Evaluating the costs and benefits of the German Energiewende

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Agora Energiewende – Who we are

Think Tank with about 40 Experts

Independent and non-partisan

Project duration 2012-2021
Mainly financed by
Mercator Foundation & ECF

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

Methods: Analyzing, assessing, understanding, discussing, putting forward proposals, Council of Agora

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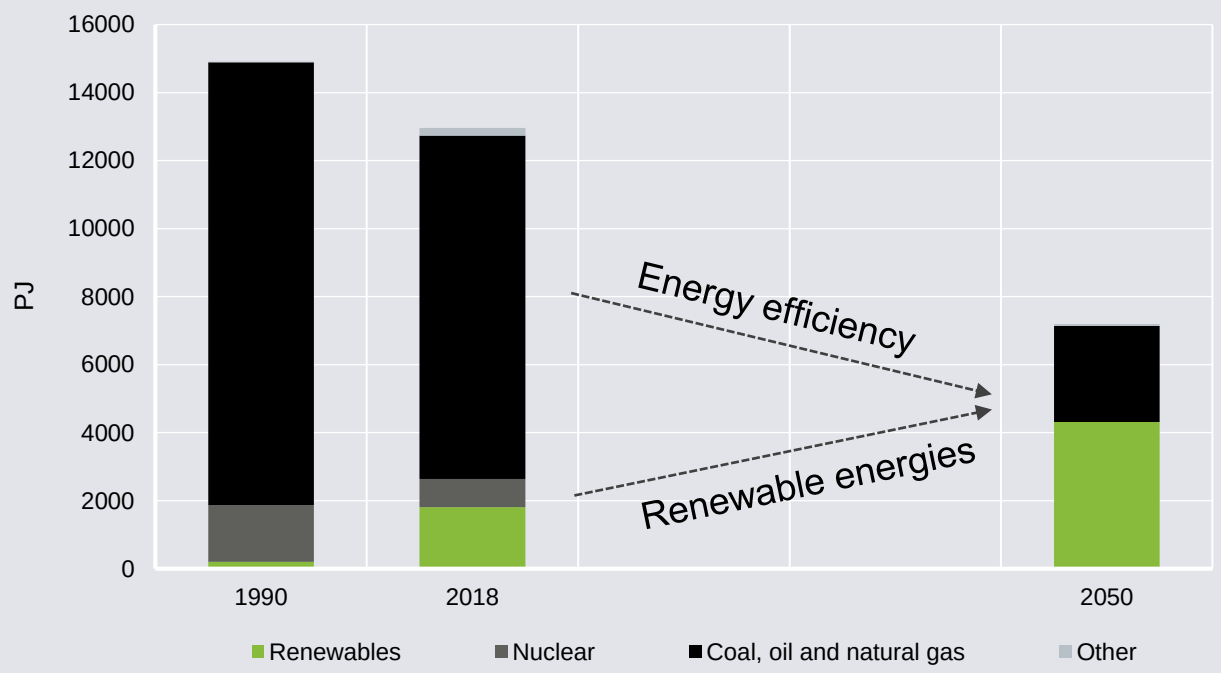
Where do we stand with the Energiewende?

The Energiewende is a long-term energy strategy, aiming to phase out nuclear power and reduce greenhouse gas emissions significantly

Primary energy consumption and minimum target 2050



AG Energiebilanzen, own calculations

Primary targets

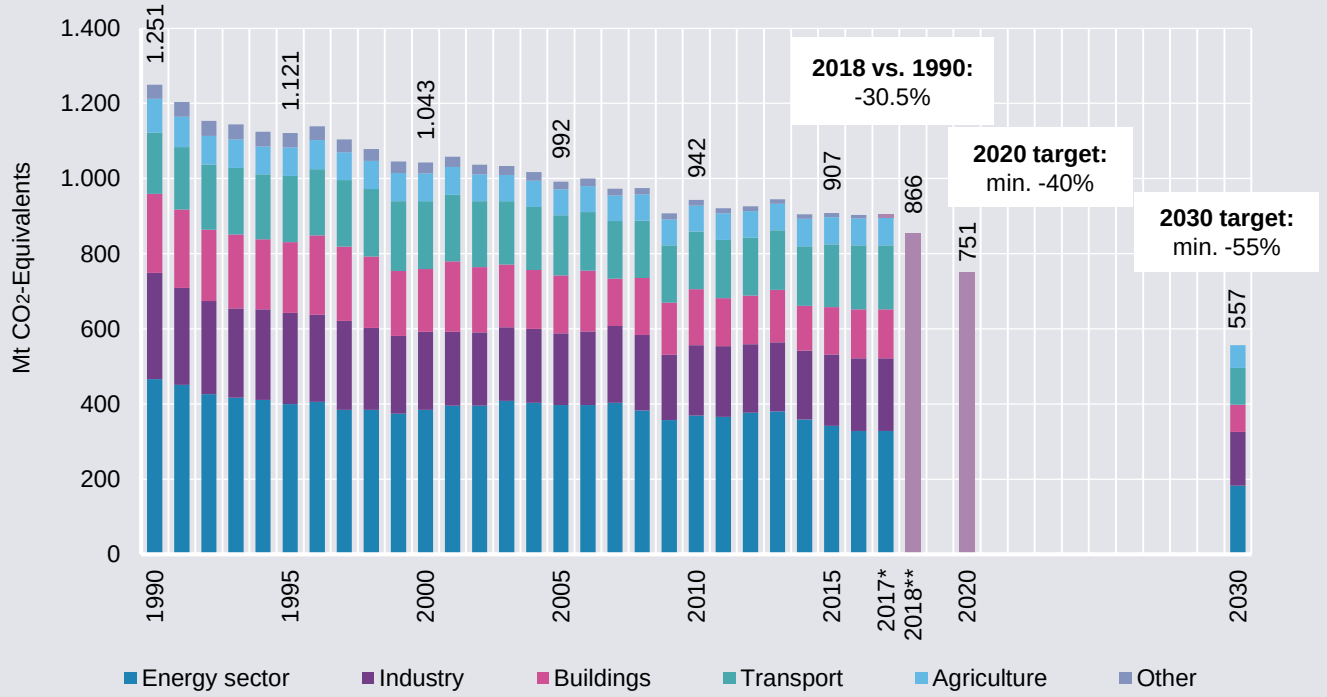
- **Climate mitigation:** Reducing greenhouse gas emissions until 2050 by 80 to 95% towards 1990 levels.
- **Nuclear phase out:** Shut down of all nuclear units by 2022.
- **Coal Phase-out:** Shut down of all coal-fired power plants by 2038

Secondary targets

- **Energy efficiency:** A 50% reduction in primary energy consumption by 2050 compared to 2008 levels.
- **Renewable energy:** Increasing the share of renewable energy in gross final energy consumption to 60% by 2050.

