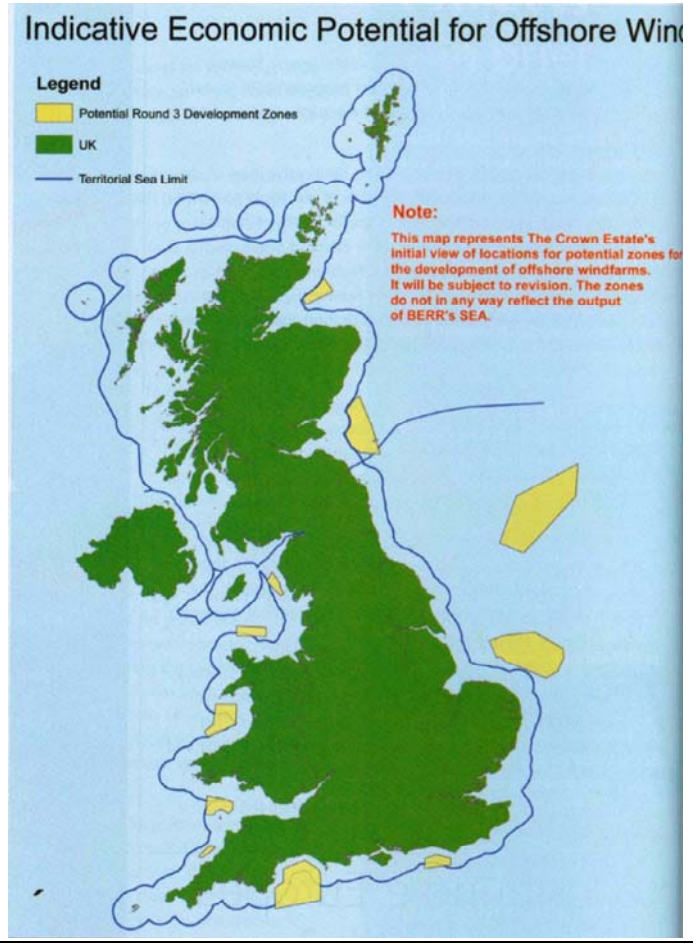
Texas: net savings of 3.8 Cents per kWh

source: Texas PUC public utility commission



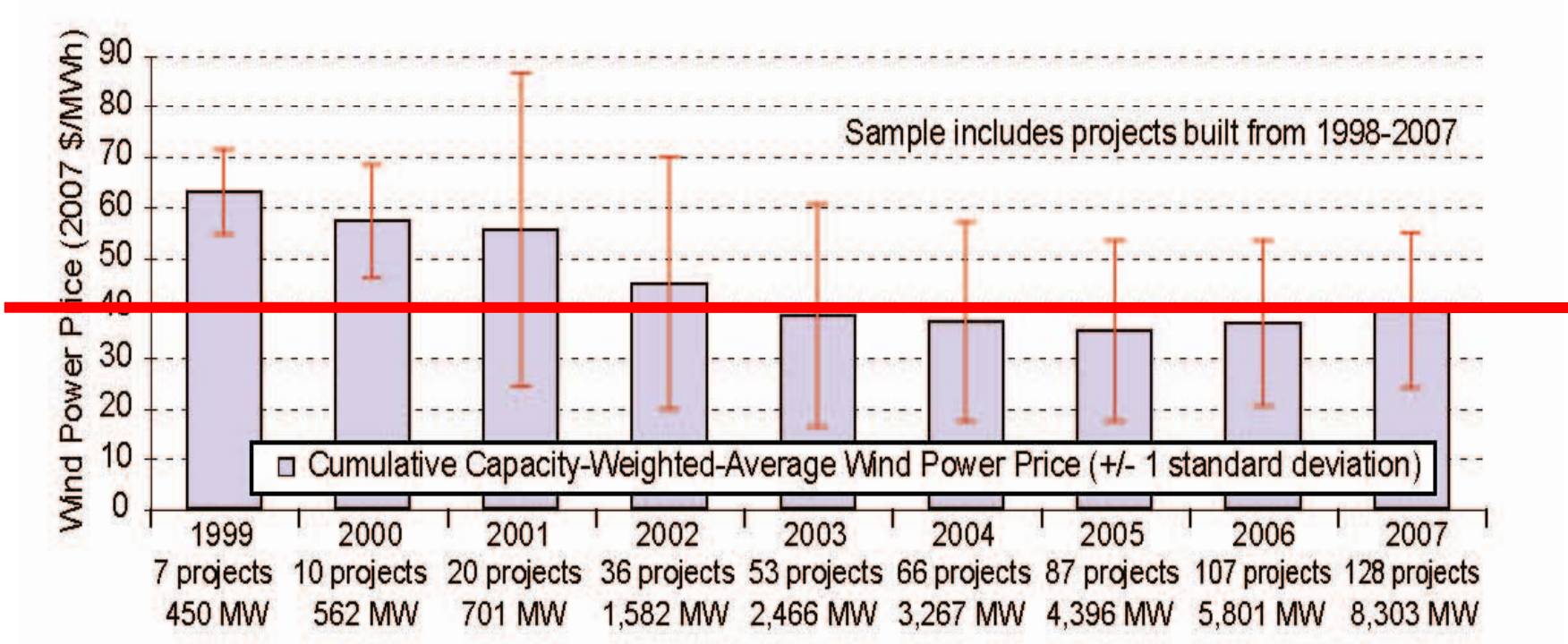
British round 1, 2 wind zones (left) and Round 3 (right)





Price: 4 US-Cents /kWh
wind today cheaper than oil

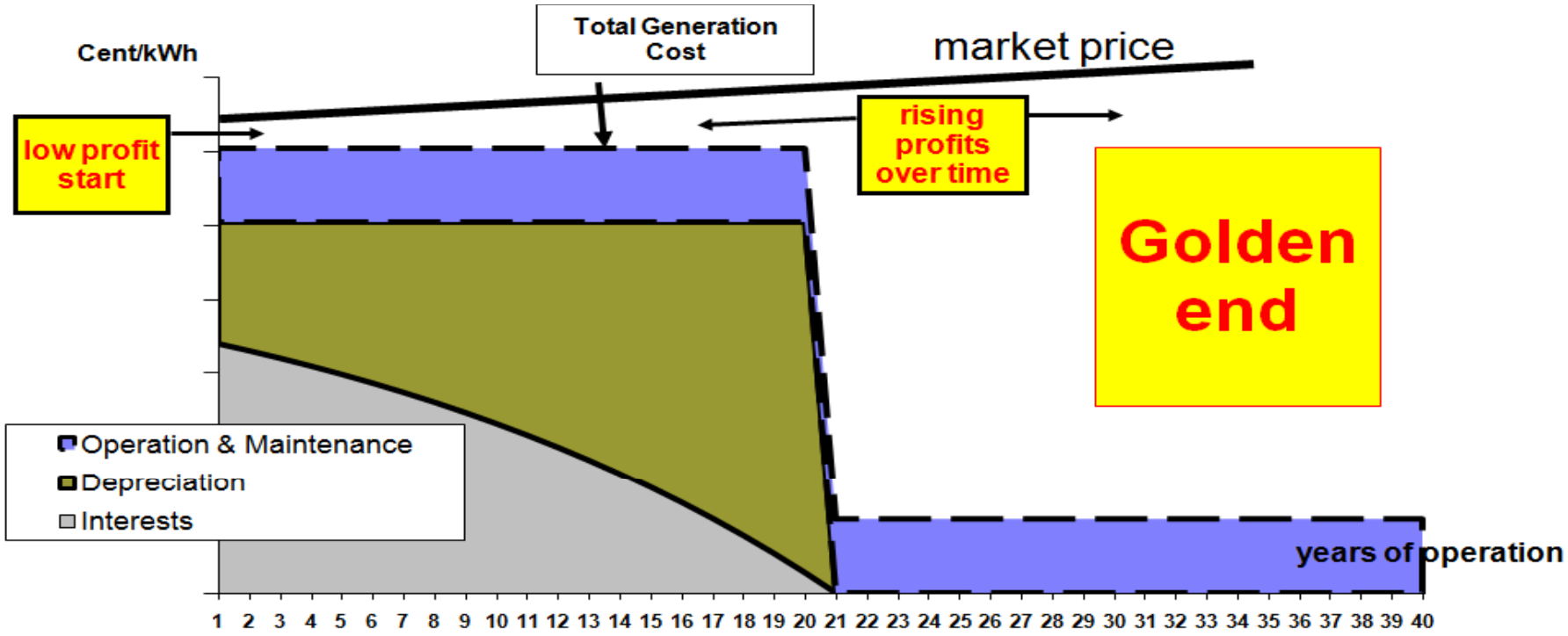
source: US DOE



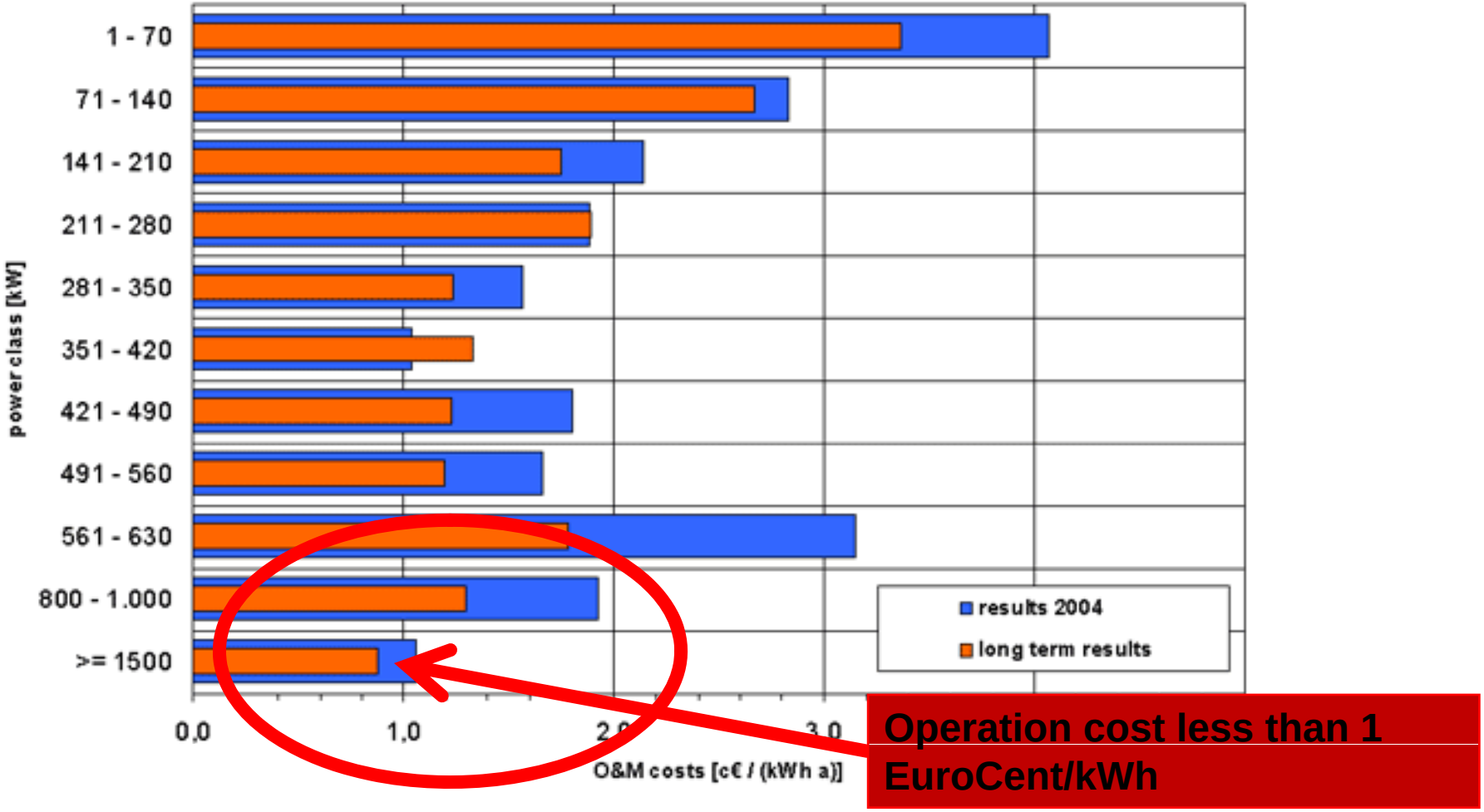
Source: Berkeley Lab database.

Figure 13. Cumulative Capacity-Weighted-Average Wind Power Prices Over Time

Cost- and pay-back-structure of renewables over time
High initial capital cost, low O&M-costs, no fuel cost bring golden end over life cycle

