# Gas vs REN / EE in Germany

## The need to complement renewables by decarbonised gas*

Discussion at EU Russia Gas Advisory Council, St. Petersburg, 10 July 2018

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*Based on OIES Paper NG 129

# Rationale

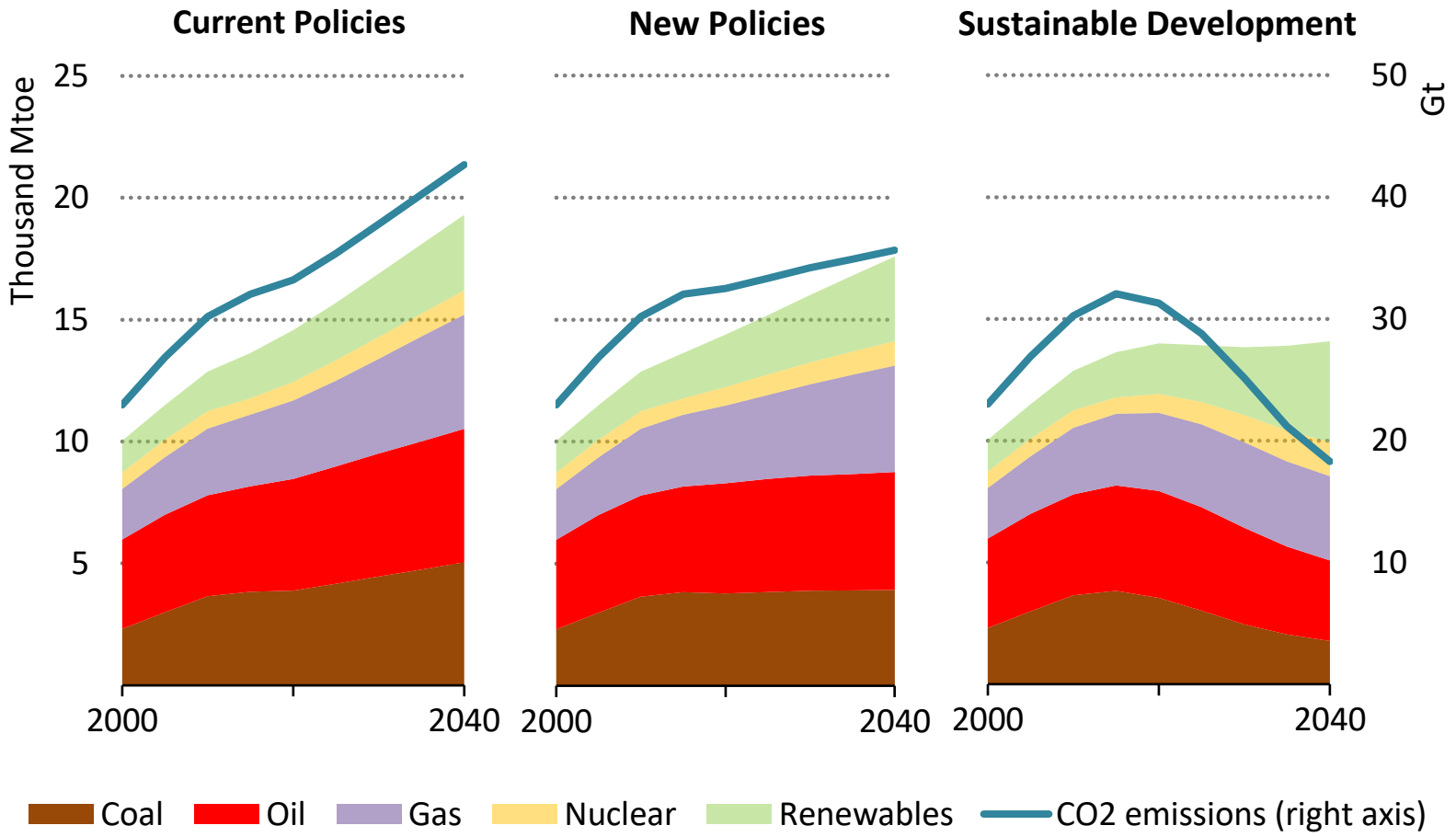
1. The Paris Agreement stipulates
   - To stay below 2 (or less) degree C : corresponding largely to staying within a carbon budget (1000 Gt CO2 as of 2015)
   - To have a carbon neutral world in 2nd half of 21 century
2. Renewables (de facto electric renewables) will not come in time to stay within the carbon budget (example Germany)
3. De carbonized energy are not necessarily renewables (misperception), fossil fuels can be de –carbonized!

