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Climate and Resource Protection

RES integration into the market – the German experience

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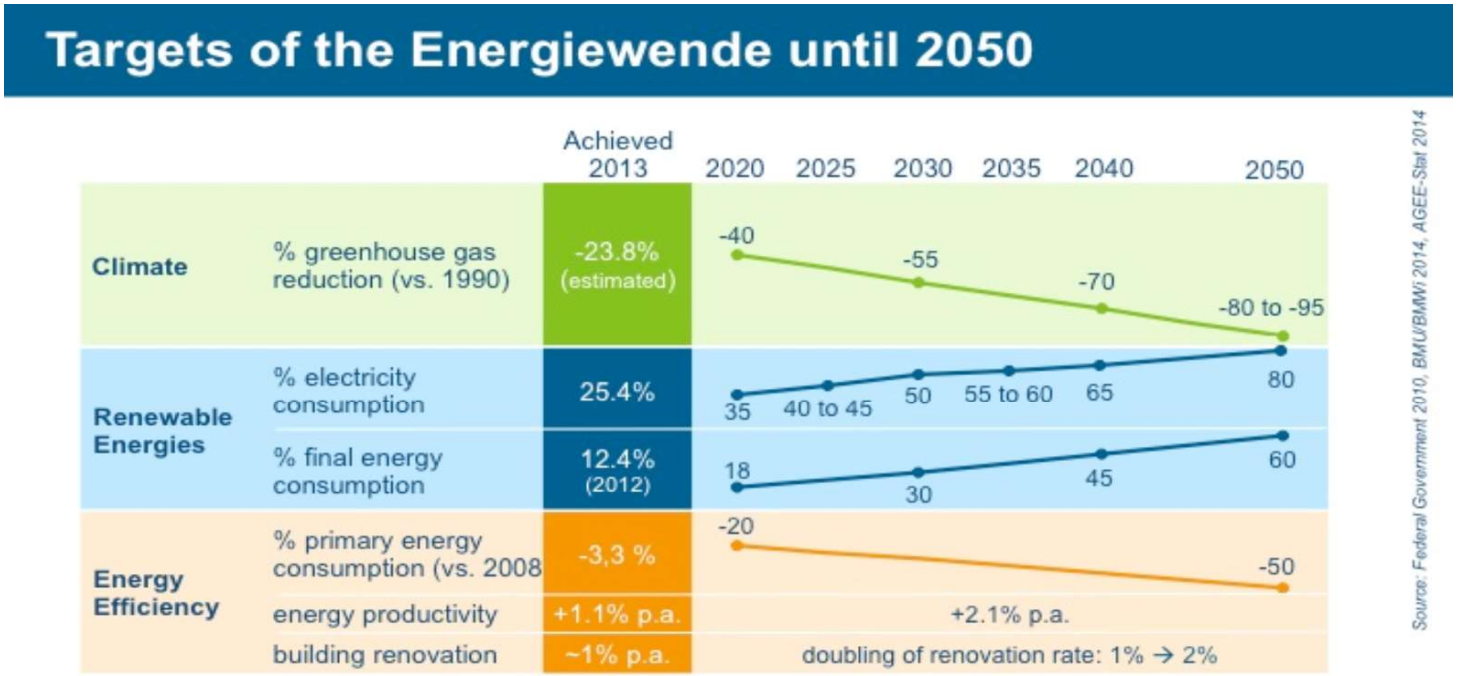
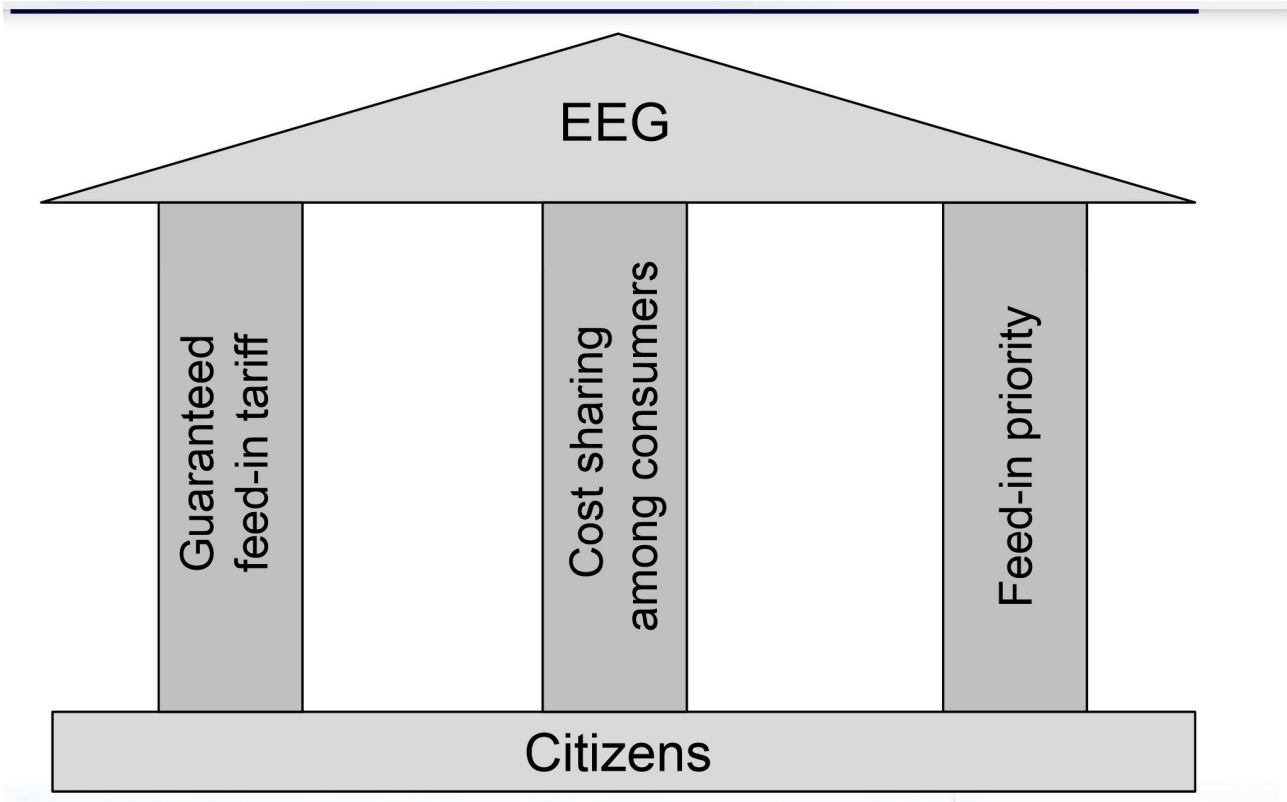
About the “Energiewende”