Germany must reduce its CO2 emissions by 25 $MtCO_2$ per year to reach its 2030 climate target and avoid paying out 30 to 60 billion euros penalties

Greenhouse gas emissions by sectors in Germany



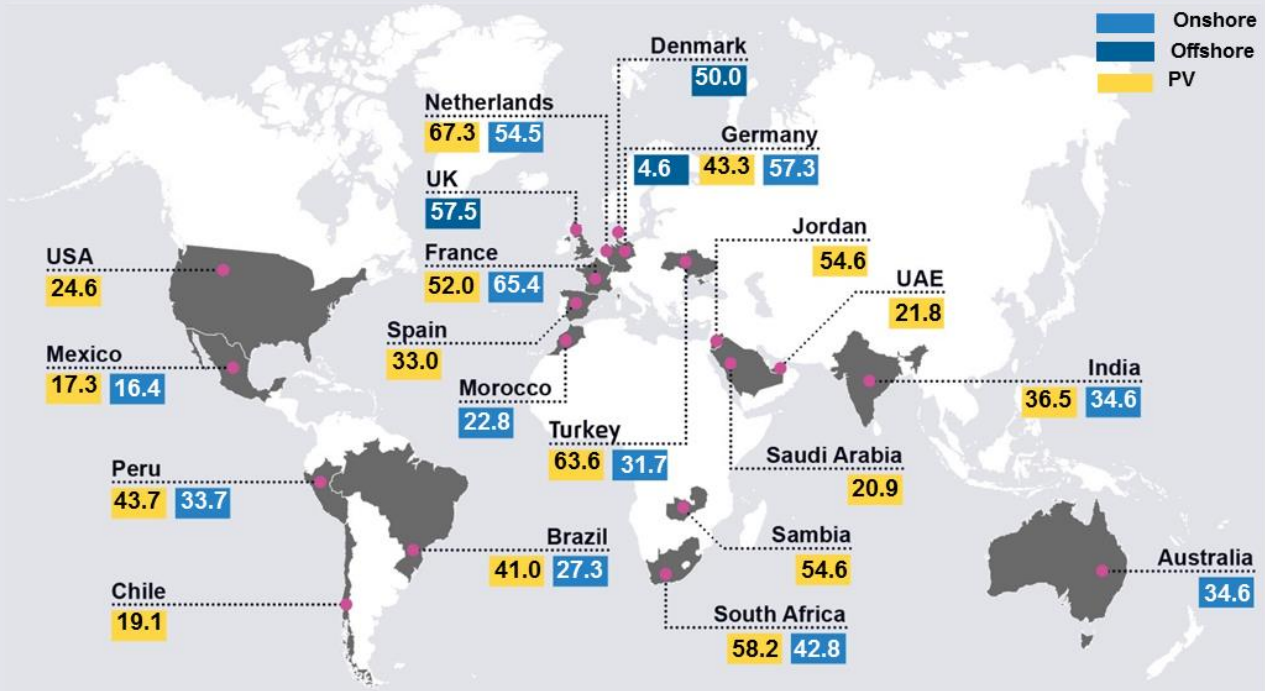
Umweltbundesamt, own calculations, *preliminary

- Germany is a large emitter of GHG (~11,4 tCO_{2eq} per capita, VS 7,1 $MtCO_{2eq}$ in France*)
- Emissions have declined slowly since 2005 (about -10 $MtCO_2$/an). The reduction was quicker over the period 1990-2000 after the reunification.
- In 2018 greenhouse gas emissions were reduced by 30.5% against 1990 levels – the 2020 climate target is basically out of reach
- Reaching the 2030 climate target (a reduction of THG by -55% against 1990) requires a strong political will. The coal phase-out is necessary but insufficient to meet 2030's targets.
- If Germany remains on its current trajectory, it will have to pay out 30 to 60 billion euros to other EU states over the next decade for carbon allowances to cover its excess GHG.

* European Environment Agency (2016, latest available data) without LULUCF

After a significant fall in costs of production, solar PV and wind energy are competitive with fossil fuel based power stations in multiple countries of the world.

Auction results/PPA 2016/17/18 in €/MWh



Representation of Agora Energiewende after BMWi, BNetzA, etc .; PPPs or minimum or average AO remuneration levels (for the EU)

- The most recent tenders have shown extremely low prices for solar PV and wind across the world.
- As a result, in many countries we see that the costs of production of solar PV and wind are lower than those of thermal power stations run on fossil fuels.
- In 2017, renewable energy accounted for 60% of new investments in energy production capacity.
- At the end of 2018, the worldwide installed capacity of photovoltaic and wind reached 509 GW and 600 GW respectively.

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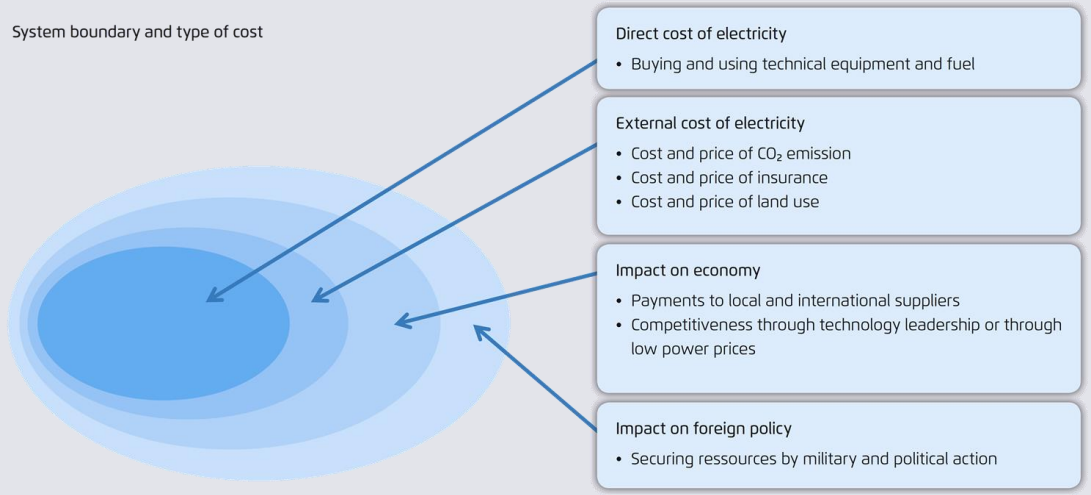
A meta-analysis of the costs and benefits of the Energiewende

