# Insights from Germany's Energiewende

*State of affairs, trends and challenges*

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**BUDAPEST, 3 NOVEMBER 2016**

# Agora Energiewende – Who are we

Independent think tank with more than 20 energy policy experts

Independent and non-partisan

Project duration 2012-2021

Financed by the Mercator Foundation and the European Climate Foundation

Mission: How do we make the energy transition in Germany and worldwide a success story?

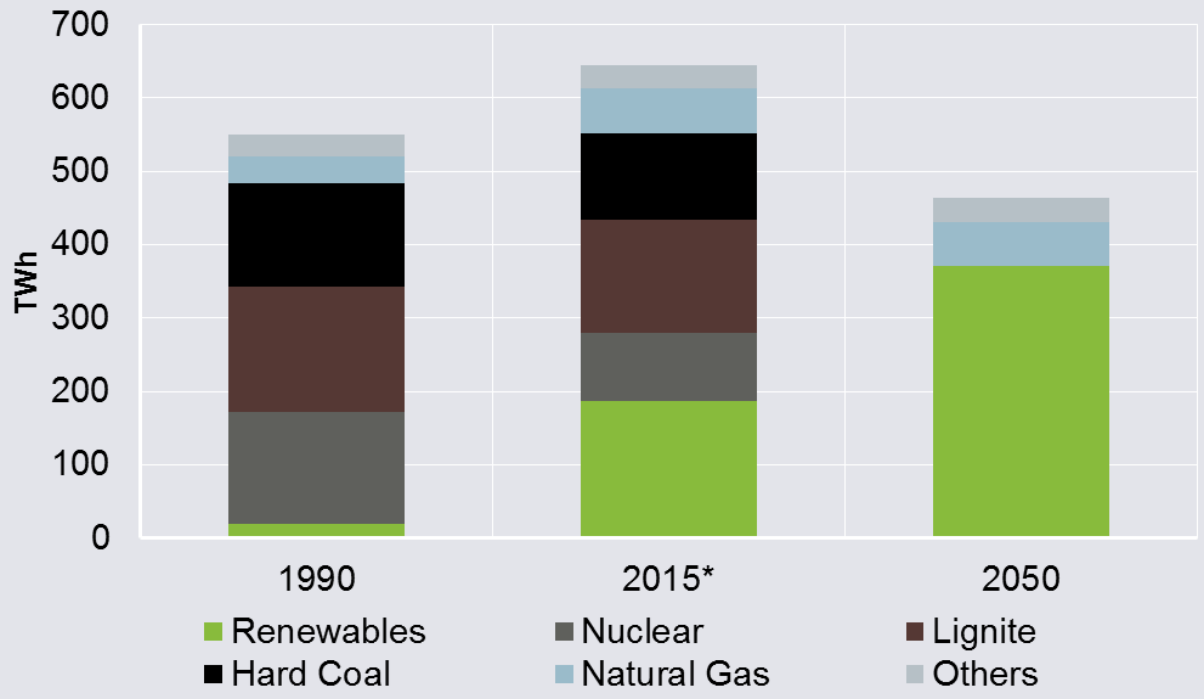
Scientific assessments

Dialogue

Putting forward proposals

# The Energiewende targets imply fundamental changes to the power system, and in turn the entire energy system

Gross electricity generation 1990, 2016 and 2050




AGEB (2016), BReg (2010), EEG (2014), own calculations * preliminary

**Phase out of Nuclear Power**
Gradual shut down of all nuclear power plants until 2022

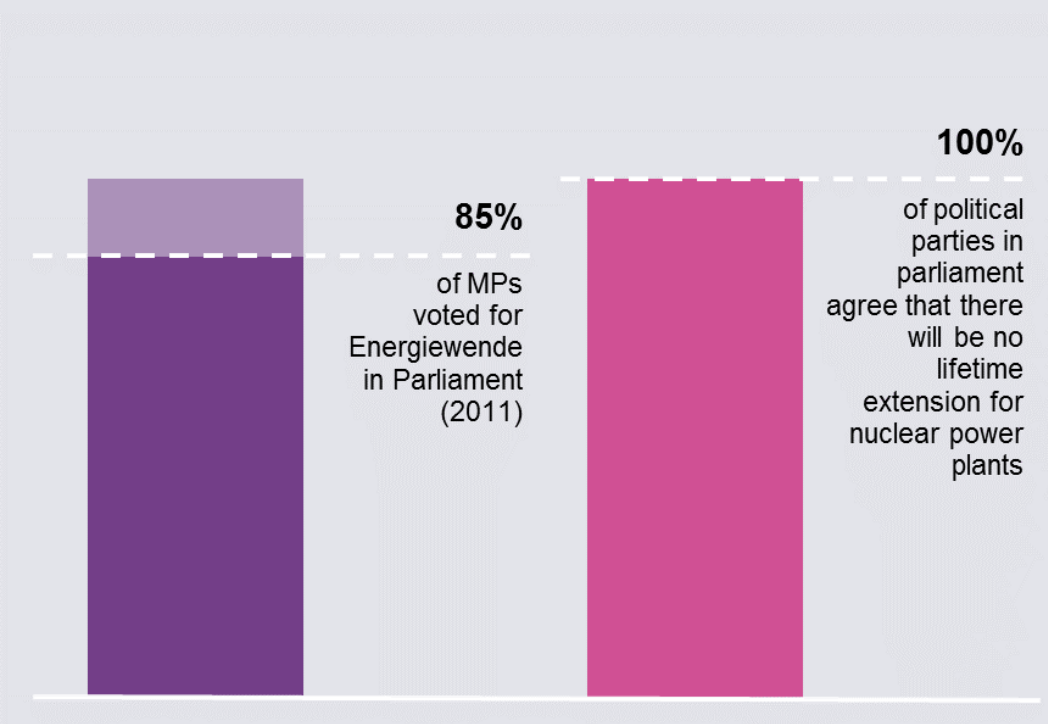
**Reduction of Greenhouse Gas Emissions**
Reduction targets below 1990 levels:
- 40% by 2020; - 55% by 2030; - 70% by 2040;
- 80% to - 95% by 2050

**Development of renewable energies**
Share in power consumption to increase to:
40 - 45% in 2025; 55 - 60% in 2035; ≥ 80% in 2050

**Increase in efficiency**
Reduction of power consumption compared to 2008 levels: - 10% in 2020; - 25% in 2050

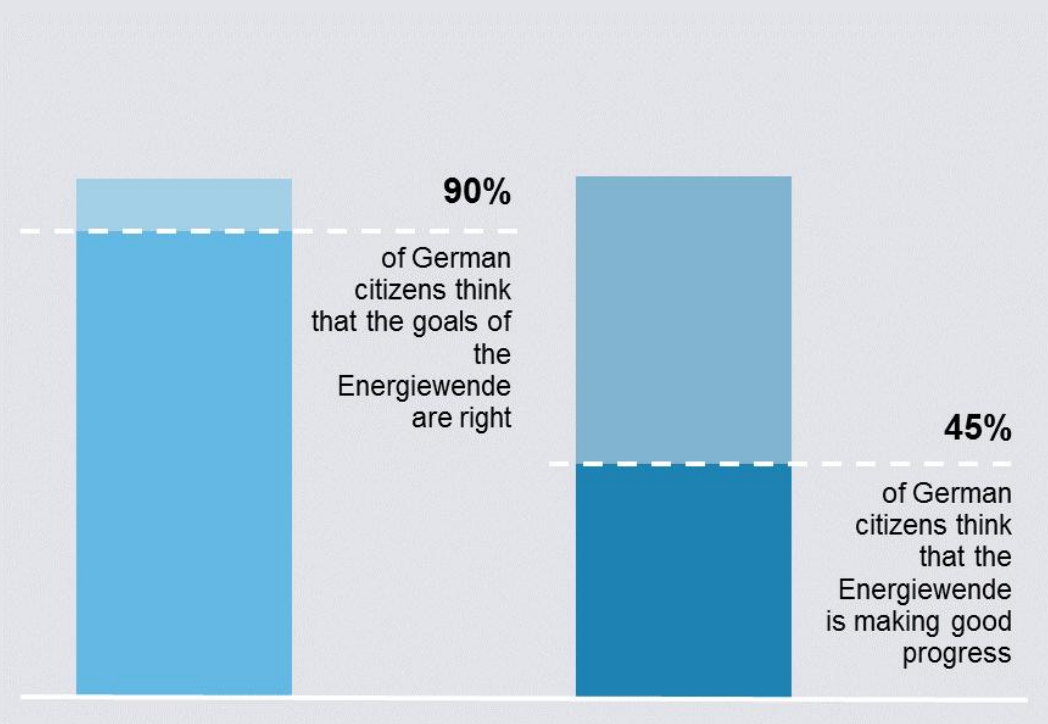
# The Energiewende is based on a broad consensus - public discussions is basically focussing on the concrete implementation

Voting results in the Bundestag on Energiewende




Deutscher Bundestag (2011)

Public opinion on Energiewende 2015



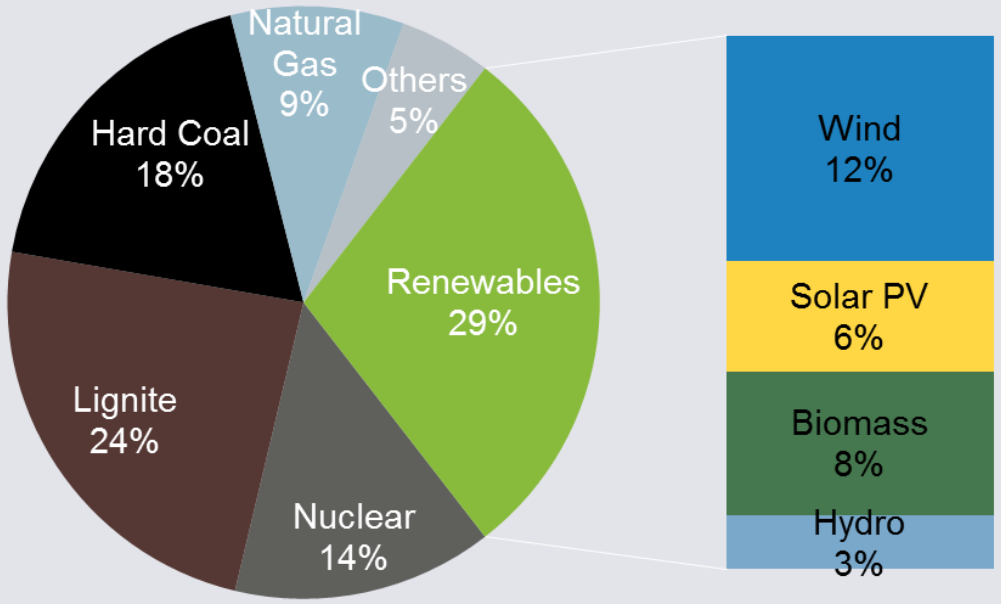

BDEW (2015a)

