The German Energy transition
State of Play

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Discussion Points

- Frame and Motivation for energy transition
- Policies and Measures
- Challenges & Opportunities
- Costs
- Nuclear phase-out
- Some Myths around the energy transition
- Way Forward – Revision of the EEG
Milestones of the *Energiewende*

Germany is part of an integrated European energy and climate strategy.
Motivation for the German Energy Transition (Energiewende): Previous energy business as usual was not sustainable, would cause huge economic and ecologic damage, therefore:

Three target areas of the Energiewende

Affordability, reliability and environmental protection are interlinked.
Long Term Scenarios and cost/benefit Strategies underlay targets and measures of the energy transition

- Multi-year modeling and simulation
- All technology sectors:
  - Electricity
  - Transportation
  - Heating
  - Combined Heat and Power
  - Energy Storage – Power to Gas
- Economic and demographic inputs:
  - 10% decline in population by 2050
  - 40% increase in GDP by 2050
  - Moderate fossil fuel price increases
- Scenario 2011A – middle scenario:
  - 50% market adoption of electric vehicles
  - Hydrogen as a renewable energy storage medium
  - Other scenarios varied by rate of adoption of electro/gas-mobility and storage for renewables.
The Concept of the Energiewende

Three pillars of the Energiewende

- Renewable energy
  - Renewable Energy Sources Act
  - National Climate Initiative
  - Market Incentive Programme
  - Steady growth
  - Cost-efficient
  - Environmentally friendly

- Energy efficiency
  - Energy Saving Ordinance
  - Reduce energy consumption
  - Improve efficiency

- Future grid
  - Grid Expansion Acceleration Act
  - Federal Requirement Plan
  - Increase flexibility
  - Enlarge capacities
  - Integrate renewables

Switch to renewables, halve energy consumption and upgrade grids.
Energiewende targets until 2050
and progress made so far

<table>
<thead>
<tr>
<th>Sector</th>
<th>Target 2014</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
<th>2040</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate</td>
<td>-26.4%</td>
<td>-40</td>
<td>-55</td>
<td>-70</td>
<td>-80 to -95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renewable Energies</td>
<td>27%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>-3.3%</td>
<td>-20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-50</td>
</tr>
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</table>

Germany has set ambitious targets in all sectors and is partly on track.

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Trends in gross German electricity production

The renewables share in electricity production tripled within ten years.

RE are now biggest source of electricity
The nuclear energy act foresees the shut down of all nuclear power plants by 2022 with renewables more than replacing their generation.

Gross electricity production by nuclear and renewable sources 1970 – 2025 in TWh

- Nuclear
- Renewables

Key events:
1. Nuclear Phase-Out Law
2. Revision of phase-out law
3. Fukushima
4. Start of the Anti-Nuclear Movement

Since 2001, Germany has produced more electricity than it uses. Usage has been decreasing since 2007, and in 2014 was below the level last seen in 2000.
Germany decoupled economic growth from energy consumption – but there is still work to do to reach the 2020 efficiency targets

Energy productivity and consumption and economic growth 1990 – 2014 (Index, 1990=100)

AG Energiebilanzen (2014), BMWi (2014)
Wind Energy has become a mature technology, with windmills of 2-3 MW being standard

Cost breakthrough in solar PV reduced cost by ~70% since 2006

Average system price for new roof-mounted PV in EUR/kWp

BSW Solar (2014), own calculations

* only Q1 2014
Today, wind and solar are already cost competitive to all other newly built conventional energy sources

Range of levelized cost of electricity (LCOE) in 2015 in EUR/MWh

- **Wind**: 80 EUR/MWh
- **PV**: 60 EUR/MWh
- **Lignite**: 100 EUR/MWh
- **CCGT**: 70 EUR/MWh
- **Coal**: 50 EUR/MWh
- **Nuclear**: 120 EUR/MWh

Agora Energiewende (2015)
Ownership structure of German RES facilities in 2012

- private investors: 35%
- farmers: 11%
- project developers: 14%
- industry: 14%
- utilities: 12%
- funds and banks: 13%
- contractors and others: 1%

Renewable installations create multiple opportunities for new entrepreneurship.

