Sustainable Energy Contribution to Solving the World‘s Energy Demands

Prof. Dr. C. Ahrens, Jadehochschule, ZDI, WCCE

Sustainable Energy Contribution to Solving the World‘s Energy Demands

54th ECCE General Meeting

Belek, Turkey, 28. – 29. Oct. 2011

SC Environment & Sustainability

just before at Departments of Civil and of Electrical Engineering,
Tsinghua University, Beijing and
Changchun Institute of Technology, Changchun Oct. 2011

Prof. Dr. Carsten Ahrens
Jadehochschule Oldenburg, Germany
ZDI, Germany
World Council of Civil Engineers (WCCE)

1. Solar Energy Contribution

to Solving the World‘s Energy Demands

Energy Comittee of WFEO

under chairmanship of Jorge Spitalnik, BR

WFEO
COMMITTEE ON ENERGY

To All Members of the
Committee on Energy, CE-WFEO

September 05, 2010

Meeting of the Committee on Energy
on 16th October 2010 in Buenos Aires

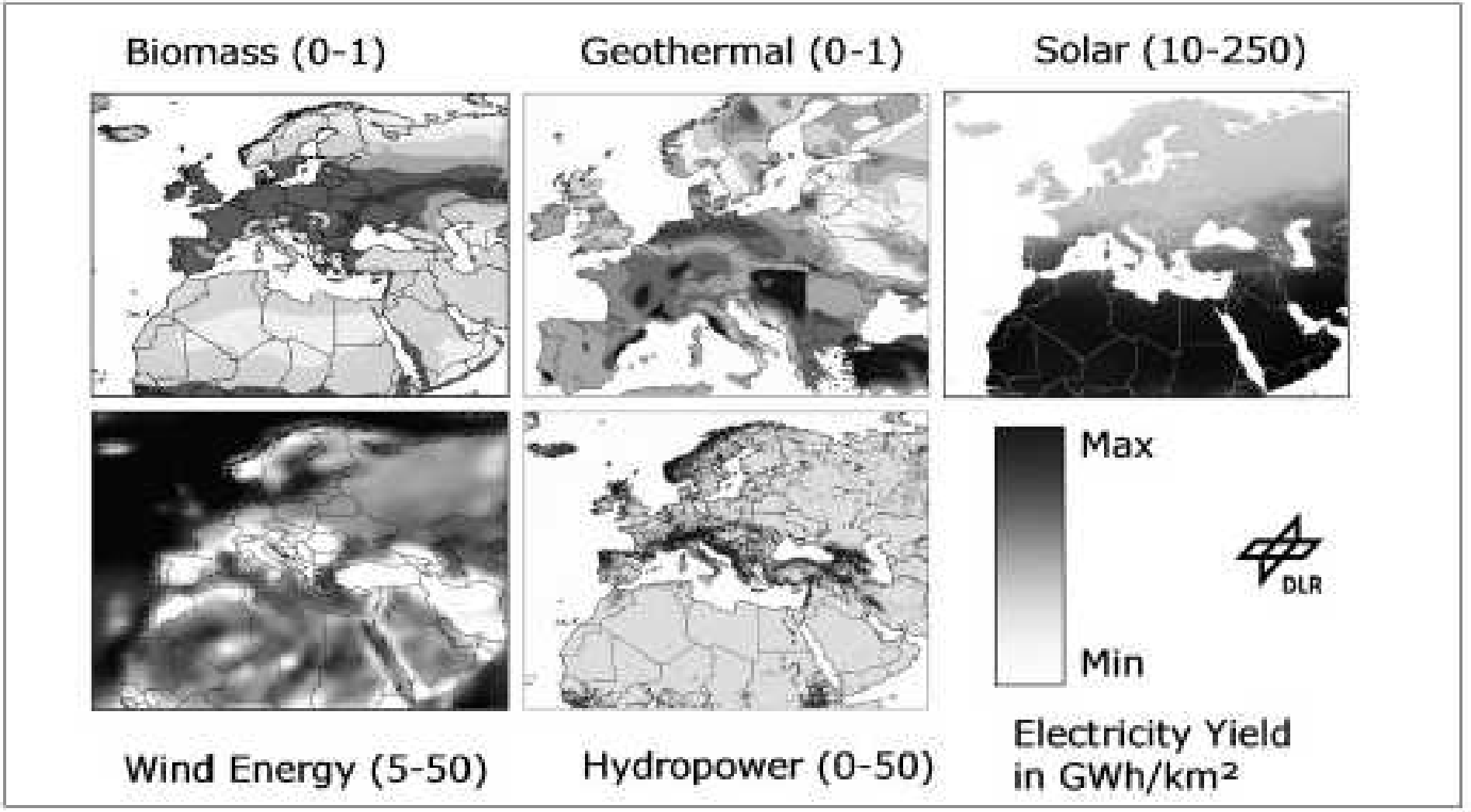
World‘s Energy Demands

World Population		Energy Demand
2008	6.5 billion	107.000 TWh / y (18.000 electrical) > 70% fossil energy
2050	min. 8.5 bio.	321.000 TWh / y > 70 % renewable ????

Fossil Energy Sources and reserves

Fossil energy source 1000 TWh (thermal) (= 3.56 EJ = 0.123 Gtce = 614 Million bbl oil)	Annual Production/ consumption 1000 TWh	Equivalent Solar delivery time in deserts, hours	Proven Reserve *(expected additional Resources)* 1000 TWh	Equivalent Solar delivery time in deserts days	Static depletion time of reserves years
All fossil fuels	107	5.7	10,400 *50,700*	47 *227*	98
Oil (conventional)	45	2.4	1,900 *960*	8.5 *4.3*	42
Oil (non-conv.)	0		780 *2,900*	3.5 *13.2*	
Natural gas (conv.)	24	1.3	1,600 *1,900*	7.2 *8.4*	65
Natural gas (non-conv.)	0		*2* *1,687*	0.1 *6.2*	
Coal (hard and lignite)	33	1.8	5,700 *29,000*	25 *129*	170
Uranium, Thorium	4	0.2	460 *1,740*	2.0 *7.8*	101

Renewable Energy Yields (per sqare km in EUMENA)



Solar Energy
Physical Data

Radiation flux density of sun

- outside atmosphere 343 W/m²
- on surface 165 W/m²

Mankind‘s energy flux density 0.03 W/m²

Sun offer 5.000 x mankind‘s needs

Motto of solar enthusiasts for the 21 Century:

Harvest just 1/5000 of the sun‘s offer

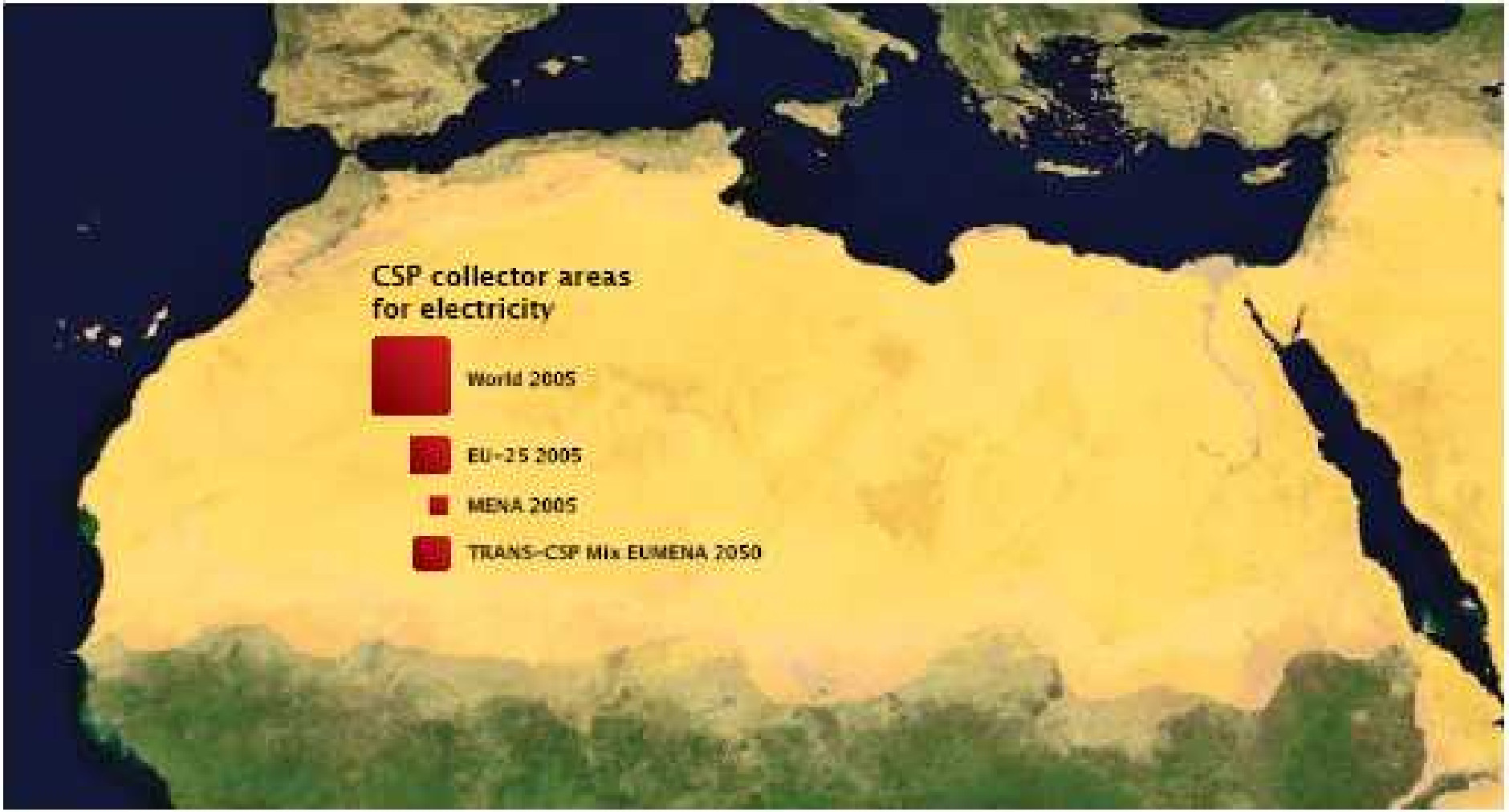
Where to harvest solar energy?

How to harvest solar energy?

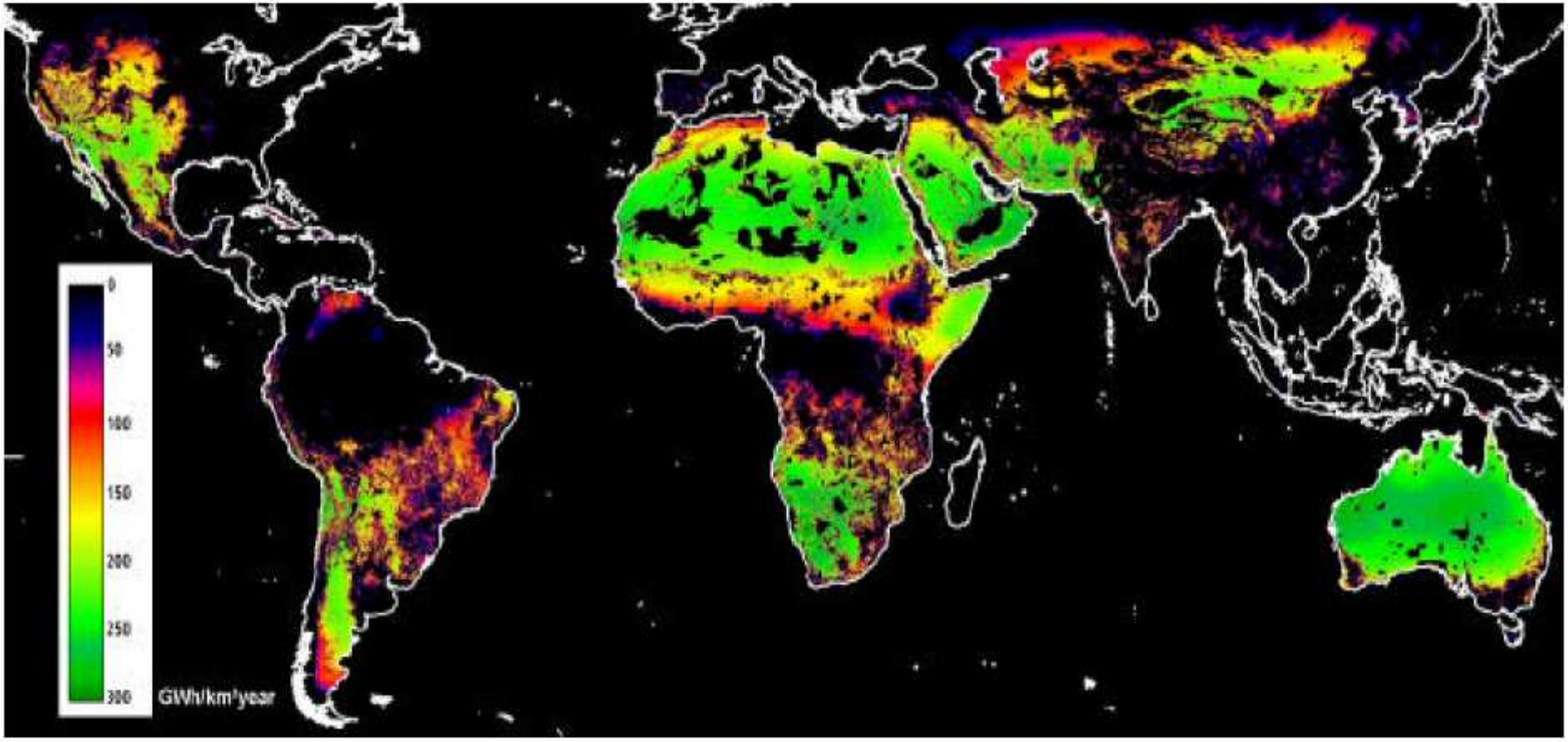
How to transport solar energy products, mainly electricity?

How to store the volatile solar energy?