Mandatory conclusion: renewables must be complemented by de carbonized fossil fuels, for practical reasons hydrocarbons and here gas first! Disposing of CO2 from decarbonization process in geological structures (reservoirs and aquifers) is necessary

4. An all renewable (electric) world would devalue the hydrocarbon resources and investment, shrinking the resource rent and cross border energy material trade
5. De carbonizing natural gas (and other hydrocarbons) to H2 (or NH3) is necessary to achieve the PA targets and avoiding devaluing gas resources /infrastructure (devices).

This requires cooperation between hydrocarbon producing and consuming countries.

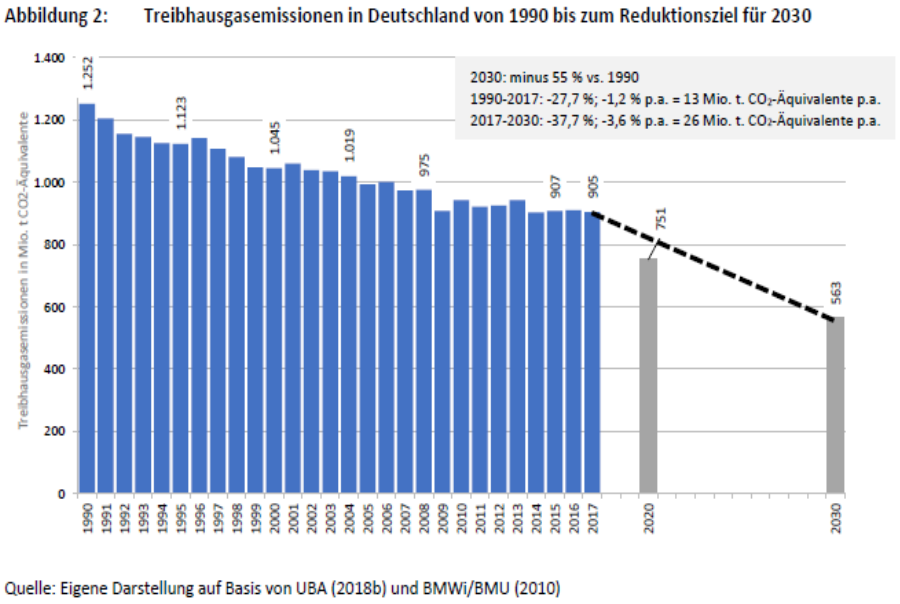
# World primary energy demand by fuel and energy-related $CO_2$ emissions by scenario (WEO 2017)




***The flattening of emissions in 2014-2016 is a pause in a slower upward journey in the New Policies Scenario, but a turning point in the SDS***

