Is a Low-Carbon-Economy Feasible? The Experiences from Germany

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Agenda: Is a Low-Carbon-Economy Feasible

- Reasons for the mixed Performance of the German Energy Concept 2050
- But there is a success story: Renewable Electricity
- Excurse: Chile
- The high contribution of renewable electricity in Germany causes new problems – and requires new solutions
- Promising innovative concepts for a low-carbon economy are still missing

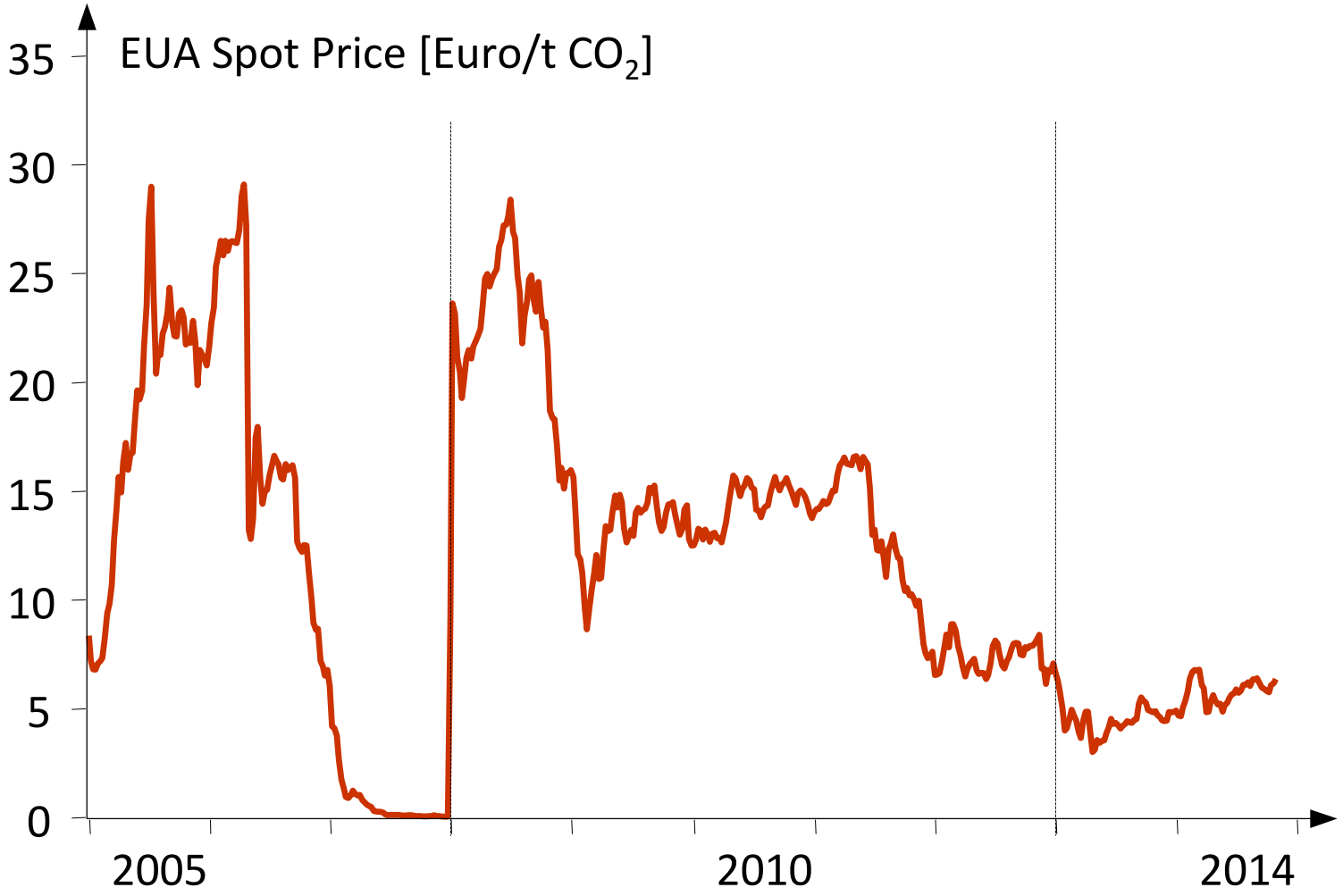
German Energy Concept 2050 [Sept.2010/May 2011]

Political target	Base year	2012	2020	2050
GHG reduction	1990	-24.7%	- 40%	-80-95%
Primary energy reduction	2008	-4.3%	- 20%	-50%
Final energy productivity growth	2008	1.1%	2.1% p.a.	
Reduction of electricity demand	2008	-1.9%	-10%	-25%
Heat demand in buildings	2005	-16%	-20%	
Primary energy in buildings	2005			-80%
Modernization rate of buildings		1%	2% p.a.	
Energy in transportation	2005	-0.6%	-10%	-40%
REN share in energy consumption		12.4%	18%	60%
REN electricity share		23.6%	35%	80%
Nuclear power capacity	21.5 GW (2010)	12.1 GW	8.2 GW	0

Mixed Performance in Germany up to now

	2011	2012	2013	2015	**2020**
Greenhouse gas emissions (against 1990)	-26.7%	-24.7%	-22.6%	-27.3%	**-40%**
Primary energy (against 2008)	-5.4%	-4.3%	-3.8%	-7.6%	**-20%**
Electricity consumption (against 2008)	-1.8%	-1.9%	-3.2%	-4.0%	**-10%**
Heat demand of buildings (against 2008)	-10.1%	-7.8%	-0.3%	-8.3%	**-20%**
Renewable share of final energy	11.5%	12.4%	12.0%	14.9%	**18%**
Renewable share of heat demand	11.3%	11.9%	12.3%	13.2%	**14%**
Renewable electricity share	20.4%	23.6%	25.3%	31.6%	**> 35%**

Price of European CO_2 Allowances (EUA)