Solar Energy Availability



Solar Thermal potentials for Electricity Generation



Solar Energy harvesting systems

Photo voltaic technology (PV)

Solar thermal technology (Th)

Photo voltaic technology (PV)

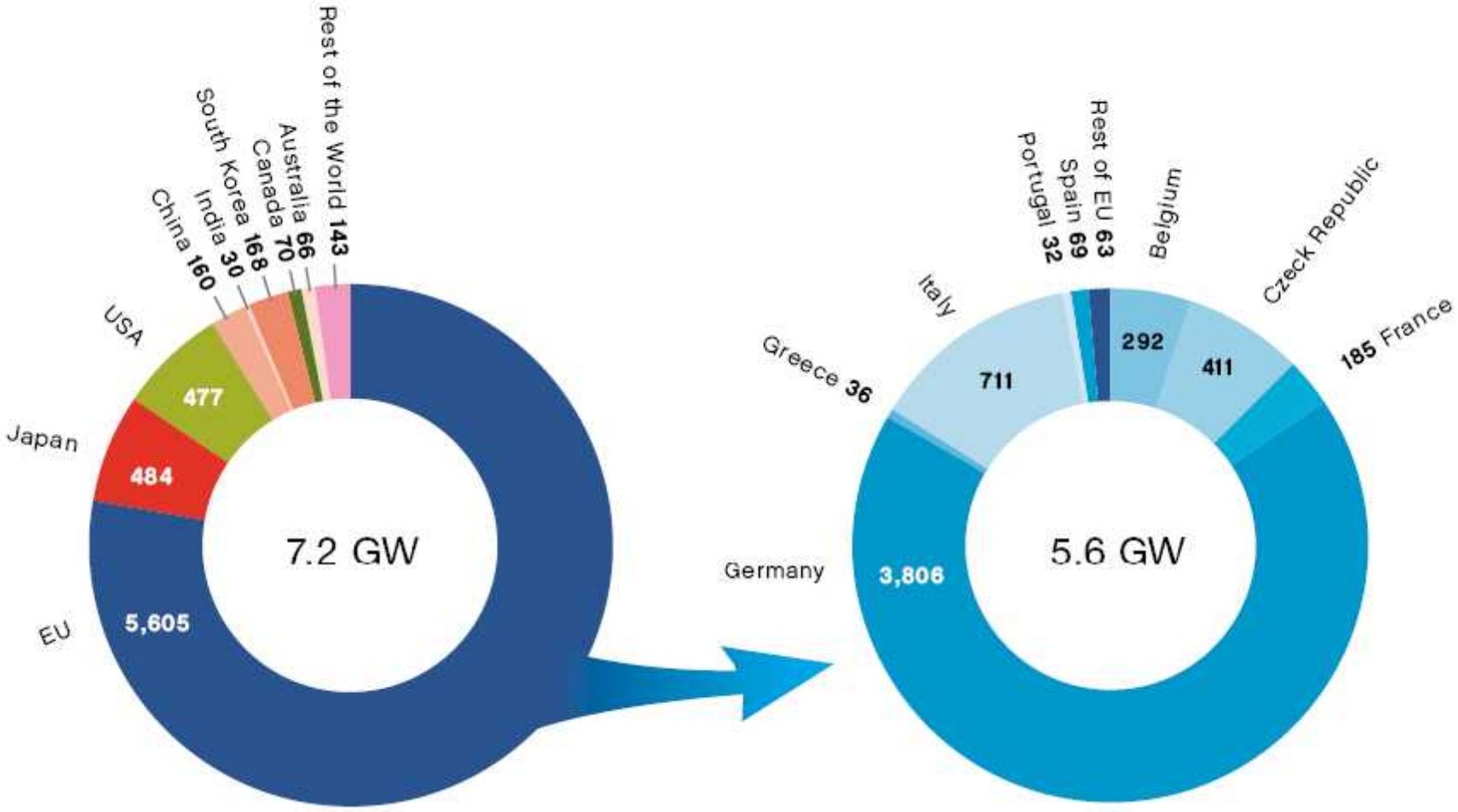
System category	size	Type of installation
Residential	3-10 kWp	Roof-top/ BIPV (roof/façade)
Commercial	100 kWp	Roof-top/ BIPV (roof/façade)
Industrial	1 MWp	Roof-top
Utility scale	1-50 MWp	Ground mounted

Photo voltaic technology (cont. 1)

Utility scale plant in Lieberose, Germany

53 MWp, 560.000 modules, 160 Mio €

PV market of the world and in Europe 2009



PV (cont. 5)

Global cumulative installed capacity share 2010

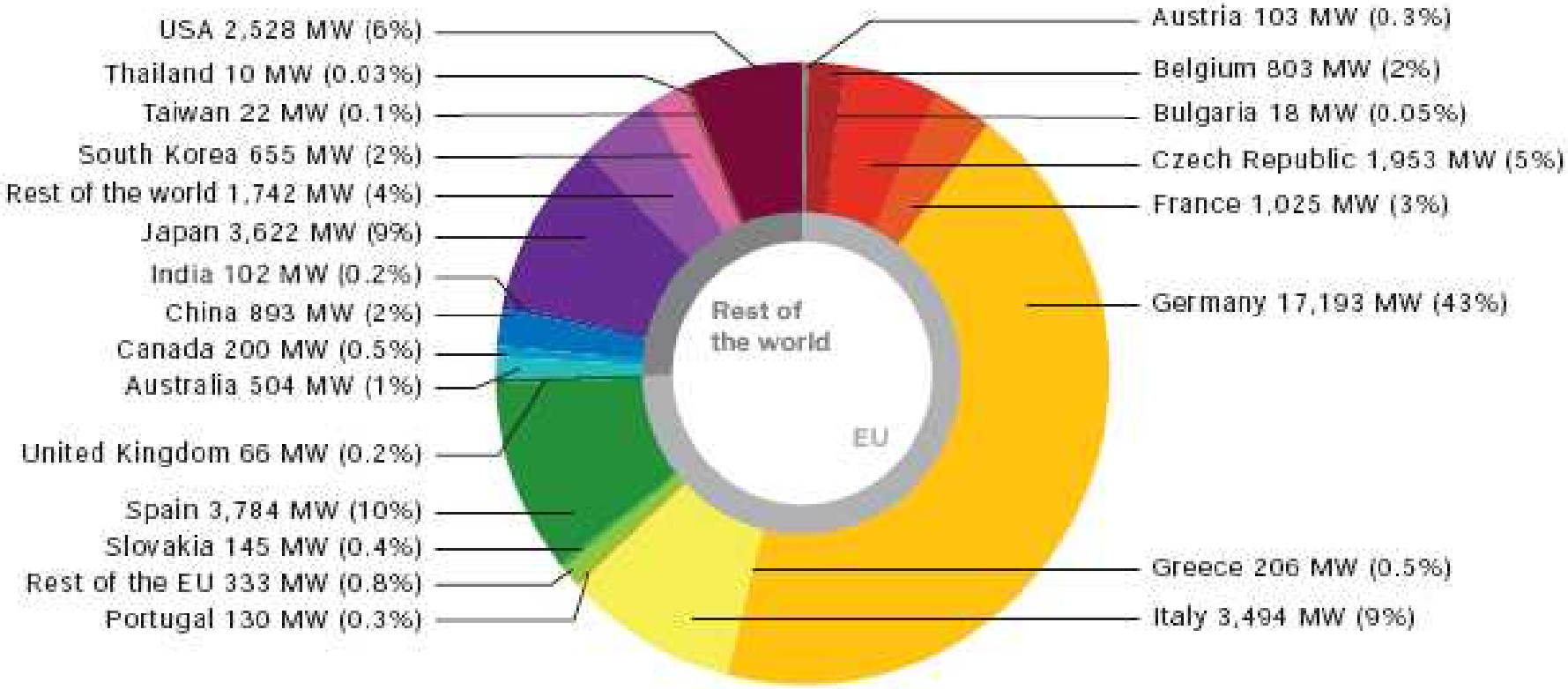
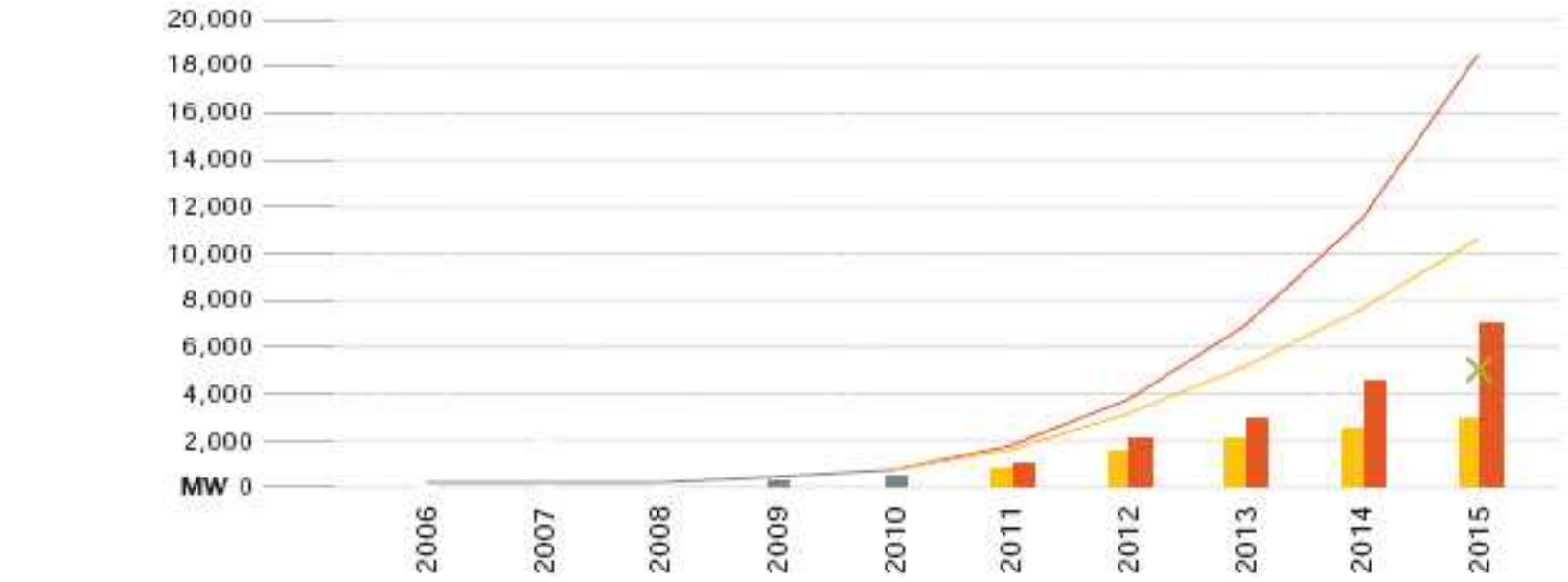


Figure 22 - 2010 global cumulative installed capacity share (MW, %)

PV (cont. 9)

Development in China 2006 - 2015

- China

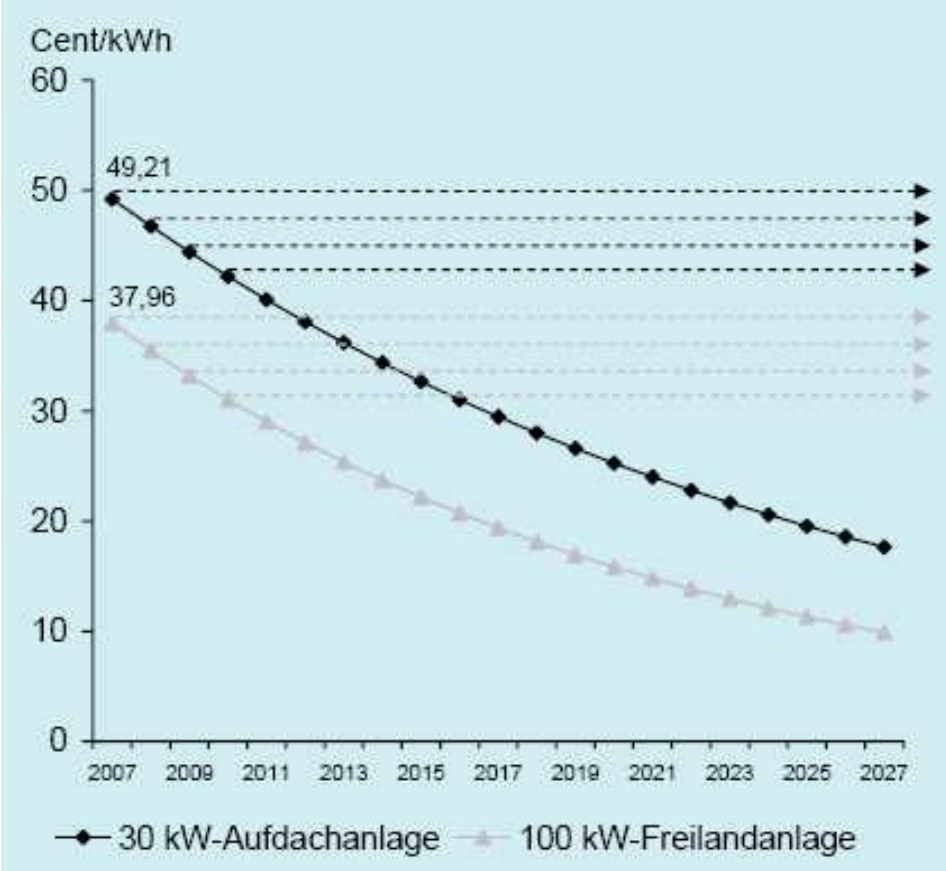


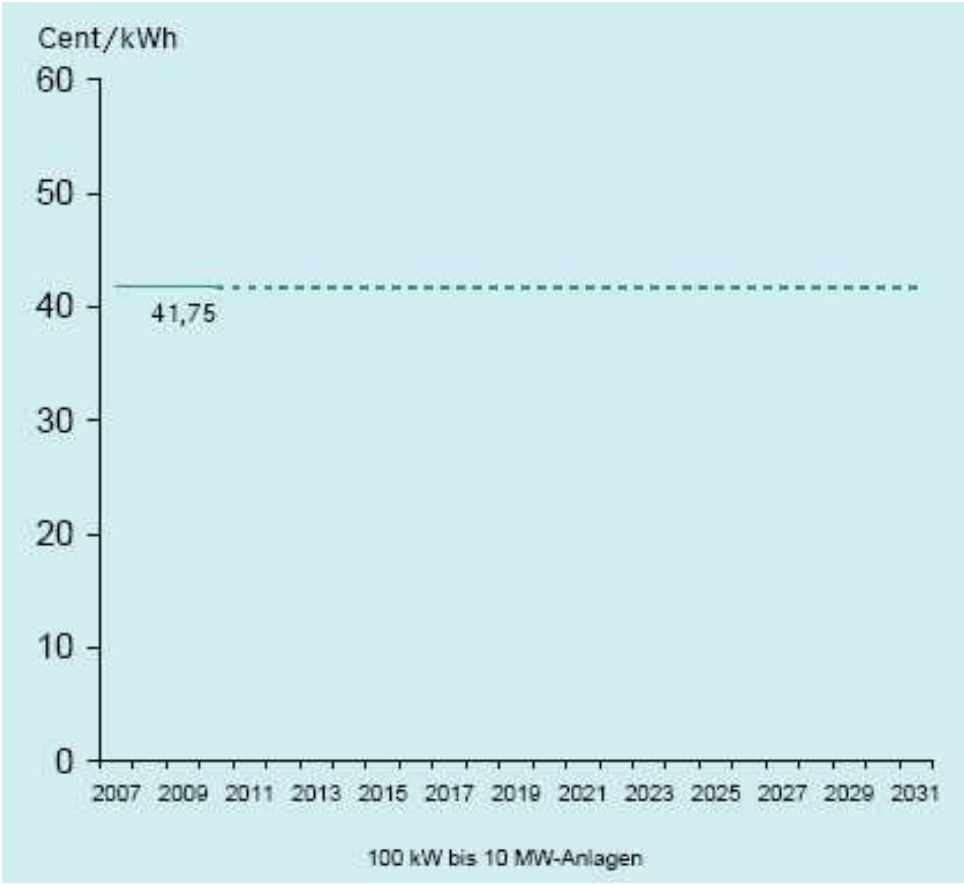
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EPIA Moderate	12	20	45	228	520	750	1,500	2,000	2,500	3,000
EPIA Policy-Driven						1,000	2,000	3,000	4,500	7,000
EPIA Moderate (cumulative)	80	100	145	373	893	1,600	3,100	5,100	7,600	10,600
EPIA Policy-Driven (cumulative)						1,900	3,900	6,900	11,400	18,400
National target 2015										5,000

