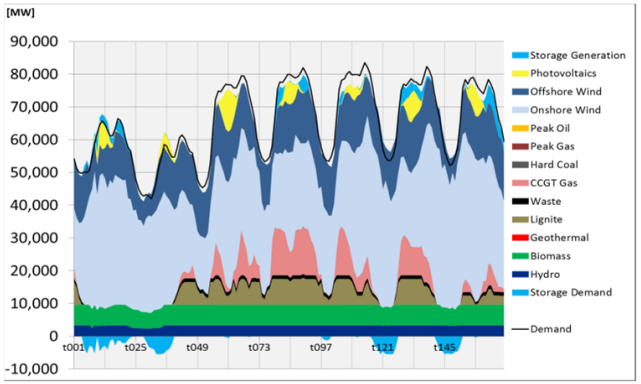
Paris, Seminar Energy Policy

06 May, 2015



Germany on its Way to Paris – Recent Developments and Future Strategy of Decarbonizing the German Electricity Sector

Christian von Hirschhausen, et al.

Berlin University of Technology, Workgroup for Infrastructure Policy (WIP)

and DIW Berlin (German Institute for Economic Research)

Agenda

1) Introduction and Conceptual Approach

2) A Primer on the “Energiewende”

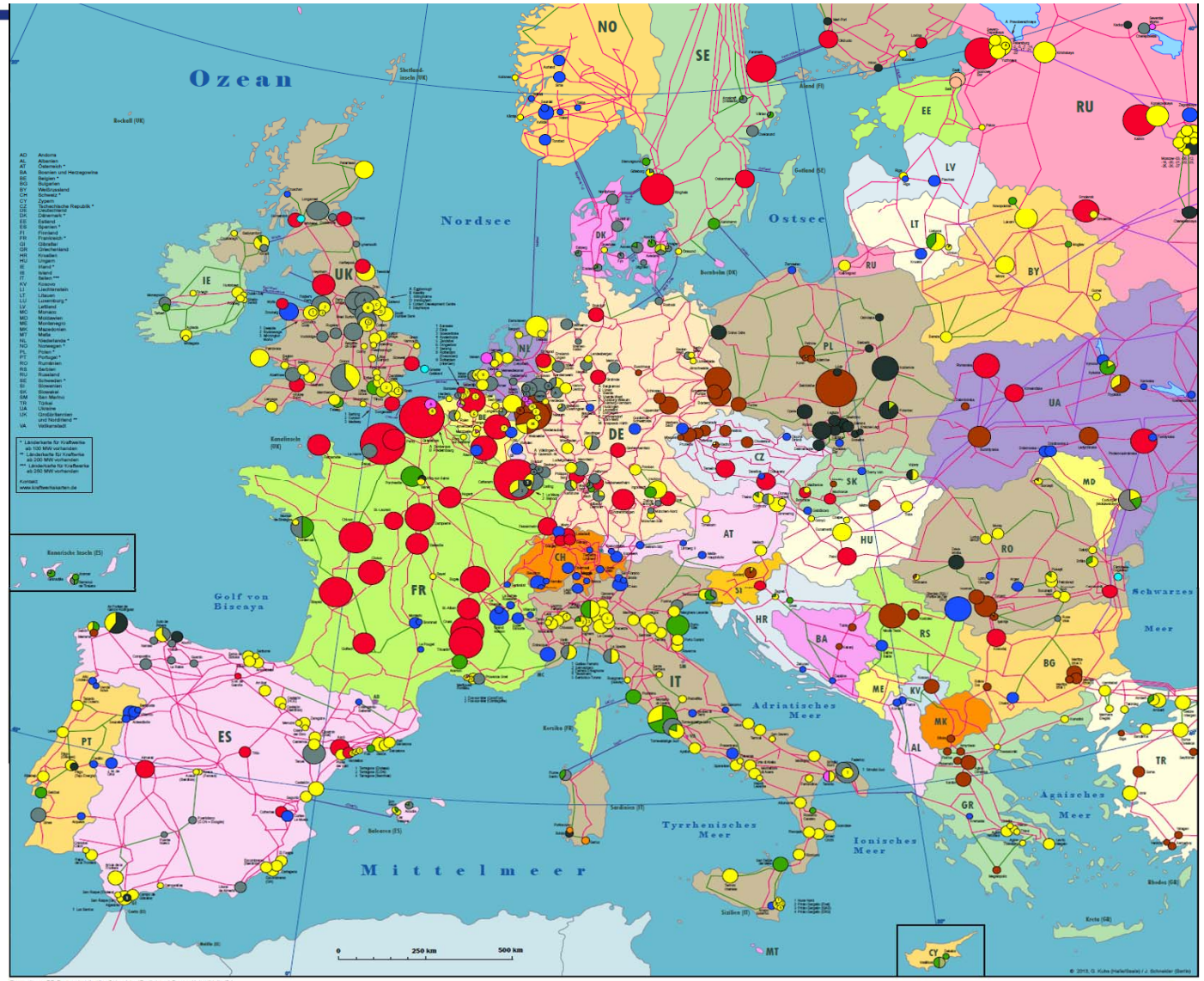
3) Climate Policies and Instruments

4) Conclusions

A European Internal Market? The Context
Power Plants and Networks in Europe

- Water
- Biomass
- Hard coal
- Wind
- Lignite
- Diesel
- Fuel Oil
- Gas
- Nuclear
- Furnace gas
- Oil shale
- Synthetic gas

Source: Schneider, Kuhs (2013)



Model: Elmod

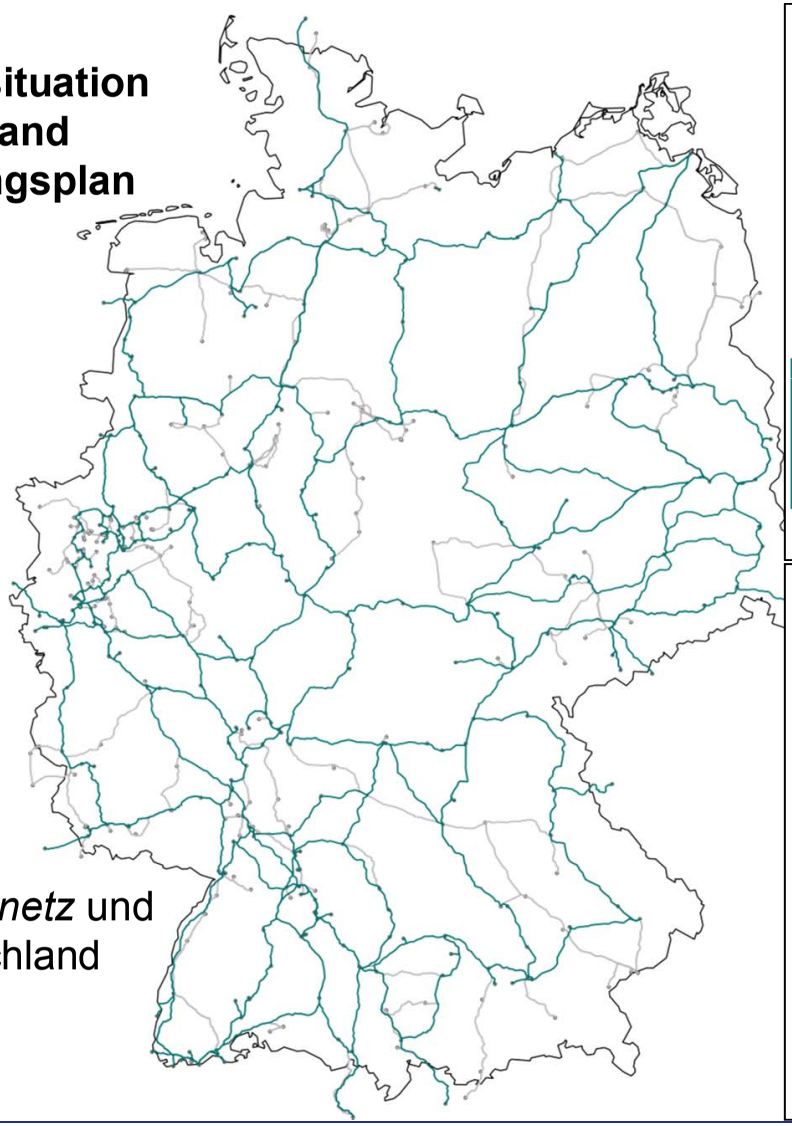
Szenarienrechnungen zur Kapazitätssituation und Redispatchbedarf in Deutschland basierend auf dem Netzentwicklungsplan 2013:

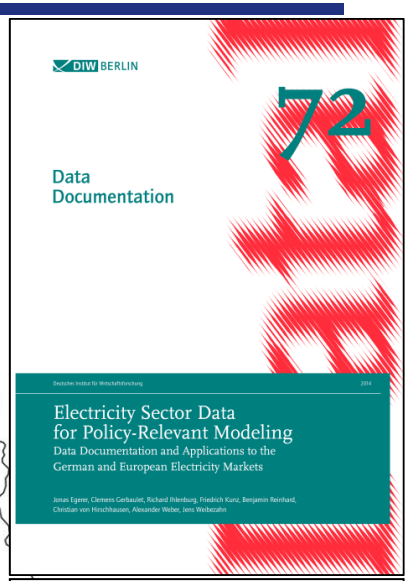
Szenario *NEP 2023*

- offizielle Darstellung des Netzentwicklungsplans 2013
- angenommener Zubau von Erzeugungskapazitäten
- Netzausbau für 2023;

Szenario *NEP 2023 verzögert*

- Angekündigte Rückbauten von Kraftwerkskapazitäten erfolgen
- Netzausbau verzögert sich; nur *Startnetz* und HGÜ zwischen Nord- und Süddeutschland (Korridor C) in Betrieb



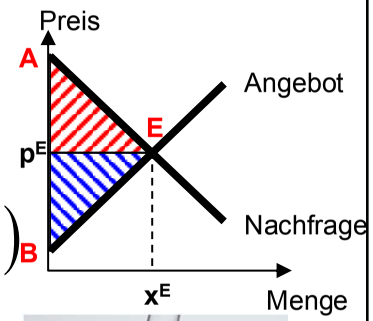


ELMOD: Mathematical Representation
(Leuthold, Weigt, von Hirschhausen, 2012)

Objective

n,t	node, hour
g_n	generation in n
d_n	demand in n
$p(d_n)$	demand function in n
$c(g_n)$	generation costs in n

$$\max \quad W = \sum_{n,t} \int_0^{q_{n,t}^*} p(q_{n,t})\, \mathrm{d}q_{n,t} - \sum_{n,t} \left(c(g_{n,t}) g_{n,t} \right)$$



Constraints

Line capacities

$P_{i,t}$ load flow on line i

$$\left| P_{i,t} \right| \leq P_i^{\max}$$

Energy balance

PSPup pump storage hydro (storage)

PSPdown pump storage hydro (generation)

windtinput from wind energy

ni netinput

$$g_{n,t} + wi_{n,t} + PSP_{n,t}^{down} - PSP_{n,t}^{up} - q_{n,t} - ni_{n,t} = 0$$

Generation capacities

on binary generation plant variable

$$on_{n,t} \cdot g_n^{\min} \leq g_{n,t} \leq on_{n,t} \cdot g_n^{\max}$$

Policentric Approach (~ multi-level governance), according to Ostrom, et al.

