

# Energiewende and Nuclear Phase-out: Goals and Reality

Jana Kittnerová, FNSPE CTU Prague  
Kamil Števanka, FEEC BUT Brno  
Anna Fořtová, FEE UWB Pilsen

# Energiewende



## Energy transition

→ **low carbon, environmental friendly, reliable, and affordable energy supply.**

The new system will rely heavily on renewable energy (particularly wind, photovoltaics, and hydroelectricity), energy efficiency, and energy demand management.



## The term Energiewende

**1980 publication:** Krause, F.; Bossel, H.; Müller-Reißmann, K.-F.: Energie-Wende: Wachstum und Wohlstand ohne Erdöl und Uran [Energy transition: growth and prosperity without petroleum and uranium].



## Legislation

**Erneuerbare-Energien-Gesetz (EEG, Gesetz für den Ausbau erneuerbarer Energien)**

**Renewable Energy Sources Act (Law for the development of renewable energies)**

# Goals



Terminate nuclear energy use by the end of 2022



Increase the share of renewable energy in total gross energy and electricity consumption



Reduce greenhouse gas emissions

	2020	2030	2040	2050
Share of gross final energy consumption	18 %	30 %	45 %	60 %
Share of gross electricity consumption	35 %	50 %	65 %	80 %
Greenhouse gas emissions (base year 1990)	-40 %	-55 %	-70 %	-80 to -95 %

# Goals



Reduce primary energy consumption



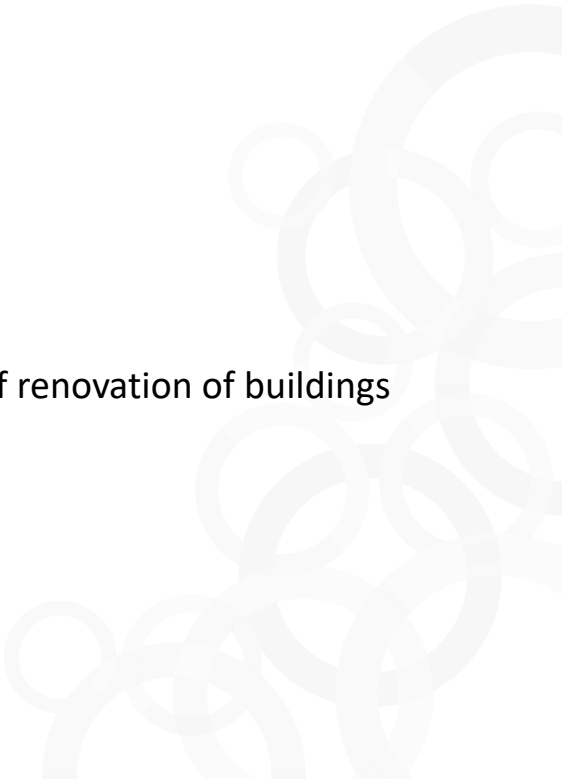
Increase energy productivity

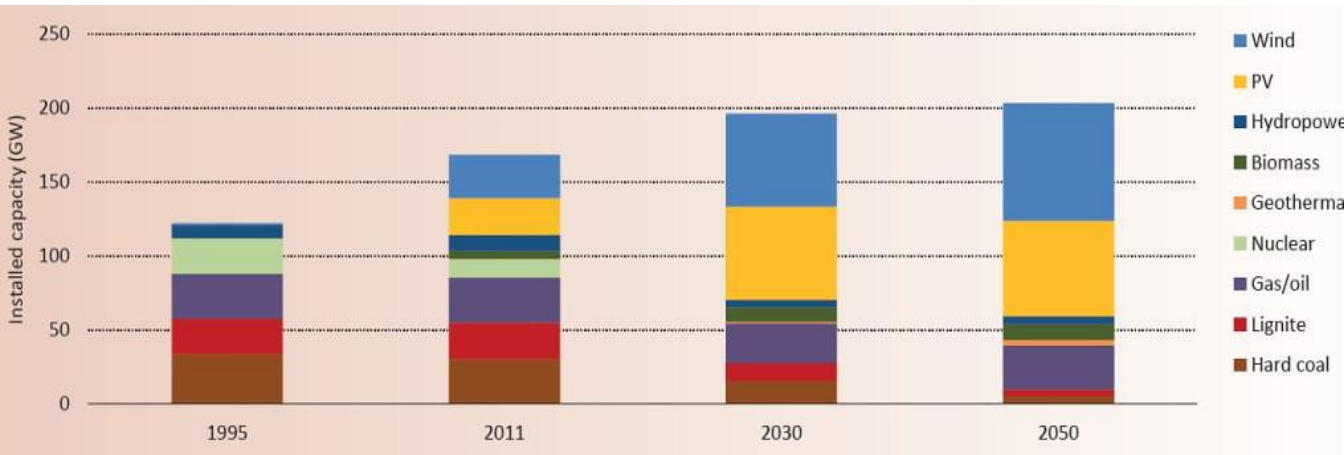


Reduce electricity consumption

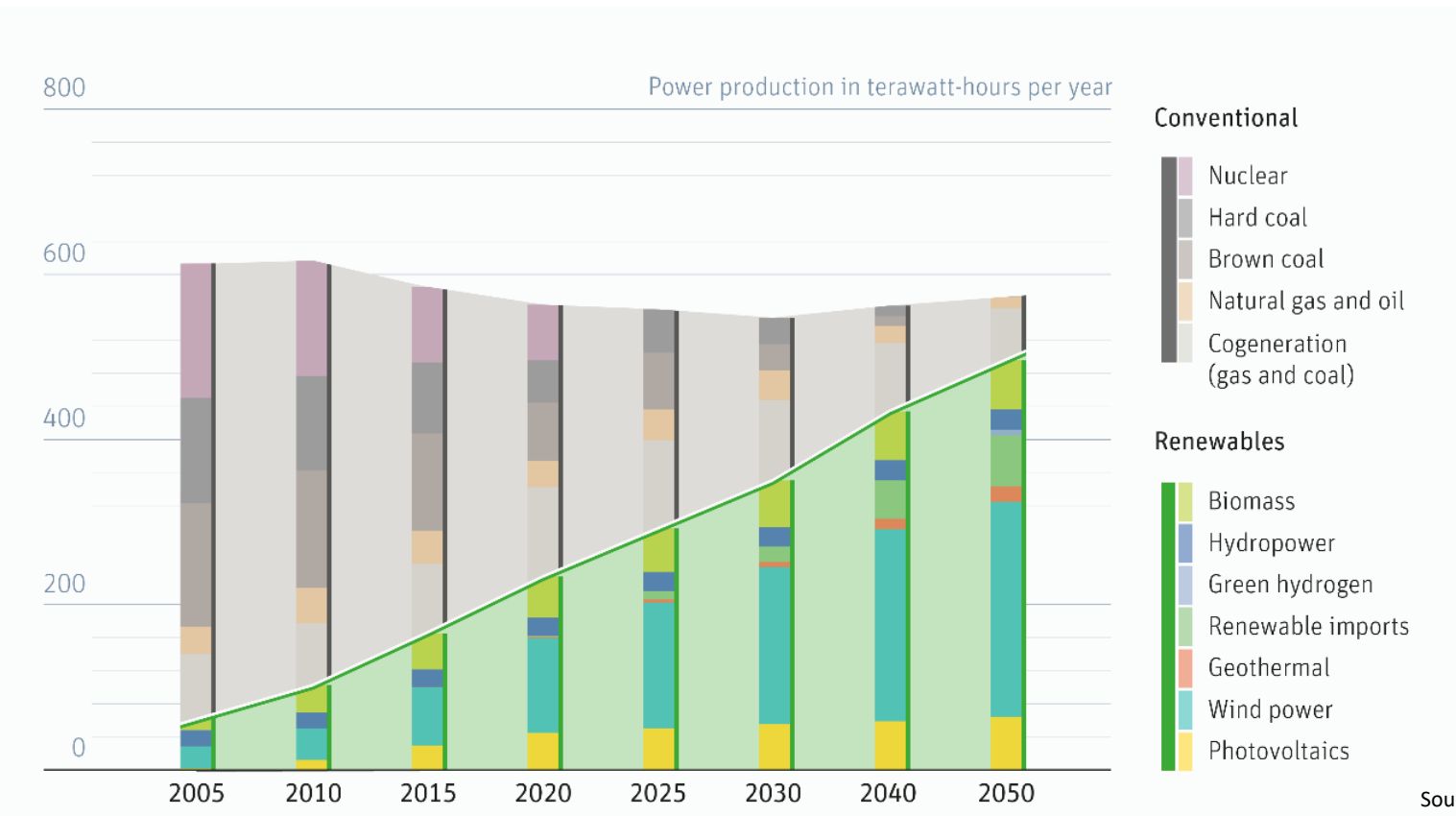


Reduce energy consumption in buildings, increase the rate of renovation of buildings










Source: Technology Roadmap Energy storage



Source: DLR and Fraunhofer IWES






# Means



-  EEG 2012: Green electricity at a guaranteed price, fixed for 20 years: “feed-in tariffs”, 2017: auction system
-  Transmission system development
-  Energy storage – e.g. pumped hydroelectric energy storage
-  Smart-grids
-  Energy saving: The less energy we need, the less we have to produce: electromobility, energy efficient buildings, etc.