Figure 27 - China

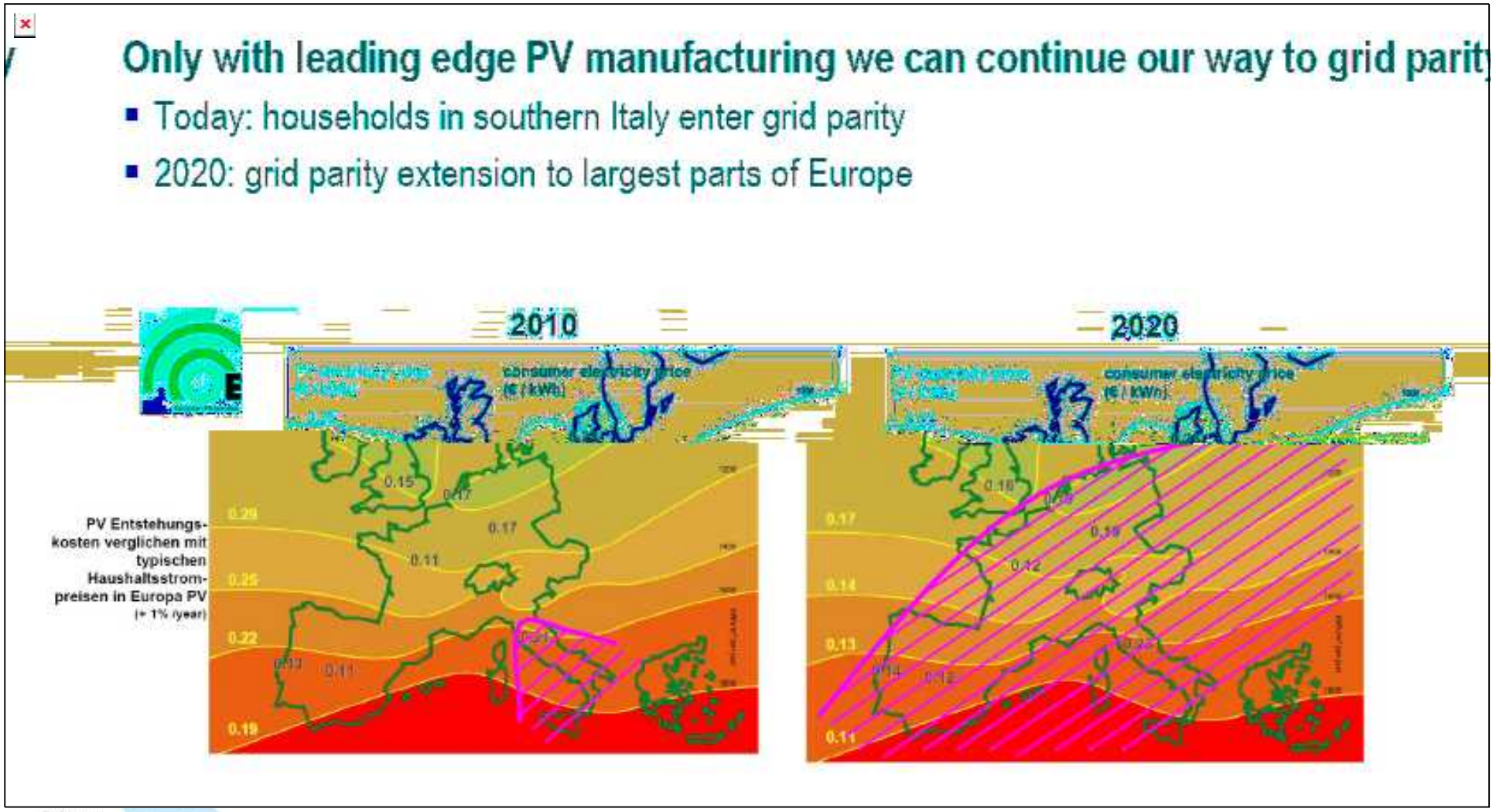
PV (cont. 10)

Politically driven situation in Europe
Feed-in Tariffs in Germany and Spain



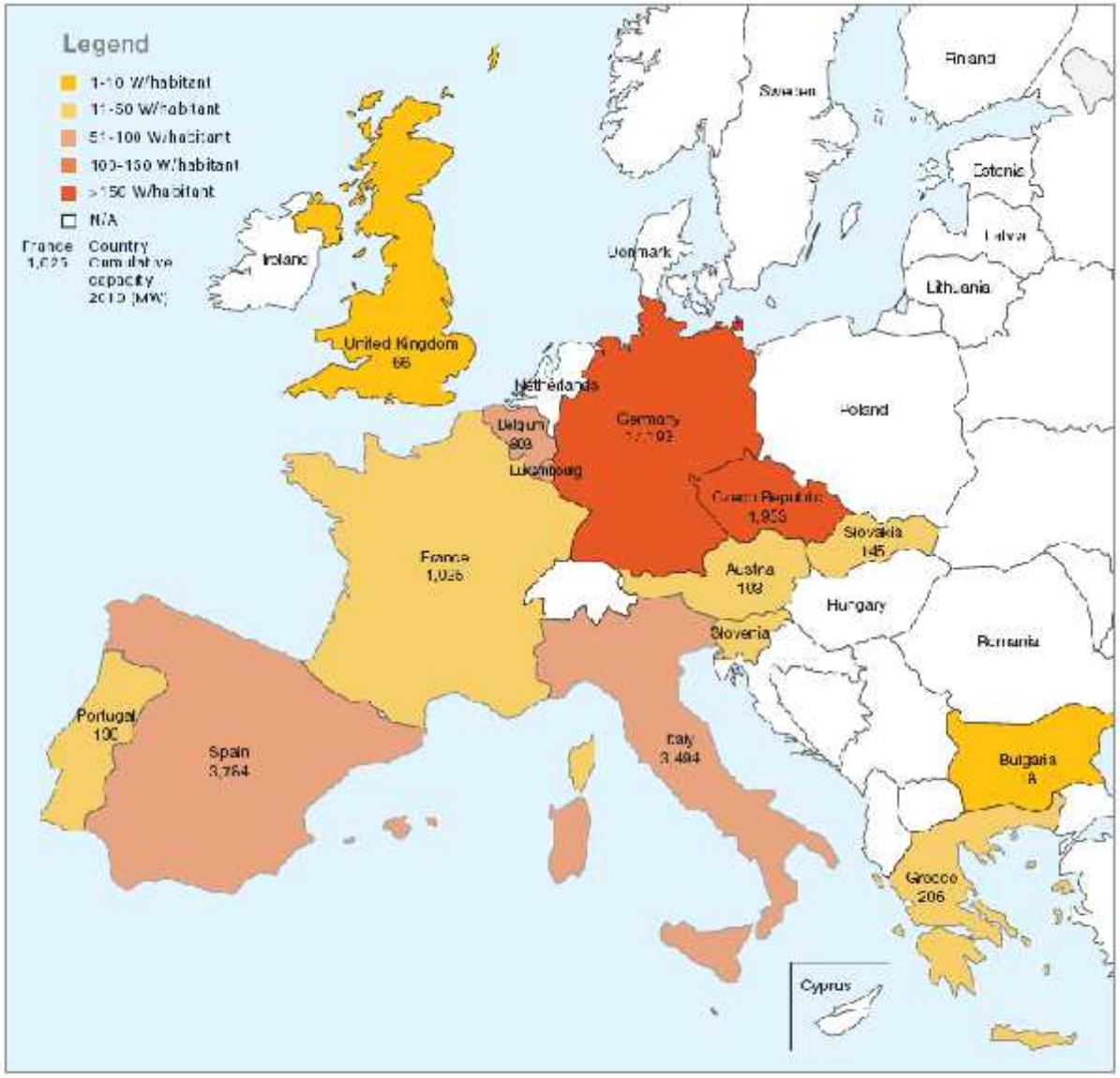


Grid parity in Europe



PV (cont. 12)

EU power map



PV (cont. 13)

EU power map

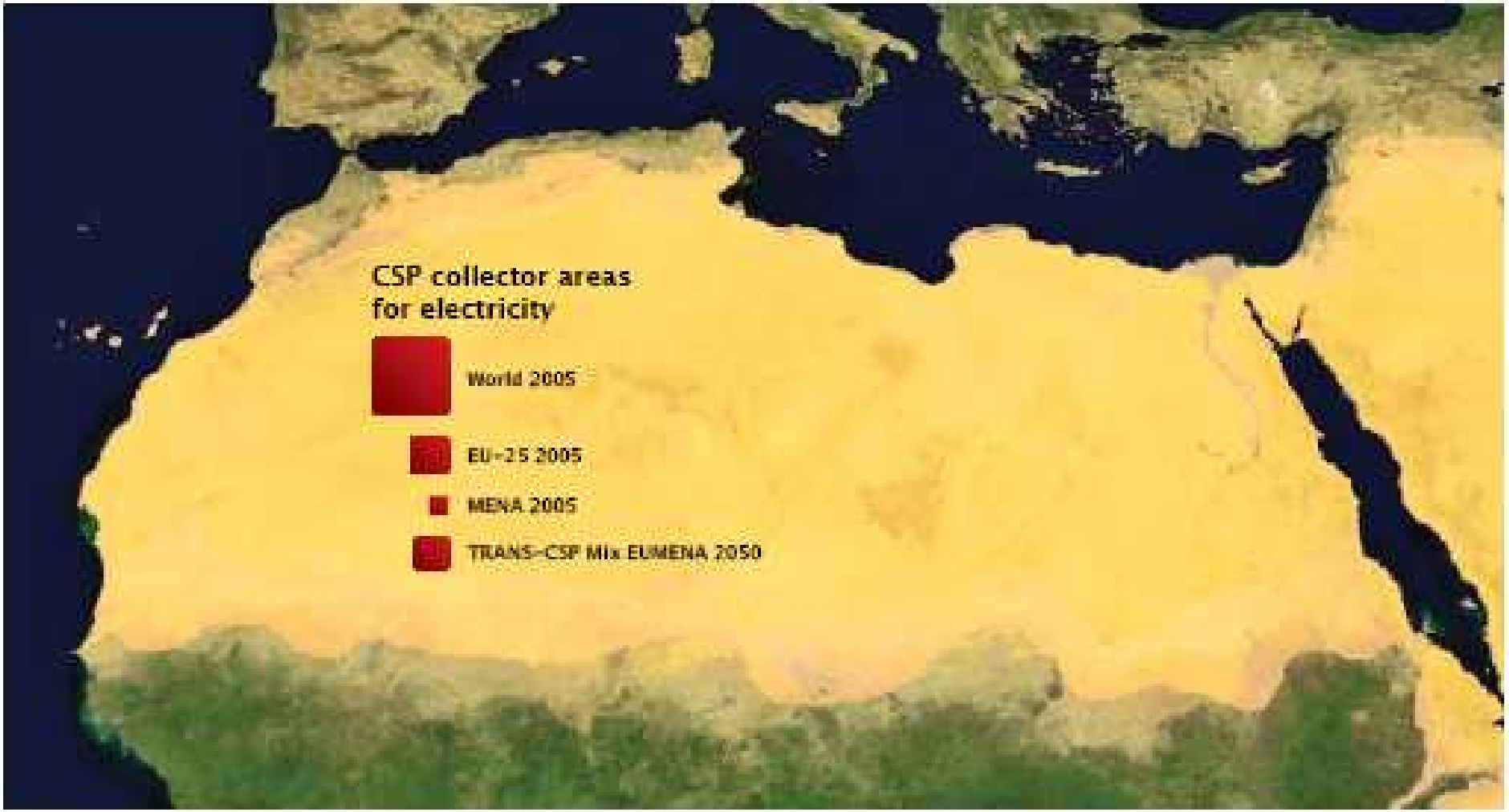
EU	Market 2009 (MW)	Cumulative 2009 (MW)	Market 2010 (MW)	Cumulative 2010 (MW)	W/habitant
Austria	20	53	50	103	12.6
Belgium	285	379	424	803	73
Bulgaria	6	7	11	18	2.4
Czech Republic	398	463	1,490	1,953	191.5
France	219	306	719	1,025	15.5
Germany	3,806	9,785	7,408	17,193	211
Greece	36	56	150	206	19.3
Italy	717	1,173	2,321	3,494	60.2
Portugal	55	114	16	130	11.5
Slovakia	0	0	145	145	26.4
Spain	17	3,415	369	3,784	80.5
United Kingdom	10	21	45	66	1.1
Rest of the EU	50	235	98	333	

CSP (cont. 1)

Harvesting in Granada Province, Spain

CSP (cont. 3)

