

Prof. Dr. Peter Hennicke

Integrating Energy Efficiency and Renewables: The German Energy Transition

Presentation at the Conference “SIEW Energy Insights”, Singapore,

24th October 2017

The energy transition in Germany is globally embedded in **two megatrends** which are about to be **strategic game changers**:

→ The paradigm shift to **“Efficiency First”** (IEA/Paris) and the spectacular **decreasing costs of electricity** from wind and PV.

The **strategic combination** of efficiency, green electricity, electrification of transport and heat sector as well as sustainable lifestyles make the energy transition possible.

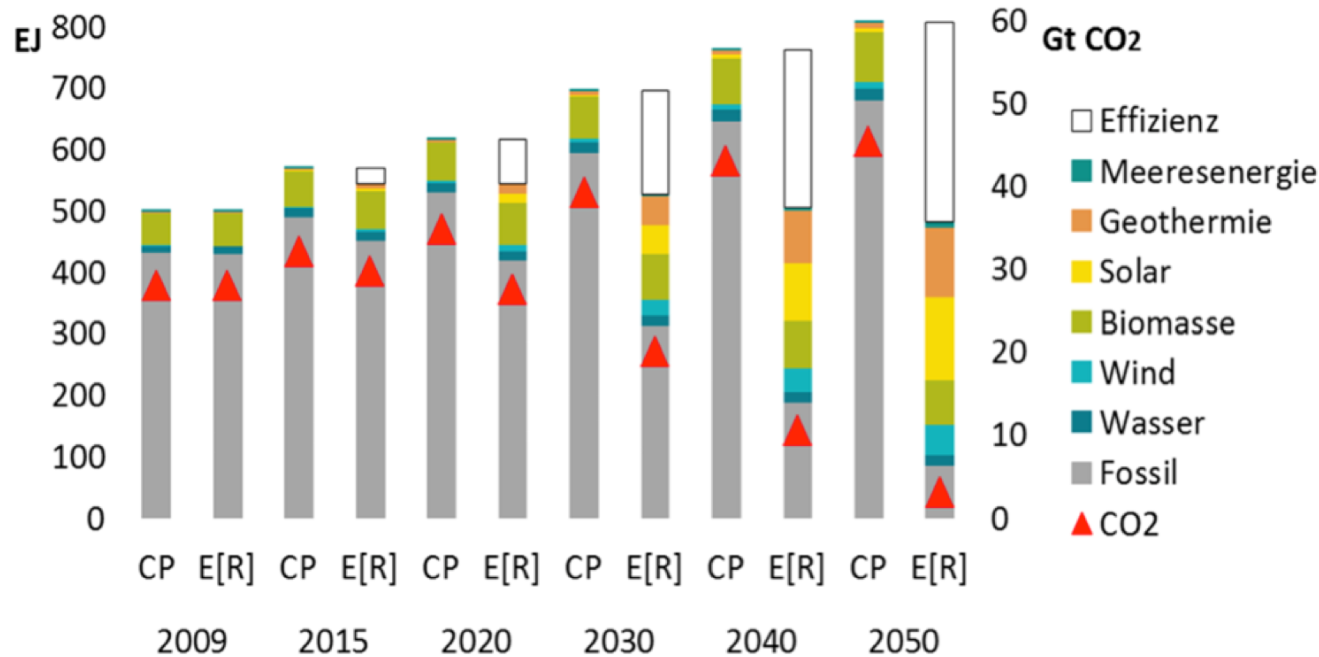
Deploying energy **innovations** needs the integration of technical **and** socioeconomic driving forces and a new polycentric governance.

A **trend to decentralization and citizen participation** as well as **macroeconomic benefits** and **regional resilience** have driven the German Energiewende.

Intensified international cooperation can speed up, scale up and tighten up innovations and strategies for decarbonization and risk minimization.

Global pathway to zero emissions: Efficiency + Renewables (+Sustainable Lifestyles)

Example: IEA Current Policy (CP) vs. Energy (r)evolution (E(R))

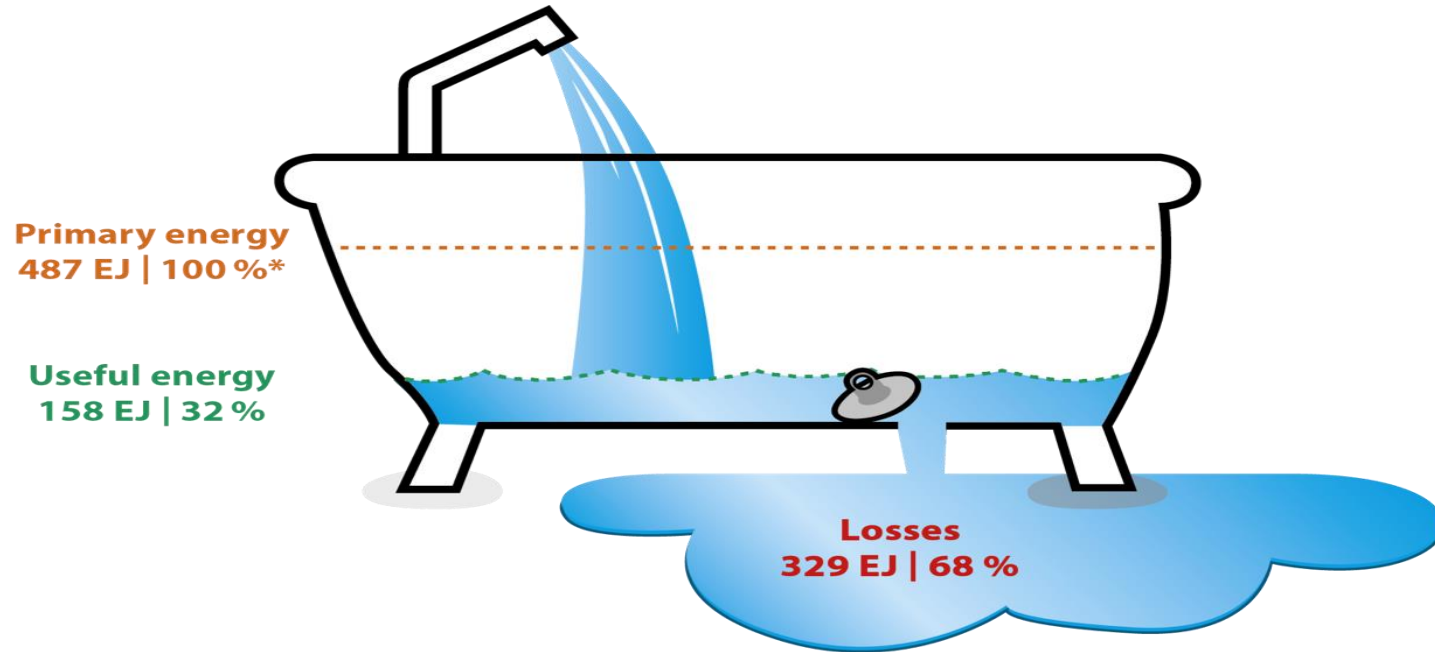


Source: DLR 2015

“Efficiency first” (IEA):

Reduce losses of the global energy system

...by the “energy efficiency revolution” and decentralized power



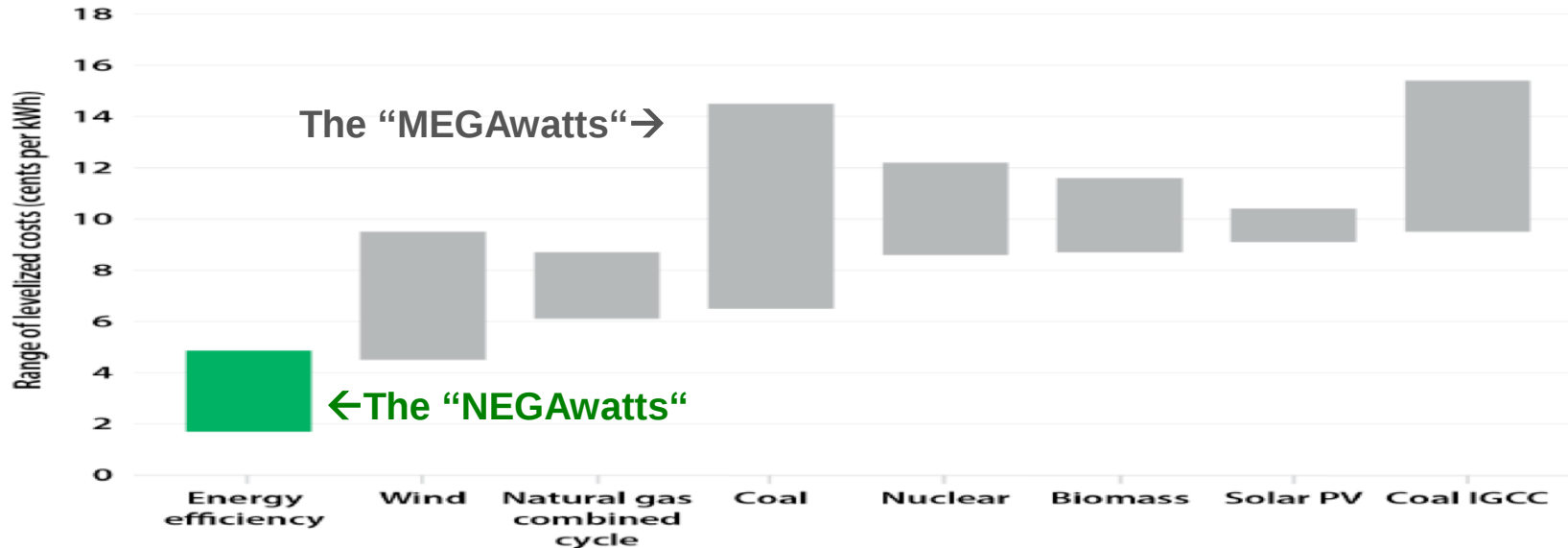
*Total primary Energy 519 EJ less 32 EJ non energetic consumption

Source: Hennicke/Grasekamp 2014; based on Jochem/Reize 2013; figures from IEA/OECD/IREES

US: Cost of utility efficiency programs

(average: 2.8 cents per kWh)

50-75% less than costs of new power supply + many co-benefits



The high-end range of **coal** includes 90 percent carbon capture and ompression. **PV** stands for photovoltaics. **IGCC** stands for integrated gesification combined cycle, a technology that converts coal into a synthesis gas and produces steam.

Source: ACEE 2014. Energy efficiency portfolio data from Molina 2014; all other data from Lazard 2013.

Unsubsidised clean energy world records 2017

-> a new “world record” for PV: 1.79 cts/kWh in Saudi Arabia!

Solar PV



Country: United Arab Emirates
Bidder: Marubeni and Jinko Solar
Signed: 2017
Construction: 2019
Price: US\$ 2.42 c/kWh

Onshore wind



Country: Morocco
Bidder: Enel Green Power
Signed: 2016
Construction: 2018
Price: US\$ 3.0 c/kWh

Offshore wind

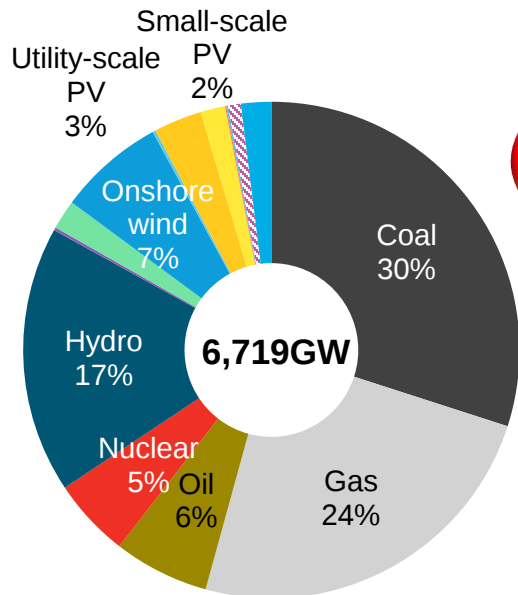


Country: Germany
Bidder: DONG/EnBW
Signed: 2016
Construction: 2024
Merchant Price: US\$ 4.9 c/kWh

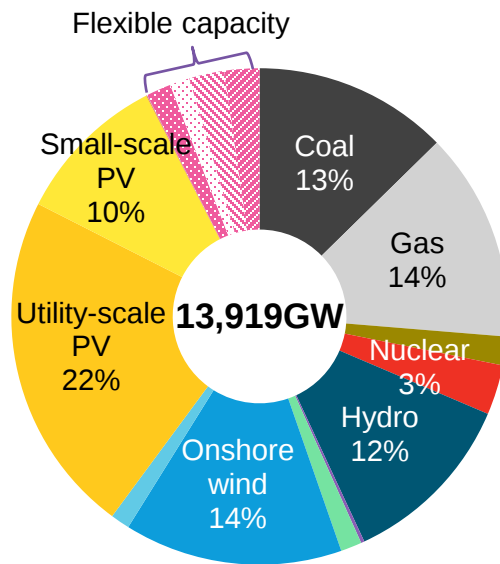
Source: Bloomberg New Energy Finance; Images Siemens; Wikimedia Commons; Masdar