# Nuclear Phase-out



-  All of Eastern German NPPs closed after reunification
-  Introduced in 2000 by Schröder's cabinet to be finished by the end of 2022  
First shutdowns in 2003 and 2005 of NPPs Stade and Obrigheim
-  Angela Merkel's cabinet agreed to delay the phase-out by 12 years in 2009  
Decision was reverted following Fukushima accident in 2011
-  6 reactors closed in 2011 after Fukushima accident
-  The total share of electricity production from nuclear decreased from almost 30 % in 2000 to 12 % today

# Nuclear reactors



## Shutdown reactors

Plant	Operator	Type	MWe net	Years operating	Shutdown	Status
Biblis A (KWB A)	RWE	PWR	1167	36	2011	Licensed decomm
Biblis B (KWB B)	RWE	PWR	1240	34	2011	Licensed decomm
Brunsbüttel (KKB)	Vattenfall	BWR	771	30	2007	Shutdown
Krümmel (KKK)	Vattenfall	BWR	1260	25	2009	Shutdown
Isar 1 (KKI)	E.ON	BWR	878	32	2011	Licensed decomm
Unterweser (KKU)	E.ON	PWR	1345	32	2011	Shutdown
Phillipsburg1 (KKP)	EnBW	BWR	890	31	2011	Licensed decomm
Neckarwestheim 1 (GKN)	EnBW	PWR	785	34	2011	Licensed decomm
Grafenrheinfeld (KKG)	E.ON	PWR	1275	33	6/2015	Shutdown
Gundremmingen B (KRB-B)	RWE	BWR	1284	33	12/2017	Shutdown
Total: 10			10,895			

Source: World Nuclear Association

## Reactors in operation

Plant	Type	MWe (net)	Commercial operation	Operator	Provisionally scheduled shutdown 2001	2010 agreed shutdown	March 2011 shutdown & May 2011 closure plan
Gundremmingen C	BWR	1288	1/1985	RWE	2016	2030	2021
Grohnde	PWR	1360	2/1985	E.ON	2017	2031	2021
Phillipsburg 2	PWR	1392	4/1985	EnBW	2018	2032	2019
Brokdorf	PWR	1370	12/1986	E.ON	2019	2033	2021
Isar 2	PWR	1400	4/1988	E.ON	2020	2034	2022
Emsland	PWR	1329	6/1988	RWE	2021	2035	2022
Neckarwestheim 2	PWR	1305	4/1989	EnBW	2022	2036	2022
Total operating (7)		<b>9,444</b>					

Source: World Nuclear Association

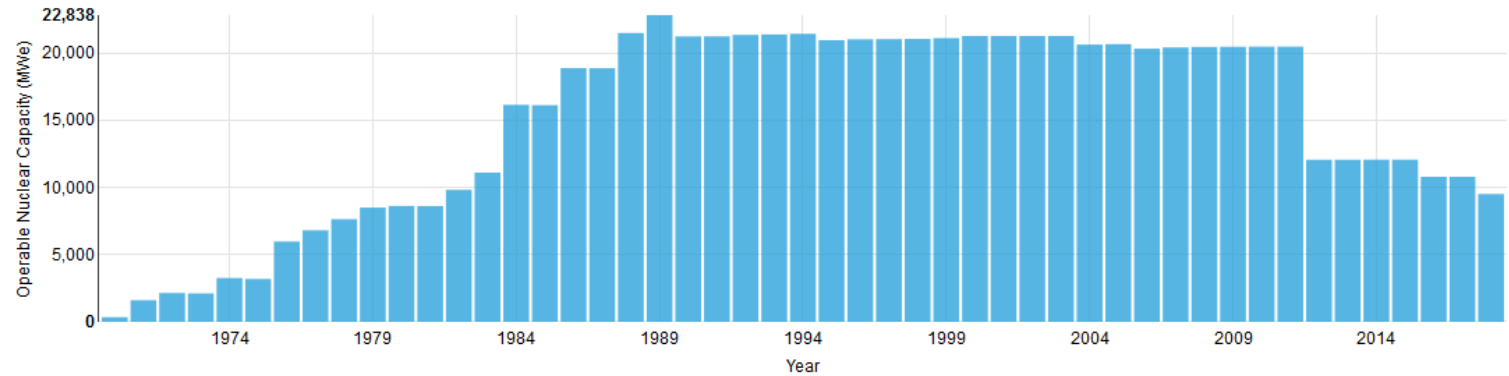


# Nuclear energy in Germany



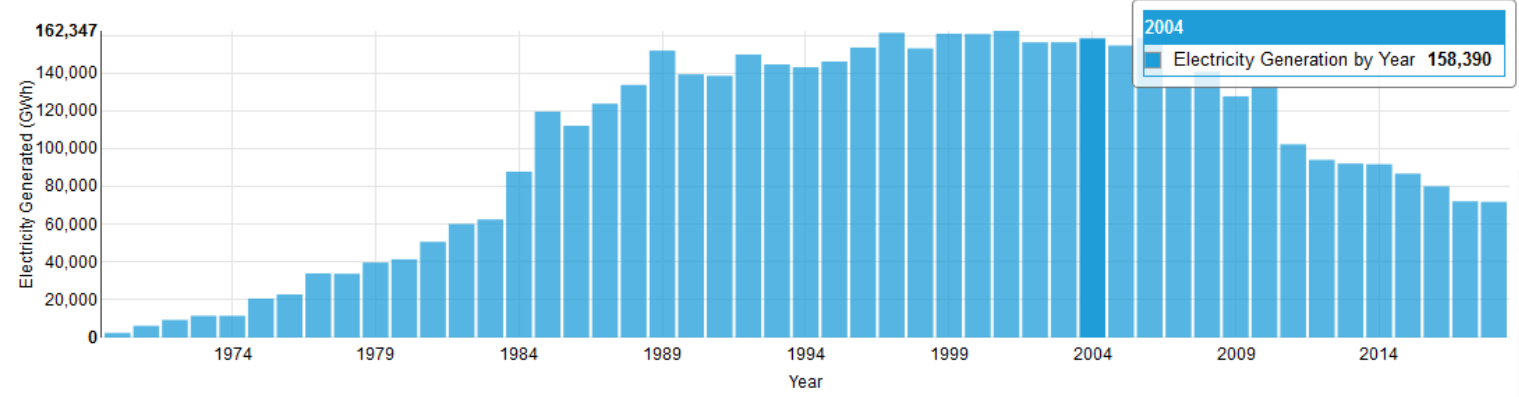
## Operable Nuclear Capacity

9,515 MWe in 2018



## Electricity Generated

71,866 GWh: electricity generation from nuclear energy in 2018



Source: World Nuclear Association

# Grid status



Grid network goal (2020): 3 582 km  
 Current status (Q1 2019): 1 087 km  
 Current goal (Q1 2019): 2 513 km