EUMENA DESERTEC project



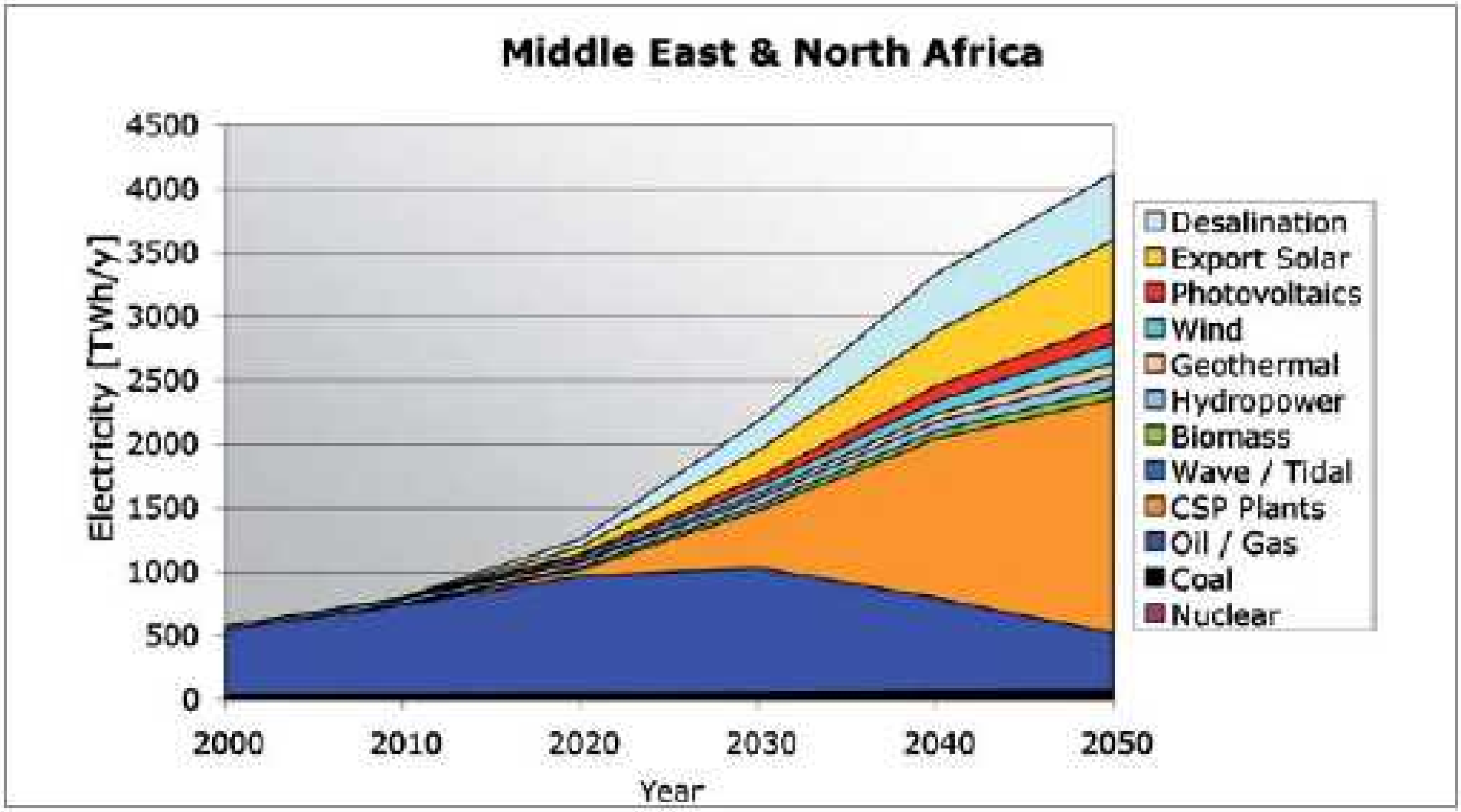
CSP (cont. 4)
Desertec

The idea

- Radiation is quite uniform across desert regions.
- The hot deserts cover around 36 Million km² (UNEP, 2006) of the 149 Million km² of the earths land surface.
- The solar energy arriving per 1 year on 1 km² desert is on average 2.2 Terawatt hours (TWh), yielding 80 Mio Terawatt hours/year.
- This is a factor of 750 more than the fossil energy consumption of 2005, and there is still a factor of 250 if this demand would triple until 2050

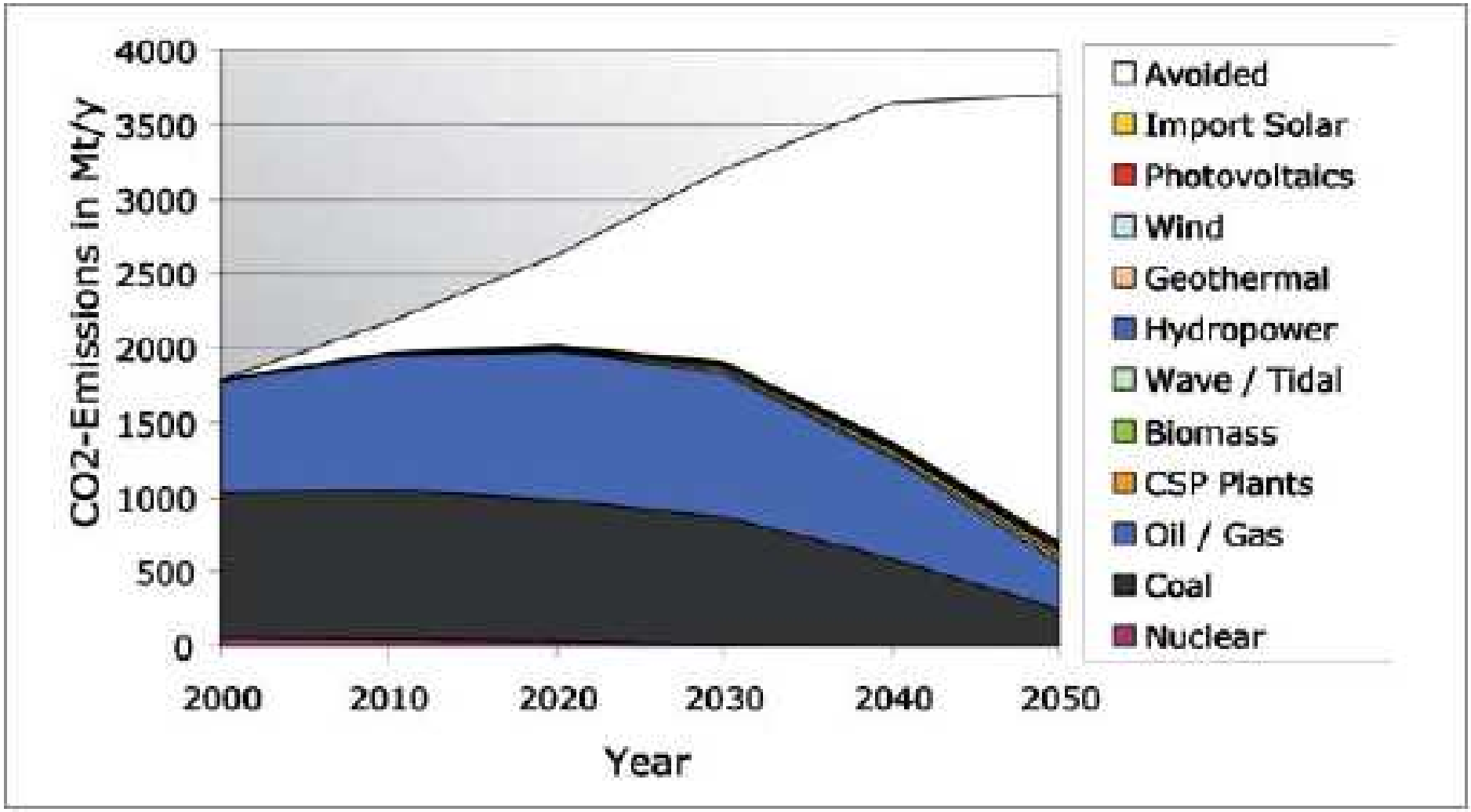
CSP (cont. 5)

EUMENA Desertec energy mix for ME &NA



CSP (cont. 6)

EUMENA Desertec CO2 emission

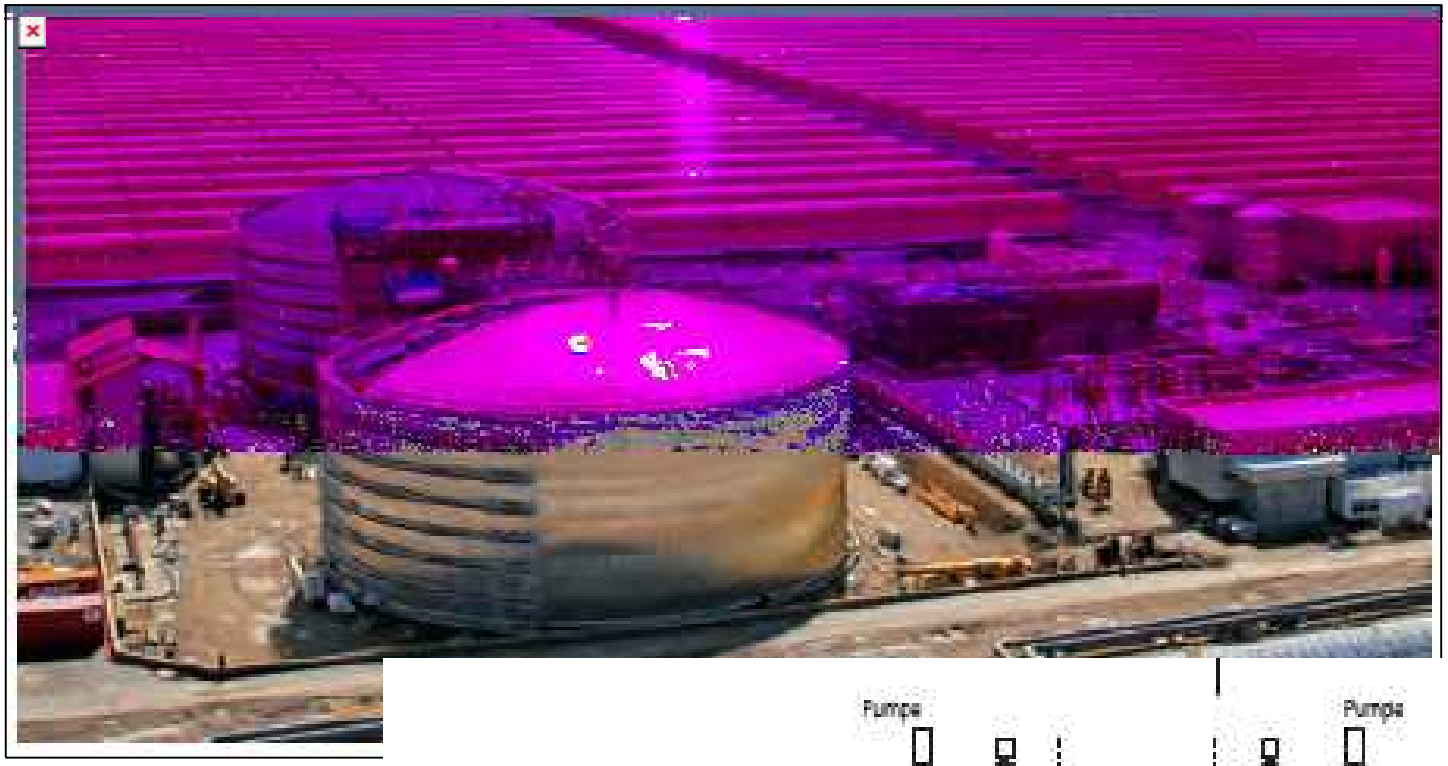


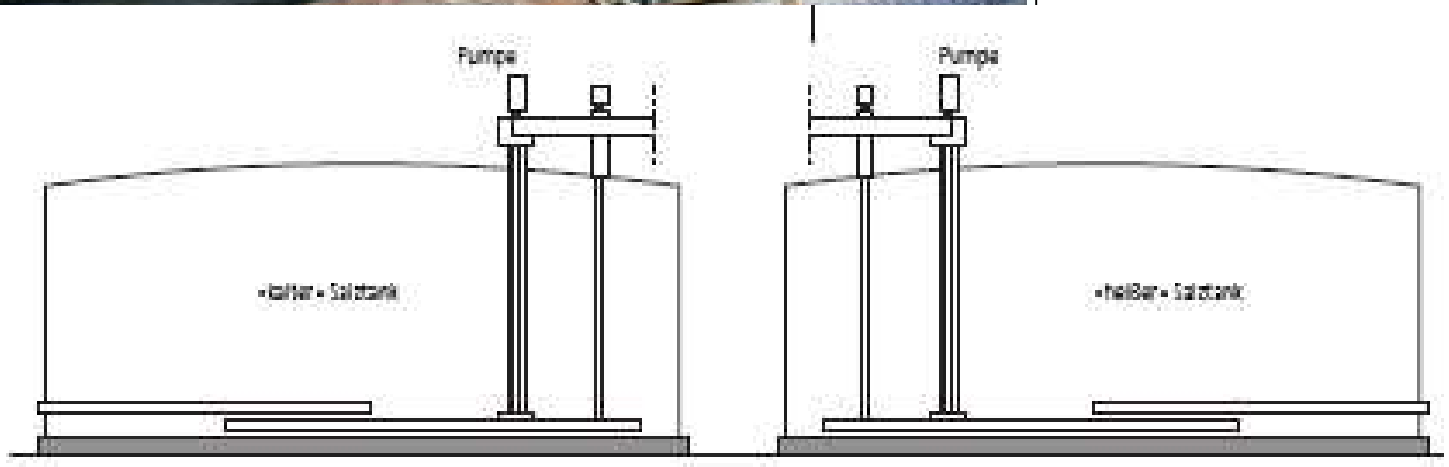
CSP (cont. 7)

EUMENA Desertec Electricity transport

CSP (cont. 8)