Level	Climate targets	~ competition vs. „planning“ (droit)
Global	2°C-Ziel / COP 20/21	JI/ CDM; CO2-tax
EU	20-20-20; 2030; 2050	ETS: - Backloading - Market Stability Reserve; Carbon Floor Price; IED-Richtlinie (Schwermetalle etc.); Flexibilitäts-anforderungen / Mindest-wirkungsgrade; Ausgestaltung Kapazitätsmarkt; Kohle-förderung KfW; Steinkohle-Union; EPS - Spezifisch vs. Jahresmengen nur neue vs. alte & neue KW; Raumplanung/ Tagebaue; Netzausbau; Kohle-Ausstiegs-gesetz
Germany *) ggü. 1990	BReg*: ‘20: -40% ‘30: -55% ‘50: -95%; Klimaschutz plan (BMUB)	
Federal states *) ggü. 1990	NRW*: 2020: -25% | 2050: -80%; BB*: 2020: -40% | 2050: -95%; **BY: Energiekonzept, 2023, 2050**	
Communities		
Energy Industry	Vattenfall: -30% (2010→2020); VATTENFALL	

Agenda

1) Introduction and Conceptual Approach

2) A Primer on the “Energiewende”

3) Climate Policies and Instruments

4) Conclusions

The true energiewende: March, 14, 2011 onwards

1991

Klaus Töpfer environmental Minister; Renewables Law (StromEinspG) Jan. 1991

1986/2001

Chancellor Gerhard Schröder (SPD) and E.on CEO Ulrich Hartmann (l.) agree on nuclear phase-out (June 2001)

2011

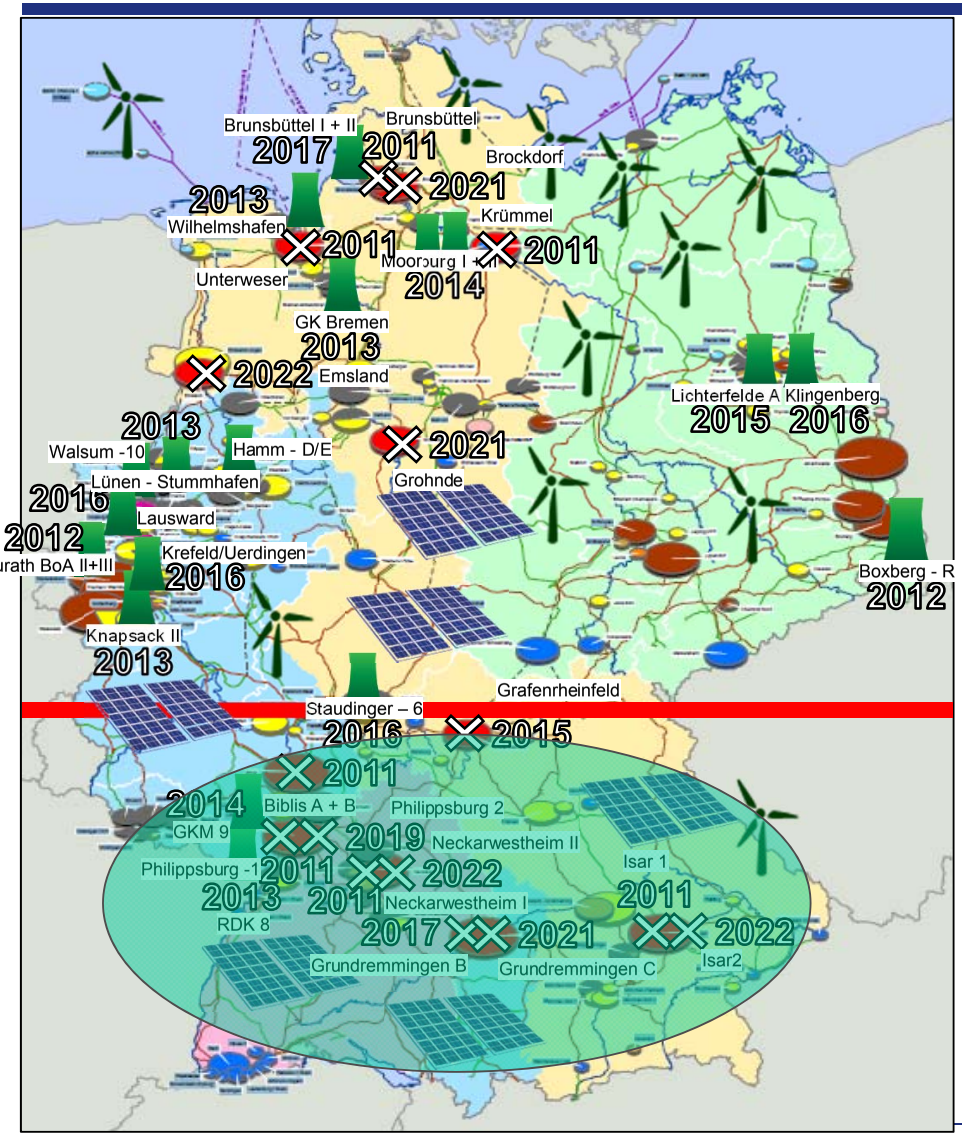
Chancellor Angela Merkel (CDU) declares moratorium on nuclear power (March 14, 2011)

The energiewende is the German version of a low-carbon energy system transformation

	Reduction of nuclear energy	Share of Renewable Energy		Reduction GHG-Emissions	Reduction of Energy Demand			
		Gross final energy	Electricity Production		Primary Energy	Domestic Heat	Final Energy Transport	Electricity Demand
2015 2017 2019	-47% -56% -60%							
2020		18%	35%	-40%	-20%	-20%	-10%	-10%
2021 2022 2025	-80% -100%		40-45%					
2030 2035		30%	50% 55-60%	-55%				
2040		45%	65%	-70%				
2050		60%	80%	-80% bis 95%	-50%	-80%	-40%	-25%
Basis	2010	-	-	1990	2008	2008	2005	2008

Source: Own Depiction based on BReg (2010, 2011, 2013)

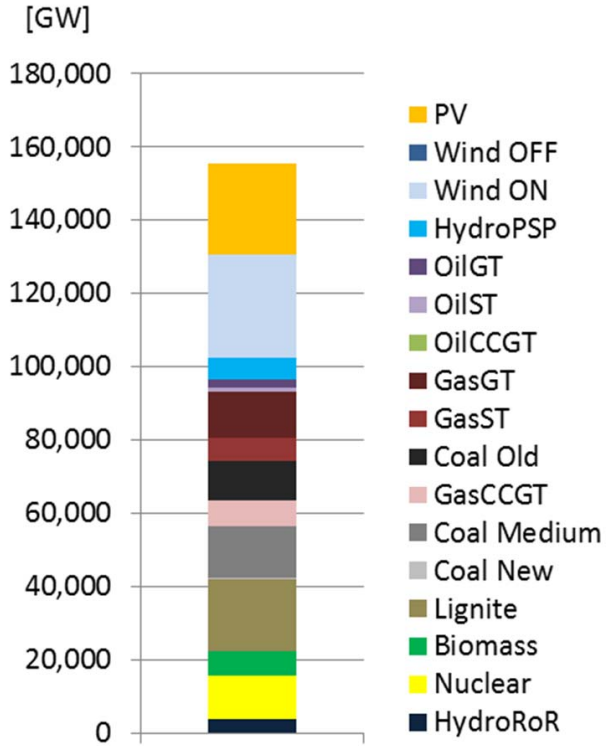
Energy Mix in Germany: Coal – Nuclear – Renewables
(Generation in Germany to 2020/2022; Focus on the South)



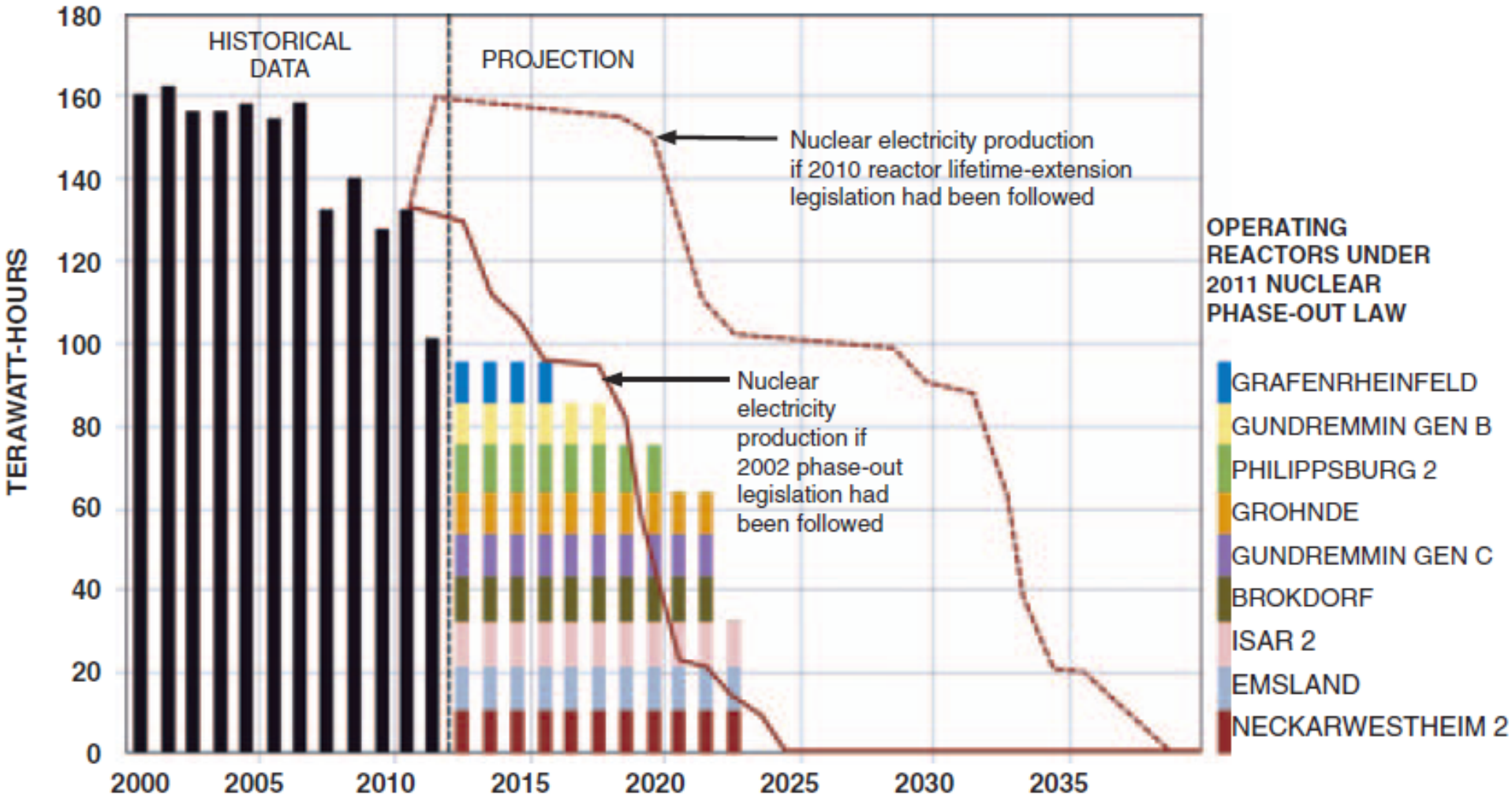
Renewables in Germany 12/2011:

Wind: 28,4 GW

Solar: 24,6 GW

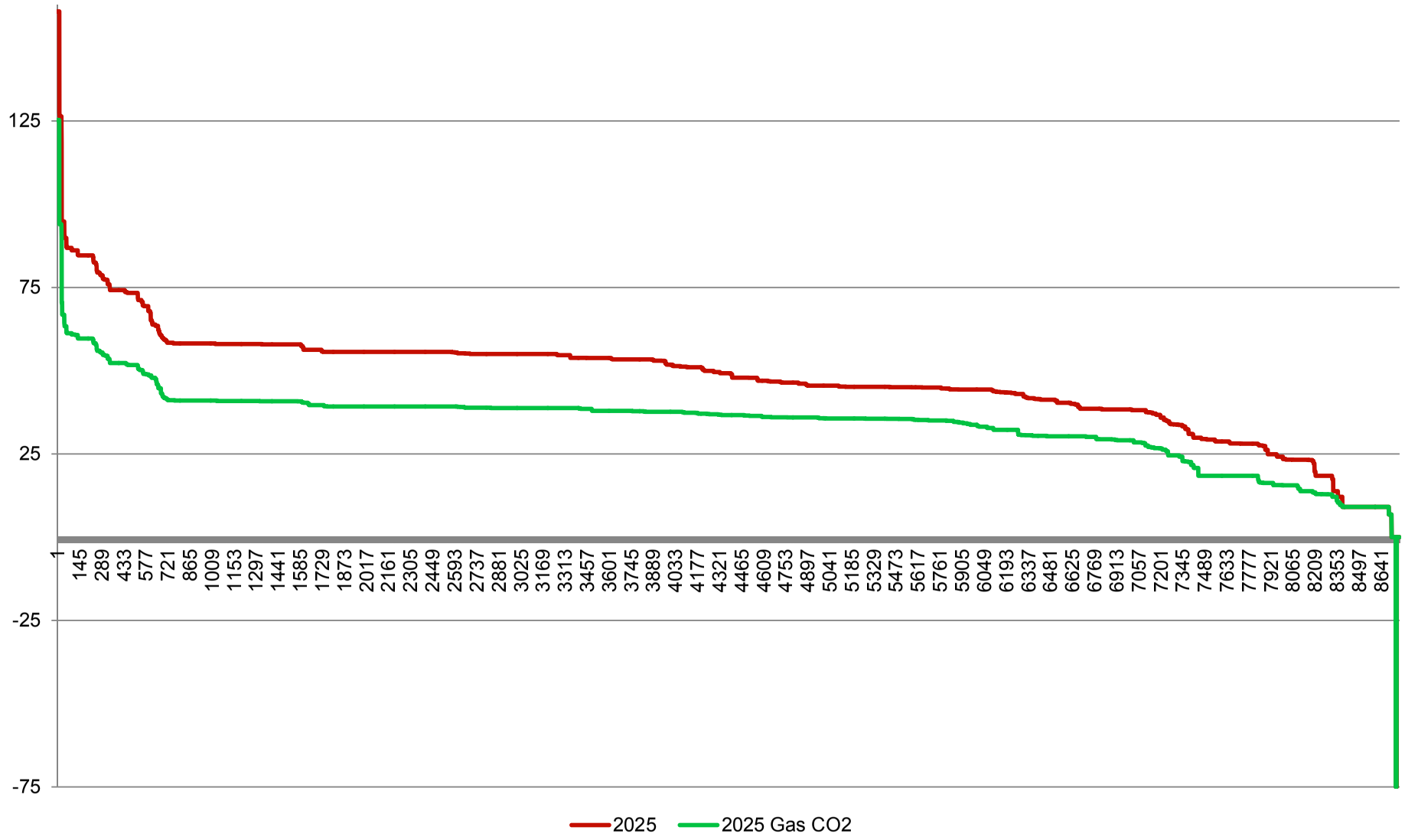


Nuclear Phasing Out "A" (the March, 2011-Moratorium)
(source: Matthes, 2012, p. 45)

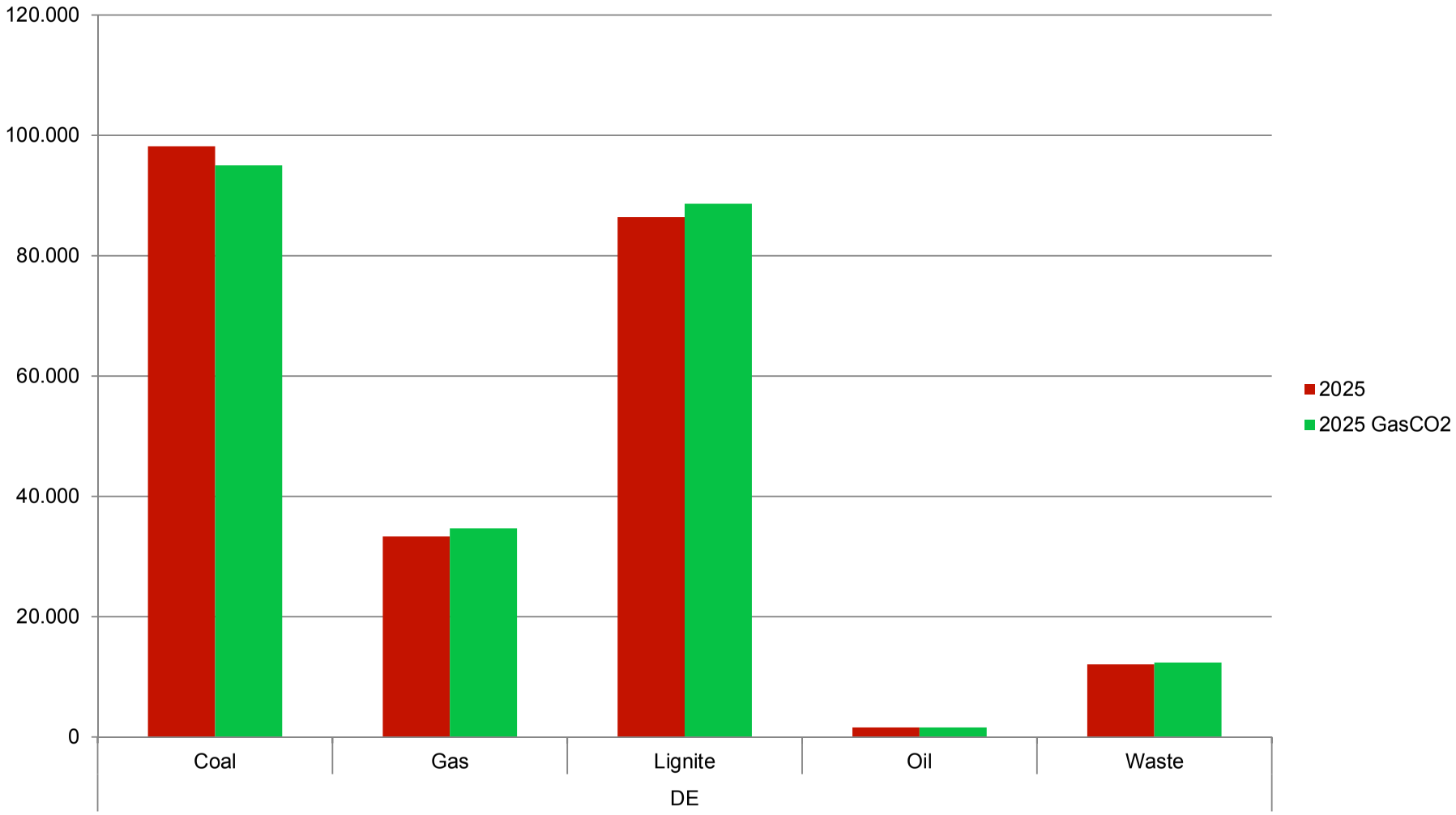


Source: Matthes (2012, p. 45)

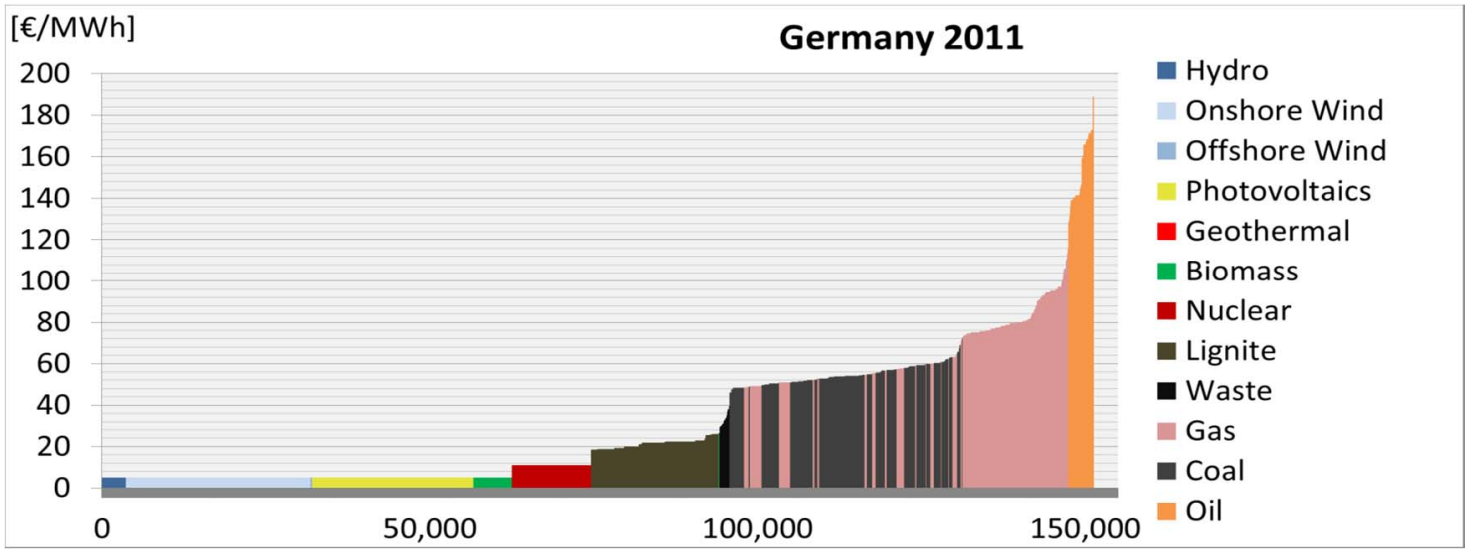
Modes Price Increases to 2025 (resource prices dominate)