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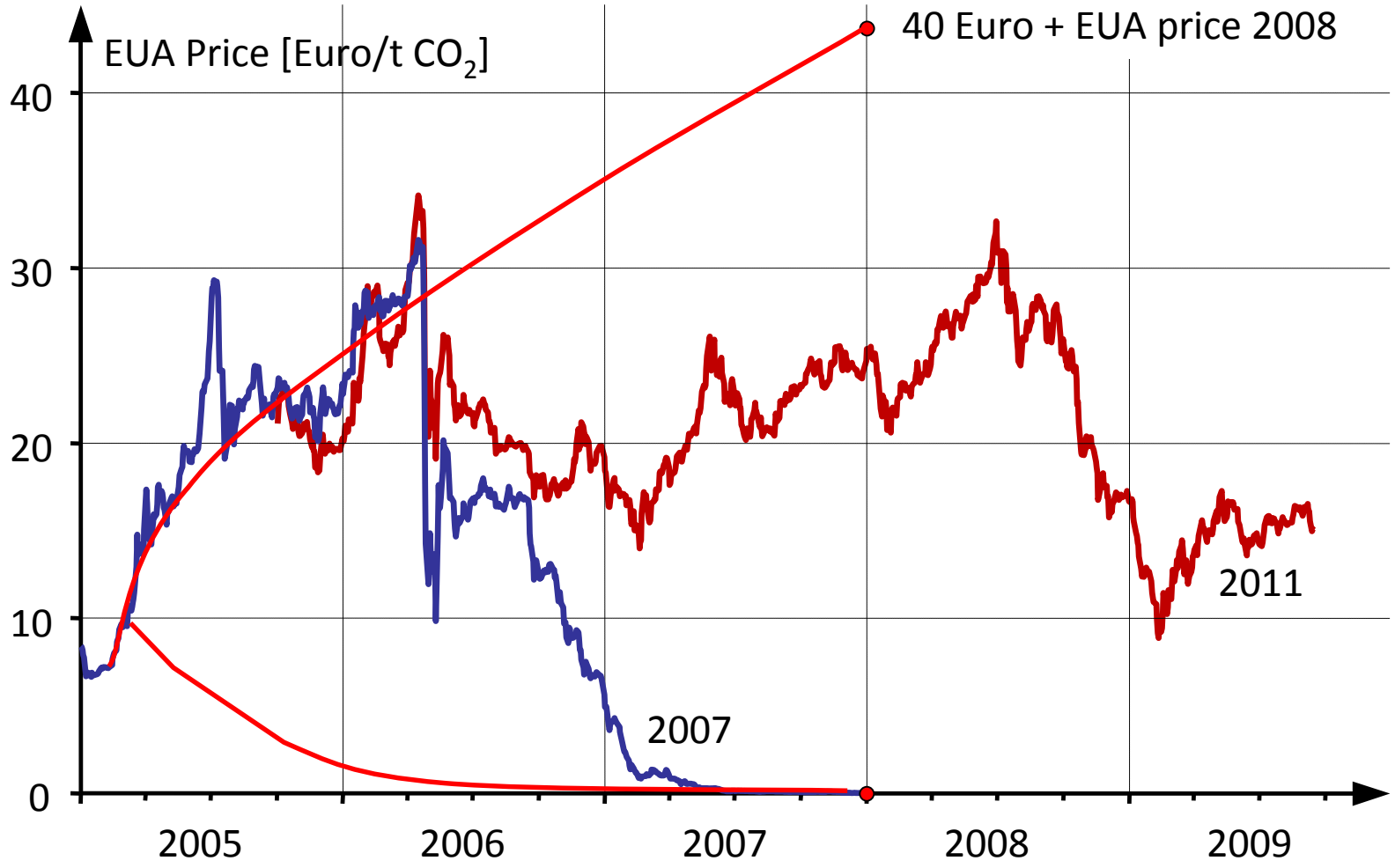

Why no Progress in GHG Reduction?

- Coal benefits from nuclear phase-out (due to high gas prices and low CO_2 prices). CO_2 price of the European Cap-an-Trade system not sufficient for the replacement of coal by natural gas
- EUA cap-and-trade system is effective and efficient: The 2020 target of -20 % GHG reduction is already achieved. The effects of additional national measures to reduce CO_2 emissions have no effect as far as the number of emission allowances is not reduced
- Instead, the German government now forces grid users pay for coal phase out. But this gives old coal fired power plans a “political value”