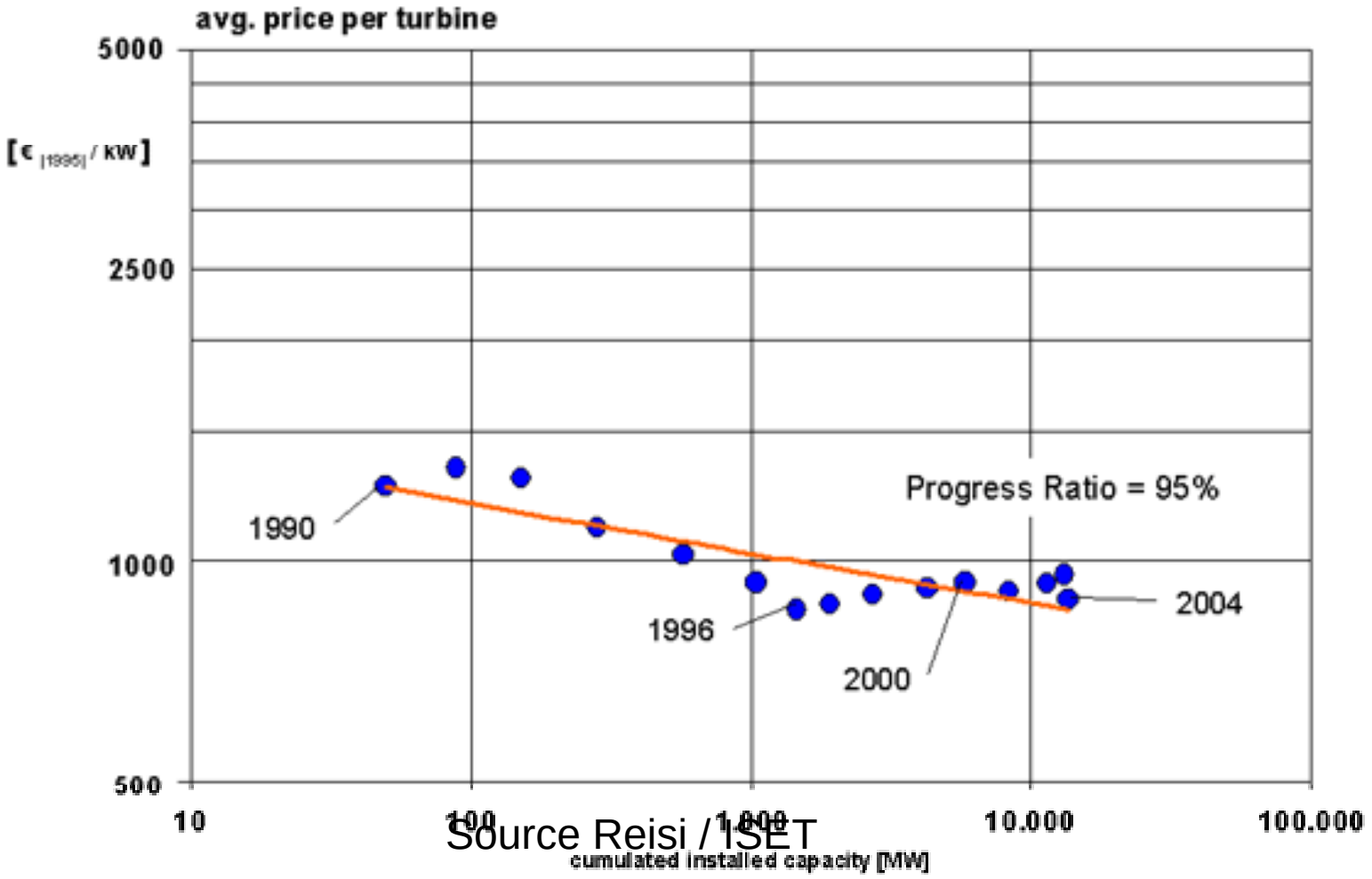


Wind power at 1 Cent/kwh when turbine is paid



Wind turbines get ever cheaper

from 1 Euro/Watt today to 0.5 Euro/Watt by 2020

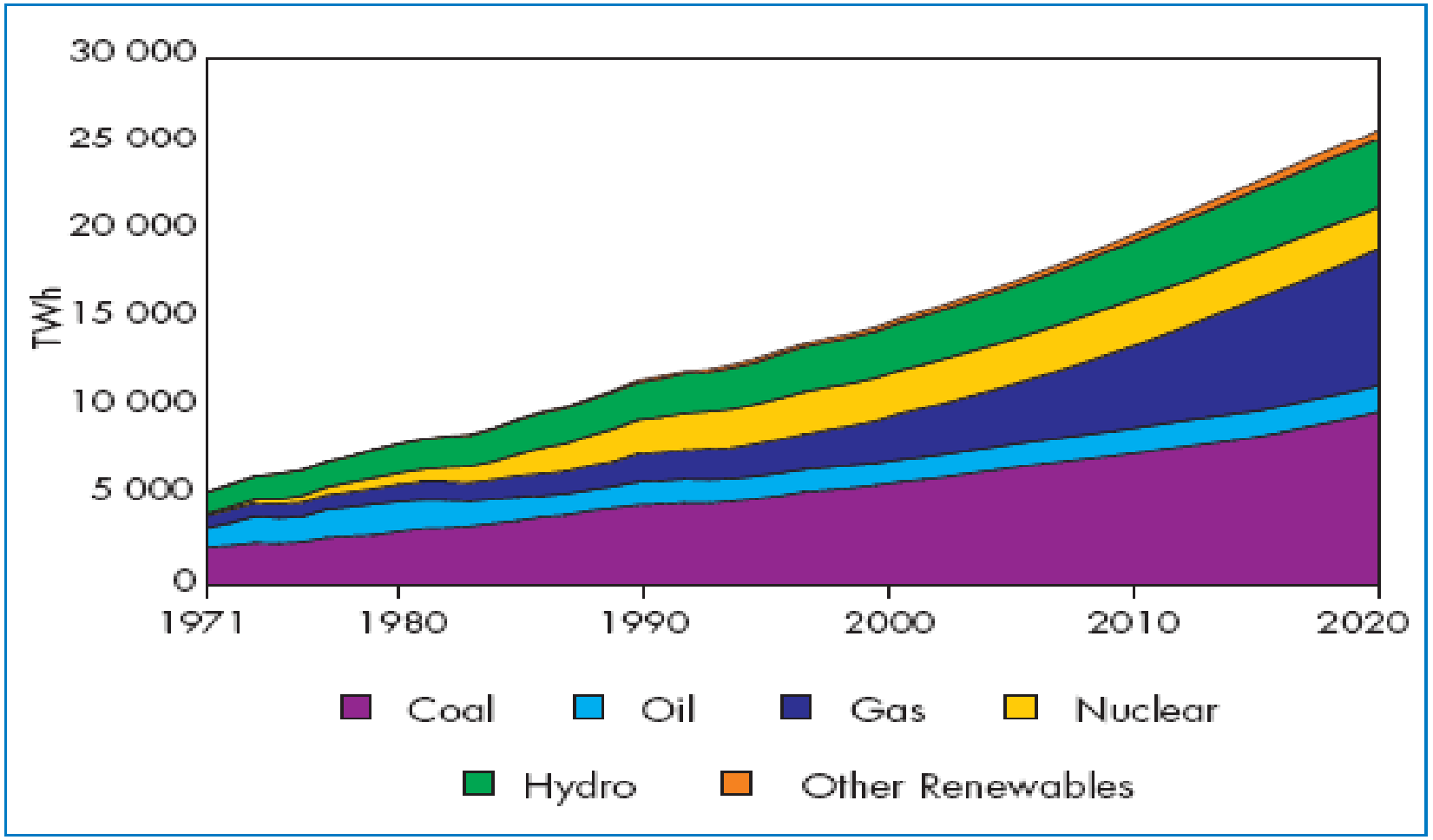


Source Reisi / ISET

WHY DID I NEVER HEAR ABOUT THAT?

IEA World Energy Outlook
(WEO 2000)

Figure 3.9: **World Electricity Generation, 1971-2020**



The IEA Projections

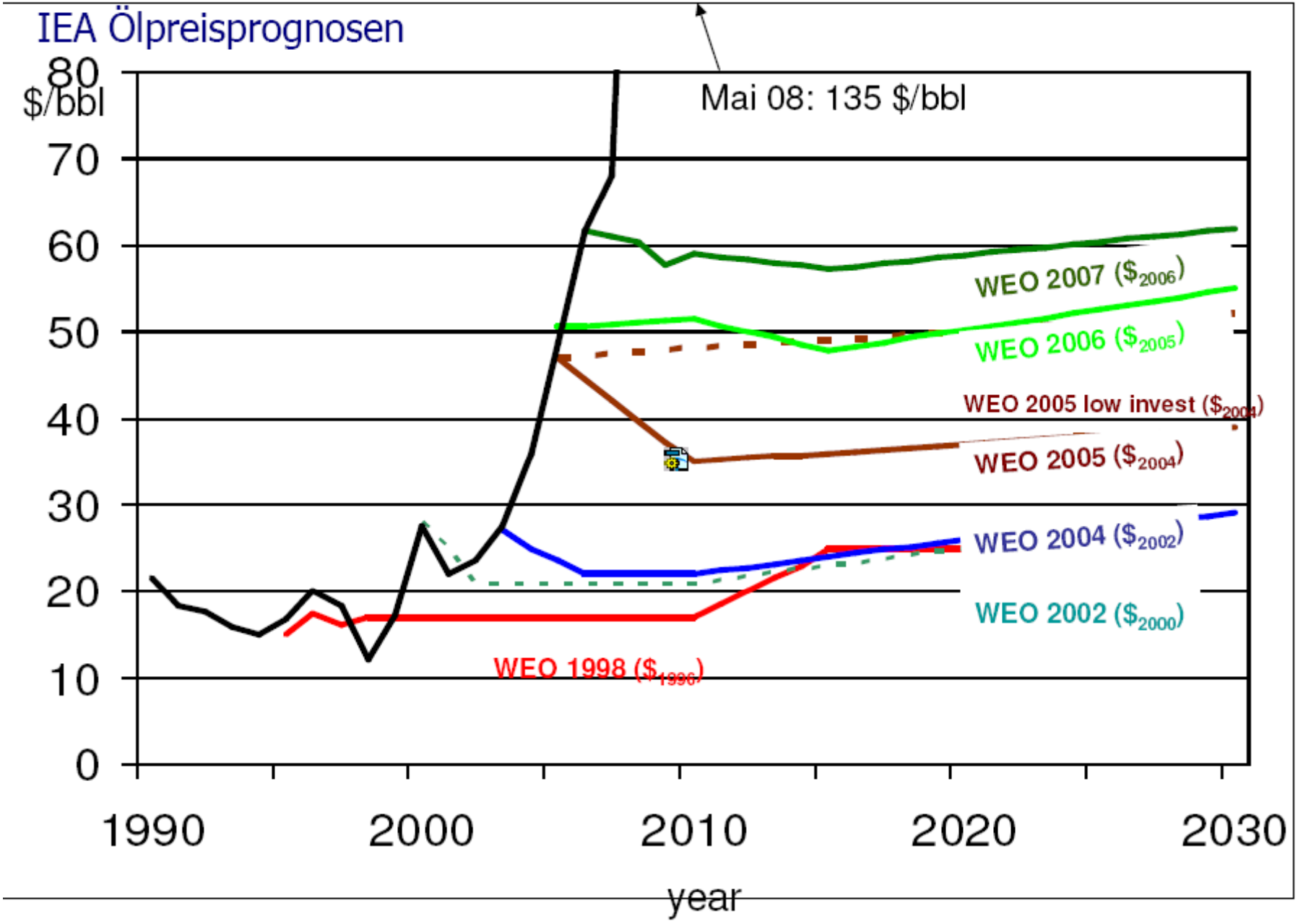
"*Crude oil prices are assumed to remain flat until **2010** at around **$21 per barrel** (in year 2000 dollars) – their average level for the past 15 years. They will then rise steadily to **$29 in 2030**. Natural gas prices will move more or less in line with oil Prices…"*

International Energy Agency:
*World Energy Outlook **2002**, S. 37*

IEA method of supply prediction: ***predict demand!***

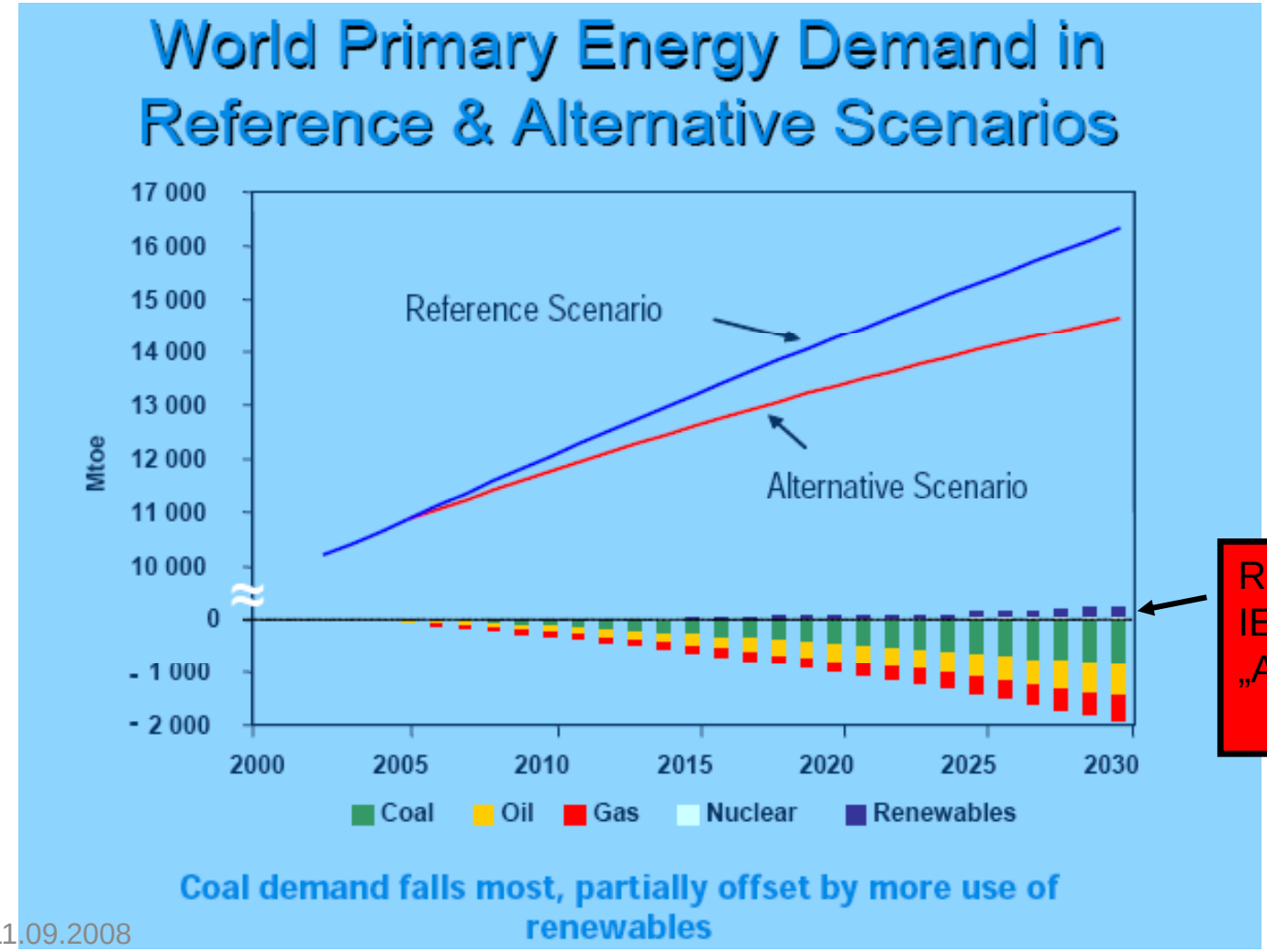
*„The **oil supply projections** of this Outlook are **derived from** aggregated projections of oil **demand**….*
Opec conventional oil production is assumed to fill the gap.“

World Energy Outlook 2002 p. 95


IEA Ölpreisprognosen
$/bbl
80
70
60
50
40
30
20
10
0
1990
2000
2010
2020
2030
year
Mai 08: 135 $/bbl
WEO 2007 ($2006)
WEO 2006 ($2005)
WEO 2005 low invest ($2004)
WEO 2005 ($2004)
WEO 2004 ($2002)
WEO 2002 ($2000)
WEO 1998 ($1996)

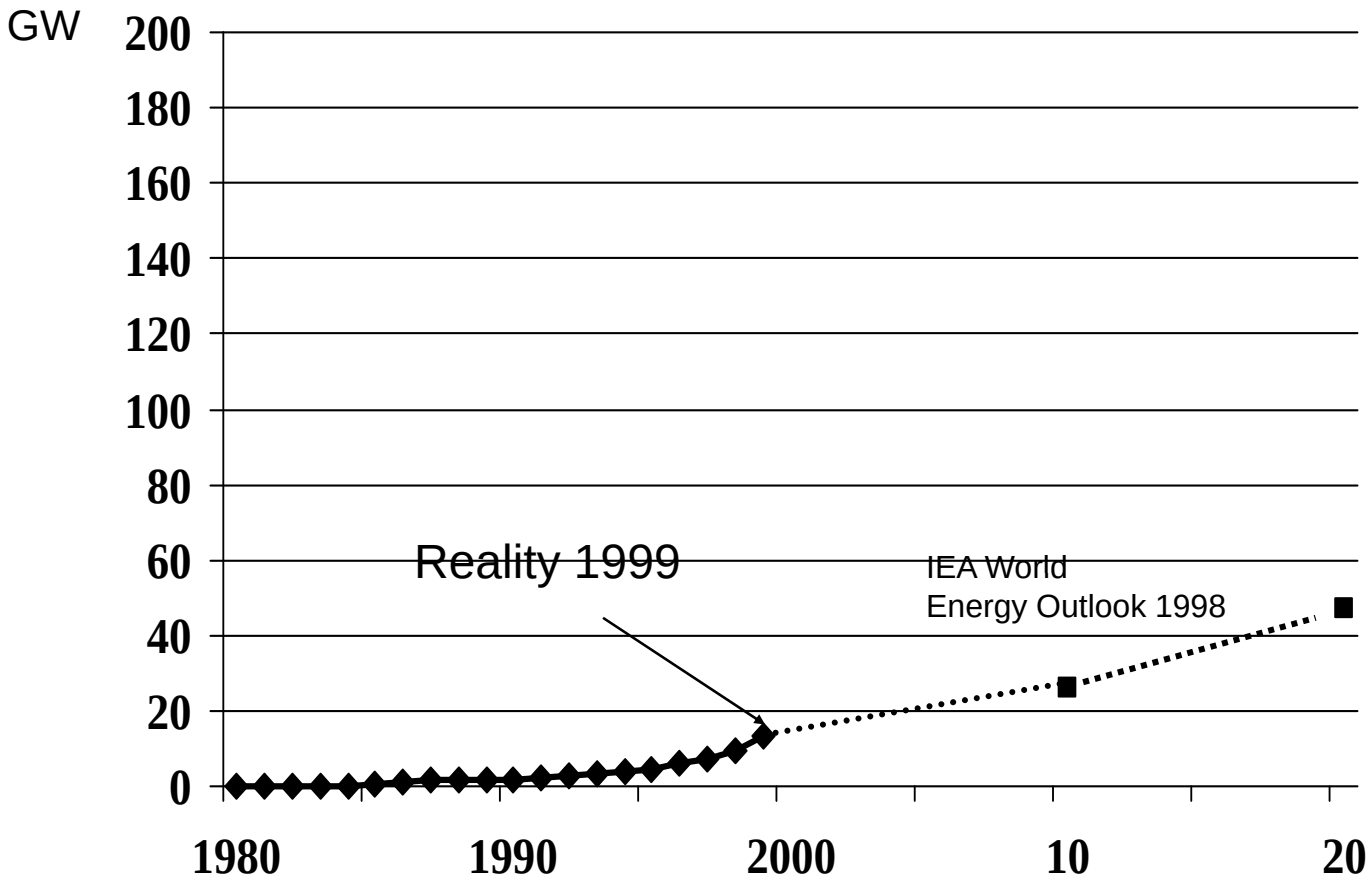
Alternative Szenario is just business as usual