Solar and wind dominate the future of electricity

Global cumulative installed capacity: 2016



Global cumulative installed capacity: 2040

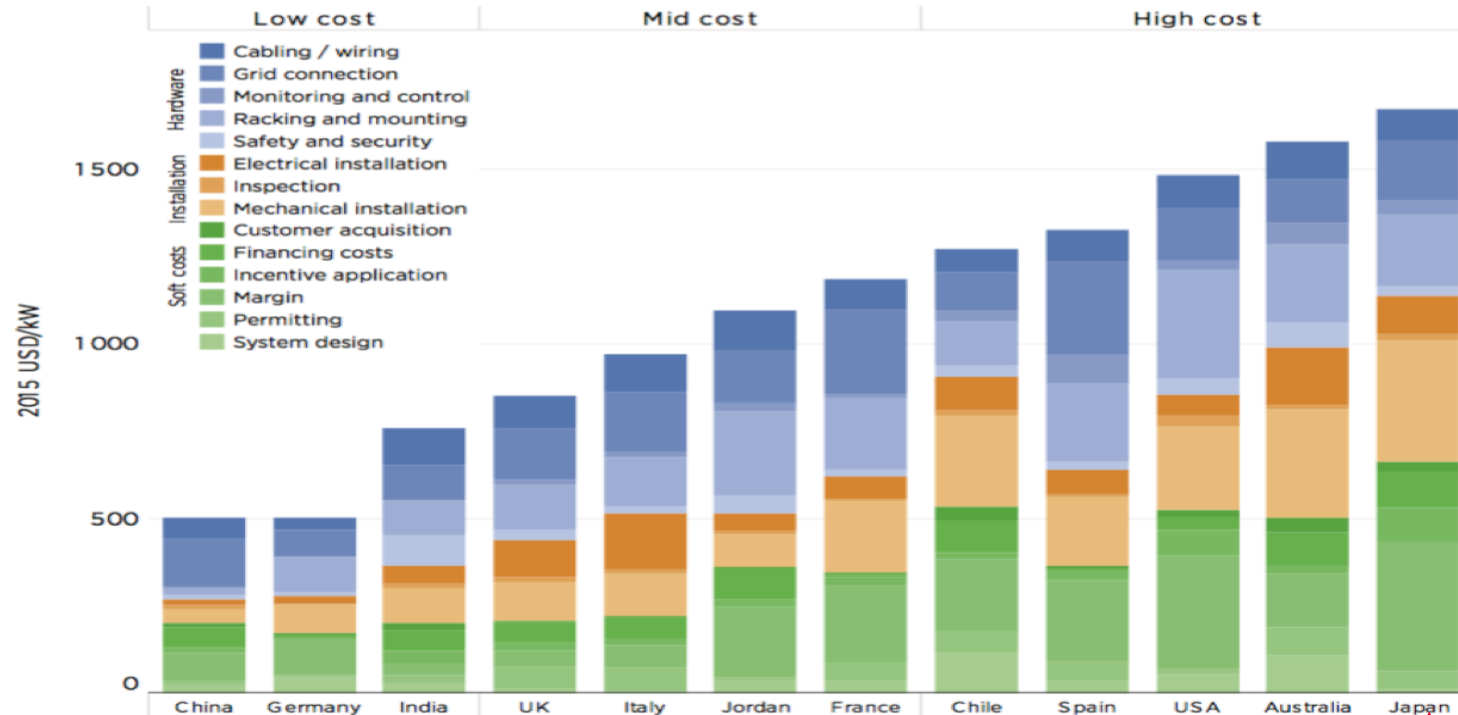


**By 2040, 66%
of generating
capacity will be
renewable**

Source: Bloomberg New Energy Finance, [NEO 2017](#)

Astonishing global differences of PV costs (2015)

→ great cost reduction potential in Japan, USA.....



Source: IRENA Renewable Cost Database.

Source: IRENA 2016

“Act locally to change globally”!

Opportunities and challenges of the German “Energiewende”

“Revolutionary Targets” (Chancellor Merkel)

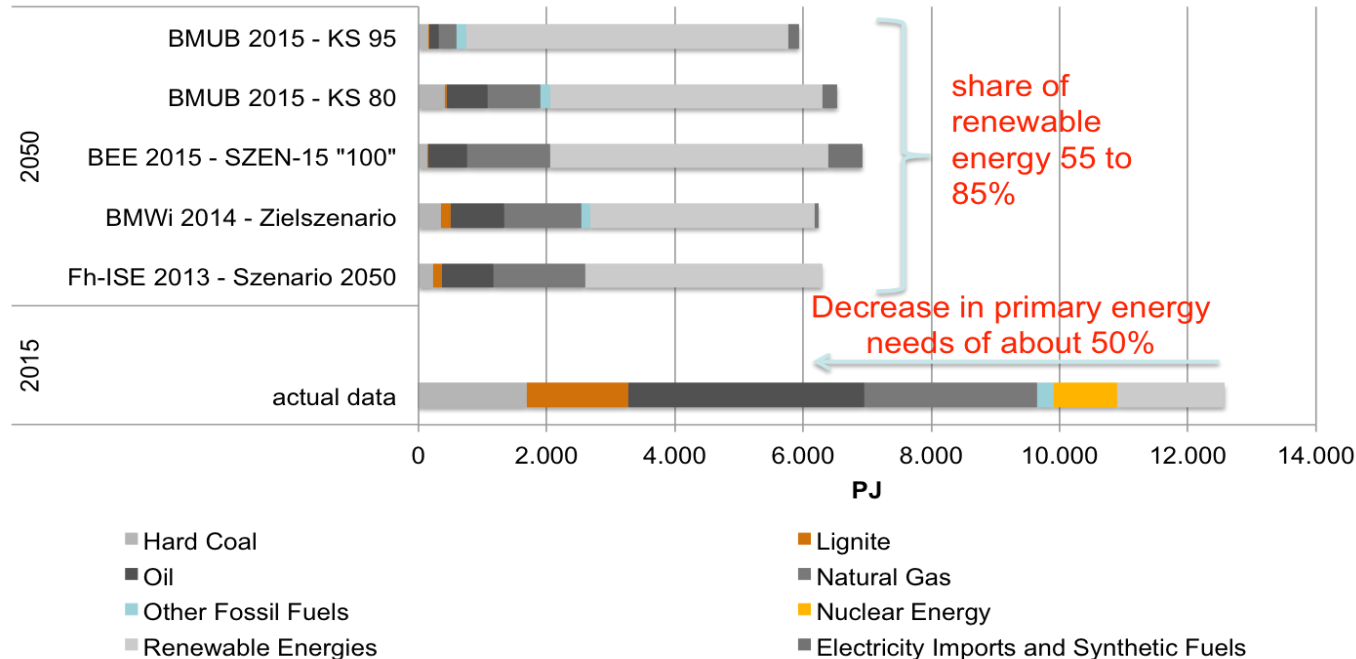
Energy Concept, Federal German Government, 09/2010



	2014	2015	2020	2030	2040	2050
Greenhouse gas emissions						
Greenhouse gas emissions (compared to 1990)	-27.7 %	-27.2 %	minimum -40 %	min -55 %	min -70 %	min -80 to 95 %
Increase in share of renewable energy in final energy consumption						
Share in gross final energy consumption	13.6 %	14.9 %	18 %	30 %	45 %	60 %
Share in gross power consumption	27.3 %	31.6 %	min 35 %	min 50 % (2025: 40-45 %)	min 65 % (2035: 55-60 %)	min 80 %
Share in heat consumption	12.5 %	13.2 %	14 %			
Share in transport sector	5.6 %	5.2 %	10 % (EU goal)			
Reduction of energy consumption and increase in energy efficiency						
Primary energy consumption (compared to 2008)	-8.3 %	-7.6 %	-20 %			-50 %
Final energy productivity	1.6 % per year (2008-2014)	1.3 % per year (2008-2015)	2.1 % per year (2008-2050)			
Gross electricity consumption (compared to 2008)	-4.2 %	-4 %	-10 %			-25 %
Primary energy demand buildings (compared to 2008)	-19.2 %	-15.9 %				around -80 %
Heat demand buildings (compared to 2008)	-14.7 %	-11.1 %	-20 %			
Final energy consumption transport (compared to 2005)	1.1 %	1.3 %	-10 %			-40 %

Research consensus on the “Energiewende”

-> phasing out nuclear (2022) and coal (2030/2040?) is feasible



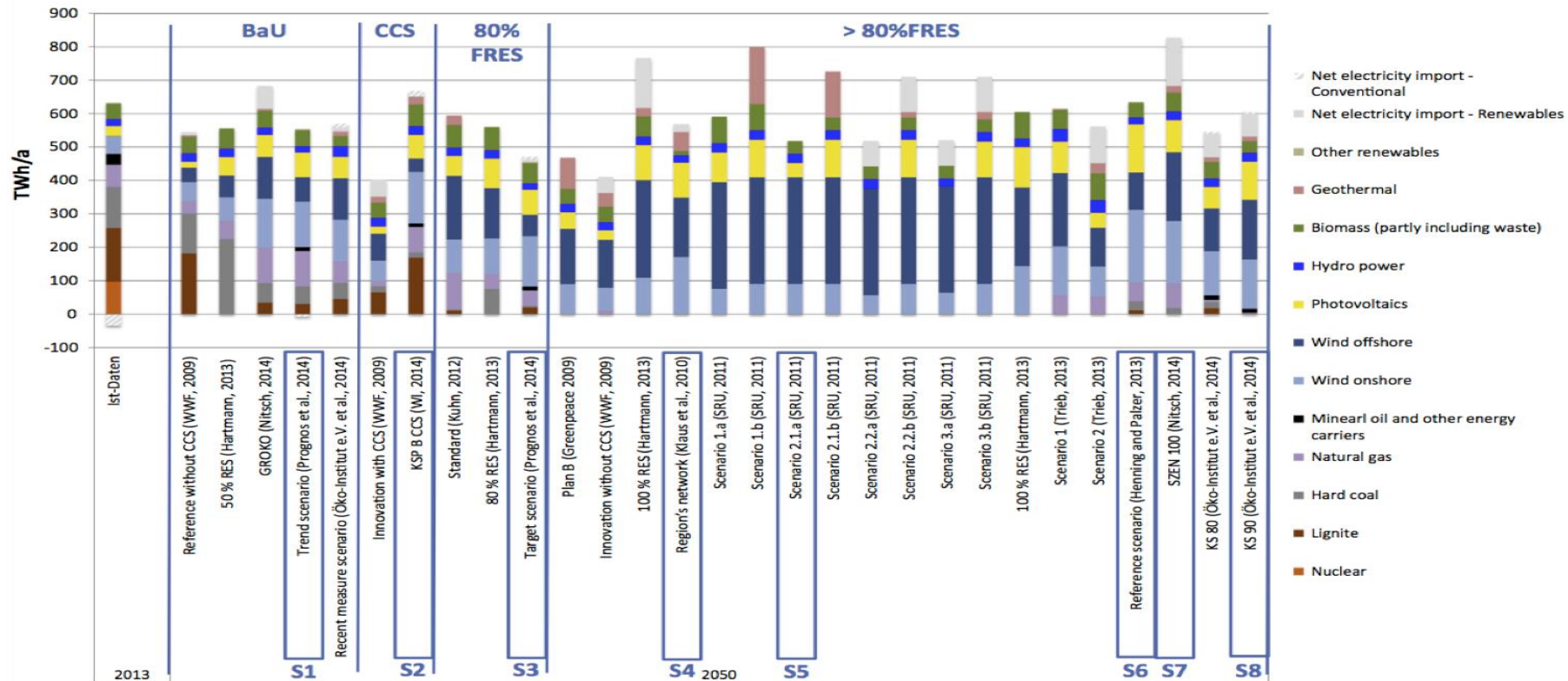
Source: Particular scenario studies and AG Energiebilanzen 2015

Typical scenarios of German electricity production



Wuppertal
Institut

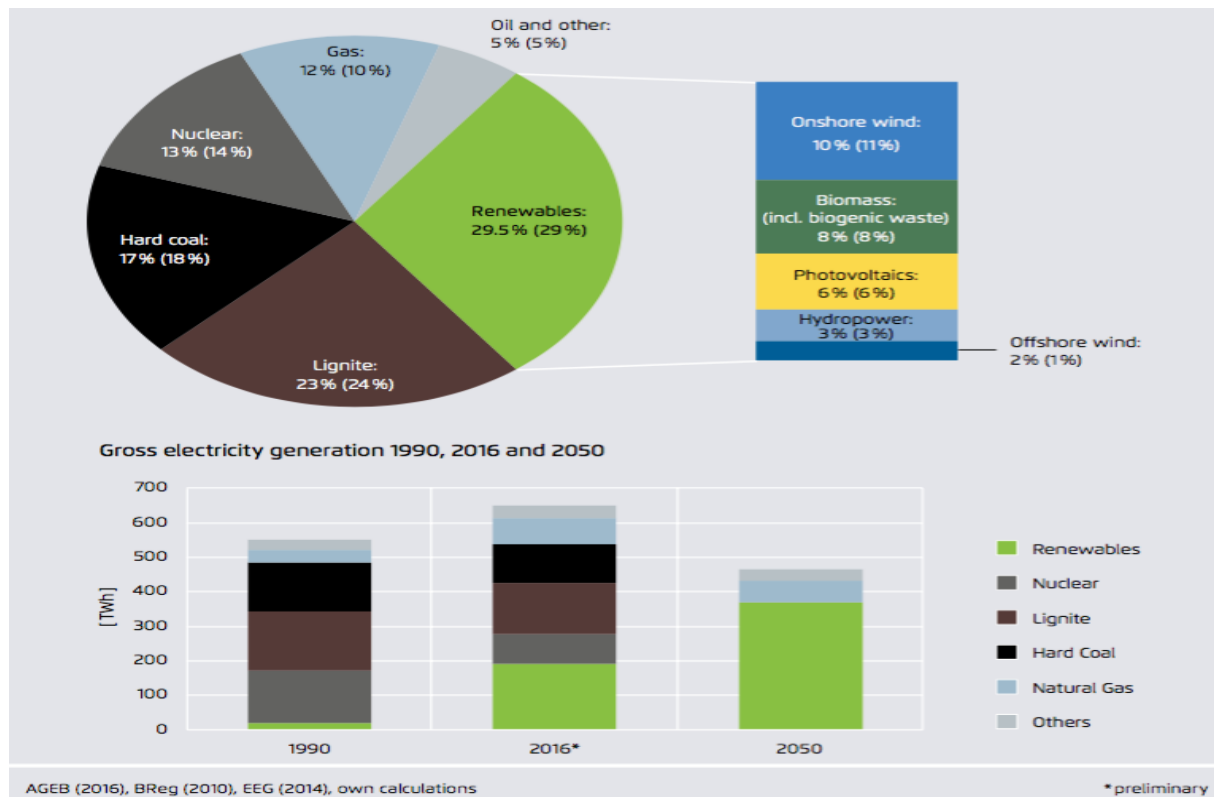
->many options and uncertainties on electricity demand in 2050



Source: B. Lunz et al. 2016.