- The German Energiewende shall result in a significant reduction of greenhouse gas emissions.
- The Energiewende has set ambitious targets for renewable energy.
- To meet the goals, the country is anti-cipating a future with large amounts of variable renew-ables, no nuclear and phasimg out of coal power, and decreasing amounts of fossil fuels.



The pillars of the EEG

From Stromeinspeisegesetz till EEG 2009



EEG 2012

EEG 2014

Market Integration

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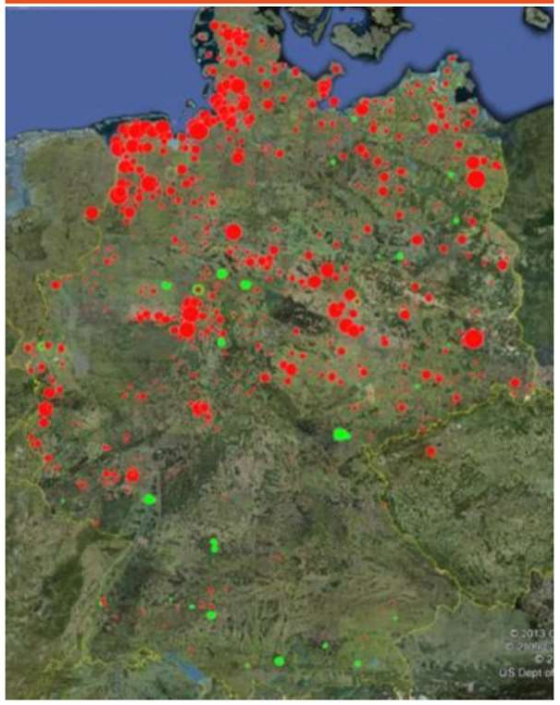
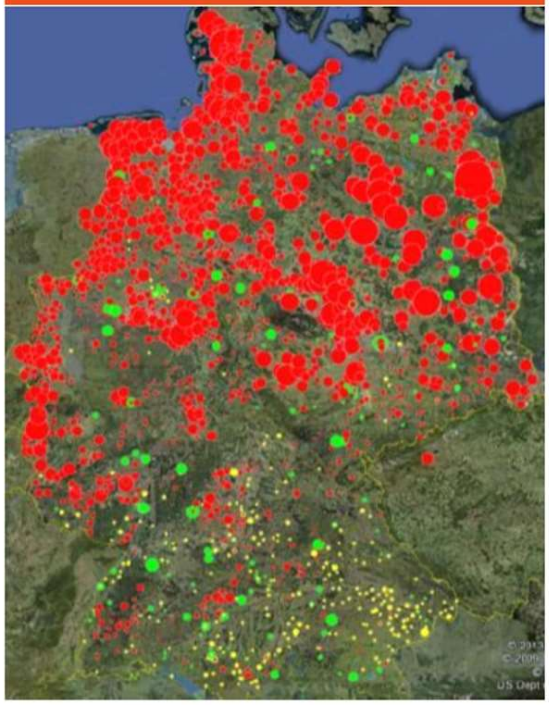
Regional Distribution of RE plants

2000



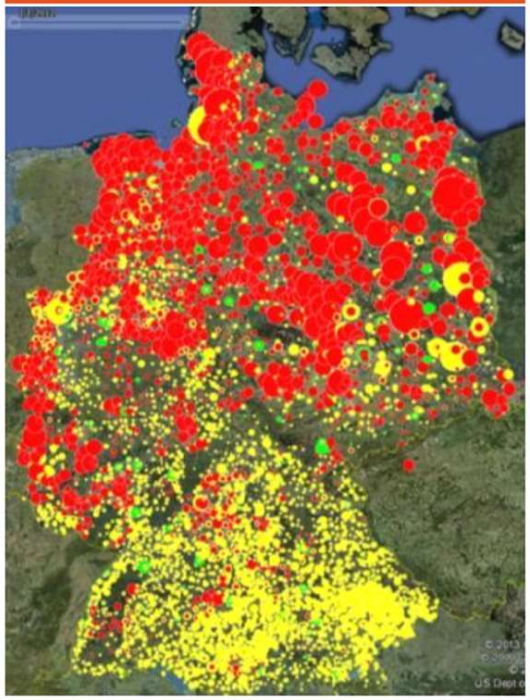
- ~ 30,000 plants
- 1.665* MW installed Wind in Germany