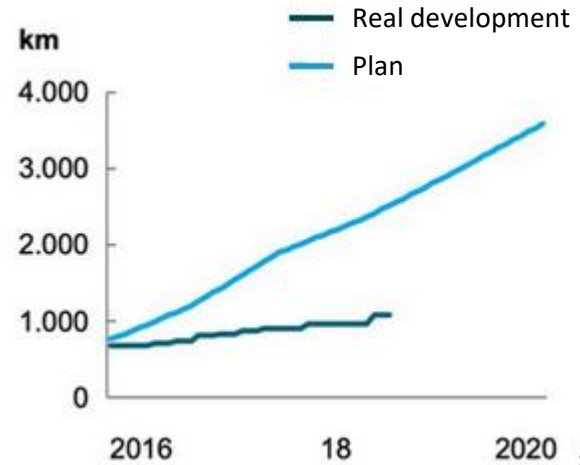
Grid reserves 4.7 % (goal 1 %)



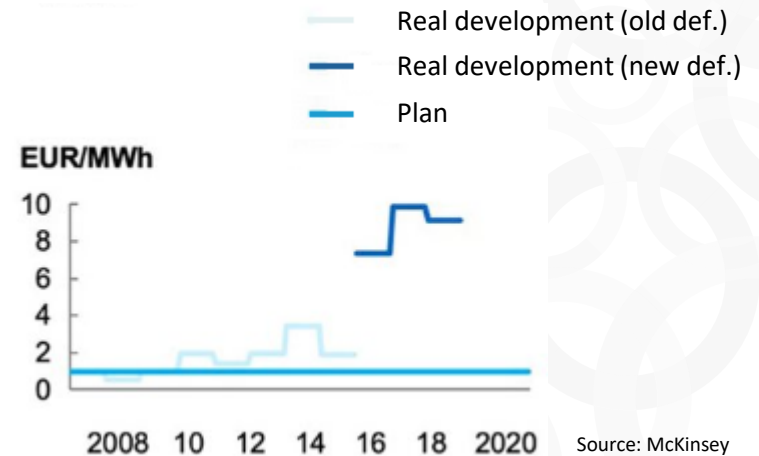
Cost of grid measures: 9.12 €/MWh  
 Goal: 1 €/MWh