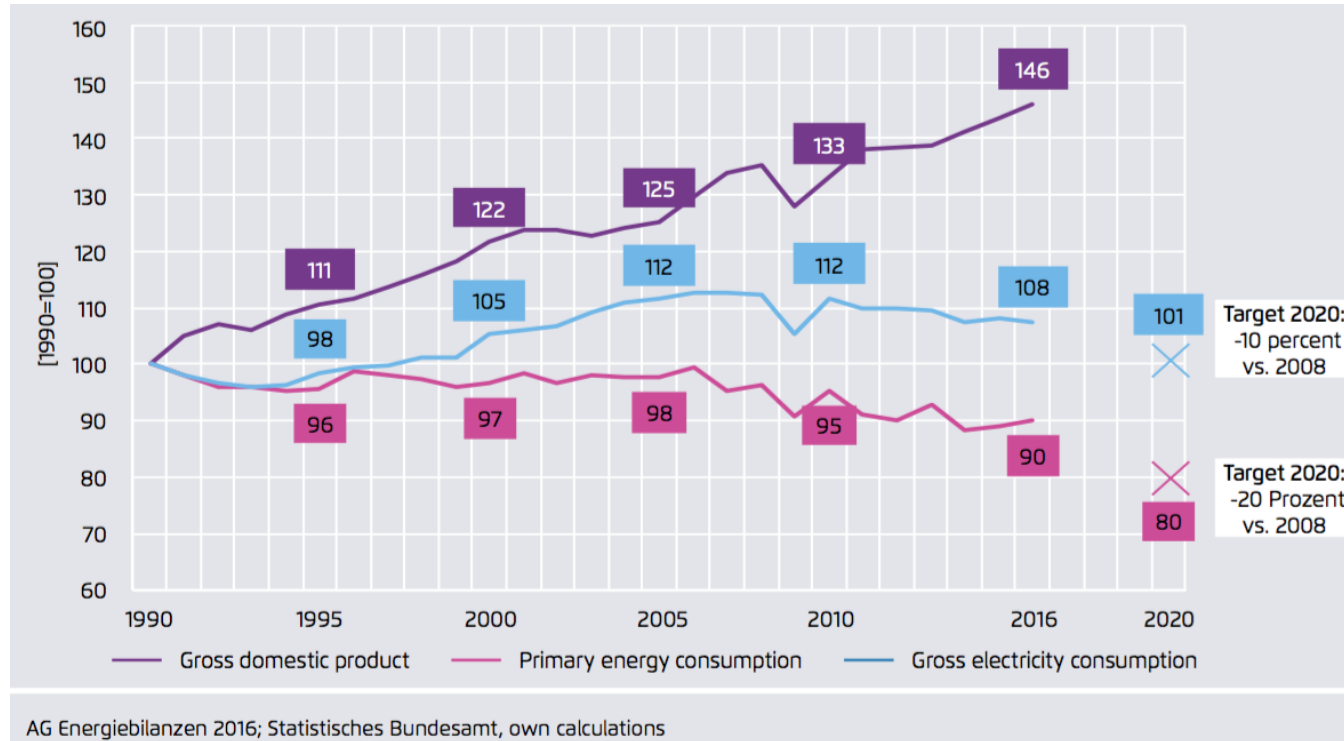
German Power Mix 2016 (2015 in brackets)

Renewables 2016: 30%



GDP, primary energy and electricity production

→ decoupling is happening, but too slow (indexed, 1990 = 100)



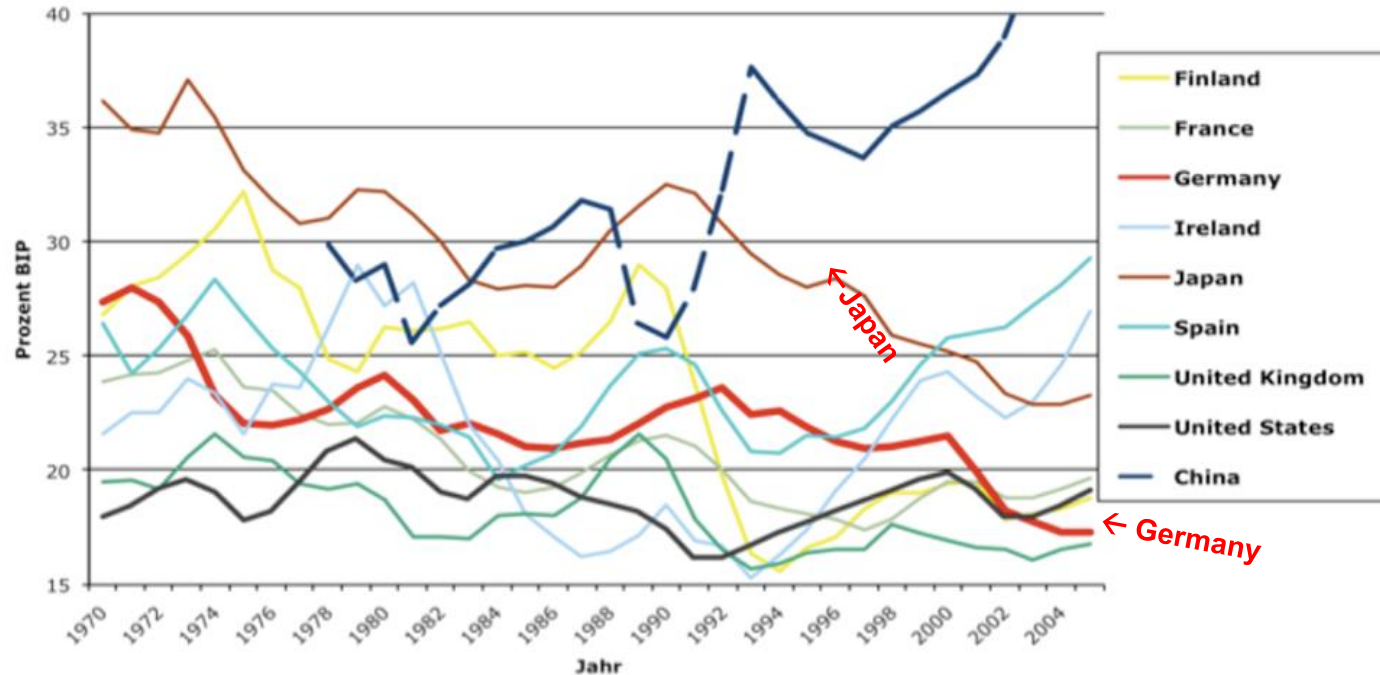
Source: Agora 2017

Investments for the energy transition create macroeconomic (net) benefits

Additional investments in climate and resource protection

-> a core strategy to foster innovations and green growth

International comparison of gross investment rates (1970-2006)



Source: C. Jäger, PIK, 2009.

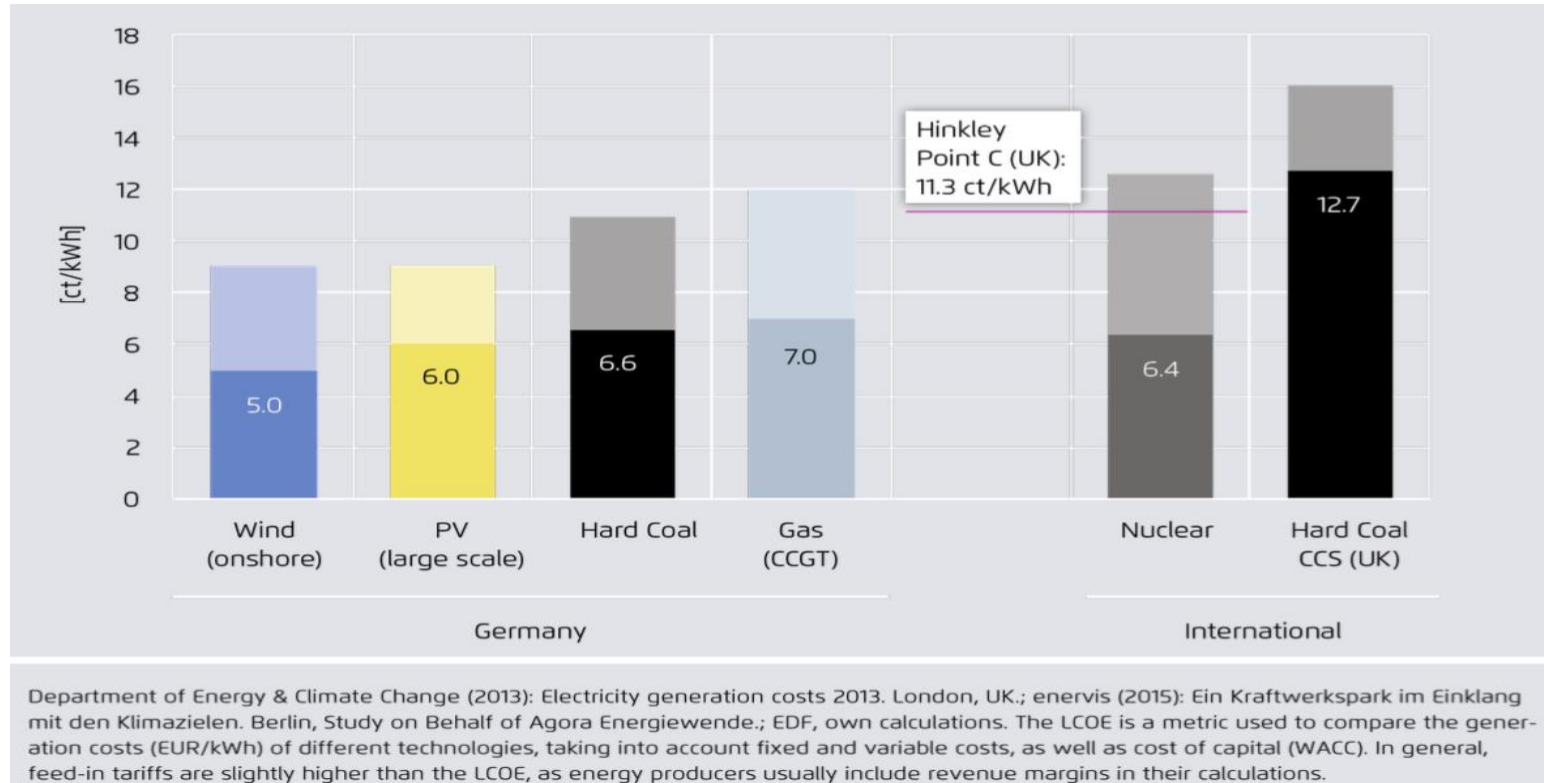
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16