source: IEA (Noé van Hulst), Security of Supply and Climate Change

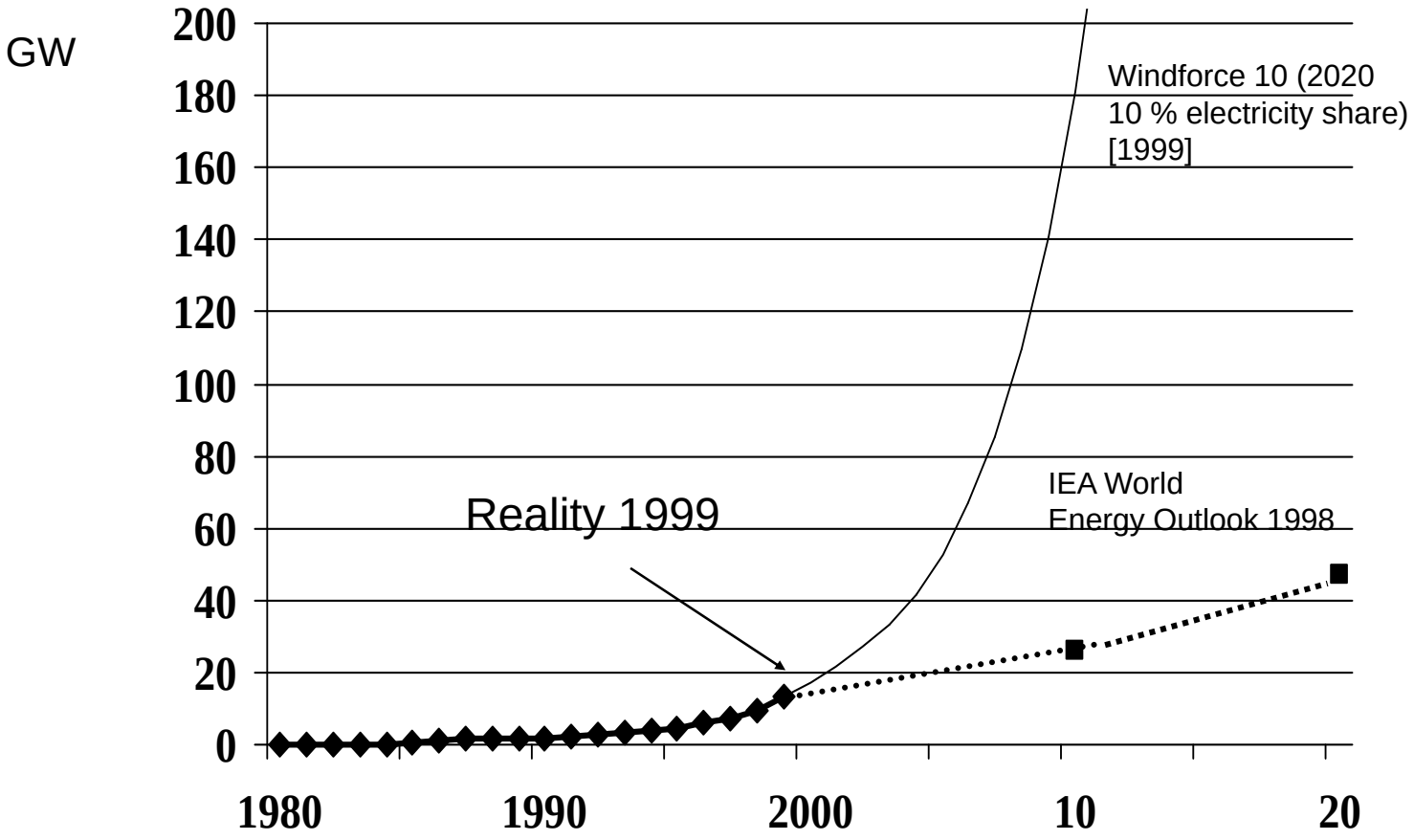


Renewables in the IEA-Perspective: „Alternative Scenario“

Wind power
IEA-forecast and reality



Wind power
IEA-forecast and reality



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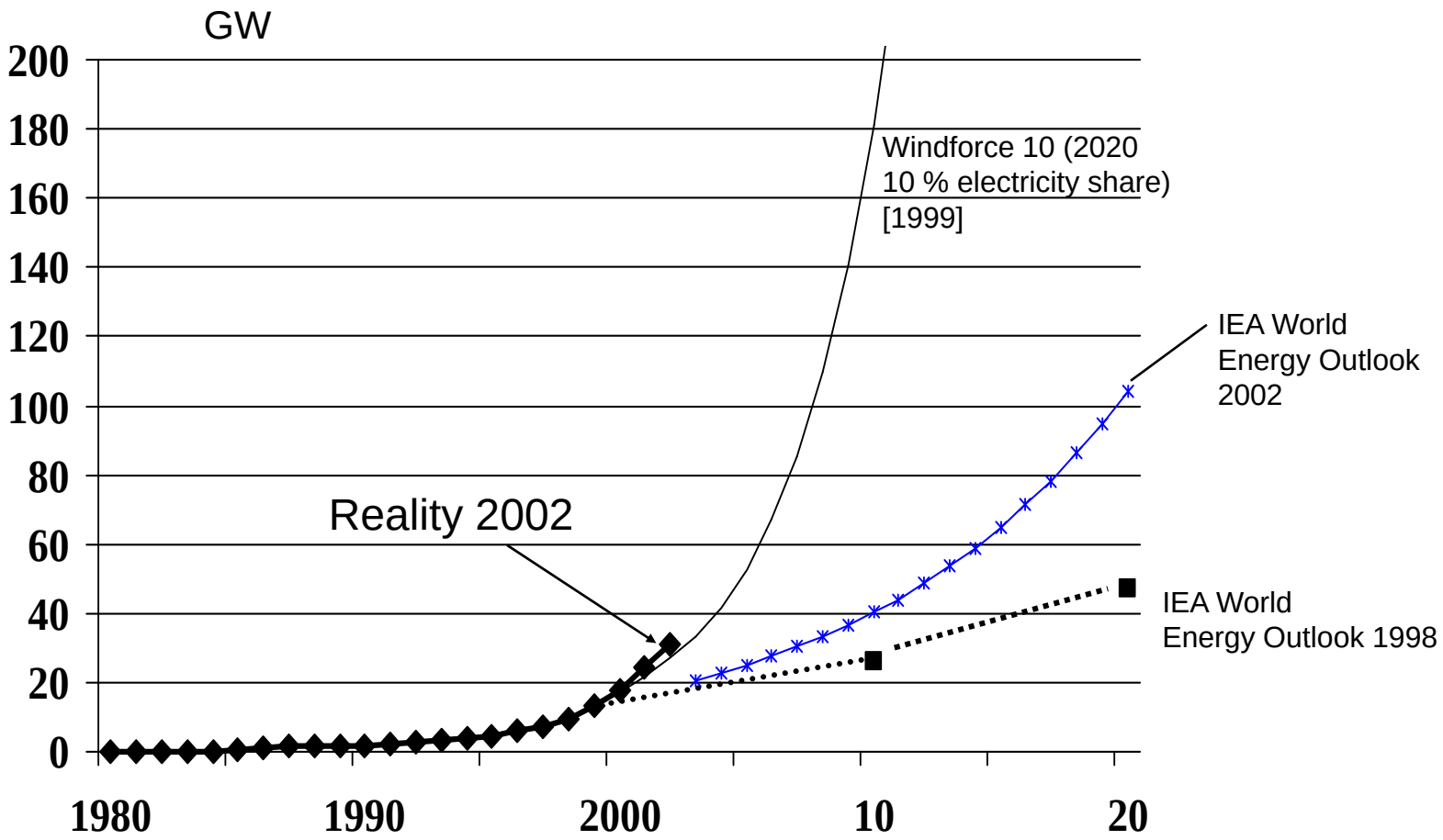
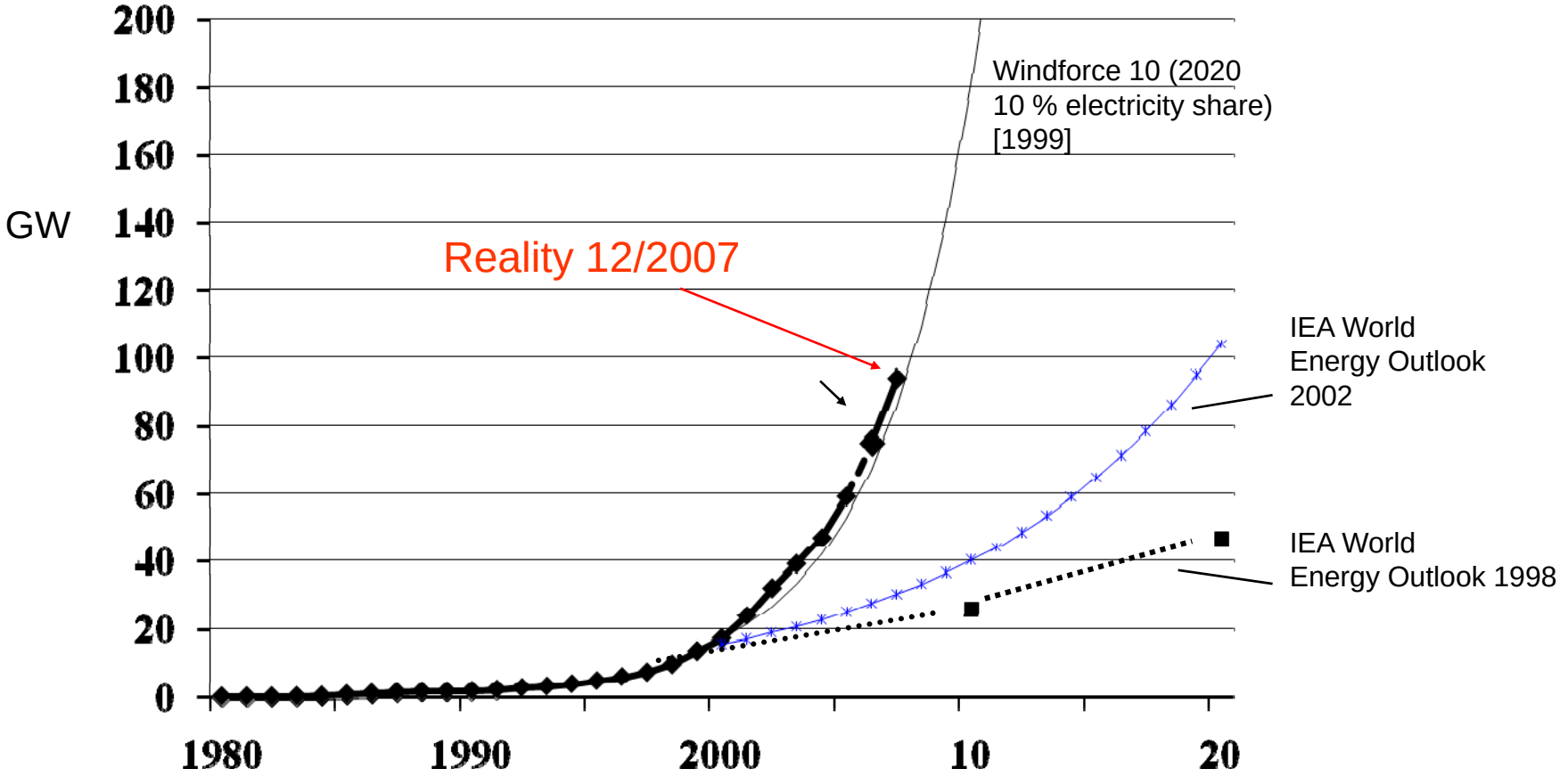
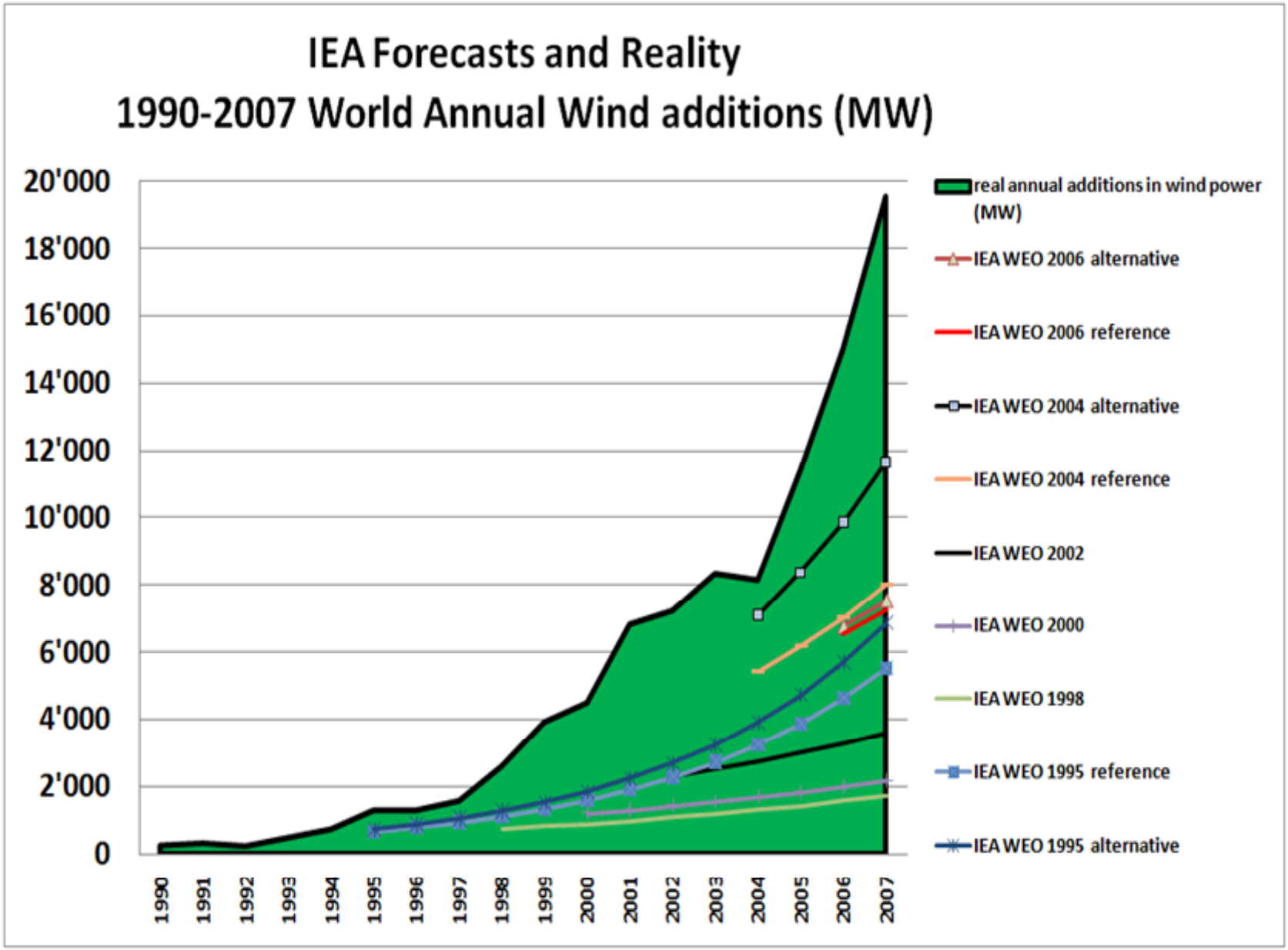
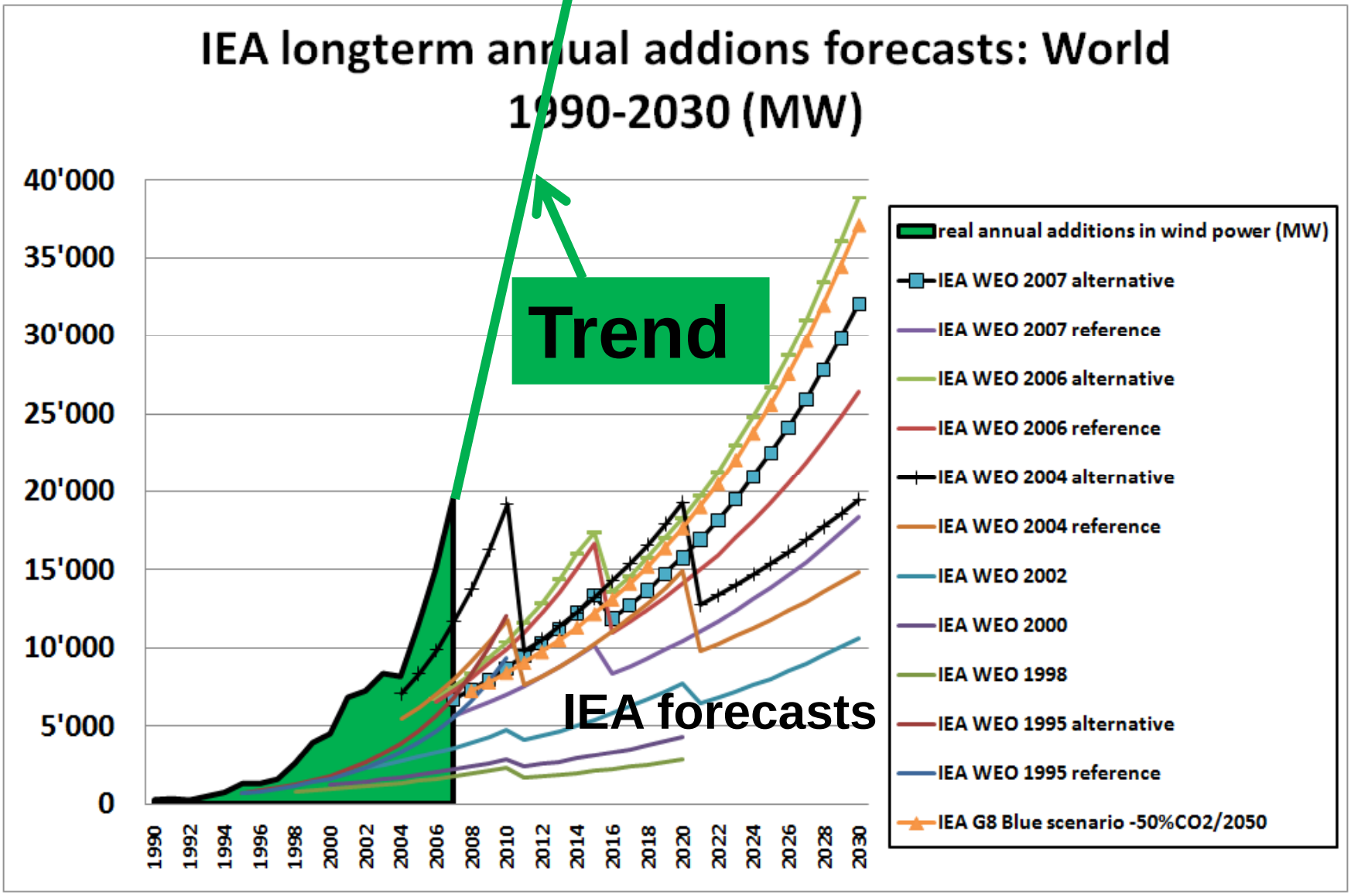