Storage of (heat) energy in Andasol 3 plant





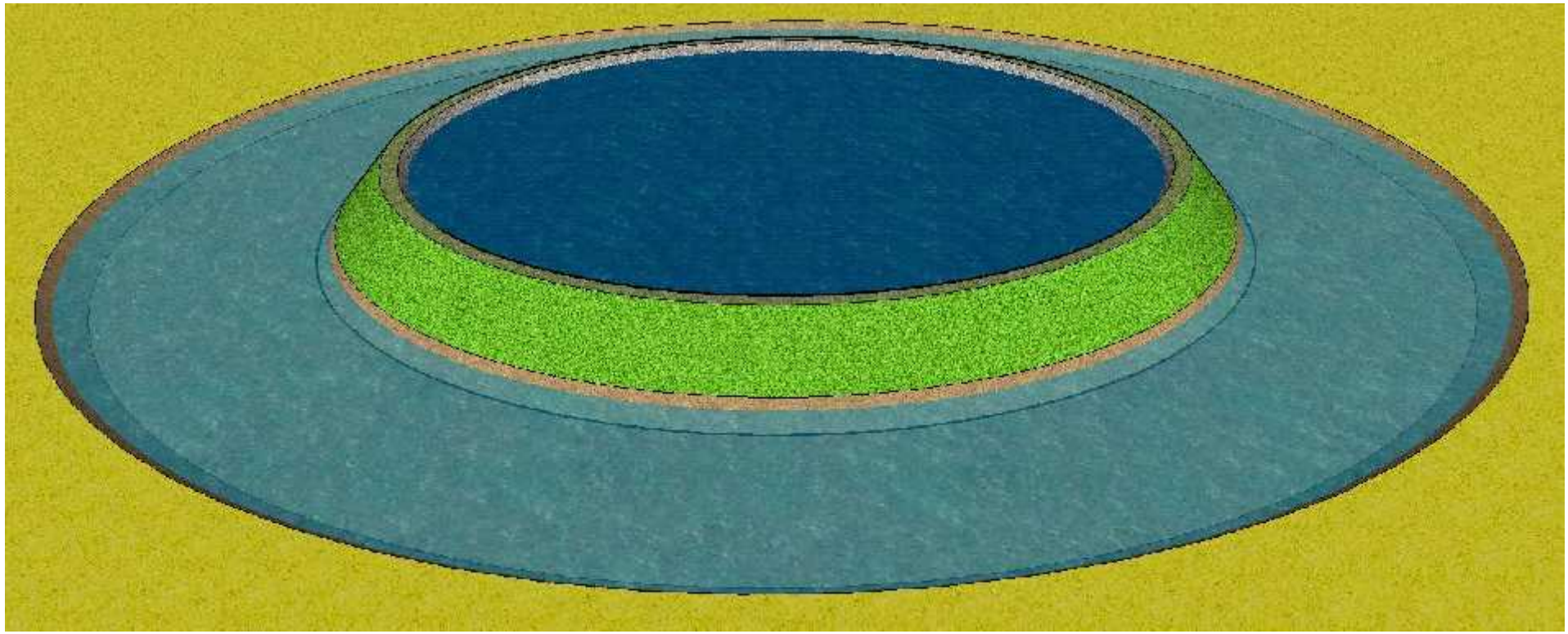
Ringwall-Speicher
as a Generation and Storage System
- self consistent for solar and wind power -

Two artificial lakes, lower lake with 10 km diameter

Water level in higher lake 215 m above lower lake

Water difference 20 m resp. 50 m at max. in lower resp. Higher lake

Average power 2 GW (max. 3.2 GW) for 14 days




(C) Dr. Matthias Popp, Burgstraße 19
D-95632 Wunsiedel,
www.poppware.de

1. Wind Power Energy Contribution

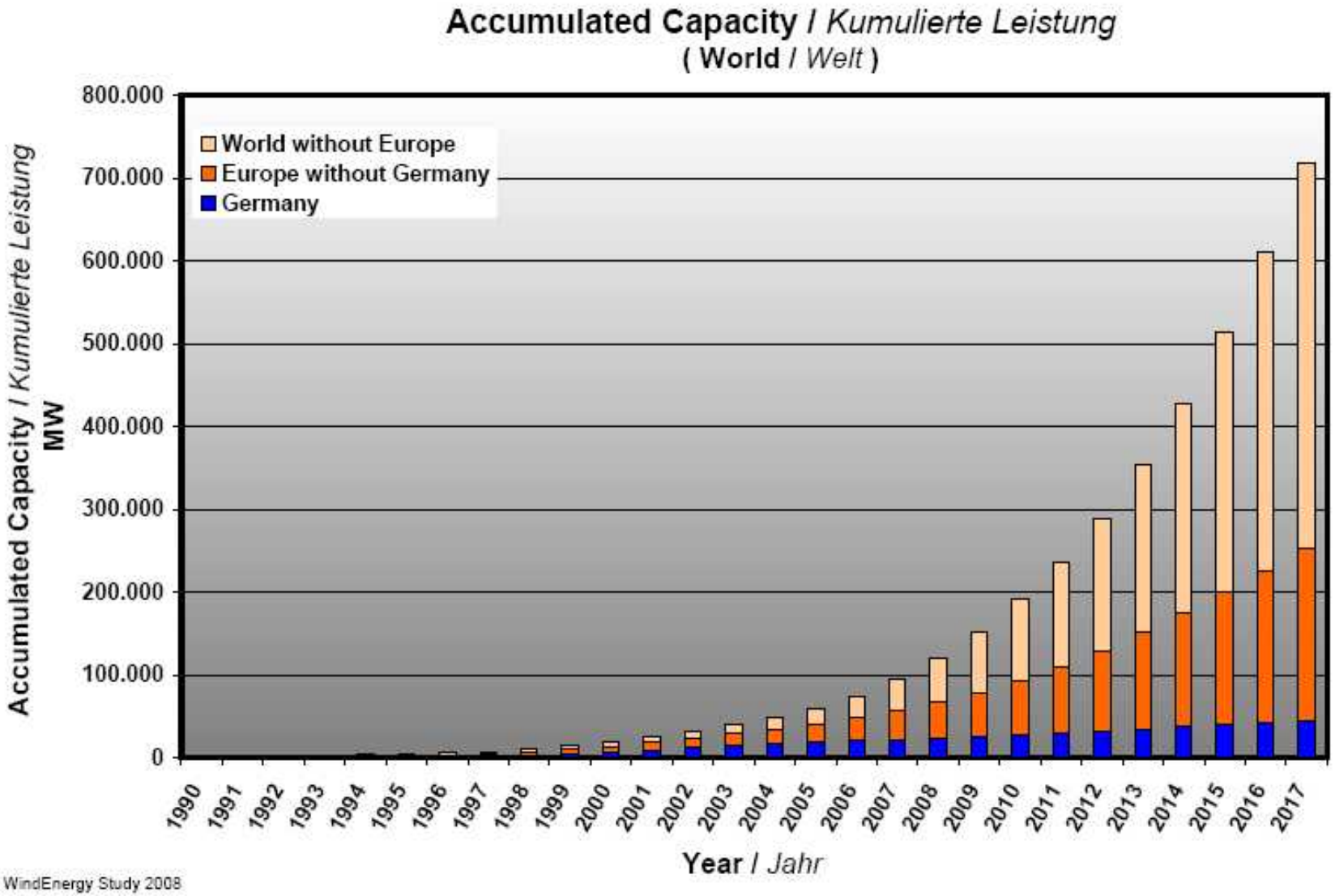
to Solving the World‘s Energy Demands

1. Wind Power Energy Contribution

by off-shore wind power plants in Germany

as an example

Accumulated Capacity (world)



Source: WindEnergy Study 2008

Fig. 2
Abb. 2

Installed Capacity (Germany)

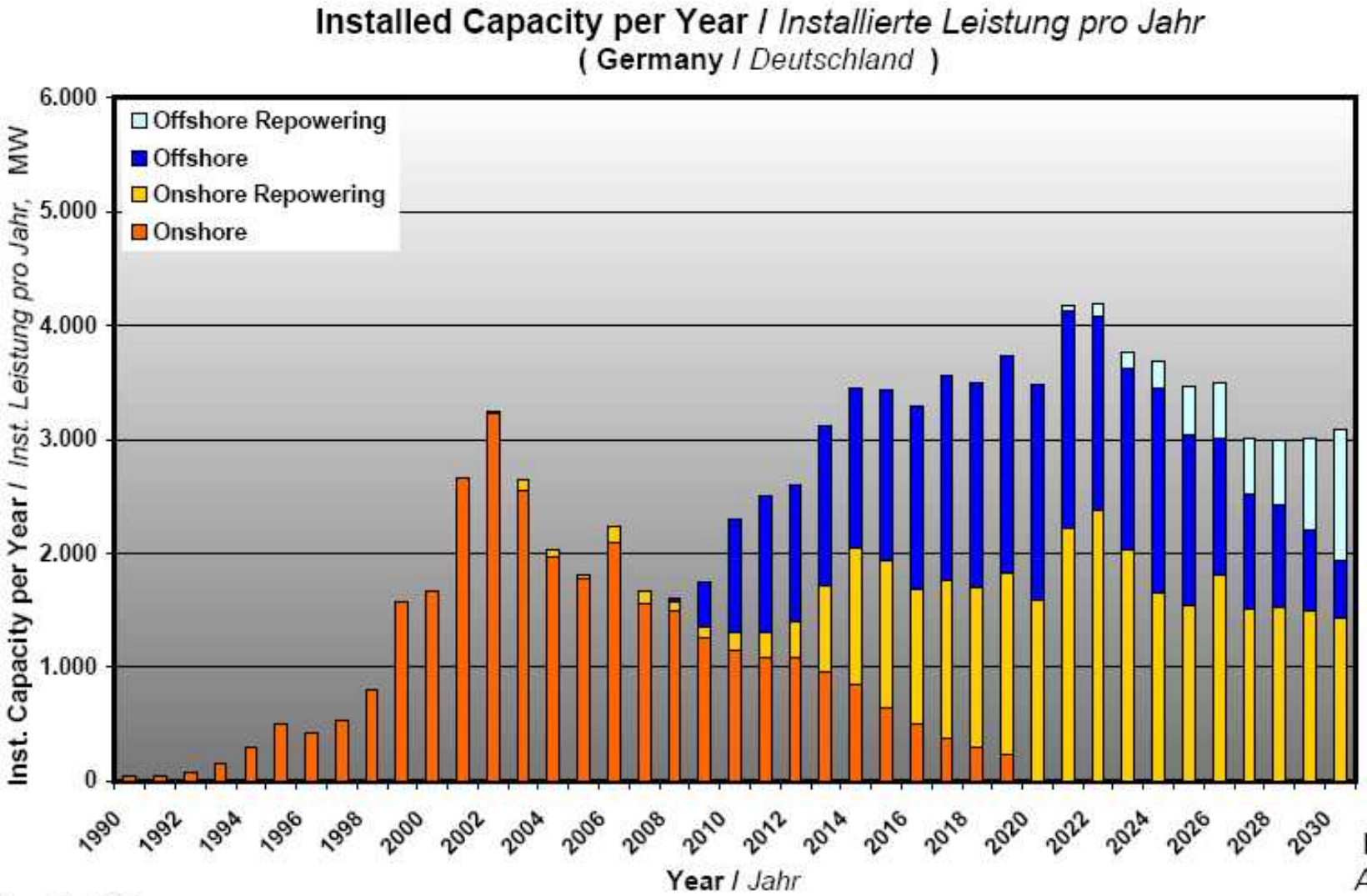
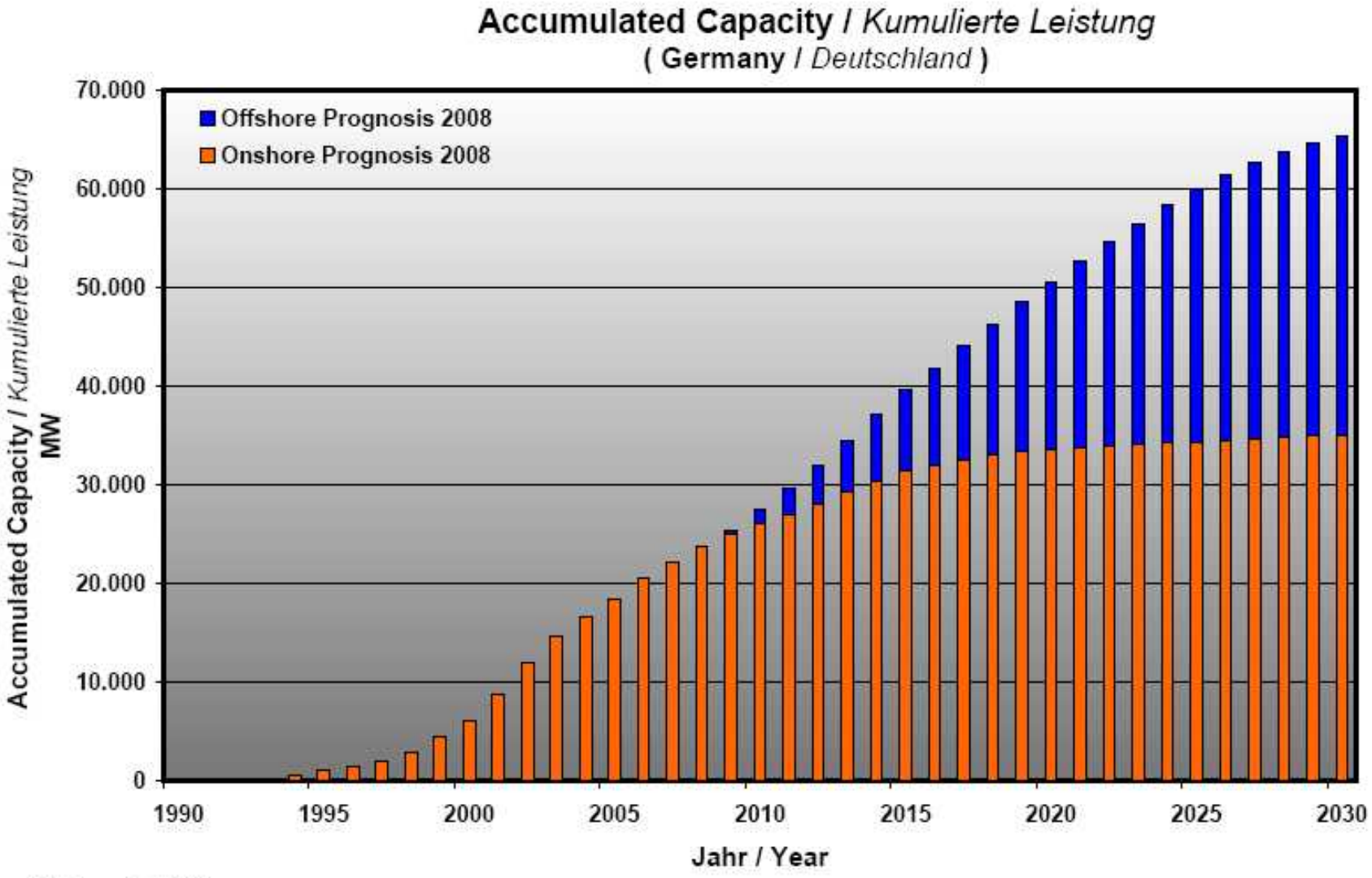