Range of green power costs in Germany

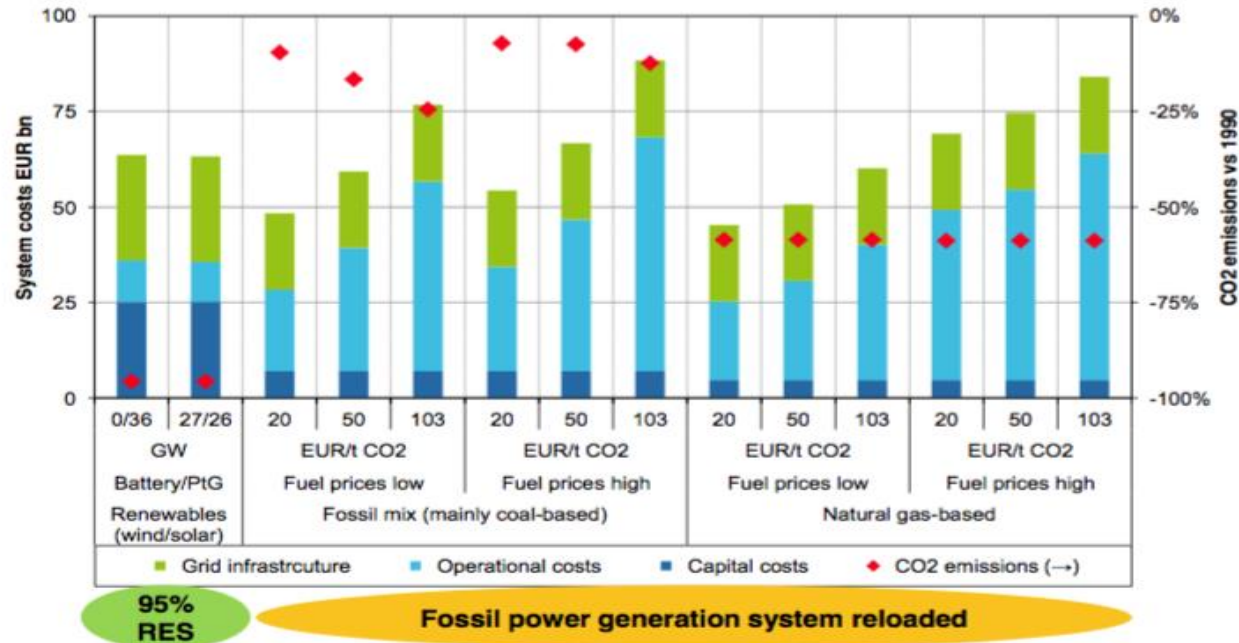
→ in comparison to new nuclear and coal/CCS (UK)



Source: Agora 2017

Going renewable is beneficial

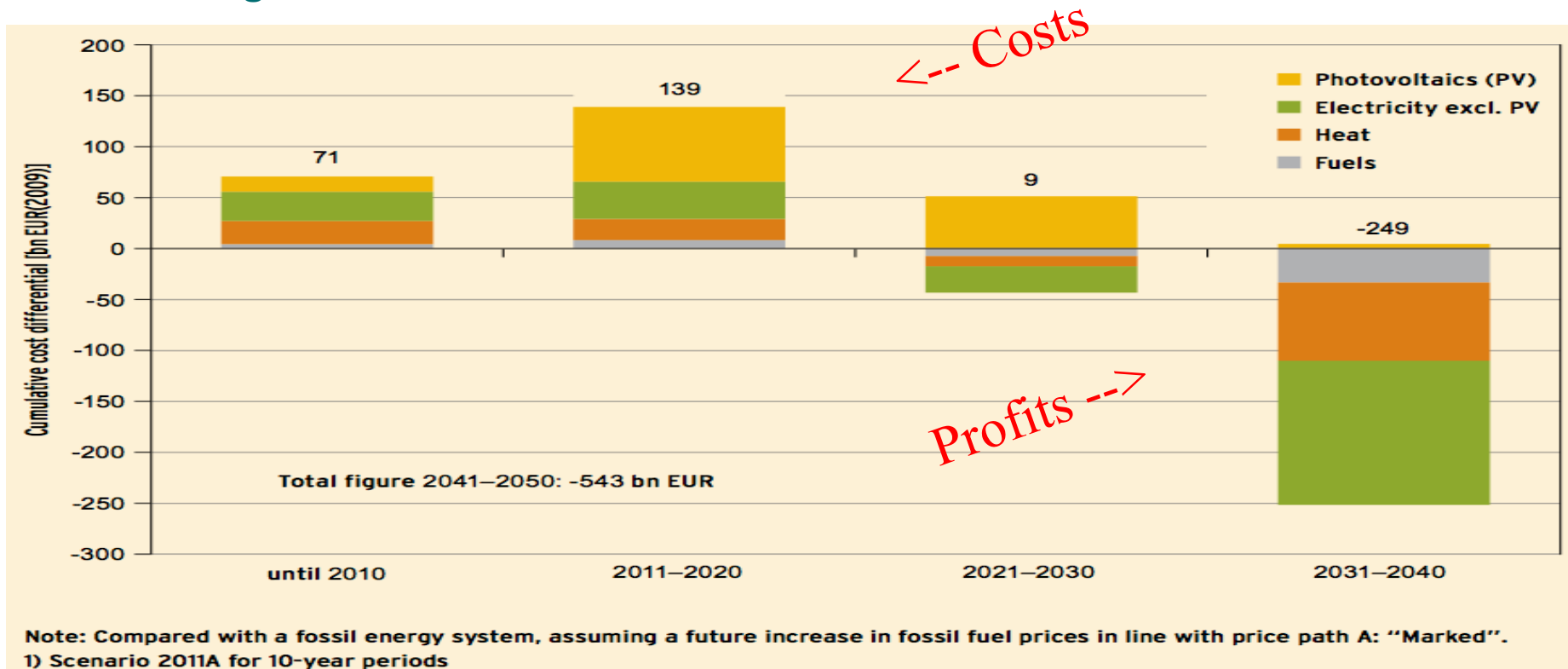
Comparing the total system costs of a renewable/fossil mix



Öko-Institut (2016)

Differential costs of the “Energiewende”

“Cost swing” in all sectors (according to the German “Lead Scenario 2011”)

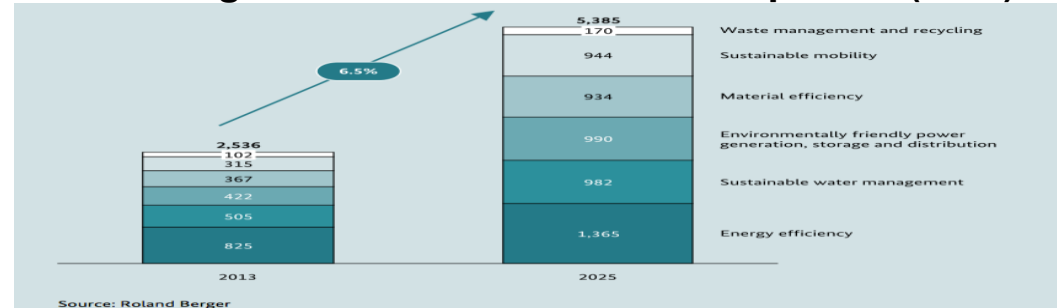


Opportunities on global “GreenTech”- markets

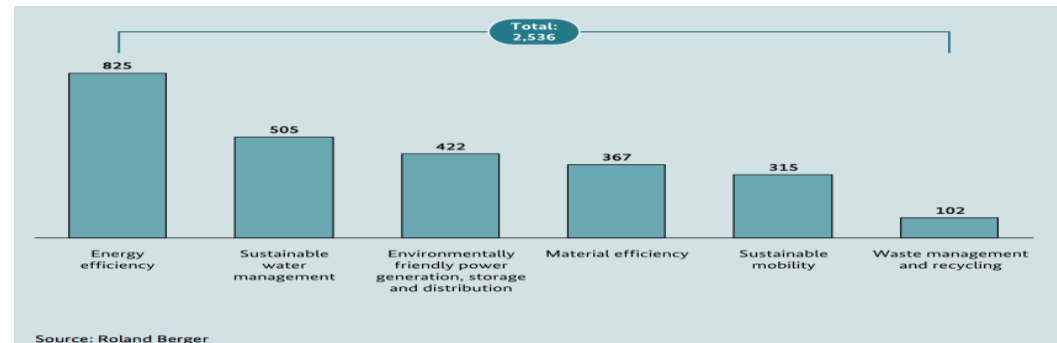
->one reason why German industry supports the “Energiewende”



Doubling of “GreenTech” markets expected (bn €)



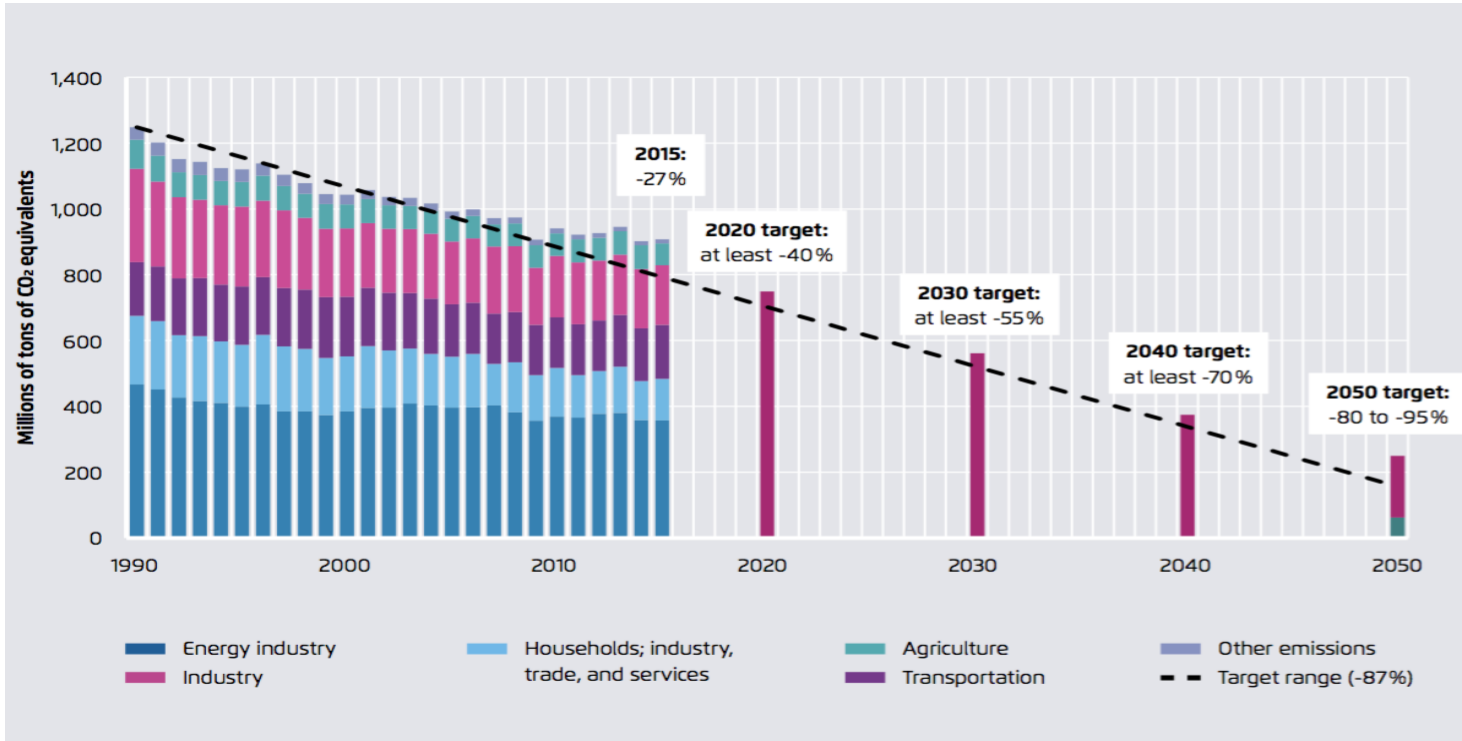
Energy efficiency - the most attractive market



- **Phasing out coal 2030/2040?** How much **increase and incentives** for REN?
- **Costs:** How much, how long, for whom?
- **Priority focus on power:** system transformation of **heat and transport** sector?
- **Supply side biased;** how to foster **energy (resource) efficiency**?
- **Decentralized** (“smart grids”) vs. centralized power (“coal”)?
- **Citizens participation** and democratization?
- **Lifestyle changes:** sustainable consumption and production?
- **Political Leadership:** Management and responsibilities?