IEA: Prognosen und Wirklichkeit




IEA Forecasts and Reality
1990-2007 World Annual Wind additions (MW)
20'000
18'000
16'000
14'000
12'000
10'000
8'000
6'000
4'000
2'000
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
real annual additions in wind power (MW)
IEA WEO 2006 alternative
IEA WEO 2006 reference
IEA WEO 2004 alternative
IEA WEO 2004 reference
IEA WEO 2002
IEA WEO 2000
IEA WEO 1998
IEA WEO 1995 reference
IEA WEO 1995 alternative

IEA: Predicting stagnation for the next ten years



FOUR SCENARIOS – RESULTS OF A SIMPLE MODEL

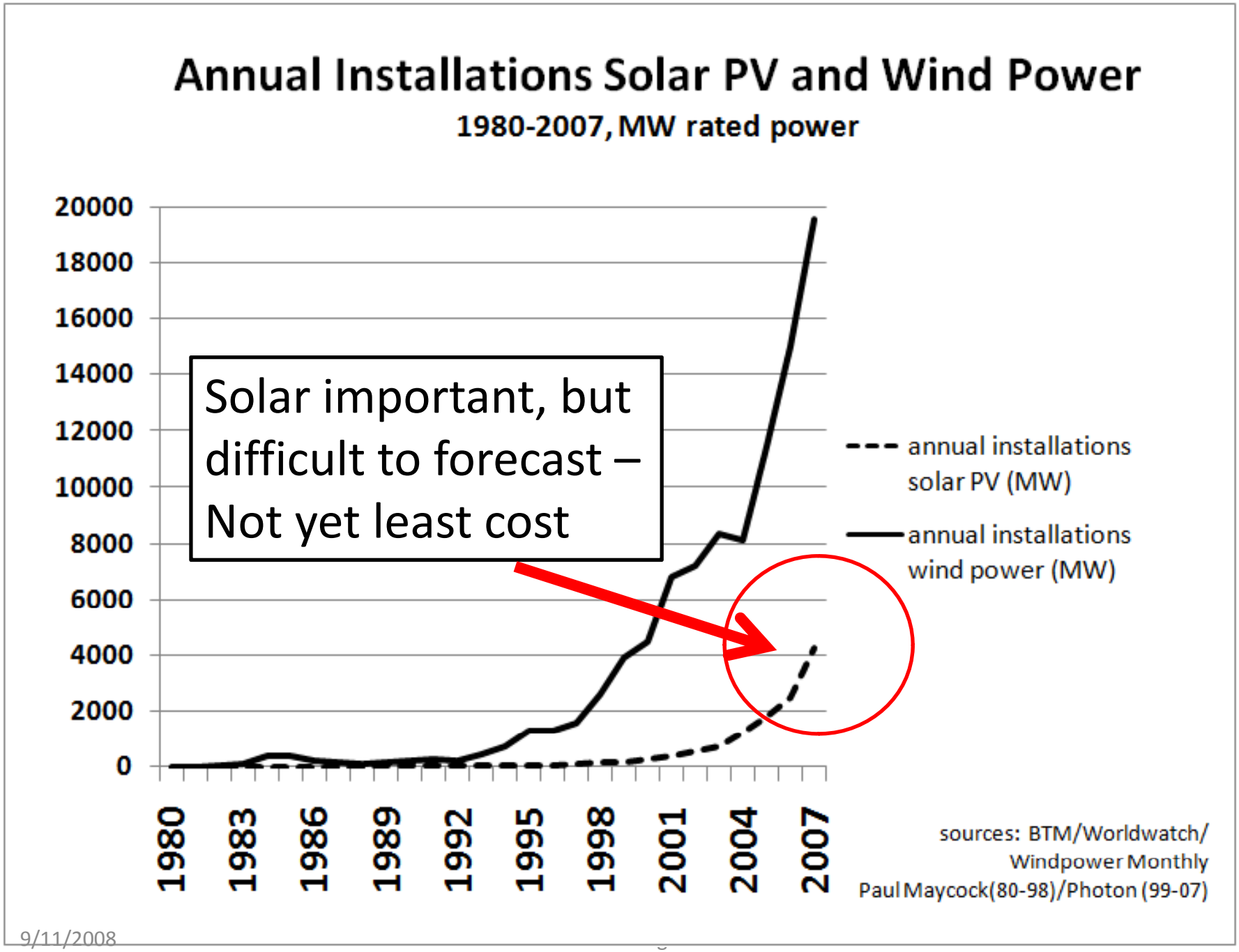
Model assumption: growth to continue!

Two parameters:
- electricity consumption
- wind-solar growth

- **High growth**
  = mean annual growth (1998-2007) <u>continuing</u>

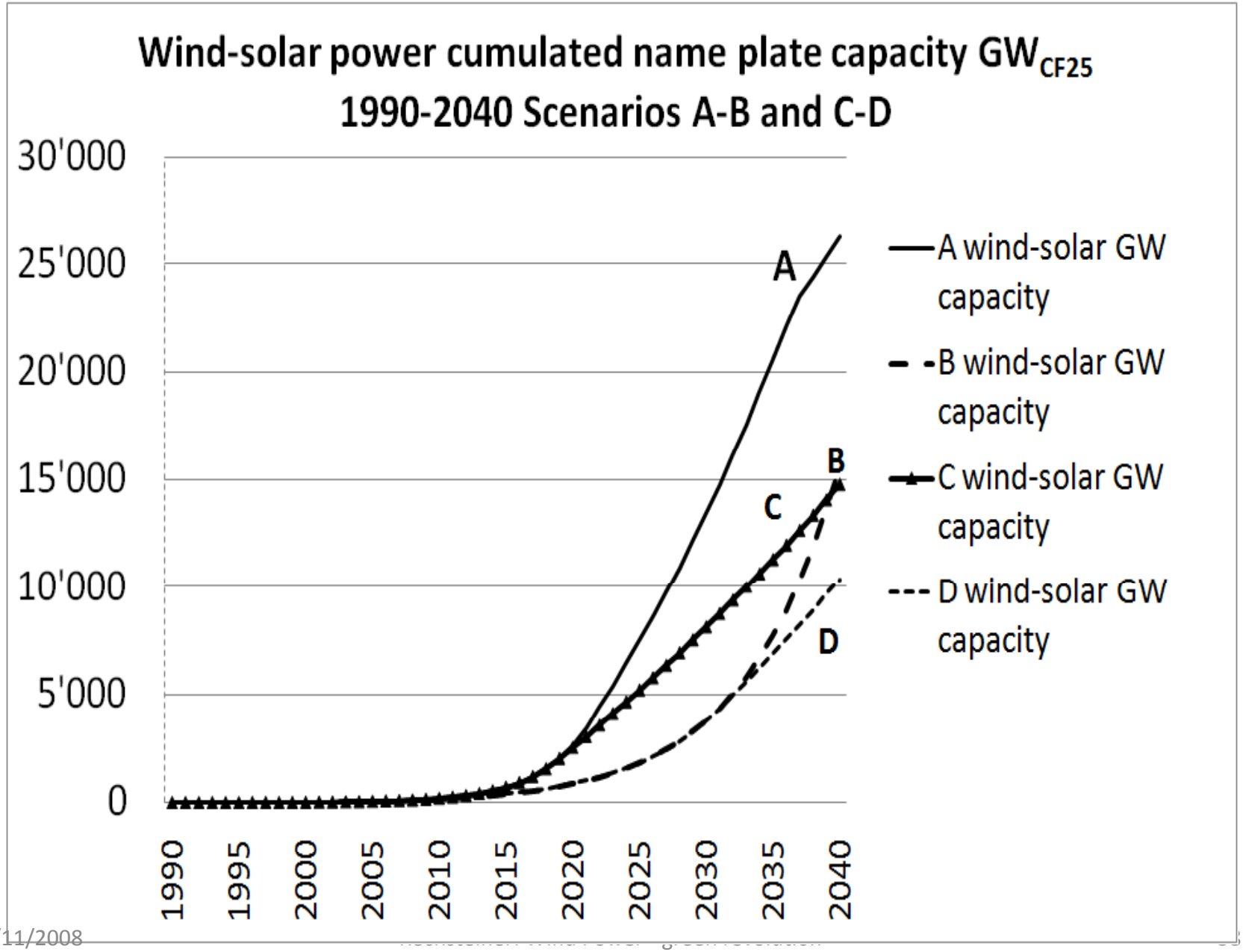
- **Moderate growth**
  = <u>half</u> of mean annual growth 1998-2007

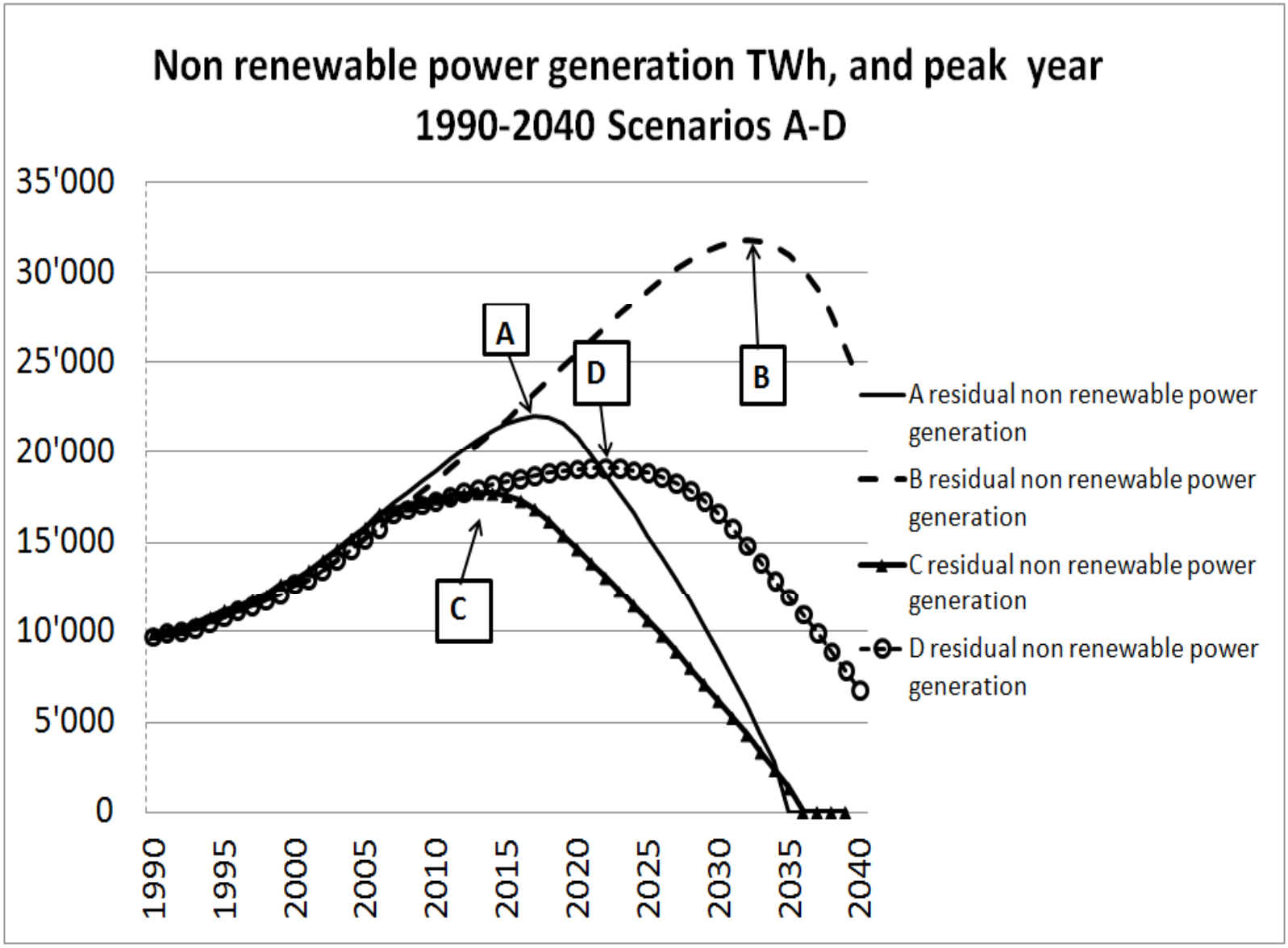
Solar in Germany:
explosive growth due to feed in tariffs


Annual Installations Solar PV and Wind Power
1980-2007, MW rated power
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1980
1983
1986
1989
1992
1995
1998
2001
2004
2007
Solar important, but difficult to forecast – Not yet least cost
annual installations solar PV (MW)
annual installations wind power (MW)
sources: BTM/Worldwatch/ Windpower Monthly
Paul Maycock(80-98)/Photon (99-07)

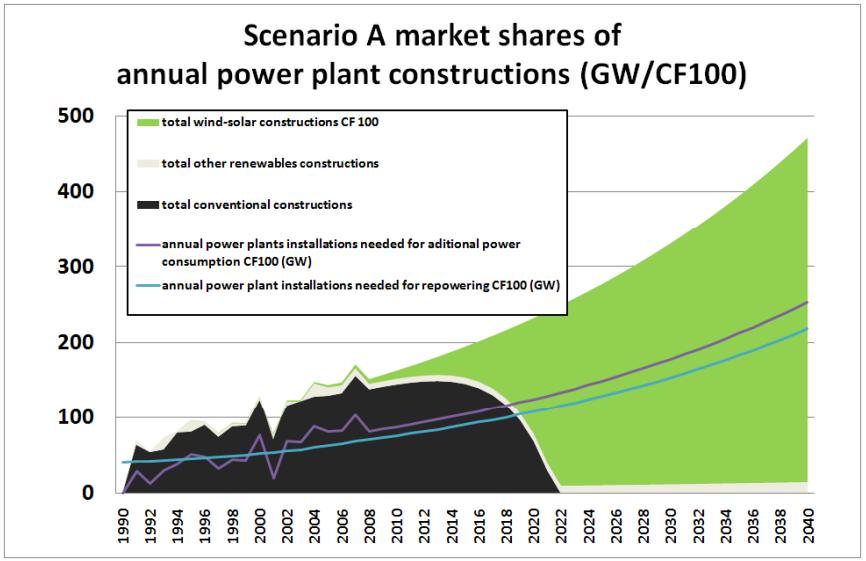
The growth rates

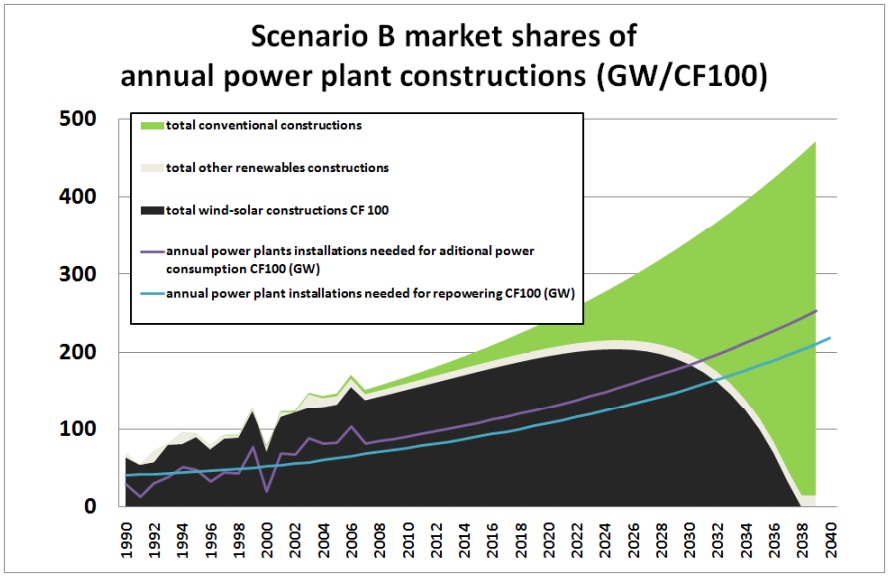
Scenario	Power consumption growth	Wind-solar sector growth (annual additions)
A	3.6%	30.4%
B	3.6%	15.2%
C	1.8%	30.4%
D	1.8%	15.2%