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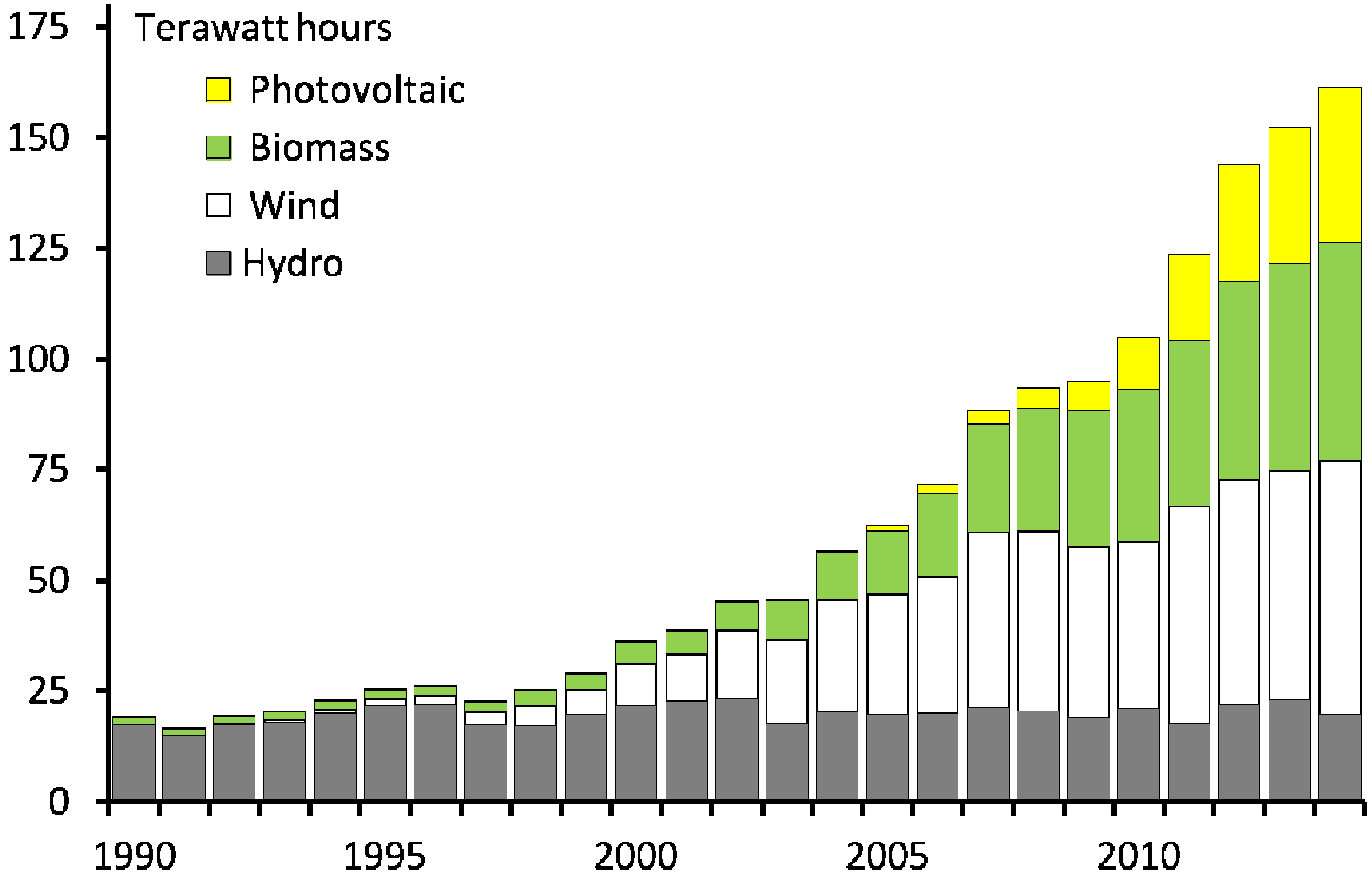
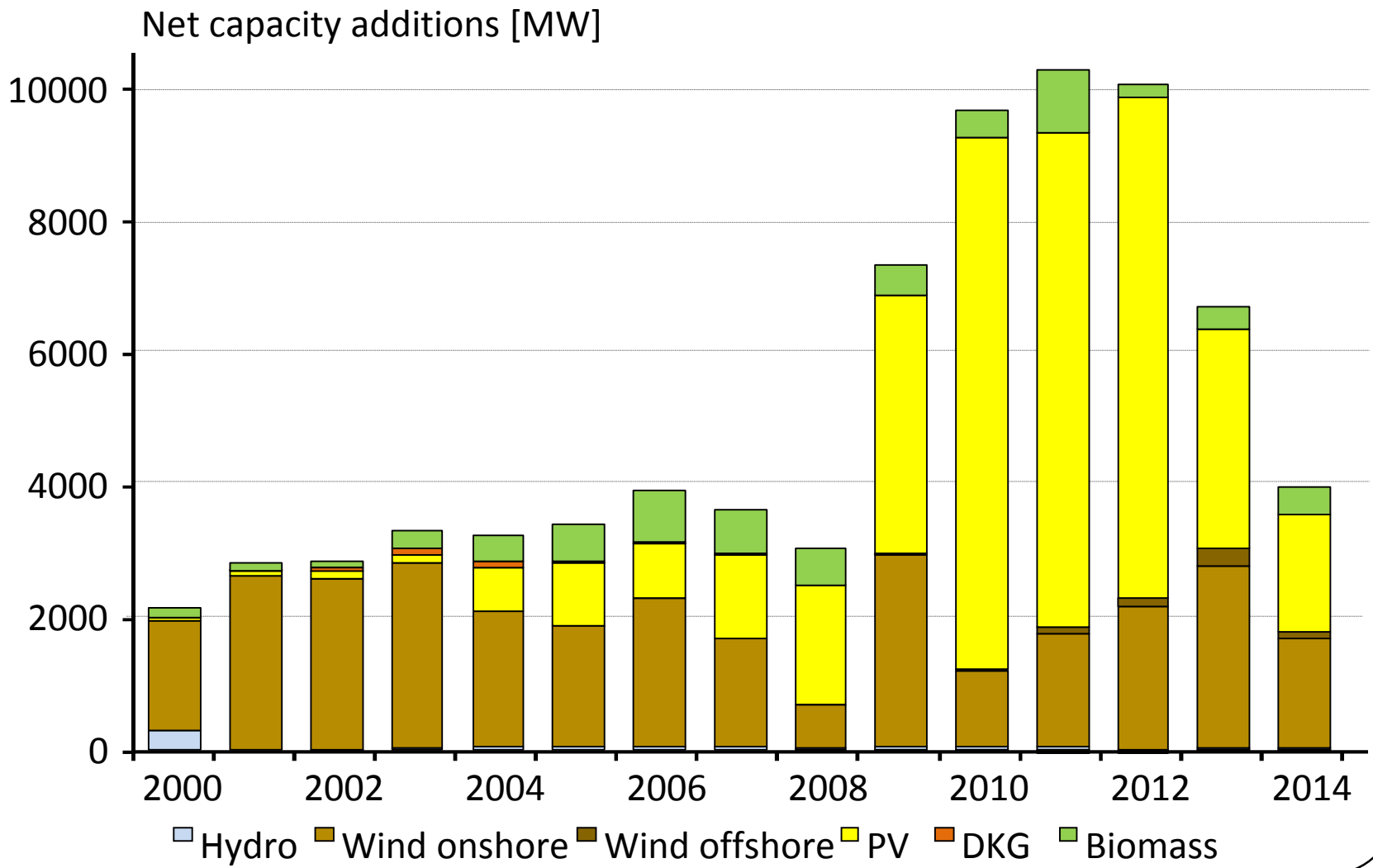
Renewable Electricity Generation in Germany

[Source: Arbeitsgemeinschaft Energiebilanzen]



REN Capacity Additions in Germany



Final User Expenditures for Electricity

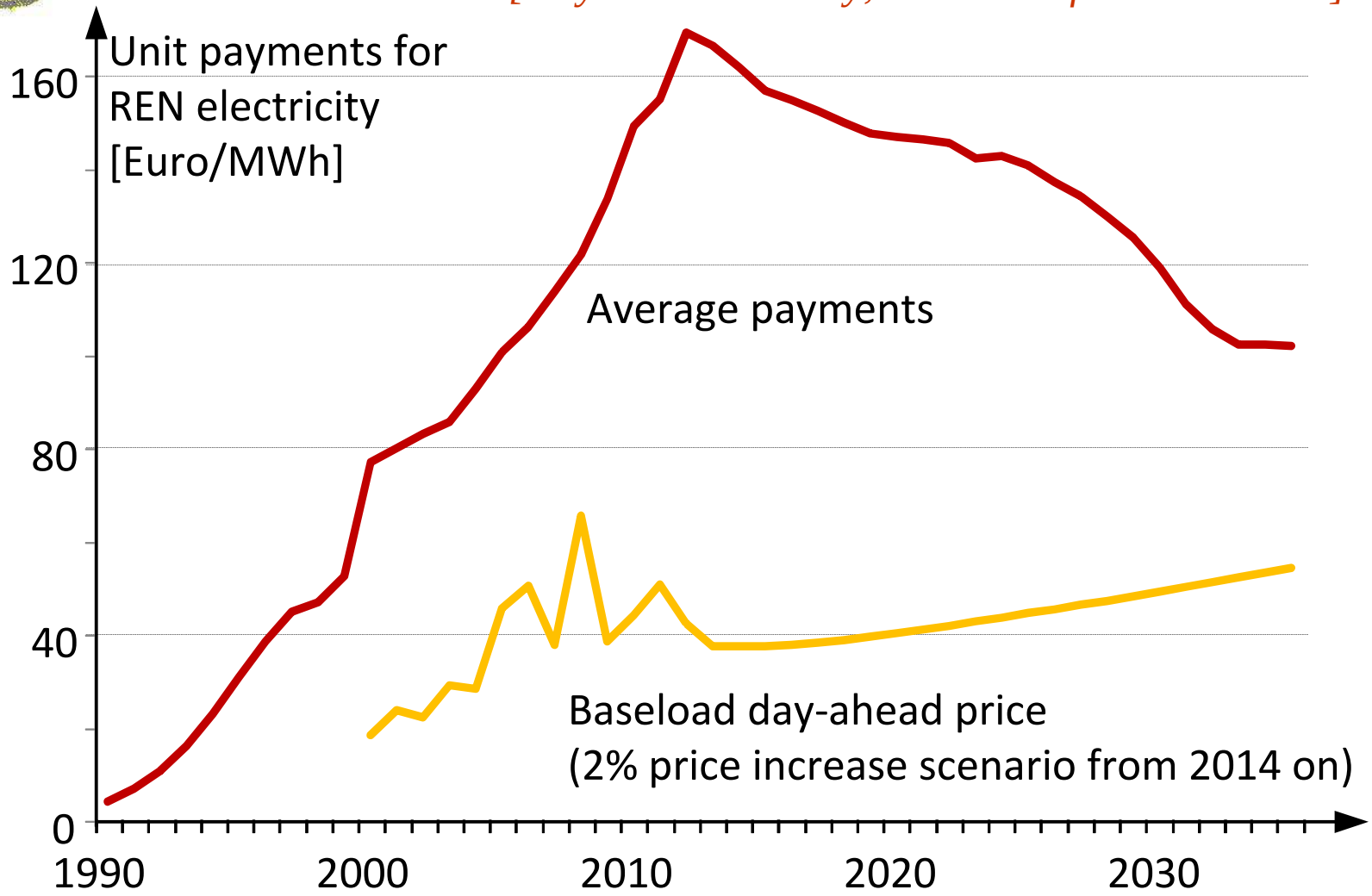
Germany	2010	2011	2012	2013	2014
	Billion Euros p.a.				
Total domestic expenditures	**60.9**	**63.6**	**64.3**	**71.0**	**70.3**
Expenditures induced by the government	**17.2**	**23.0**	**23.3**	**30.0**	**32.3**
Electricity taxes	6.4	7.2	7.0	7.0	6.6
Concession fees	2.1	2.2	2.1	2.1	2.0
Renewable electricity levy	8.3	13.4	14.0	19.8	22.3
Combined heat and power Levy	0.4	0.2	0.3	0.4	0.5
Offshore grid levy (§ 17F ENWG)	-	-	-	0.8	0.8
Expenditures regulated by the government	**16.9**	**17.6**	**19.0**	**21.2**	**21.4**
Fees for the transmission grid	2.2	2.2	2.6	3.0	3.1
Fees for the distribution grid	14.7	15.4	16.4	18.2	18.3
Expenditures driven by the market	**26.8**	**23.1**	**22.0**	**19.8**	**16.6**
Market value of renewable electricity	3.5	4.4	4.8	4.2	4.1
Conv. generation, marketing, sales	23.3	18.6	17.2	15.6	12.6