Power outages: 15.1 min/year  
 Goal: 17 min/year

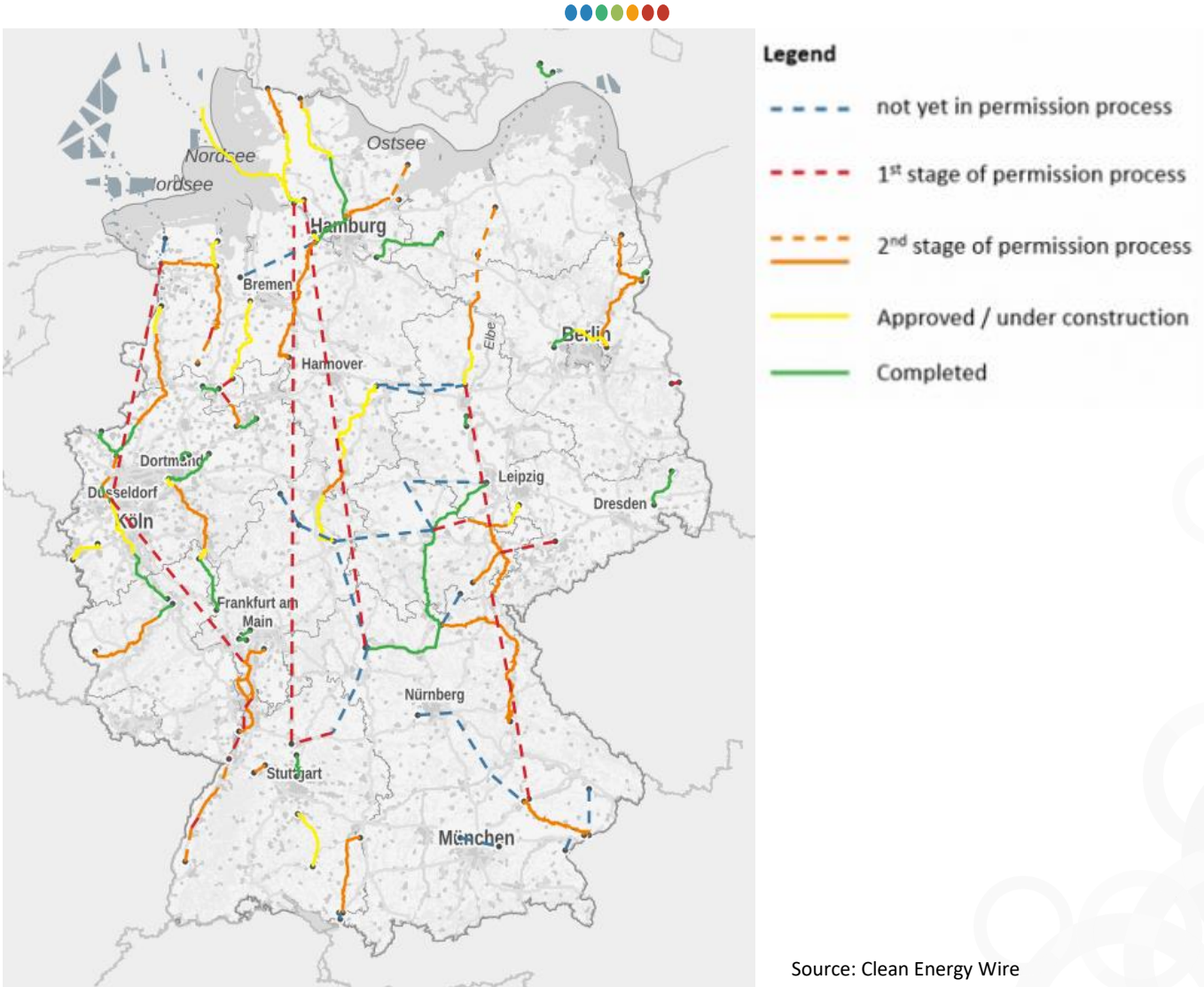


Source: McKinsey



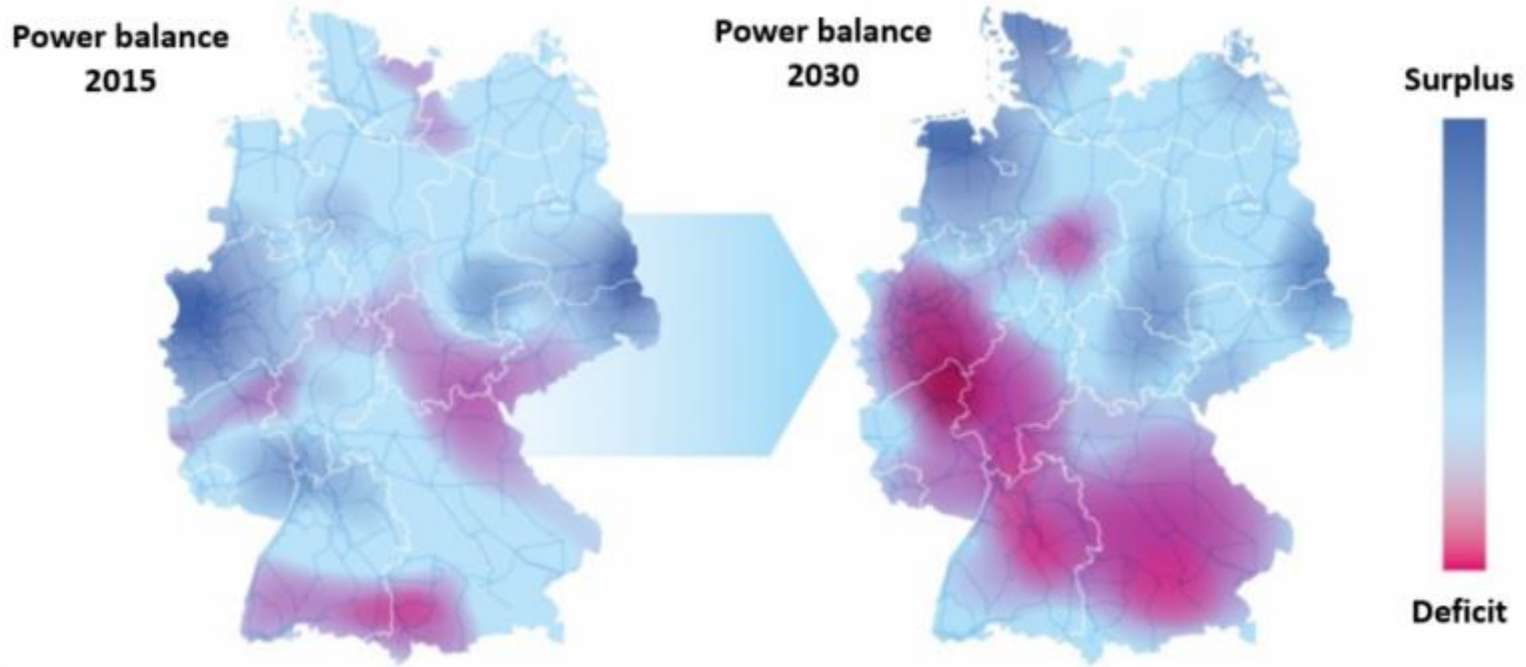
Source: McKinsey

# Transmission lines



Source: Clean Energy Wire

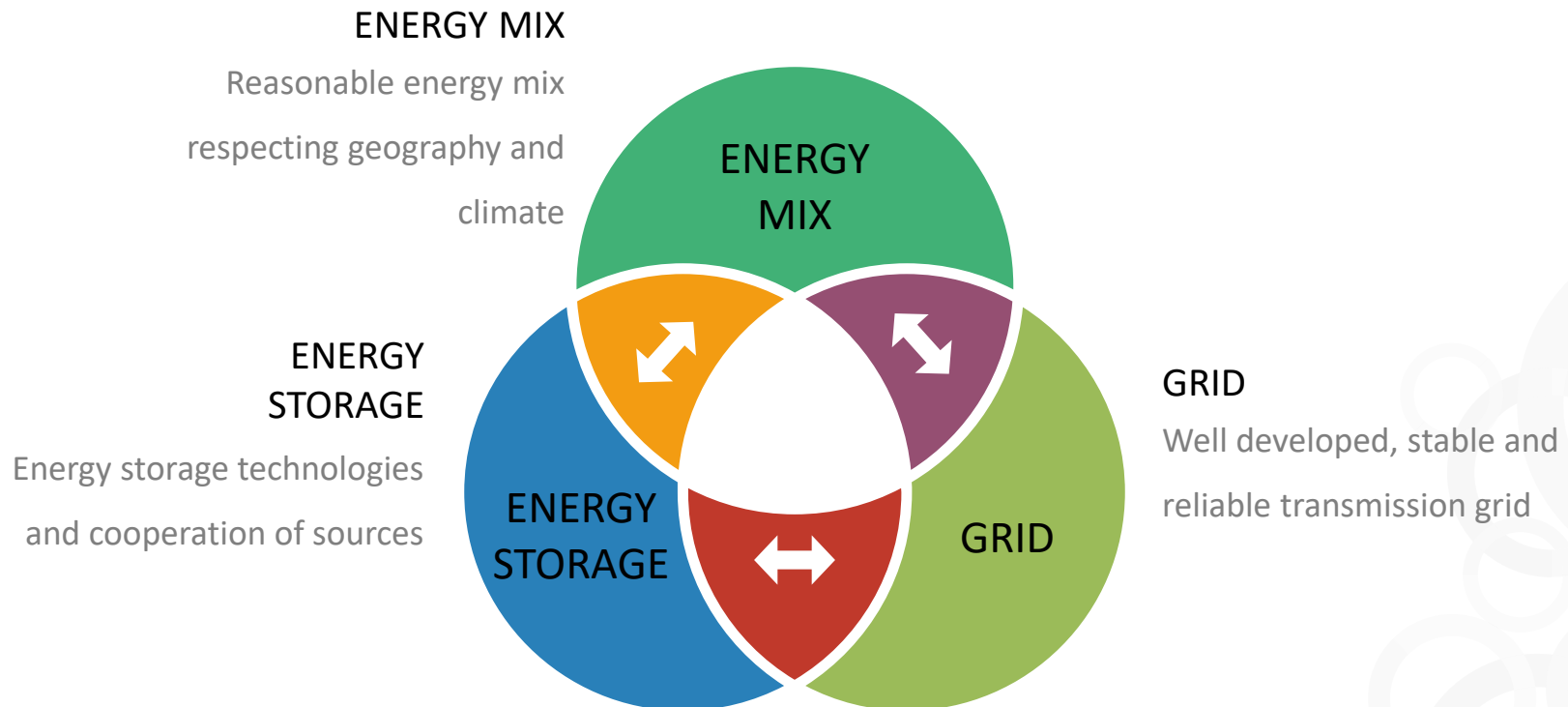
# Power balance



*Schematical overview*

Source: Clean Energy Wire

# Future of the energy (world)

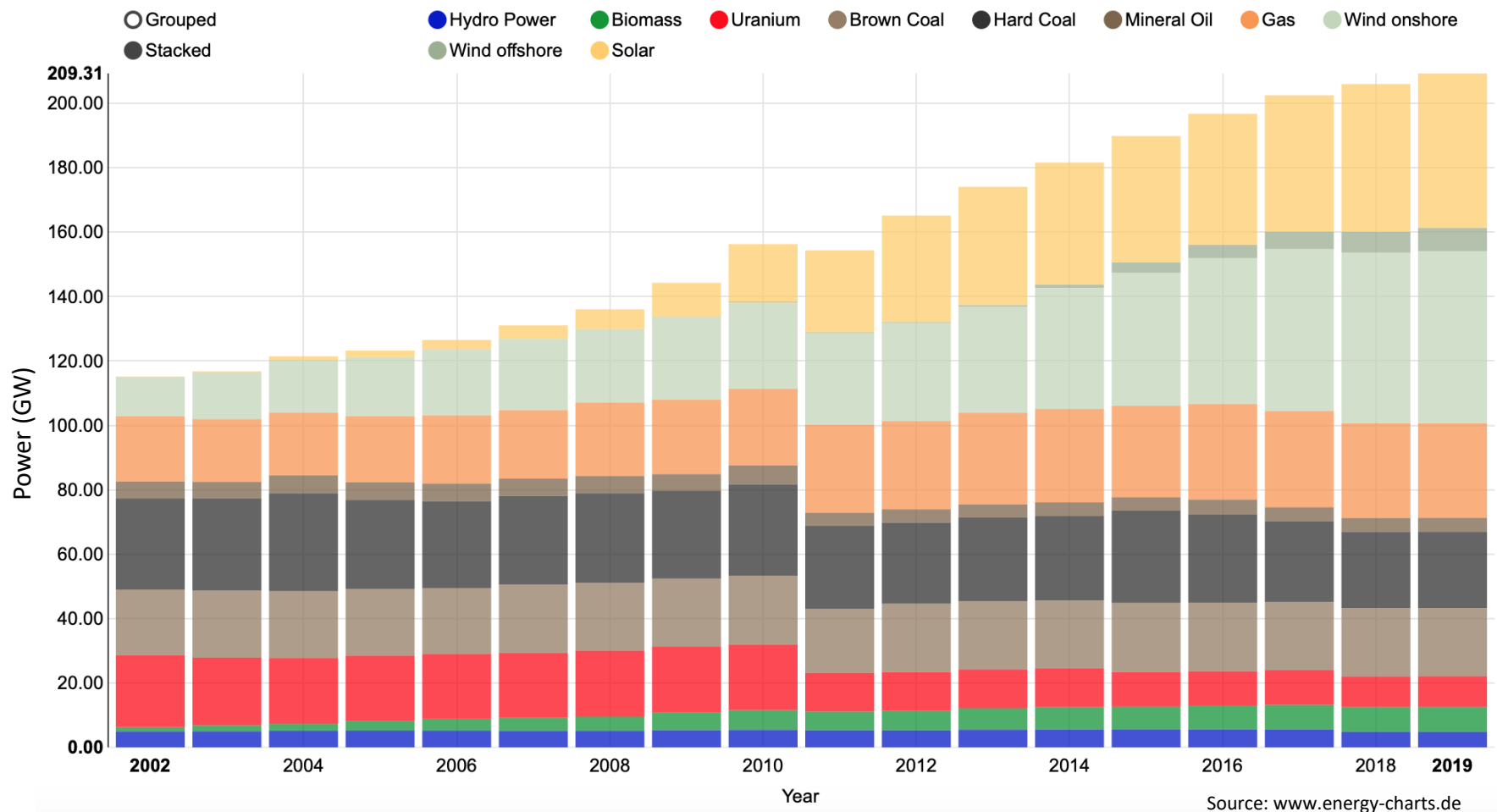


# Installed capacity

(of electricity generation)



