Prof. Dr. Peter Hennicke

Integrating Energy Efficiency and Renewables: The German Energy Transition

Presentation at the Conference "SIEW Energy Insights", Singapore,

24th October 2017

Thesis

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.

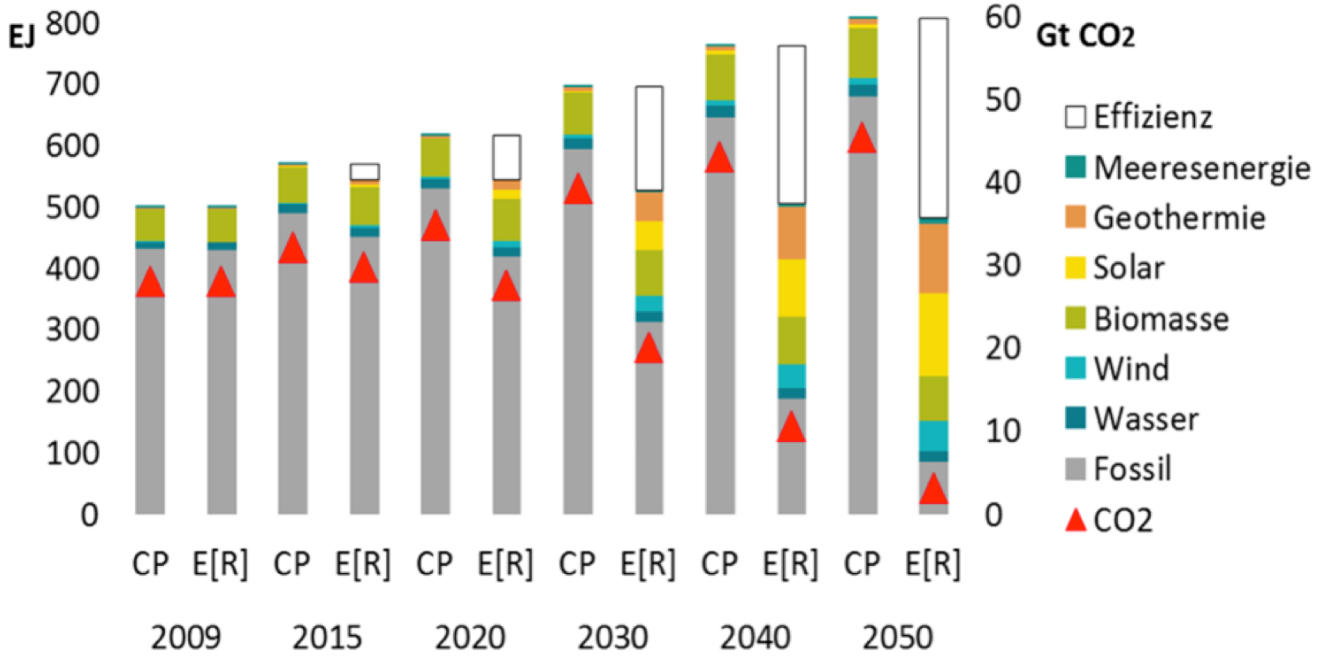
Deploying energy innovations needs the integration of technical and socioeconomic driving forces and a new polycentric governance.

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))

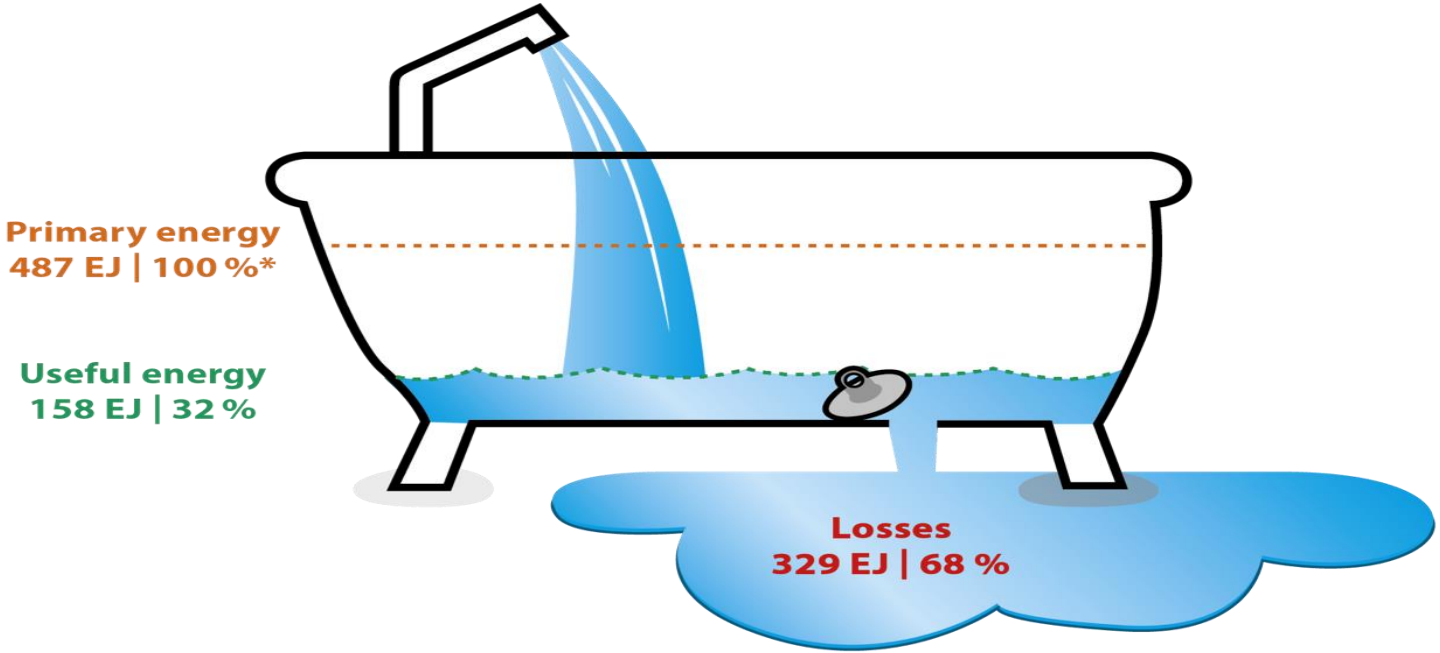


Source: DLR 2015

“Efficiency first” (IEA):

Reduce losses of the global energy system

…by the “energy efficiency revolution” and decentralized power



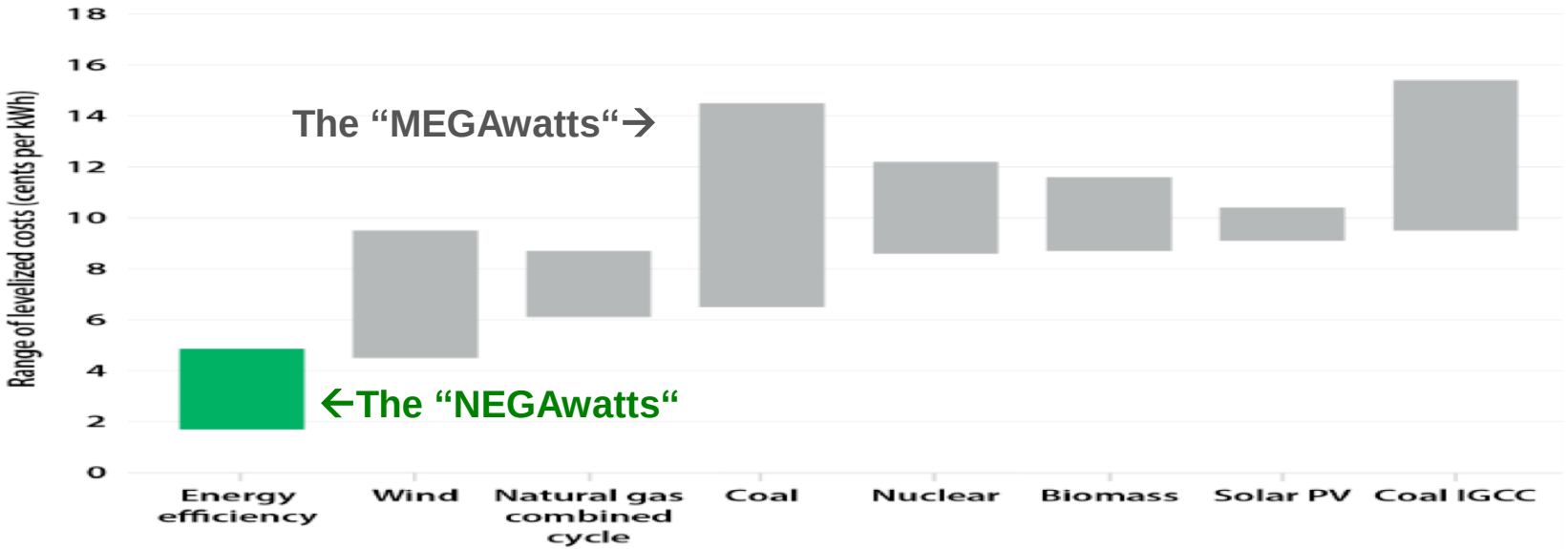
*Total primary Energy 519 EJ less 32 EJ non energetic consumption

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**

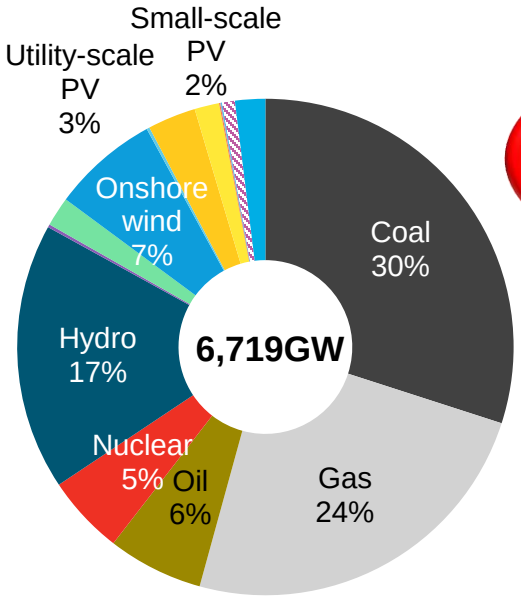
Offshore wind

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

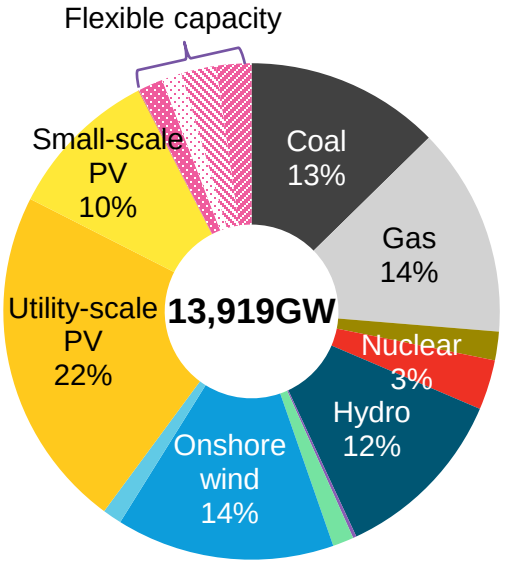
Solar and wind dominate the future of electricity