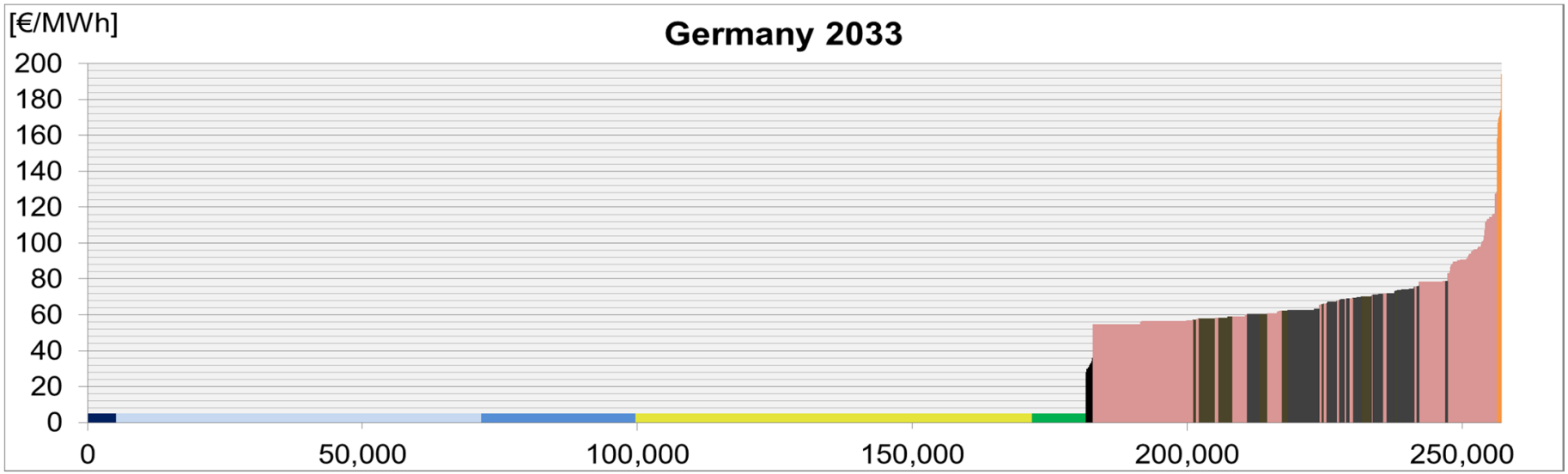


but: high level of CO2-Emissions

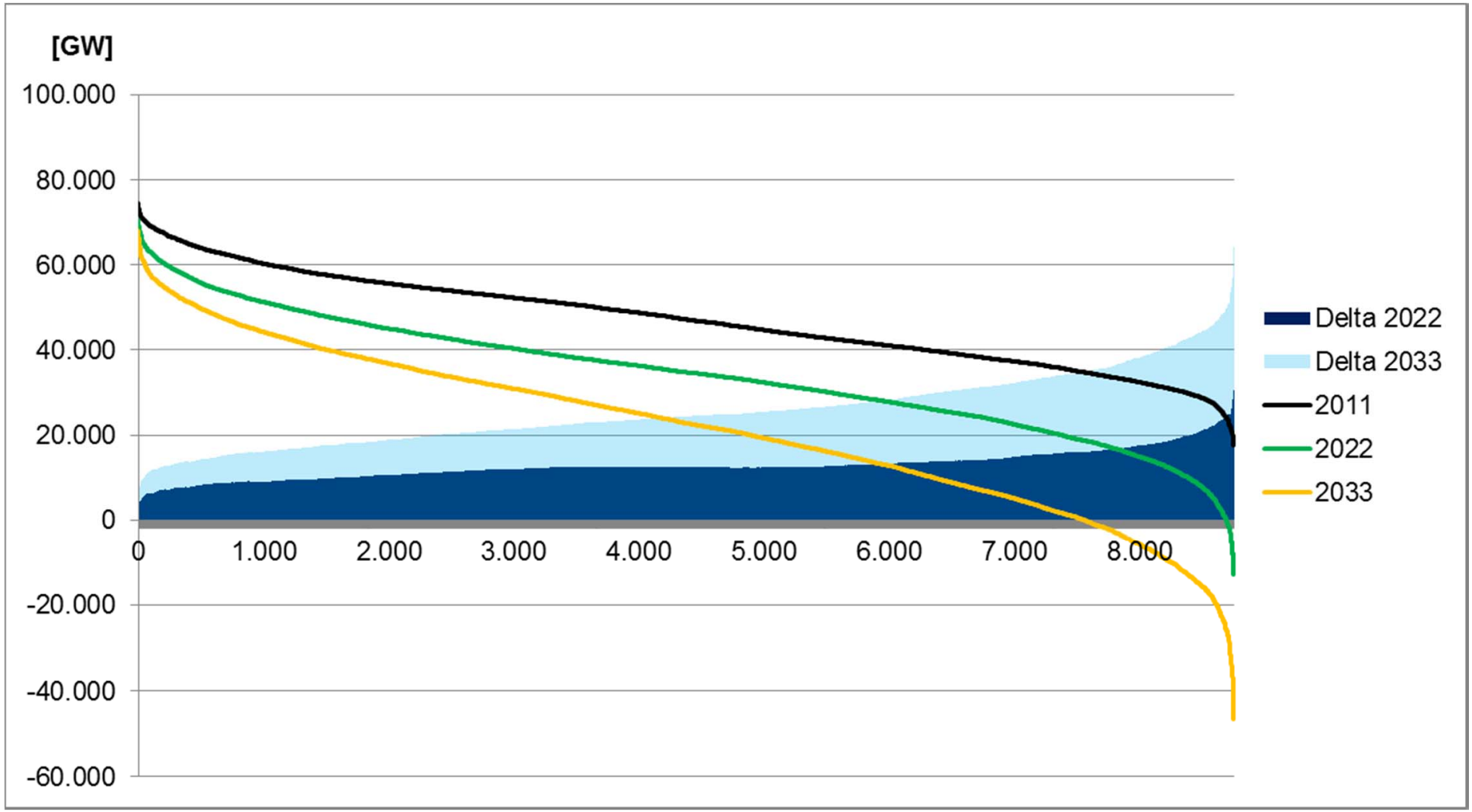


Renewables Targets and Policies (Egerer and Schill, 2012)

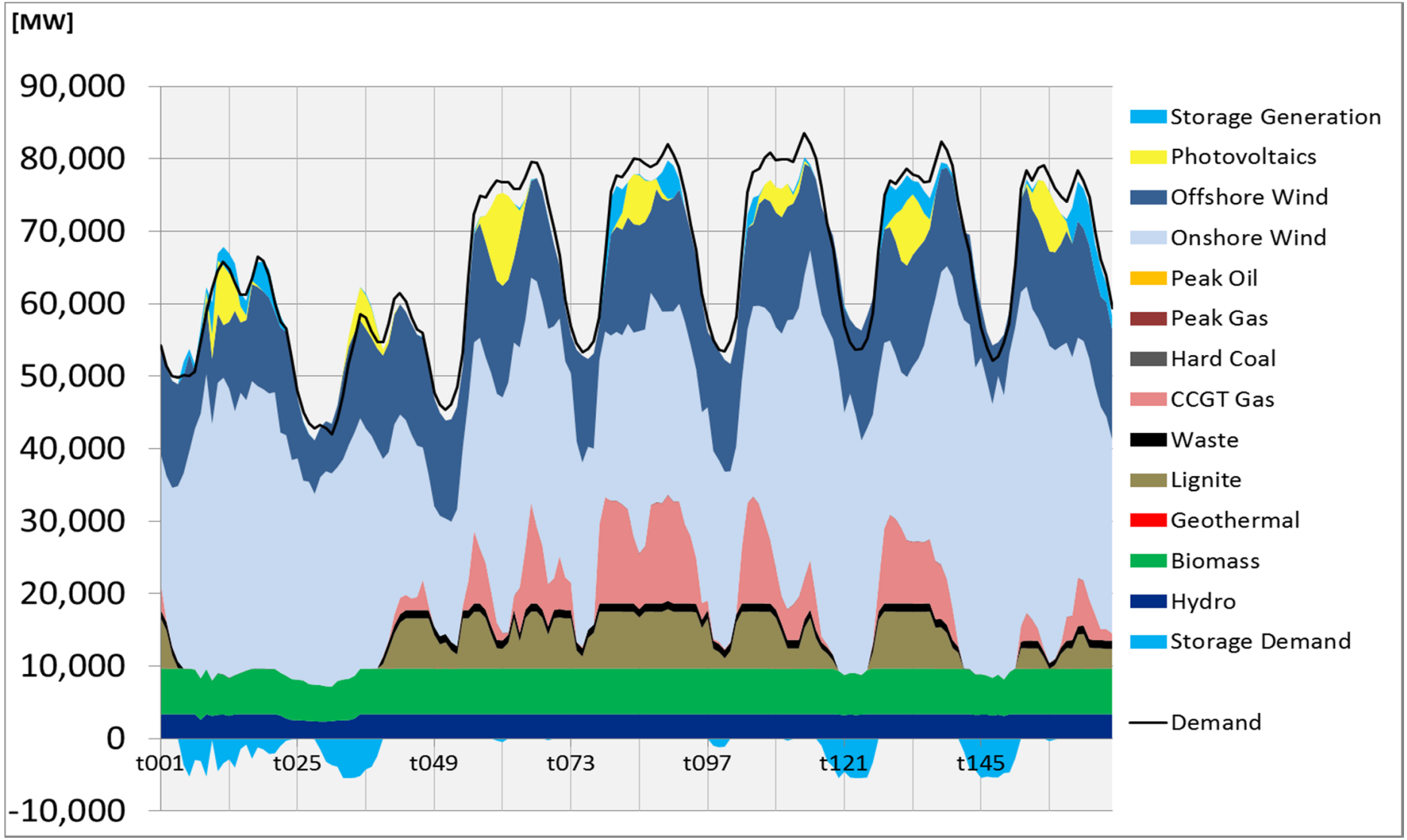




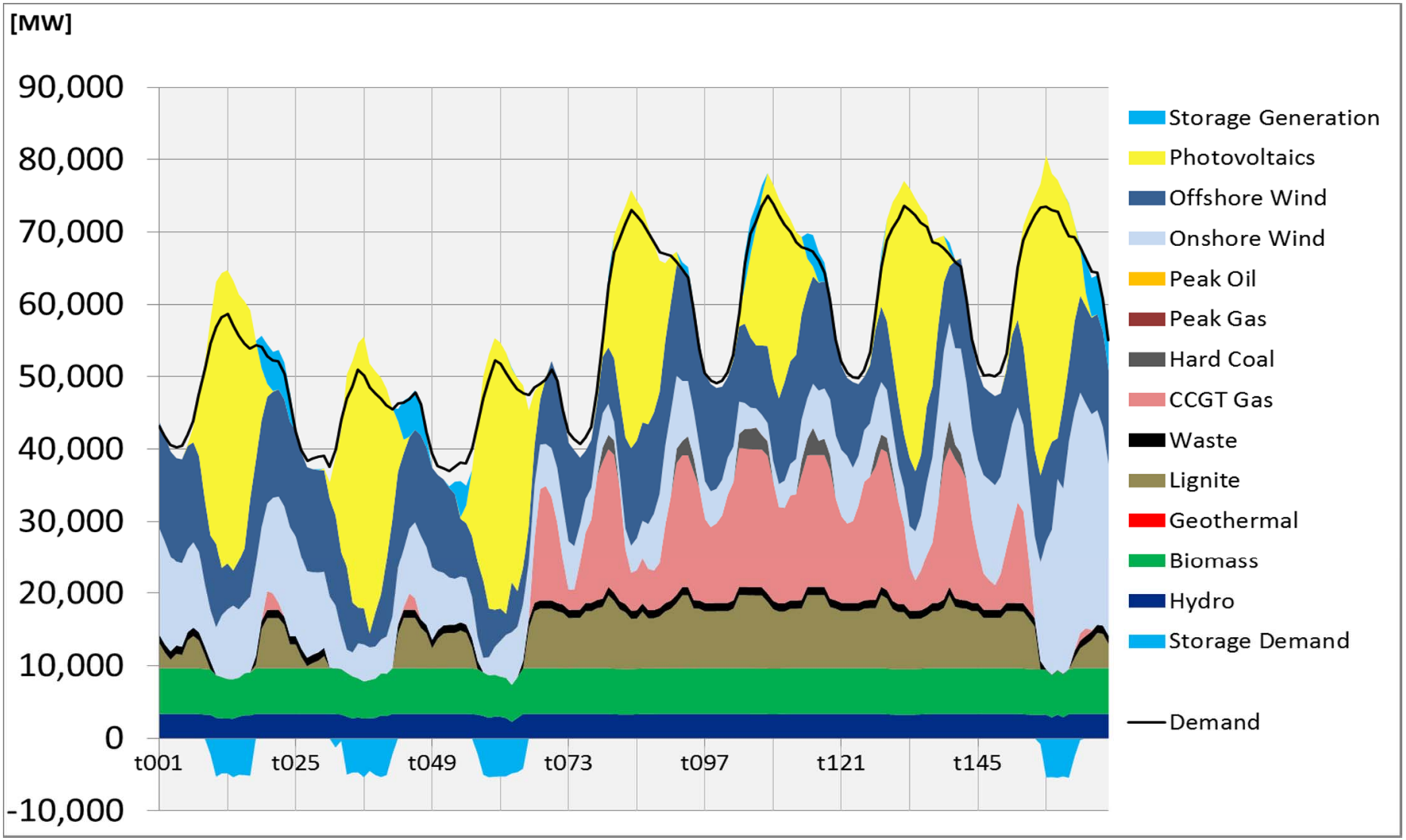
From „Base/Mid/Peak-Load“ to „Residual Load“: Load Duration Curves in Germany 2011/2022/2033 (Egerer and Schill, 2012)