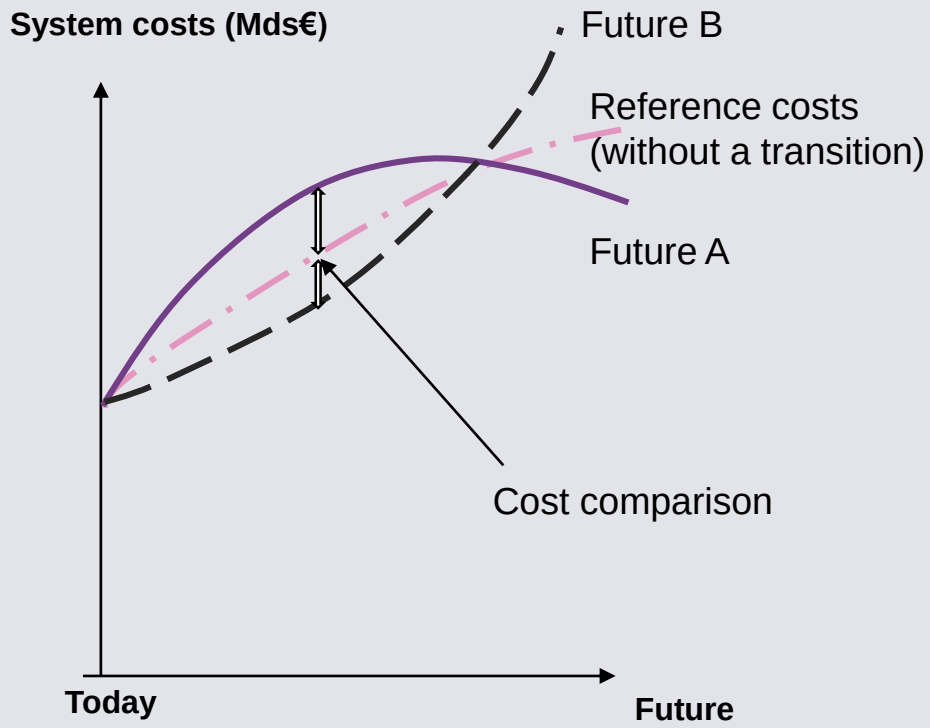
An objective definition of „costs“ is likely to be impossible : it depends on system boundaries and on the reference chosen

Overview of possible system boundaries and types of costs and benefits



Adapted from NEA (2012)

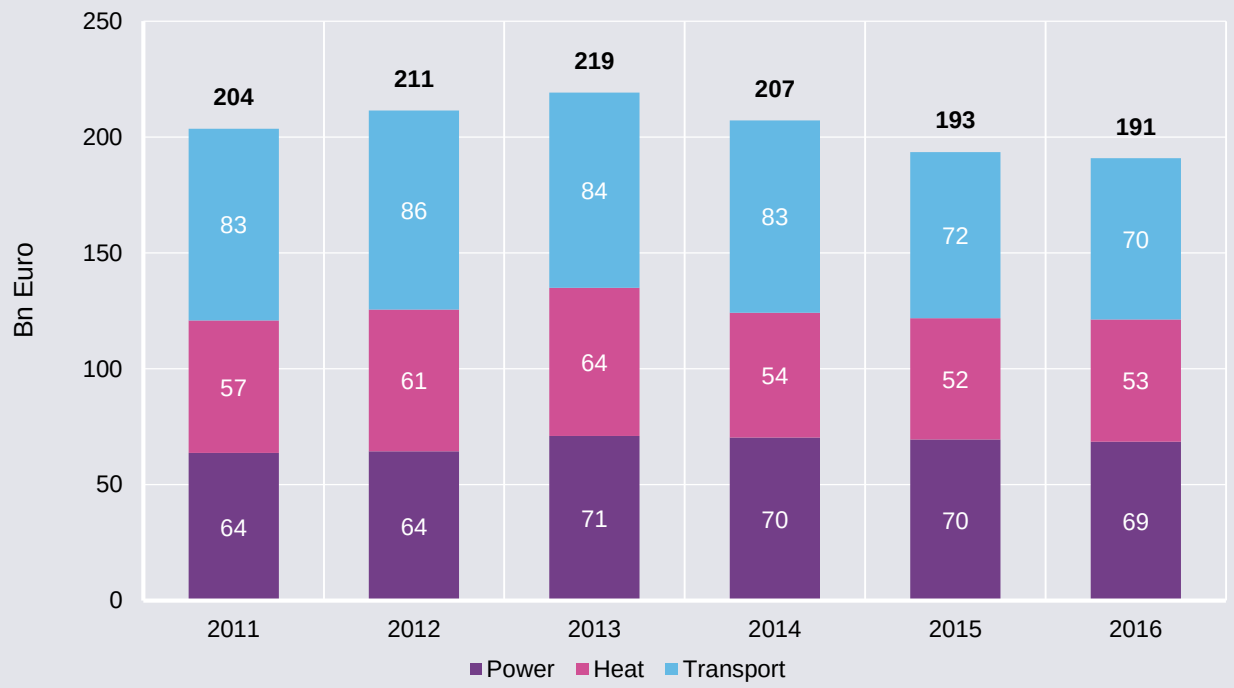
Illustration of possible present and future costs



Own illustration

Consumer spending gives an indication of historic costs for supplying and consuming energy. With about €200 bn per year, those spending have been relatively stable since 2011

Consumer spending on energy in Germany, 2011–2015



BMWi (2018)

- In Germany, between 2011 and 2015, consumer spending on energy is relatively stable at around €200bn. Consumer spending on energy demonstrates a downward tendency since 2013.
- In 2016, the consumer spending on energy accounted for roughly 6% of the GDP.
- A structural shift can be observed: while spending for fuel and heating decreased, those for power increased.
- The reasons for lower fuel and heating expenses are decreased world prices for oil and gas, while cost of renewables expansion have driven up power spending.

The additional costs of the energy transition in Germany has been analysed in several comprehensive studies*

		EWI, Prognos & GWS (2014)	Fraunhofer ISE (2015)	Fraunhofer IWES (2015)	Öko-Institut & Fraunhofer ISI (2015)	Öko-Institut (2017)
Method	Simulation	Modeling of German energy system + Quantification of total economic effects	Cost-optimized modeling of German energy system with hourly supply-demand balance	Cost-optimized modeling of German energy system with hourly supply-demand balance	Cost-optimized modeling of German energy system with hourly supply-demand balance + Quantification of total economic effects	Constrained cost-optimized modeling of German energy system with hourly supply-demand balance
	Scope	Power, Heat, Transport & Industry	Power, Heat, Transport & Industry	Power, Heat, Transport & Industry	Power, Heat, Transport & Industry	Power system only
	Scenarios	1 – Probable ET scenario; 2 – BAU scenario Exogenous RES capacities	1 – 8 ET scenarios: -80 to -90% CO_2 emissions in 2050; 2 – BAU scenario with same energy system between 2014-2050	Target scenario: -80% CO_2 emissions in 2050 for DE and EU	1 – ET scenario -80% CO_2 + Energiekonzept 2011; 2 – ET scenario -95% CO_2 + Energiekonzept 2011; 3 – BAU scenario 2012-2050	2 ET scenarios (95% RES); 2 BAU scenarios (RES discontinued)
	Period	2009-2020	2015-2050	(2025, 2035) 2050	2050	2050
Assumptions/ results	Electricity consumption	Endogenous 1 – 577 TWh in 2020 2 – 609 TWh in 2020	Exogenous 733 TWh in 2050	Exogenous excl. new usage: 415 TWh Endogenous incl. new usage: 793 TWh in 2050	Exogenous per scenario: 1 – 609 TWh 2 – 779 TWh 3 – 630 TWh in 2050	Exogenous 550 TWh in 2050
	CO_2 price	Exogenous 12,9€/t in 2011 4,6€/t in 2014 10€/t in 2020	Exogenous 10€/t in 2015 40€/t in 2020 100€/t in 2030-2050	Endogenous 180€/t in 2050	Exogenous per scenario 1 – 130€/t 2 – 200€/t 3 – 50€/t in 2050	3 scenarios in 2050: 20€/t 50€/t 103€/t