Fig. 3
Abb. 3

Source: WindEnergy Study 2008

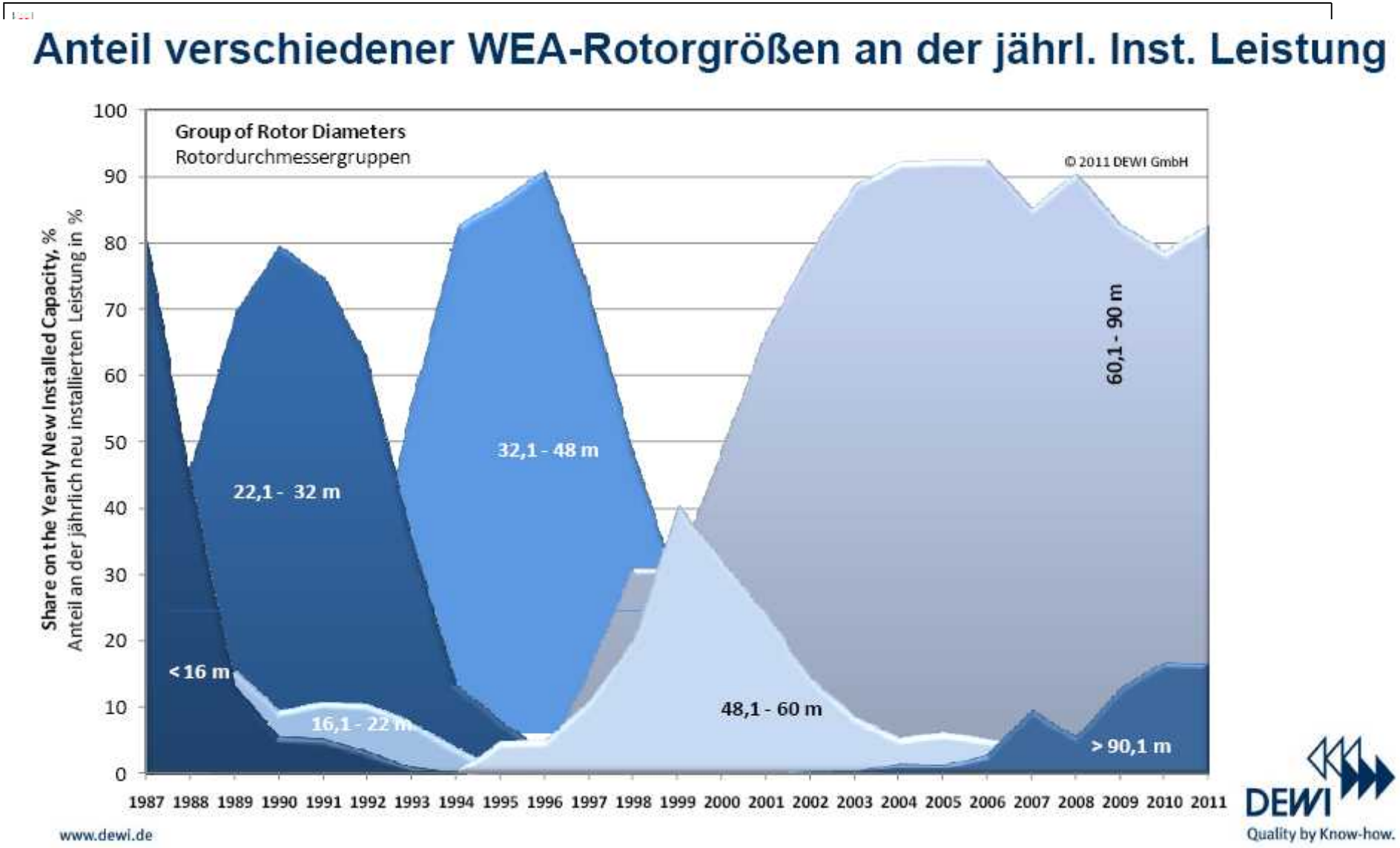
Accumulated Capacity (Germany)



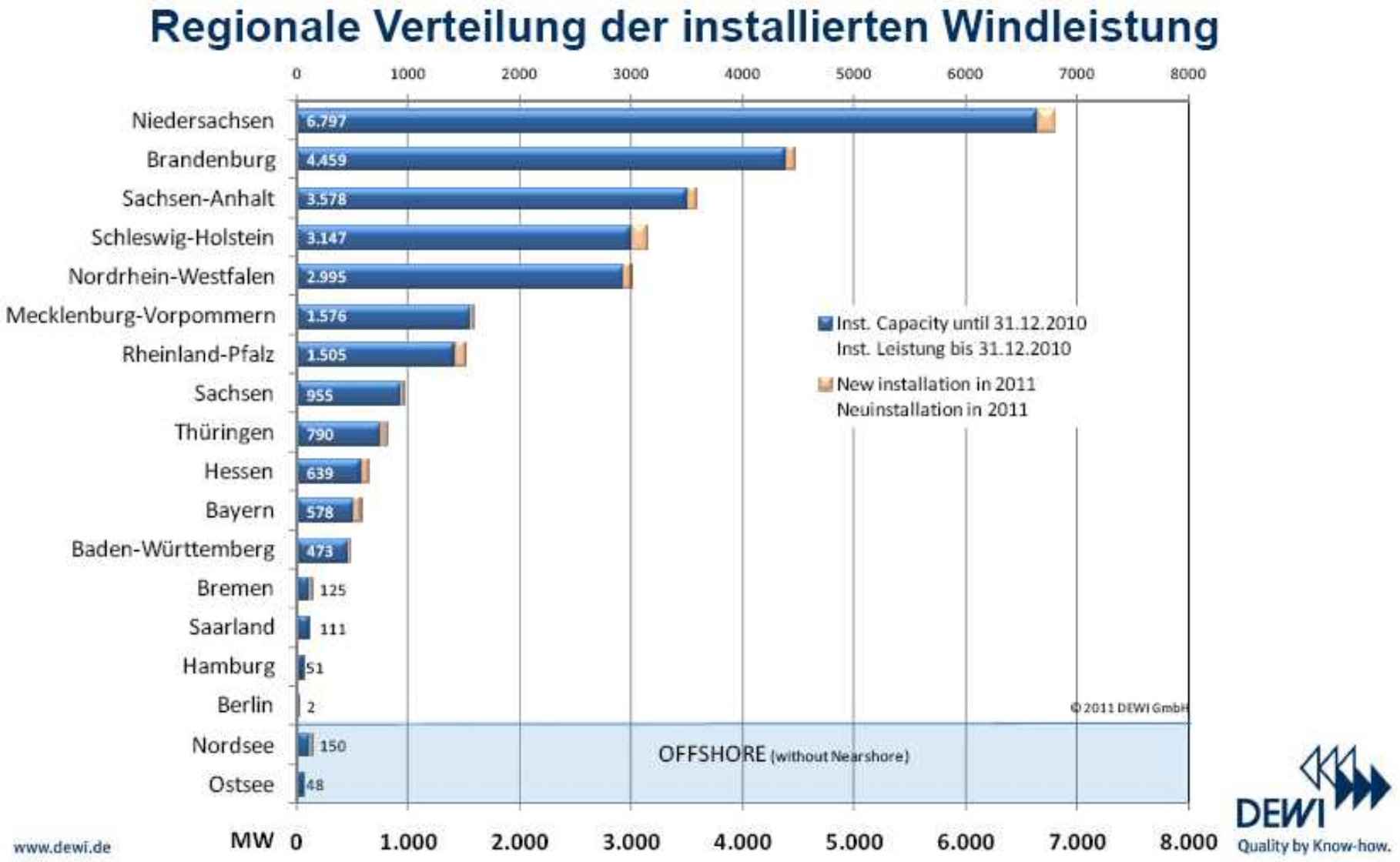
Source: WindEnergy Study 2008

Fig. 4
Abb. 4

Share and rotor diameter (Germany)



Regional distribution (Germany)

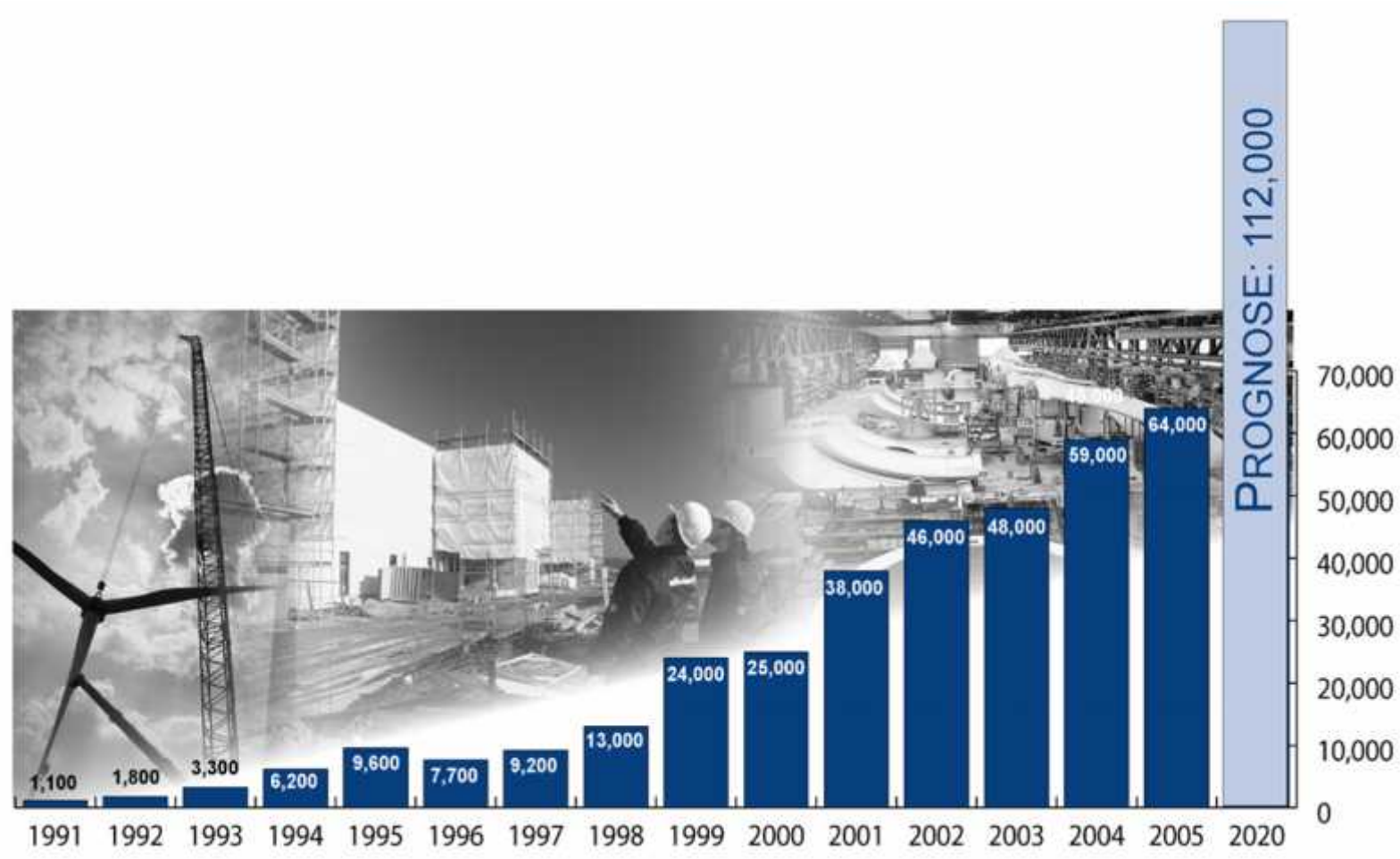


Wind Energy as Job Market

www.wind-energie.de

German Wind Energy Association (BWE)

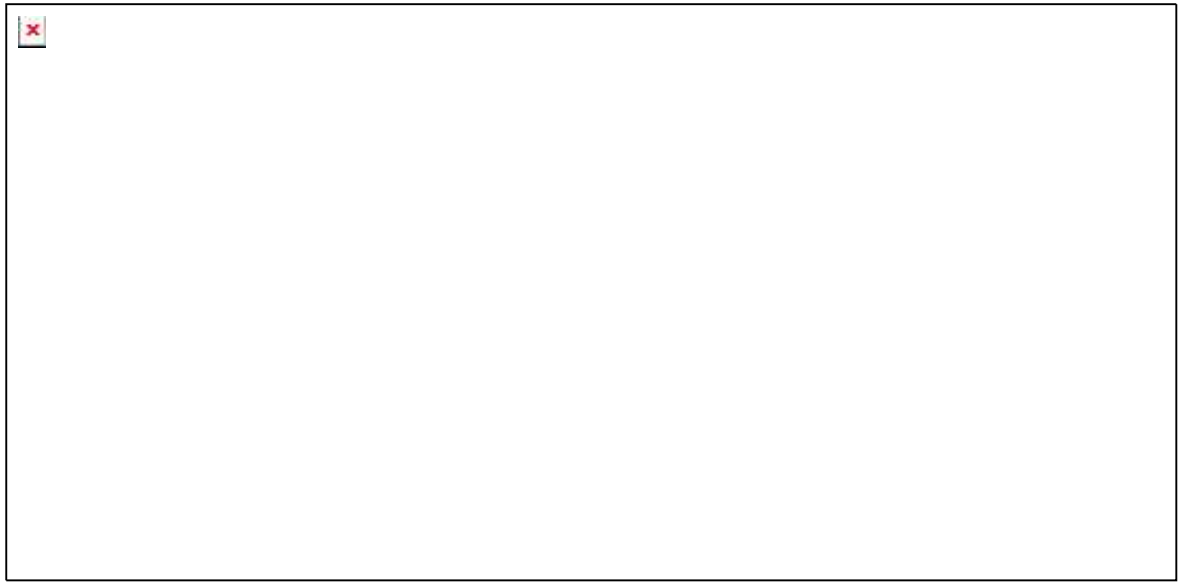
Jobs in the wind energy sector: chance for the future



Offshore Power Plants
Is this the future?