Source: trend:research 2013
The Challenge No. 1:

Saving potential of buildings

The Energiewende can only be successful if existing buildings are included.
The Challenge No.2: New (and smart) Infrastructure

- 2013 Network Development Plan led by Federal Network Agency
  - Identified need for over 3800 km of new transmission (HVDC)
  - Financing mechanisms in development
- Grid Expansion Acceleration Act (NABEG)
- Additional efforts on energy storage:
  - Pumped hydro
  - Power to gas
  - EU electricity grid interconnection
  - Research funding
- Smart Grid and E-Energy pilot communities
- Demand-side management
The Challenge No. 3:
German greenhouse gas emissions

Reduced emissions by the energy industry and the mild winter lead to a major decline in greenhouse gas emissions 2014. However, there is still a lot to do in order to reach the 2020 climate target.
Its worth the efforts and investments:

Benefits of fostering energy efficiency and renewables

The energy transition has positive effects on various levels.
Energy imports and domestic production in Germany

Renewables reduce Germany’s energy dependence.

Source: BMWi 2013
Job creation in the German renewables sector

The renewables sector will grow to around 600,000 jobs in 2020.
Public acceptance of the Energiewende

The German public broadly supports the Energiewende.

“How do you assess the decision to carry out the Energiewende from today’s perspective?”
- Very good: 40%
- Good: 66%

“Renewable energy use and development are…”
- Extremely important: 27%
- Important: 93%

Attitude towards increasing the Renewable Energy Source Act surcharge to approximately six eurocents:
- Not enough: 5%
- Appropriate: 50%
- 55% total

Source: Infratest 6/2012, 9/2013
Costs
Investments and additional capacity in Germany

Market growth has significantly driven down costs per megawatt.
The main share of payments for renewable electricity goes to existing plants. New installations account for a much smaller share.
In 2015, the rise in household electricity prices will be suspended

<table>
<thead>
<tr>
<th>Year</th>
<th>Procurement, distribution, margin</th>
<th>Grid charges</th>
<th>Taxes</th>
<th>Concession fee</th>
<th>EEG surcharge</th>
<th>KWKG surcharge</th>
<th>Other surcharges</th>
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</thead>
<tbody>
<tr>
<td>2006</td>
<td>0.9</td>
<td>4.5</td>
<td>7.1</td>
<td>4.7</td>
<td>1.0</td>
<td>6.3</td>
<td>6.1</td>
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<tr>
<td>2007</td>
<td>1.0</td>
<td>5.2</td>
<td>6.3</td>
<td>6.1</td>
<td>1.2</td>
<td>5.9</td>
<td>7.4</td>
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<tr>
<td>2008</td>
<td>1.2</td>
<td>5.5</td>
<td>5.9</td>
<td>7.4</td>
<td>2.1</td>
<td>5.8</td>
<td>8.5</td>
</tr>
<tr>
<td>2009</td>
<td>1.2</td>
<td>5.8</td>
<td>5.8</td>
<td>8.5</td>
<td>2.1</td>
<td>5.9</td>
<td>8.7</td>
</tr>
<tr>
<td>2010</td>
<td>2.1</td>
<td>6.1</td>
<td>5.8</td>
<td>8.5</td>
<td>3.5</td>
<td>6.3</td>
<td>8.8</td>
</tr>
<tr>
<td>2011</td>
<td>3.5</td>
<td>6.3</td>
<td>5.8</td>
<td>8.5</td>
<td>6.1</td>
<td>6.5</td>
<td>8.9</td>
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<tr>
<td>2012</td>
<td>3.6</td>
<td>6.7</td>
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<td>8.5</td>
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<td>6.5</td>
<td>8.9</td>
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<tr>
<td>2013</td>
<td>5.3</td>
<td>6.7</td>
<td>6.7</td>
<td>8.5</td>
<td>6.1</td>
<td>6.5</td>
<td>8.9</td>
</tr>
<tr>
<td>2014</td>
<td>6.2</td>
<td>6.8</td>
<td>6.8</td>
<td>8.5</td>
<td>6.1</td>
<td>6.5</td>
<td>8.9</td>
</tr>
<tr>
<td>2015*</td>
<td>6.2</td>
<td>6.7</td>
<td>6.7</td>
<td>7.7</td>
<td>7.9</td>
<td>6.7</td>
<td>7.7</td>
</tr>
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BDEW 2014, BNetzA 2014, own calculations; *Prognosis for 2015
German household spending on energy

Electricity share in consumer spending is lower than other energy costs and has remained constant at around 2%. (this share is around 2.4% in the US)
Electricity market price plotted against merit order

Renewables shift the merit order and lower price levels.

Merit order (stylised)
The price is determined by the cost of the marginal technology.