Global cumulative installed capacity: 2016



By 2040, 66% of generating capacity will be renewable

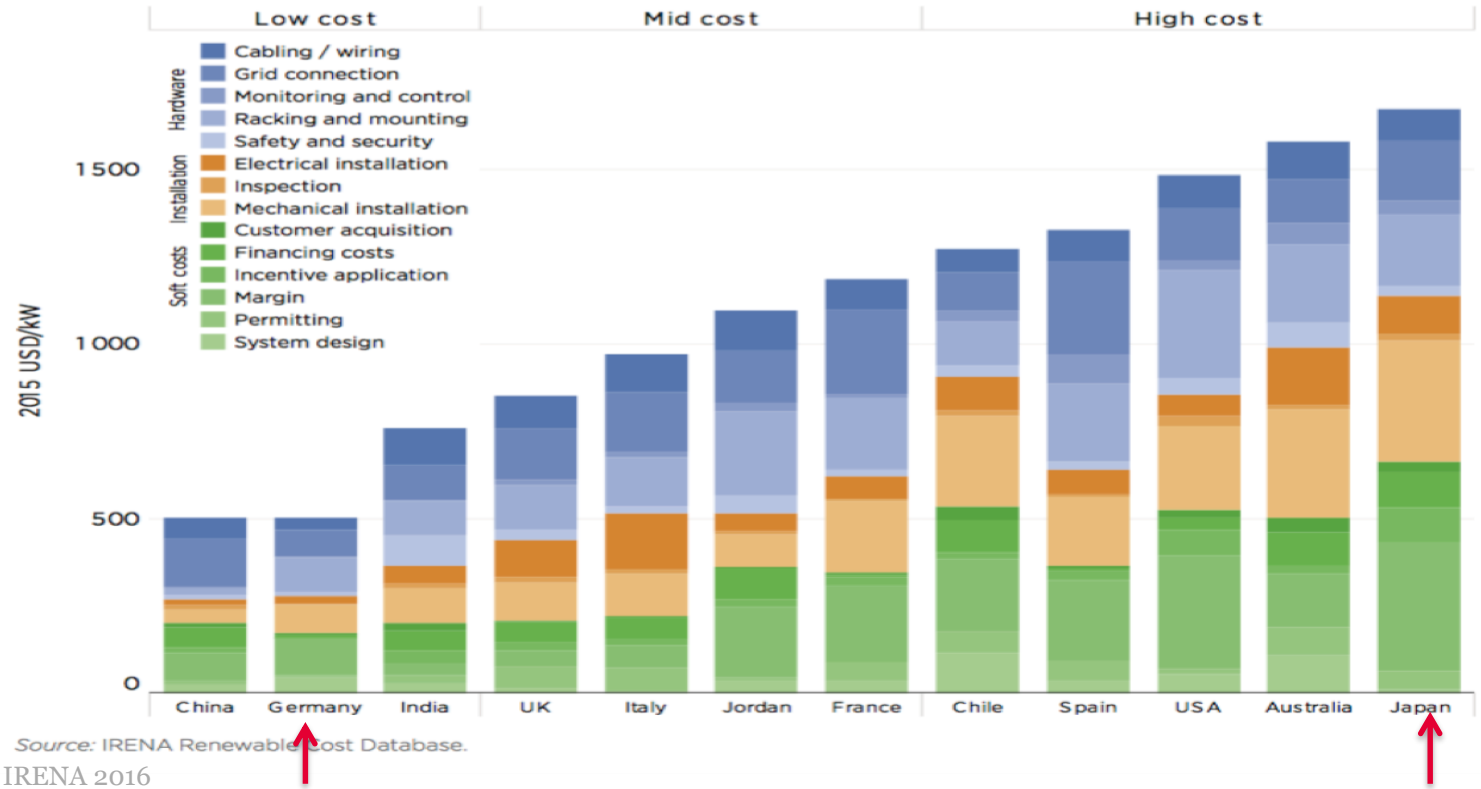
Global cumulative installed capacity: 2040



Source: Bloomberg New Energy Finance, NEO 2017

Astonishing global differences of PV costs (2015)

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



Source: IRENA 2016

“Act locally to change globally”!
Opportunities and challenges of the German “Energiewende”

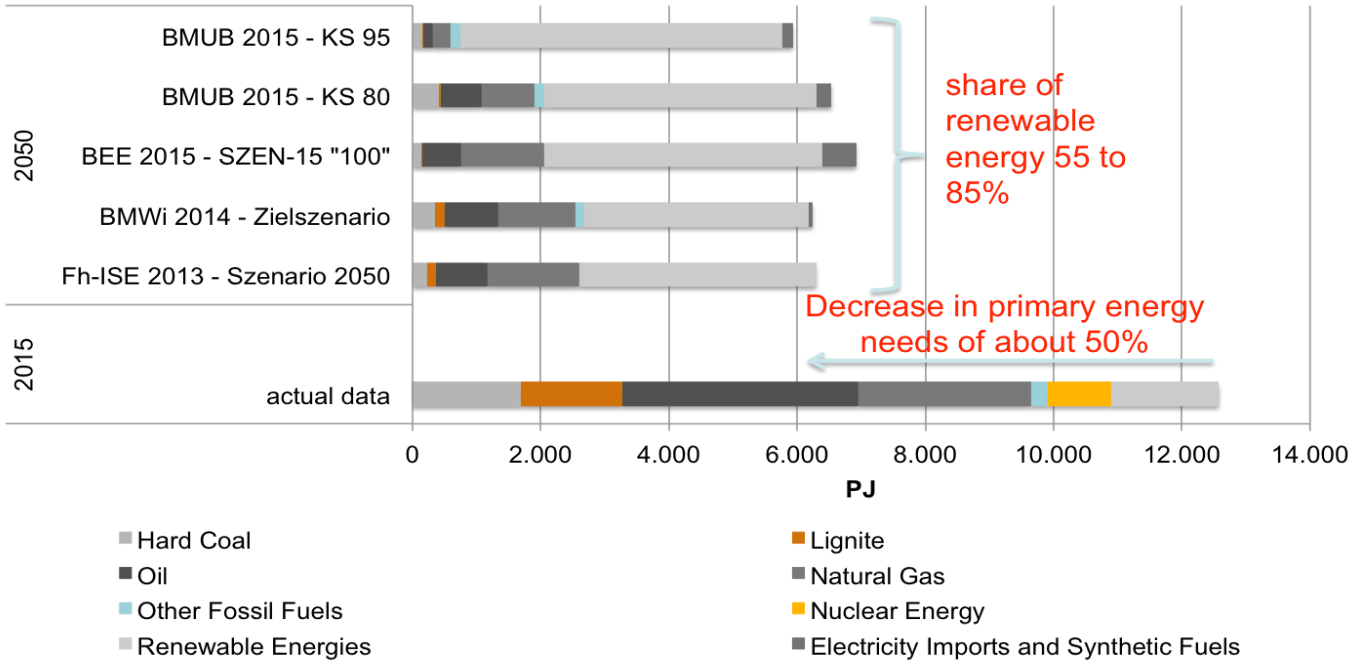
“Revolutionary Targets” (Chancellor Merkel)