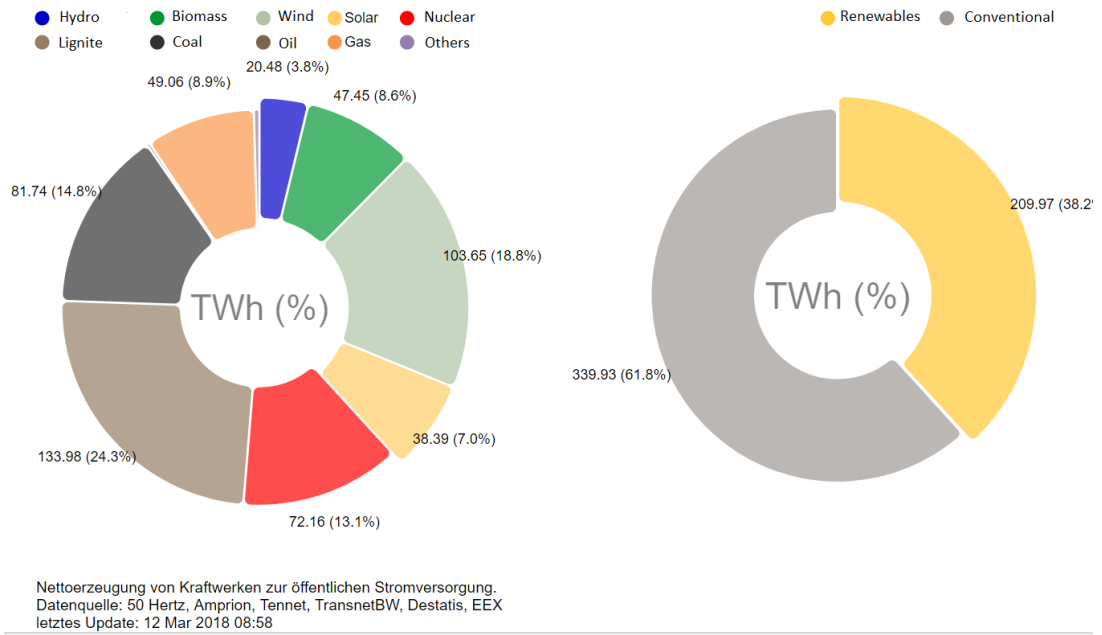
# Germany will fall short of its decarbonisation targets

## GHG Emissions Germany as of 1990 (Mio t CO2 eq)




Source: Clean Energy Wire, UBA 2018

## But it will meet its electric renewables target




Source: 50 Hertz, Amprion, Tennet, TransnetBW, Destatis, EEX

# German decarbonisation policy

Germany was and is a pioneer

- Aiming at the targets of the 4th IPCC assessment report
- Fostering renewables internally and externally (promoting IRENA)

Flaws:

- Policy instrument flaws
  - Overlap of electric renewables policy with the ETS, leading to a reduced demand for EUAs without shortening the supply of EUAs: EUA prices stay low
  - Mistaking the instrument for the target (renewables instead of de-carbonization)
- Conceptual flaw (shared by many): decarbonising can only work with renewables
  - Equating sustainable energy supply (renewables) with GHG-free energy (can also be decarbonised fossil fuels, especially hydrocarbons)

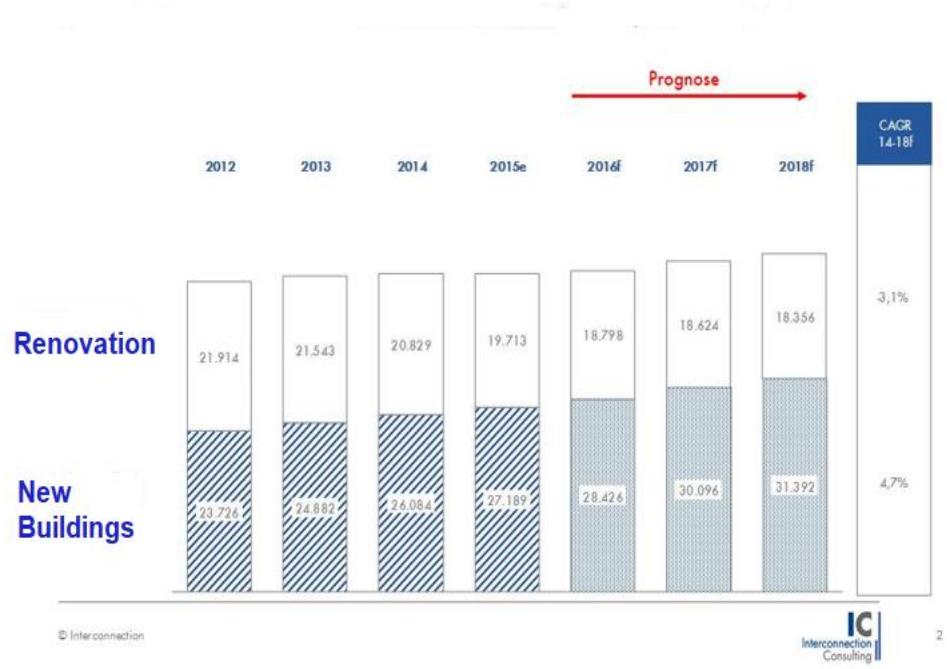
=> Renewables policy will not deliver in time for Germany's decarbonisation target / for its contribution to reach the PA targets