2006



- ~ 221,000 plants
- 2.233* MW installed Wind in Germany

2017

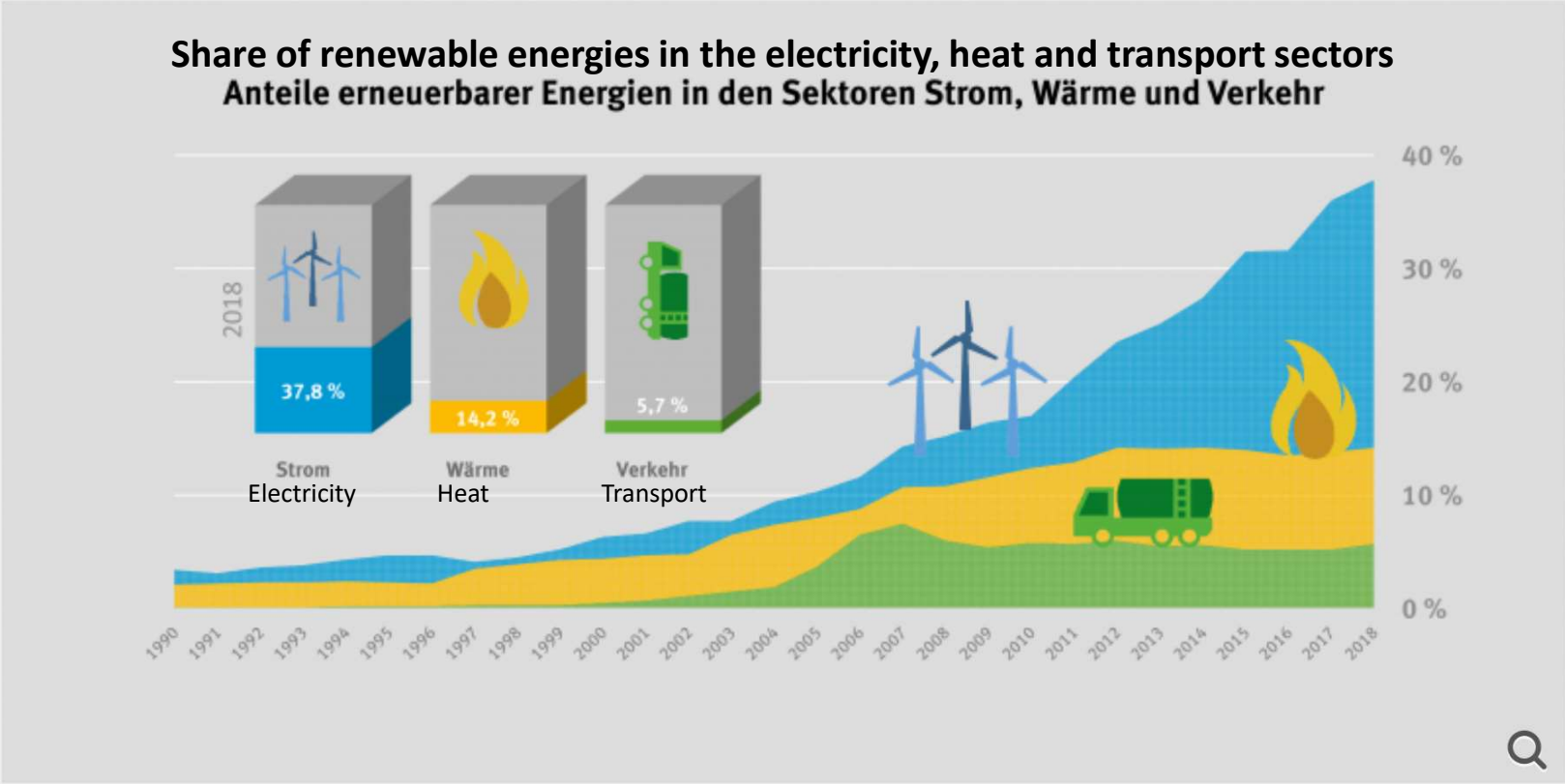


- ~ 1,600,000 plants
- 45.628* MW installed Wind in Germany

PV Wind Biomass * BWE Figures

50hertz

Shares of renewables in 2018



Entwicklung der Anteile erneuerbarer Energien 1990 – 2018
Quelle: AGEE-Stat / Umweltbundesamt

Gross Electricity Production since 2000

Bruttostromerzeugung seit 2000

bdew
Energie. Wasser. Leben.

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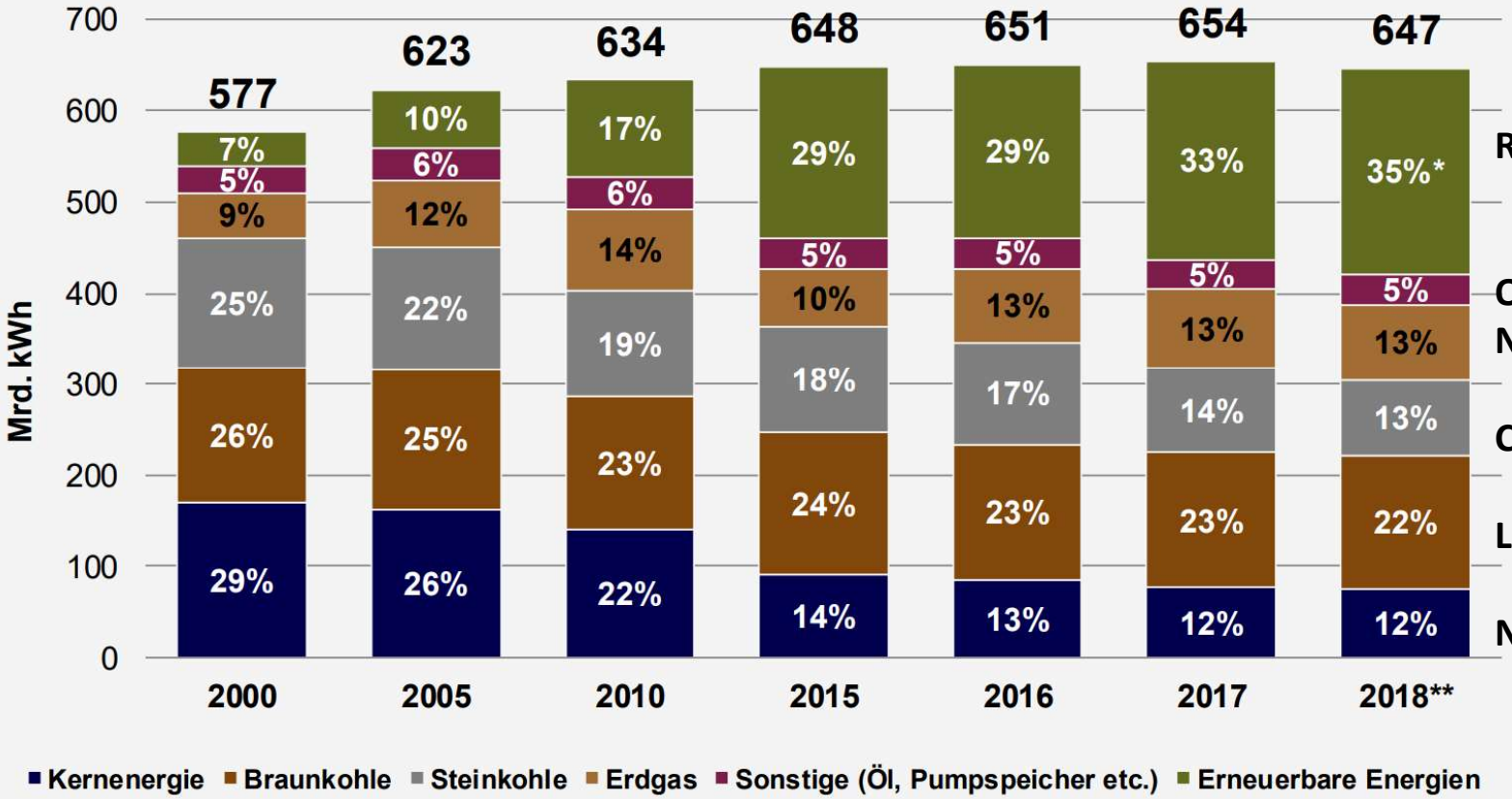