National Model Results 2033: Wind Intense Week (November Week 49) (November 2011 RES distribution, calculations by Jonas Egerer)



National Model Results 2033: PV Intense Week (May W. 19) (May 2011 RES distribution)



What Market Design? Capacity instruments are, for the time being, purely national, Germany already has one (~ 4 GW today, 6.5 GW by 2018/19)

UK-EMR:
Capacity instrument

D: Strategic reserve

www.pse-operator.pl

Polskie Sieci Elektroenergetyczne Operator S.A.

Basic Market Architecture for the future Polish market

- **Integrated Energy and Ancillary Services Markets**
  - Day-Ahead, Intra-Day and Real-Time Market
  - Energy and reserves compete for access to the transmission grid
  - Coherent incentives for the grid users
  - Consistent rules throughout all market segments
- **Hedging instruments against the risk of congestion**
  - Financial Transmission Right (FTR) Markets
  - FTR allocation and FTR auction
- **Capacity Markets ensuring long-term generation adequacy**
  - Decentralized bilateral market
  - Centralized market run by TSO

LE POINT DE VUE DE **CLAUDE CRAMPES ET THOMAS-OLIVIER LÉAUTIER**

Marché de l'électricité : quand la France donne l'exemple

La création du premier marché de capacité électrique en Europe facilitera le renouvellement du parc nucléaire à partir de 2025.

Agenda

1) Introduction and Conceptual Approach

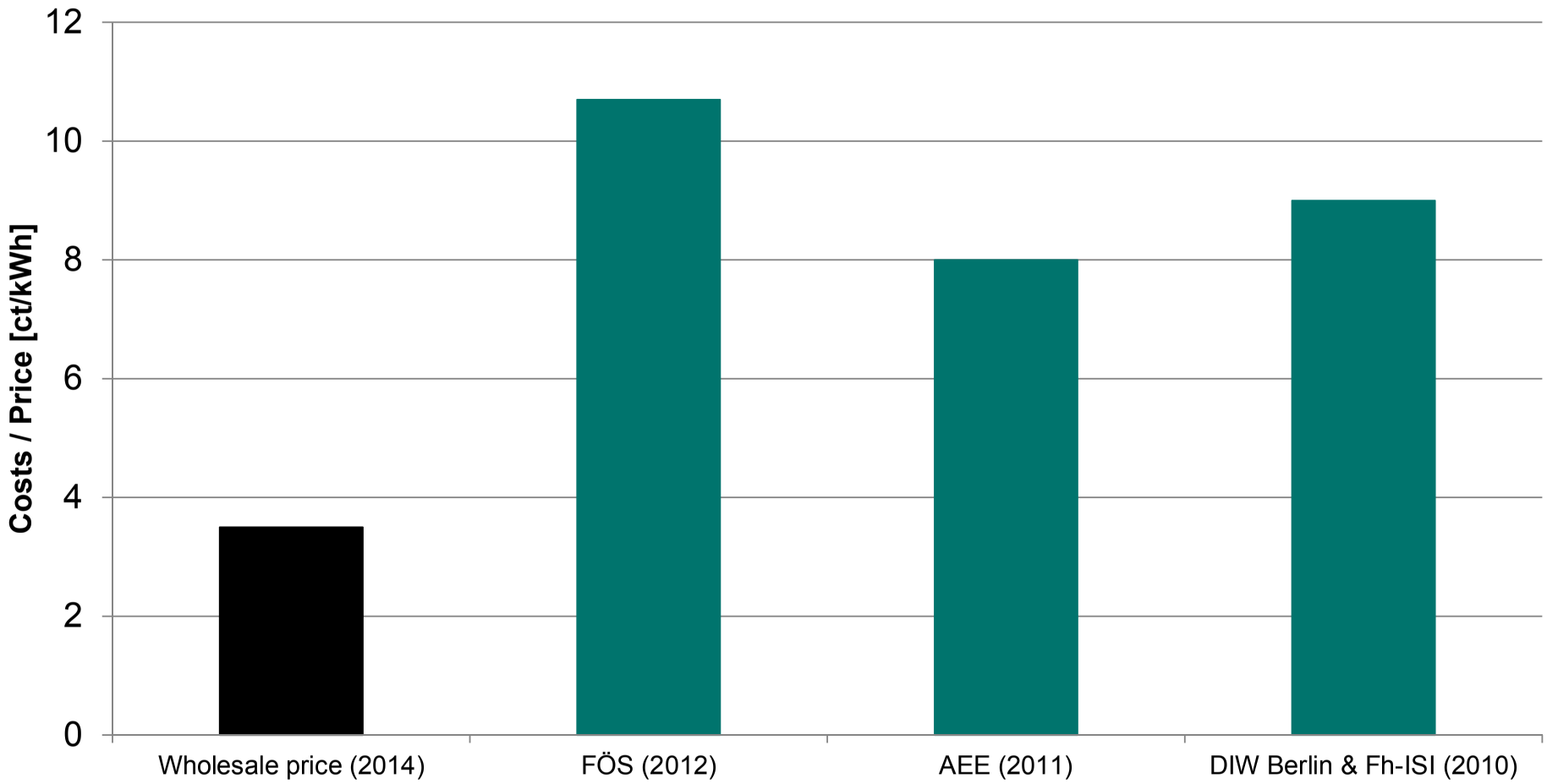
2) A Primer on the “Energiewende”

3) Climate Policies and Instruments

4) Conclusions

Phasing-out Coal is Economically „Efficient“:

The social costs of lignite, including externalities, are way above the revenue!



External costs of lignite according to different studies compared to the current electricity price in Germany

Climate Objectives have a Long History in Germany

1990: Chancellor Helmut Kohl: -25% by 2005

➔ Goal not reached (17.8%, update by red-green gov‘t (Schroeder/Fischer) in 2000L addtional 70 Mio. t by 2005

1997: Chancellor Helmut Kohl: (Kyoto – EU internal allocation): -21% by 2012

➔ Goal obtained (by 2007 already)

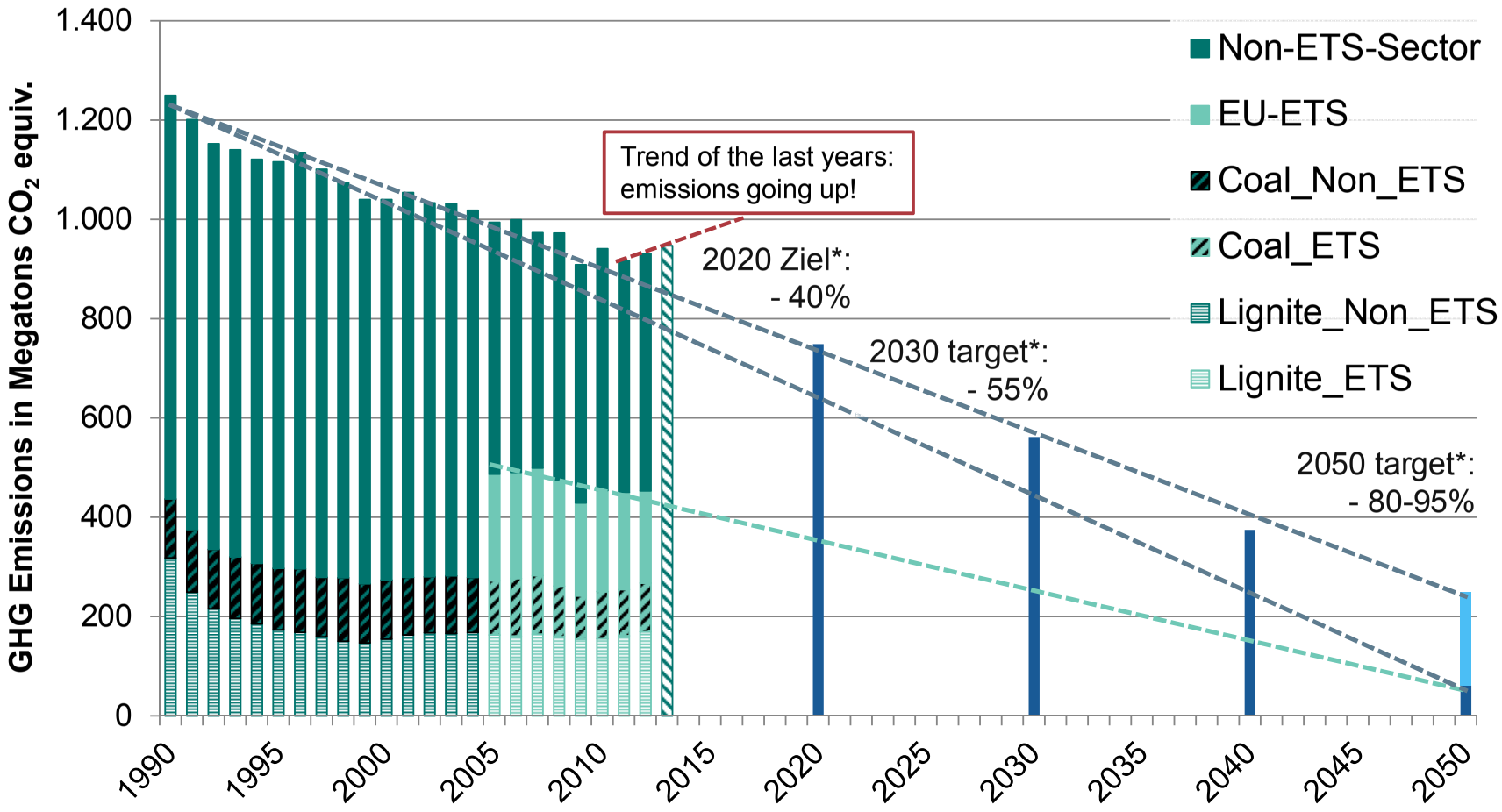
2007: Big coalition (Merkel, Environment: Gabriel): - 40% to 2020