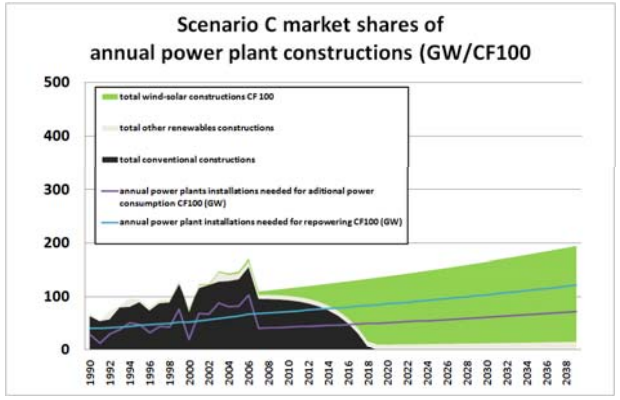

Wind-solar power cumulated name plate capacity GW$_{CF25}$
1990-2040 Scenarios A-B and C-D
30'000
25'000
20'000
15'000
10'000
5'000
0
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
A
B
C
D
A wind-solar GW capacity
B wind-solar GW capacity
C wind-solar GW capacity
D wind-solar GW capacity

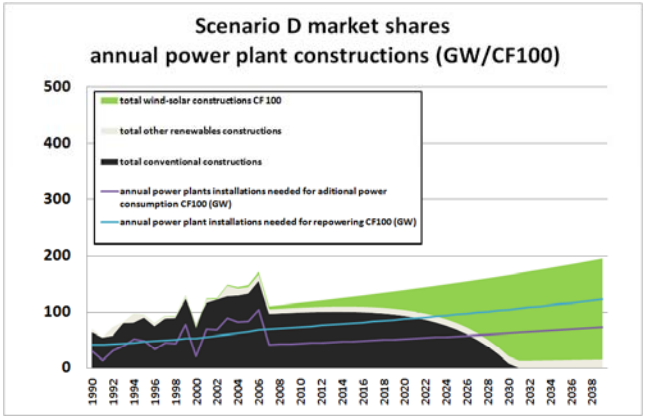

Non renewable power generation TWh, and peak year
1990-2040 Scenarios A-D
35'000
30'000
25'000
20'000
15'000
10'000
5'000
0
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
A
B
C
D
A residual non renewable power generation
B residual non renewable power generation
C residual non renewable power generation
D residual non renewable power generation

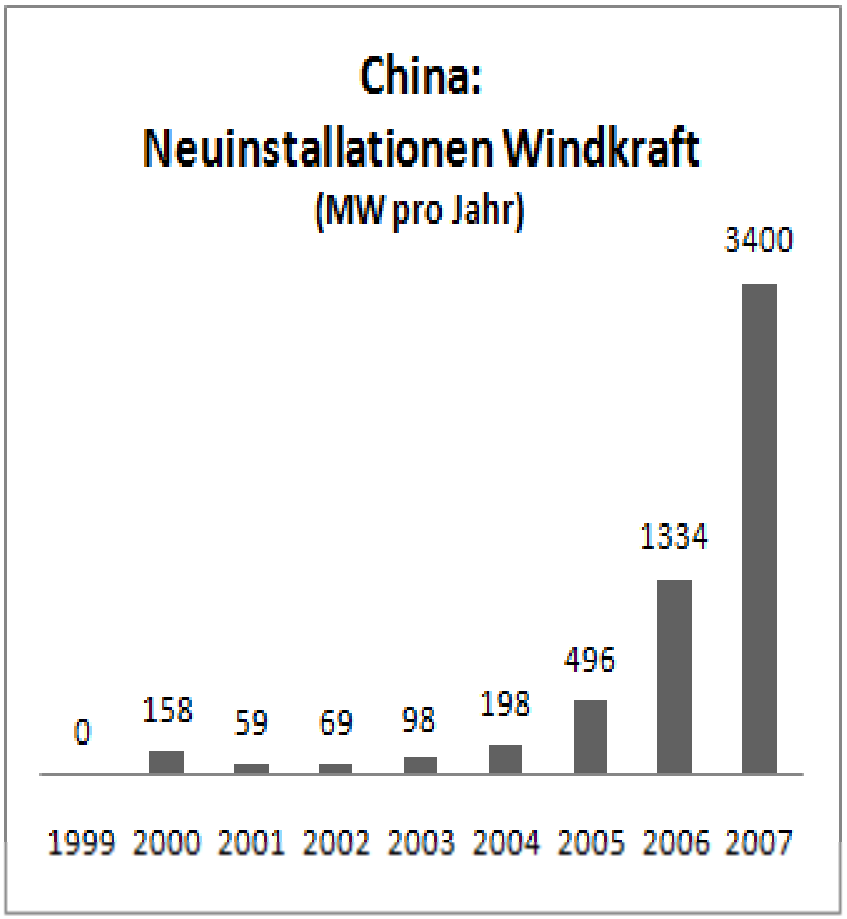
Power plant investment shares scenarios A-D

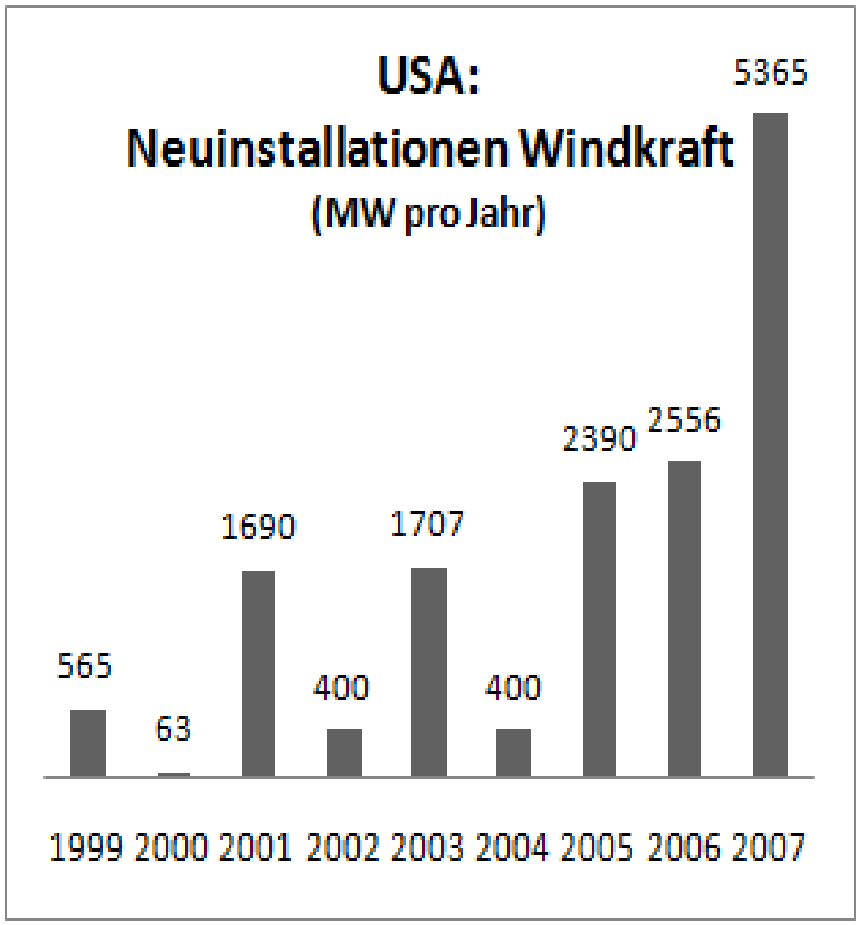












Reality shows: change is possible

Texas is not alone…

Wind power ~40 percent of new US power plants 2007

Wind power number one in Europe in MW 2007

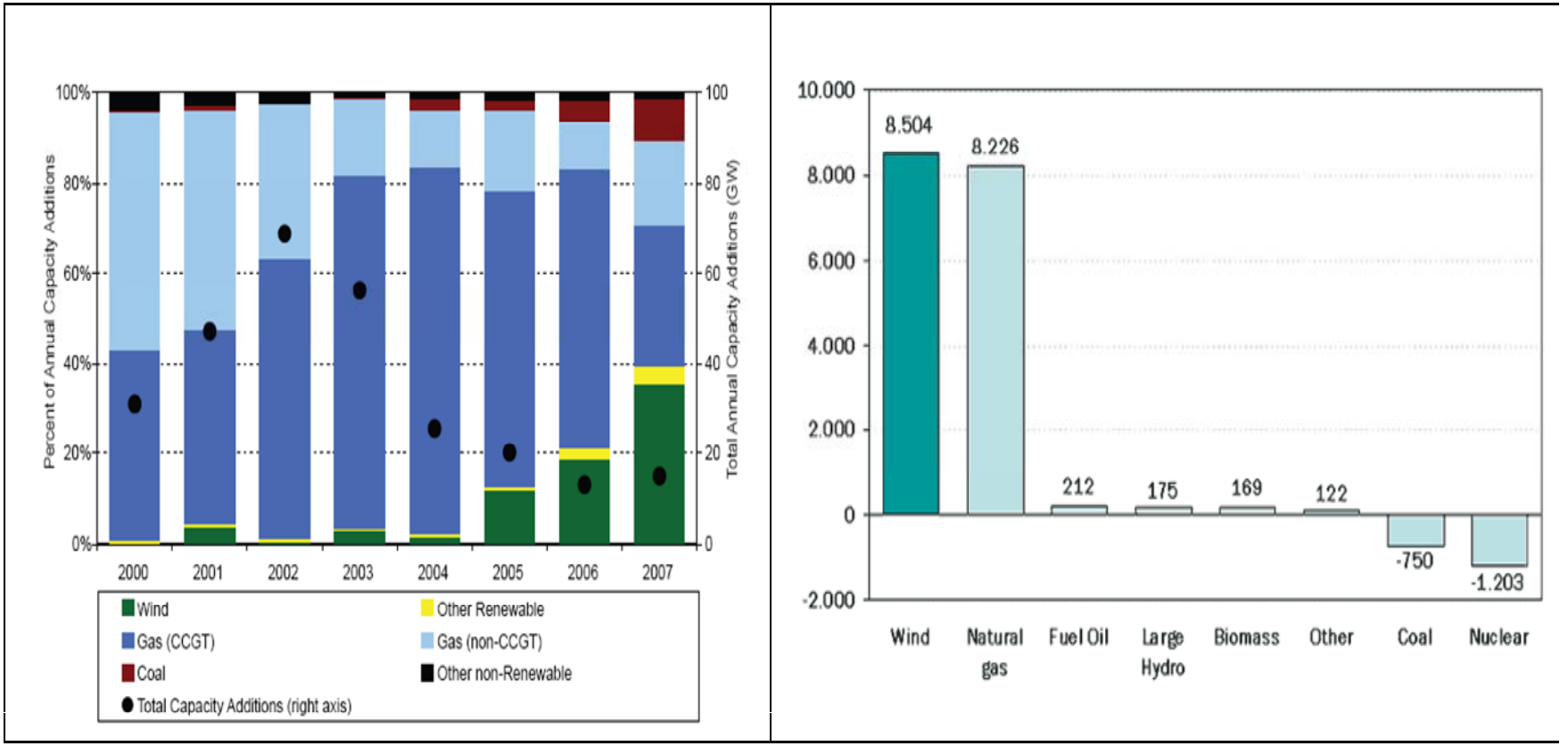
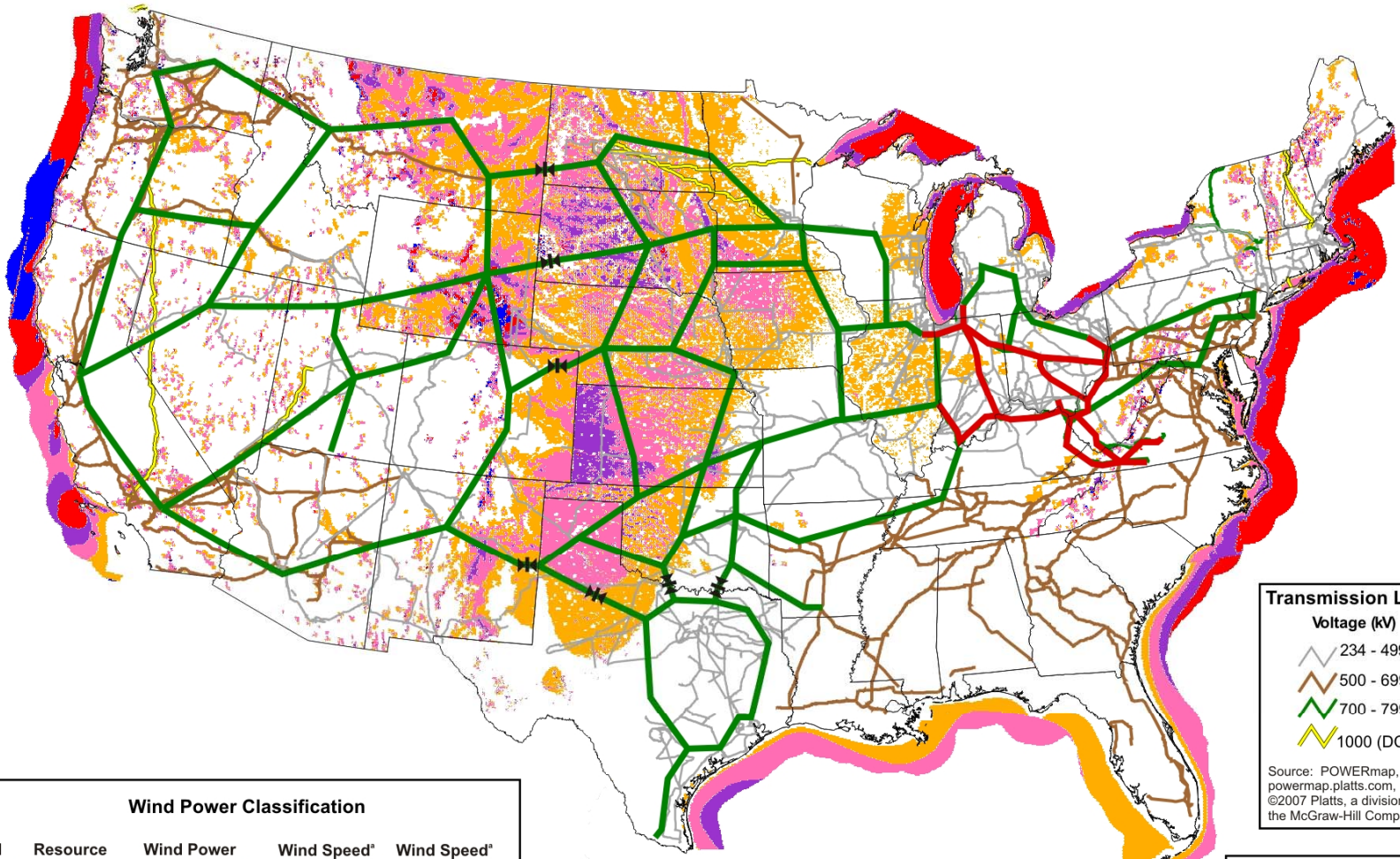


Figure 1 power mix of capacity additions in the US 2000-2007 and in Europe 2007



Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m²	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1600	8.8 - 11.1	19.7 - 24.8

[a] Wind speeds are based on a Weibull k value of 2.0

This map shows the wind resource data used by the WinDS model for the 20% Wind Scenario. It is a combination of high resolution and low resolution datasets produced by NREL and other organizations. The data was screened to eliminate areas unlikely to be developed onshore due to land use or environmental issues. In many states, the wind resource on this map is visually enhanced to better show the distribution on ridge crests and other features.

WHAT HAPPENS WHEN THE WIND IS NOT BLOWING?