Direct and Indirect REN Support

New installations January 2014 [Euro/MWh]	Onshore wind	Offshore wind	PV	Biogas	Bio-methane
Net support (Feed-in ./. Market value)	**62**	**162**	**92**	**164**	**187**
Gas grid integration of bio-methane					22
"Avoided costs" of gas grids					19
Extension electricity distribution grid	26		15	4	
Extension electricity transmission grid	8	8	1	1	
Extension offshore grid		26			
Offshore levy		3			
Short term merit order effect	-28	-29	-32	-29	-29
Backup capacity	27	22	27		
Transmission losses	2	12	12		
Total	**97**	**204**	**104**	**140**	**199**
- Thereof for electricity	97	204	104	120	149
- Thereof for heat / gas grid				20	50

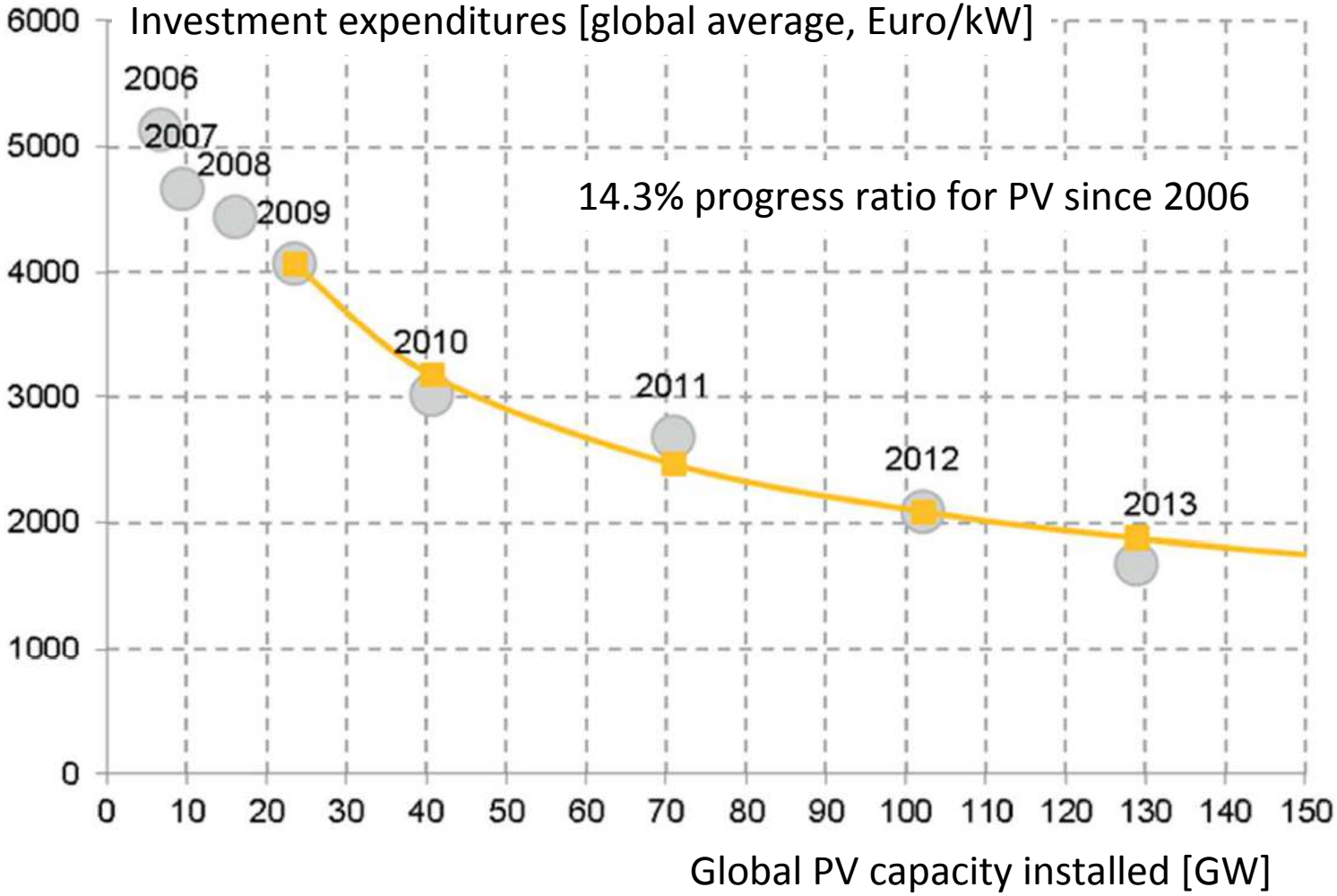
High Unit Payments for Renewable Electricity

[only EEG electricity; calculated from EEG 2014]



PV Cost Reduction due to Learning Effects

[Source: Prognos/EWI/GWS 2014, p. 119]