# The Energiewende in the power sector

***State of affairs 2015***

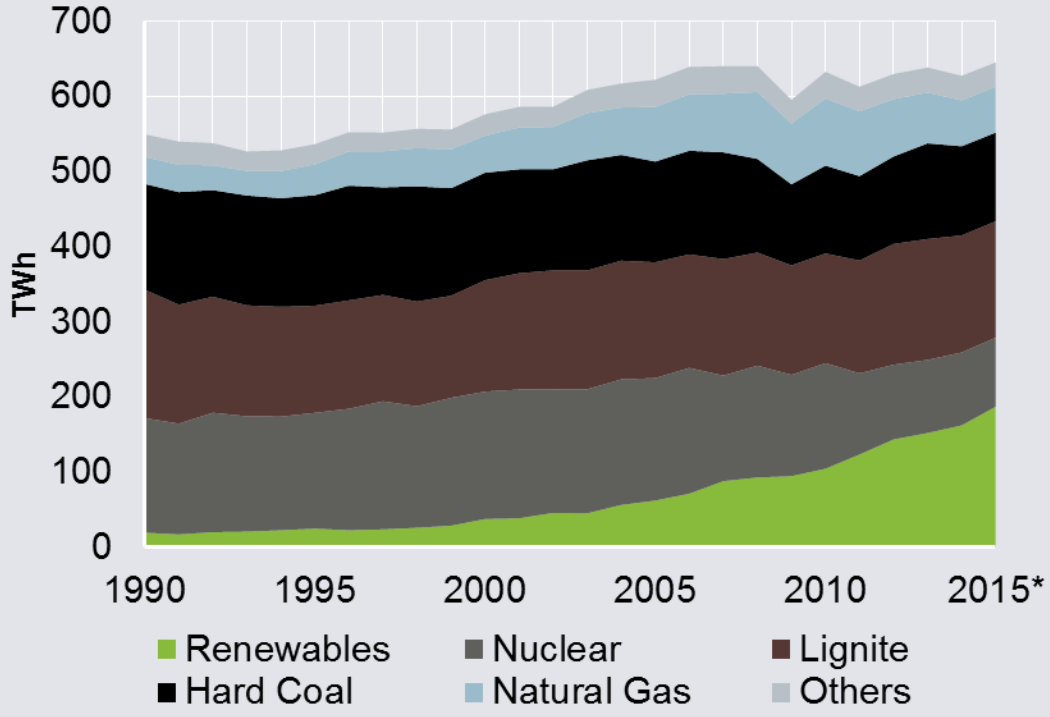
# Renewables are the largest source in the electricity mix – followed by lignite and hard coal

Share in gross electricity generation by fuel 2015




AGEB (2016) * preliminary

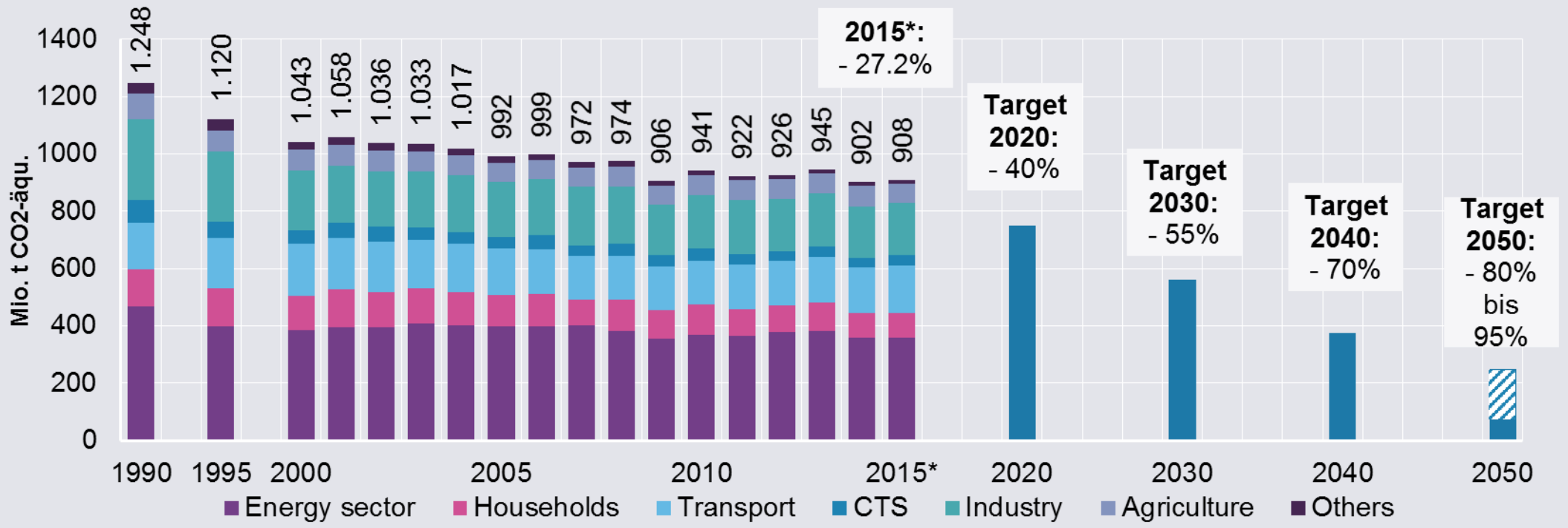
Gross electricity generation by fuel 1990 - 2015




AGEB (2016) * preliminary

# Greenhouse gas emissions are currently at -27% compared to 1990 levels – the energy sector is the largest emitter

Greenhouse gas emissions by sector 1990 - 2015 and climate targets 2020 - 2050

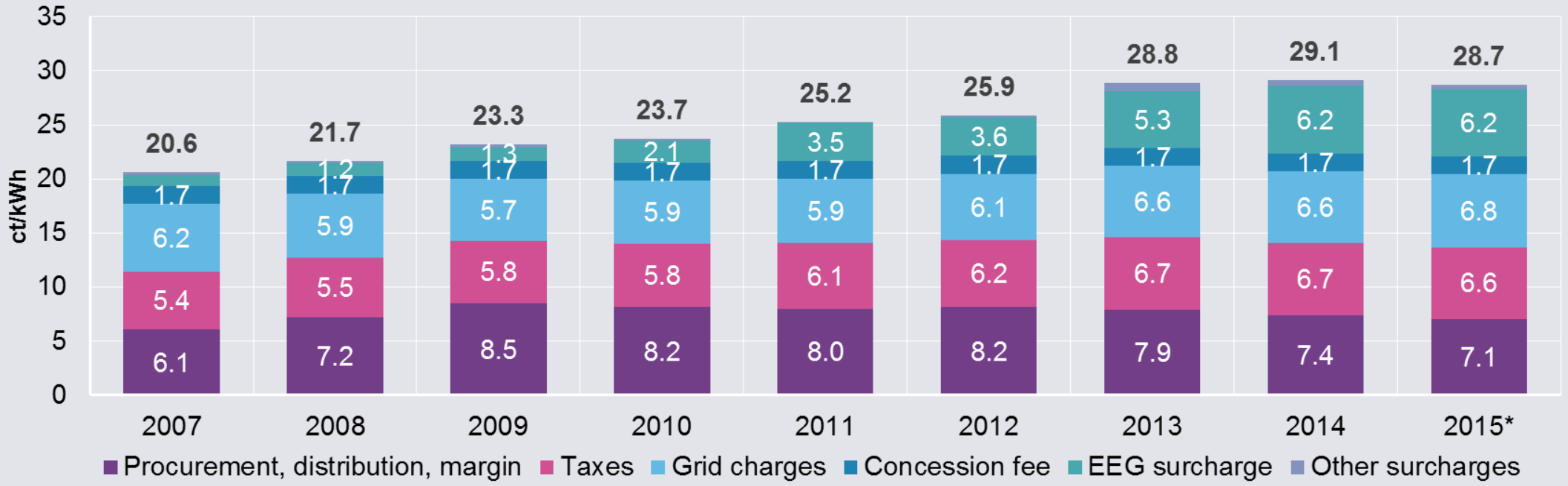



AGEB (2015a), UBA (2015), own calculations

* preliminary

# After significant increases in previous years, household electricity prices are relatively stable since 2013

Average household electricity prices in a 3-person household 2007 - 2015



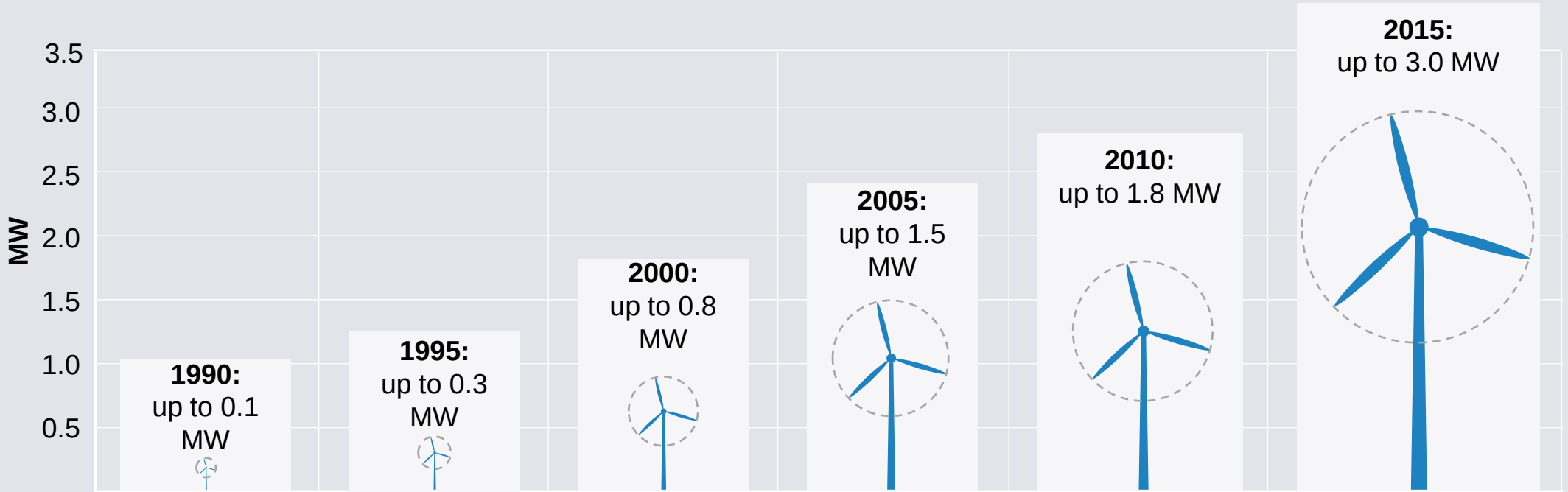

BDEW (2015b)

* preliminary

# The Key Insight: It’s all about Wind and Solar!

# Wind Energy has become a mature technology, with windmills of 2 - 3 MW being standard

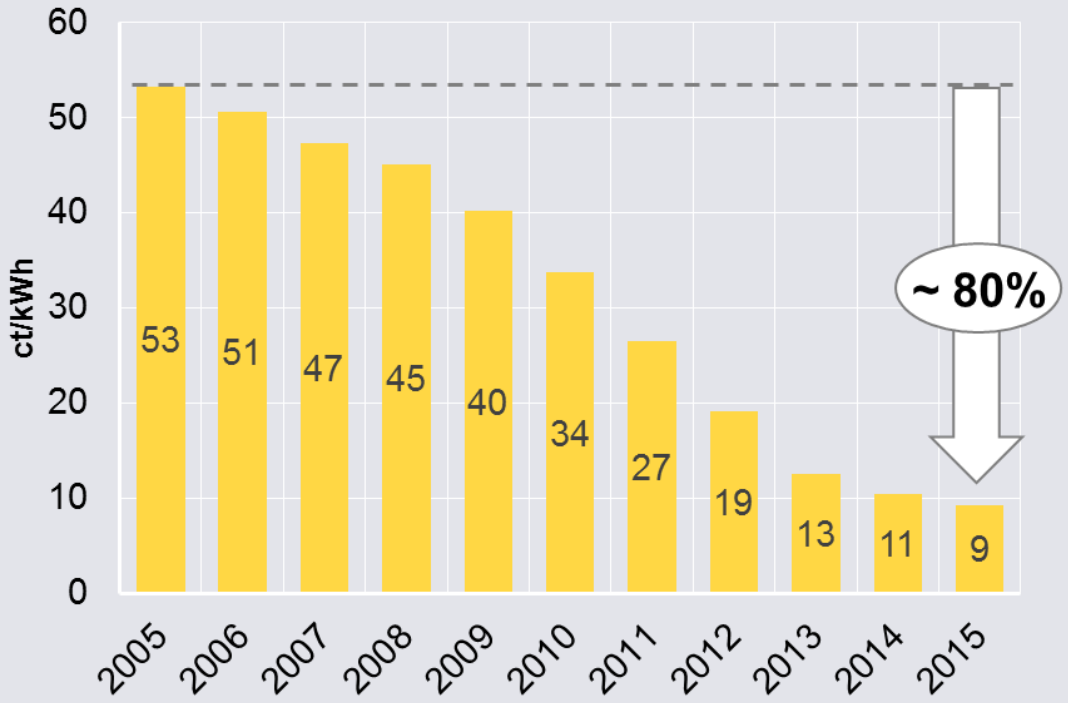
Size development of wind turbines 1990 - 2015




IEA (2013)