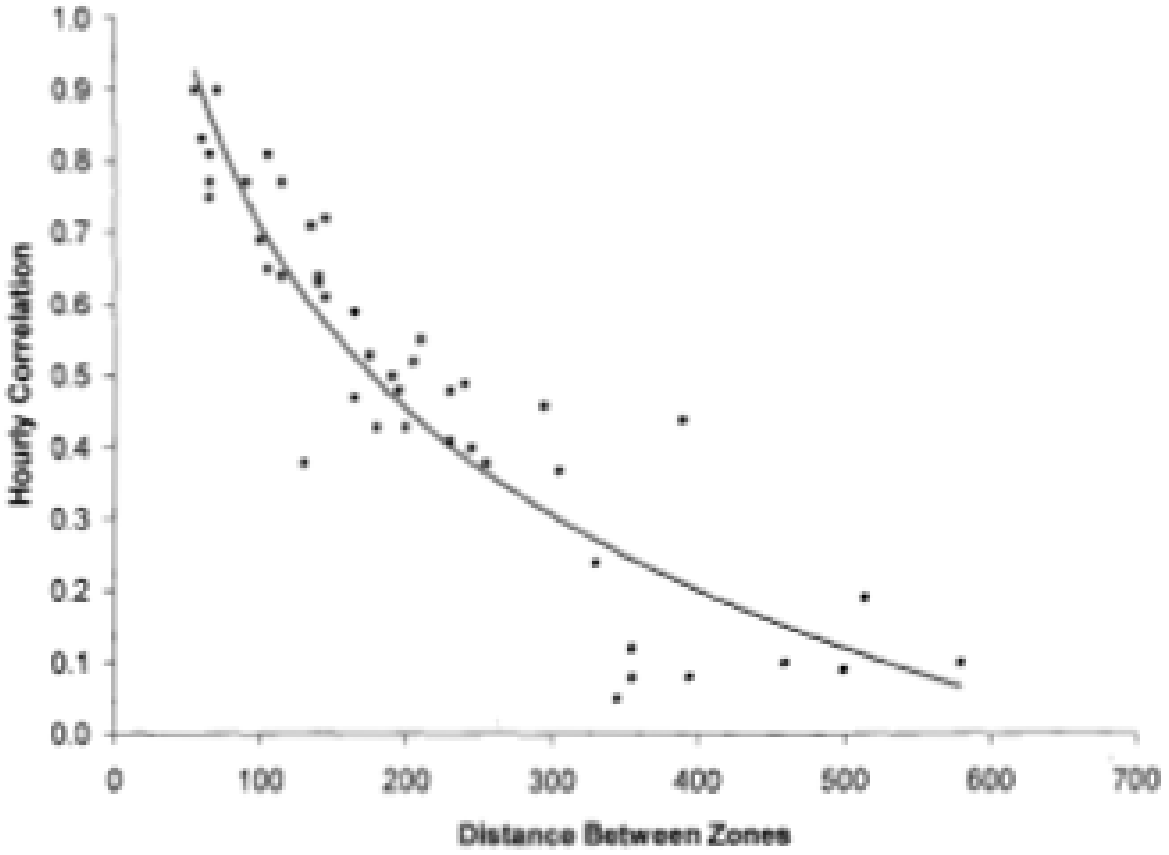
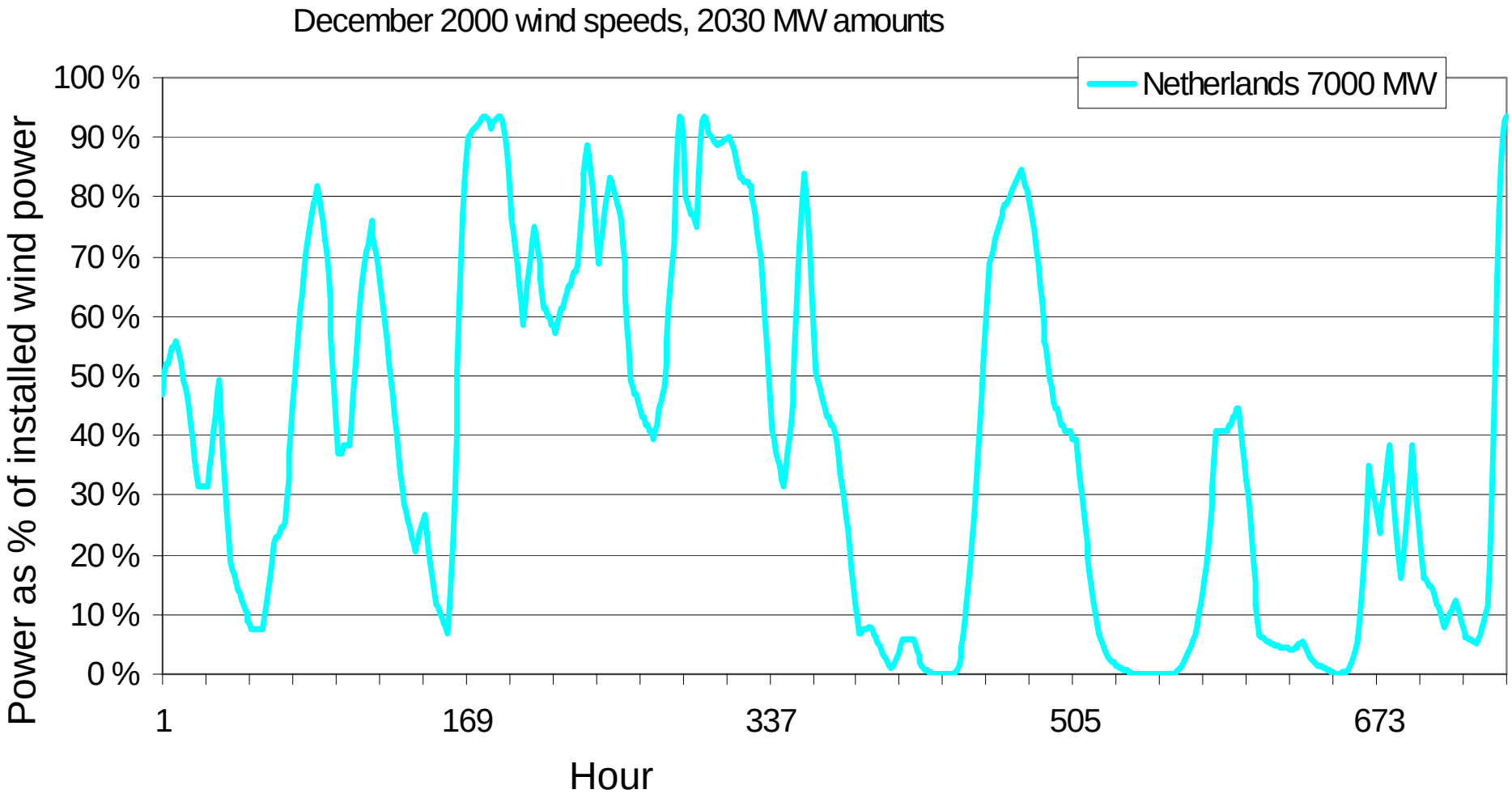
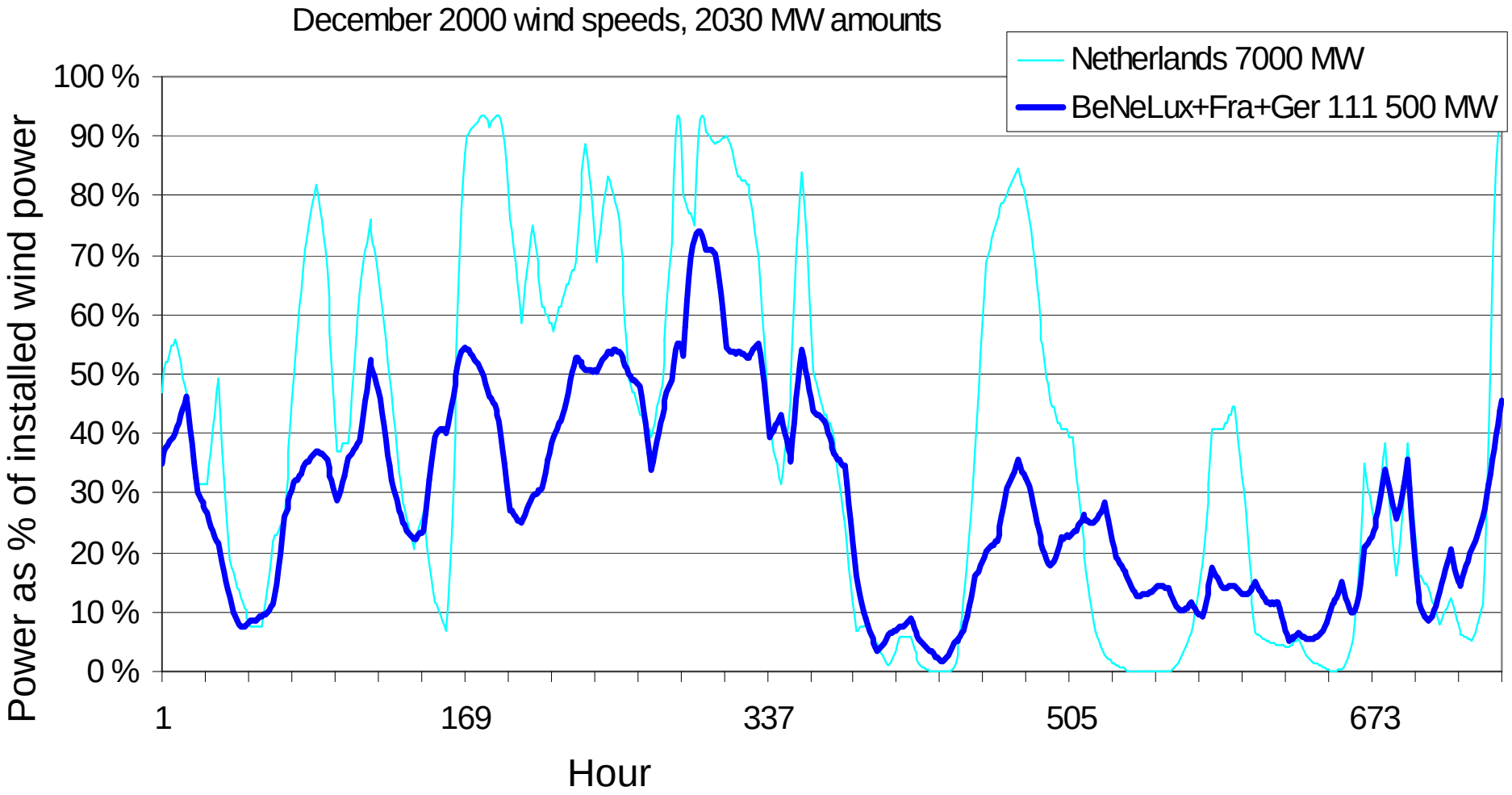


Figure 4 Wind variability hourly correlation drops dramatically with distance between wind zones.