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

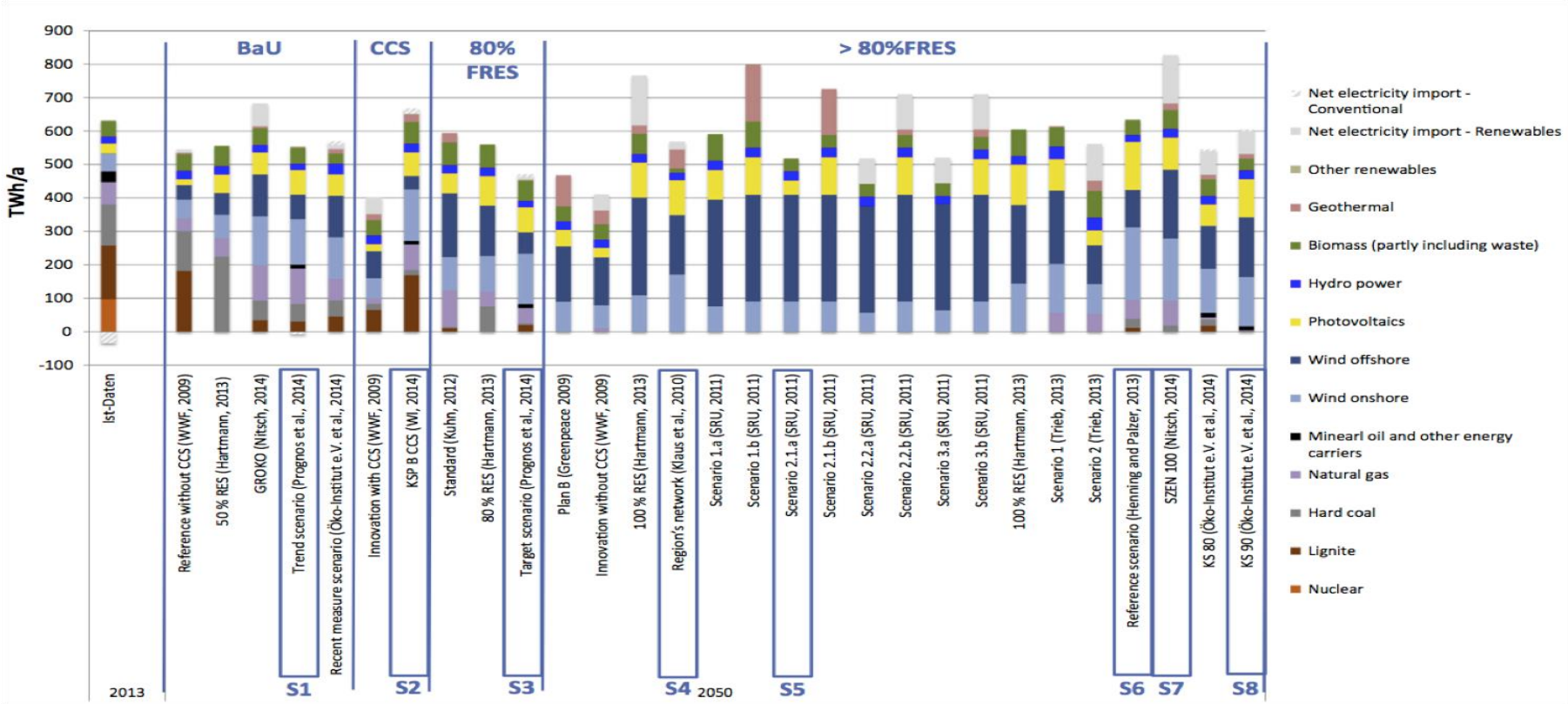


Source: Particular scenario studies and AG Energiebilanzen 2015

Typical scenarios of German electricity production

Wuppertal Institut

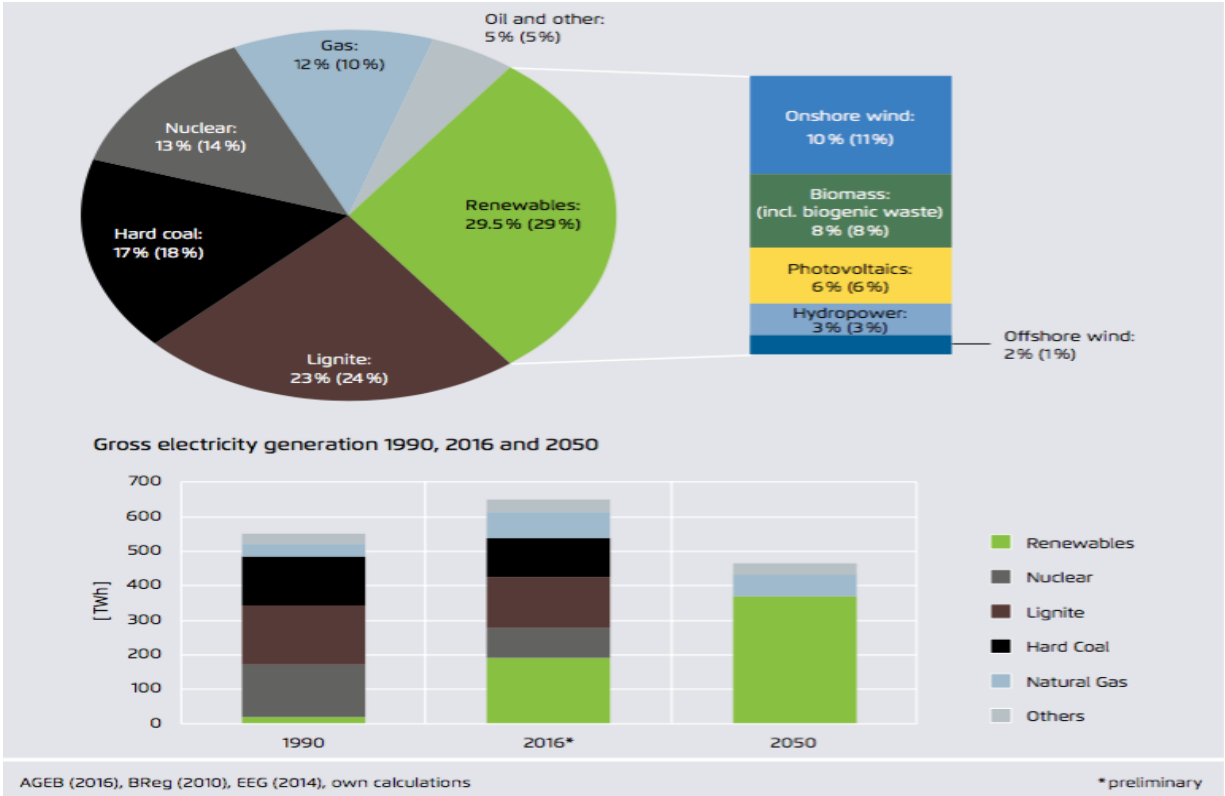
->many options and uncertainties on electricity demand in 2050



Source: B. Lunz et al. 2016.

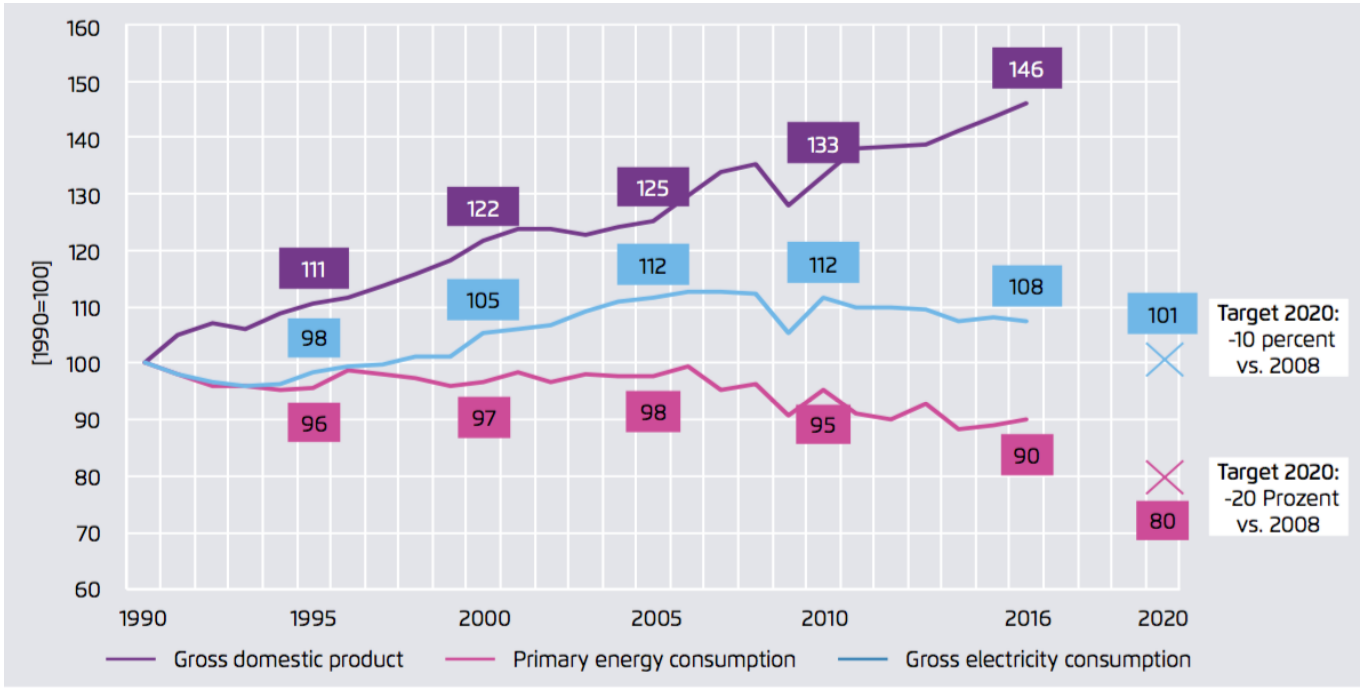
German Power Mix 2016 (2015 in brackets)

Renewables 2016: 30%



GDP, primary energy and electricity production

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



AG Energiebilanzen 2016; Statistisches Bundesamt, own calculations

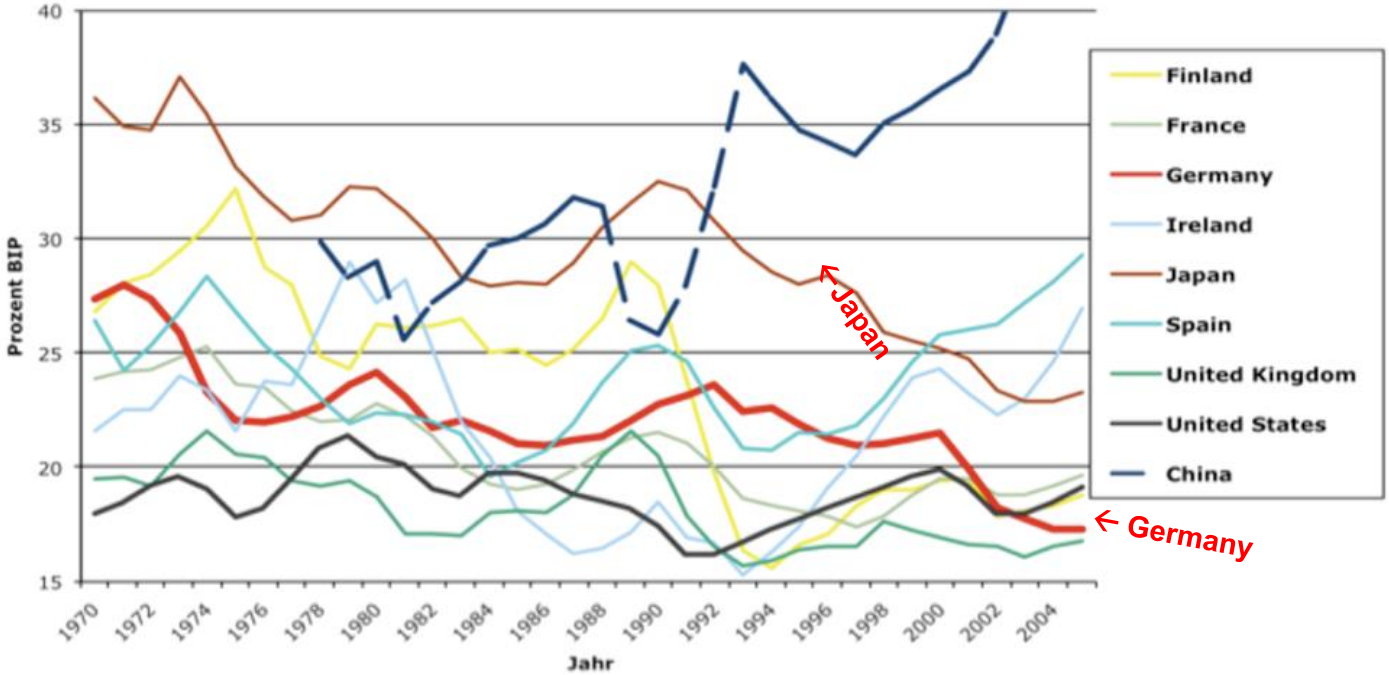
Source:Agora 2017

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

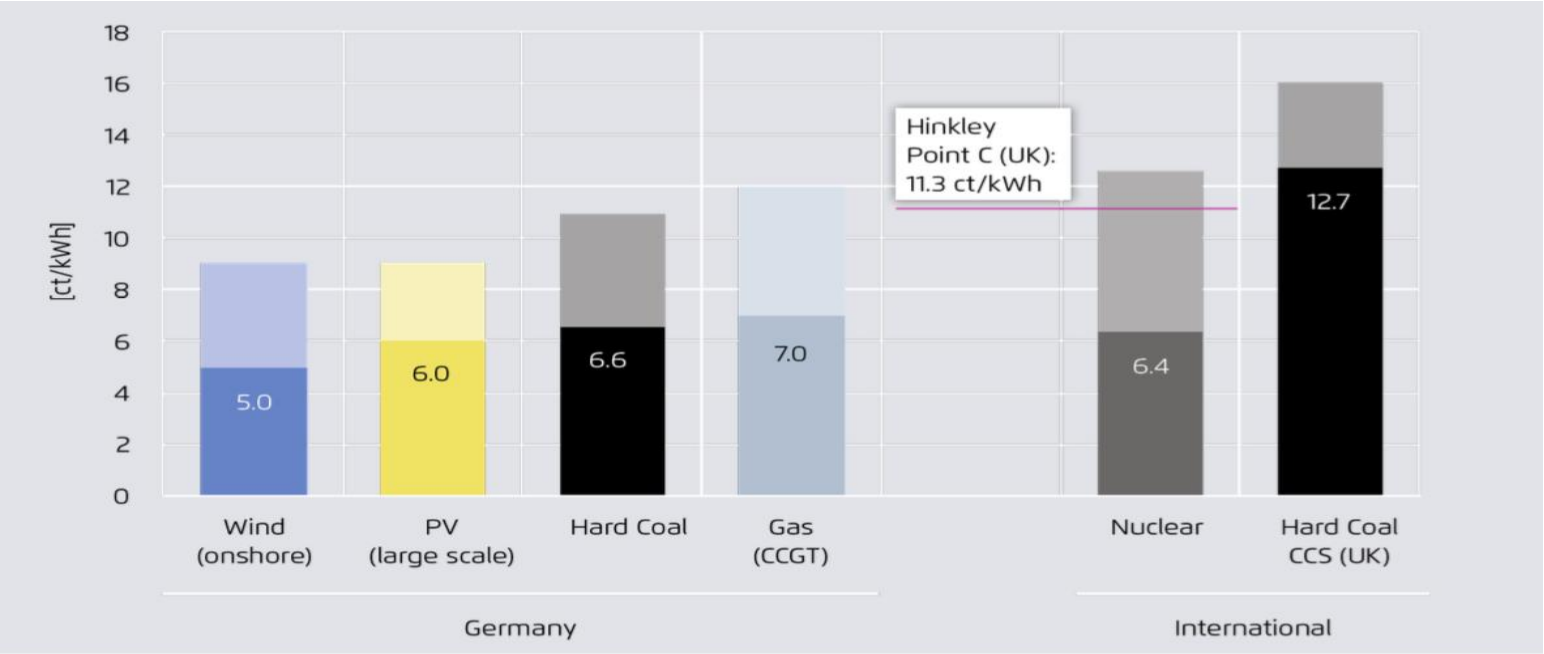
International comparison of gross investment rates (1970-2006)



Source: C. Jäger, PIK, 2009.