# Energy efficiency in buildings

**Saving in building stock stagnates**

- Energy saving in existing buildings (42 mln dwellings) is decisive
- Easy / economical measures have been implemented
- Lower gas prices make insulation unattractive
- Polystyrol on the decline (impact of the Grenfell disaster)

**Sales of insulation materials in 1000 m³**



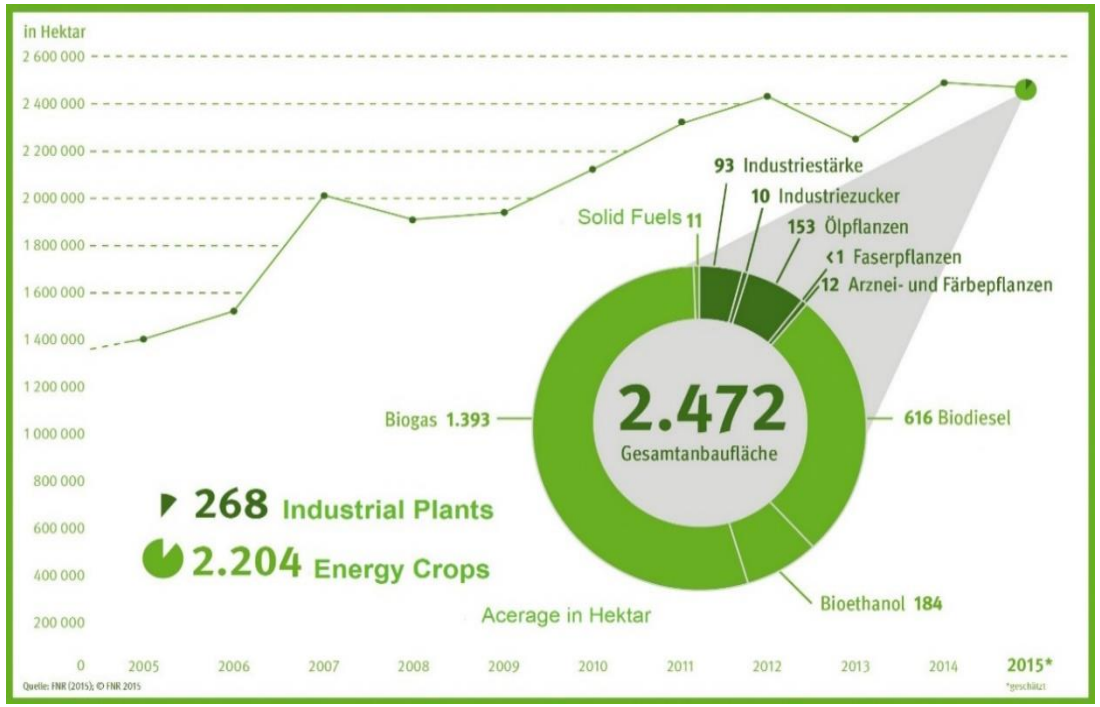

Source: Interconnection Consulting

# Use of biomass for energy purposes

## Limitations

- Biomethane less than 1 bcm/a compared to the 6 bcm/a target
- Use of renewables for heating, mainly wood
- Limitations by need for $CO_2$ absorption
- Biomass waste for small power and in industry reached its limits
- Limited acreage for energy crops