Source: TU Wien, DIW Berlin, 2013
Nuclear Phase-Out
1) The Decision in 2011 to phase out nuclear was not an „irrational act“, but rather a comeback to previous policy

The History of Anti-Nuclear policy in Germany

> 1990: Shut-down of the 4 nuclear power plants in East Germany
> 1994: New nuclear power plants effectively ruled out
> 2001: Phase-out of nuclear power plants by 2022 put into law
> 2003/2005: Two nuclear power plants being shut down
> 2010: New law prolonging life-time of nuclear power until ~2040
> 3/2011: After Fukushima: 8 oldest nuclear power plants shut down
> 6/2011: Phase-out of all nuclear power plants (9 still in operation) by 2022 put back into law with 85% majority in parliament
Germany is gradually shutting down all nuclear power plants

Declining nuclear energy installed capacity in Germany, 2000–2022

Source: Institute of Applied Ecology, BMJ, own calculations

Remaining nuclear capacity in megawatts

22,100


Nov 2003 Stade
May 2005 Obrigheim
Aug 2011 Biblis A+B
Brunsblittel
Isar 1
Krümmel
Neckarwestheim 1
Philippsburg 1
Unterweser
May 2015 Grafenheinfeld
Dec 2017 Gundremmingen B
Dec 2019 Philippsburg 2
Dec 2021 Grohnde
Brokdorf
Gundremmingen C
Dec 2022 Isar 2
Neckarwestheim 2
Emsland

Phase-out over 20 years
Fact-Check for some Myths around the Energiewende (1)

- Does Germany need to import electricity after shutting down 8 NPP?
  - Does Germany face outages with rising RE and less NPP?
  - Does Germany have to use more coal to compensate for NPP?
  - (Industry) Studies from 2011 predicted negative effects on German GDP due to increase in wholesale electricity prices, CO2 prices. Did that happen?
No! Germany rather exported (net) more electricity than ever (in 2014 net export added up to 35 TWh = 6 % of total production.)

In 2014, Germany set a new record in net power exports – especially the Netherlands, Austria and France have been importing power due to lower German wholesale prices.

Cross-border power trades in TWh

Own calculations based on ENTSO-E 2014; commercial trade flows, not displaying physical power flows
Fact-Check for some Myths around the Energiewende (2)

- Does Germany need to import electricity after shutting down 8 NPP?

- Does Germany face outages with rising RE and less NPP?

- Does Germany have to use more coal to compensate for NPP?

- (Industry) Studies from 2011 predicted negative effects on German GDP due to increase in wholesale electricity prices, CO2 prices. Did that happen?
Average duration of supply failures in 2012

Germany will maintain top security levels despite the energy transition.

Source: CEER 2014

(Kimberly)
Fact-Check for some Myths around the Energiewende (3)

- Does Germany need to import electricity after shutting down 8 NPP?

- Does Germany face outages with rising RE and less NPP?

- Does Germany have to use more coal to compensate for NPP?

- (Industry) Studies from 2011 predicted negative effects on German GDP due to increase in wholesale electricity prices, CO2 prices. Did that happen?
Renewables have become the biggest source of power generation.

German electricity mix (gross power generation) trends: continuous RE growth; less fossils/nuclear
Fact-Check for some Myths around the Energiewende (4)

- Does Germany need to import electricity after shutting down 8 NPP?
- Does Germany face outages with rising RE and less NPP?
- Does Germany have to use more coal to compensate for NPP?
- *(Industry) Studies from 2011 predicted negative effects on German GDP (German Industries) due to increase in wholesale electricity prices, CO2 prices. Did that happen?*
Negative predictions did not come true

1) Electricity wholesale prices down by > 30% since 2011
good for industry, bad for renewable surcharge

2) CO2 prices down by > 60% since 2011
The Way Forward

Renewable Energy Sources Act Amendment 2014

More coordination
• Binding development corridor

More precision
• Technology-specific regulatory instruments

More efficiency
• Focus on cost-efficient technologies
• Avoid excessive support, implement degression mechanisms

More market integration
• Compulsory direct marketing
• Tendering model

Affordability

Environmentally friendly energy supply

Security of supply

Germany is maintaining ambitious goals, but is optimising mechanisms and increasing market integration.
Feed-in Tariffs for PV: support costs decline constantly

<table>
<thead>
<tr>
<th>Feed-In Tariff Solar energy (Cent/kWh)</th>
<th>January 2006</th>
<th>August 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roof-top installations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 10 kW</td>
<td>51,80</td>
<td>13,15</td>
</tr>
<tr>
<td>&lt; 30 kW**</td>
<td>51,80</td>
<td>12,8</td>
</tr>
<tr>
<td>&lt; 100 kW</td>
<td>49,28</td>
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</tr>
<tr>
<td><strong>Ground-mounted</strong></td>
<td>40,60</td>
<td>9,23 (2015: tender)</td>
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</tbody>
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Source: EEG 2014 (Draft, 26.06.2014), BSW 2013, BMWi 2013
German electricity-system volatility in 2022

Renewables will partially cover 100% of demand by as early as 2022.
No baseload capacities are needed any more – the fossil power fleet rather needs to become highly flexible.