Range of green power costs in Germany

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

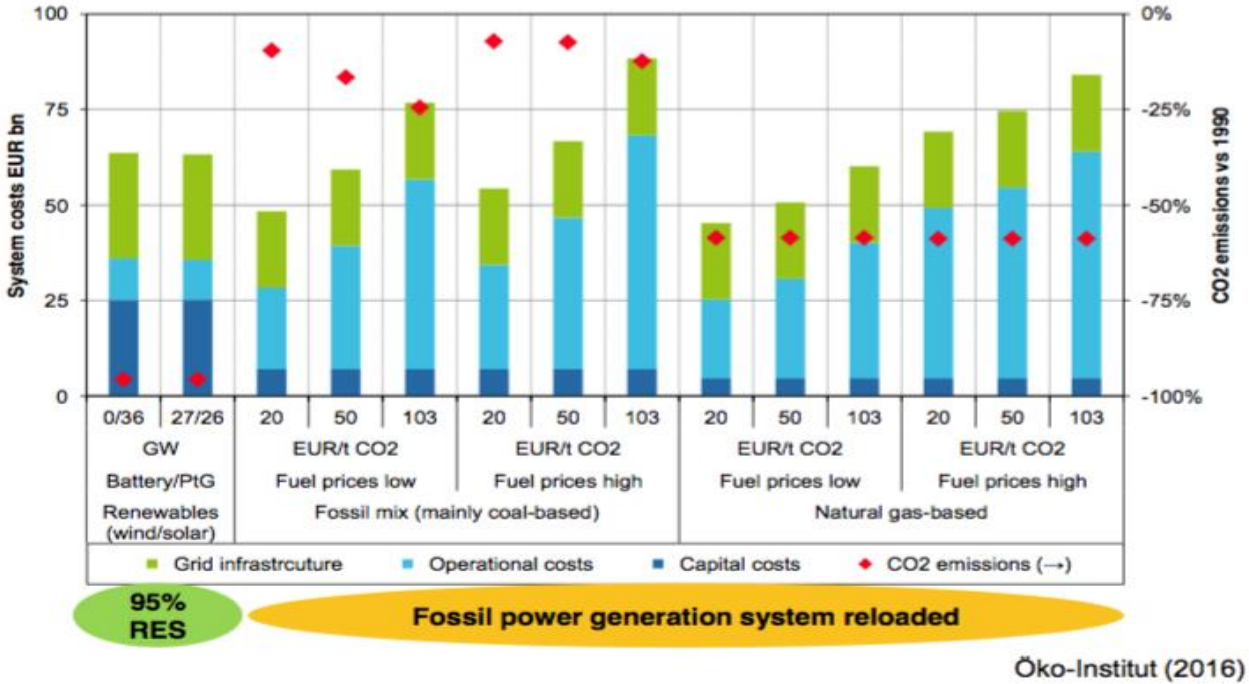


Department of Energy & Climate Change (2013): Electricity generation costs 2013. London, UK.; enervis (2015): Ein Kraftwerkspark im Einklang mit den Klimazielen. Berlin, Study on Behalf of Agora Energiewende.; EDF, own calculations. The LCOE is a metric used to compare the generation costs (EUR/kWh) of different technologies, taking into account fixed and variable costs, as well as cost of capital (WACC). In general, feed-in tariffs are slightly higher than the LCOE, as energy producers usually include revenue margins in their calculations.

Source: Agora 2017

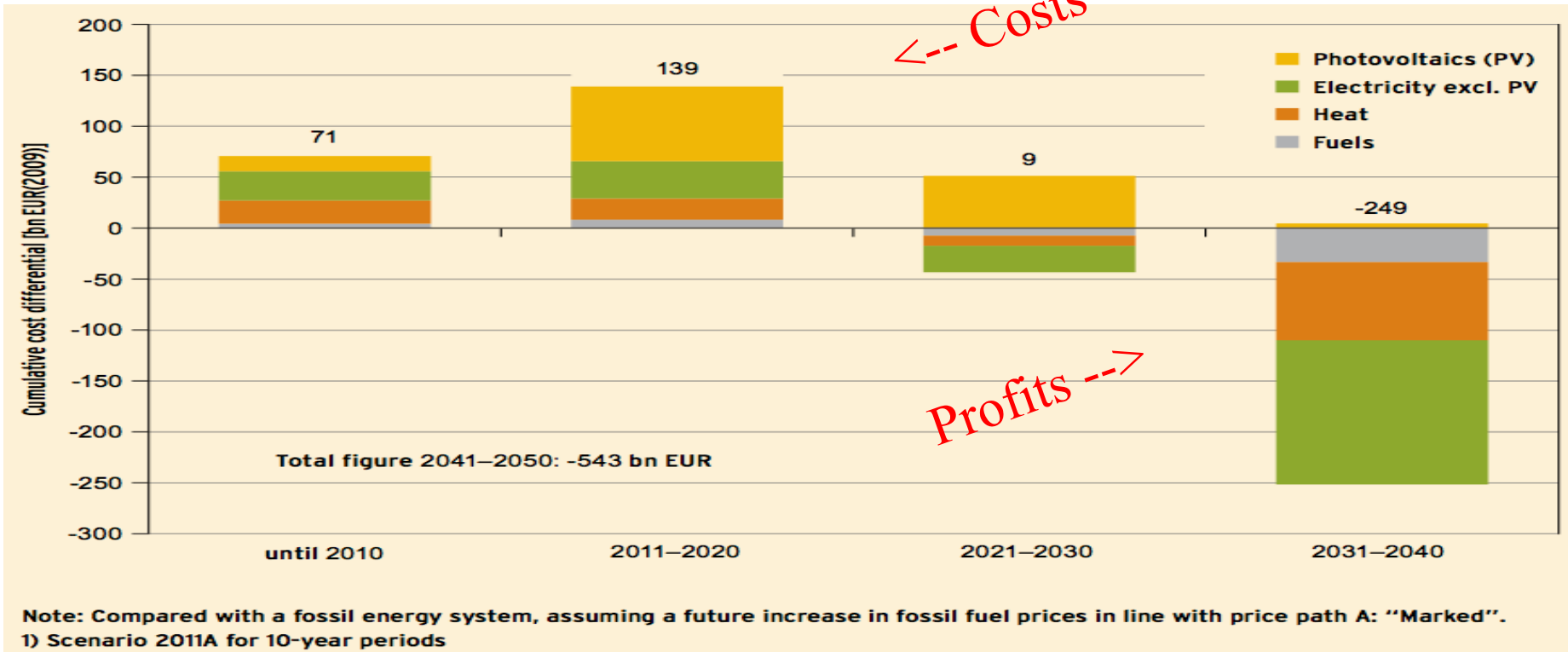
Going renewable is beneficial

Comparing the total system costs of a renewable/fossil mix



Differential costs of the “Energiewende”

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



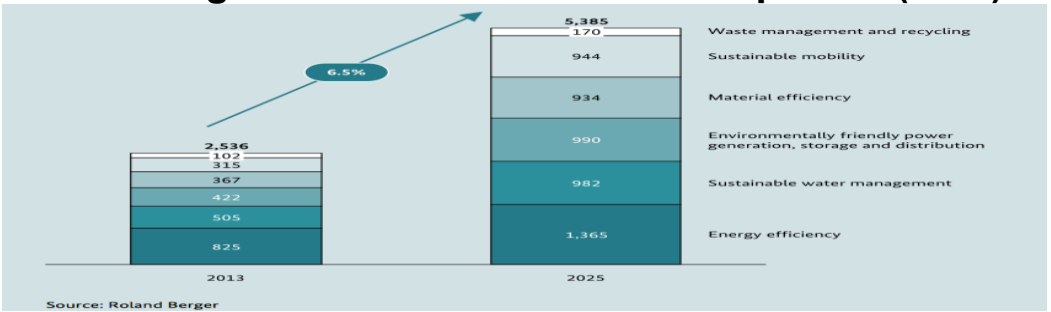
Note: Compared with a fossil energy system, assuming a future increase in fossil fuel prices in line with price path A: “Marked”.
1) Scenario 2011A for 10-year periods

Source: BMU 2012

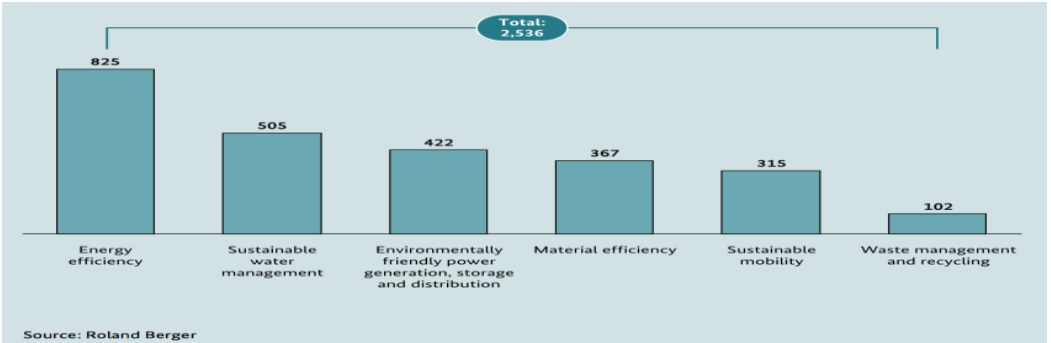
Opportunities on global "GreenTech"- markets

->one reason why German industry supports the "Energiewende"

Doubling of "GreenTech" markets expected (bn €)