Gradual phase out of coal - necessary to reach the CO₂-reduction goals

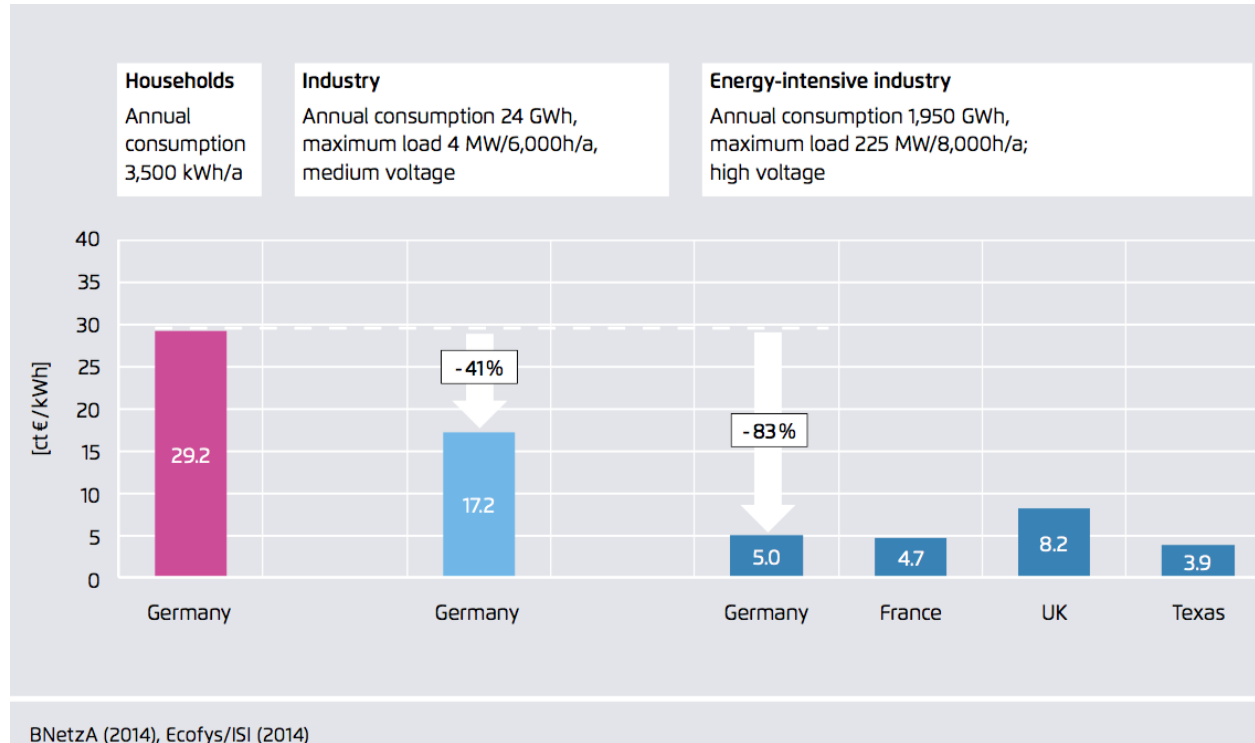
The currently most controversial topic of the Energiewende



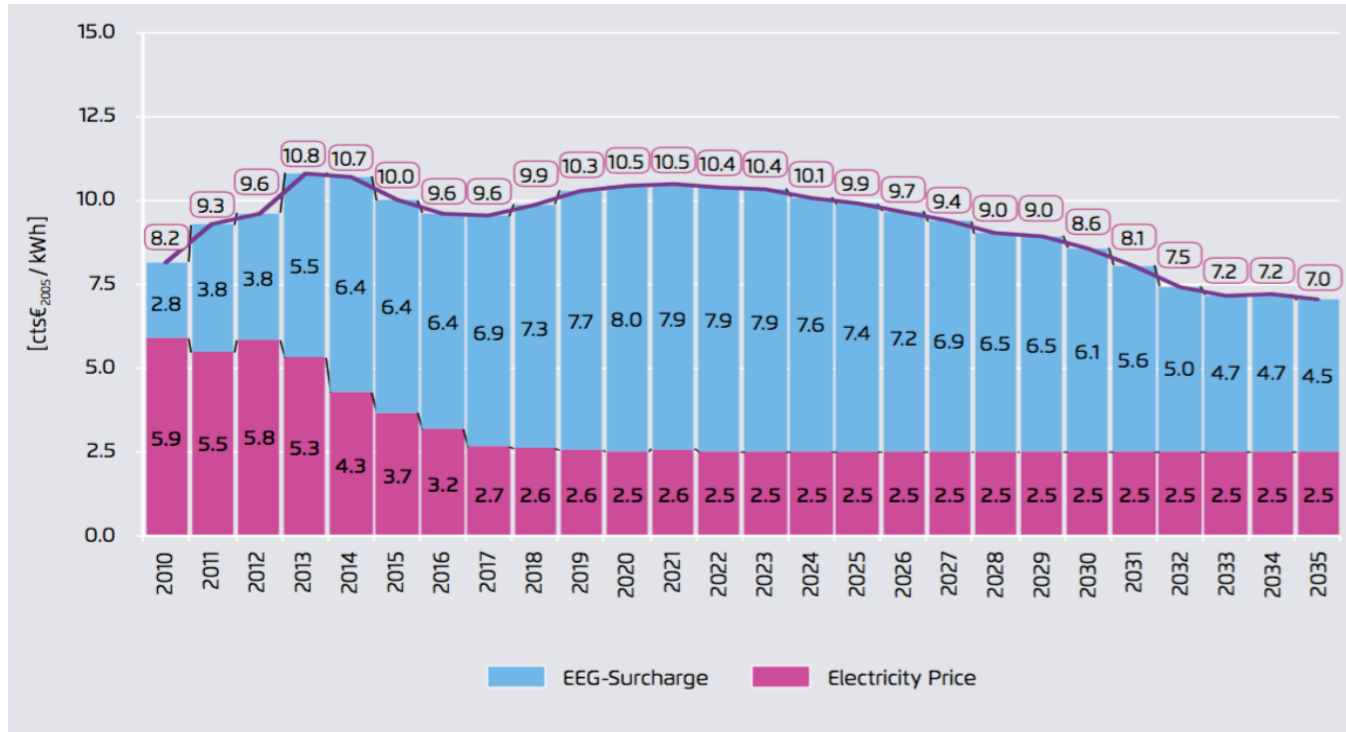
Distributional effects of the Energiewende

Average electricity prices

→ expensive: households/SME – cheap: industry



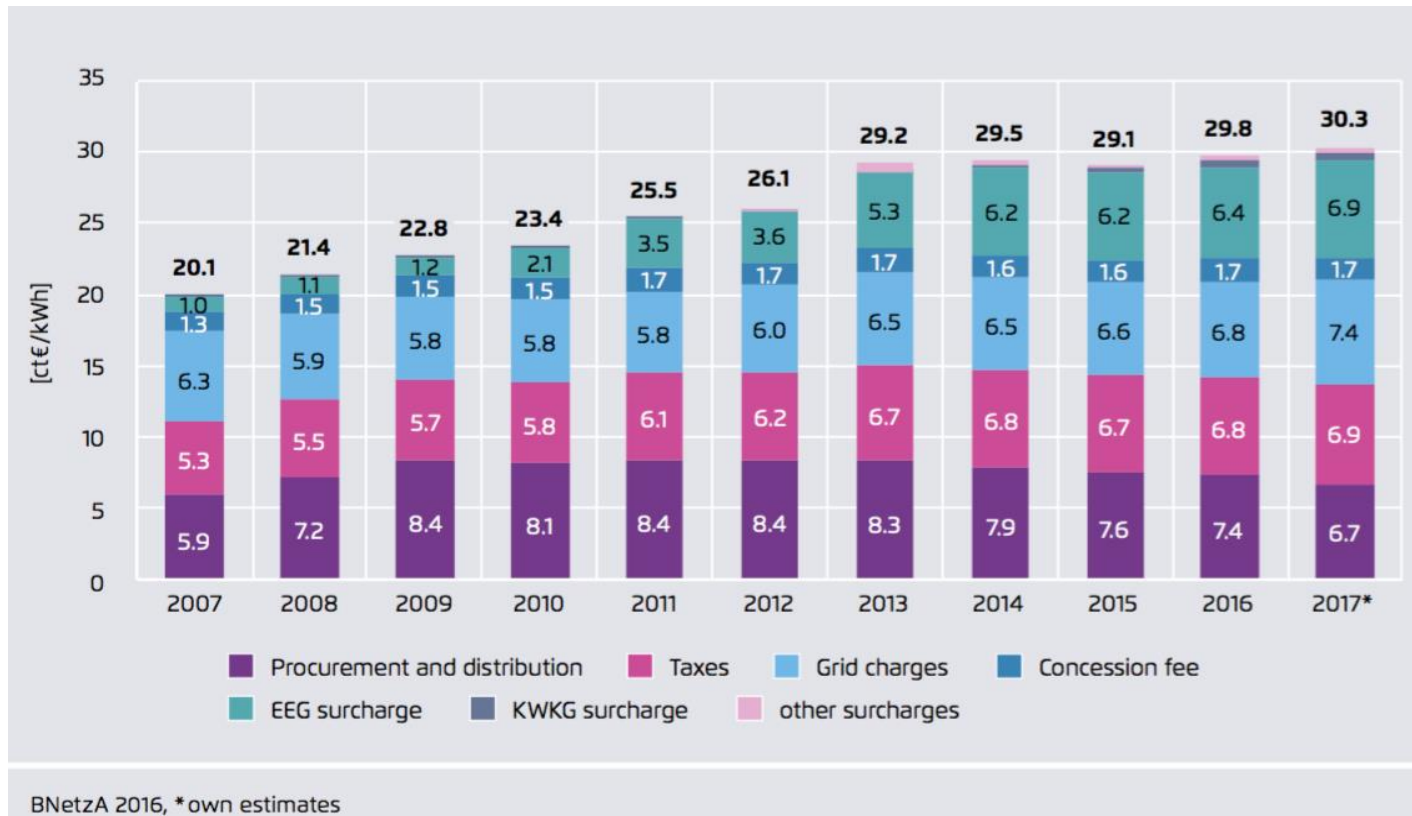
Electricity wholesale price and surcharge of the EEG (cts/kWh)



Ökoinstitut (2005), Agora Energiewende

Average electricity prices (2007-2017)

German 4-person household



Electricity prices and consumption

- higher prices can be compensated by more efficient use!

	Annual household consumption in kWh	Electricity price in EURct/kWh	Annual electricity bill in EUR
Denmark	3,820	29.4	1,121
US	12,294	9.0	1,110
→ Germany	3,362	29.1	978
→ Japan	5,373	18.1	971
Spain	4,038	22.6	912
Canada	11,303	7.5	851
France	5,830	14.3	834
UK	4,143	17.3	717
Italy	2,485	23.3	580
Poland	1,935	15.1	291

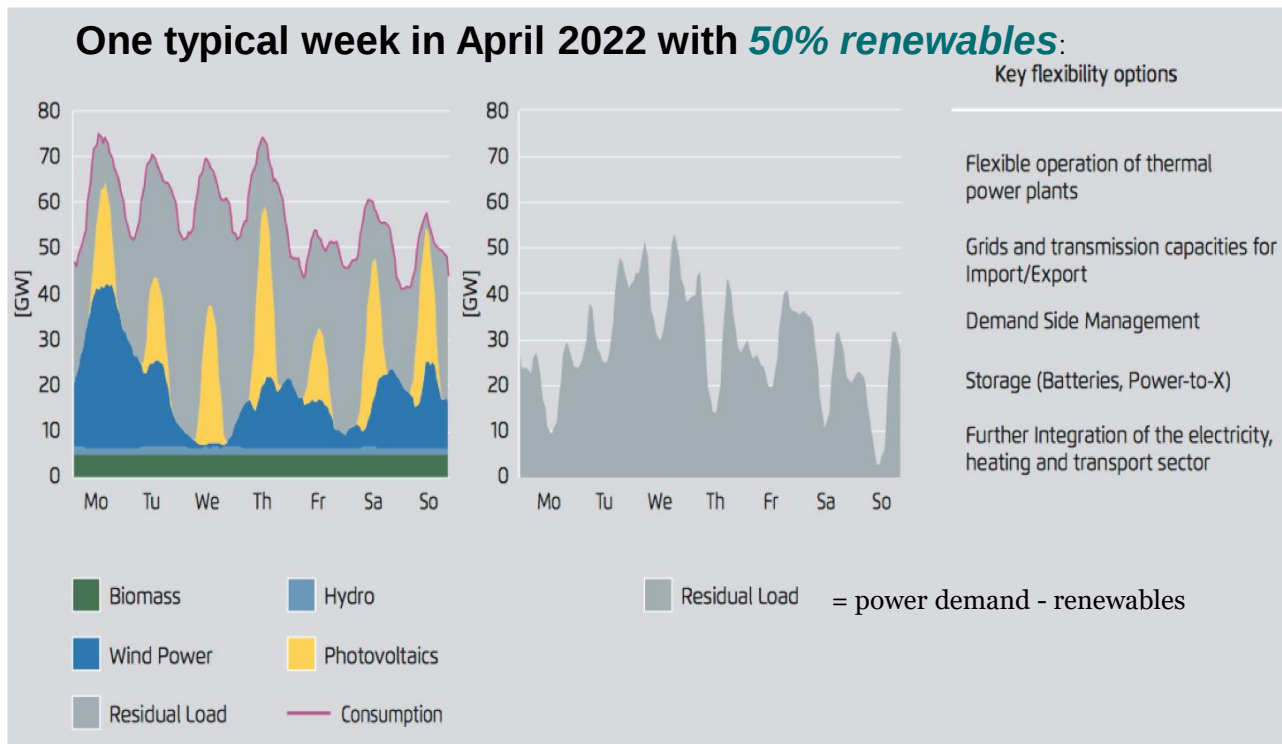
Enerdata (2015), World Energy Council (2015), own calculations

* consumption data from 2013; electricity prices data from 2014

**Base load power reduced
→ flexibility options needed!**

Electricity generation and fluctuating residual load

A paradigm shift: From base load to flexibility options!