2002 – 2019



# Electricity generation



2002 - 2018

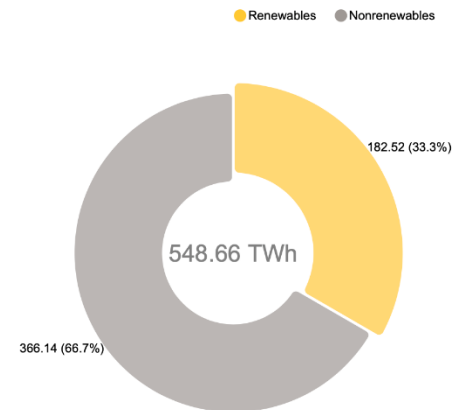
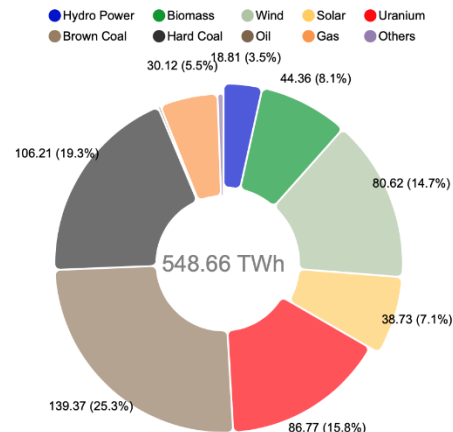
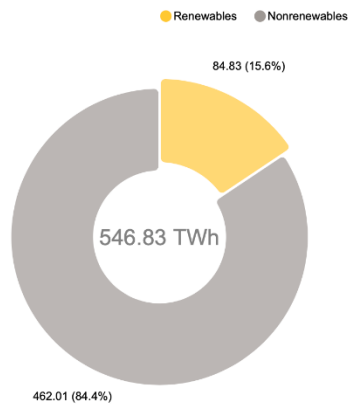
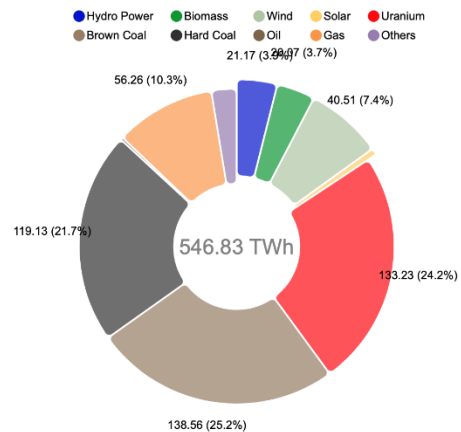
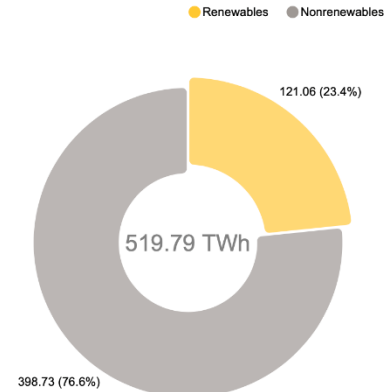
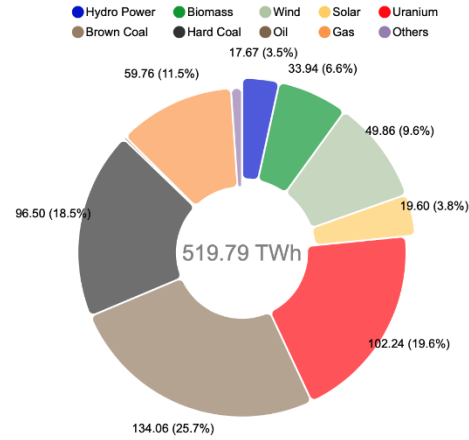
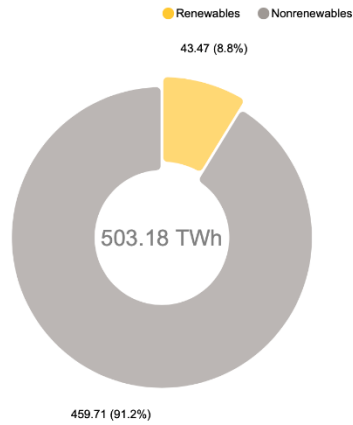
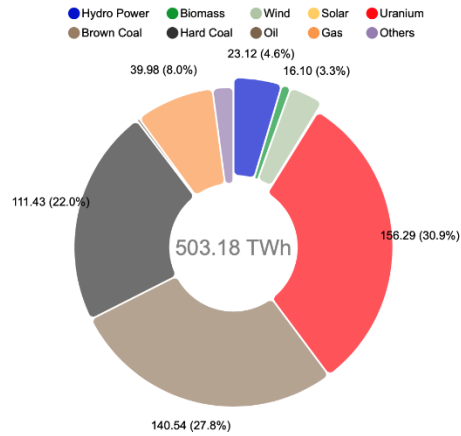
Source: [www.energy-charts.de](http://www.energy-charts.de)

2002

2011

2007

2015



# Electricity generation



2002 - 2018

Source: www.energy-charts.de

2002

2011

2018

- Hydro Power
- Biomass
- Wind
- Solar
- Uranium
- Brown Coal
- Hard Coal
- Oil
- Gas
- Others

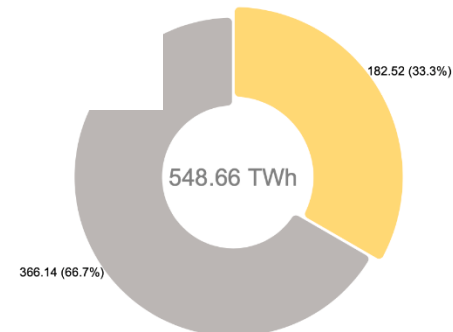
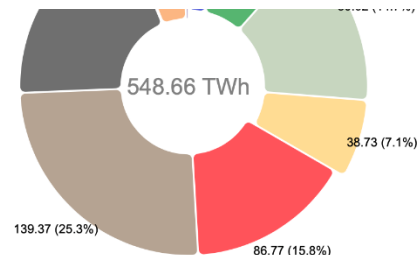
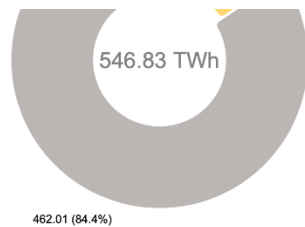
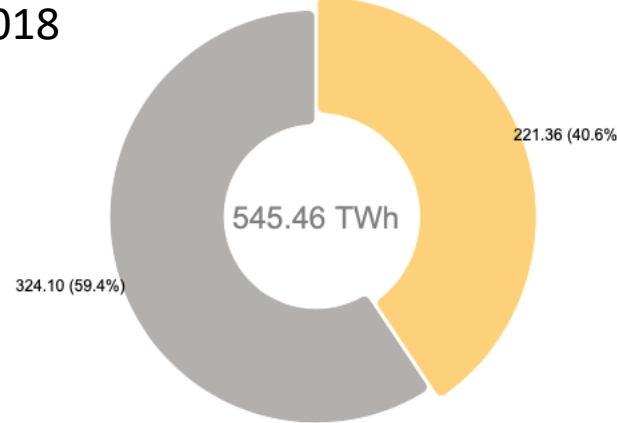
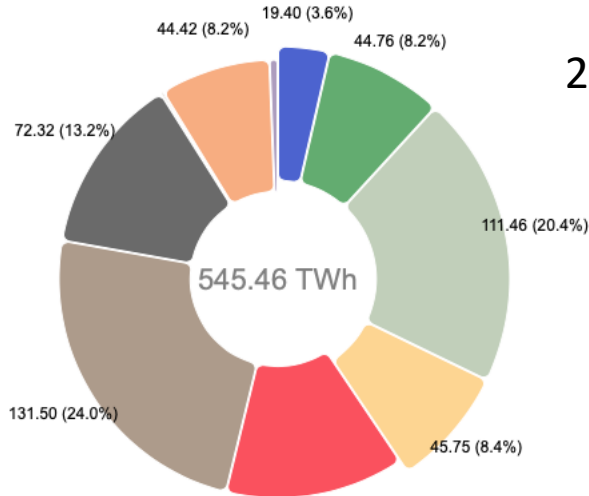
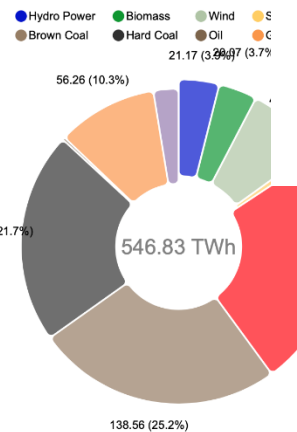
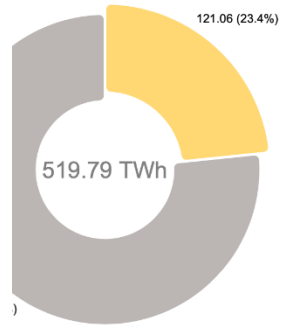
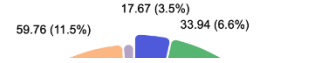
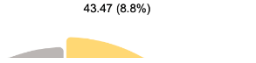
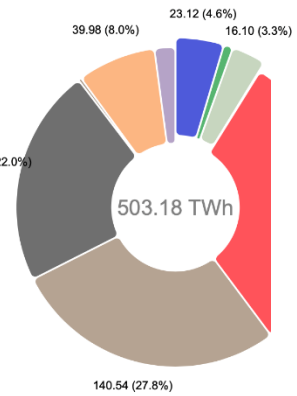
- Renewables
- Nonrenewables