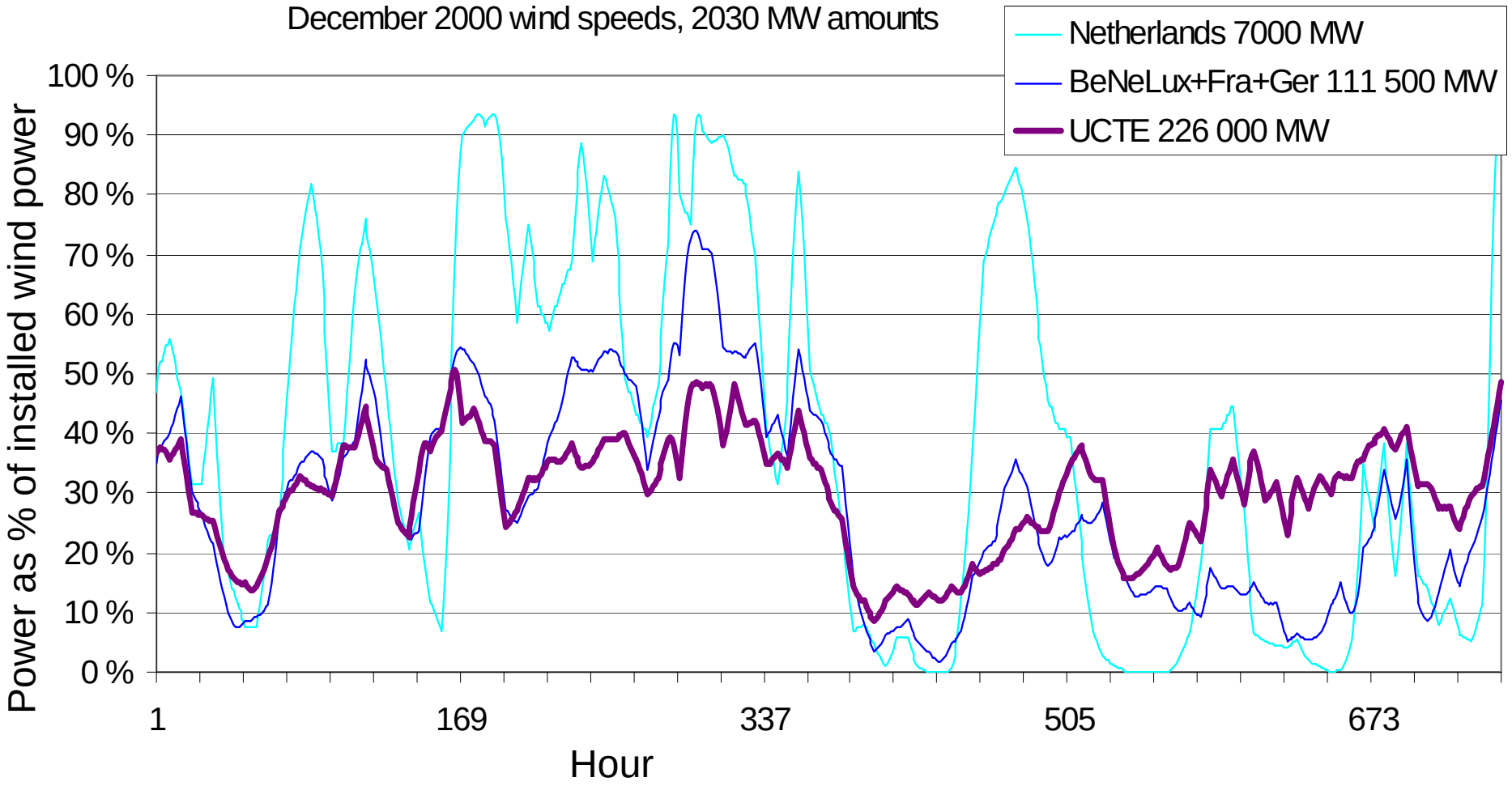
Smoothing effect
Netherlands only



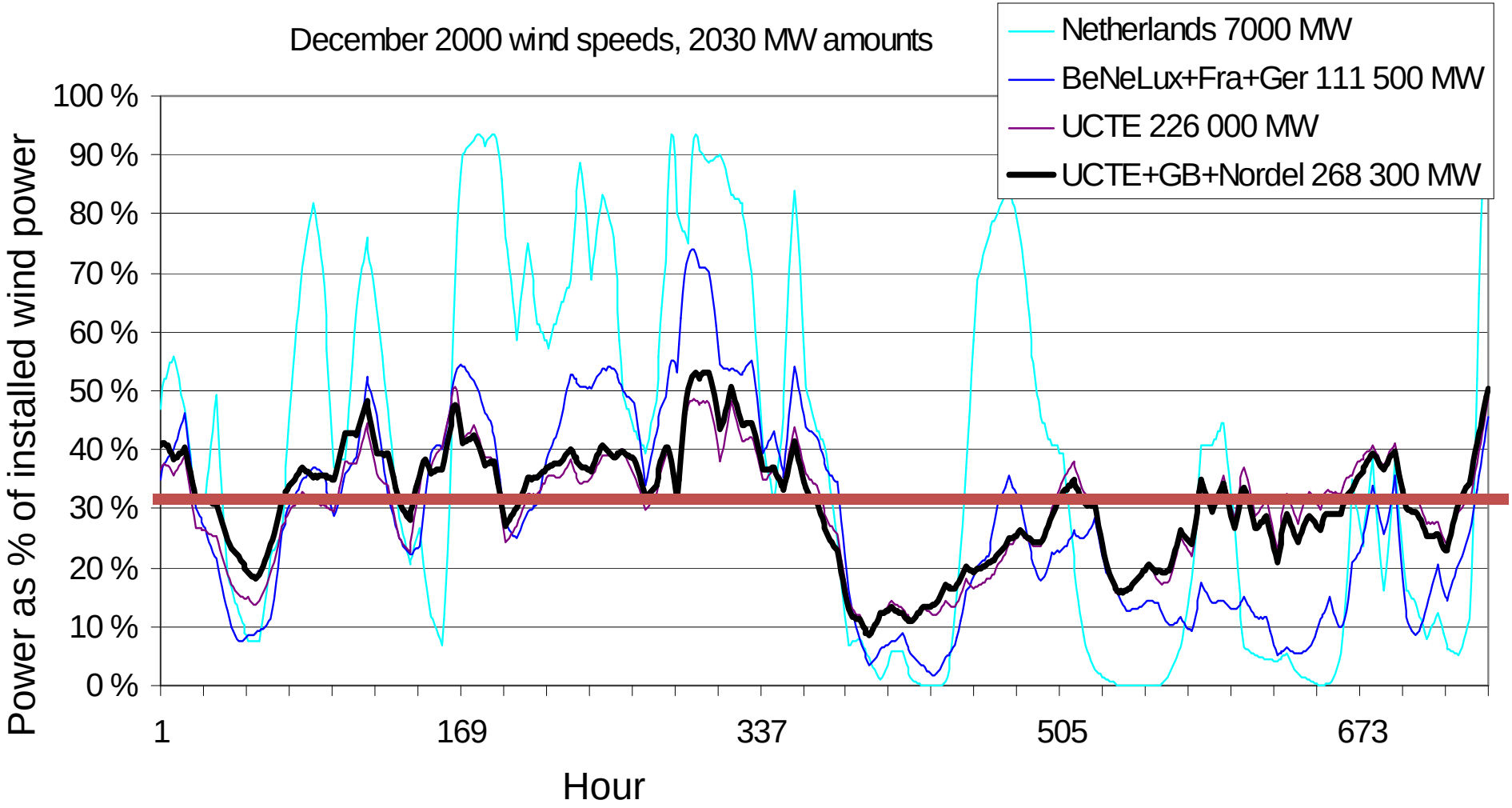
Smoothing effect Benelux+France+Germany



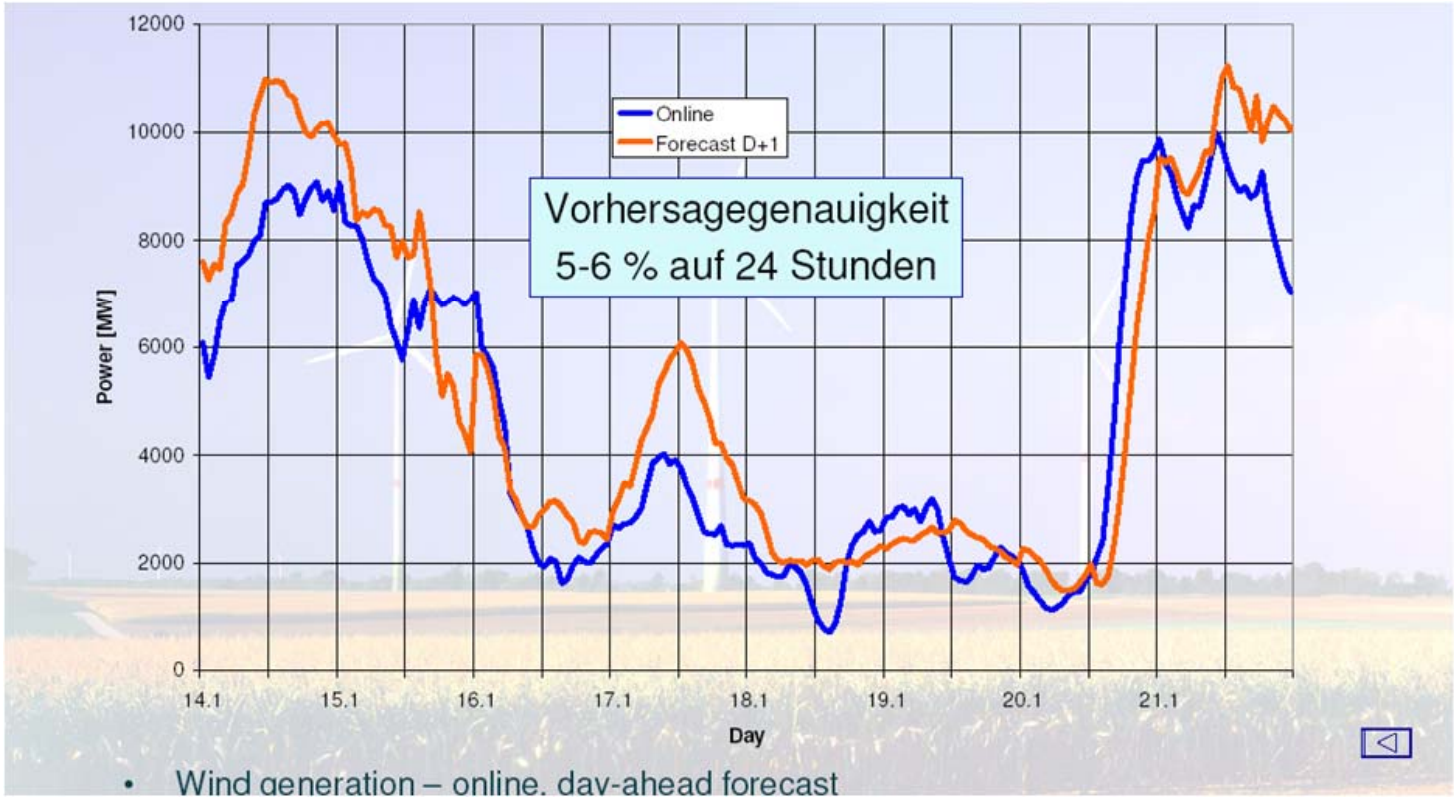
Smoothing effect
UCTE



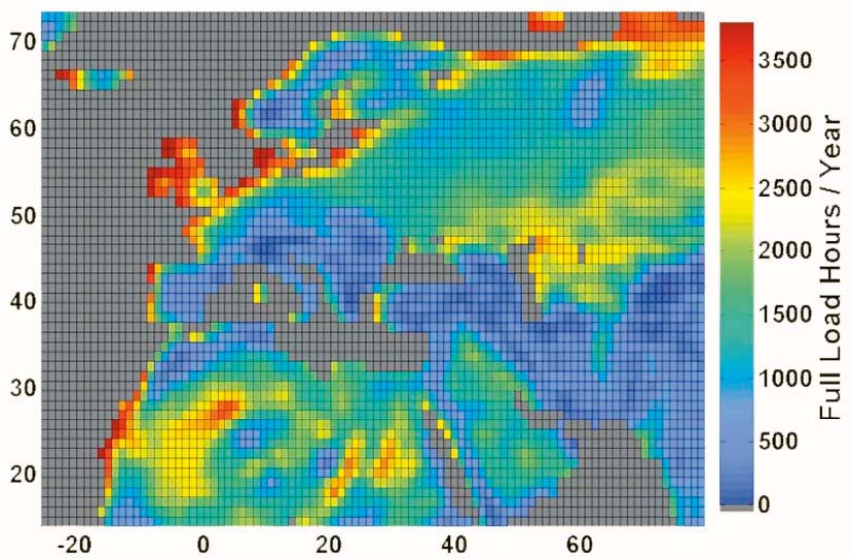
Smoothing effect UCTE+Nordel+UK



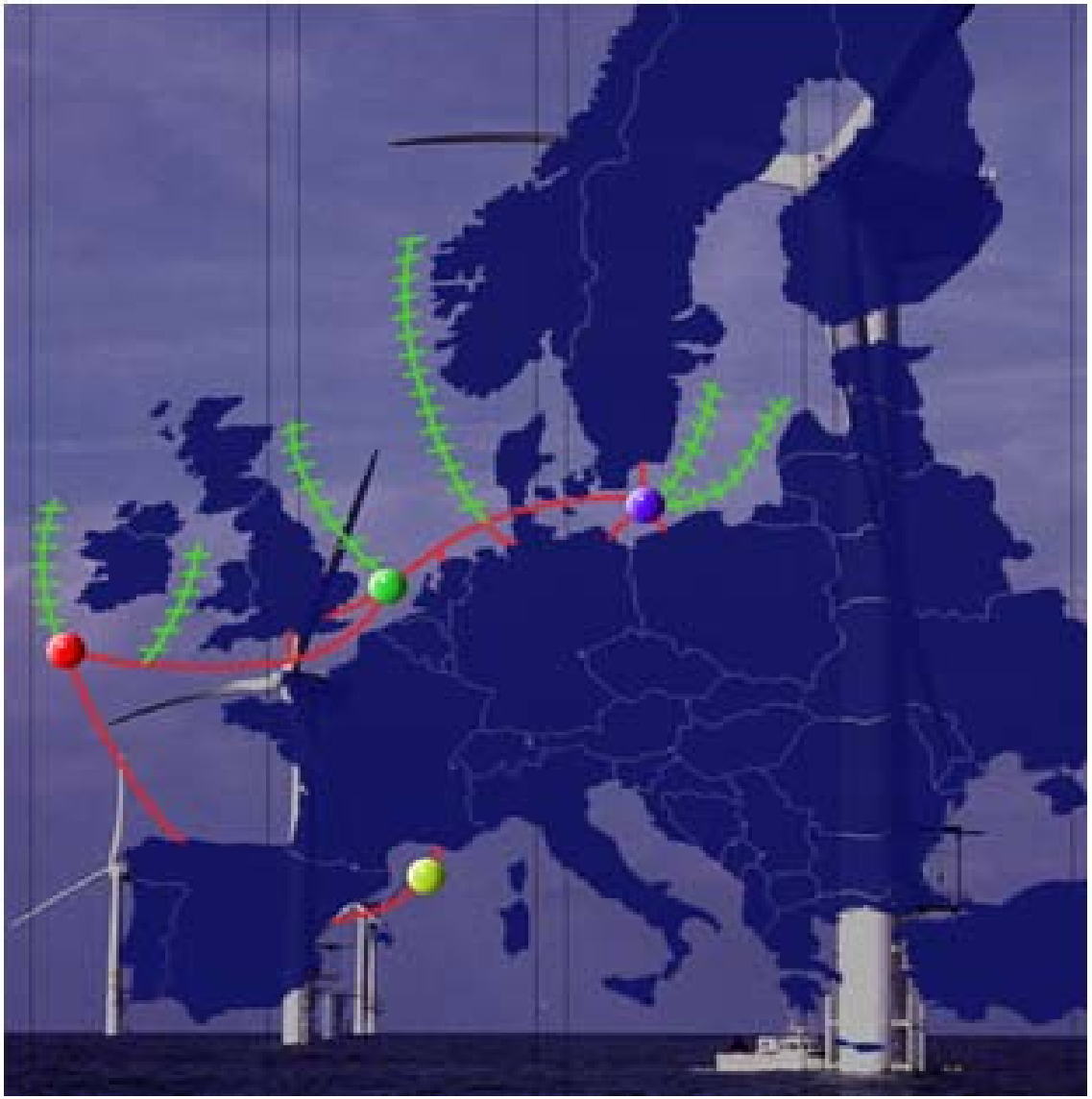
Forecast precision 24 h: 5-6 % deviation



Lower overall costs by continental capacity management



- Create HDVC-lines continent-wide
- Make hydro storage available for nations with low storage capacities
- Use fossil fuels like nat gas for capacity management instead of base-load power until renewables deliver 100% of overall consumption.



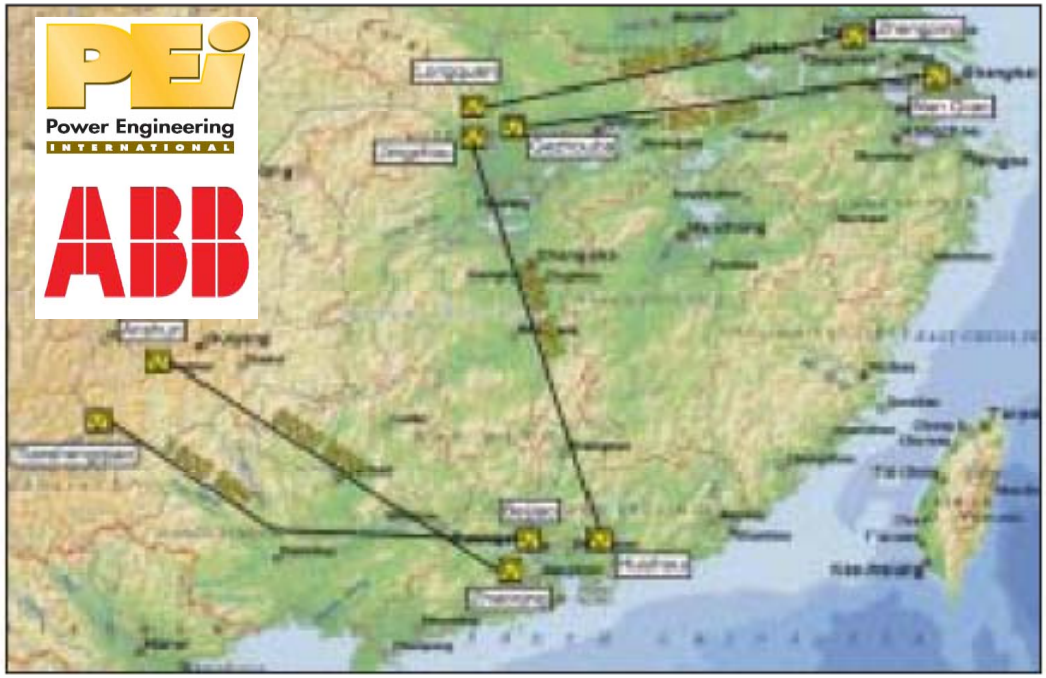
HVDC-lines: high power – low losses, no electro smog

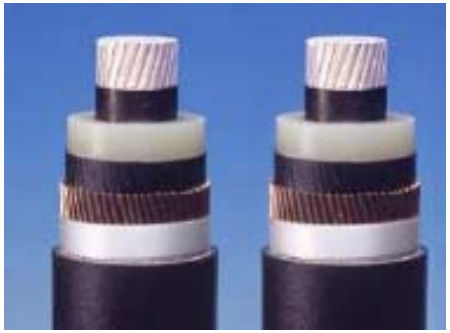
Figure 1-B. Left powerline: The Pacific Direct Current Intertie (PDCI), near Bishop, CA. HVDC, 3,000 MW, +/- 500 kv bipole, 846 miles from Celilo, at The Dalles Dam, OR to Sylmar (NW Los Angeles, CA). Commissioned in 1970 as 1,500 MW line. The right powerline is conventional high voltage AC.

HVDC
High
Voltage
Direct
Current

Normal
AC grid

state of the art: 1-3 GW capacity in one cable
many new projects – earth cables cheap





Europe: Storages exist already interconnection insufficient

Storage Hydro Power in Europe:

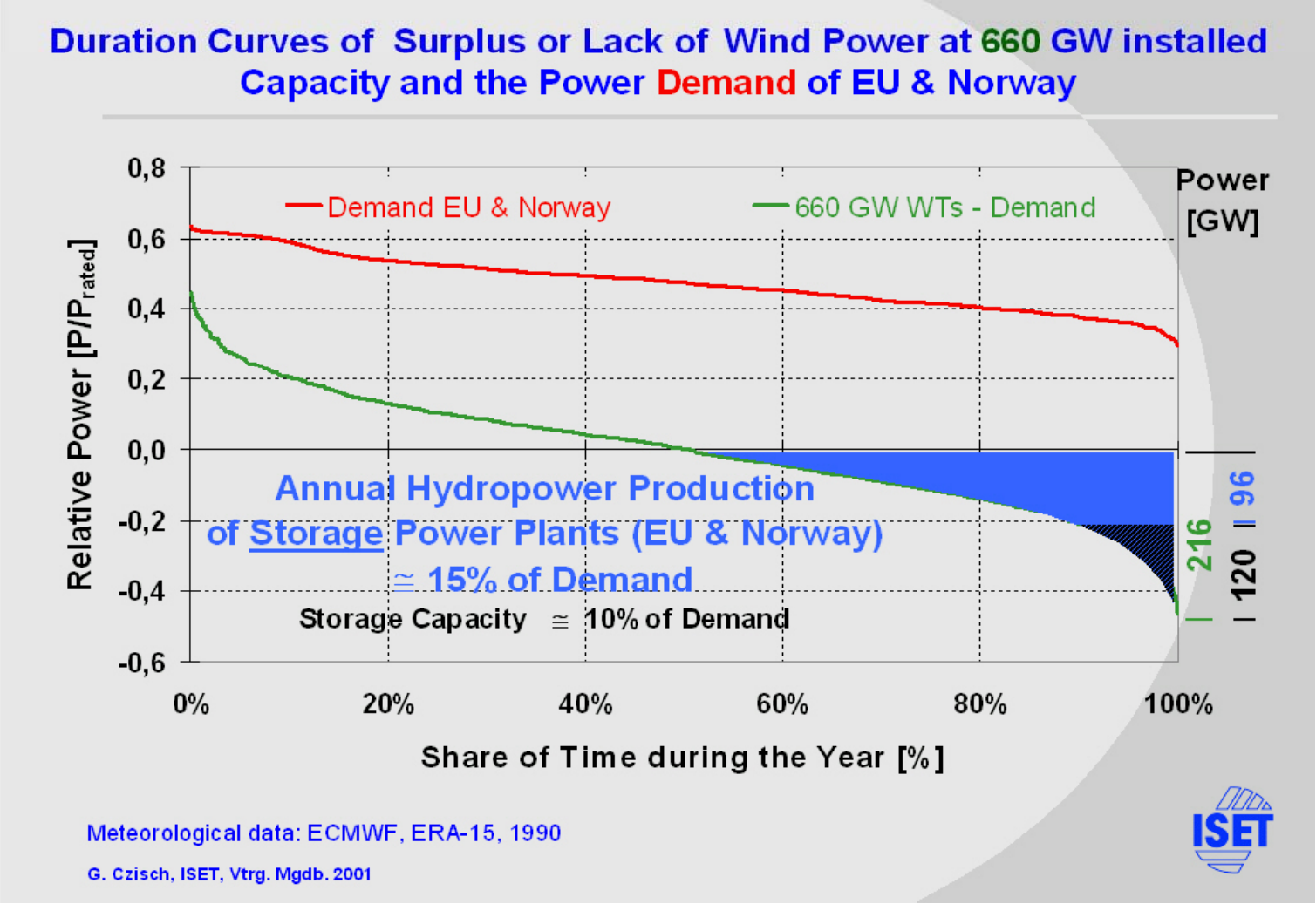
Rated Power, Storage Capacity and Annual Energy Production