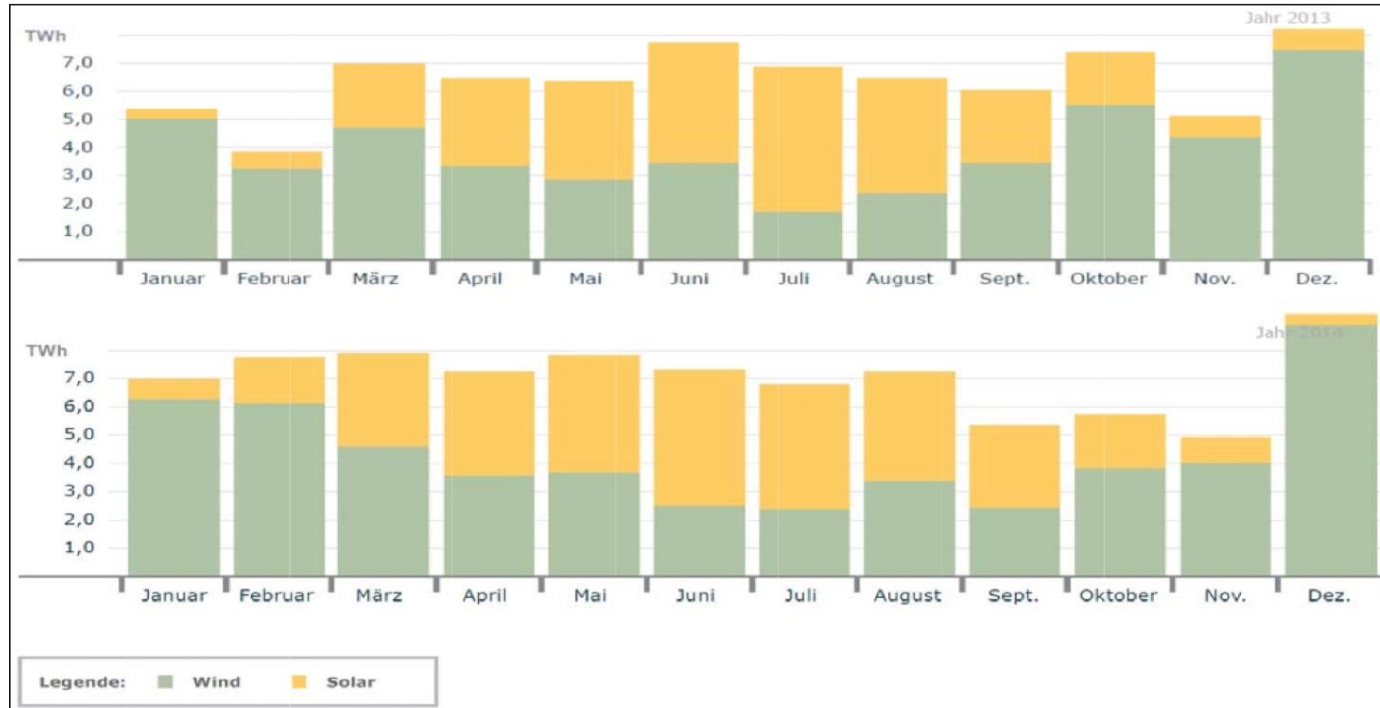


Source: Agora 2016

Connecting wind (north) and PV (south) by transmission lines

A cost-effective way to raise security of power supply

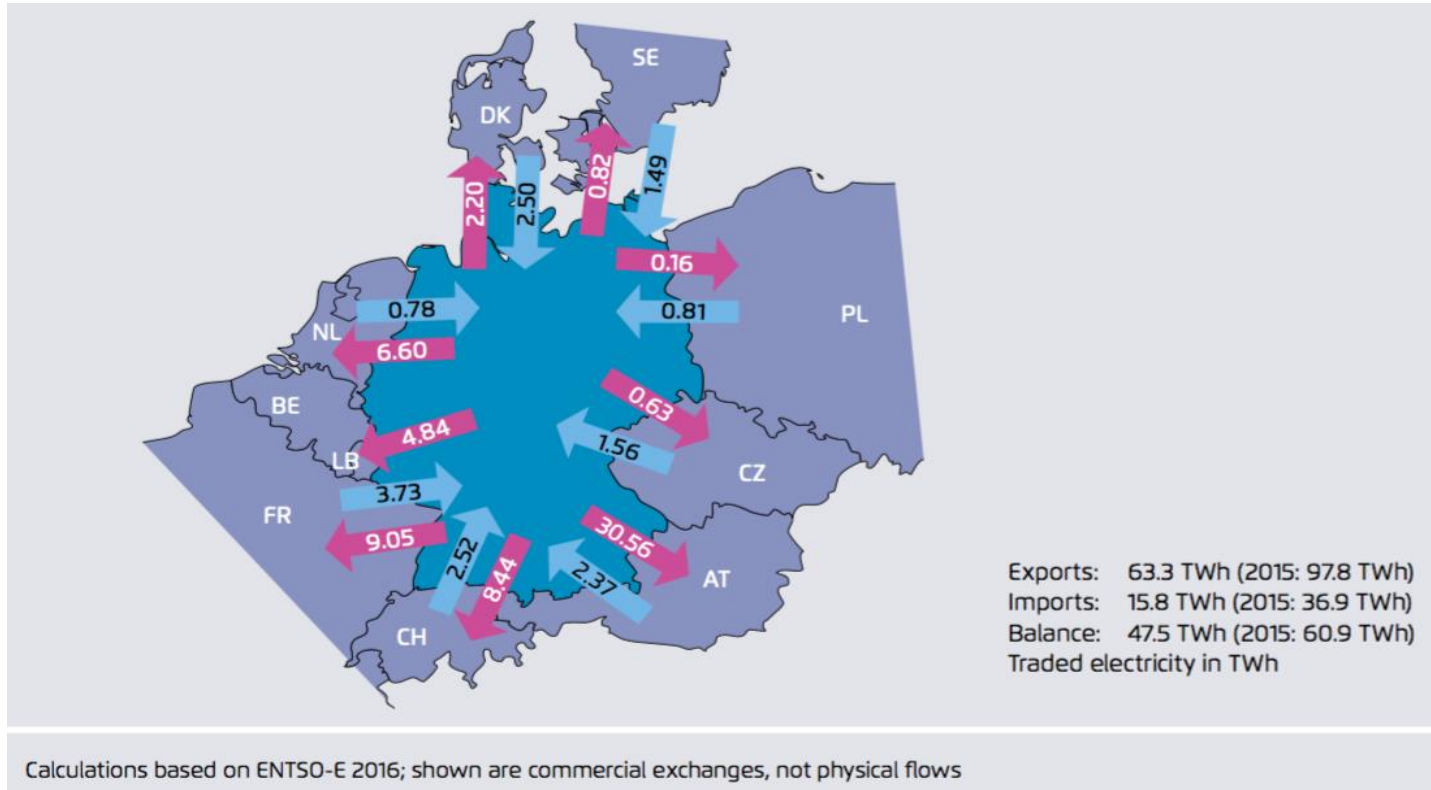
Monthly power production from PV and Wind in Germany (2012 and 2013)



Source: Fraunhofer ISE 2015; Samadi 2016.

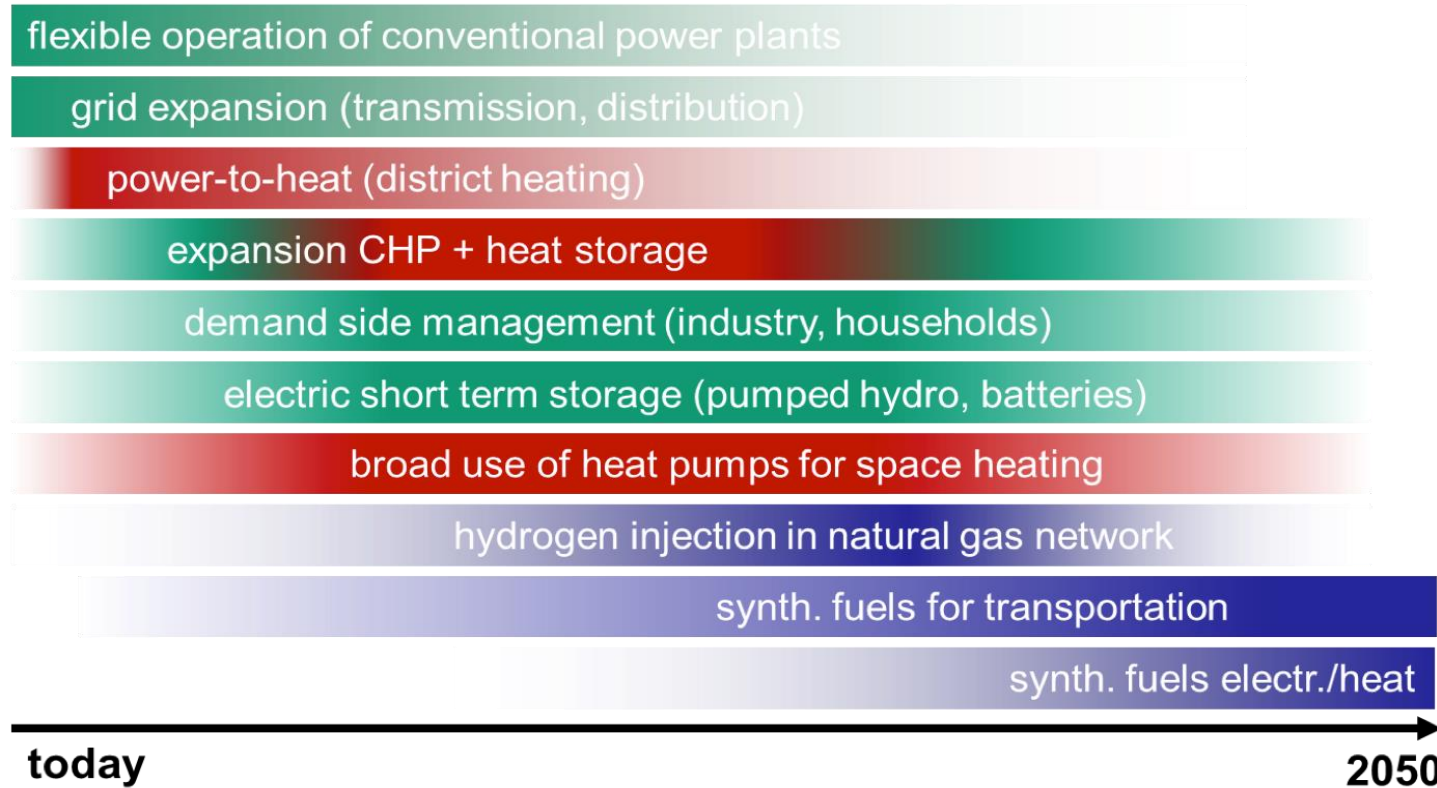
Electricity trade flows Germany ↔ EU

-> contributes to flexibility - high German export surplus



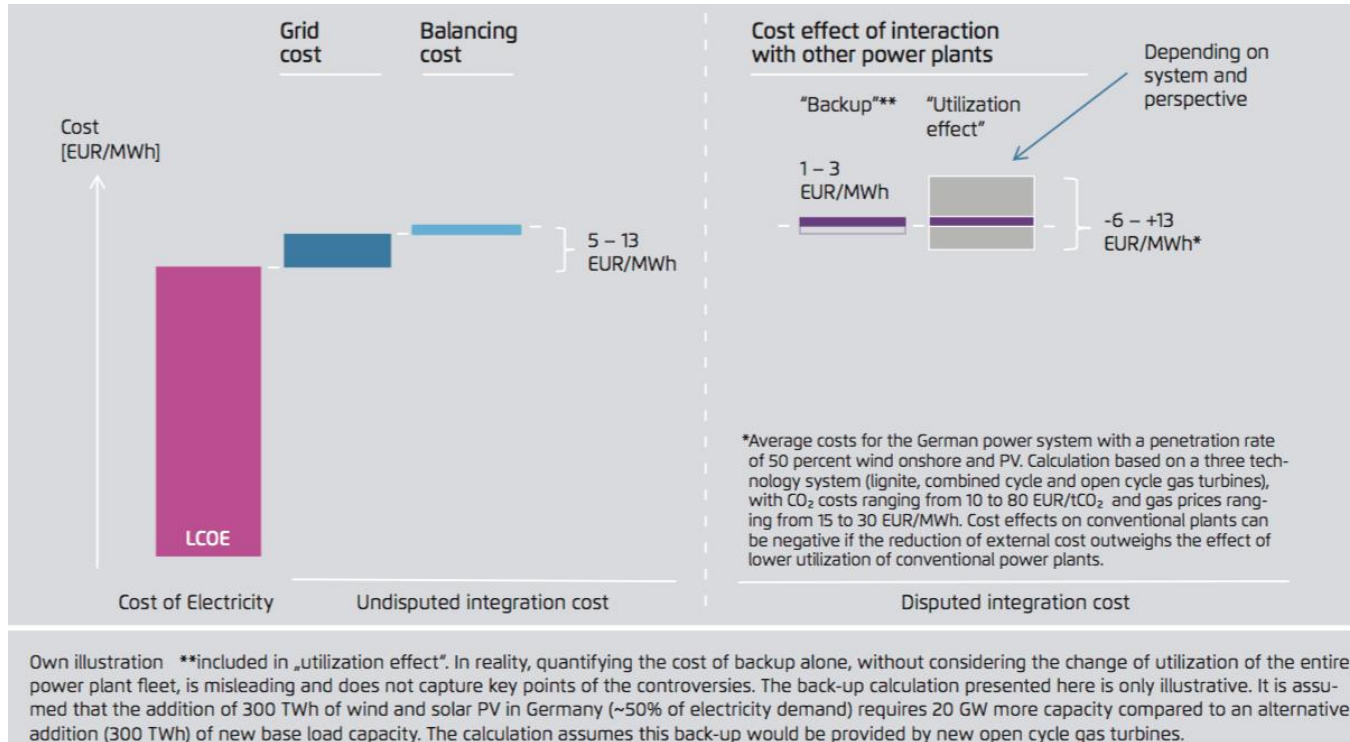
Flexibility options on the transition to 2050