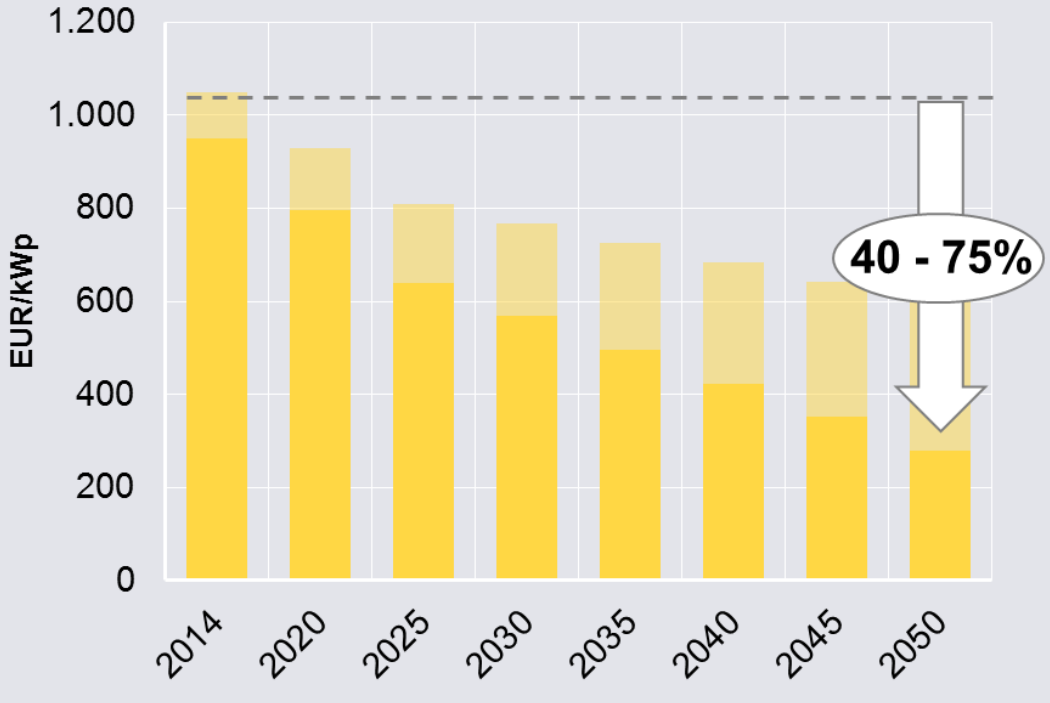
# Due to falling module prices, feed-in tariffs for Solar PV dropped massively in the last 10 years - and the end of the cost digression is not yet reached

Average PV feed-in tariff for new installations 2005 - 2015




ZSW et. al (2014), own calculations

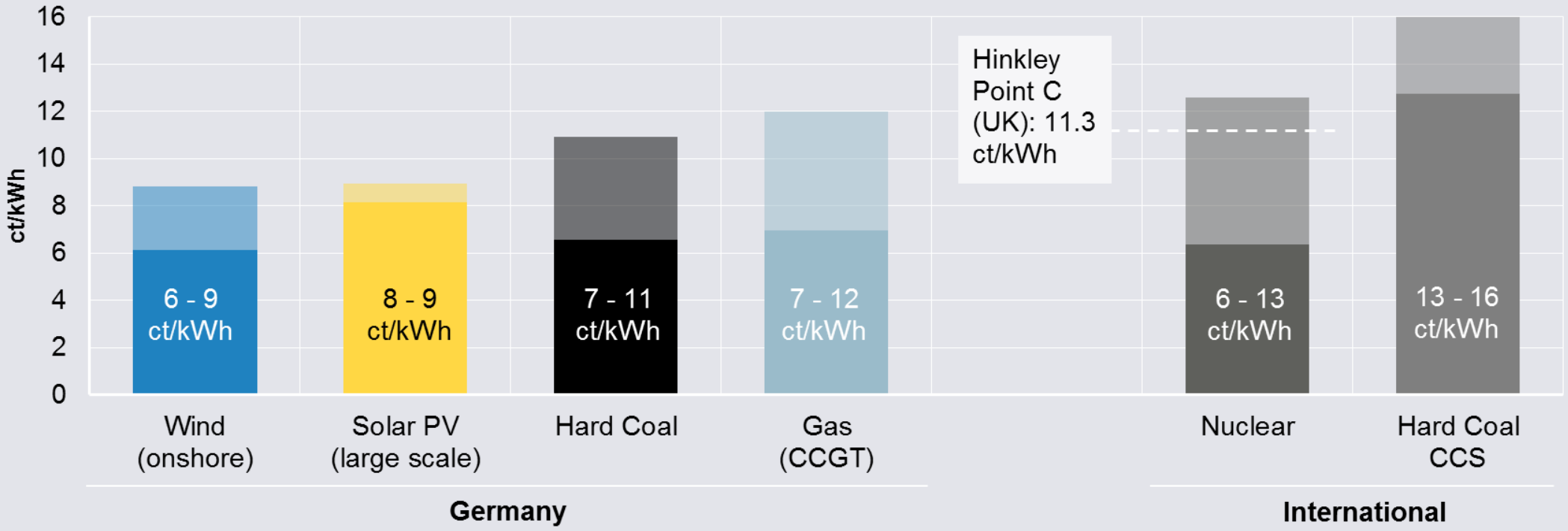
Expected cost digression for large-scale PV systems 2014 - 2050




Fraunhofer ISE (2015)

# Today, wind and solar are already cost competitive to all other newly built power plants

Range* of levelized cost of electricity (LCOE) 2015

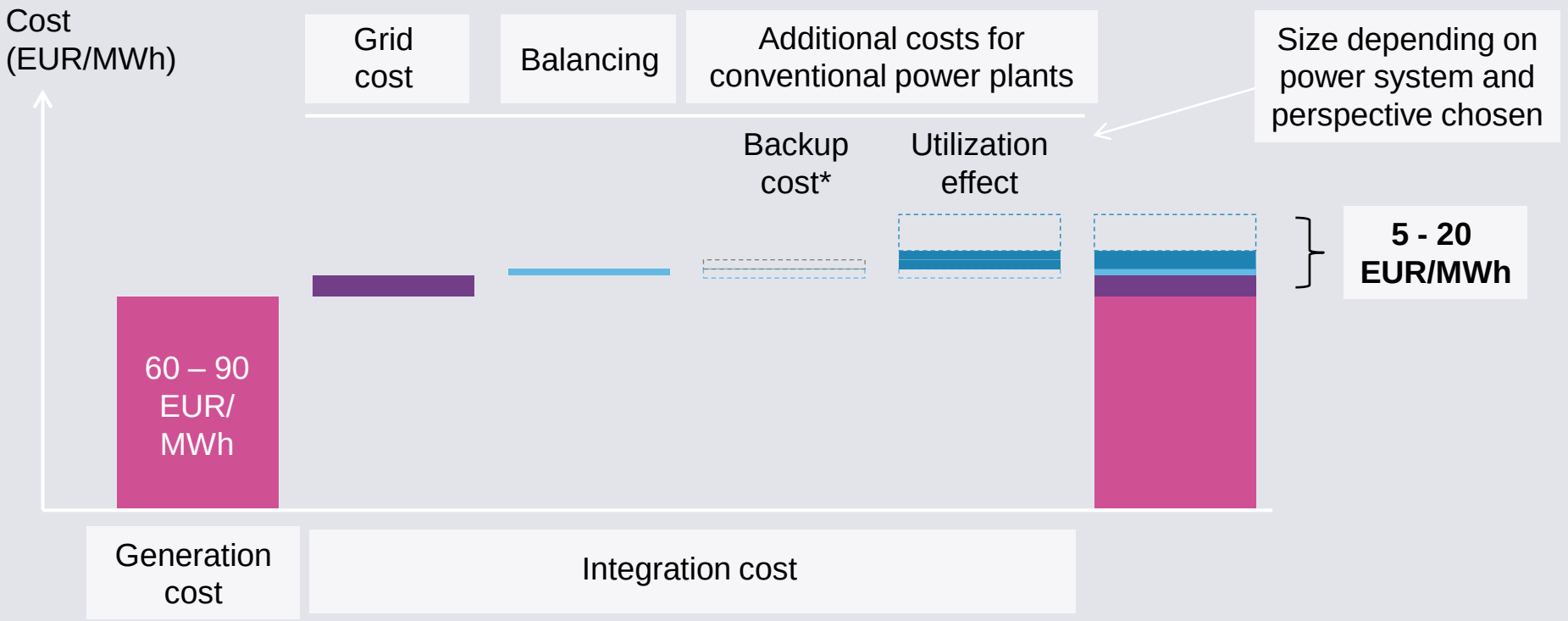



Agora Energiewende (2015e)

* based on varying utilization, $CO_2$-price and investment cost

# The integration cost of wind and solar (5 to 20 EUR/MWh) do not change the picture

Components of integration costs for a simulation of the German power system with 50% RES-E

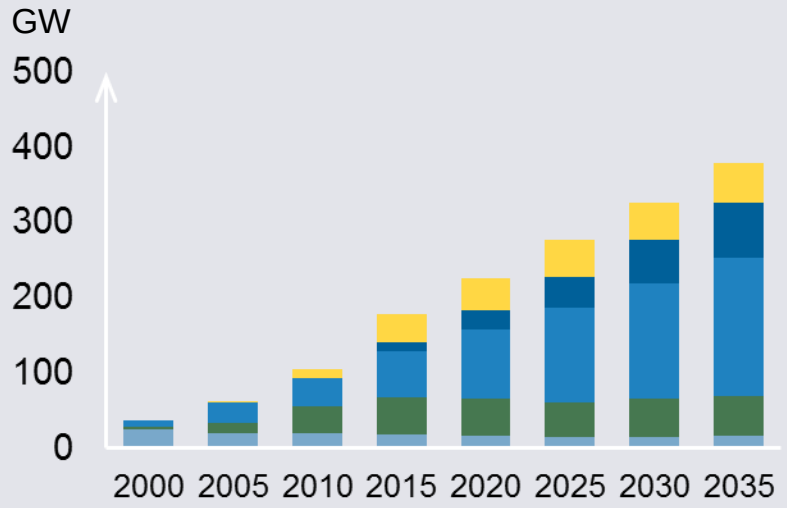



Agora Energiewende (2015a)