Energy efficiency - the most attractive market

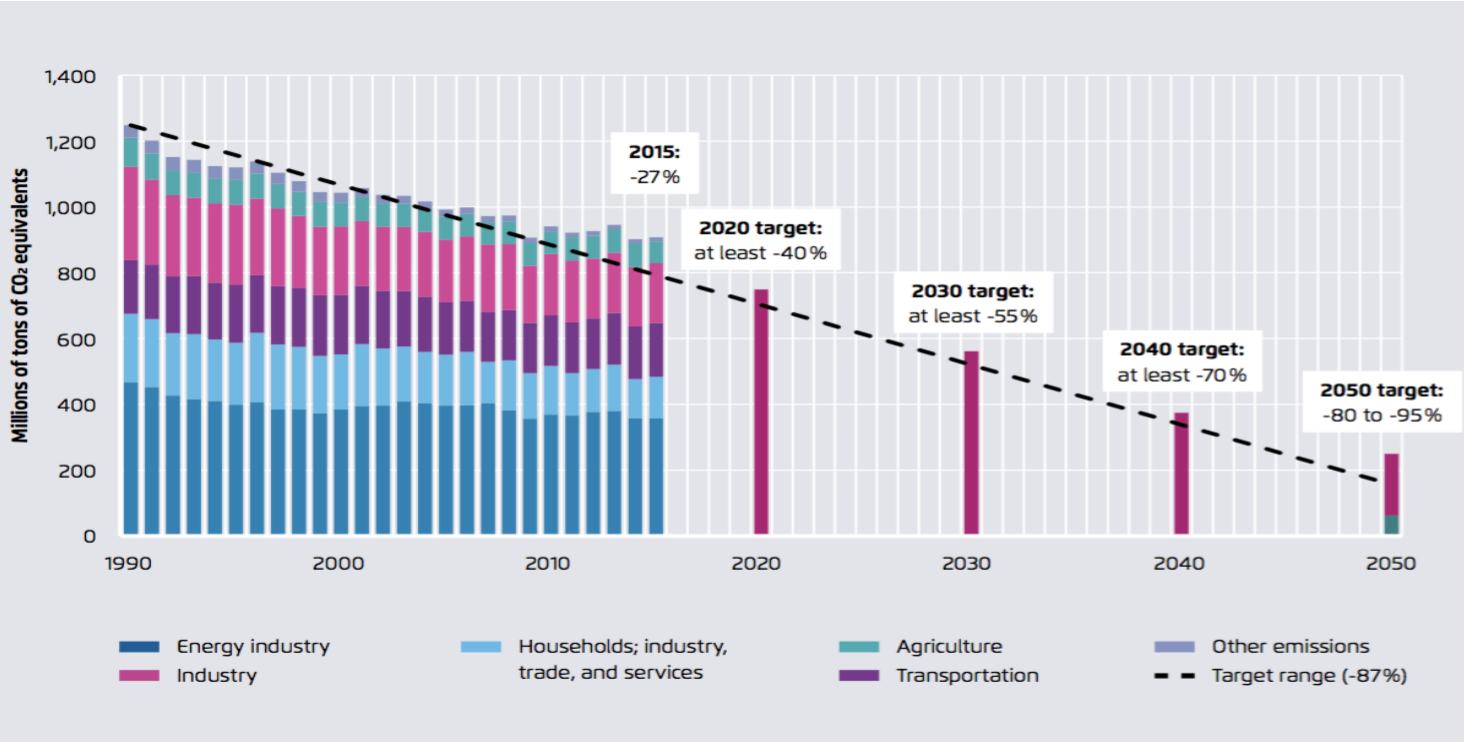


Controversial topics of the Energiewende

- **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 $C0_2$-reduction goals

The currently most controversial topic of the Energiewende



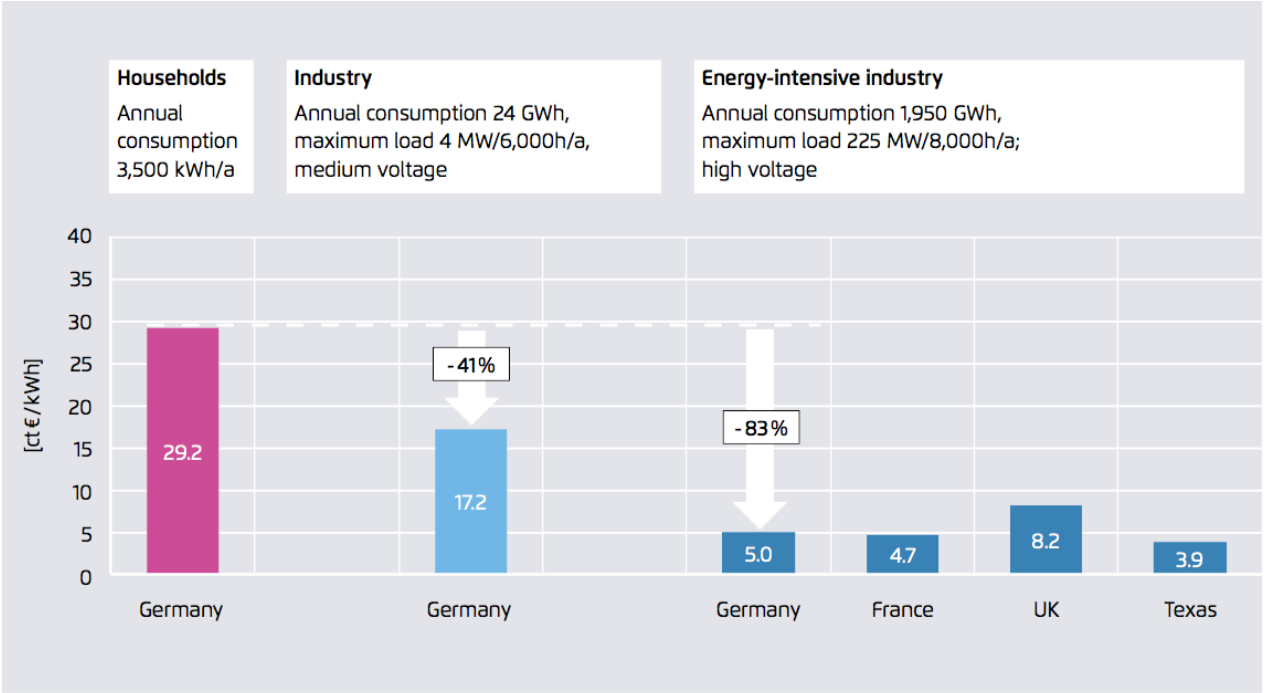
Source: Agora Energiewende

Source: Agora 2016

Distributional effects of the Energiewende

Average electricity prices

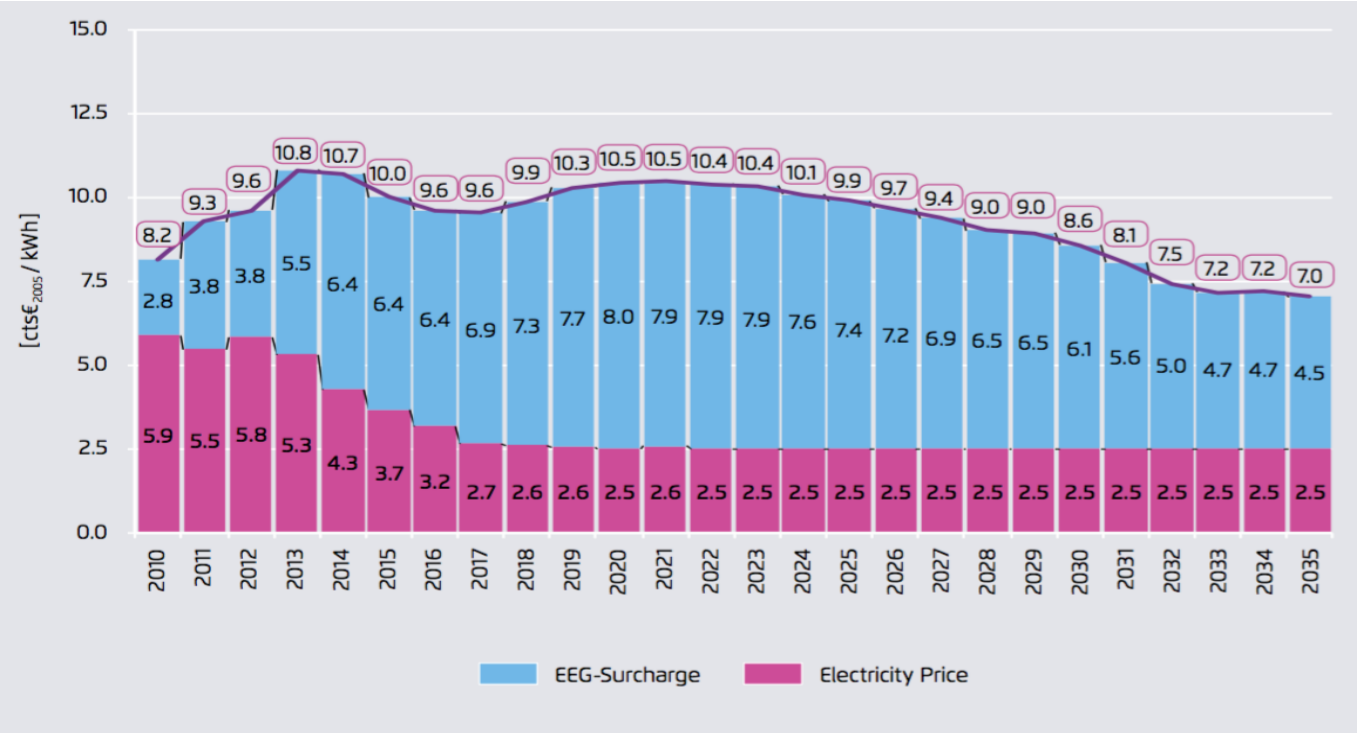
→ expensive: households/SME – cheap: industry



BNetzA (2014), Ecofys/ISI (2014)

Electricity wholesale price

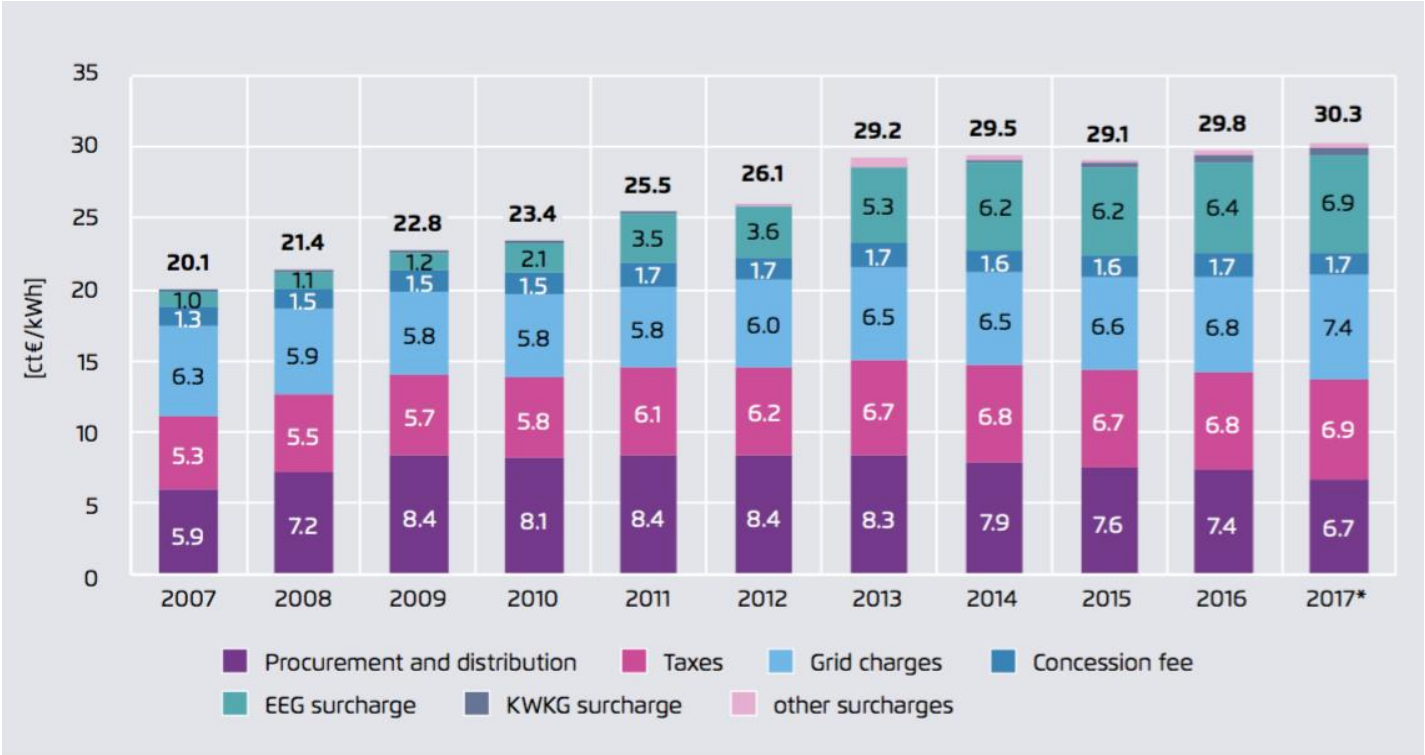
and surcharge of the EEG (cts/kWh)



Ökoinstitut (2005), Agora Energiewende

Average electricity prices (2007-2017)