Renewables
Others
Natural Gas
Coal
Lignite
Nuclear Power

* entspricht 38% bezogen auf den Stromverbrauch
**vorläufig

Quelle: BDEW, Stand: 03/2019

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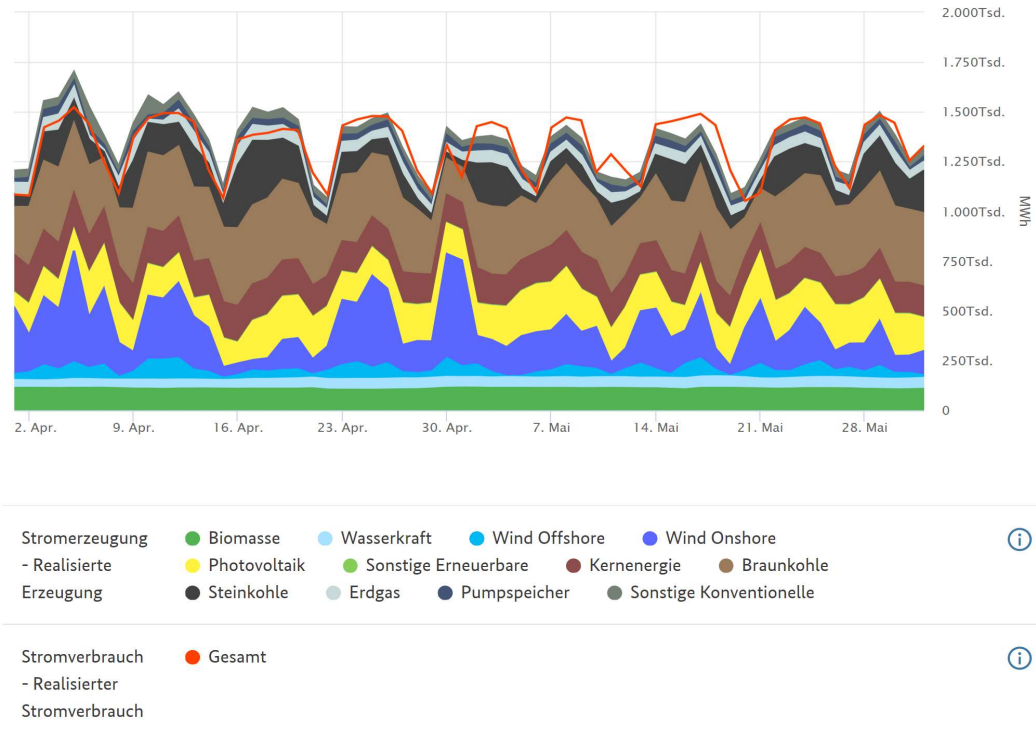
System Integration of Renewables

- Germany traditionally relied on a significant share of relatively inflexible thermal generation such as coal and nuclear to supply the grid. Resources were dispatched to meet load, and variable resources were few.
- The objectives of the system integration of renewable energies are in particular:
  - Secure grid operation with increasing proportion of renewable energies,
  - making electricity generation and demand more flexible,
  - an intelligent interplay of power generation, consumption and modern (digitalised) networks,
  - efficient use of the existing network structure.



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Phases of VRE Integration

Table 2 • Four phases of VRE integration

	Attributes (incremental with progress through the phases)			
	Phase One	**Phase Two**	**Phase Three**	**Phase Four**
Characterisation from a system perspective	VRE capacity is not relevant at the all-system level VRE up to about 3%	VRE capacity becomes noticeable to the system operator VRE from 3% to almost 15%	Flexibility becomes relevant with greater swings in the supply/demand balance VRE 10% to 25%	Stability becomes relevant. VRE capacity covers nearly 100% of demand at certain times VRE 25% to 50%
Impacts on the existing generator fleet	No noticeable difference between load and net load	No significant rise in uncertainty and variability of net load, but there are small changes to operating patterns of existing generators to accommodate VRE	Greater variability of net load. Major differences in operating patterns; reduction of power plants running continuously	No power plants are running around the clock; all plants adjust output to accommodate VRE
Impacts on the grid	Local grid condition near points of connection, if any	Very likely to affect local grid conditions; transmission congestion is possible, driven by shifting power flows across the grid	Significant changes in power flow patterns across the grid, driven by weather condition at different locations; increased two-way flows between high and low voltage parts of the grid	Requirement for grid-wide reinforcement, and improved ability of the grid to recover from disturbances
Challenges depend mainly on	Local conditions in the grid	Match between demand and VRE output	Availability of flexible resources	Strength of system to withstand disturbances

Source: IEA

Table 3 • Technological options and operational practices for different phases of VRE deployment

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Type	Measures	Phase 1	Phase 2	Phase 3	Phase 4
Technical	Real-time monitoring and control		■	■	■
	Enhancing capacity of transmission lines		■	■	■
	Power plant flexibility			■	■
	Special protection scheme			■	■
	Advanced VRE technologies and design			■	■
	System non-synchronous penetration (SNSP) limit				■
	Inertia-based fast frequency response (IBFFR)				■
	Smart inverter				■
	Advanced pump hydro operation				■
	Grid level storage				■
Economic	Integrating forecasting into system operations	■	■	■	■
	Incorporating VRE in the dispatch	■	■	■	■
	Sophisticated sizing of operating reserves		■	■	■
	Faster scheduling and dispatch		■	■	■
	Co-ordination across balancing areas			■	■

Key point • The appropriate technological options and operational practices for managing VRE integration depend on the level of VRE deployment.