* part of utilization effect

# With wind and solar, the new power system will be based on two technologies that completely change the picture

Gross electricity generation of renewable energies 2000 - 2035

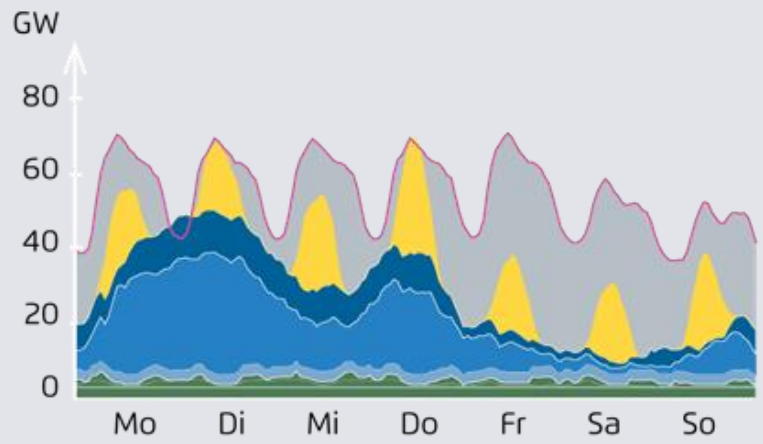



AGEB (2015a), BNetzA (2014), BNetzA (2015b), own calculations

**Specific characteristics of Wind and Solar PV**

1. Intermittent
2. High capital costs
3. Very low variable cost

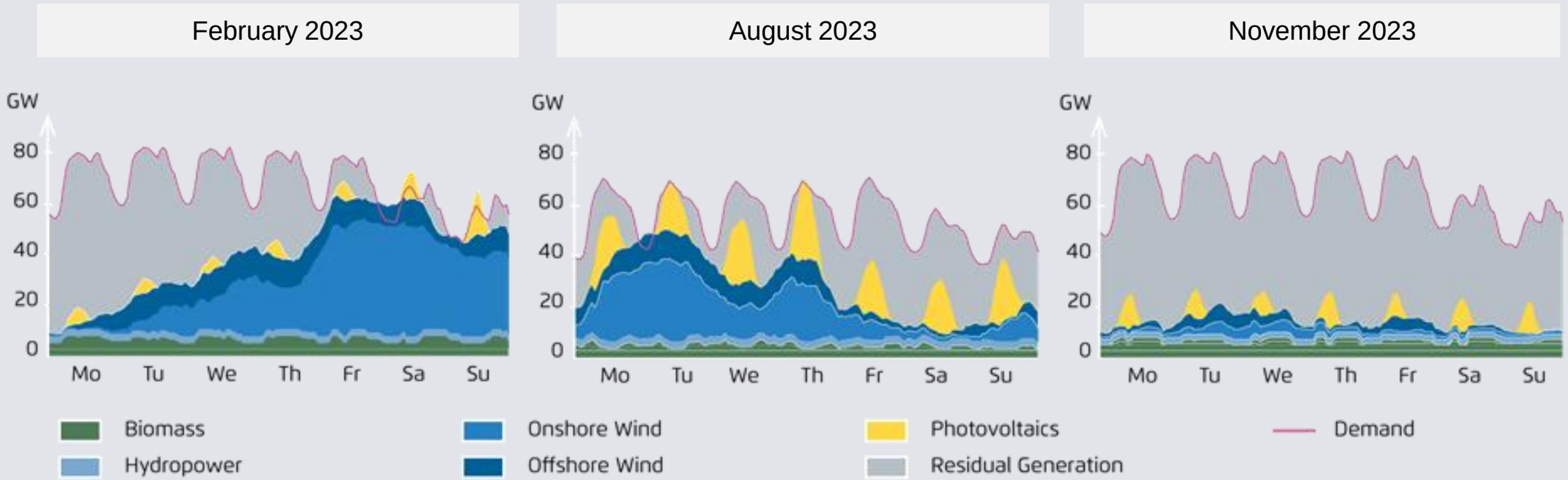
Electricity generation and consumption in a sample week 2023




Fraunhofer IWES (2013)

# The power system and power markets will need to cope with a highly fluctuating power production from wind and solar

Electricity generation* and consumption* in three sample weeks, 2023

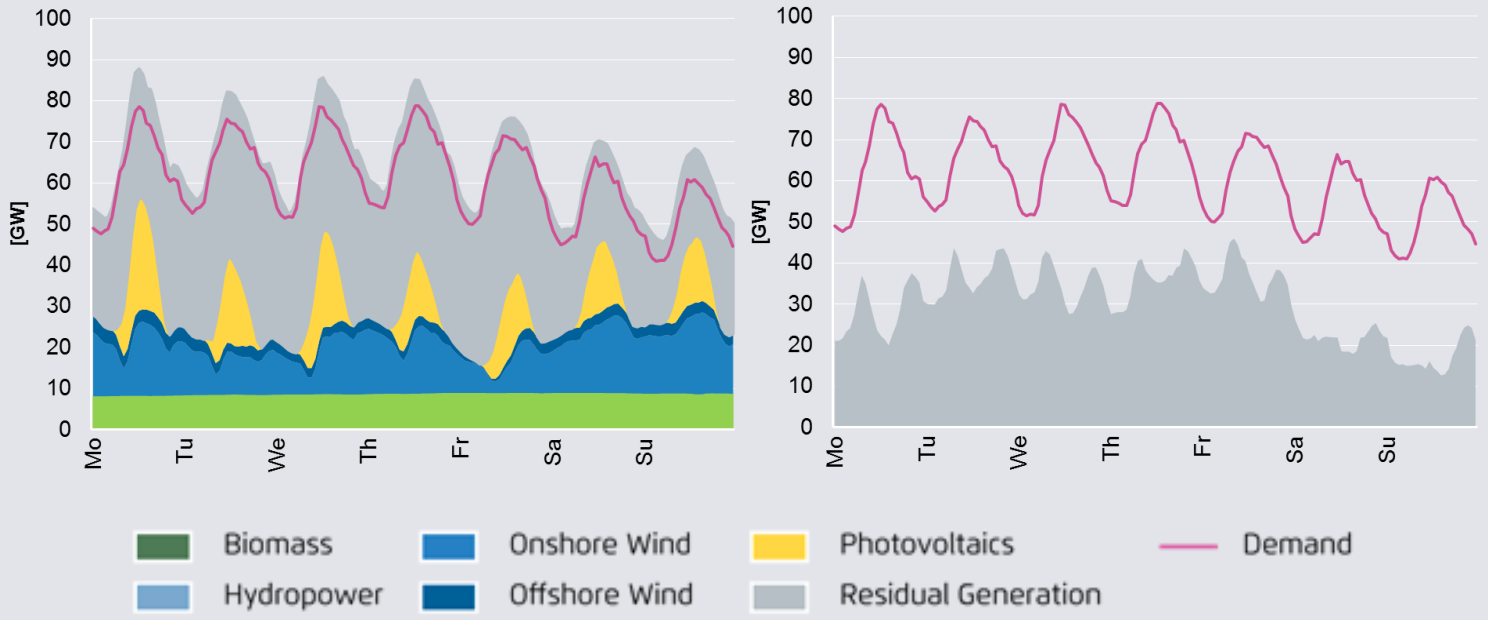



Fraunhofer IWES (2013)

* Modelling based on 2011 weather and load data

# *Flexibility* is the paradigm of the new power system – baseload capacities are not needed any more

Power generation and consumption in Germany, 9 to 15 May 2016 (50% RES-E share)




Key flexibility options

- Flexible fossil and bioenergy power plants (incl. CHP)
- Electricity grid infrastructure (domestic and cross-border)
- Demand Side Management
- Storage technologies (Hydro storage, batteries)
- Integration of the power, heat and transport sectors (P2H, electric mobility, P2G)

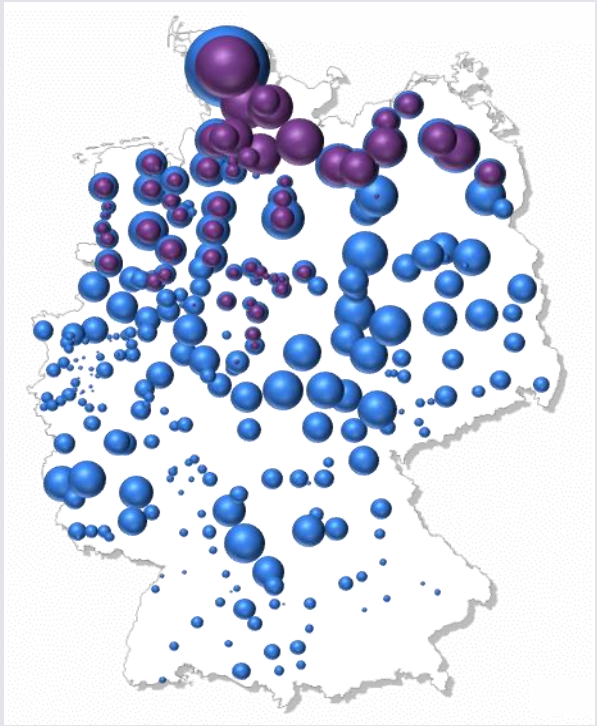
Agorameter

# Key challenges ahead towards a world with 50% renewable energies

## *Challenge 1: Grids*

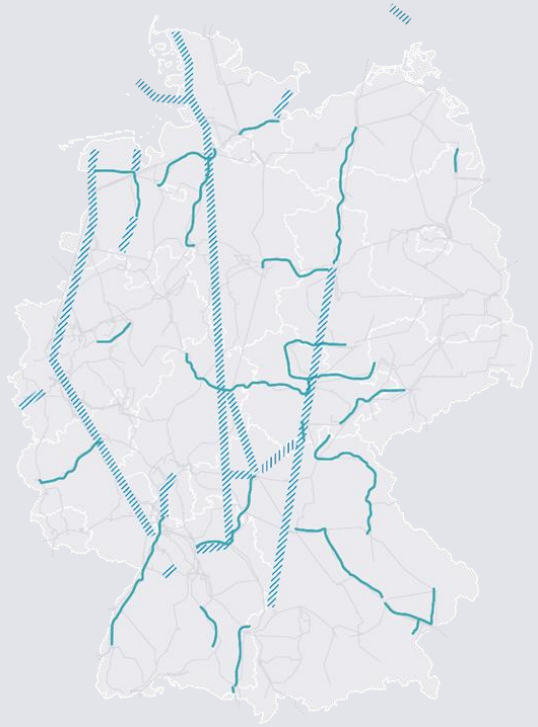
# More grids to transport wind energy to the south of Germany

Installed wind capacity (103 GW, Scenario „Best Sites“) 2033



Fraunhofer IWES (2013)

German network development plan 2024*



BNetzA (2014) * approved Sep 2015

Wind power will be installed mainly near the coast in the north of Germany, but key consumptions centres are located in the south

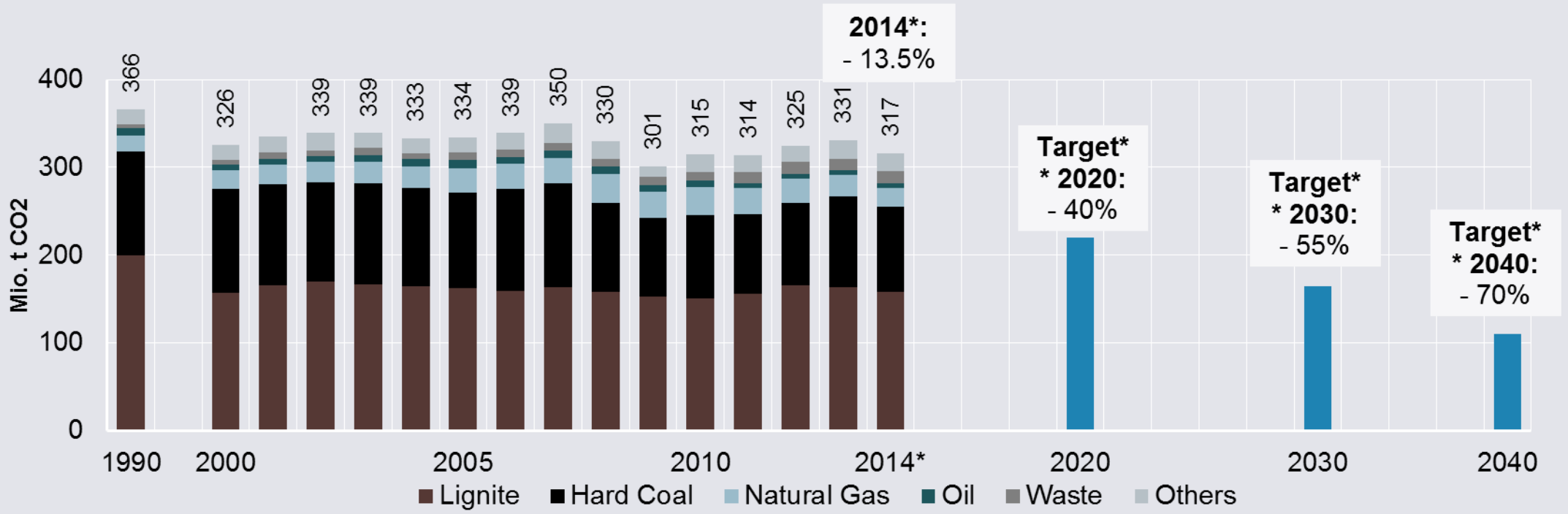
Additional power lines are necessary to transport wind electricity from north to south (3 HVDC corridors)

There has been a delay in grid expansion, thus redispatch and curtailment have increased significantly

New policy to use underground cables whenever necessary. Measures to reduce consternation and compensation for concerned parties need to be considered from the very beginning

# *Challenge 2: Climate Targets and Coal phase-out*
# In 2017, a “lignite reserve” is implemented, for 2030/2040 horizon we need a “coal consensus” phasing out coal entirely

$CO_2$ emissions from electricity generation 1990 - 2014 and climate targets** 2020 - 2040