Data of UCTE 1998	Rated Power of Reservoir and mixed pumped Storage [GW]	Storage Capacity of Reservoir and mixed pumped Storage [TWh]	Annual Energy Prod. of Reservoir and mixed pumped Storage [TWh]
Slovenia/Croatia	1.4	1.8	?
Swizerland	8.2	8.4	18.0
Serbia and Montenegro	2.0	2.0	?
Portugal	2.1	2.6	4.2
Austria	5.6	3.2	7.0
Luxemburg	0.0	0.0	0.0
Italy	7.5	7.9	17.6
Greece	1.9	2.4	2.8
France	11.6	9.8	18.2
Germany	1.4	0.3	1.1
Belgium	0.0	0.0	0.0
Spain	7.7	18.4	16.7
Sum of UCTE	**49**	**57**	**86**
Data of NORDEL			
Norway	27.3	84.1	112.6
Finland	2.9	4.9	12.6
Sweden	16.2	33.7	63.6
Sum of NORDEL	**46**	**123**	**189**
Sum of NORDEL + UCTE	**96**	**180**	**275**

ISET

G. Czisch 2000

Some 10 % energy backup + 26 % capacity backup needed



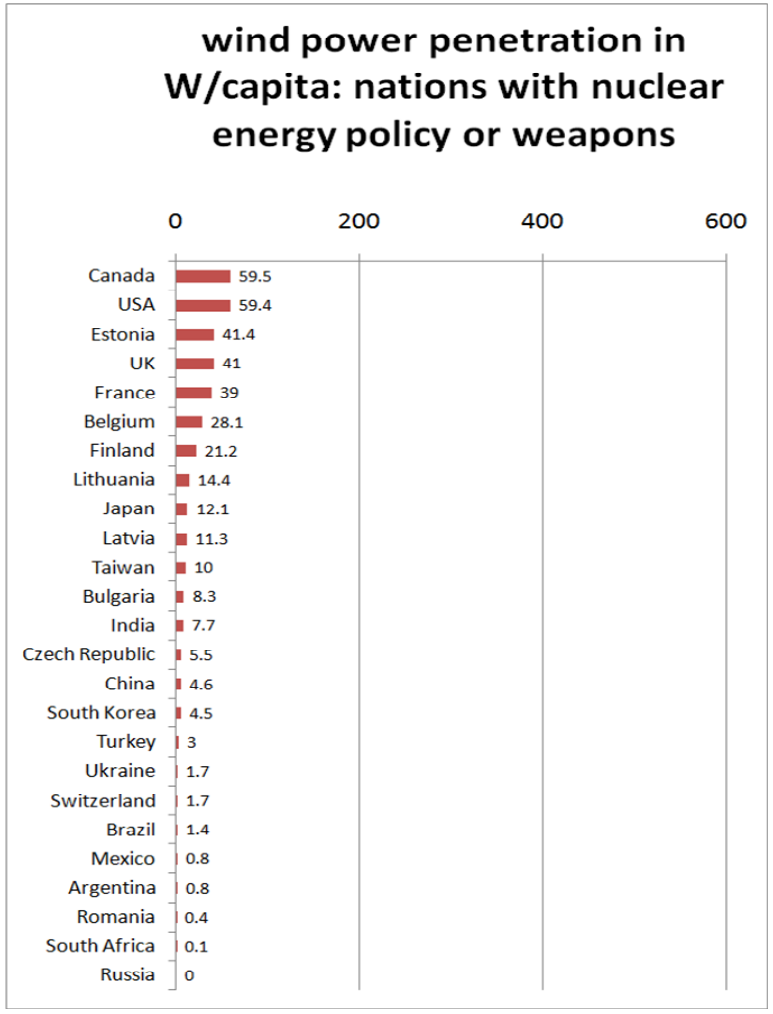
Hybrid cars and electric trains: plug-in, clean traffic

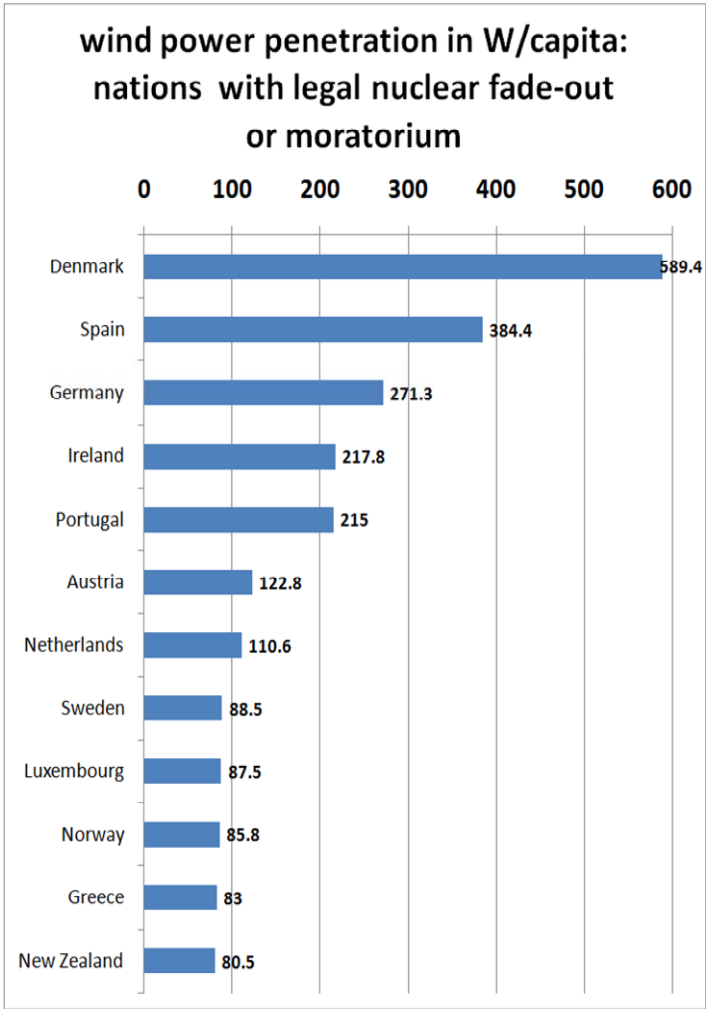
Today: ~ **<u>20% well-to-wheel-efficiency</u>**

Tomorrow: Plug-in-Hybrid = electric car+ big battery + renewable power
<u>~ 70 % wind-to wheel-efficiency achievable</u>

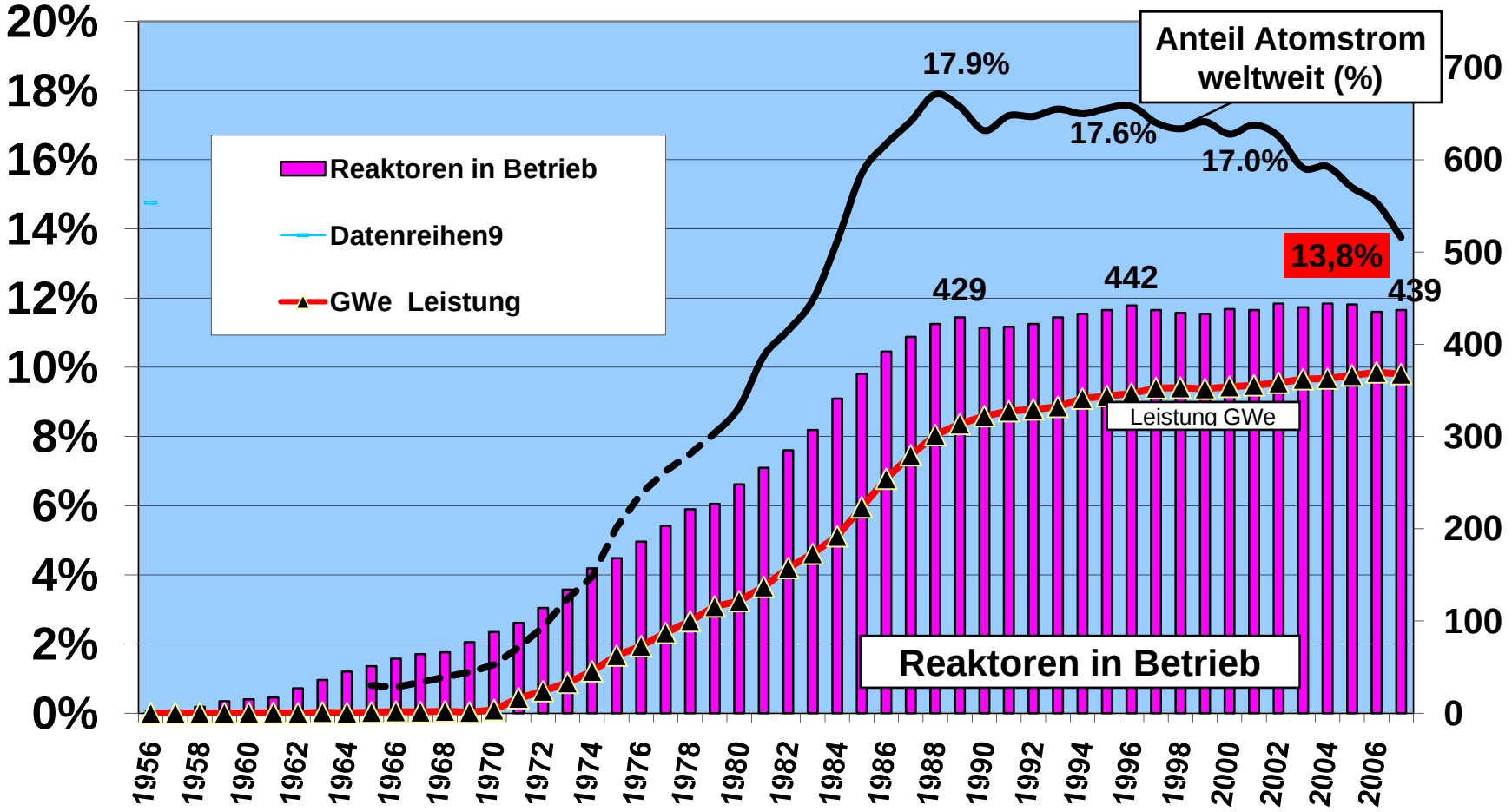
Elektrische Zweiräder in Shanghai

WHO IS HOSTILE TO RENEWABLES AND EFFICIENCY?


wind power penetration in W/capita: nations with nuclear energy policy or weapons
0
200
400
600
Canada 59.5
USA 59.4
Estonia 41.4
UK 41
France 39
Belgium 28.1
Finland 21.2
Lithuania 14.4
Japan 12.1
Latvia 11.3
Taiwan 10
Bulgaria 8.3
India 7.7
Czech Republic 5.5
China 4.6
South Korea 4.5
Turkey 3
Ukraine 1.7
Switzerland 1.7
Brazil 1.4
Mexico 0.8
Argentina 0.8
Romania 0.4
South Africa 0.1
Russia 0


wind power penetration in W/capita: nations with legal nuclear fade-out or moratorium
0
100
200
300
400
500
600
Denmark 589.4
Spain 384.4
Germany 271.3
Ireland 217.8
Portugal 215
Austria 122.8
Netherlands 110.6
Sweden 88.5
Luxembourg 87.5
Norway 85.8
Greece 83
New Zealand 80.5

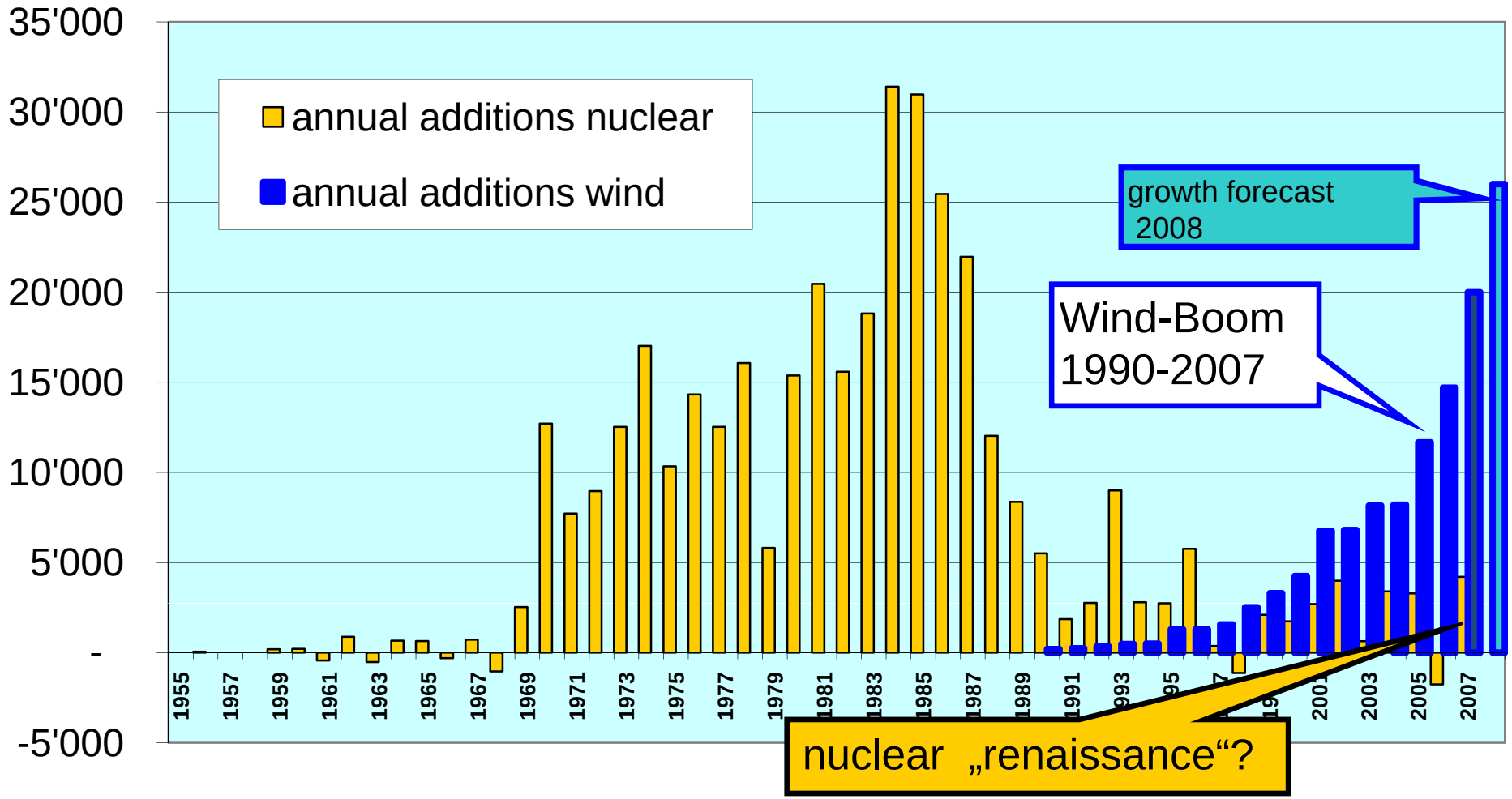
Share of nuclear power in world electricty reactors in service since 1956



Annual additions of nuclear and wind capacities

in Megawatt

Quellen: IAEA: Nuclear Power Reactors in the World, REFERENCE DATA SERIES No. 2, April 2006 / PRIS



Renewable energy and efficiency can save the day

- They are here
- progress is visble
- They are cheap
- They are growing

- **Put them in place now!**