→ managing fluctuating power (PV, Wind) remains a challenge



Components of average “integration costs”

→ assumed penetration rate: 50% wind + PV



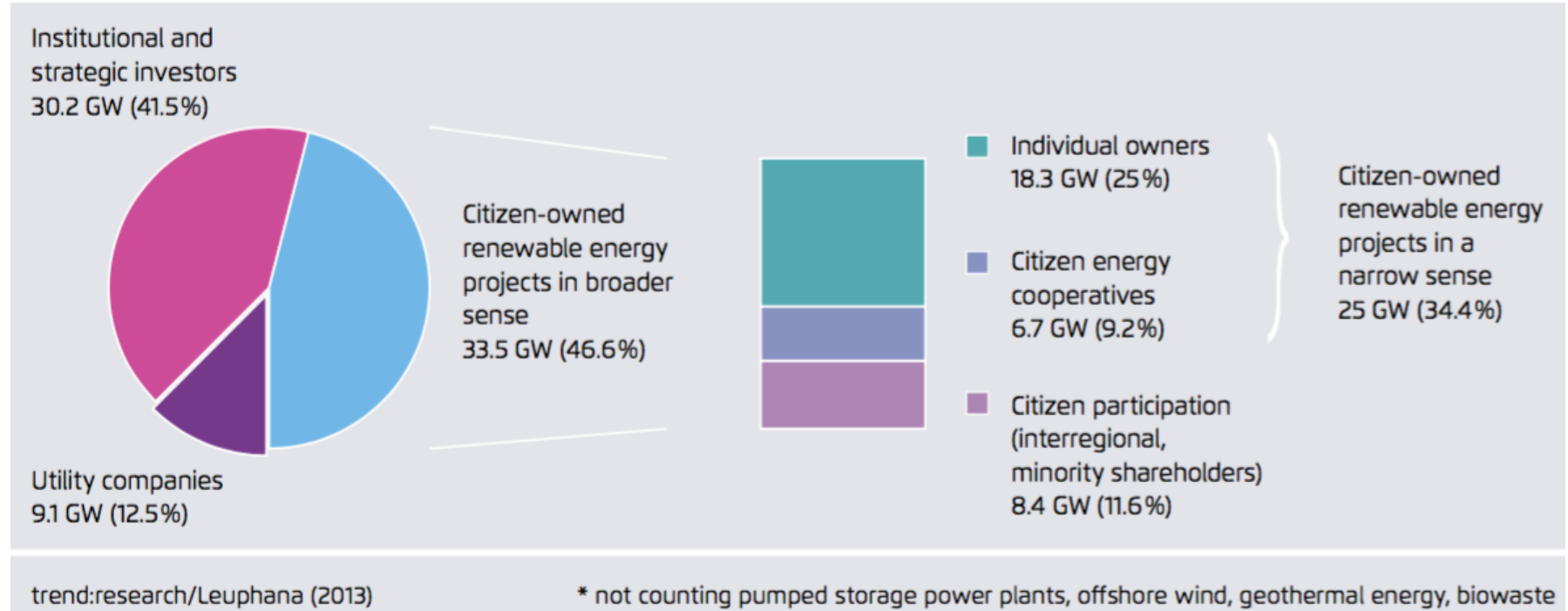
Source: Agora

Decentralisation drives the energy transition.

But:

**Challenges for incumbents have to be
anticipated**

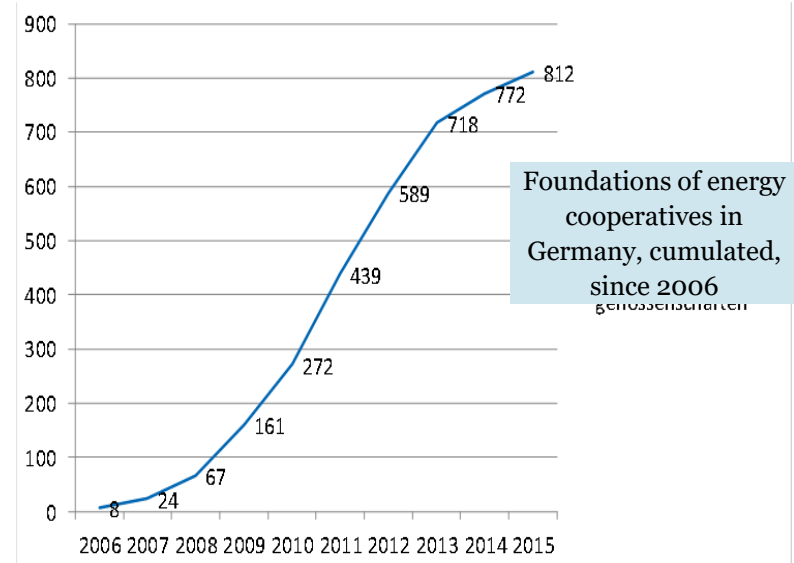
Ownership of installed renewable capacity in Germany in 2012



Citizen financed energy cooperatives

Status and development of an unexpected surprise!

- Overall: **812** cooperatives have been founded
 - with 165 000 citizens
 - 655 million Euro member's capital
 - 1,8 billion investments in renewable energies

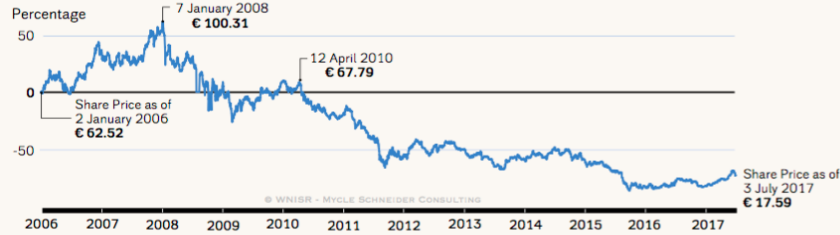


- Survey 2015: Slower development due to EEG-reform (e.g.tendering)

Source: Results of the DGRV annual survey 31.12.2015

Nuclear under pressure: Share Price Development of leading Nuclear Power Companies

RWE (Germany) Share Price Development Since 2006



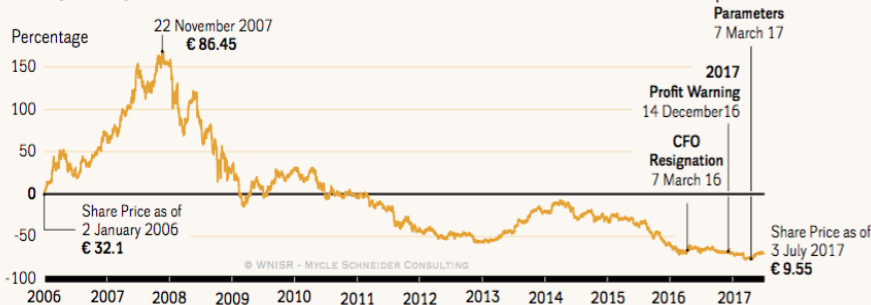
Source: Yahoo Finance, August 2017

E.ON (Germany) Share Price Development Since 2006



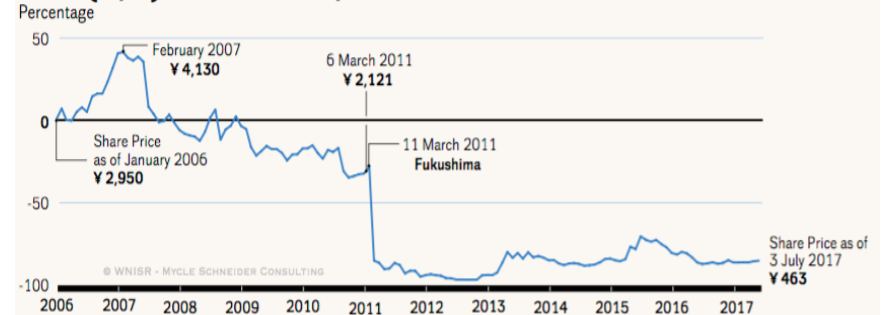
Source: Yahoo Finance, August 2017

EDF (France) Share Price Development Since 2006



Source: Yahoo Finance, August 2017

TEPCO (Japan) Share Price Development Since 2006



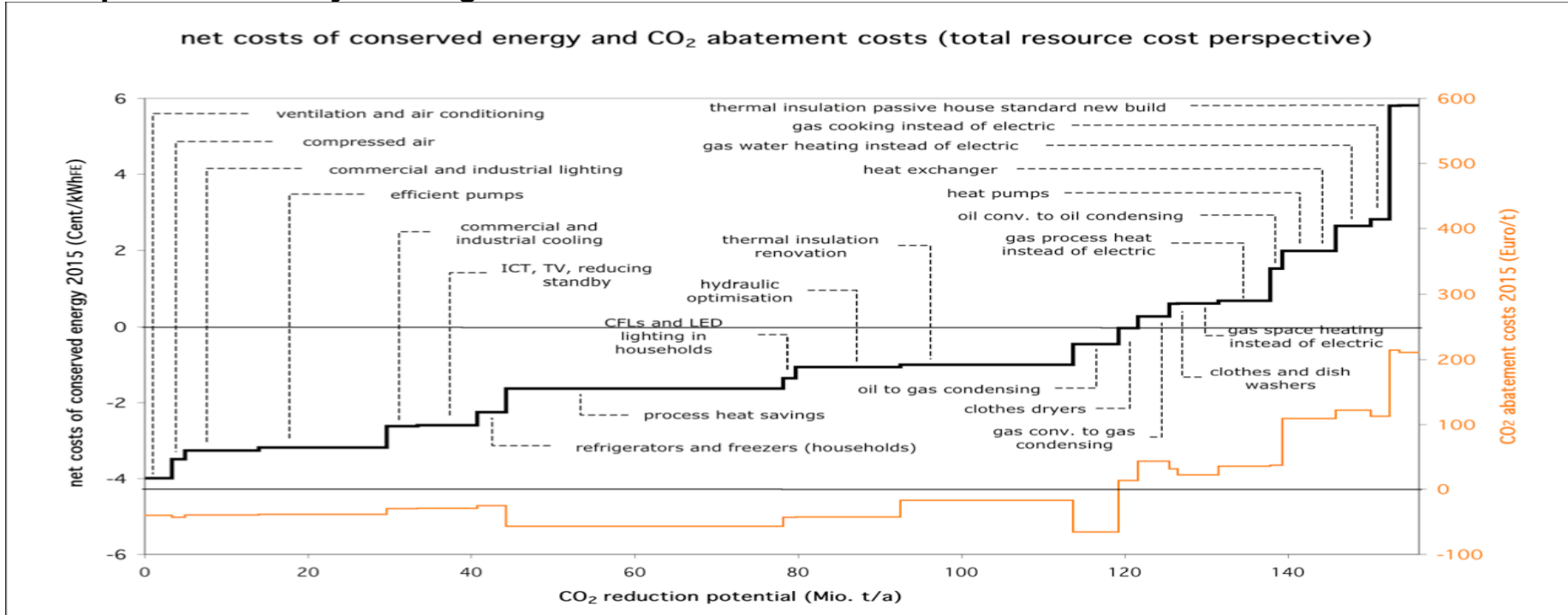
Source: Investing.com, August 2017

“Efficiency first” (IEA):
How to overcome the barriers?
New policy packages to foster efficiency
needed, to harvest the benefits!
(“The carrots, the sticks, the tambourines”)

The economic benefits of “Negawatts”:

140 TWh can be saved with a profit – when barriers are removed!

Example of Germany's budget allocation chart



Source: Wuppertal Institute 2006

State of the art: Buildings as power plants

“Plus-energy-houses” in Freiburg/Germany



Caption: Plus energy houses are designed to produce more energy than they consume in the course of the year.