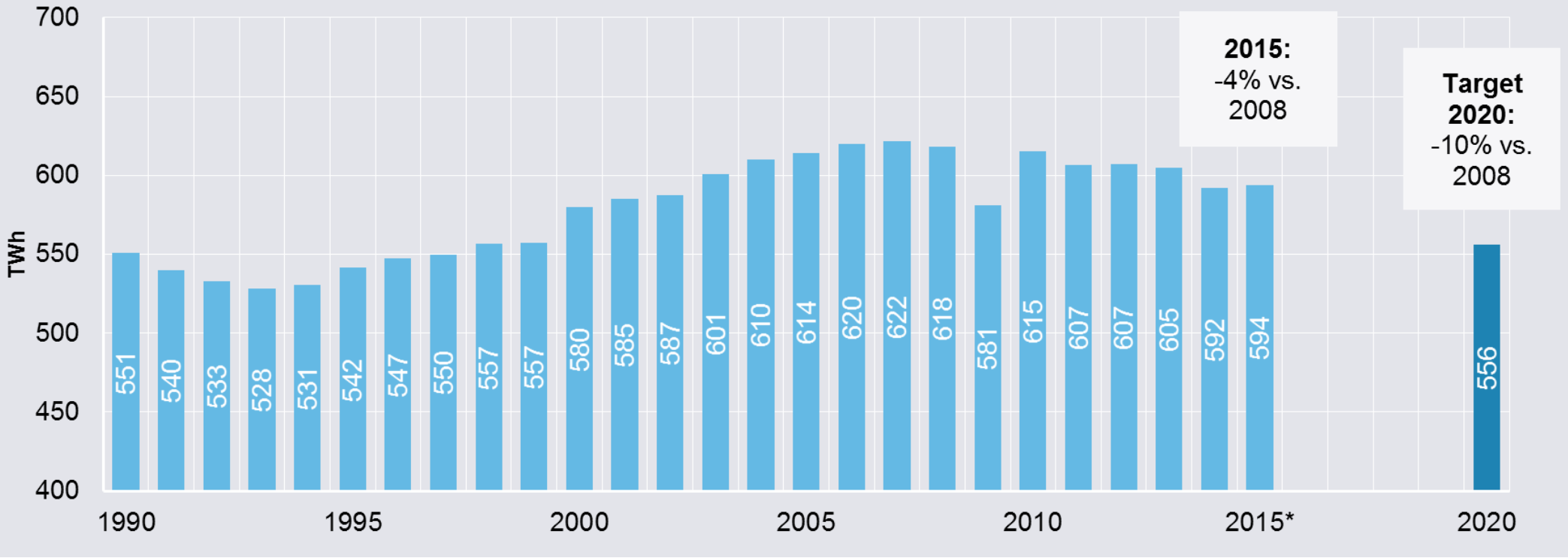

UBA (2015), own calculations

*preliminary, **application of a sectoral 40%-target

## *Challenge 3: Energy efficiency*

# Strengthened energy efficiency policies to reach 2020 target

Gross electricity consumption 1990 - 2015




AGEB (2016)

* preliminary

# *Challenge 5: European Cooperation*
# Further enhance the cooperation between neighbouring countries and deepen European power market integration

Time series of onshore wind generation in May 2030 at different levels of aggregation


- Power system integration mitigates flexibility needs due to smoothing effects
- Hourly wind ramps decrease by ~50% comparing the national and European scale
- Reduced residual load gradients & balancing requirements; Minimised renewables curtailment
- Cross border system integration key for minimising flexibility challenge
- ➔ Grid interconnections, cooperation in system operations and market design

Fraunhofer IWES (2015)

* One pixel is equivalent to an area of 2.8 x 2.8 km; PLEF are the countries AT, BE, CH, DE, FR, LU, NL

# *Challenge 6: Power Market Design* (Germany *and* the EU) Which market design gets us efficiently to a 2030 power system with 50% RES-E, -2/3 coal generation and flexible mix?

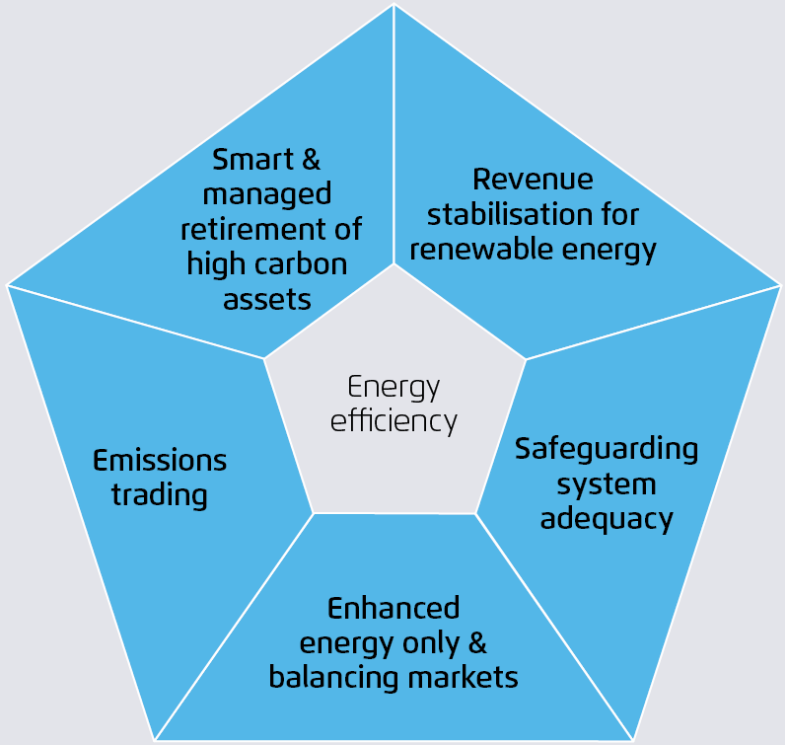
Market design for the energy transition based on simplified textbook economics

**Energy-only market, System adequacy through peak pricing**

**Emissions Trading (with $CO_2$ price reflecting social cost of carbon, i.e. > 60 EUR/t)**

Agora Energiewende (2016)

The Power Market Pentagon

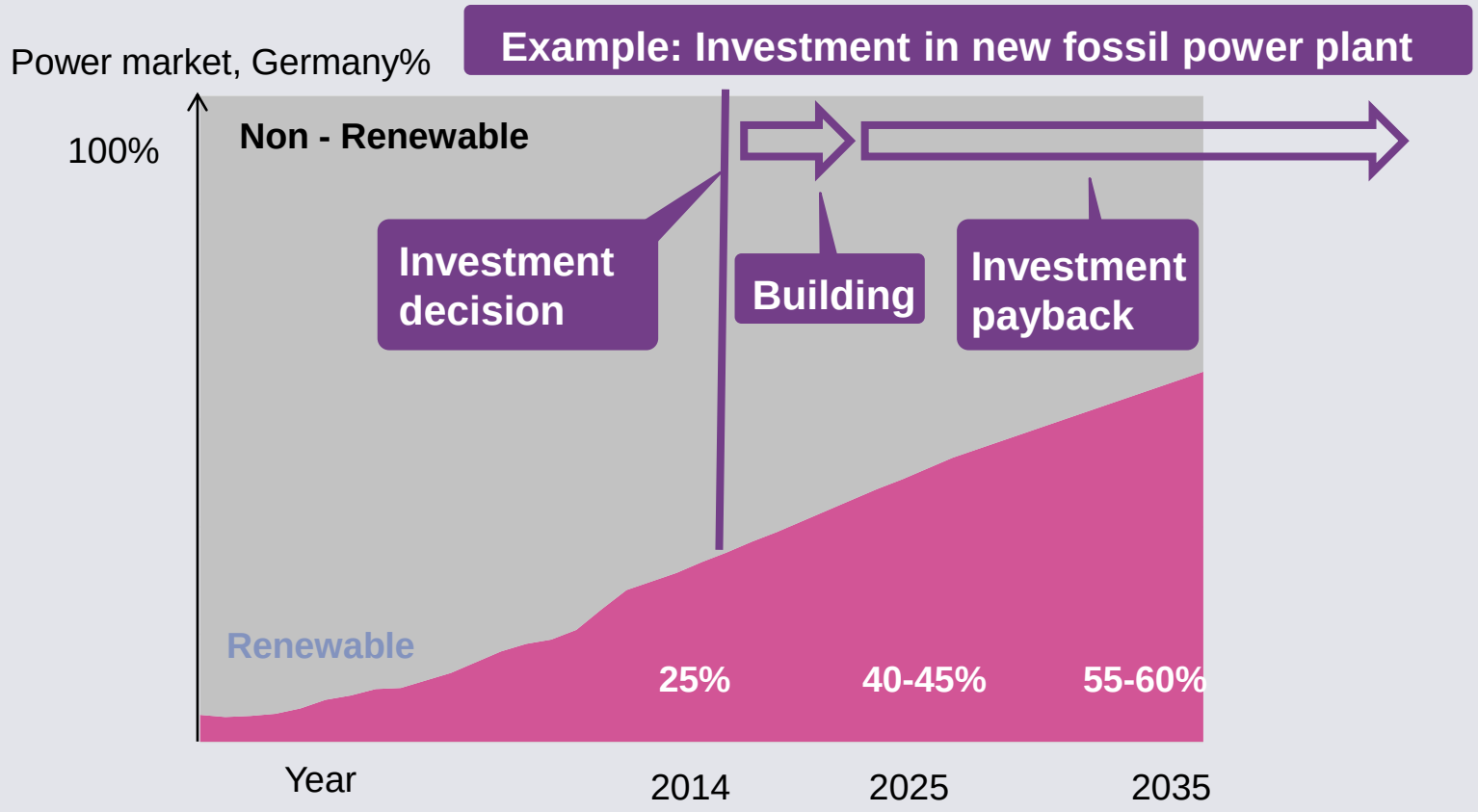



Agora Energiewende (2016)

# Key messages from the German expirience

# Policy targets required to enable the market to find efficient solutions and provide investor certainty

Renewable targets allow market actors to make efficient investment decisions – for both non-renewable and renewable investments



# Nimble policies: Adjust along the way considering investment risks

**Renewable Energy Law (EEG) – reform steps 2000 to 2014**


1991: first Feed-in Tariff (FiT) in DE

Aim: double RES capacity by 2010; FiT started, priority dispatch, guaranteed grid access, grid follows generation paradigm, cost digression

Aim: 20% RES in 2020; changes in FiT

Aim: 30% RES in 2020; changes in FiT, curtailment regulation; feed-in management

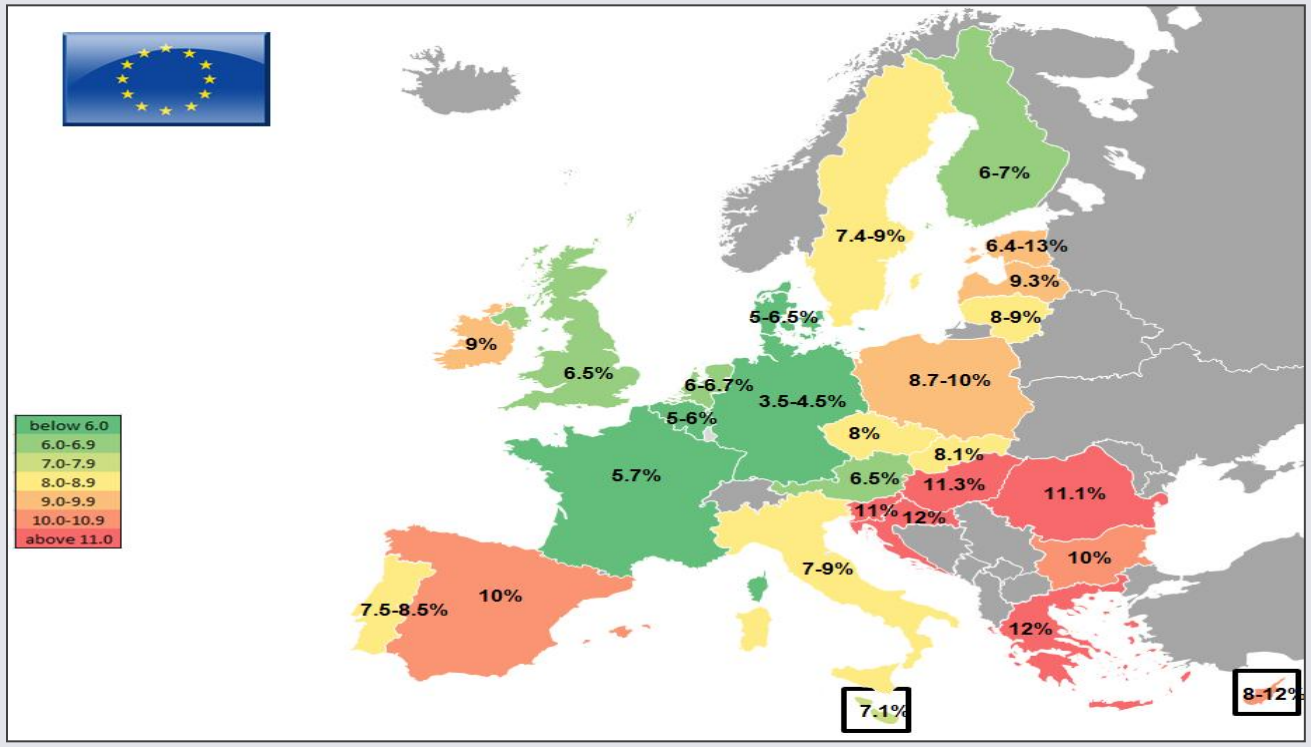
Aim: min. 35% by 2020, FiT lowered, voluntary market premium (FiP); 52 GW cap on PV