* EWI, Prognos & GWS (2014): Gesamtwirtschaftliche Effekte der Energiewende; Fraunhofer ISE (2015): Was kostet die Energiewende?; Fraunhofer IWES (2015): Geschaftsmodell Energiewende; Öko-Institut & Fraunhofer ISI (2015): Klimaschutzszenario 2050 – 2. Endbericht; Öko-Institut (2017): Renewables versus fossil fuels – comparing the costs of electricity systems. Study for Agora Energiewende

Despite differing assumptions, the five studies come to several similar conclusions

1. **The energy transition require considerable added investment, that remains manageable**
   - → Total added annual investment: €15-40bn (compared to gross fixed capital formation €700bn in 2018)
   - → ~ +5% investments compared to a world without energy transition

2. **If climate-related damage is valued at 50-60 €/tCO_2 or if the price of fossil fuels increases, energy transition will be cheaper**
   - → Additional investments required do not produce added costs, but added benefits

3. **Overall, energy transition has a slightly positive effect on the economy**
   - → Mainly thanks to efficiency measures decreasing the import of coal, oil and gas and stimulating GDP

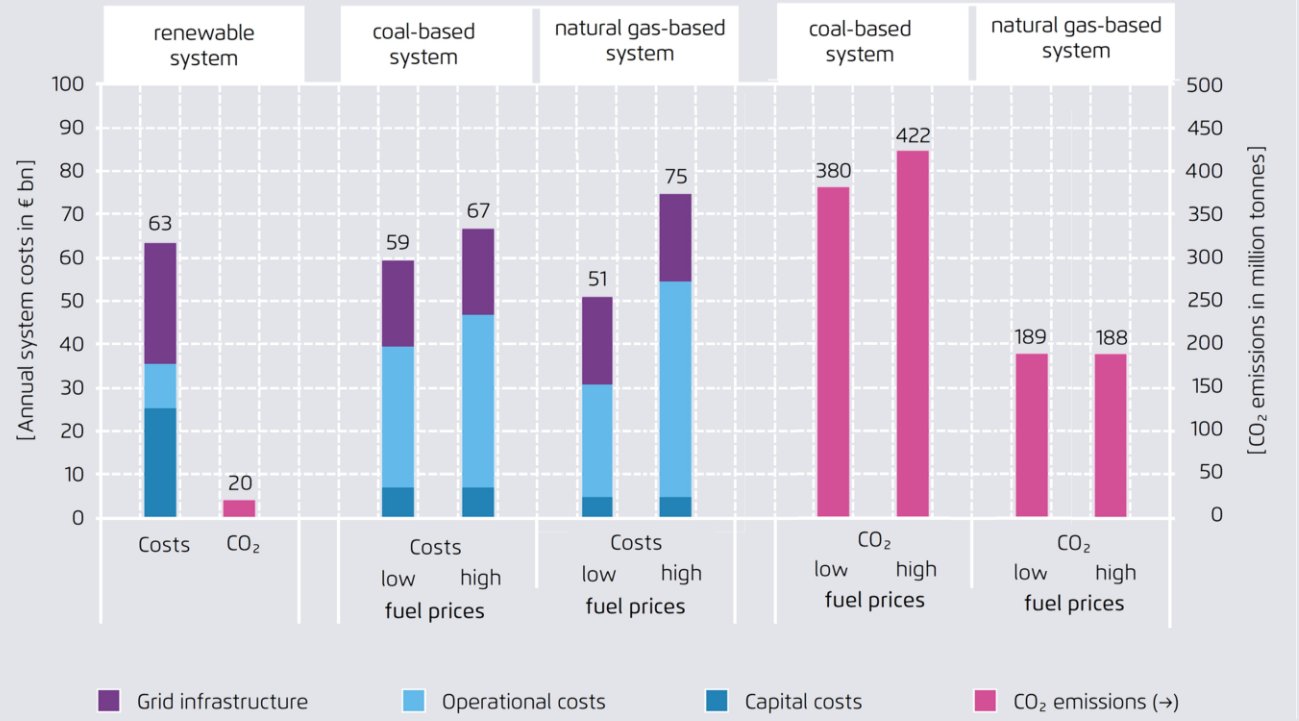
4. **Additional positive effects could be expected from the exports of Energiewende technologies** – but none of the studies integrates them

5. **Cost of capital has a massive effect on the total expense of the energy transition**
   - → Technologies used in the energy transition have low operating costs but high investment costs
   - → Decisive role of the rate of return

6. **Previous financial commitments from launching renewables will put a strain on consumers until 2022-2023**
   - → Sum of the wholesale price and the EEG surcharge will fall until 2035, although the share of RES will have more than doubled

If climate-related damage is valued at 50-60 €/tCO_2 or if the price of fossil fuels increases, energy transition will be cheaper

Comparison of total system costs of predominantly renewable (95%), coal and natural gas-based power systems with a CO_2 price of €50 in 2050

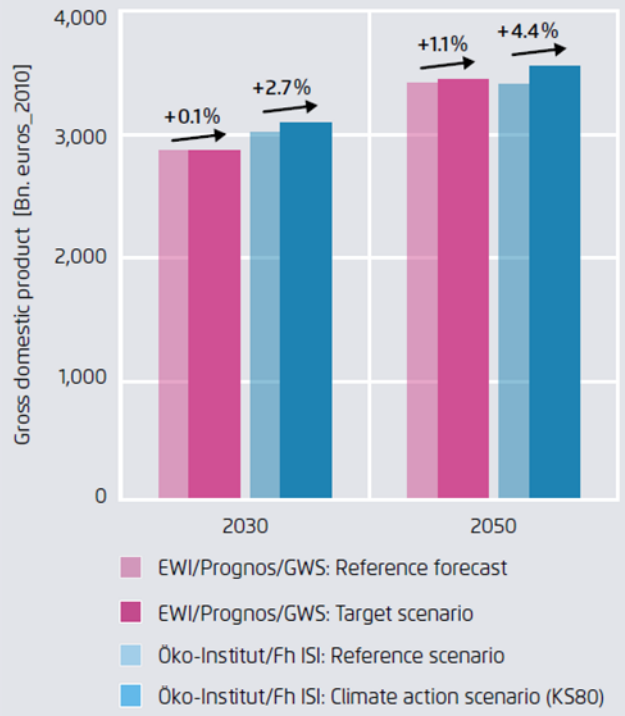


Öko-Institut (2017)