- Hydro Power
- Biomass
- Wind
- Solar
- Uranium
- Brown Coal
- Hard Coal
- Oil
- Gas
- Others

- Renewables
- Nonrenewables

- Hydro Power
- Biomass
- Wind
- Solar
- Uranium
- Brown Coal
- Hard Coal
- Oil
- Gas
- Others

- Renewables
- Nonrenewables

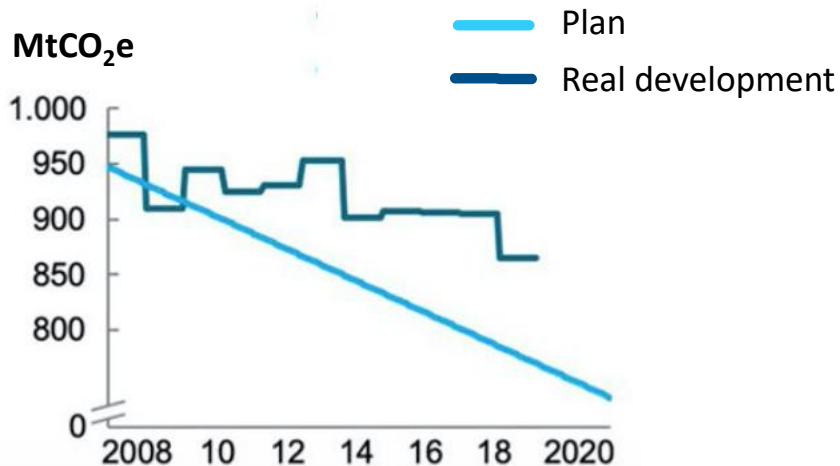




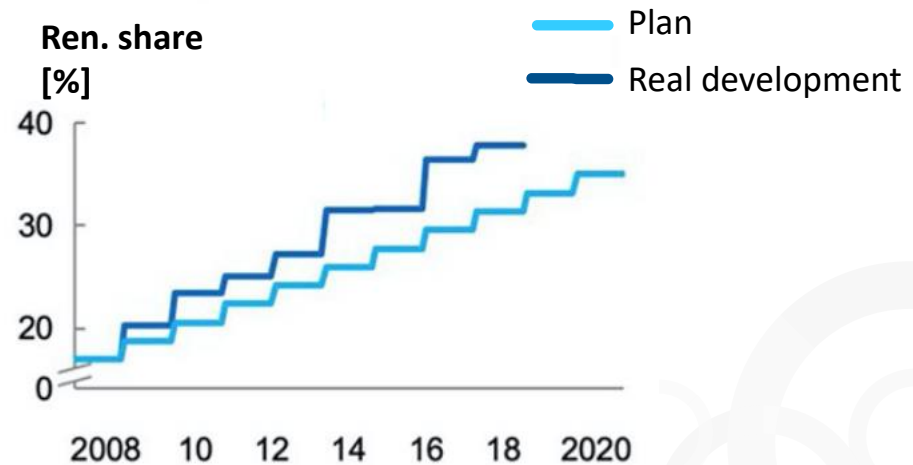
# Goals vs. Reality



## CO<sub>2</sub> emissions



## Renewable share in el. production



- Till 2020 reduce emissions by 40 % compared to 1990 (to 720 MtCO<sub>2</sub>e)

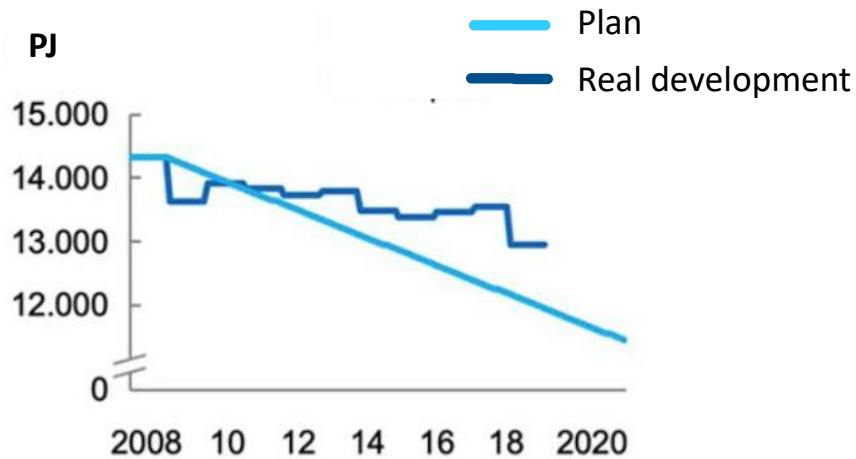
- Targets for el. production from Renewables 2020 35 %, 2025 40-45 %, 2030 50 %, 2050 80 %

Faster growth of electricity production from renewable does not ensure sufficient emission reduction