Retrofitting the building stock

→ public subsidies needed, but large macroeconomic benefits

Promotional effects

	2009	2010	2011
Commitments (in millions of EUR)	8,863	8,746	6,510
housing units (in 1.000)	617	953	282
reduction of CO ₂ (in 1.000 Tonnen p.a.)	1,452	1,049	567
jobs * (in 1.000)	292	342	247
investments (in millions of EUR)	18,335	21,330	18,427
federal budget (in millions of EUR)	2,033	1,337	934
leverage	9.0	16.0	19.7

* safeguarded employment for one year

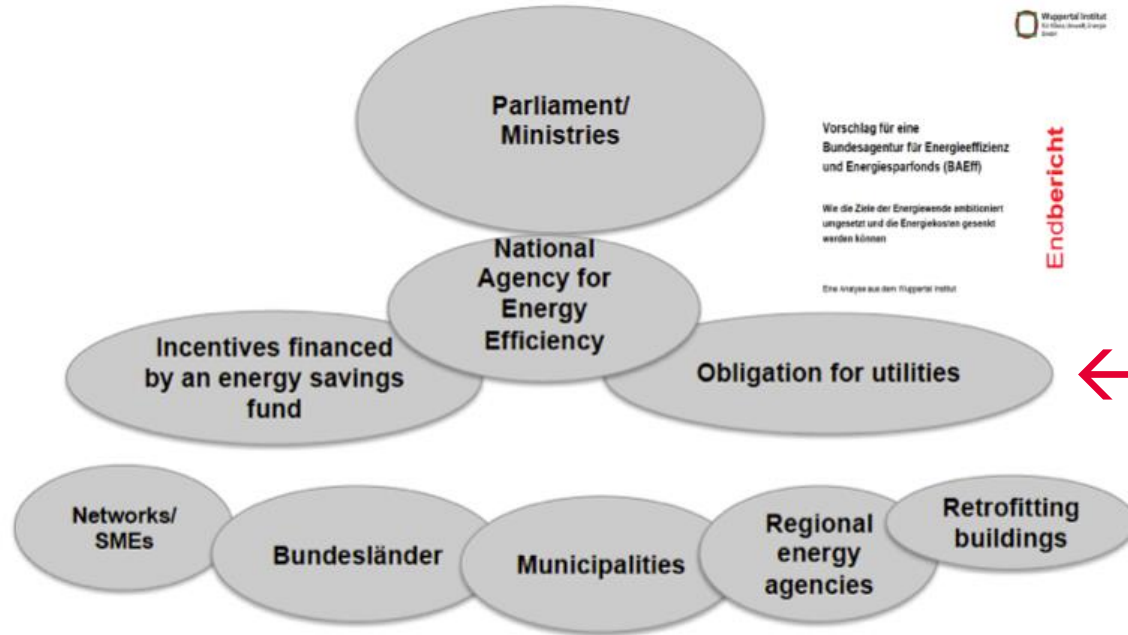
Effects of promotion

- Increase of retrofitting ratio
- Sustainable reduction of CO₂-emissions
- Promotion for SMEs and creation of employment
- Substantial investments in buildings be triggered

Budget funds being recovered by additional revenues of taxes

National Agency for Energy Efficiency + Savings Fund

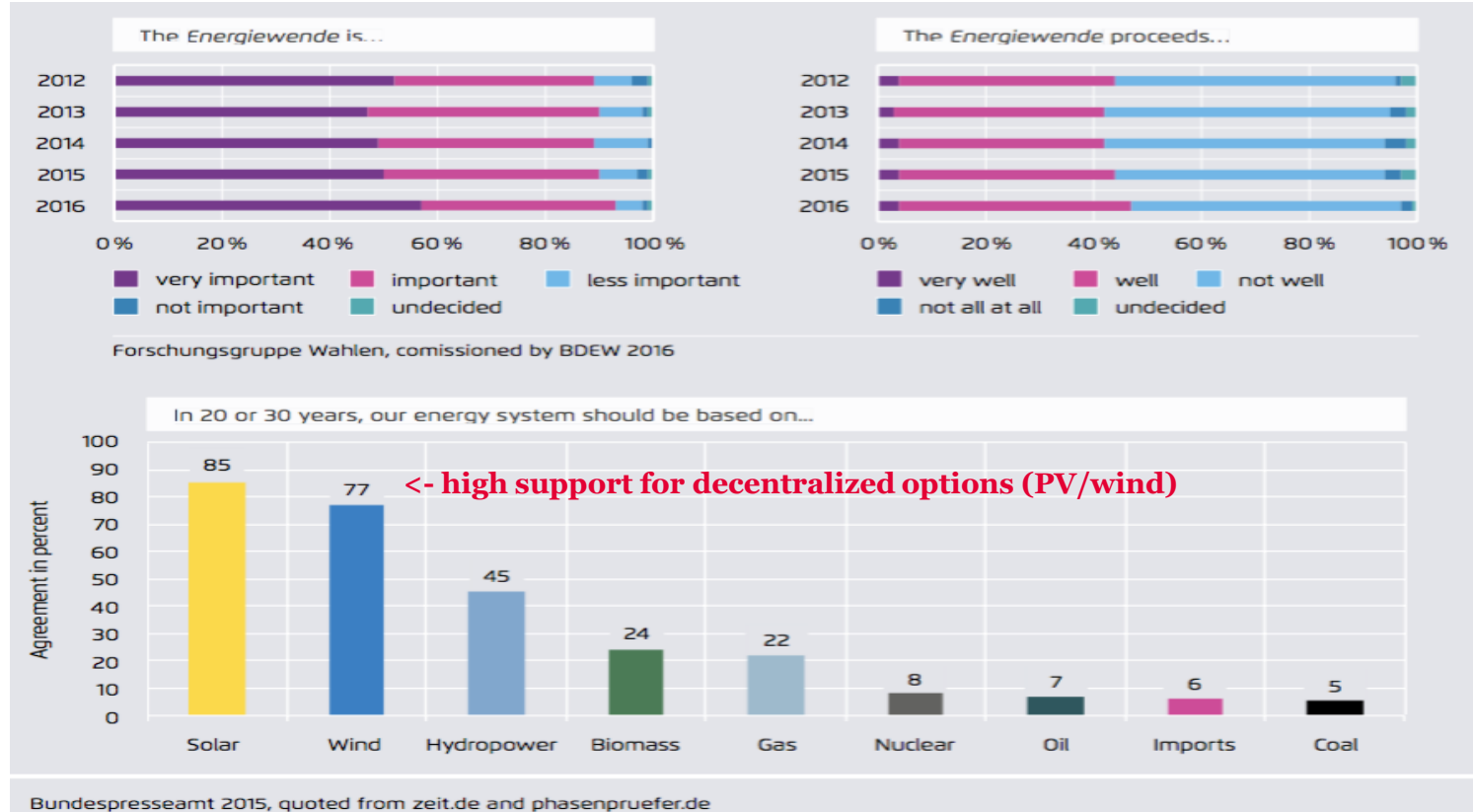
→ “polycentric governance” of energy efficiency policies needed!



Quelle: Wuppertal Institut 2014

Public opinion about the Energiewende

90%: important! But 50% say: proceeds not well!



**Enable and incentivize sustainable
consumption and production:
“More with less”!
“Reduce rebound effects”!**

„Prestige eats up efficiency“



**VW Käfer, 1955, 730 kg,
30 PS, 110 km/h,
7,5l/100km**



**VW New Beetle, 2005, 1200 kg, 75
PS, 160 km/h, 7,1 l/100km**

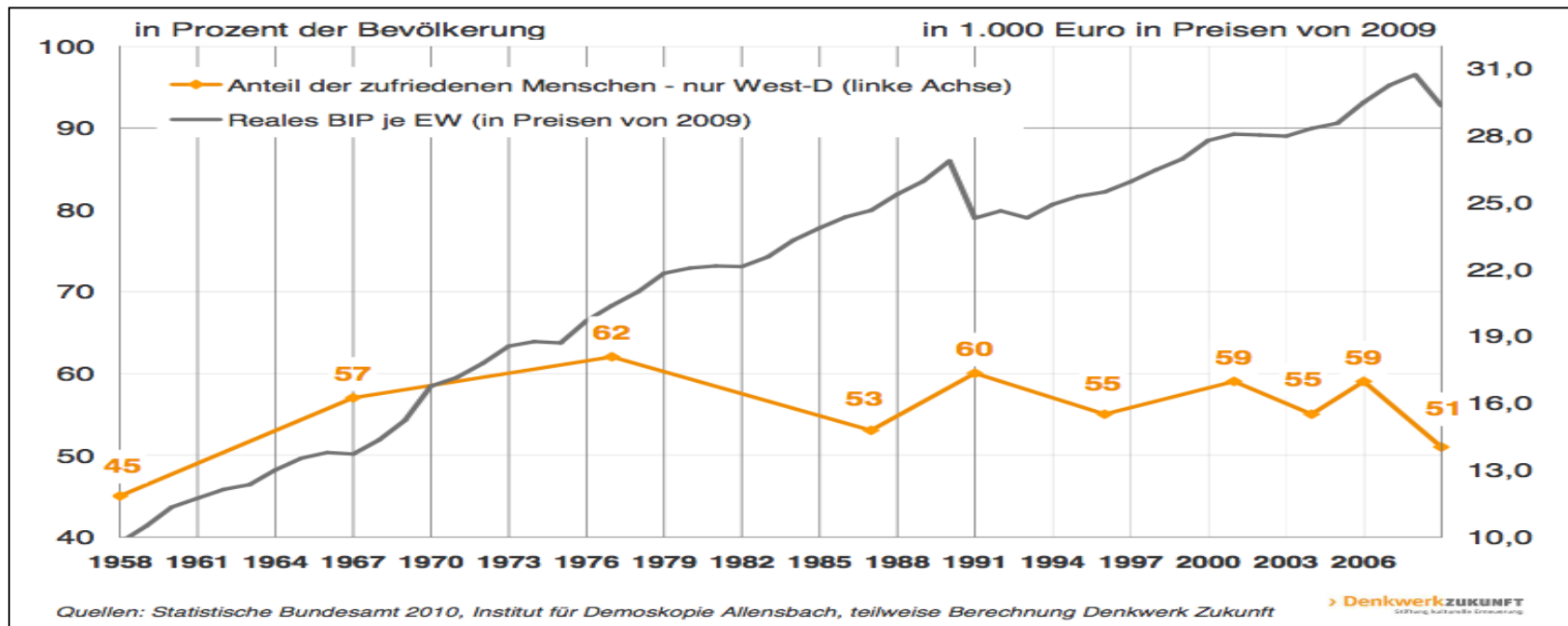
Average HP for the German car fleet

1973: 60HP -> 2015: 147 HP !

Source: WI 2008/2016

GDP decouples from life satisfaction in the OECD

GDP per capita and life satisfaction in Germany



Quelle: Denkwerk Zukunft (2010)

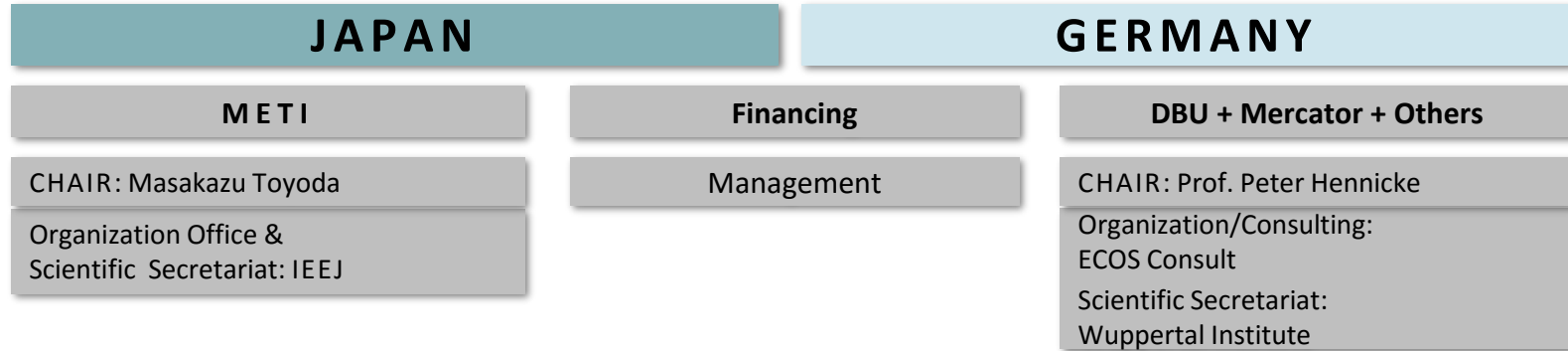
Mutual learning can foster the energy transition: The case of the “German-Japanese Energy Transition Council (GJETC)”

First GJETC-Meeting at IEEJ Tokyo, September 29-29th

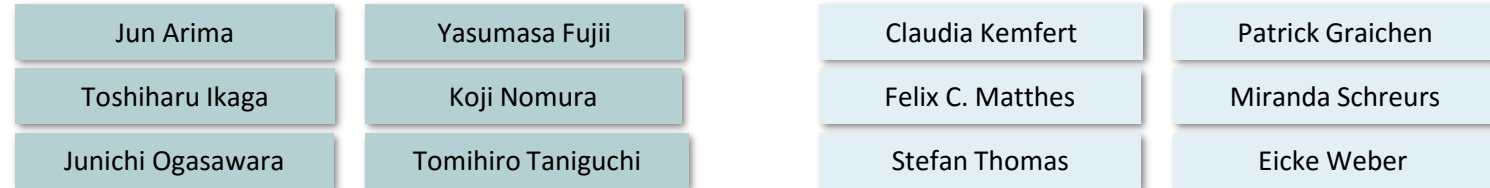


Structure of the GJETC

from Japan and Germany



Full Member Experts



Associated Members



Lessons learned so far...

- Establish a longterm vision and **consensus on targets** to reduce uncertainty
- Implement strategies for **“Energy efficiency first”** - this makes everything easier
- Create a **“polycentric governance structure”** for energy efficiency policies
- Avoid **lock-in effects** and the risk of stranded investments in coal/nuclear
- Use the chances of **“leap frogging”** to “Green BAT” in developing countries
- **Diversify** the incumbents – “The future will be more decentralized” (Siemens)
- Mobilize **citizens capital** and **participation** in the regional energy transition
- Enable **continuity of knowledge exchange** by international cooperation

Prof. Dr. Peter Hennicke

Thank you for your attention!

Publication: The Energiewende

Available under www.wupperinst.org/info/details/wi/a/ad/3319/