➔ Goal maintained in 2014, but difficult to reach

2010: CDU-FDP (Merkel, Environment: Roettgen): -80-95% by 2050

➔

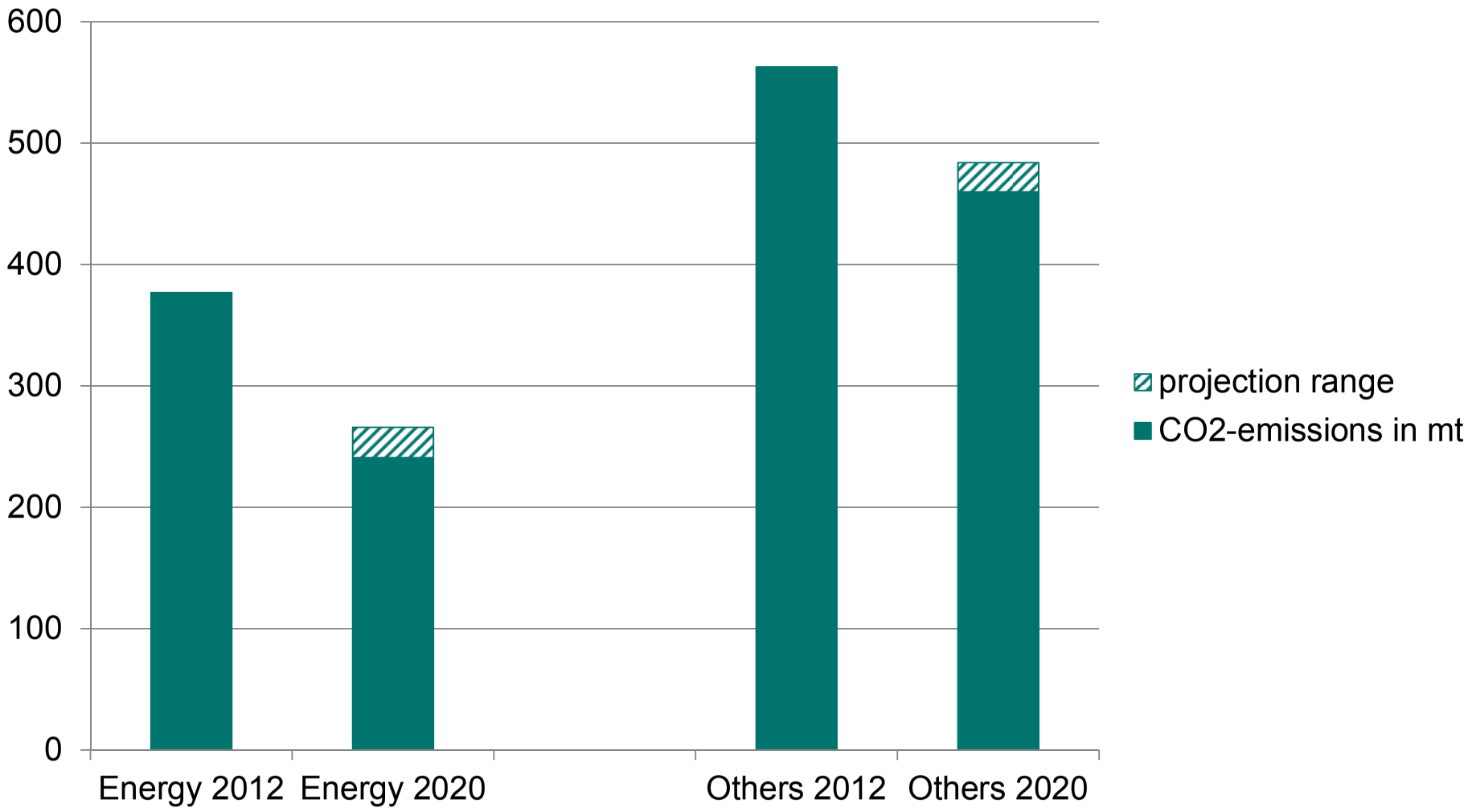
GHG Targets and Coal Phasing Out
Germany‘s national GHG reduction target implies further measures



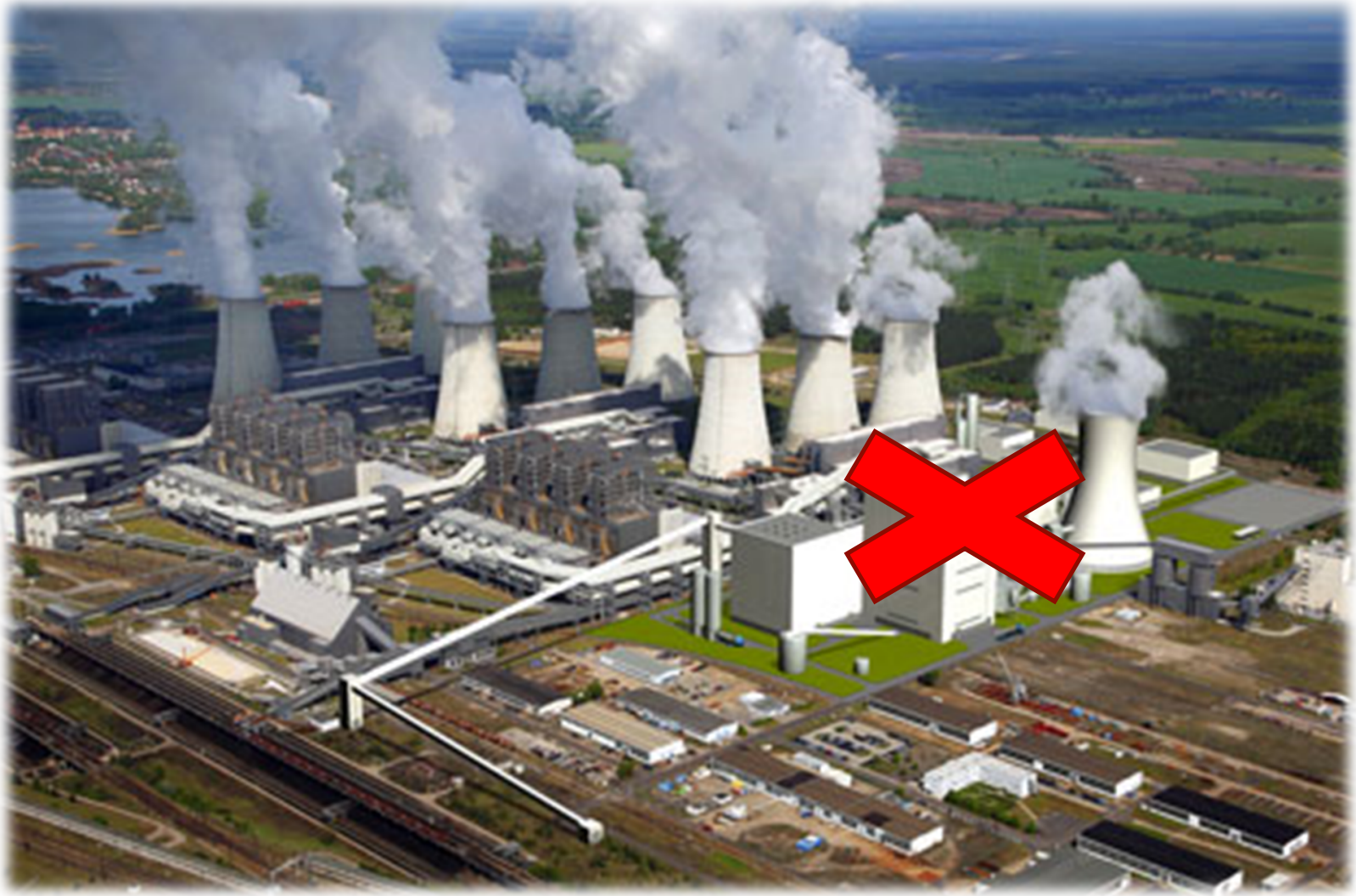
*) Base line: 1990

Source: Oei, et al.(2014).

Proposal Ministry for the Environment (June 2014)



CCTS ???
Pilot Plant in Jänschwalde is being cancelled on 5.12.2011



Development of the CCTS Projects since 2011

Source: Own depiction based on GCI (2011, 2013) and MIT (2014).

The Failure of CCTS

Hürth (De, RWE)

08.12.2010

„CO_2 sequestration not relevant for energy transition“

29.10.2011

19.10.2011

Longannet (UK, 1 Milliarde £)

05.12.2011

Jänschwalde (De, Vattenfall)

„It‘s doubtable that [CCS] will come into action in Germany. [...]

14.07.2012

18.12.2012

No EU-funding through NER-300

Mongstad (Norway)

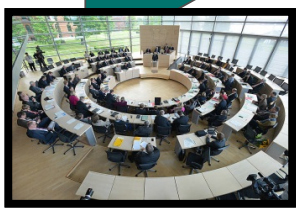
20.09.2013

14.10.2013

No CO_2-priority infrastructure projects

9 cancelled projects in 2 years

22.10.2013

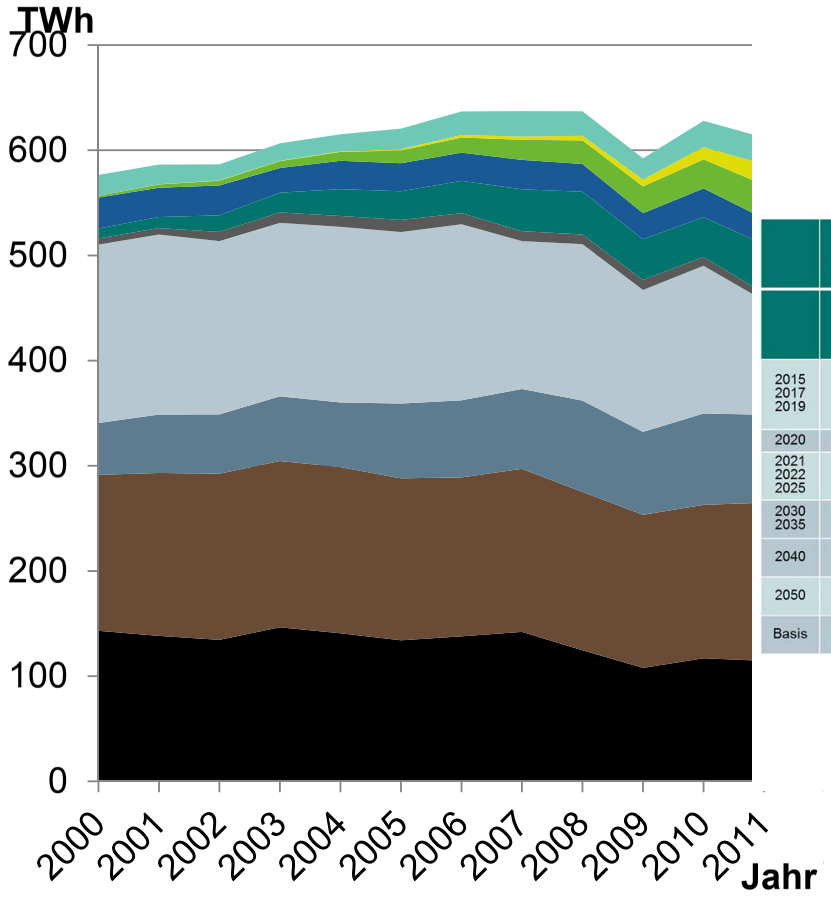


27.01.2014

Schleswig-Holstein (De) forbids CO_2-storage

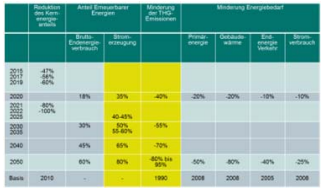
Source: Own illustration based on Tagesspiegel (2010), BBC (2011), Märkische Rundschau (2011), Vattenfall (2011), Bundesregierung (2012), EC (2012), Bellona (2013), EC (2013), GCI (2013), EUWID (2014).