Source: IEA

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Market Integration of RES

Three steps of market integration

1) Pure system integration — EEG Stage 1

   (no price risk, promotion outside the market (FIT),
   unconditional marketing by UNB.)

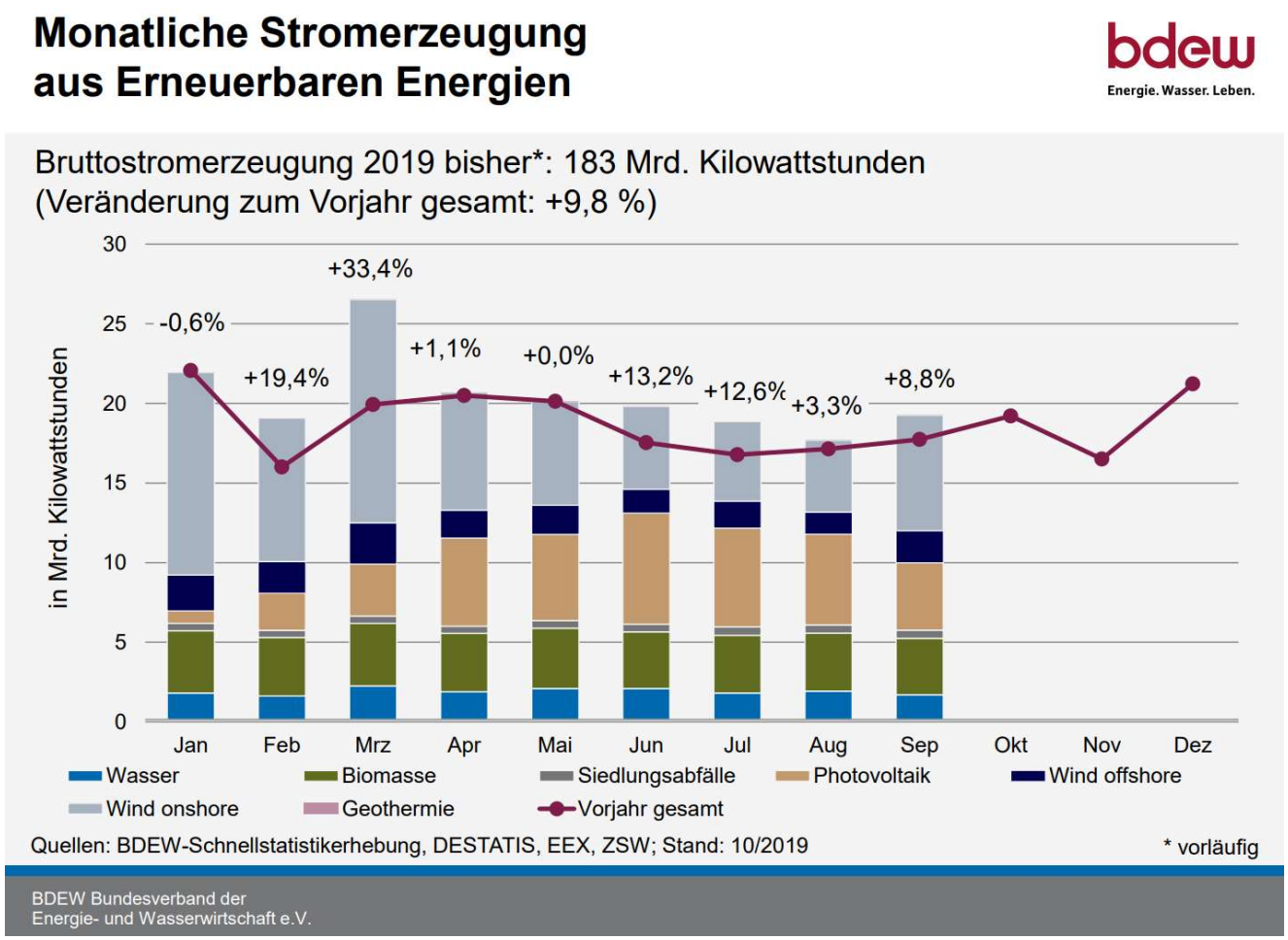
2) Direct marketing — EEG 2014

   (mixture of market revenues and external promotion
   (market premium)

3) Full market price risk — Post EEG

   (no funding, PPA)