Global Success Story: REN Generation

- Early mover disadvantages for most German final electricity consumers, but global REN capacities grow faster than expected
- Without the German REN program the average costs of PV investments would have been 2600 Euro/kW_{el} instead of 2000 Euro/kW_{el} (assuming 70 GW_{el} cumulated PV capacities outside Germany in 2012)
- Without the German PV program the global PV investments in 2012 would have been 40 billion Euros more expensive
  (5 times the German REN levy for PV)

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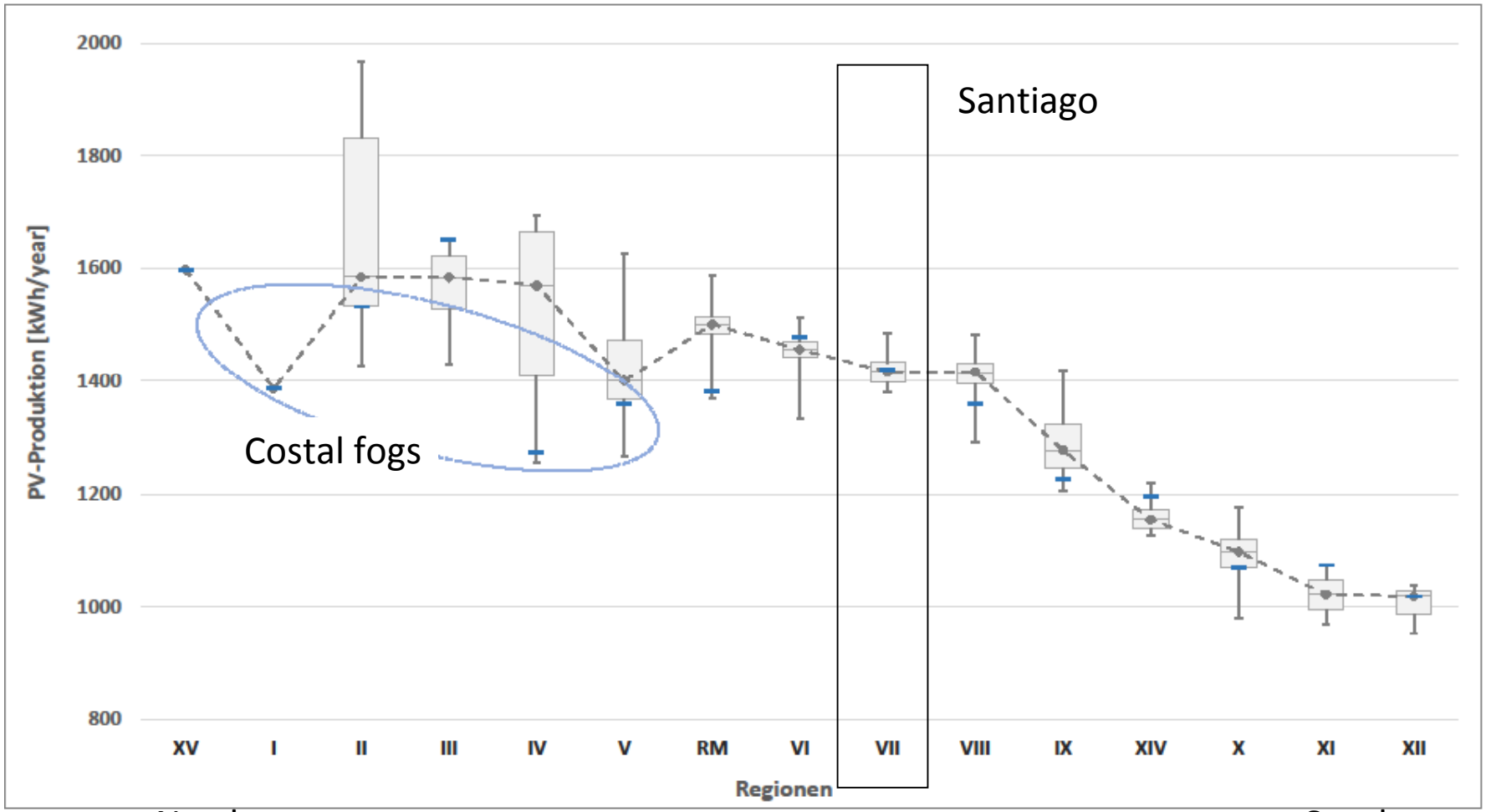
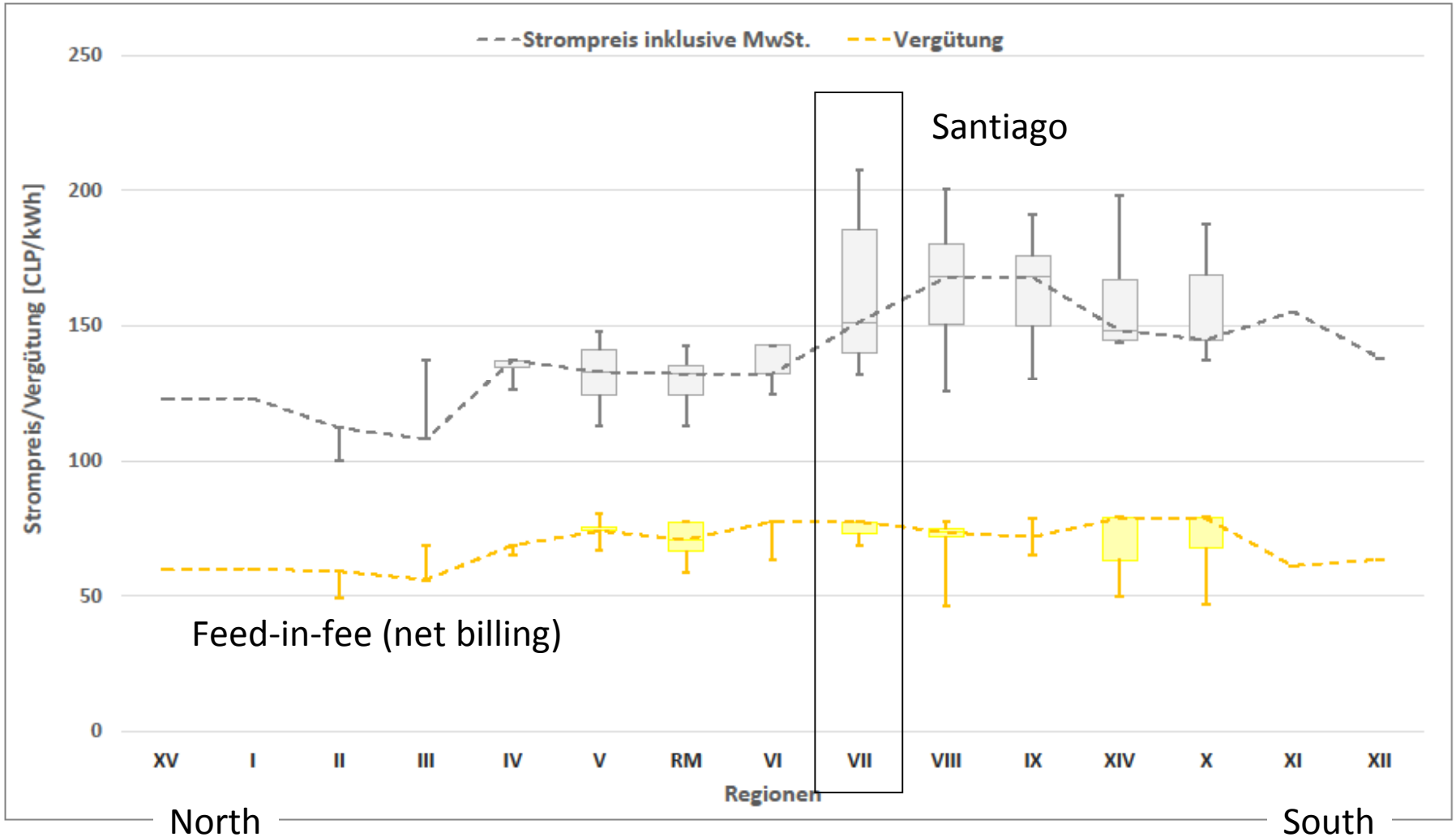
Example Chile: Solar Radiation [Source Barnier 2016]