German 4-person household



BNetzA 2016, *own estimates

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

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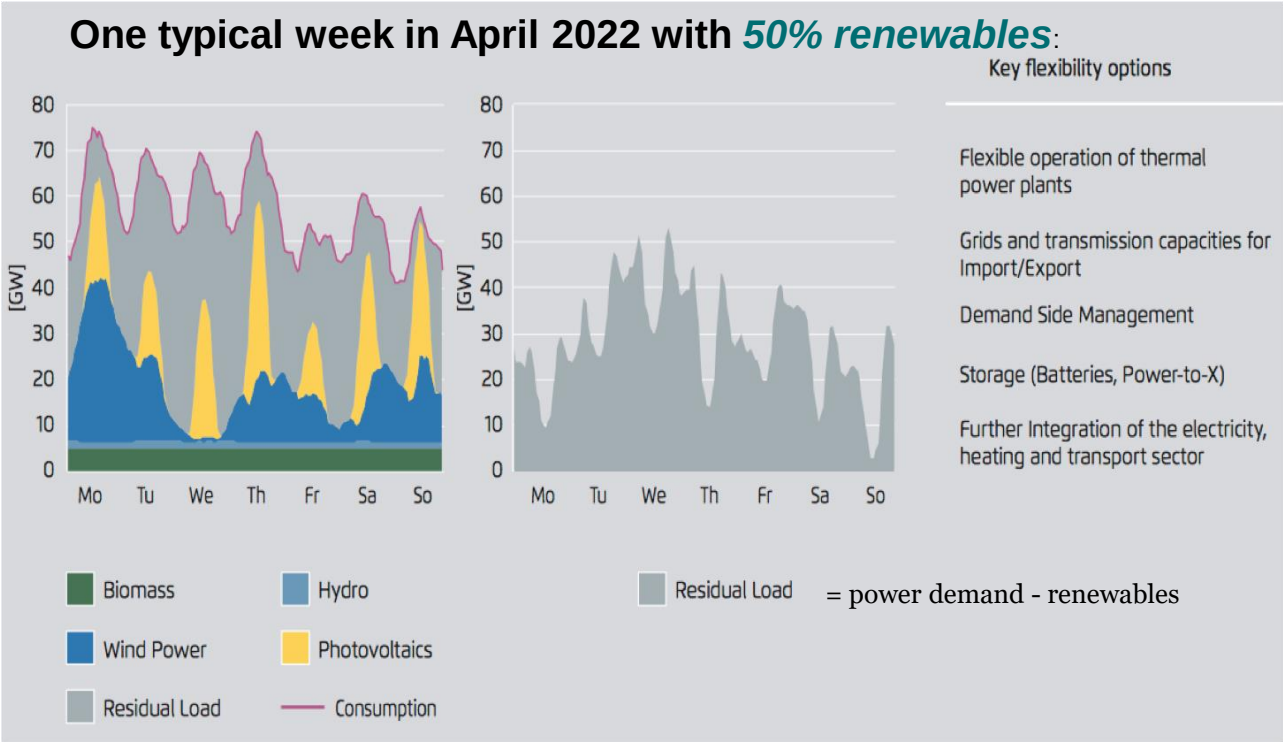
Base load power reduced

→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

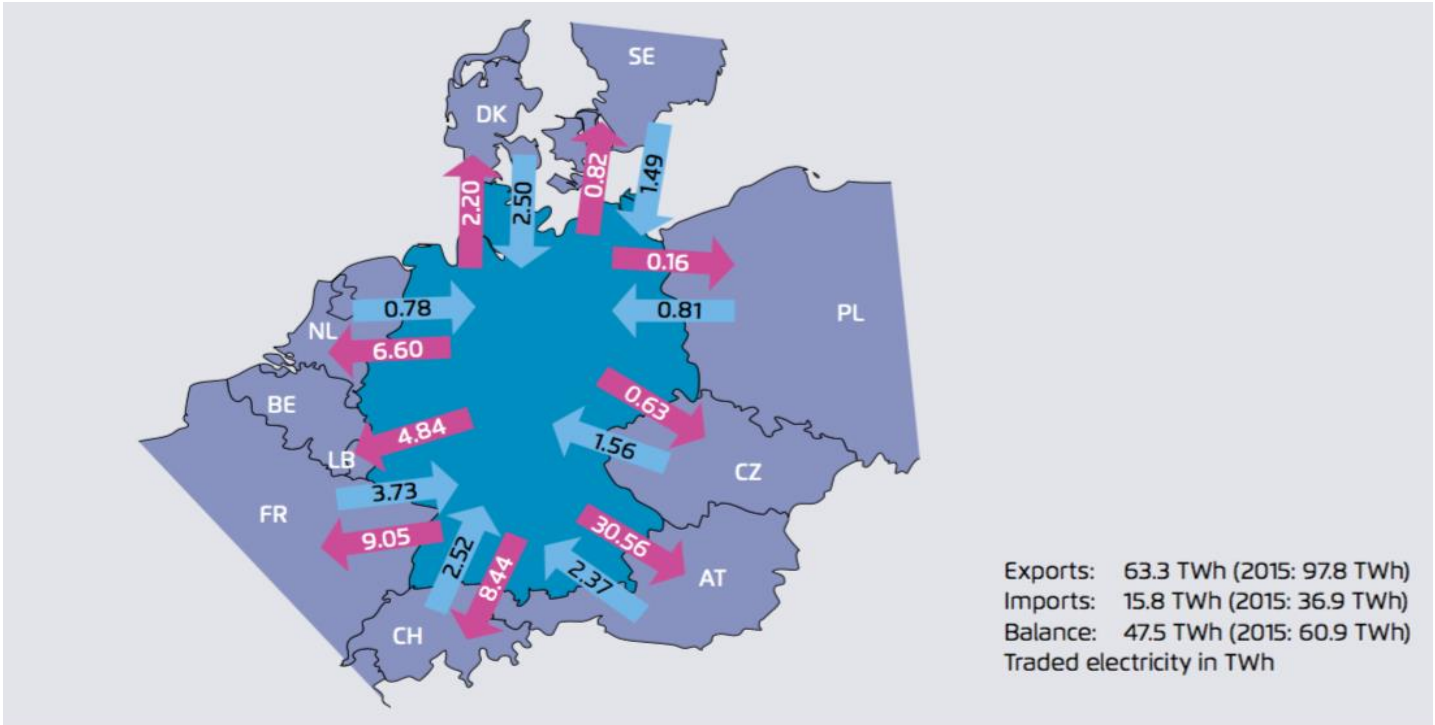
A cost-effective way to raise security of power supply

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

Source: Fraunhofer ISE 2015; Samadi 2016.

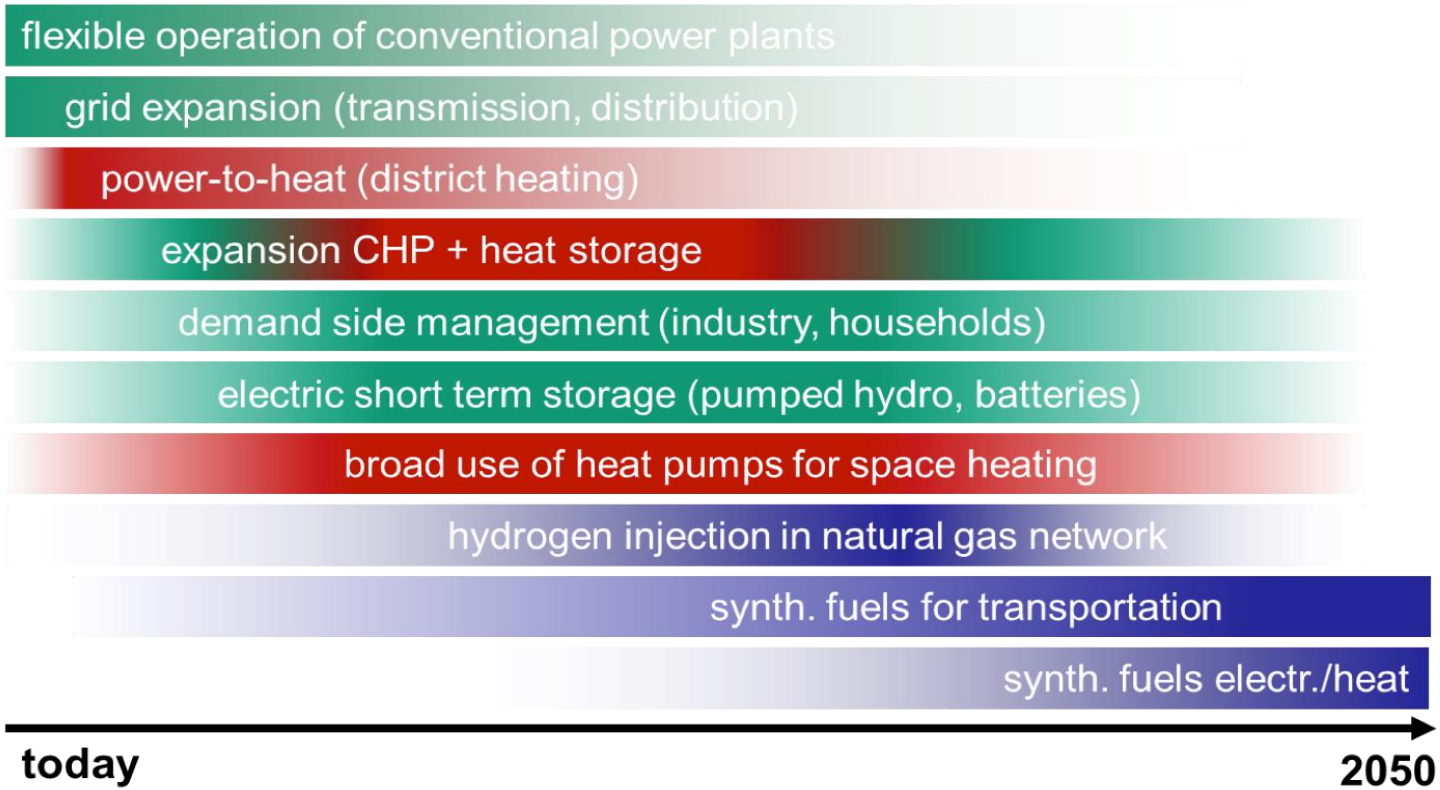
Electricity trade flows Germany ⟷ EU

-> contributes to flexibility - high German export surplus



Flexibility options on the transition to 2050

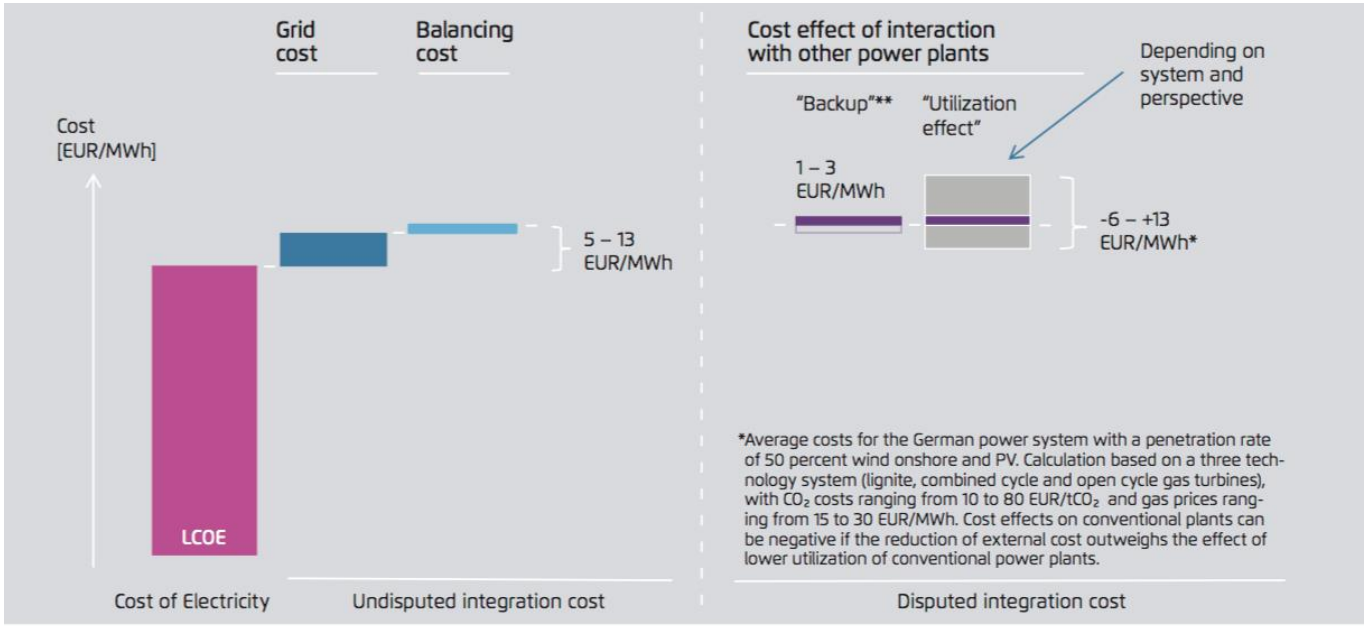
→ managing fluctuating power (PV, Wind) remains a challenge



Source: Henning 2016.