Residual load in a sample week in February 2023 in GW

Agora Energiewende/RAP (2013)
Caps for new Capacity

Wind Onshore: 2,5 GW/year
Solar PV: 2,5 GW/year
Biomass: 0,1 GW/year
Wind Offshore: 6,5 GW until 2020 aver. 0,85 GW/year
Flexibility measures depending on renewables share

Flexibility needs can mainly be covered by market mechanisms. New storage capacities are only needed for high renewables shares.
The German energy transformation is a concrete programme and it is happening.

Renewable energy generation will be led by wind and solar power.

Grid expansion and integration is required within Germany and across Europe.

Energy efficiency potential is greatest in the residential sector and in a shift to co-generation.

The restructuring offers numerous economic opportunities (for new and existing industries).

Transportation sector and energy storage are largest variables in planning for the future.

The implementation will be monitored regularly.
Thank you for your attention!

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Renewables expansion led to huge growth in capacity. Nuclear and fossil-fuel phase-out only started recently.
GHG emission savings through renewables use

In 2013 renewables avoided 148 million tonnes of CO₂ in Germany.

Source: AGEE-Stat (2014)
Netzentgelte im Zeitverlauf

Quelle: BNetzA, Monitoringbericht 2013
Redispatch-Kosten sind Teil der vorgelagerten Netzkosten und werden auf die Netzentgelte umgelegt.

Regionales Problem betrifft hauptsächlich 50Hertz und TenneT.

Quelle: BNetzA
Energy efficiency and the switch to renewables are gaining momentum.
(3) Feed-in Tariffs for PV: support costs decline constantly

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</tbody>
</table>

Source: EEG 2014 (Draft, 26.06.2014), BSW 2013, 2014, BMWi 2013
Development of energy prices for private households

The household spending for electricity has increased much less than heating cost.
The green tech sector already employed 1.4 million people in 2011, with efficiency and renewable energies as the main drivers.
Cost decline of photovoltaic systems

Broad market development and constant tariff reduction have more than halved photovoltaic system costs in Germany.
(4) Increase market integration through premium system

- Market price signal reaches RES-E generators, who thus react to market needs
  - RES-E generators can create additional profit by adjustment to market prices
  - Efficient market integration, incentives improved prognosis and balancing

The market premium bears new opportunities and incentivises flexibility.
(7) Exemptions for energy intensive industries

<table>
<thead>
<tr>
<th>Eligibility criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electricity intensity</strong></td>
<td>Companies that work in one of the electricity intensive sectors registered in the EU wide “list 1”</td>
</tr>
<tr>
<td><strong>International trade</strong></td>
<td>Additional sectors prone to international competition as featured in „list 2“ of the EU Commission</td>
</tr>
<tr>
<td><strong>Electricity cost intensity</strong></td>
<td>• List 1: required electr. cost intensity of 16-17%</td>
</tr>
<tr>
<td></td>
<td>• List 2: required electr. cost intensity of 20%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Support scheme</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimum contribution:</strong></td>
<td>full EEG surcharge for the first GWh</td>
</tr>
<tr>
<td><strong>Price:</strong></td>
<td>In principle, 15% of the EEG surcharge, cap at 0.5 % / 4% of gross value added, but at least 0.1 ct for every kWh beyond 1 GWh</td>
</tr>
</tbody>
</table>

*The adjusted compensation scheme follows the EU Commission guidelines.*
Citizens form cooperatives to drive the energy transition

Number of energy cooperatives in Germany, 2001–2011

Source: AEE
Regional power markets and energy exchanges

Market coupling is an essential bottom-up approach towards establishing a European internal electricity market.
The is no single European wholesale market, but rather a range of regional and national market segments.
Fossil and nuclear have received by far more subsidies than renewables

Energy subsidies in Germany, 1972–2012

Source: Green Budget Germany

Billion €

Hard coal
Nuclear
Brown coal
Renewables

German Energy Transition  energytransition.de