North

South

Regional Power Prices in Chile [Source Barnier 2016]



Economics of PV Systems in Chile

[Source Barnier 2016]

- In spite of high radiation in the northern part of Chile, PV rooftop investments are more attractive in Central Chile – due to regional electricity prices
- Internal Rate of Return of 7.5% at most
- Due to smog, Santiago is not attractive for PV rooftop investments (40% of the population of Chile)

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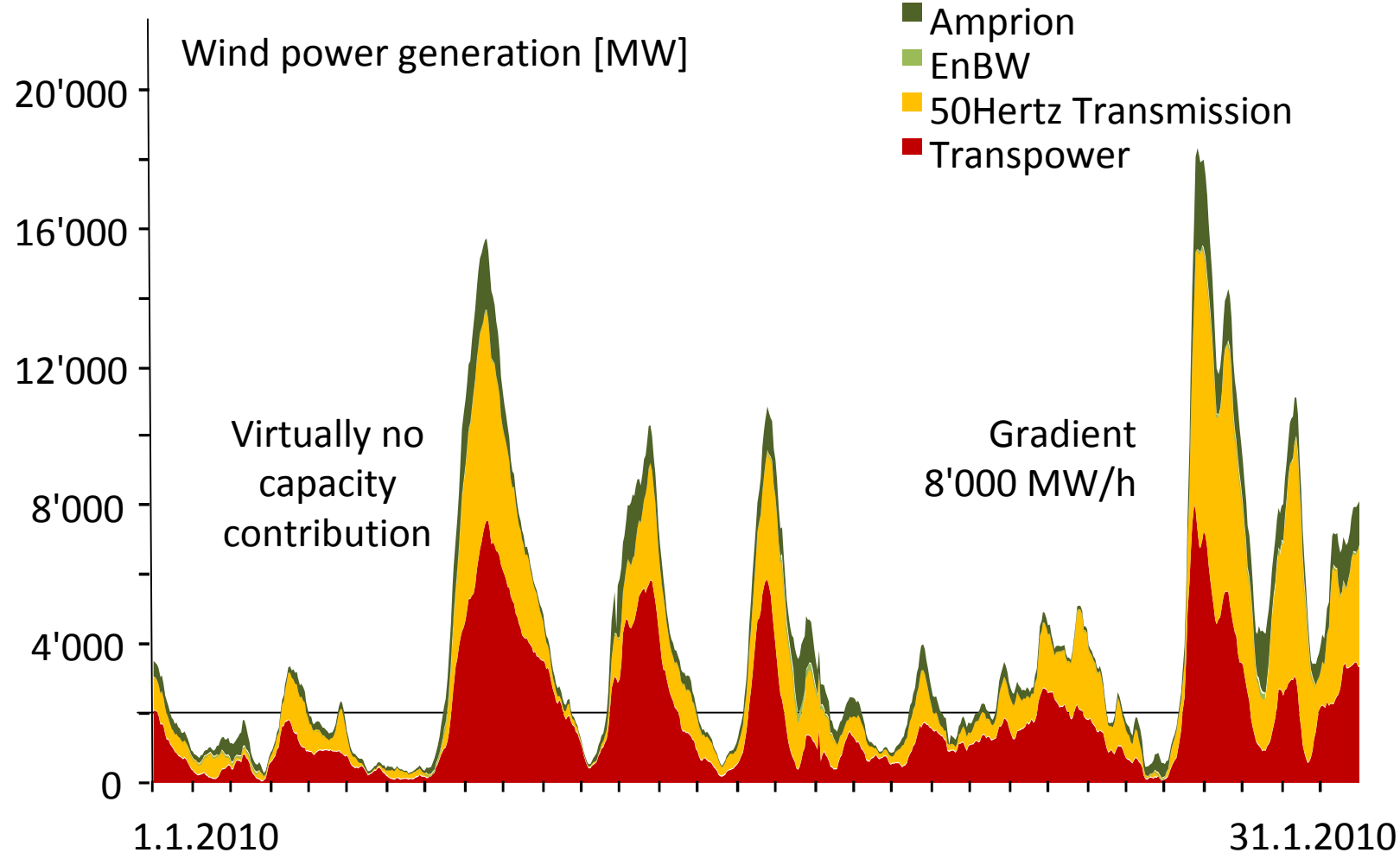
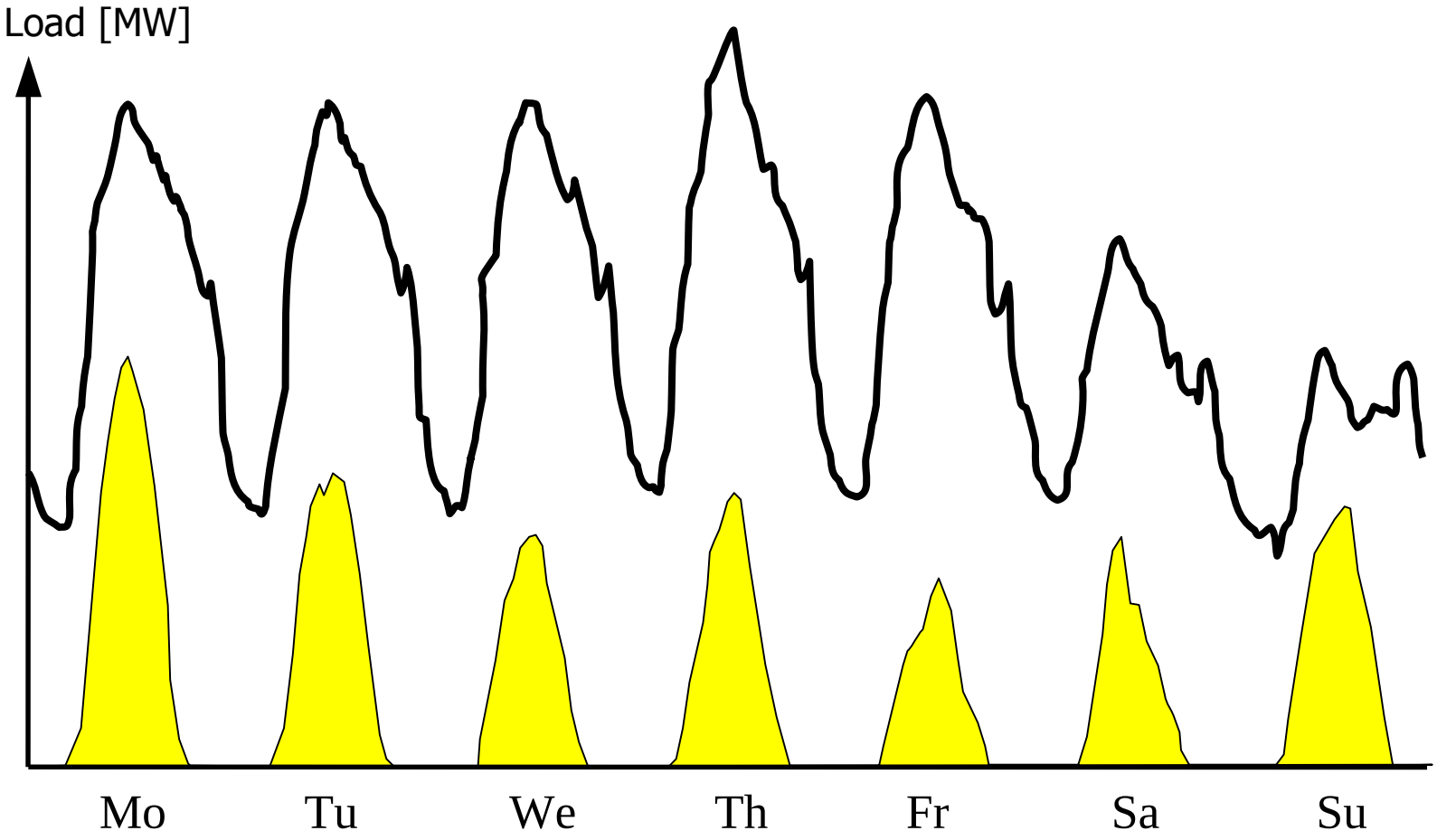
Volatility of Wind Power [Source: Ehlers 2011, S. 100]