- → Our assessment for Germany shows that – under a range of sensitivity analysis - the Energiewende represents the least-cost option with €50 to €60 per tonne of CO_2 or with increasing commodity prices
- → A RES-based system insulates the economy against volatile commodity prices. Variable costs (largely for fuel and CO_2) account for 30-67% of the total costs of the fossil-based systems. By contrast, variable costs represent less than 10% of costs in the RES-based systems.
- → A power system with a 95% share of RES reduces CO_2 emissions by 96% (against 1990 levels) at a CO_2 price of about 50€/t. A RES based energy transition can thus be considered efficient climate policy, as CO_2 damage costs are estimated a lot higher

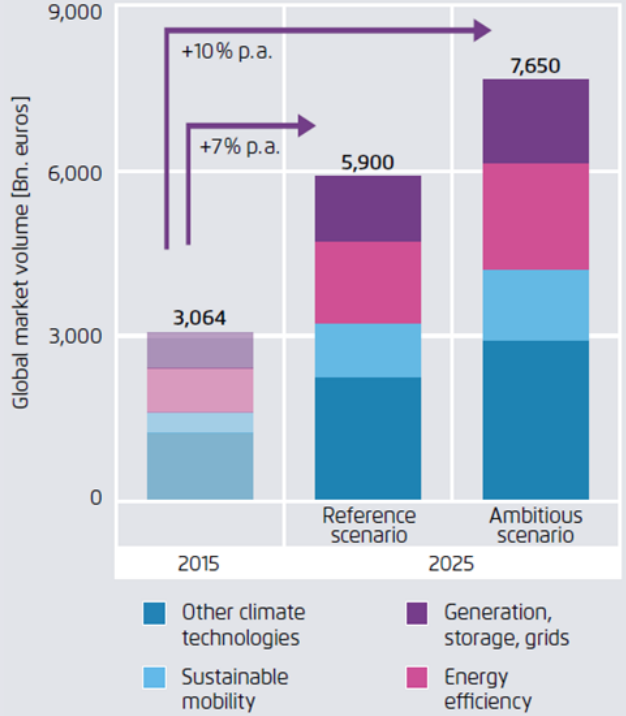
A broader macro-economic assessment puts in perspective costs of the energy transition with its benefits. Overall, energy transition has a slightly positive effect on the economy.

Impact of different scenarios on GDP



Agora based on EWI/Prognos/GWS (2014a), Öko-Institut/Fraunhofer ISI (2015)

Impact on global market volume



Agora based on Roland Berger (2017)

- The German Energiewende in 2030 and 2050 brings a slightly positive effect on the economy (+0,1% to 2,7% GDP increase in 2030; +1,1% to 4,4% in 2050), especially because the national efficiency gains reduces/replaces coal, oil and gas imports.
- Additional effects are expected through globally rising export markets for energy-related technologies (they were not considered in the scenario-based assessments).

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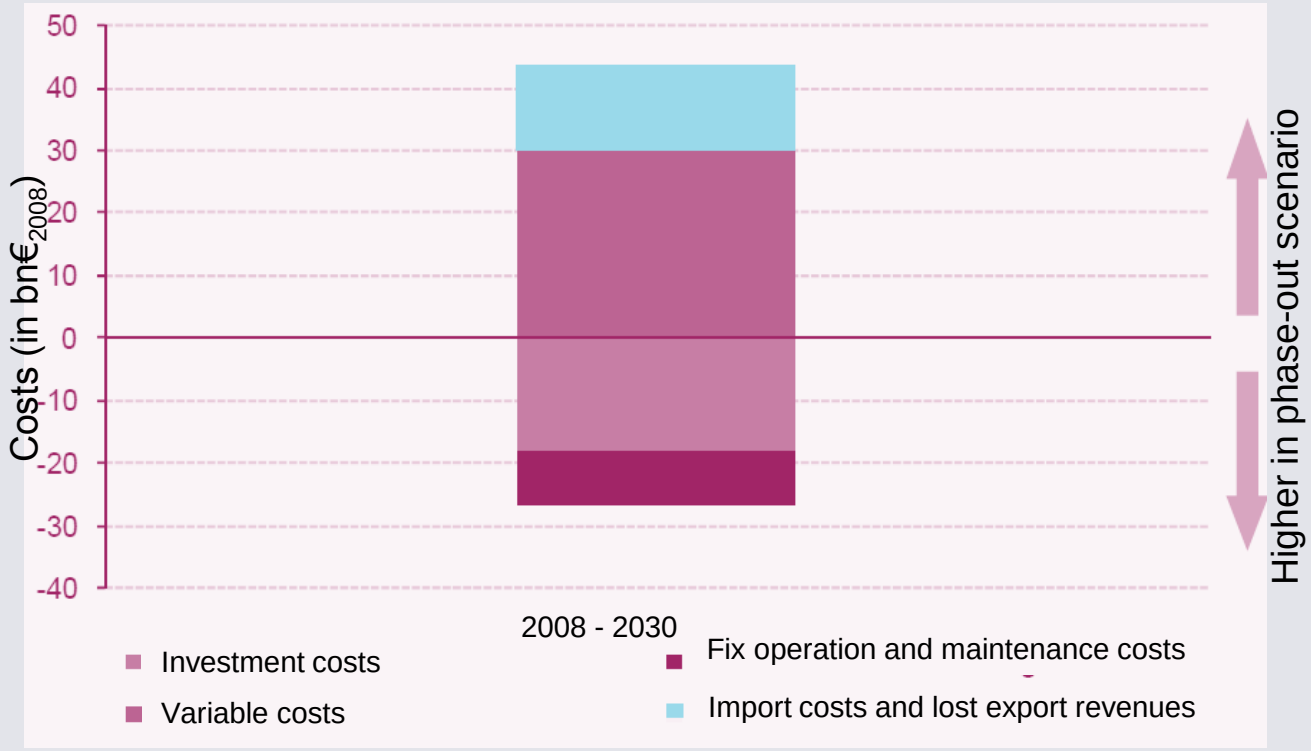
The additional costs of accelerated phasing-out of nuclear and coal power

An accelerated nuclear phase-out in Germany leads to additional cumulated costs of electricity production of about 16 bn€$_{2008}$ until 2025

Cumulated difference in electricity production costs between a phase-out scenario and a scenario with prolonged nuclear capacities in bn EUR$_{2008}$