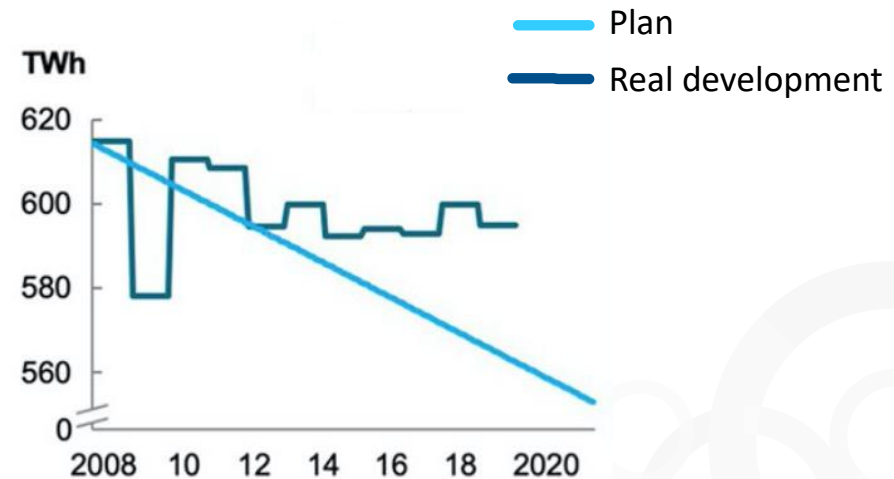
# Goals vs. Reality



## Primary energy consumption



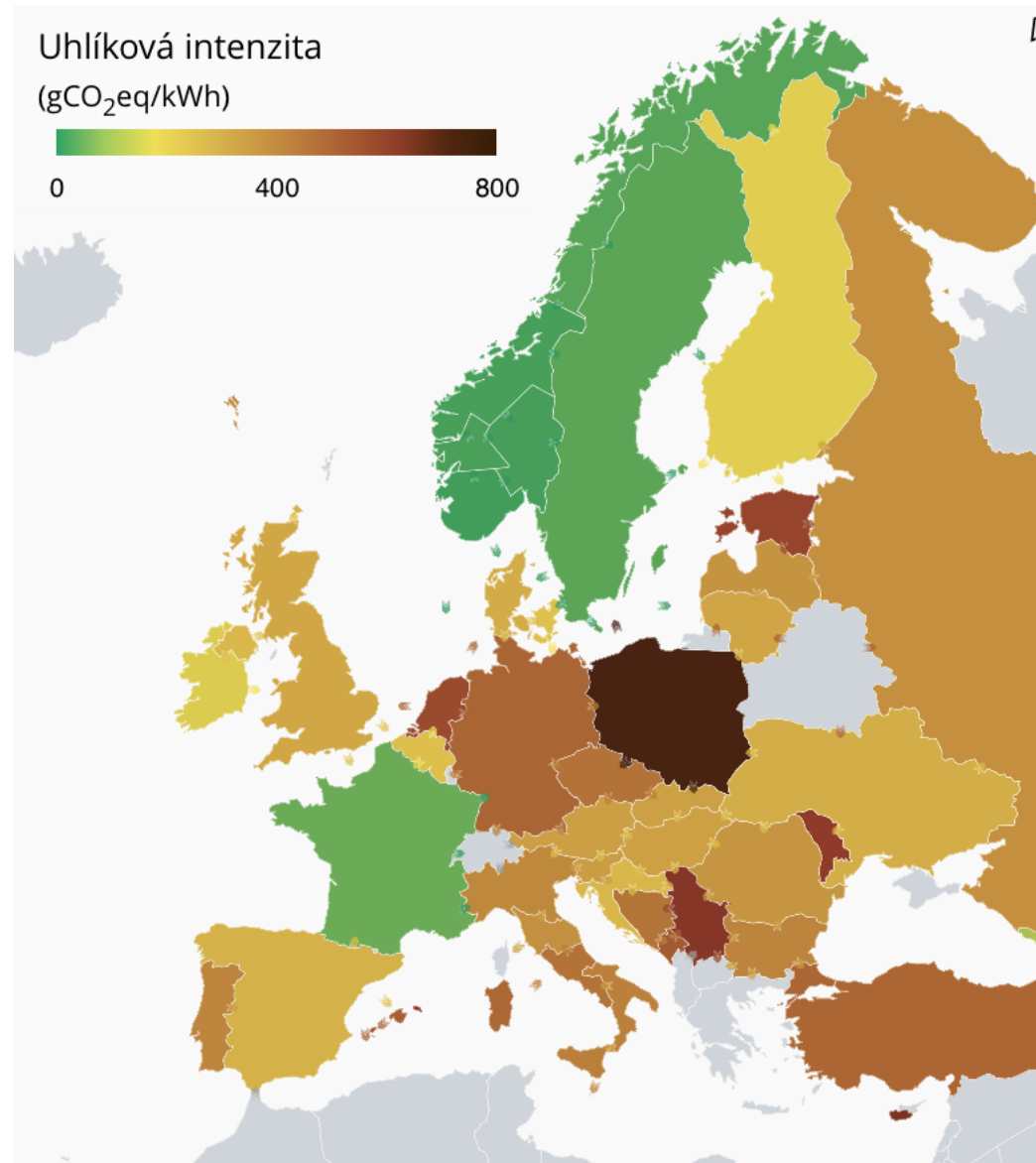
## Electricity consumption



- Till 2020 reduce primary energy consumption by 20 % compared to 2008 (to 11 454 PJ)

- Till 2020 reduce electricity consumption by 10 % compared to 2008 (to 553 TWh)

# Electricity production map



←  Francie

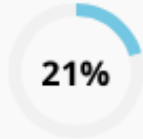
30. říjen 2019 16:47



Uhlíková intenzita  
(gCO<sub>2</sub>eq/kWh)

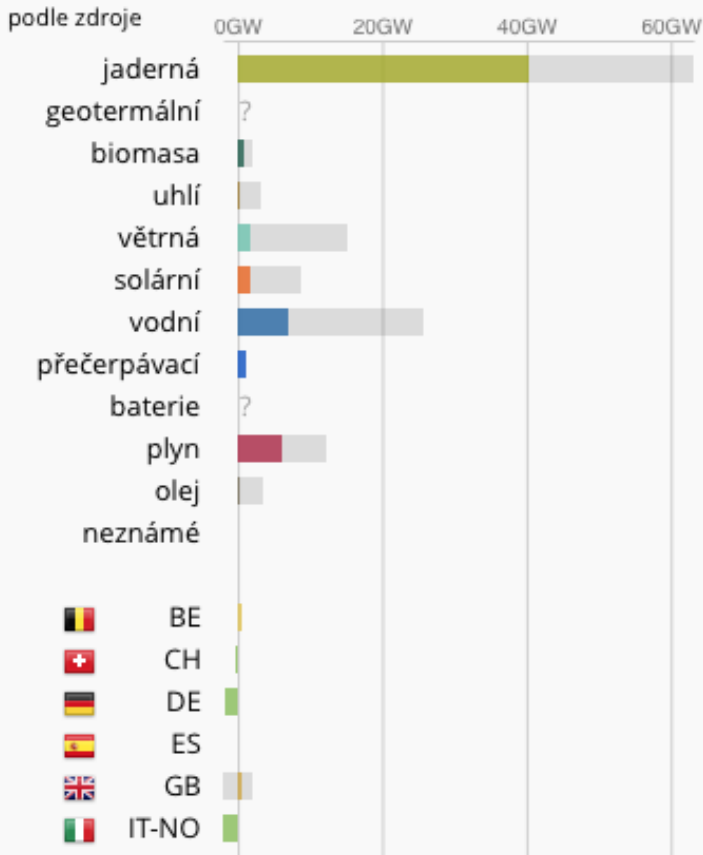


Nízké emise



Obnovitelné

Spotřeba elektřiny | Uhlíkové emise



←  Německo

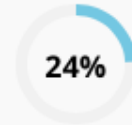
30. říjen 2019 16:47



Uhlíková intenzita  
(gCO<sub>2</sub>eq/kWh)