First offshore projects with 5 MW converters

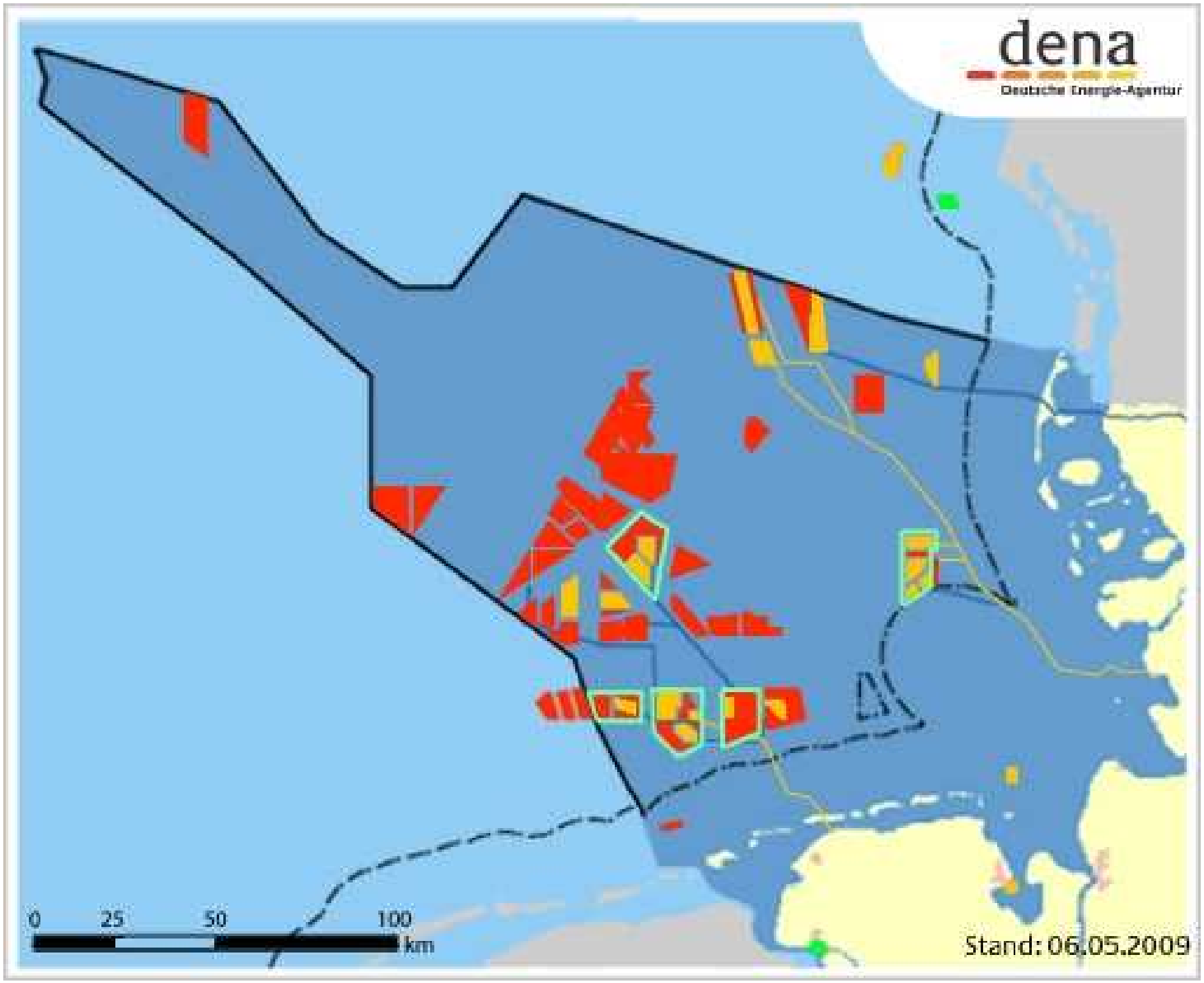
BARD on Tri-Piles
Alpha Ventus on Mono-Piles



Alpha Ventus

Distance
about 1km

Offshore Areas in the German Bight of the North Sea



Offshore Area in the German Bight

Suitable area: 3.574 km^2

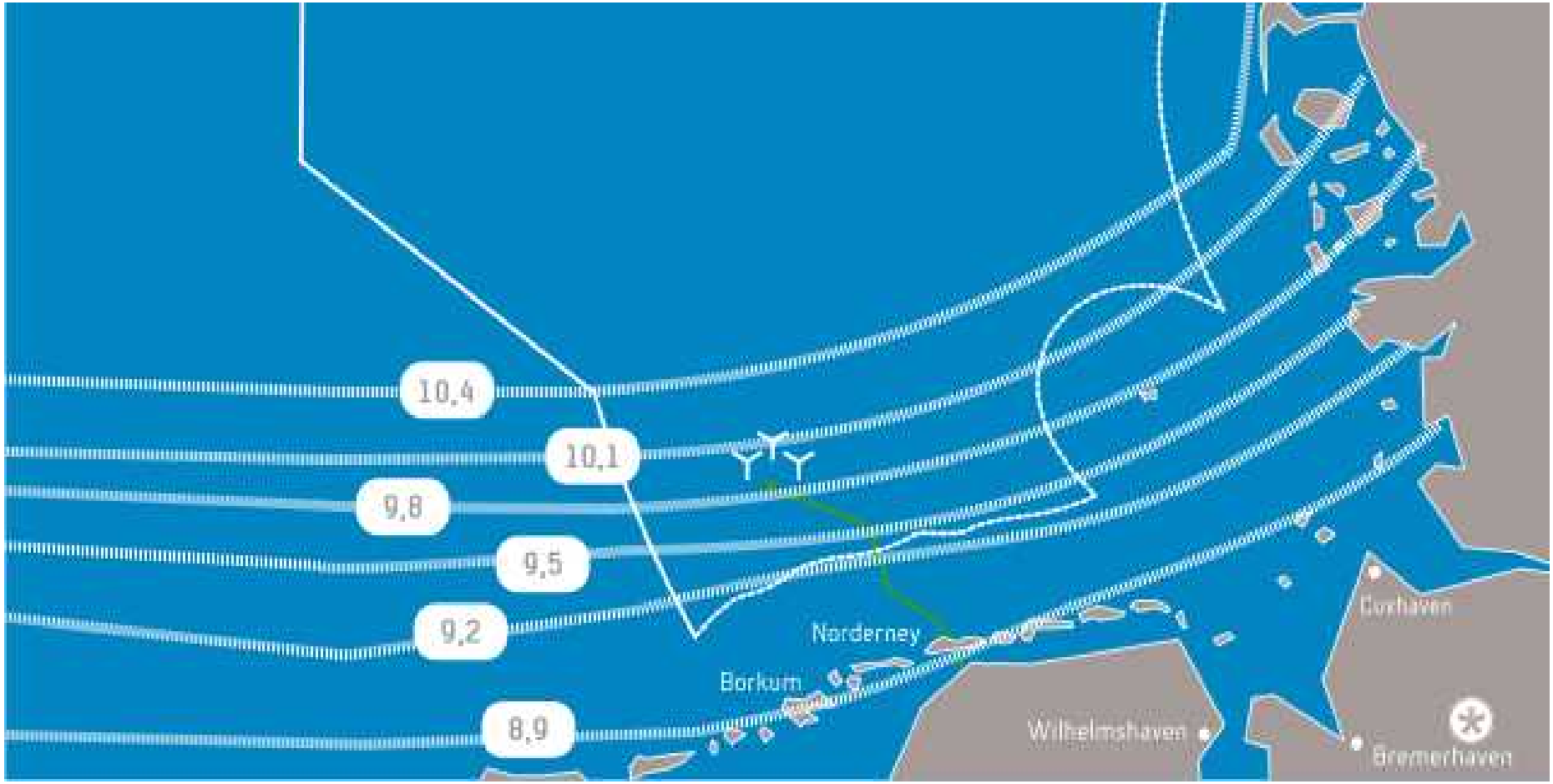
more than 20 project fields are licensed

Including the relatively small and suitable
German part of the Baltic Sea

up to 1.400 wind power generators are licensed

summing up to a capacity of > 7.000 MW

Wind Speed Isoclines in m/s in the German Bight



Wind and Operating Conditions

German Wind Energy Association (BWE):

Average wind speed 10 m/s (force 5) in about 50 m height
Prevailing directions 210 - 240^0

Operating time 3.800 – 4.250 hours/year

Height of waves: average 6 – 8 m (up to 10 m) in winter
Main direction North-West

First „Pilot“ Projects

Alpha Ventus

- 12 wind power generators
- 5 MW each sums up to 60 MW

Bard Offshore 1

- 80 wind power generator
- 5 MW each sums up to 400 MW
- area is 60 km x km

Installation Platform
Bard Offshore 1

Offshore Tranformer Stations

Power of Biggest Windturbines

www.wind-energie.de

German Wind Energy Association (BWE)

Technical development – also for the Offshore market

The currently biggest wind turbines

	Enercon E-112	Repower 5M	Multibrid M5000
Capacity	4,5 MW	5 MW	5 MW
Hub hight	112 meters	120 meters	102.6 meters
Rotor diameter	114 meters	126 meters	116 meters
Currently installed	5 turbines (Emden, Wilhelmshaven, etc.)	1 turbine (Brunsbüttel)	1 turbine (Bremerhaven)

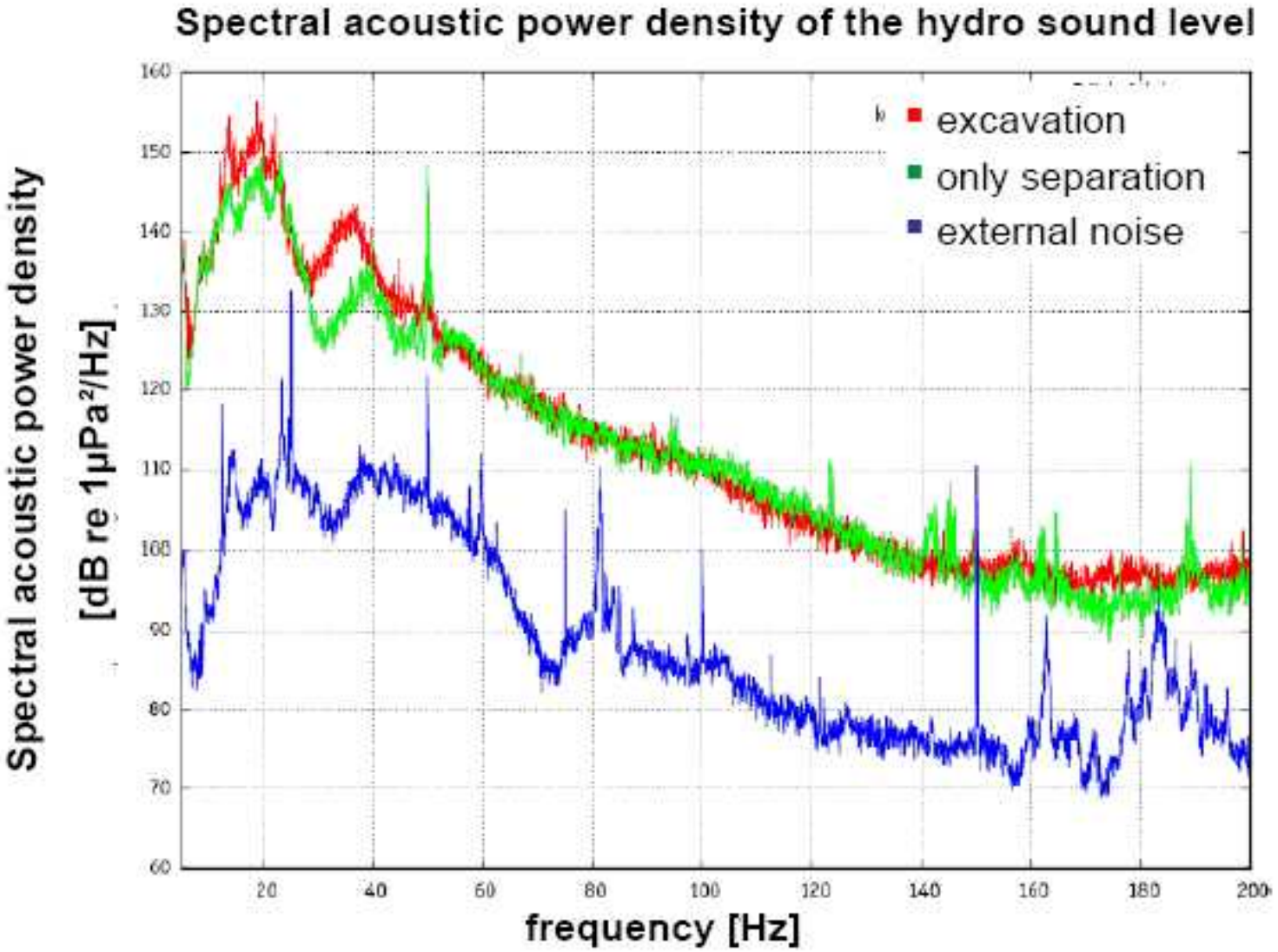
The 5 MW turbine BARD VM

(soon 6.5 MW)

Side-effect
Repowering of Old Windparks

Common Purpoise
(50 000 each year in the North

Hydrosound level measurements



Herrenknecht AG, 2009.