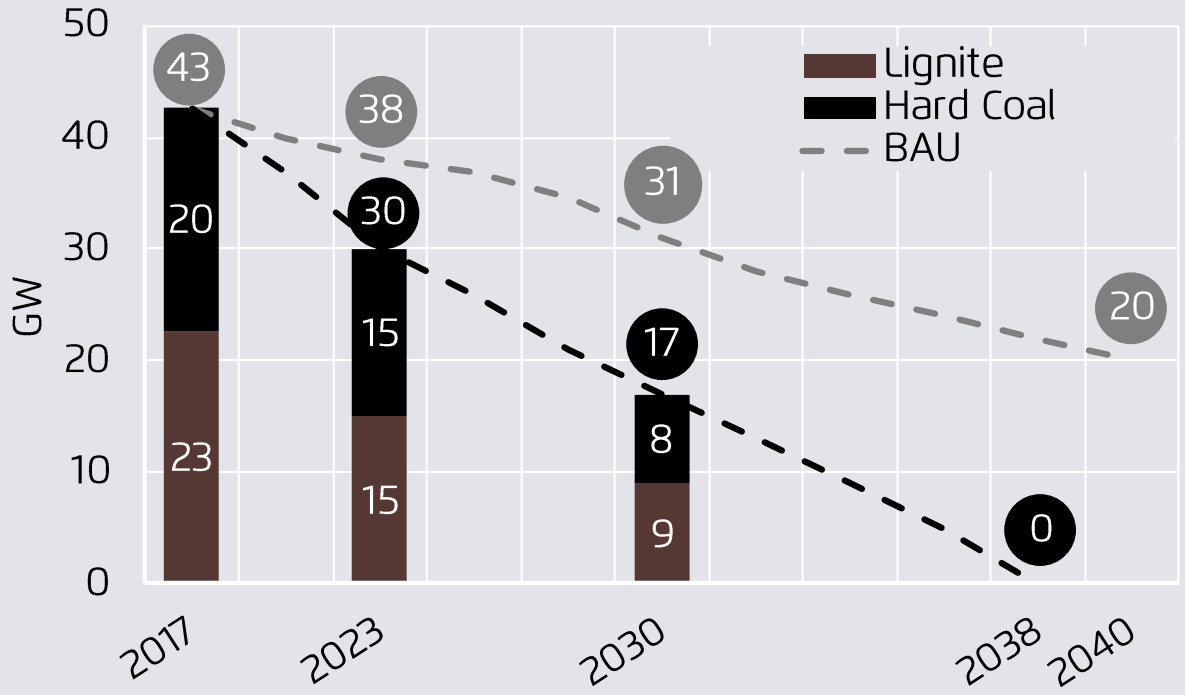
Prognos, EWI, GWS Energieszenarien 2011

- The accelerated nuclear phase-out* is compared to a reference scenario with life-time extension of nuclear reactor (+ 8 to 14 years) resulting in 12,7 GW nuclear in operation in 2030 (against 21 GW in 2008)
- The nuclear phase-out scenario costs 16,4 bn€ more than the life-time extension scenario: increased variable costs (nuclear compensated by gas and hard coal-fired generation) but lower investment costs (no life-time extension)
- Cost borne by consumers increases by 32 bn€2008 through price increase (including multiplicative effect from VAT) despite a slight decrease of EEG levy.
- The ETS CO_2 price is 1 to 2 EUR$_{2008}$/tCO_2 higher in the phase-out scenario by 2030

* Phase-out scenario: Immediate decommissioning of old plants; 9 reactors (12,7 GW) in operation in 2015; 3 reactors (4,3GW) in 2020; phase-out by 2022

In January 2019, the Commission “Growth, Structure Change and Employment” agreed upon a coal phase-out plan that could cost between 3,5 and 5 bn€ a year to the federal budget

Capacity development along the phase out plan and in the business as usual



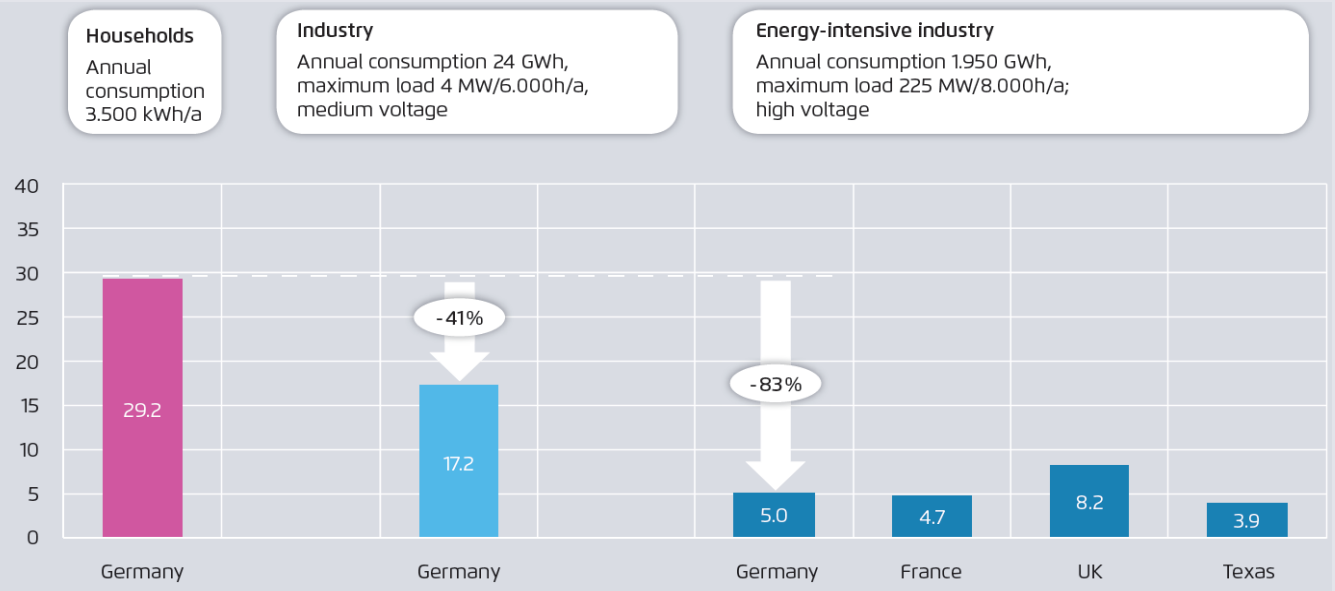
Aurora Energy Research, Kommission WSB

- The 2038 phase-out plan (at the latest) allows Germany to achieve medium and long term climate targets. However, these targets are still not compliant to a fair contribution as defined by the Paris Agreement
- The costs of the coal-phase-out plan for the federal budget is still uncertain but is estimated at 69-93 bn€ by 2038 (3,5-5 bn€ per year, 1-1,4% of the total federal budget) :
- **40 bn€:** support to the coal mining region
- **5-10 bn€:** compensation to power producers for the early retirement of coal power plants
- **4-7 bn€:** compensation to employees of coal companies (early retirement)
- **16 bn€:** compensation to electro-intensive
- **3-4 bn€:** cancellation of CO2 certificates