Monthly Renewable Electricity Production



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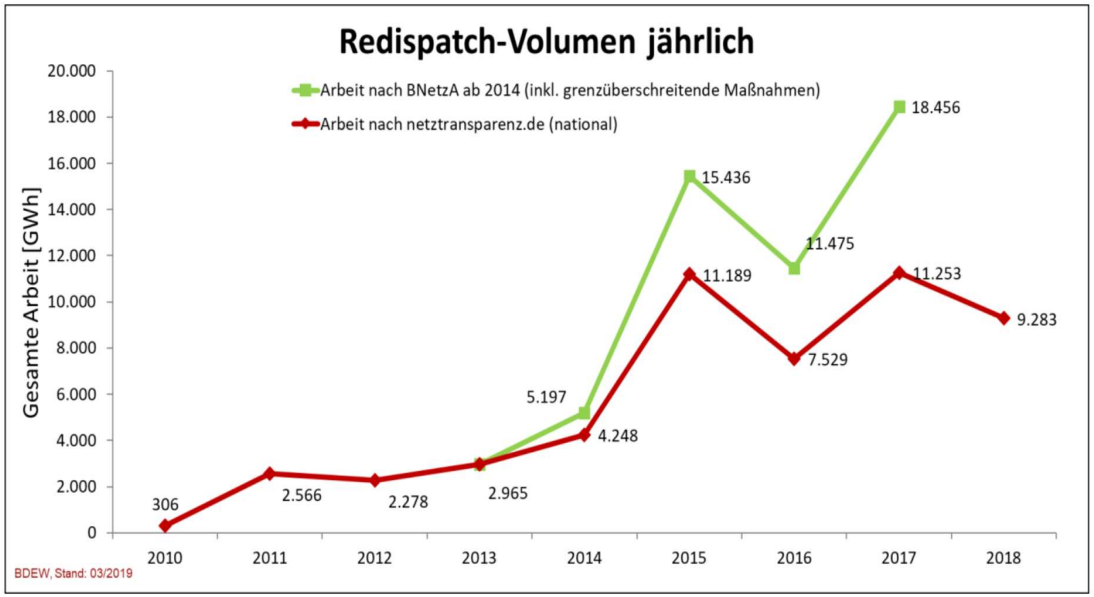
Renewables in the Grid

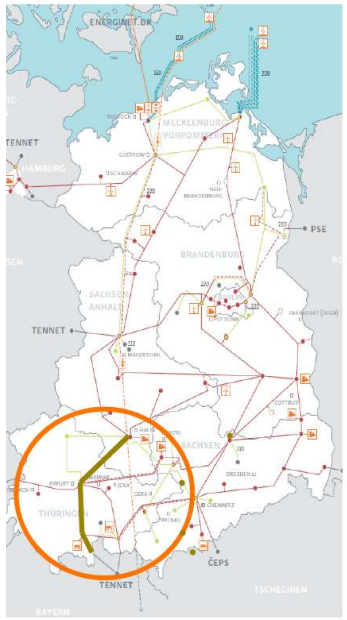
Development of Redispatch Volumes

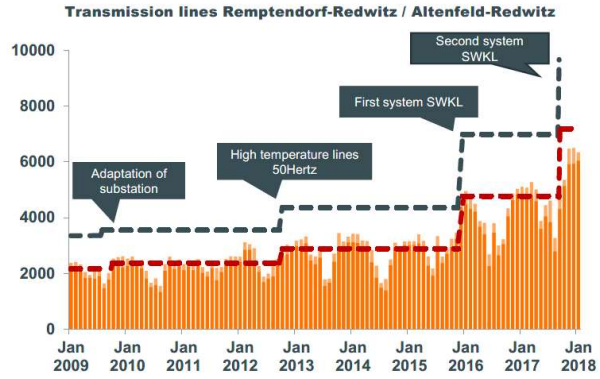


50hertz

Grid extension decreases costs

Avoided congestion management costs due to 50Hertz‘ Südwest-Kuppelleitung (SWKL)





Status as of 21.03.2018

318 Millionen Euro

weniger Redispatchkosten durch die Südwestkuppelleitung seit dem 01.01.2016

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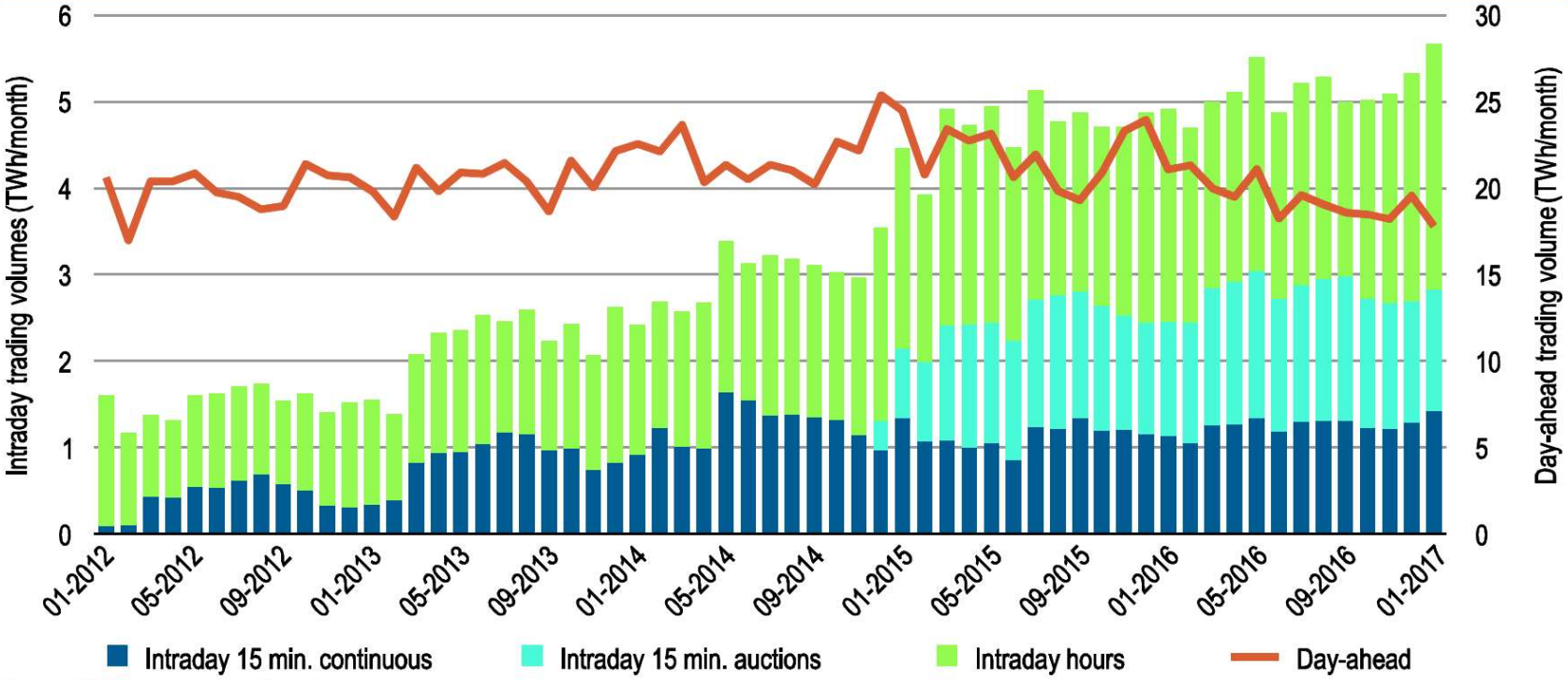
Market Integration

Figure 15 • Monthly trading volumes on the German intraday market, 2012-16



Note: TWh = terawatt hour.