BEng. Wiegand, Jens

Comparison of sound impact due to VSM and Pile Driving

	VSM	Pile Driving	BSH Standard
Sound pressure level	< 117 dB	162 – 173 dB	160 dB
Peak level	< 122 dB	ca. 195 dB	160 dB

The BSH standard of 160 dB is valid for a distance of 750 m

(BSH is the German Office for Sea Traffic and Hydrography)

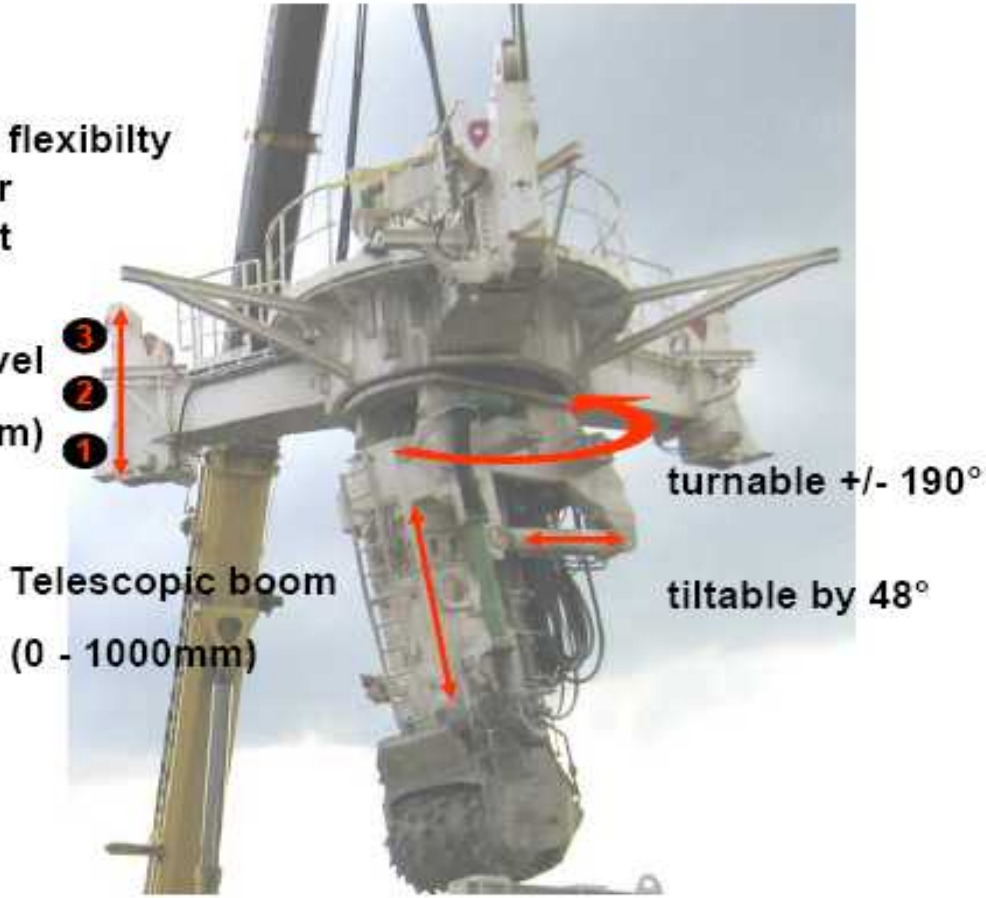
VSM Technology
Kinematic features

Spacer for flexibilty
in diameter
adjustment

Maschinelevel

(0 - 1000mm)

3
2
1



turnable +/- 190°

tiltable by 48°

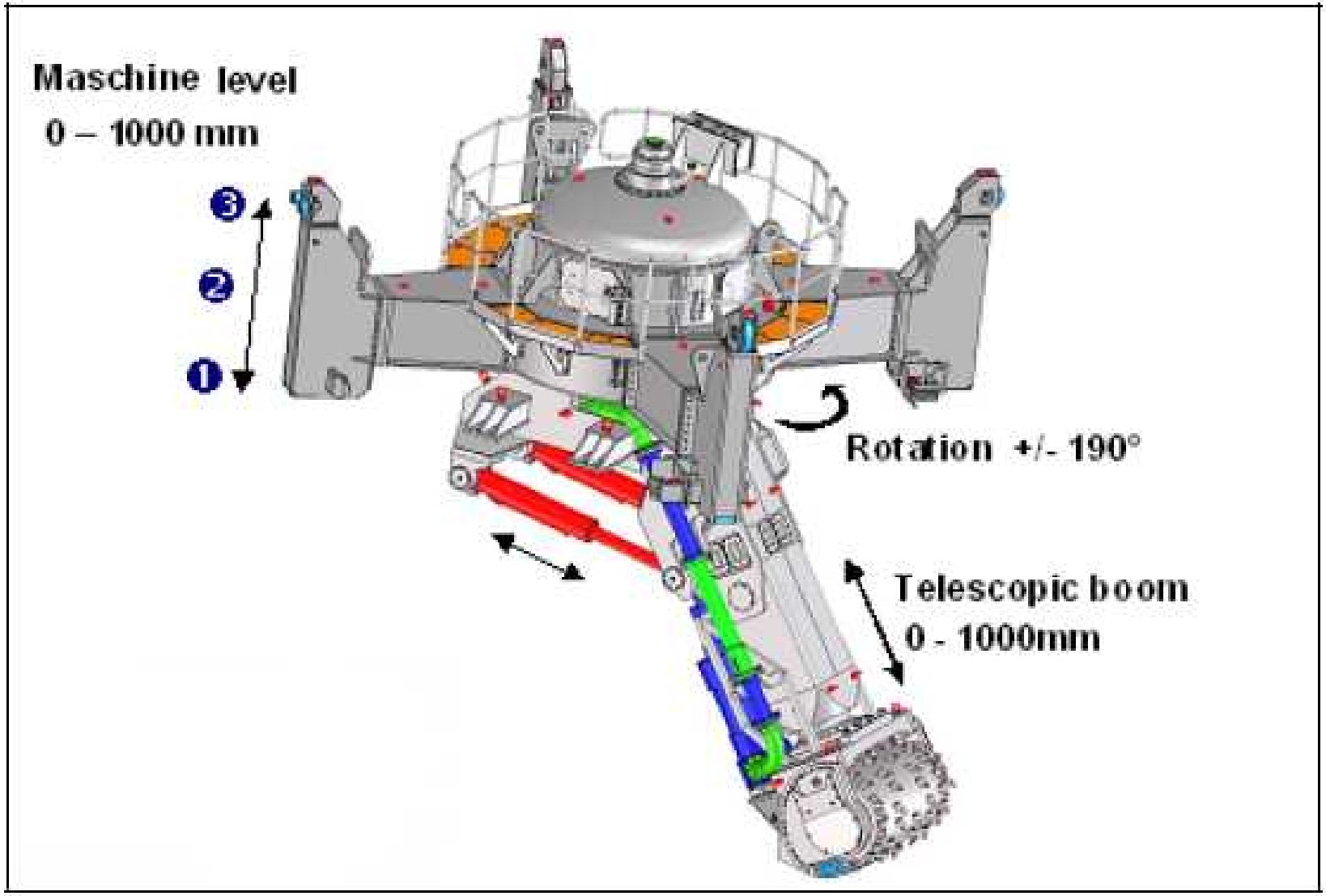
Telescopic boom

(0 - 1000mm)

TECHNICAL DATA:

- excavation power : 315kW / 400kW
- torque: 30kNm / 80kNm
- rotation speed: 0-90 rpm / 0-80rpm

VSM (detailed principle)

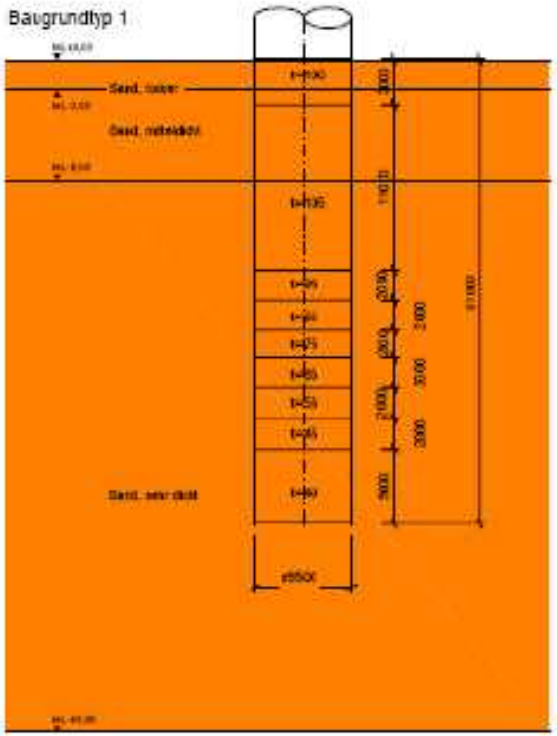


VSM-offshore feasibility study (cont.)

Monopiles for 30 m waterdepth and 5 MW converter

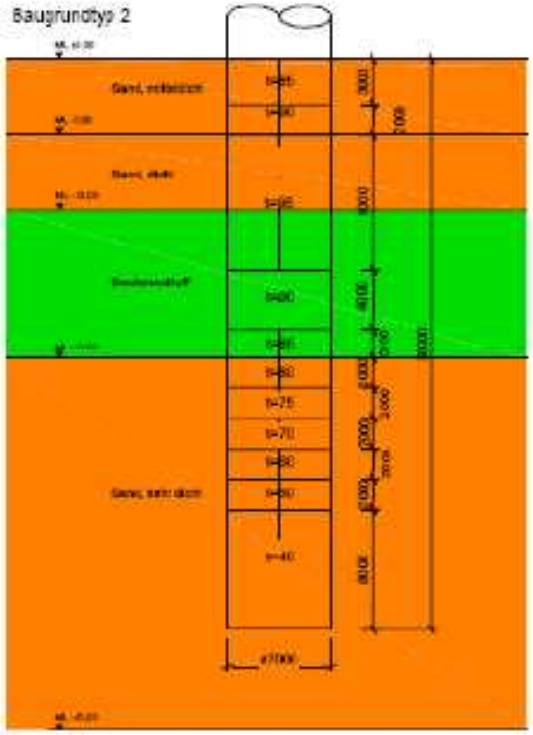
sand

Ø 6,50 m, depth 31 m



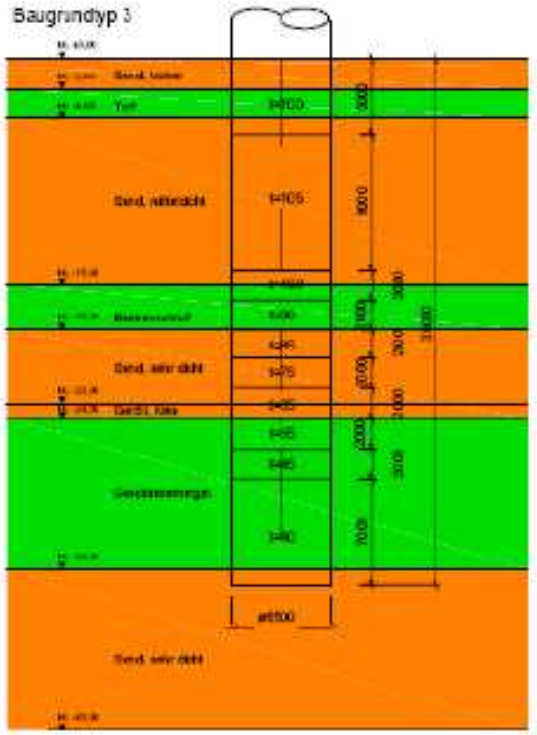
sand, silt

Ø 7 m, depth 38 m



sand, clay, silt, gravel, till

Ø 6,50 m, depth 35 m

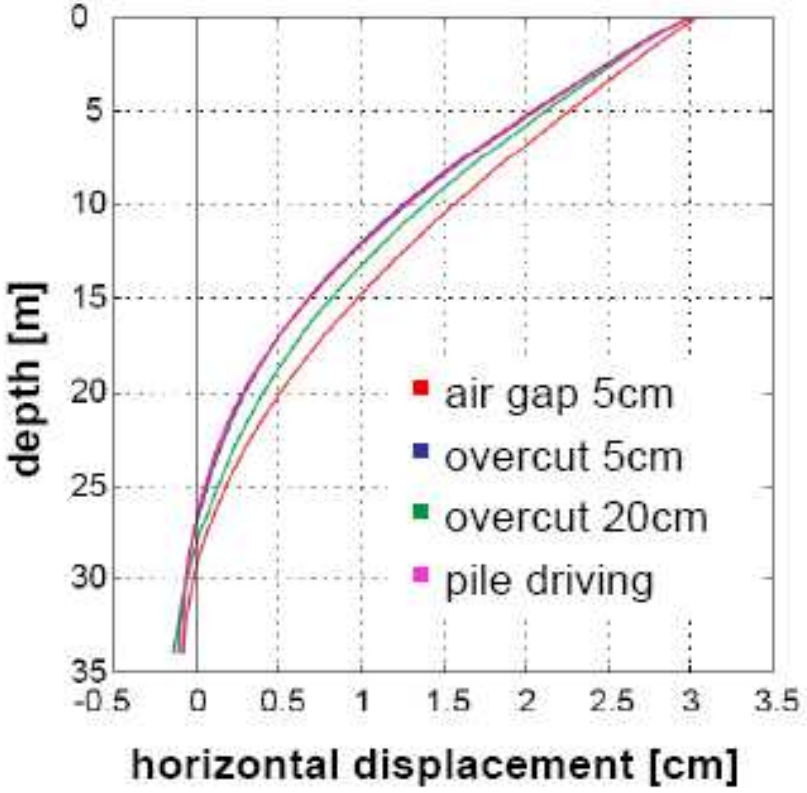


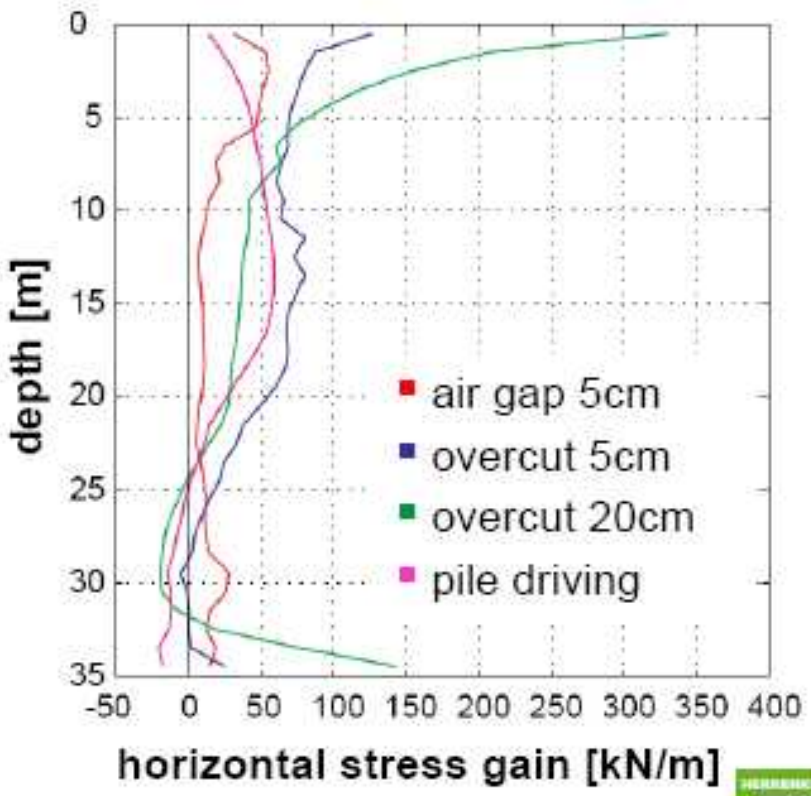
Herrenknecht AG, 2009.

BEng. Wiegand, Jens

Feasibility study - comparison

Comparison of horizontal displacement and stress gain for VSM and pile driving





Possibility of Founding by VSM and Pile Driving

Type of soil	Pile Driving	VSM
Light – medium dense (sand)	good	good
Dense with stones (sand and silt)	bad/difficult	good
Very dense (sand, silt, clay,, gravel)	impossible	(quite) good

Green energy in Germany

Germany owns 16 nuclear power stations

In 2011 8 of them are shut down (1/2 of all!)

And nobody really realised it

The overall share of wind power in D is about 10%

- in lower saxony (my province) it is close 50 % -

Thank you for your Attention

Carsten Ahrens
Jadehochschule
ZDI, Germany

carsten.ahrens@jade-hs.de