Components of average “integration costs”

→ assumed penetration rate: 50% wind + PV



Own illustration **included in „utilization effect“. In reality, quantifying the cost of backup alone, without considering the change of utilization of the entire power plant fleet, is misleading and does not capture key points of the controversies. The back-up calculation presented here is only illustrative. It is assumed that the addition of 300 TWh of wind and solar PV in Germany (~50% of electricity demand) requires 20 GW more capacity compared to an alternative addition (300 TWh) of new base load capacity. The calculation assumes this back-up would be provided by new open cycle gas turbines.

Source: Agora

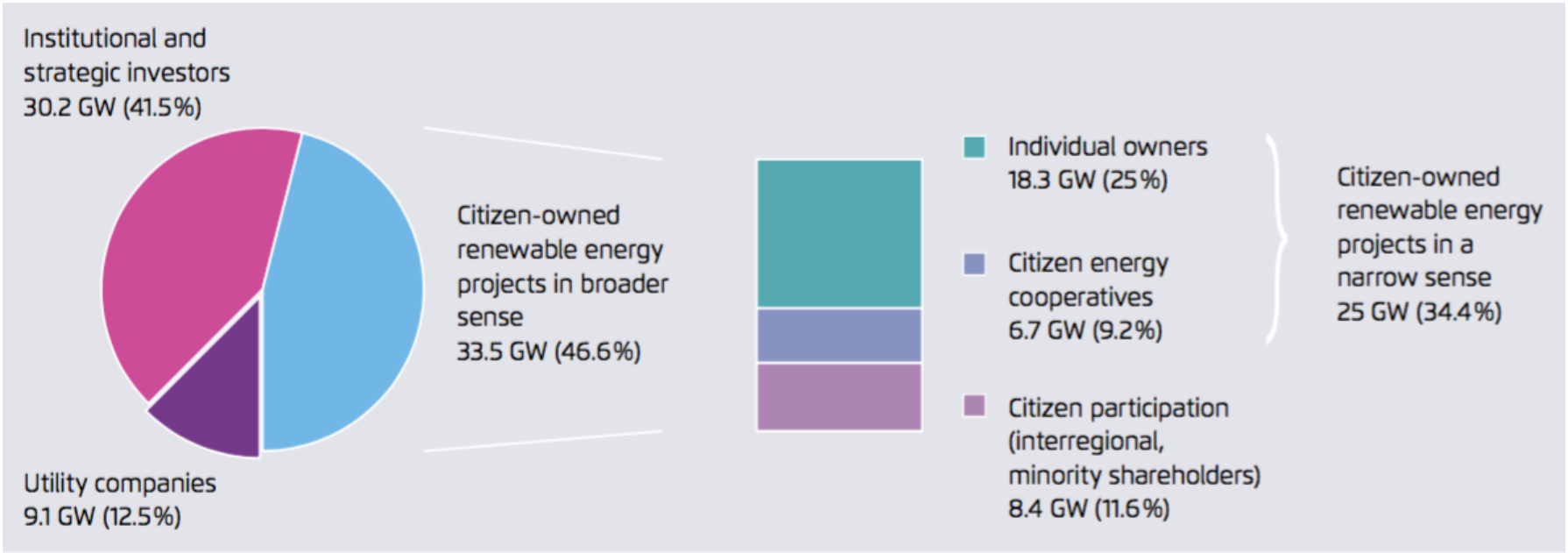
Decentralisation drives the energy transition.

But:

Challenges for incumbents have to be anticipated

Ownership of installed renewable capacity

in Germany in 2012



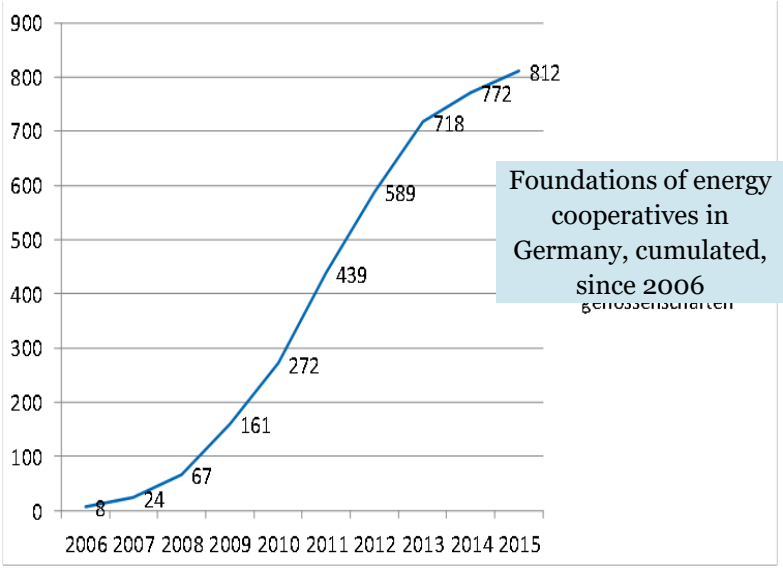
trend:research/Leuphana (2013)

* not counting pumped storage power plants, offshore wind, geothermal energy, biowaste

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



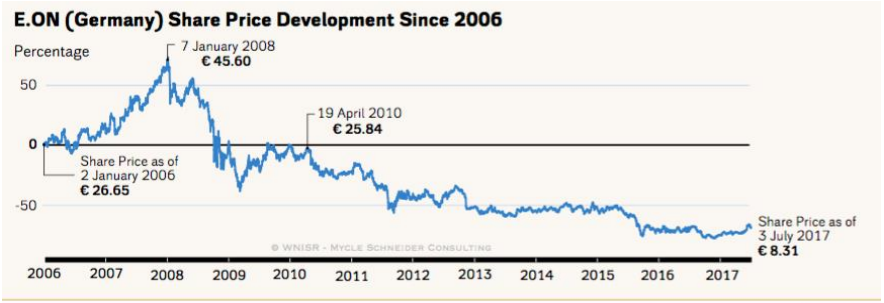
Foundations of energy cooperatives in Germany, cumulated, since 2006

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

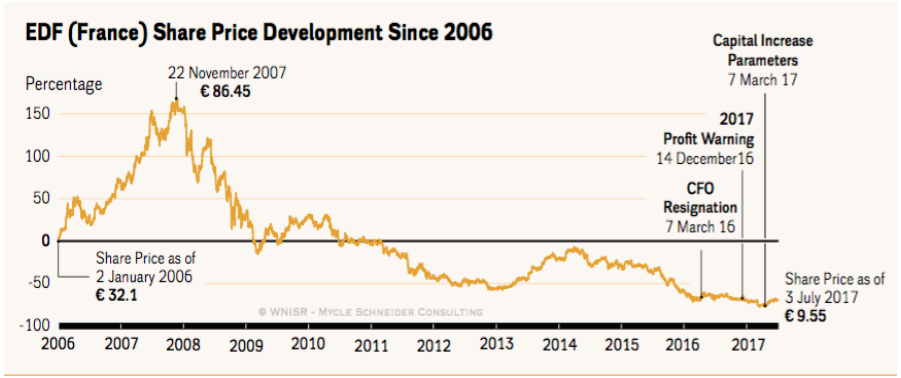
Source: Results of the DGRV annual survey 31.12.2015

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

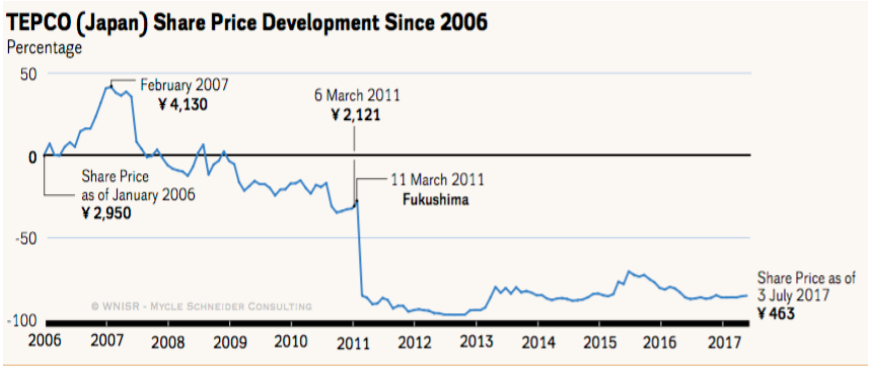
Source: Yahoo Finance, August 2017



Source: Yahoo Finance, August 2017



Source: Yahoo Finance, August 2017



Source: Investing.com, August 2017

“Efficiency first” (IEA):

How to overcome the barriers?

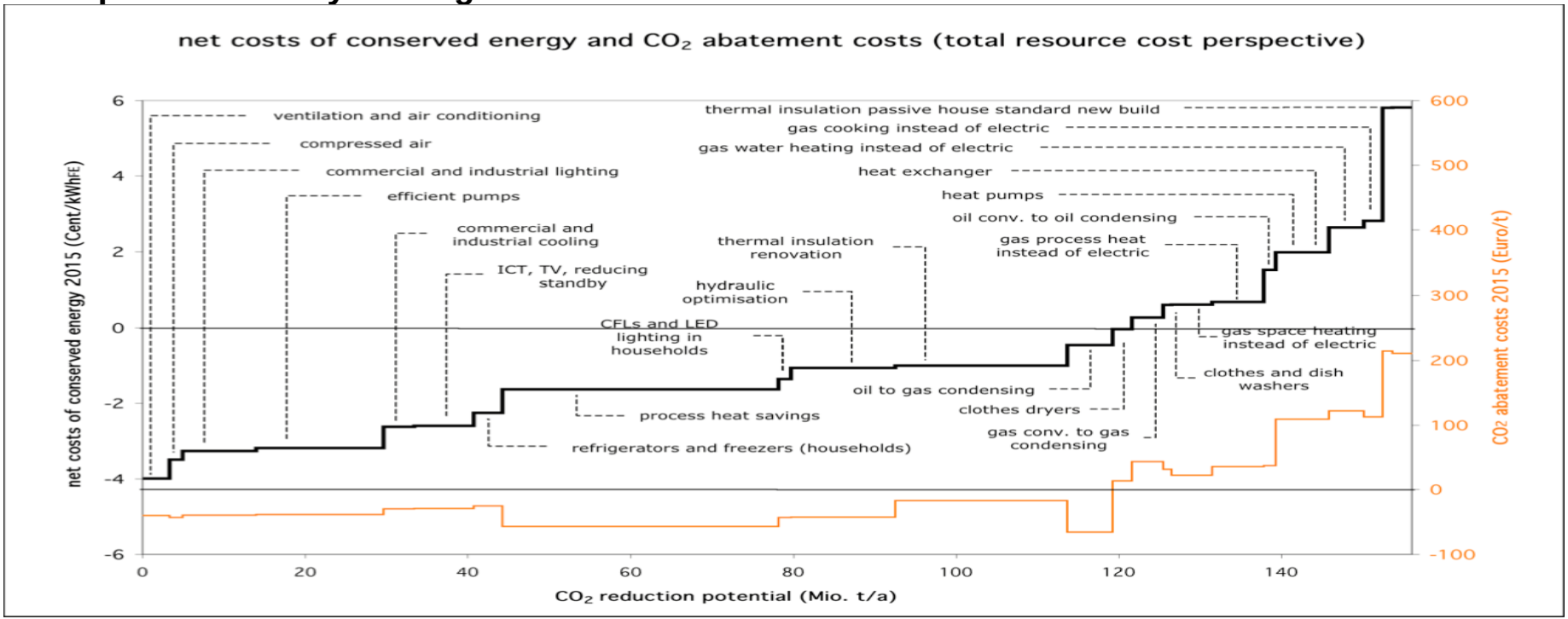
New policy packages to foster efficiency needed, to harvest the benefits!