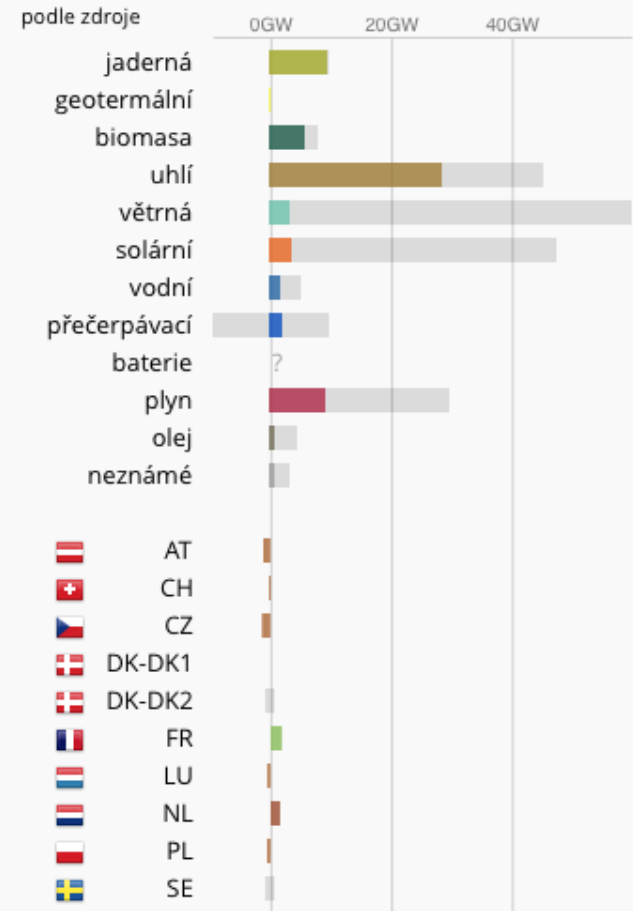


Nízké emise



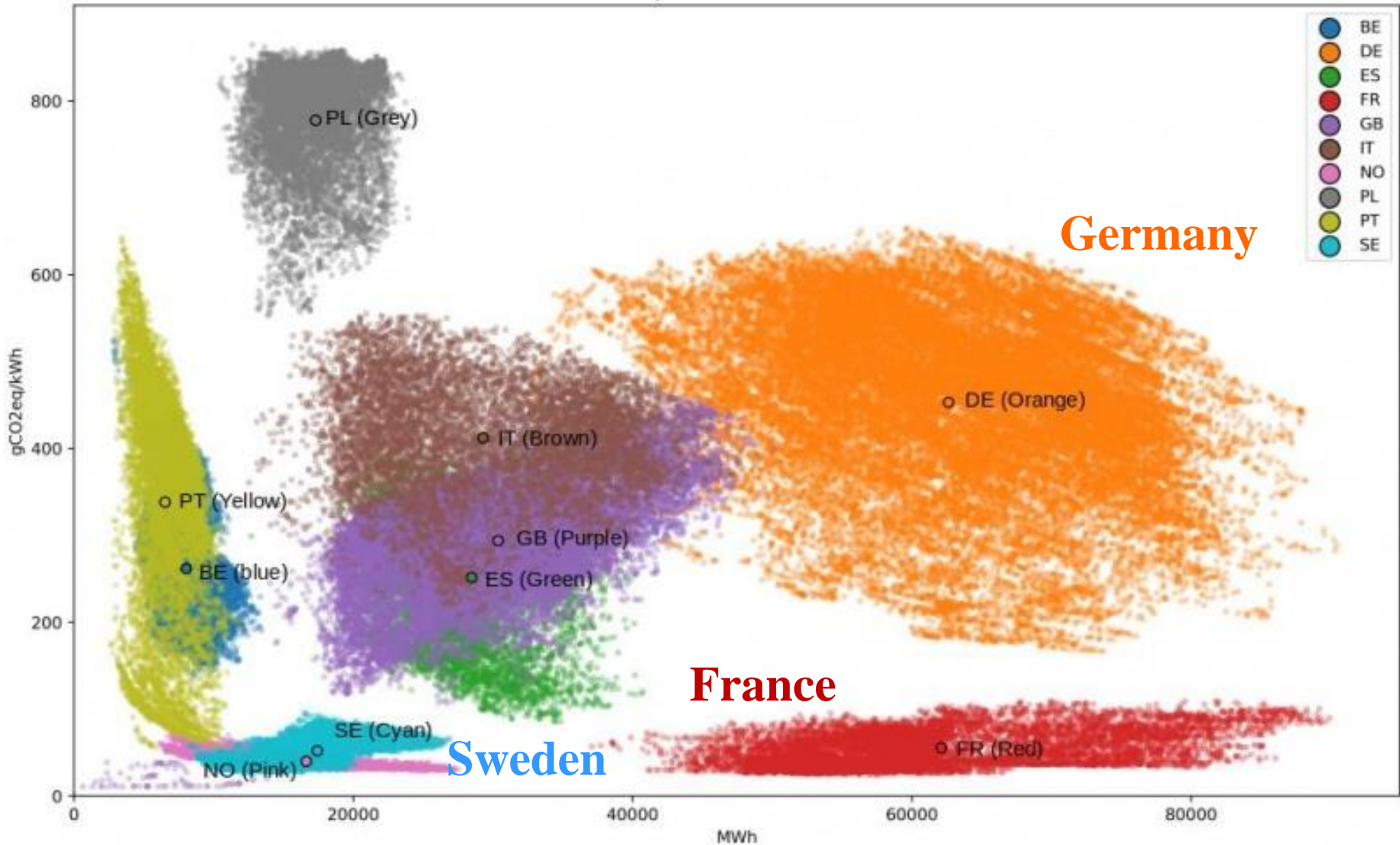
Obnovitelné

Spotřeba elektřiny | Uhlíkové emise

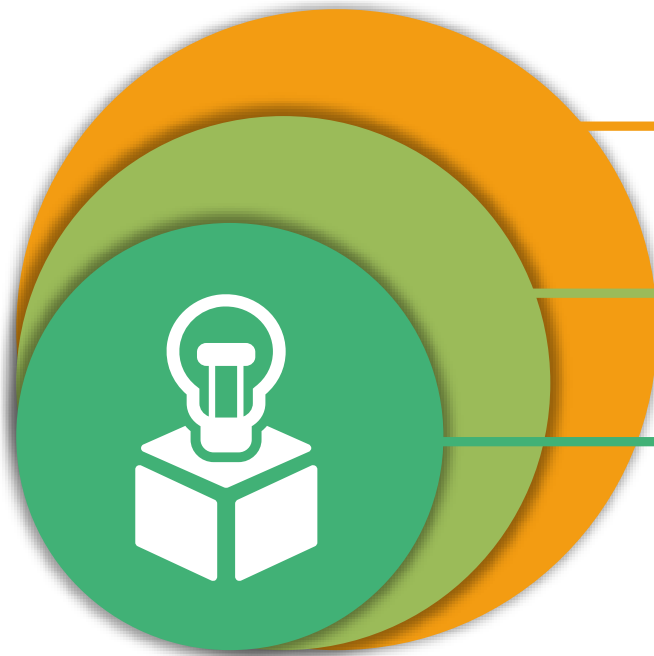


# CO<sub>2</sub> emissions overview 2018

Relative emission compared to power generation  
Source: ENTSO-E, IPCC 2018  
From: 01-Jan-2018 to: 31-Dec-2018



# Where are we heading?



● Should Germany stop phasing-out nuclear?

● Is/will be the security of energy supply guaranteed?

● Is Energiewende a way for efficient/successful decarbonization?

# References



<https://oenergetice.cz/elektrina/Energiewende-a-jeji-cile/>

[http://www.gesetze-im-internet.de/eeg\\_2014/](http://www.gesetze-im-internet.de/eeg_2014/)

<https://oenergetice.cz/akumulace-energie/vyznam-akumulace-energie-v-nemecke-energiewende/>

[https://www.researchgate.net/publication/261848307\\_Technology\\_Roadmap\\_Energy\\_storage](https://www.researchgate.net/publication/261848307_Technology_Roadmap_Energy_storage)

<https://www.spiegel.de/international/germany/phasing-in-the-phase-out-germany-reconsiders-reactor-lifespan-extensions-a-750836.html>

<https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/germany.aspx>

<https://www.world-nuclear.org/country/default.aspx/Germany>

<https://www.mckinsey.de/branchen/chemie-energie-rohstoffe/energiewende-index>

[https://www.netzausbau.de/leitungsvorhaben/de.html?cms\\_map=2](https://www.netzausbau.de/leitungsvorhaben/de.html?cms_map=2)

<https://www.cleanenergywire.org/dossiers/energy-transition-and-germanys-power-grid>

<http://atominfo.cz/2019/10/handelsblatt-nemecko-ma-v-energetice-vazny-problem/>

<https://oenergetice.cz/energostat>

<https://webstore.iea.org/world-energy-balances-2019>

<https://ag-energiebilanzen.de/4-1-Home.html>

[https://www.energy-charts.de/energy\\_pie.htm?year=2011](https://www.energy-charts.de/energy_pie.htm?year=2011)

<https://www.electricitymap.org/?page=country&solar=false&remote=true&wind=false&countryCode=FR>

<https://www.world-nuclear.org/information-library/energy-and-the-environment/energiewende.aspx>



THANK YOU  
FOR YOUR  
ATTENTION