Aim: 40-45% in 2025; auctions for PV; obligatory market premium (FiP); breathing cap for wind and PV

Auctions for PV & wind; obligatory market premium (FiP);

# Stable regulatory and political frameworks are a precondition for the cost-efficient increase in renewable energies

WACC for investments in wind onshore projects of EU Member States




DiaCore Project (2015)

**Main factors creating uncertainty**

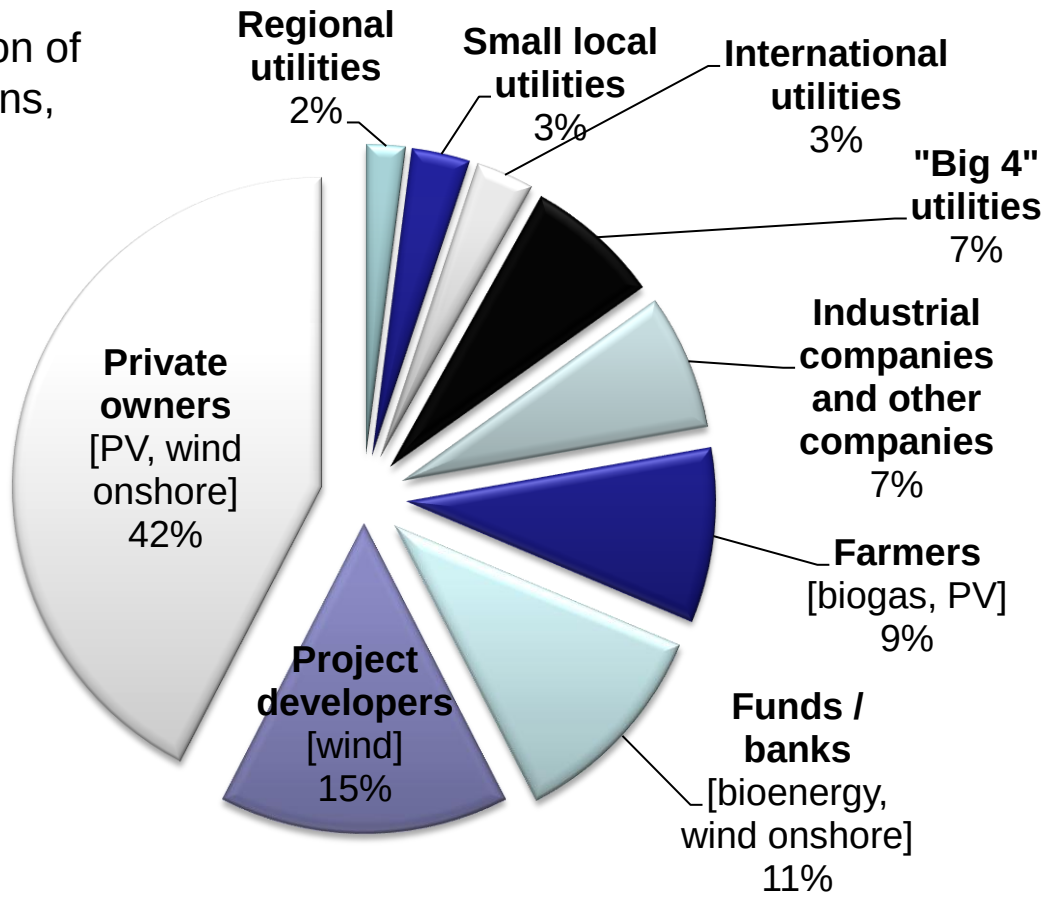
Future policy choices

Administrative procedures

Market design & grid access

# Renewables are being installed and owned by citizens enabled by policies: Involvement, ownership and acceptance

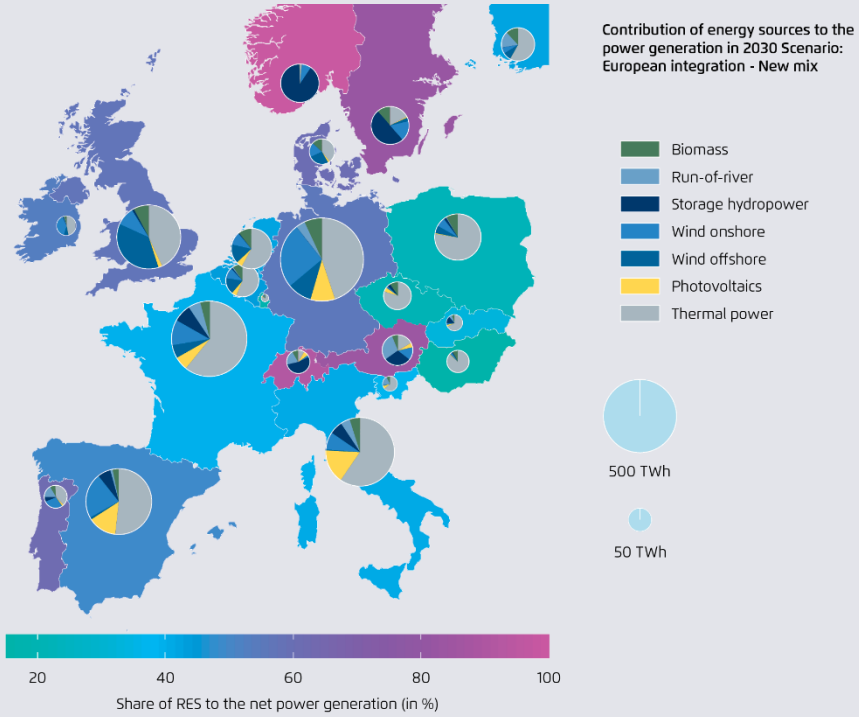
Ownership distribution of renewable installations, 2011



# Is Germany a special case?

# *Europe:* The EU 2030 targets imply a 50% renewables share in the European power sector – with high shares of wind and PV in many EU member states

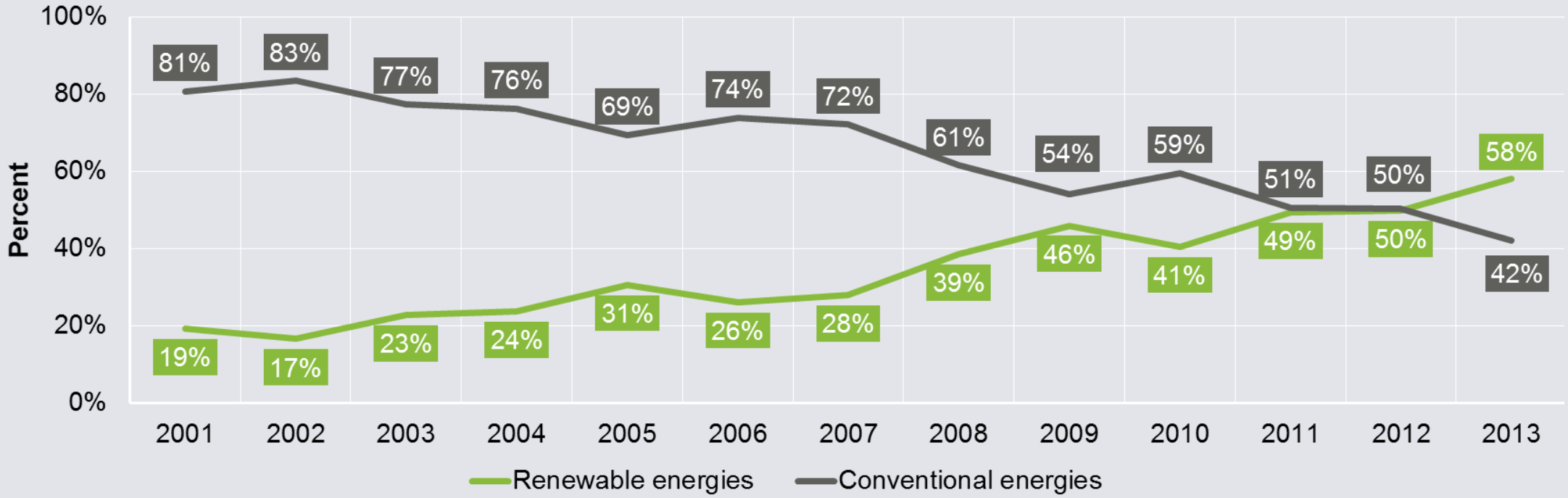
RES-E share in the EU generation mix 2030




Fraunhofer IWES (2015): Assumptions based on national energy strategies and ENTSO-E scenarios in line with EU 2030 targets

# *World:* Global capacity additions in renewables have overtaken those of conventional sources (coal, gas, nuclear)

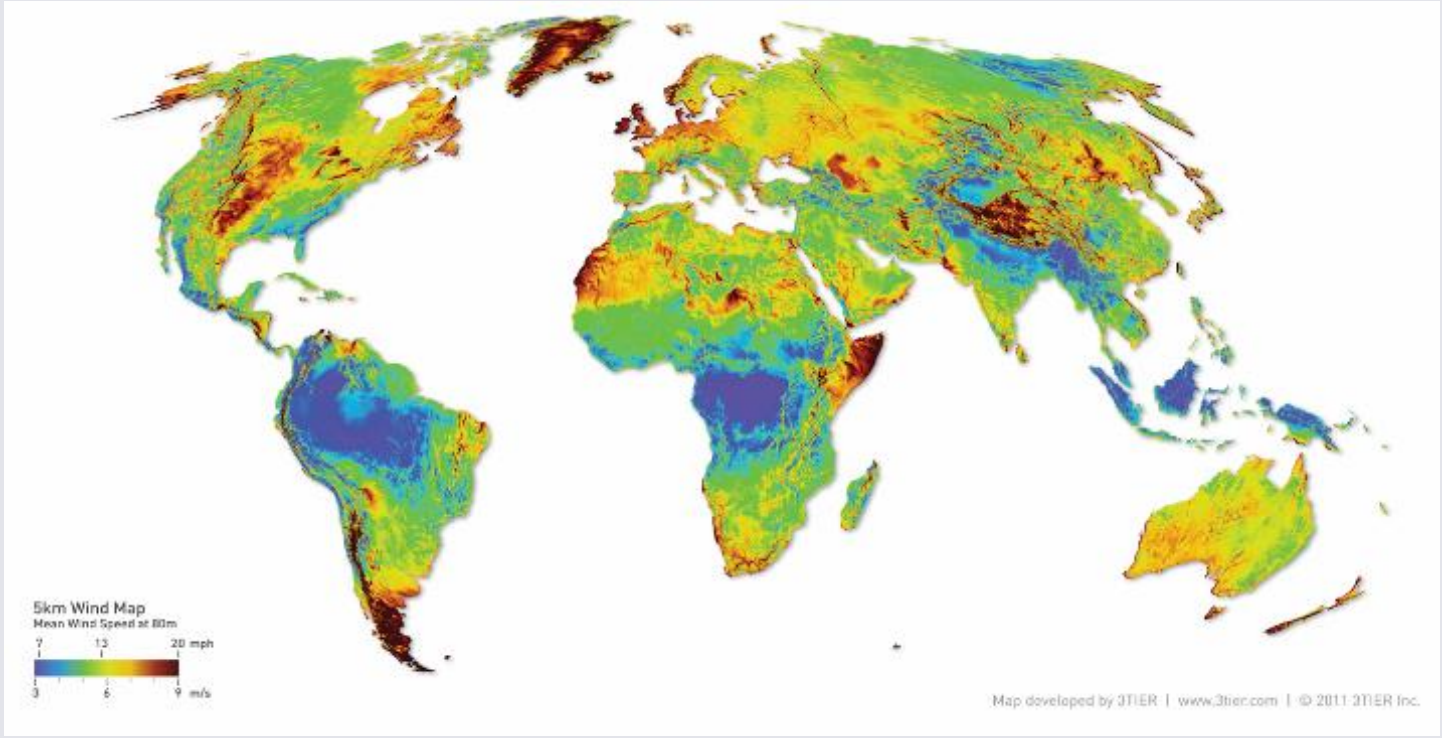
Share in global capacity additions 2001- 2013