Source: 50Hertz Transmission GmbH (2017), "The transmission perspective".

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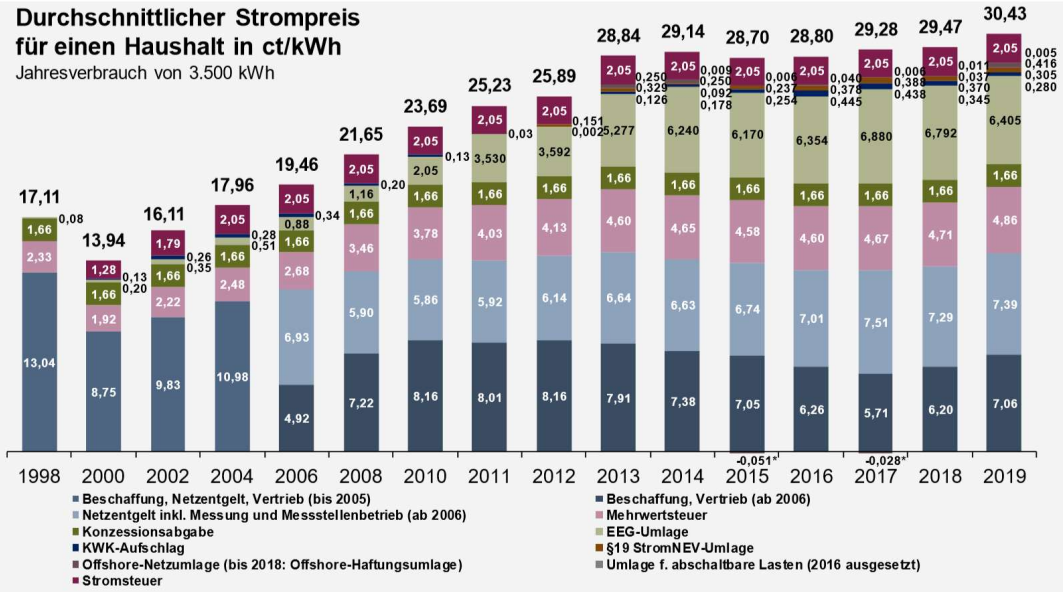
Development of electricity prices Germany

Electricity Prices for private housholds

Strompreis für Haushalte

bdew Energie. Wasser. Leben.



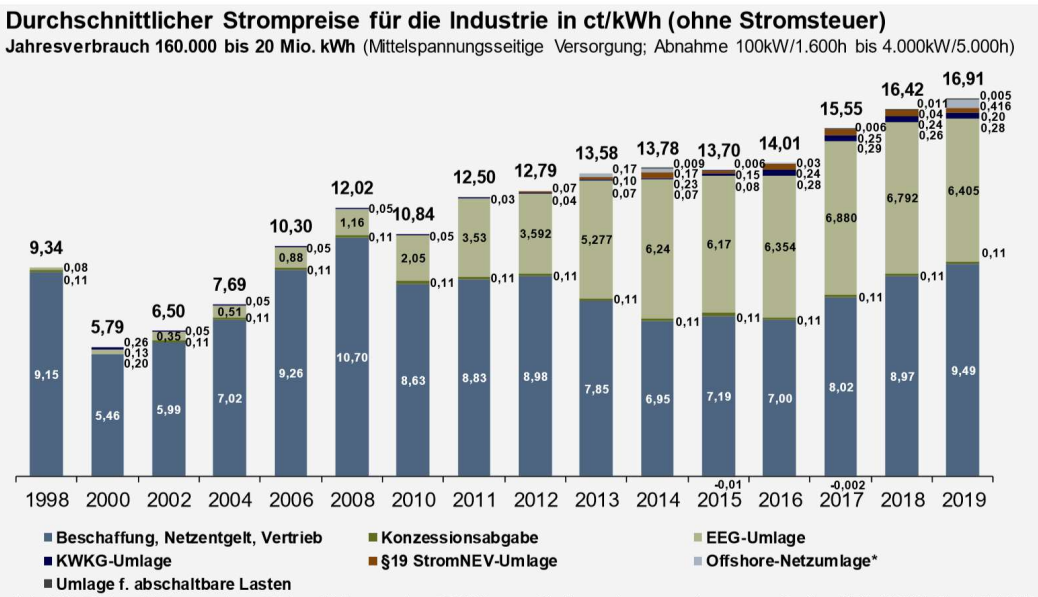
*Offshore-Haftungsumlage 2015/17 wegen Nachverrechnung negativ

Quelle: BDEW, Stand: 07/2019

Electricity Prices for Industry

Strompreis für die Industrie (ohne Stromsteuer)

bdew Energie. Wasser. Leben.