Some views on cost distribution

The distribution of the costs vary strongly between different economic agents

Average electricity prices for households and industrial consumers in 2013

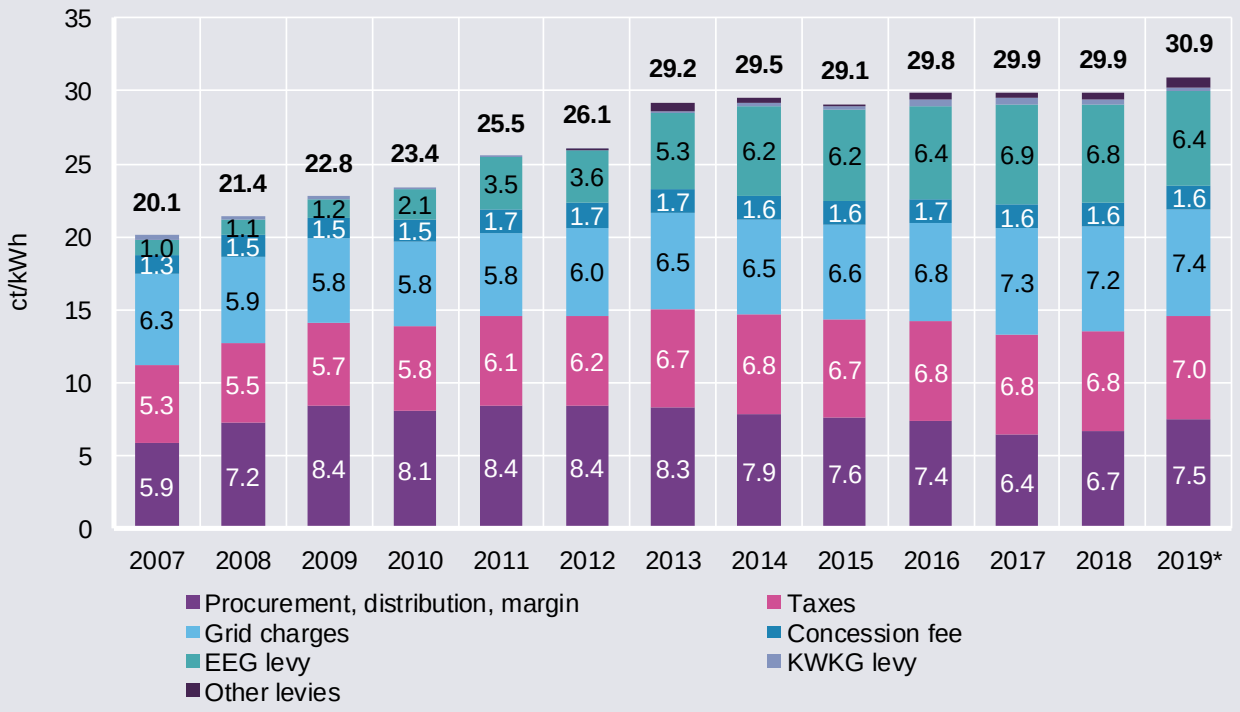


Agora based on BNetzA &Ecofys/ISI, Strompreise und ihre Komponenten (2014)

- Electricity prices for German households, currently about 30 cts€/kWh, are the second highest in the EU, behind Denmark
- While small German industrial consumers (consumption below 20 MWh) pay one of the highest retail prices in EU, German energy-intensive industries pay one of the lowest
- The energy intensive industries (steel, aluminum, cement) pay almost no taxes and levies (pro kWh consumed) in order to preserve their international competitiveness.
- In 2019, about 2000 companies in Germany benefited from this situation. They represent about 25% of the national consumption, but pay only 2% of the costs for supporting renewables (average EEG levy of 0,38 cts/kWh VS 6,4cts/kWh for other consumers)

Consumer prices have increased over the years, mostly due to the increase in grid charges and the EEG levy

Average household electricity prices in a 2500-5000 kWh/year household

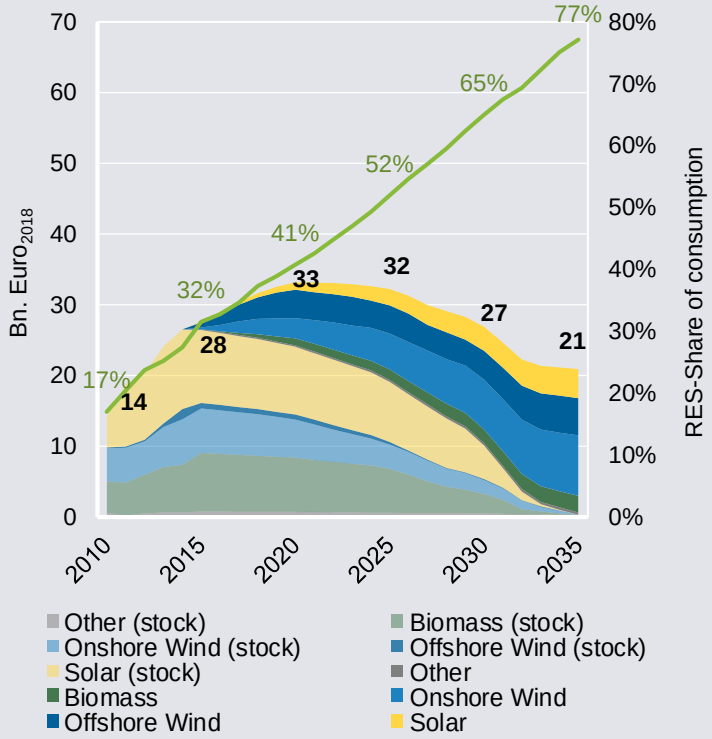


BNetzA, *own estimations

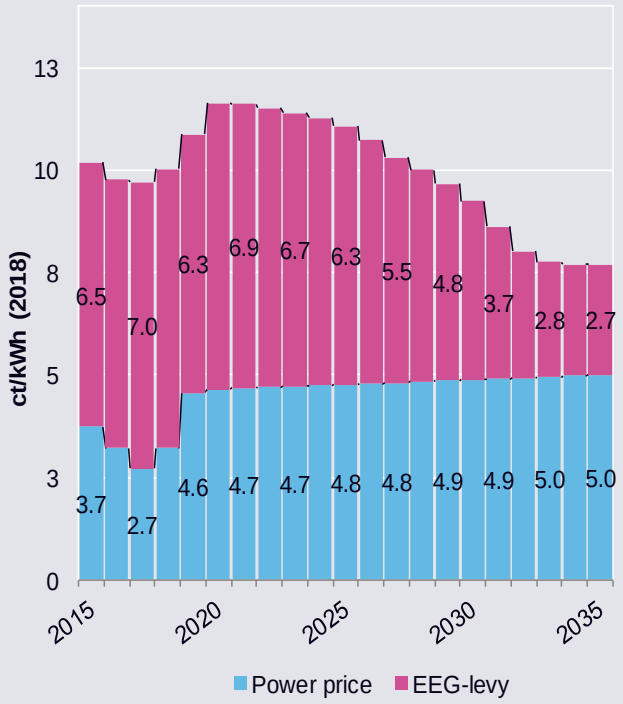
- In contrast to wholesale prices, household prices have increased almost every year since 2007. However the increase has flattened since 2013.
- Beside an increase in procurement costs, the grid charges have also risen during the last 10 years due to grid expansion and the integration of RES (redispatch and curtailment measures).
- The grid connection costs for offshore wind power plants will be included in the offshore wind levy, which will therefore also increase.
- The other price elements have remained stable.