IRENA (2014)

# There is wind available all over the world…

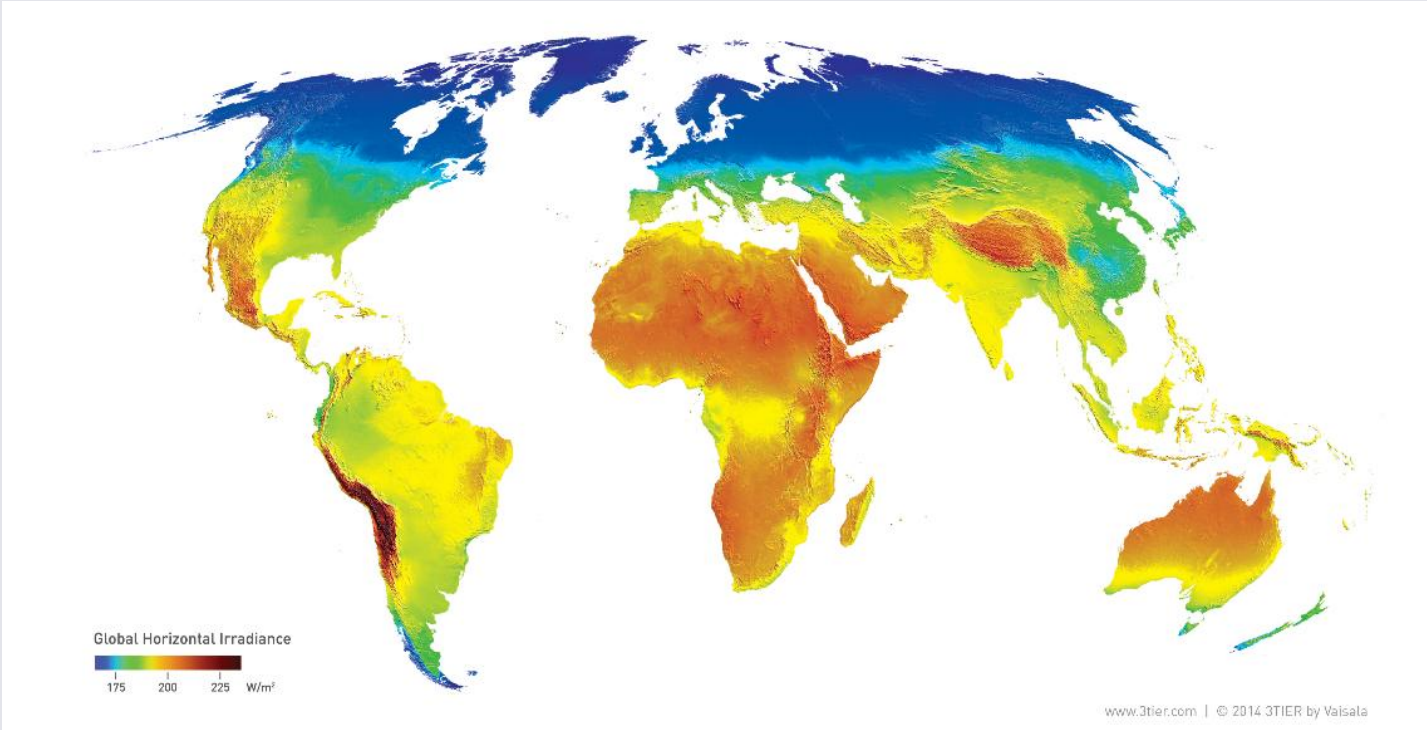
Average wind speed at 80m




3TIER (2011)

# …and almost everywhere there is more sun than in Germany!

Global horizontal irradiance




3TIER (2011)

# More information and studies available at our website www.agora-energiewende.org



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# Thank you for your attention!

Questions or Comments? Feel free to contact me:

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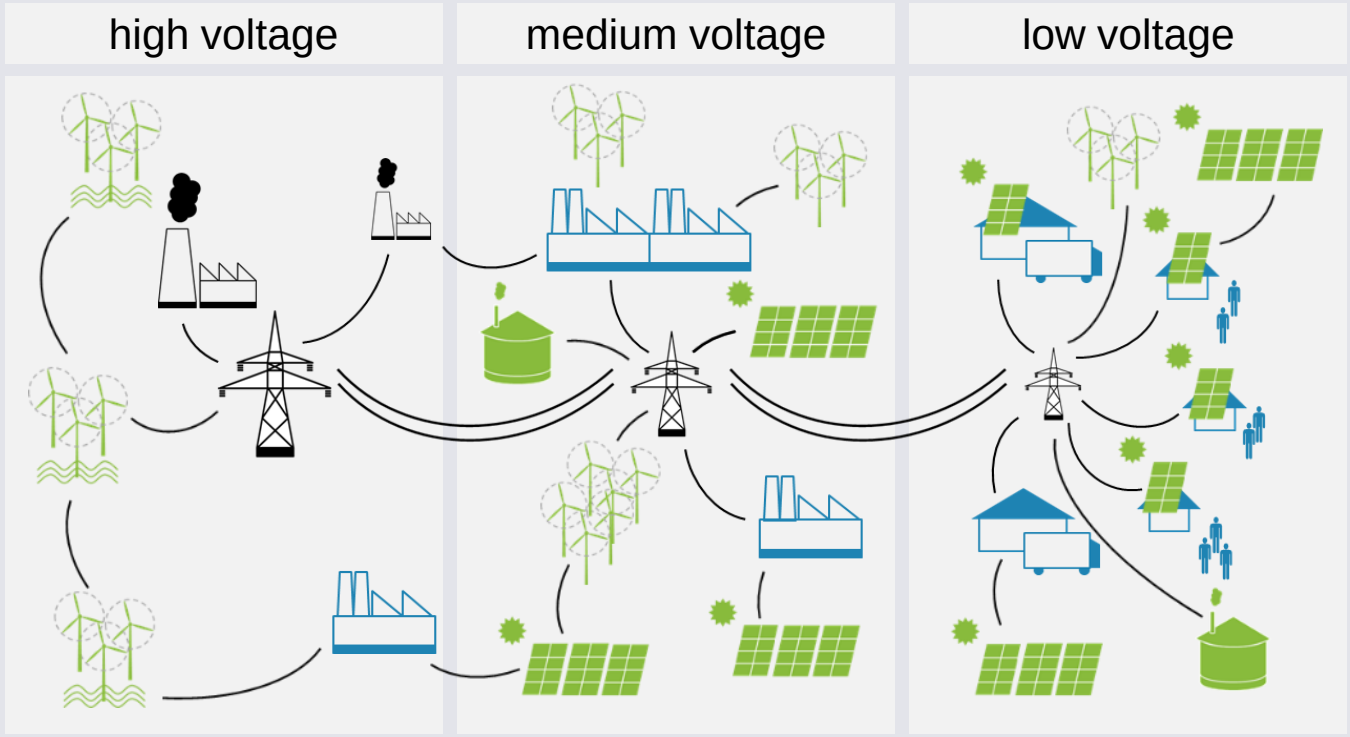
Agora Energiewende is a joint initiative of the Mercator Foundation and the European Climate Foundation.

# Insights from Germany´s Energiewende

***Backup***

# The Energiewende implies a new energy world – characterized by flexibility, decentralized structures and a wide variety of actors

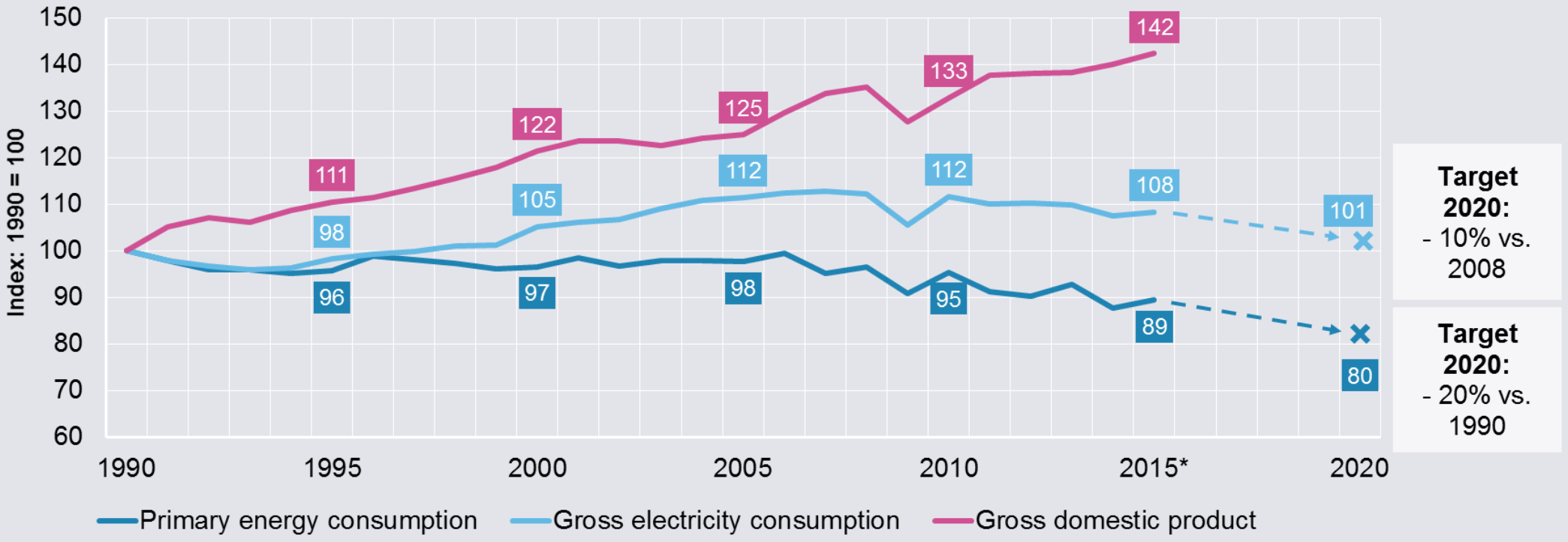
Illustrative visualisation of the old and the new electricity system




Own illustration

# Germany decoupled economic growth from energy consumption – but there is still work to do to reach the 2020 efficiency targets

Primary energy consumption, gross electricity consumption and GDP 1990 - 2015 and efficiency target 2020