there is no future for lignite neither coal power plants in Germany



	Reduktion des Kern-energie-anteils	Anteil Erneuerbarer Energien		Minderung der THG-Emissionen	Minderung Energiebedarf			
		Brutto-Endenergie-verbrauch	Strom-erzeugung		Primär-energie	Gebäude-wärme	End-energie Verkehr	Strom-verbrauch
2015 2017 2019	-47% -56% -60%							
2020		18%	35%	-40%	-20%	-20%	-10%	-10%
2021 2022 2025	-80% -100%		40-45%					
2030 2035		30%	50% 55-60%	-55%				
2040		45%	65%	-70%				
2050		60%	80%	-80% bis 95%	-50%	-80%	-40%	-25%
Basis	2010	-	-	1990	2008	2008	2005	2008

- Andere
- Photovoltaik
- Biomasse
- Wasserkraft
- Windkraft
- Mineralöl
- Kernenergie
- Erdgas
- Braunkohlen
- Steinkohlen



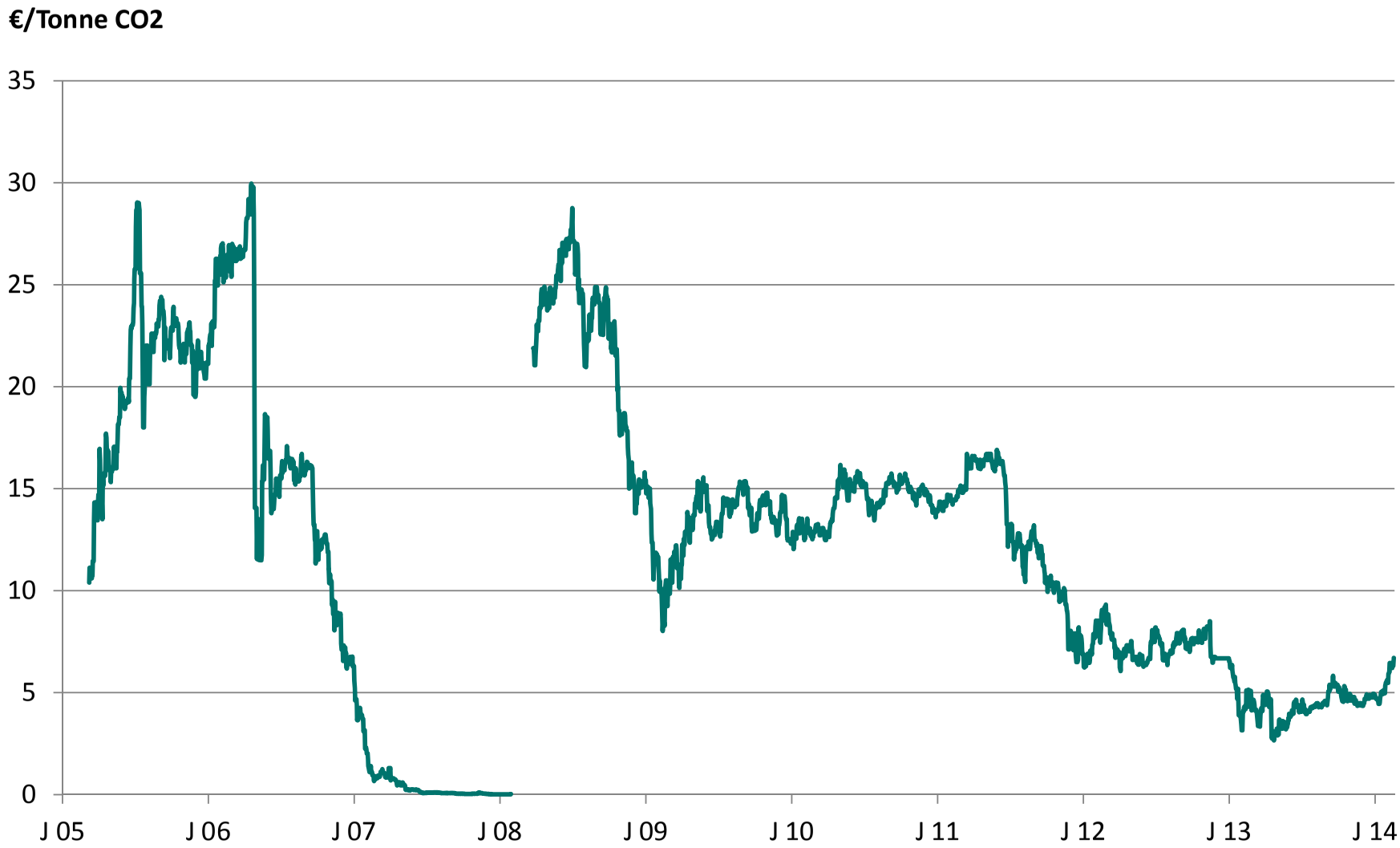
Source: AG Energiebilanzen 2012, BMU, 2011

The Phasing-Out of Coal is Politically Unanymous: Different instruments are under discussion

Instrument	Effect	Possible advantages	Possible shortcomings	Proposed by
ETS reform	Price signal through the introduction of a market stability reserve (MSR), 900 million backloading allowances directly in MSR, start of MSR in 2017 instead of 2021	EU-wide instrument; thus, no cross-border effects	Structural reforms uncertain from today's perspective; the extent of the impact is unpredictable	German government (2014)
Min. CO_2 price ("floor")	CO_2 certificates would become more expensive	Investment security for investors	Feasible prices probably too low to result in a switch from coal towards natural gas	Bündnis 90/the Green Party (2014)
Minimum efficiency level	Closure of inefficient power plants	More efficient utilization of raw materials	Open cycle gas turbines (OCGT) would also be affected; complex test and measurement processes	Bündnis 90/the Green Party (2009)
Flexibility requirements	Closure or singling out of inflexible power plants	Better integration of fluctuating renewable energy sources	Combined cycle gas turbines (CCGT) might also be affected	Öko-Institut/LBD/Raue (2012)
Coal phase-out law	Maximum production or emissions allowances	Fixed coal phase-out plan & schedule	Auctioning difficult to predict	Greenpeace (2012), DIE LINKE (2014)
Emissions performance standard (specifically for new plants and retrofits)	Restrictions for new plants and retrofits (without CO_2 capture)	Prevention of CO_2- intensive investments	Minor short-term reduction in emissions	IASS (2014)
Emissions performance standard (cap for existing plants)	Reduce load factor for older coal-fired power plants that have been written off	Maintenance of generation capacities, e.g., by shifting into a strategic reserve	Negative impact on economic efficiency of power plants; effect on energy efficiency unclear	IASS (2014)
Capacityinstruments	Incentives to develop lower-carbon conventional capacities	Support to natural gas plants, move coal plants into strategic reserve	Danger of micro-management, difficulties to identify concrete technical parameters to ensure lower-carbon output	Öko-Institut/LBD/Raue (2012)

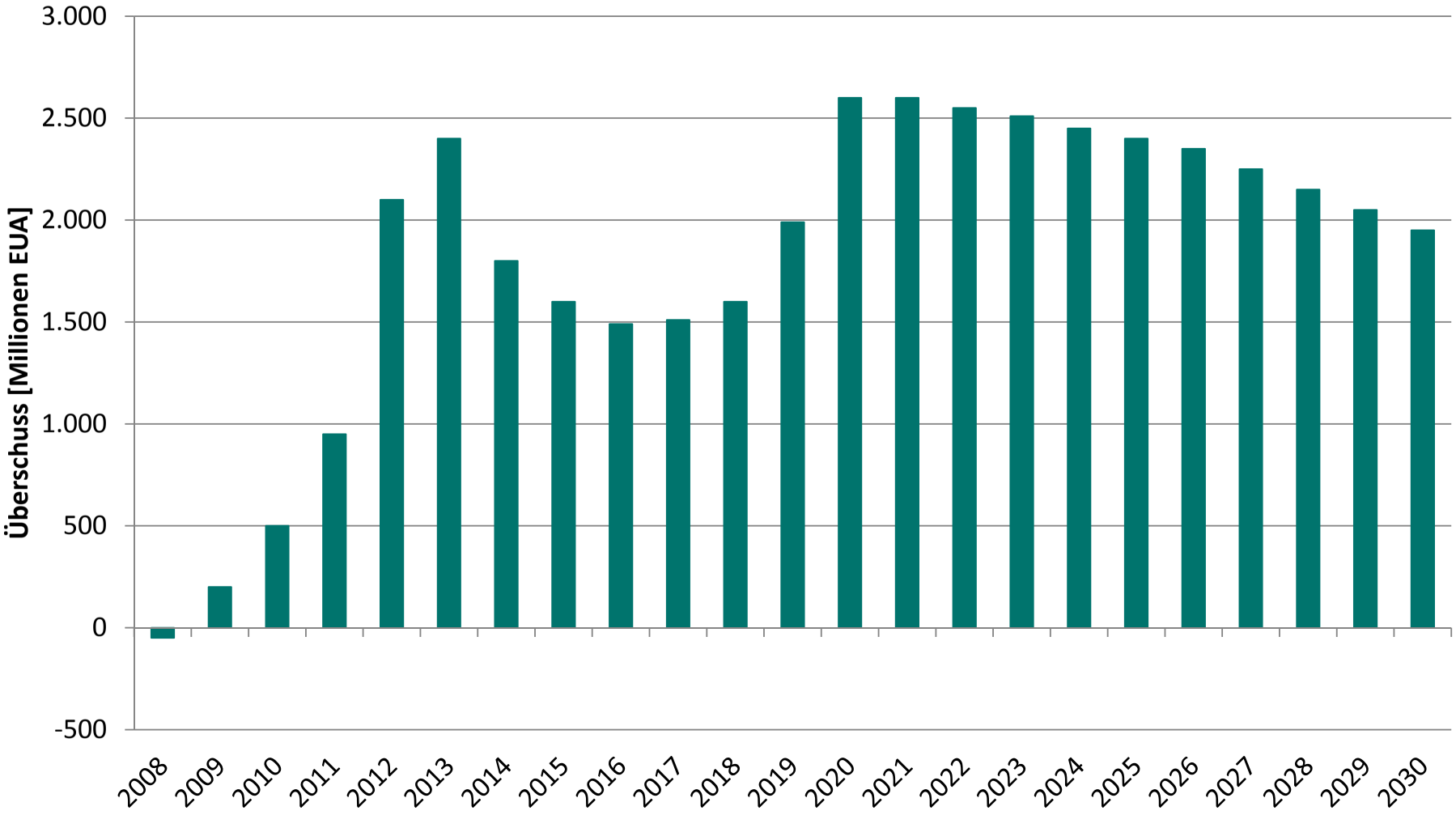
Source: Vattenfall risky business reoprt