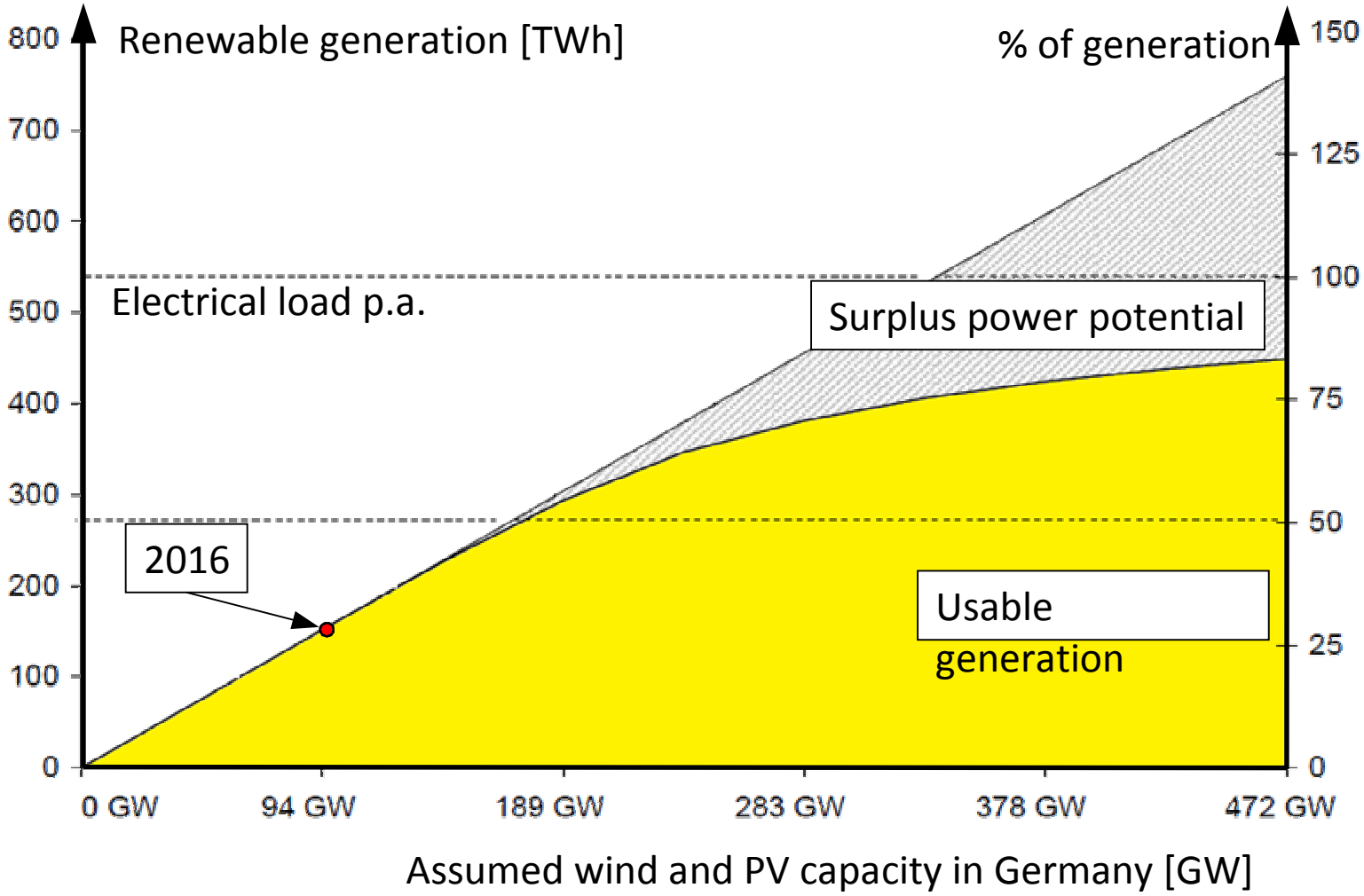


Sample Schedule [1/4 hour values]



Electricity Generation from Wind and PV

[Source: from Grosse Böckmann 2010]



Negative Day-ahead Prices in Germany

[Own calculations; data source: EPEX]

Year	Number of hours with day ahead price ≤ 0	Minimal price [Euro/MWh]
2010	12	-20.45
2011	16	-38.82
2012	55	-221.99
2013	621	-100.93
2014	61	-65.03
2015	118	-79.94
2016	?	-130.09

Nature of the Problem to be Solved

- Curtailments of renewable electricity can also be a consequence of grid bottlenecks

- Why not using excess renewable electricity in non-electric sectors?
  - Heat (Power-to-Heat, hybrid heating systems)
  - Chemistry, refineries (Power-to-Gas, Power-to-Liquid)
  - Transportation (electric mobility)
  - …