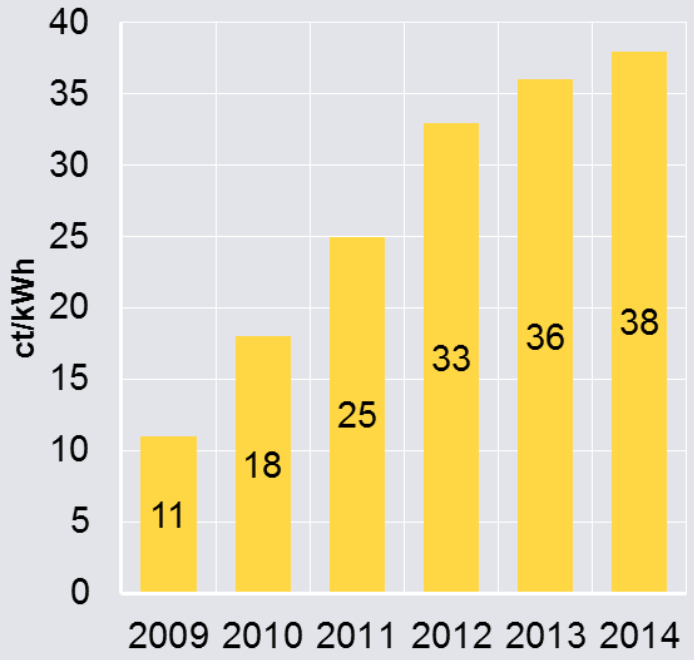



BMWi (2015) following AGEB (2016), AGEB (2015b), Destatis (2015c); BReg (2010)

* preliminary

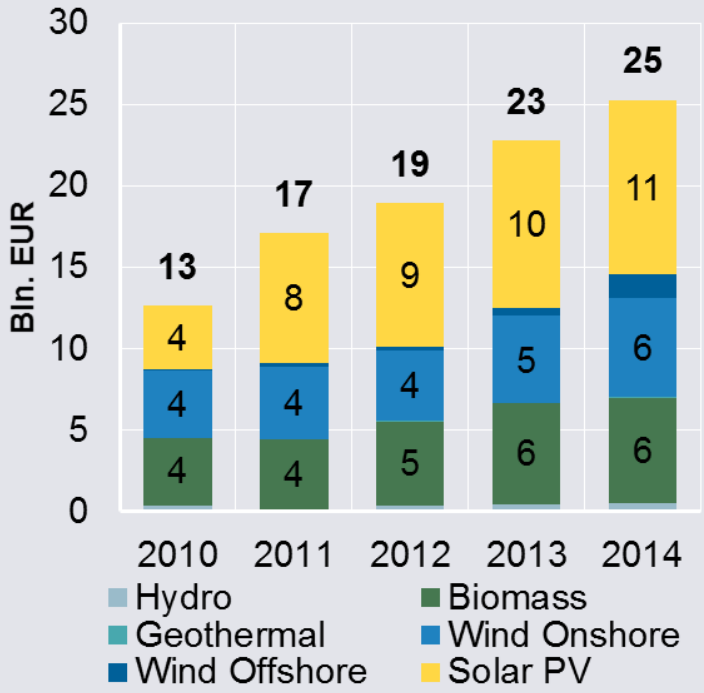
# The renewable cost increase was due to high solar PV capacity additions between 2009 and 2012 – at times when PV feed-in tariffs were still rather high

Installed PV capacity 2009 – 2014*



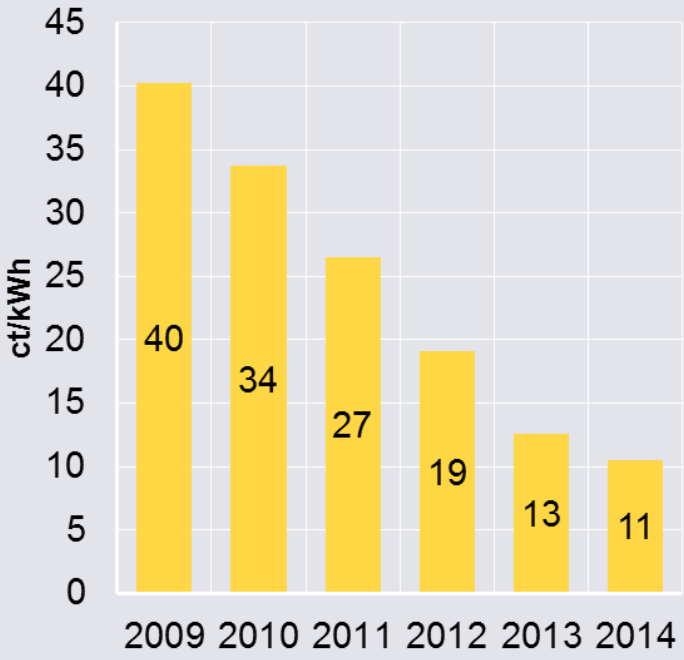

AGEE (2015) *end of the year

EEG cost 2010 - 2014




Öko-Institut (2015)

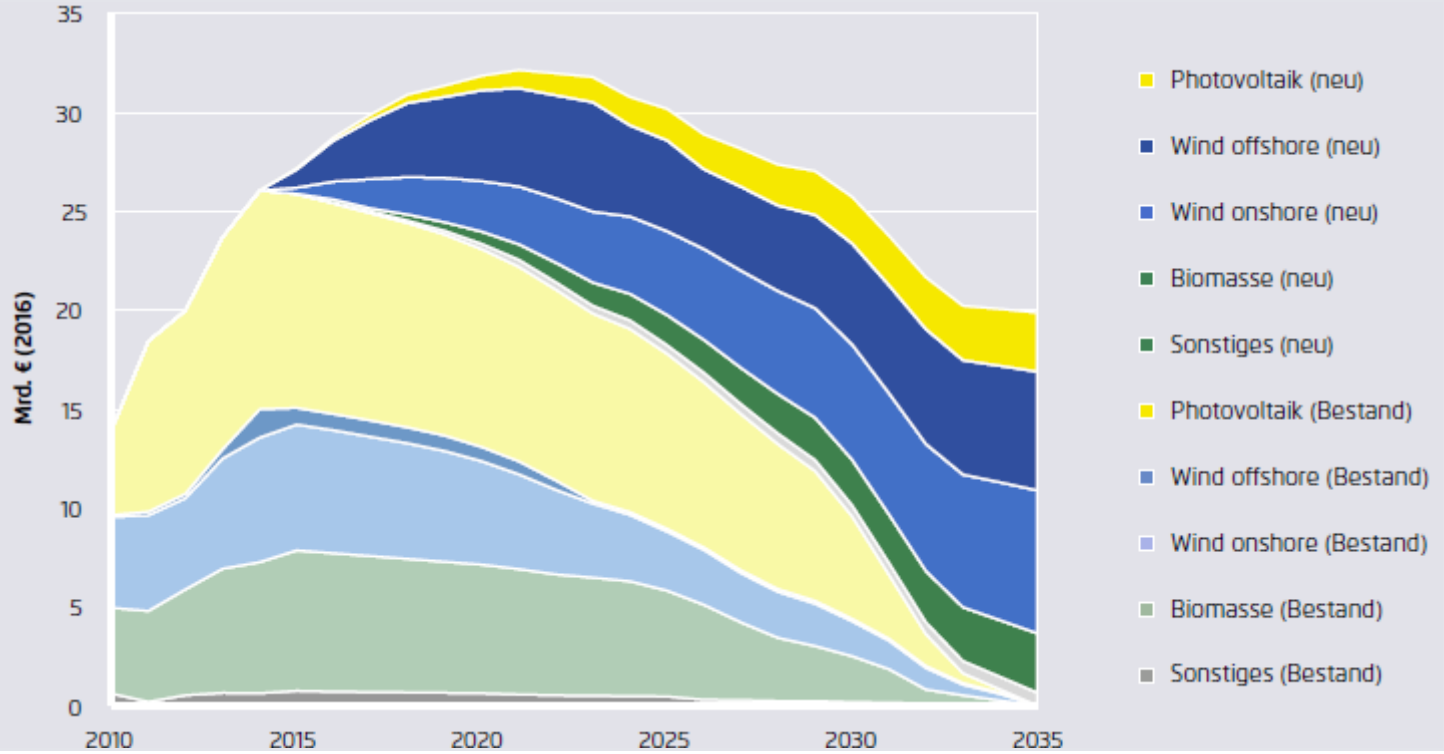
Average PV-remuneration 2009 – 2014*




ZSW (2014) *for new plants

# The initial investments in the energy transition are paying off after 2023 – in 2035 the EEG-surcharge is a lot lower than in 2015, but the share in renewables is doubled (around 60%)

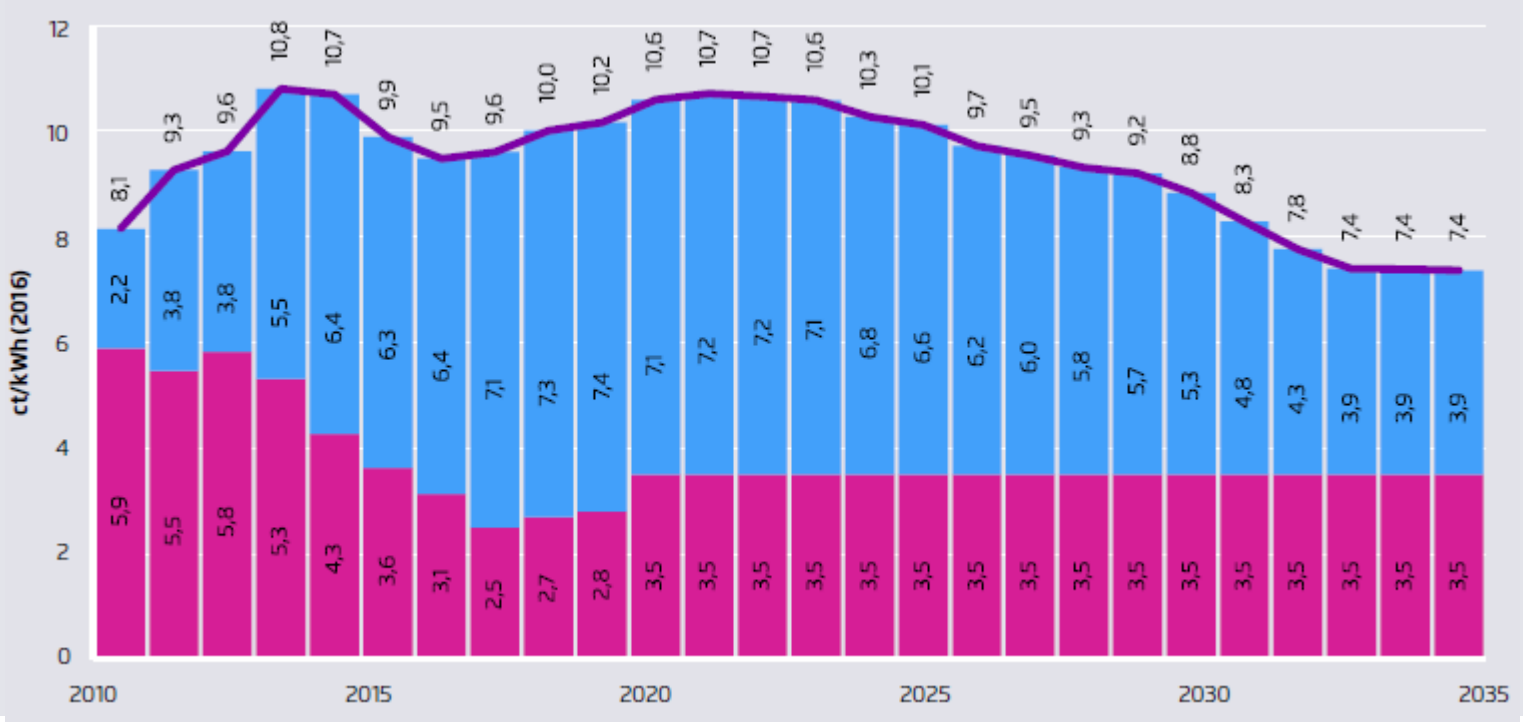
Yearly remunerations to renewable power plants 2010 - 2035




Agora Energiewende based on Öko-Institut (2016); Forecast as of 2016

# The initial investments in the energy transition are paying off after 2023 – in 2035 the EEG-surcharge is a lot lower than in 2015, but the share in renewables is doubled (around 60%)

Sum of wholesale electricity price (pink) and EEG surcharge (blue), 2010 - 2035




Agora Energiewende based on Öko-Institut (2016); Forecast as of 2017