CO2-Price



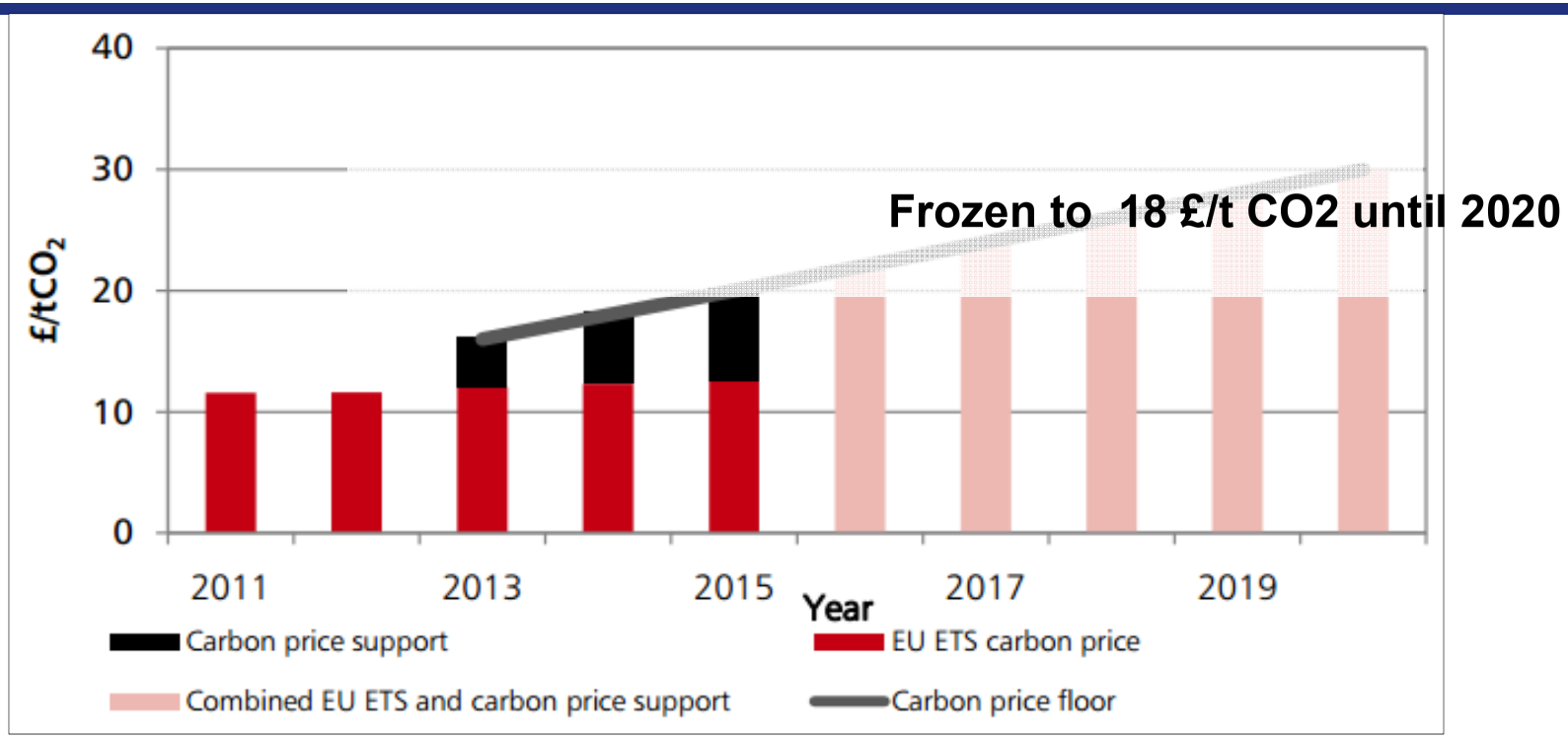
Quelle: Kemfert et al (2014)

(expected) Surplus in the ETS: Will the MSR Yield a Price Signal?



Quelle: Kemfert et al (2014)

Carbon Floor Price? The UK Example

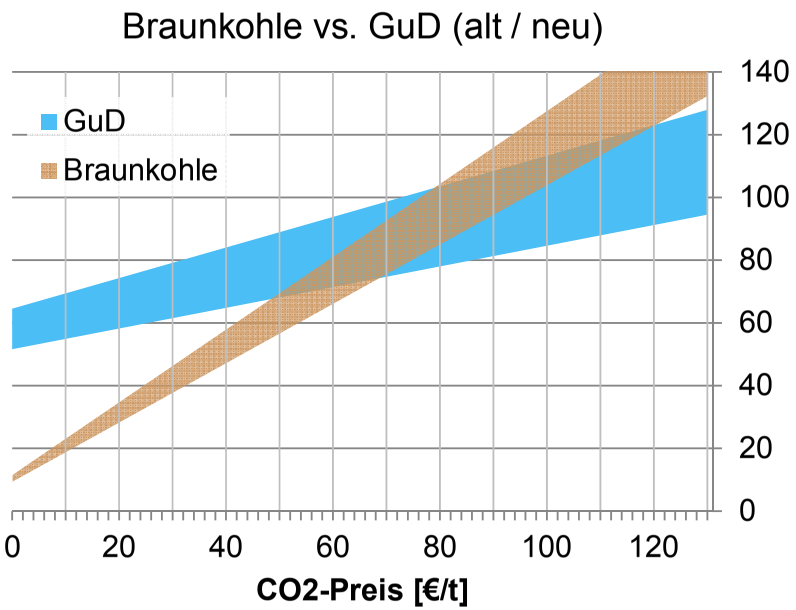


- **Großbritannien hat den CO_2-Floorprice bei 18 £/t CO_2 bis 2020 eingefroren**
- **Möglich über Energiesteuer als Zuschlag auf den CO_2-Zertifikatepreis**

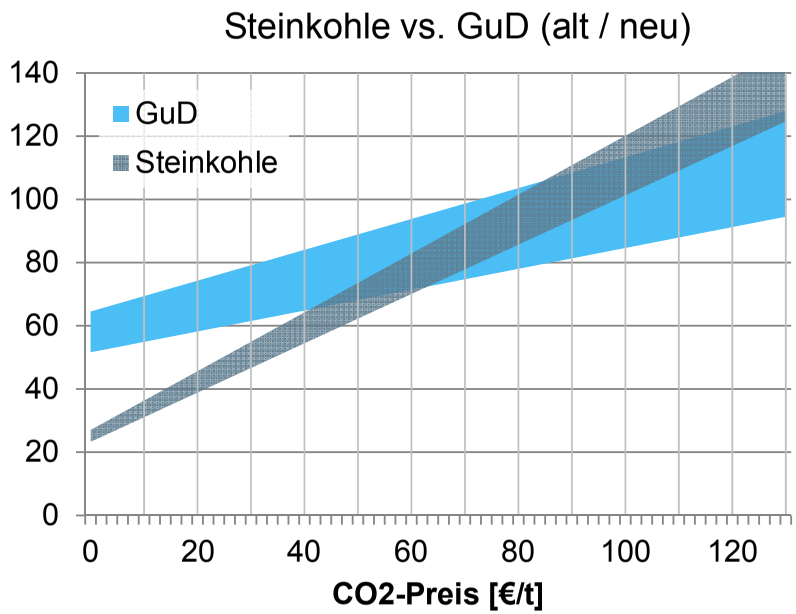
➔ Aber: Switchpreise von Kohle zu Gas liegen deutlich über derzeit möglichen Mindestpreisen.

Quelle: eigene Darstellung basierend auf HM_Treasury (2011)

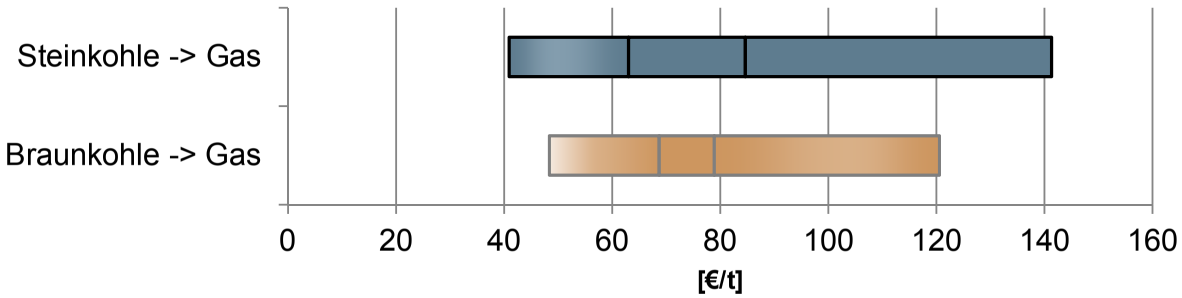
CO_2-Price Unlikely to Have an Effect on Fuel Mix Change, e.g. Coal to Natural Gas



Kurzfr. Erzeugungs-kosten inkl. CO2-Kosten [€/MWh_el]



Benötigter CO2-Preis für Brennstoffwechsel



Annahmen für Brennstoffpreis:
BK: 4 €/MWh_th
SK: 10 €/MWh_th
Gas:32 €/MWh_th

Quellen: Eig. Berechn. bas. auf Wagner et al. (2007), Stadtwerke Düsseldorf (2013), DIW Data Documentation (2014), BAFA (2014)

„The“ Instrument: The „Climate Contribution“

- **Objective: reduction of CO_2-emissionens in the power sector, to reach an additional - 22 Mio. t CO_2 vis-à-vis baseline for 2020**
- **Instrument should have little price effects, high flexibility for operators, low transaction costs**
- **Current status (under discussion)**
  - Older plants have to pay an additional „climate contribution“, after the 20th year of operation
    → instrument targets older power plants
  - Government purchases European ETS-certificates and takes them out of the market
    → avoid „waterbed effect“
  - Free allocation reduced linearly by 7 Mio. t CO_2/GW (age 20 years) to auf 3 Mio. t CO_2/GW (40 years)
    → The instrument targets mainly older lignite plants
  - „Climate contribution“ to be introduced in 2017, should increase towards 18-20€/t CO_2 by 2020

  → 90% of plants not effected, targeting mainly older lignite plants.

Agenda

1) Introduction and Conceptual Approach

2) A Primer on the “Energiewende”

3) Climate Policies and Instruments

4) Conclusions

Conclusions

1. Germany has embarked on a path to a low-carbon energy sector, which includes a substantial overhaul of generation and transmission (and many other issues); all scenarios include a share of renewables in electricity consumption of over 60%, and generally in the range of 80-95%
2. There is a long history of climate targets, some of them not reached ; but the current attempts seem to be serious (-40% by 2020)
3. Policy instruments are not generic, but “tailor-made”; ETS plays a role, but is complemented by national instrument(s)
4. In the medium-term, the generation structure in Germany (and other European countries) is likely to change; this also holds for the corporate structures