- To be economically feasible, “sector coupling” requires electricity end-user prices to be lower than the price of the substituted fuel (40-60 Euro/MWh for gas)

Electricity Price Components in Germany in the Year 2016

	Power purchase from the grid	Auto generation	Generation in „local context“
	Euro/MWh		
Grid fee	18.00 – 30.00		18.00 – 30.00
REN levy	63.54	22.24	0.00
Electricity tax	20.50	Legally unclear	
Concession fee	1.1 – 23.90		1.1 – 23.90
CHP levy	4.45		4.45
§ 19 StromNEV	3.78		3.78
Offshore levy	0.40		0.40
Total	86.77 – 121.57	22.24 – 42.74	23.73 – 83.03

Improving the Use of Excess Electricity

- Solution 1: Selective exemptions from fees, levies and taxes for certain applications, certain periods and certain regions → high regulatory requirement
- Solution 2: Shift from energy related to load related grid fees (eventually including levies) → fundamentally new market design
- Solution 3: Financing the (remaining) levies through other taxes or levies (for example a traffic jam levy or higher fossil fuel taxes reflecting the associated CO_2 emissions) → politically difficult
- **Attention: Using capital intensive technologies (such as electrolysis) causes a strong economic pressure towards base-load operation**

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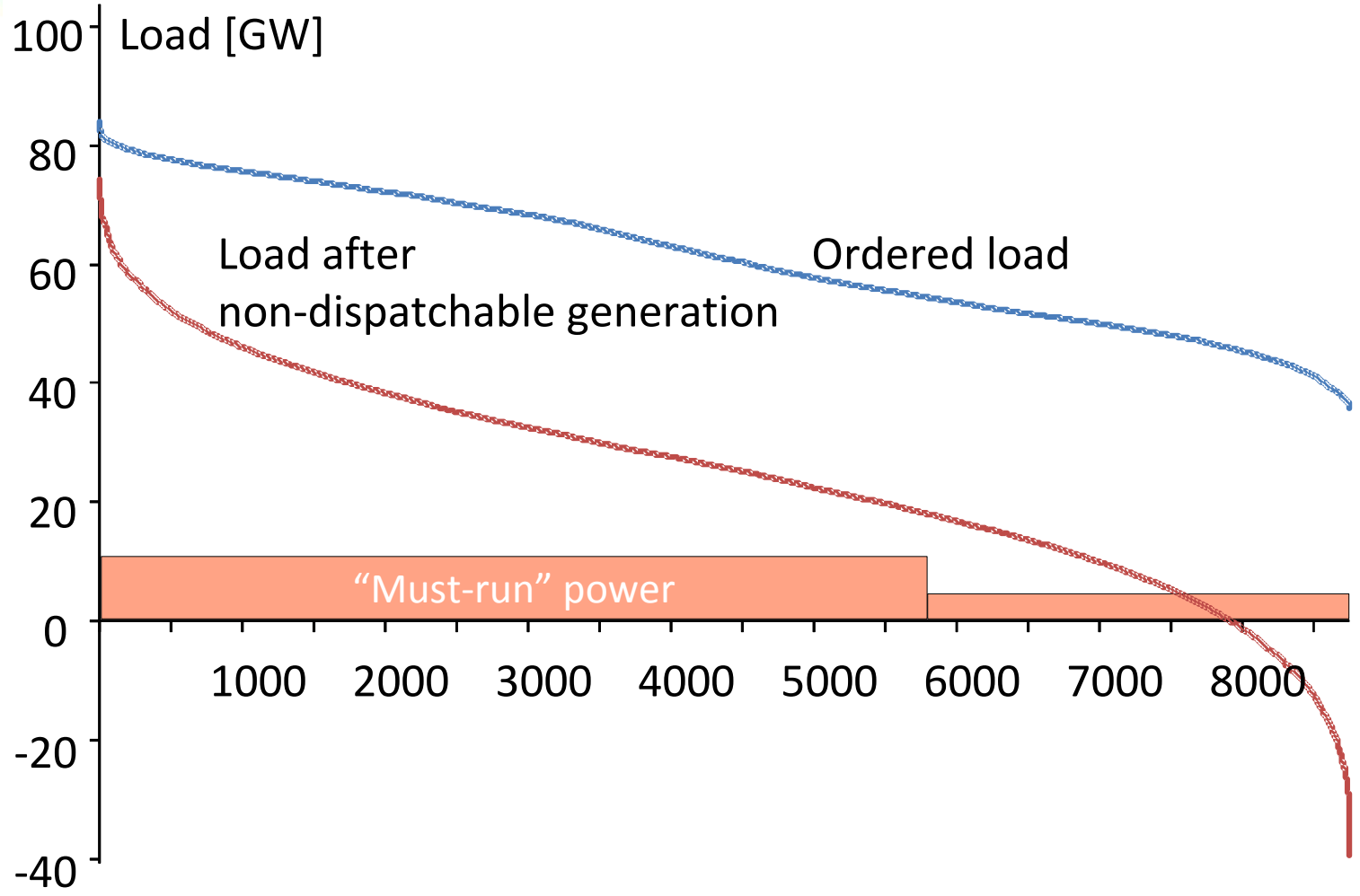
Structure of Residual Load in 2030



Assumed Renewable Electricity until 2050

	2011	2015	2020	2030	2050	Secured load
Renewable share of power generation	12.0%	17.8%	35.0%	50.0%	80.0%	
- Biogas	21.0%	19.0%	18.0%	22.0%	13.8%	100%
- Onshore wind	35.0%	34.0%	33.0%	30.0%	18.8%	3%
- Offshore wind	1.0%	4.0%	8.0%	14.0%	46.0%	9%
- Photovoltaik	15.0%	20.0%	22.0%	19.0%	11.9%	0%
- Other renewables	28.0%	22.0%	19.0%	15.0%	9.4%	70%
Renewable share without biogas	9.5%	14.2%	28.7%	39.0%	68.8%	
Electric load secured by renewables	2.0%	2.4%	4.3%	4.9%	6.8%	

Remaining Non-renewable Power Plants

[incl. plants under construction 2013]

Generation capacity [GW]	Years in operation	2011	2015	2020	2030	2040	2050
Nuclear [GW]		12	10	4	0	0	0
Lignite [GW]	55	19	22	20	15	11	9
Hard coal [GW]	50	24	25	20	14	3	0
Gas [GW]	40	26	22	17	14	10	3
Others [GW]	40	14	14	12	10	8	5
Total [GW]		95	93	73	53	32	17
Total adjusted	15%	81	79	62	45	27	14

Disruptive Innovations are Needed

- Presently discussed ideas can contribute to the carbon reduction but this is not sufficient for a carbon free economy
- Many demand side innovations are still outside the mainstream discussion (air traffic, marine navigation, carbon-free steel works, …)
- No much activities address the supply side (except renewables). Can a climate friendly use of fossil fuels become feasible one day?
  - CCS, CCU
  - In-situ gasification of coal deposits
  - New and simpler design concepts for nuclear plants
  - Geo-engineering

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