Cost challenge in the power sector: Overcoming the „cost hill“ between 2018 and 2025

Total remuneration for RES-operators



Wholesale prices and EEG surcharge



Calculations by Agora Energiewende, based on Öko-Institut

- In the middle of the 2020s, the costs of RES will decline, while simultaneously, the RES share in gross power consumption will increase. The main challenge is to overcome this “cost hill”
- Reasons:
  - RES power plants become cheaper.
  - In 2021, a high number of old plants will exit the support scheme, as they will have reached the maximum support period of 20 years.
  - A stronger effect of the emissions trading system makes power generation from fossil fuels more expensive.

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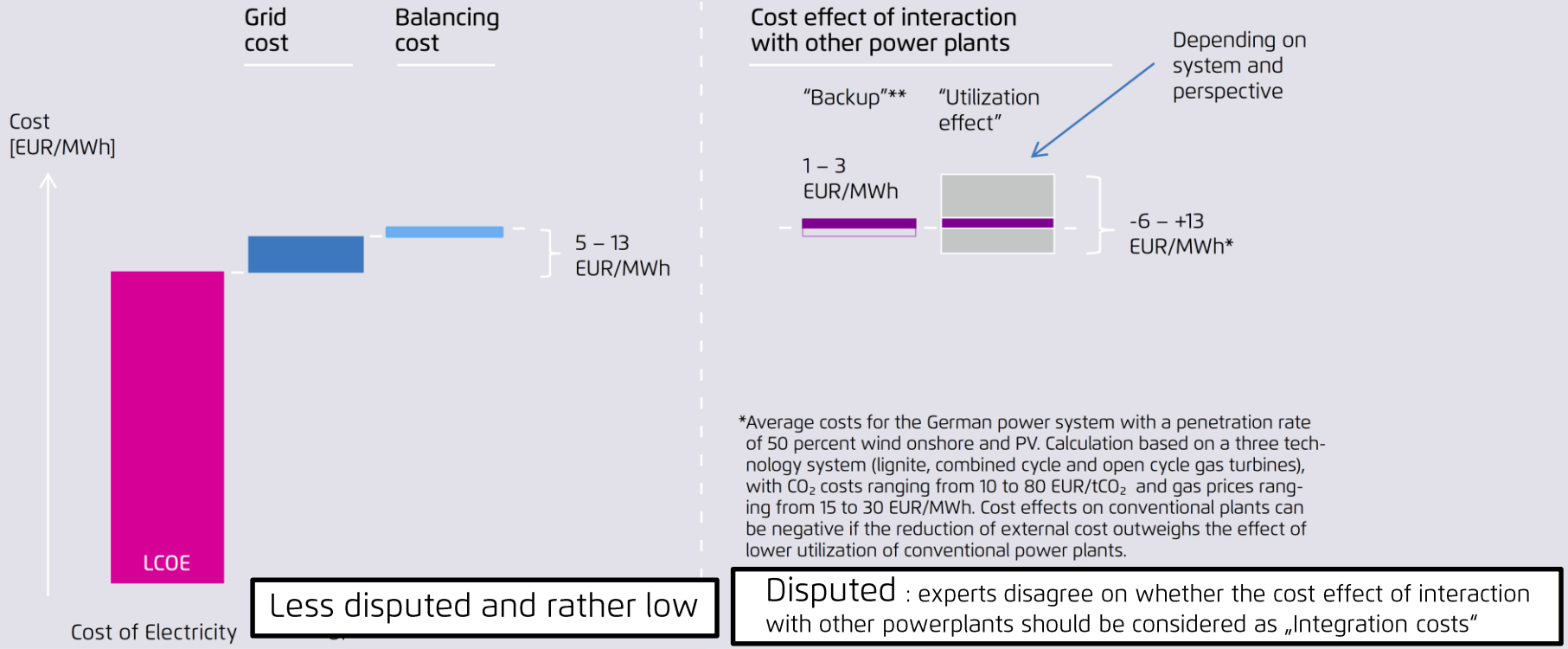
Evaluating cost causation in a system in transition : an elusive task?

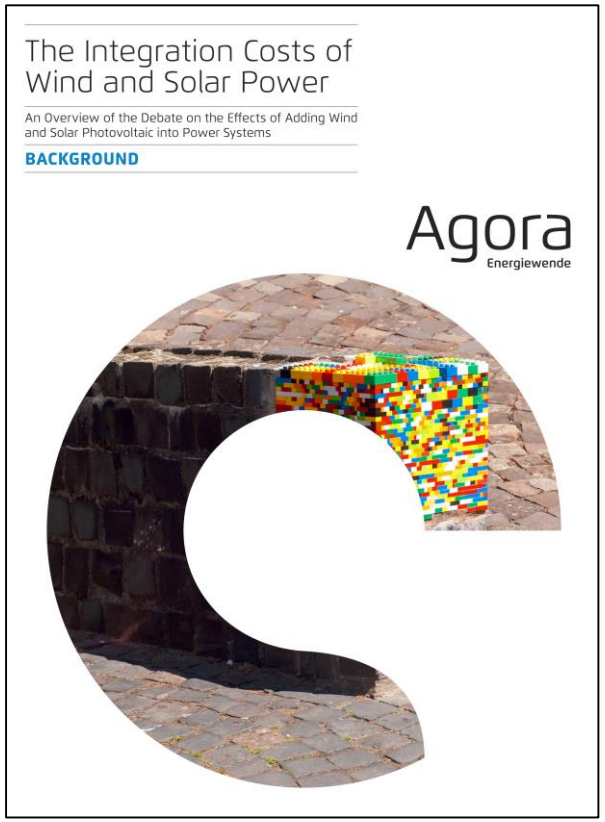
Cost causation – from total costs to integration costs : an elusive task?

Overview of components discussed under “integration costs” of renewables for the German system with ~50% variable renewables



Agora Energiewende (2015)

Key findings of the Study : the Integration Costs of Wind and Solar Power



1	**Three components are typically discussed under the term "integration costs" of wind and solar energy: grid costs, balancing costs and the cost effects on conventional power plants (so-called "utilization effect").** The calculation of these costs varies tremendously depending on the specific power system and methodologies applied. Moreover, opinions diverge concerning how to attribute certain costs and benefits, not only to wind and solar energy but to the system as a whole.
2	**Integration costs for grids and balancing are well defined and rather low.** Certain costs for building electricity grids and balancing can be clearly classified without much discussion as costs that arise from the addition of new renewable energy. In the literature, these costs are often estimated at +5 to +13 EUR/MWh, even with high shares of renewables.
3	**Experts disagree on whether the "utilization effect" can (and should) be considered as integration costs, as it is difficult to quantify and new plants always modify the utilization rate of existing plants.** When new solar and wind plants are added to a power system, they reduce the utilization of the existing power plants, and thus their revenues. Thus, in most cases, the cost for "backup" power increases. Calculations of these effects range between -6 and +13 EUR/MWh in the case of Germany at a penetration of 50 percent wind and PV, depending especially on the CO_2 cost.
4	**Comparing the total system costs of different scenarios would be a more appropriate approach.** A total system cost approach can assess the cost of different wind and solar scenarios while avoiding the controversial attribution of system effects to specific technologies.

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