(“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.

Retrofiting 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

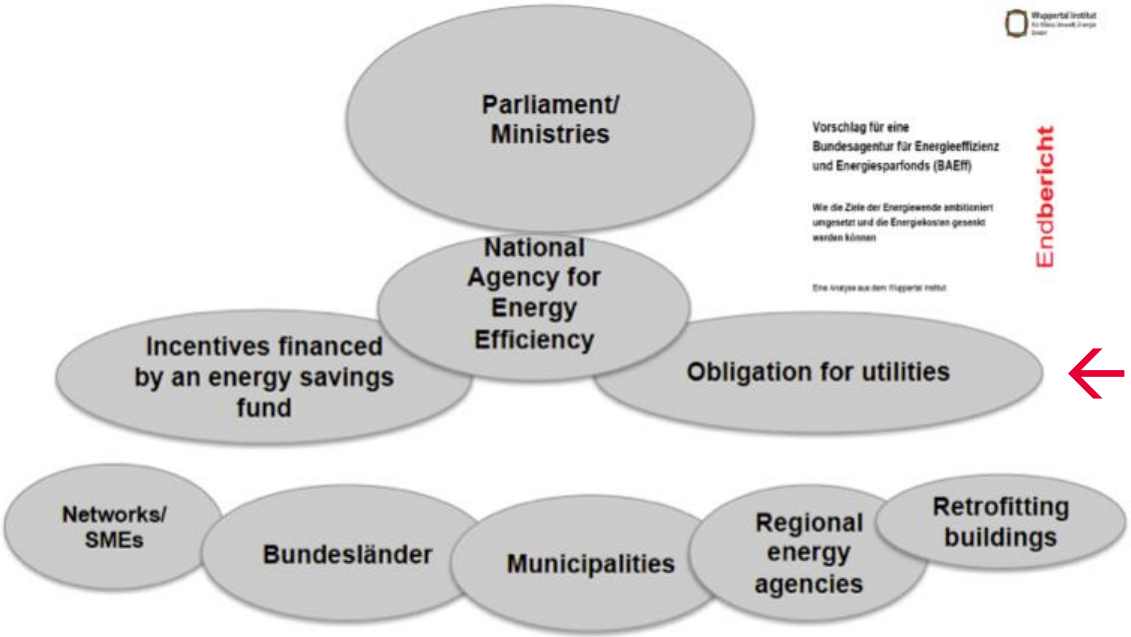
Effects of promotion

- Increase of retrofitting ratio
- Sustainable reduction of CO_2-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

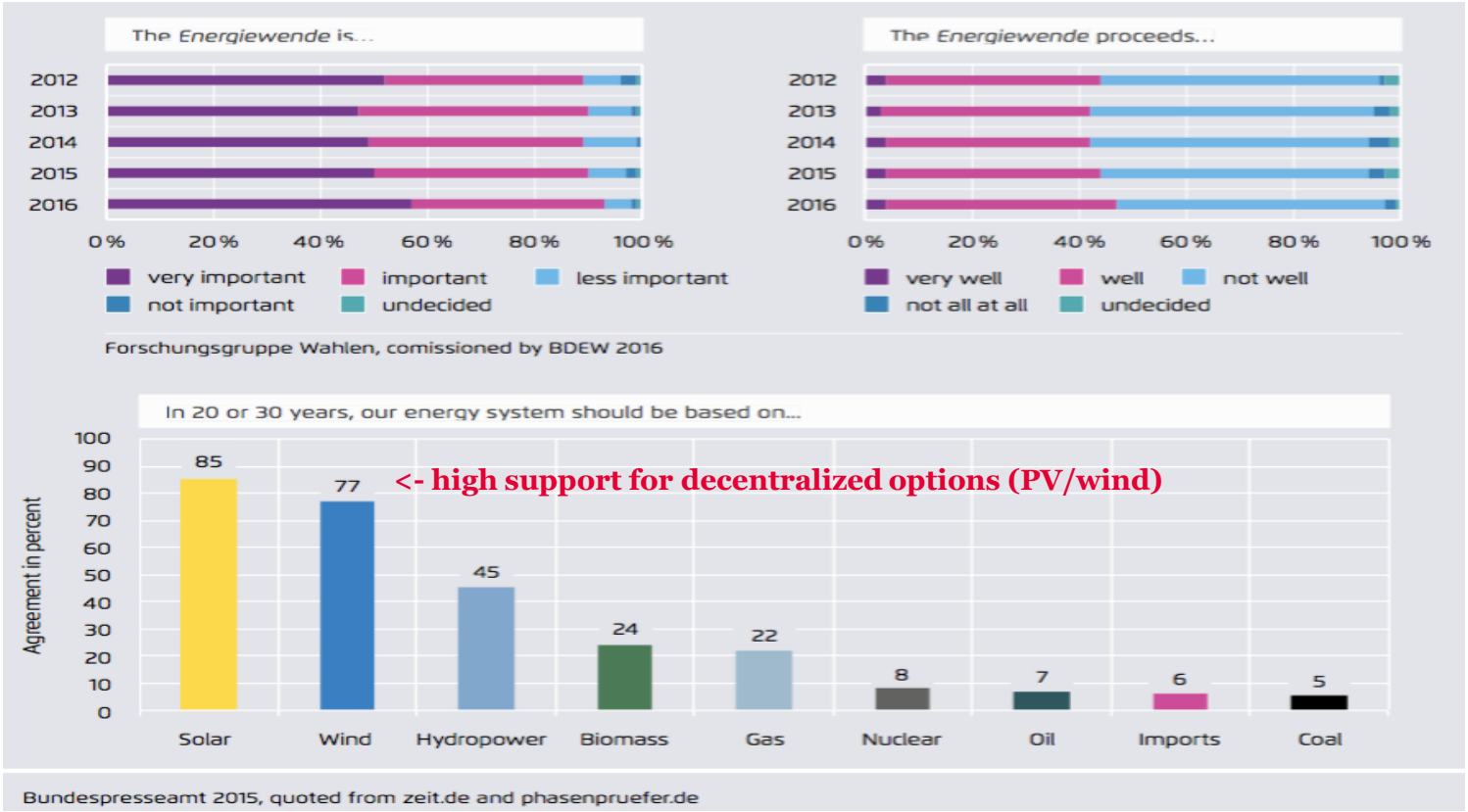
→ “polycentric governance” of energy efficiency policies needed!



Quelle: Wuppertal Institut 2014

Public opinion about the Energiewende

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



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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, 7,51/100km

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

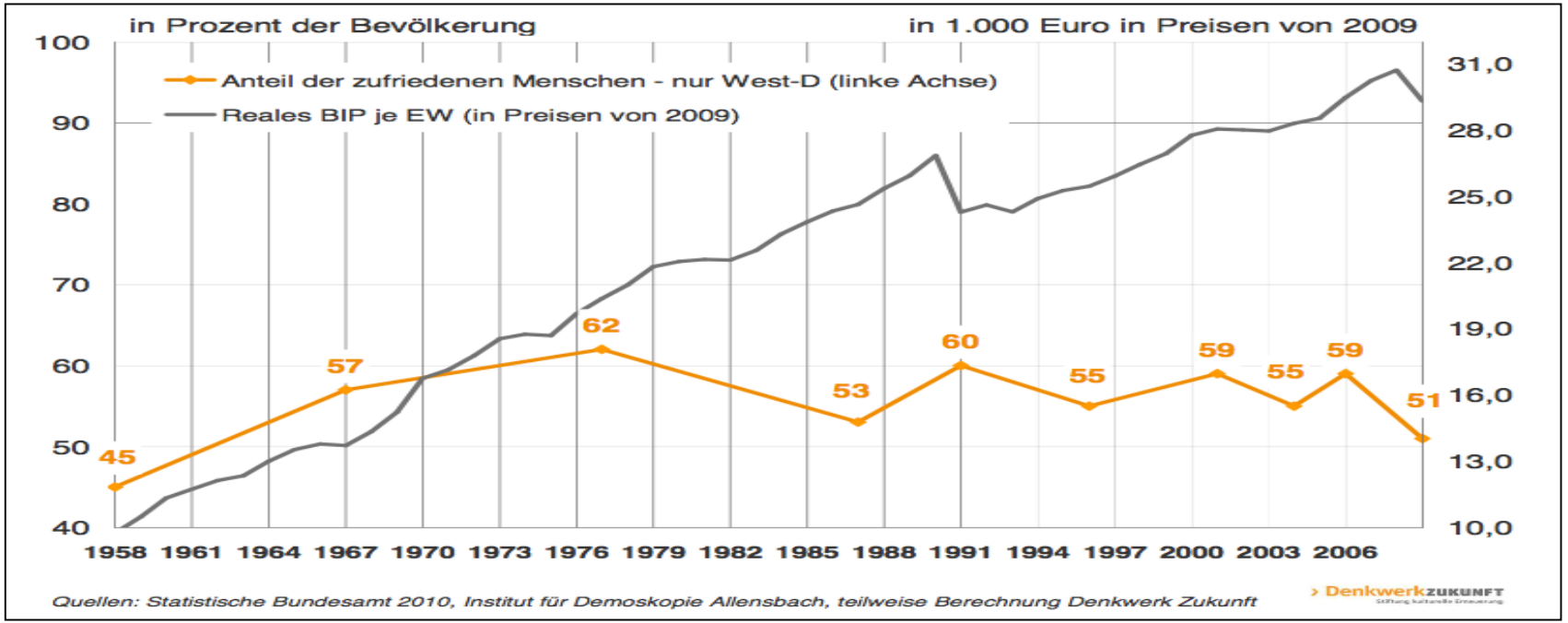
Average HP for the German car fleet

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

JAPAN		GERMANY
METI	**Financing**	**DBU + Mercator + Others**
CHAIR: Masakazu Toyoda	Management	CHAIR: Prof. Peter Hennicke
Organization Office & Scientific Secretariat: IEEJ		Organization/Consulting: ECOS Consult Scientific Secretariat: Wuppertal Institute

Full Member Experts

Jun Arima	Yasumasa Fujii	Claudia Kemfert	Patrick Graichen
Toshiharu Ikaga	Koji Nomura	Felix C. Matthes	Miranda Schreurs
Junichi Ogasawara	Tomihiro Taniguchi	Stefan Thomas	Eicke Weber

Associated Members

Mami Ito	Hiroshi Okamoto	Shinichi Sasayama	Uwe Leprich	Manfred Rauschen	Franzjosef Schafhausen

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

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Thank you for your attention!

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