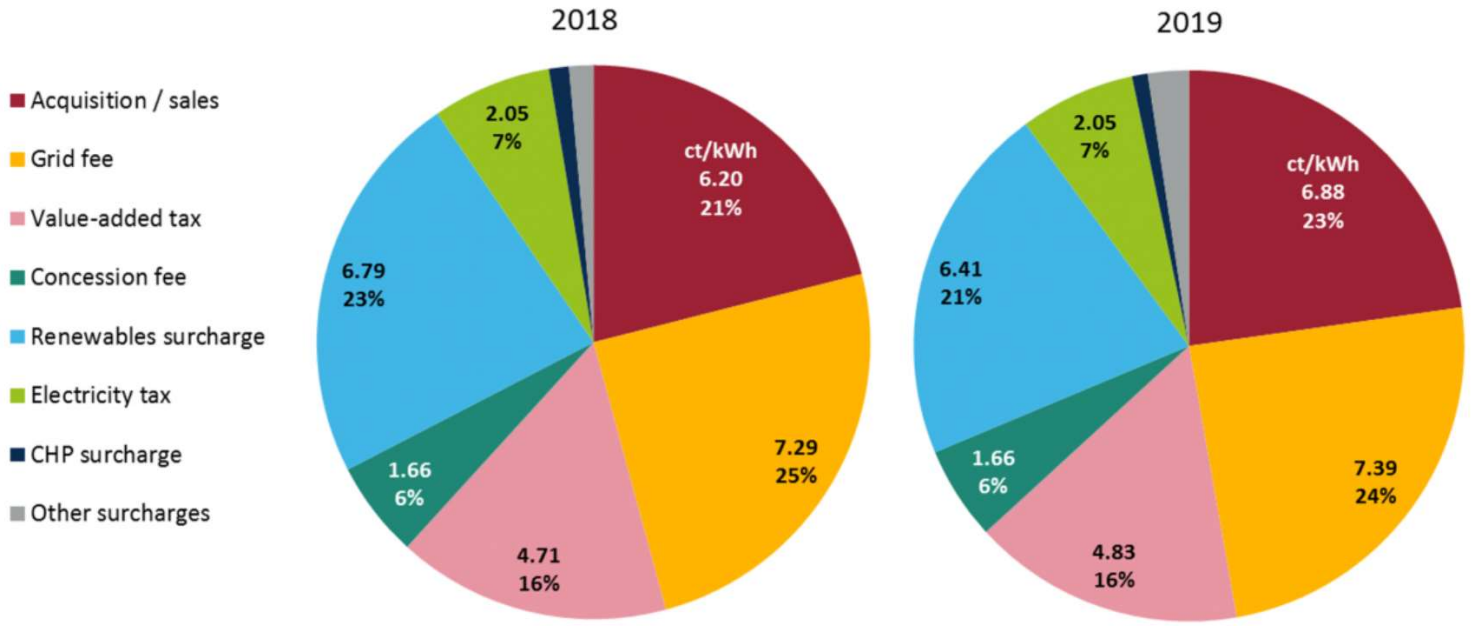
* bis 2018 Offshore-Haftungsumlage; Offshore-Haftungsumlage 2015/17 wegen Nachverrechnung negativ

Quellen: VEA, BDEW; Stand: 07/2019

Composition of power price for German households using 3,500 kWh per year in 2018 and 2019.

Data: BDEW January 2019.

CLEAN ENERGY WIRE



Lessons learned

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- In spite of the fact that Germany is meeting more than a third of its electricity requirements the country has not experienced severe reliability problems on either the distribution or bulk electric system.
- Cost of the renewable subsides and the impacts on the national economy and private households should not be neglected. Policy Makers underestimated these costs significantly when deciding on the EEG (Minister Trittin in 2004: monthly costs for an average household will be about 1 €. EEG costs per household in 2018: 20 €/month).
- Retail prices for the end-users in Germany has increased significantly and therefore having public support is highly important.
- Exit strategy for the conventional power plants is a necessity.
- The grid has to be upgraded and extended to absorb the flexibility of the renewables. Adjustment of the grid code and digitalization are key.
- In Germany Large-scale investments in the grid are being required to expand transmission grids so they can connect offshore and onshore wind projects in the north to consumers in the Total investment cost for the build-out of German onshore and offshore transmission systems is estimated to be around $52 billion (€40 billion)

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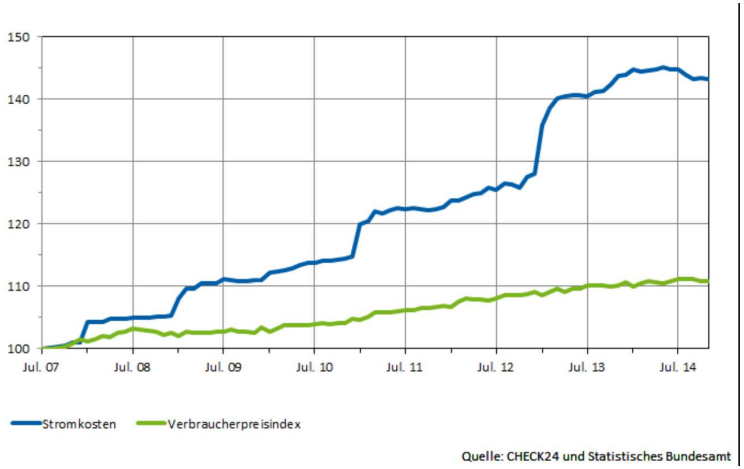
Lessons learned - Pricing

- The wholesale pricing model must change when integrating Renewables.
- Previously, the German wholesale prices followed the demand curve but now they react to the weather i.e. going down when the sun shines and the wind blows and up during times of high demand.
- This has resulted in the necessity of short-term power trading as opposed to that in a conventional generation environment.
- The EEG was designed as not technology open very specific support program with very specific and sophisticated support schemes for each technology (solar, wind, biomass, water, geothermie).
- Overgenerous and unsustainable subsidy programs resulted in numerous redesigns of the renewable support schemes, which increased regulatory uncertainty and financial risk for all stakeholders in the renewable energy industry.
- Just with the recent reform a shift to integration and more market oriented support was introduced.



Quelle: CHECK24 und Statistisches Bundesamt

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Lessons Learned – Regional and International Co-opertion

- Appropriate operation of an interconnector can provide the system with greater flexibility.
- In addition, interconnection can provide frequency response, and interconnection via AC transmission lines can also contribute to the sharing of inertia between systems.
- Co-ordination between balancing areas effectively requires inter-regional planning between different jurisdictions. This can also be a platform for achieving market integration.
- These activities are being pursued in a number of European markets. Recent developments include the International Grid Control Co-operation (IGCC) platform.

Thank you very much for your attention

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