## Acreage for energy crops in Germany, 2005-2015



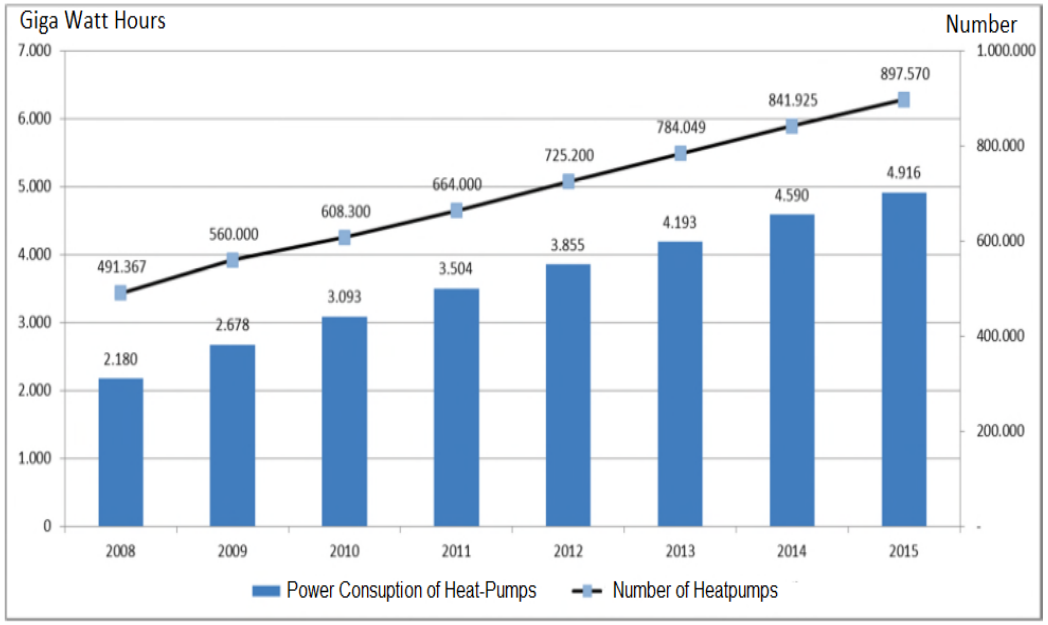

Source: FNR 2015

# Heat pumps as major renewables in heating?

## Obstacles to further deployment of heat pumps (6 mln by 2030)

- Major effect needs use in existing building stock (42 mln dwellings)
- Only one third installed in existing buildings
- Restrictions in urban areas
- Decreasing yields at low temperatures
- Add to the winter peak load

## Number of heat pumps and power consumption of heat pumps



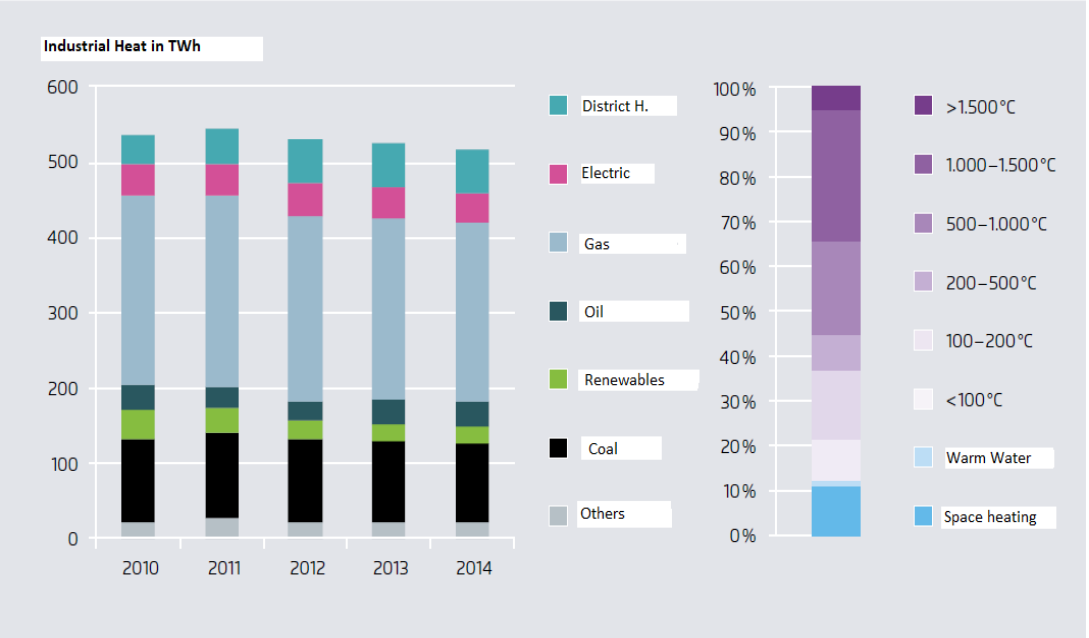

Source: Bundesumweltamt

# Renewables in industry

## Renewables in industry: marginal

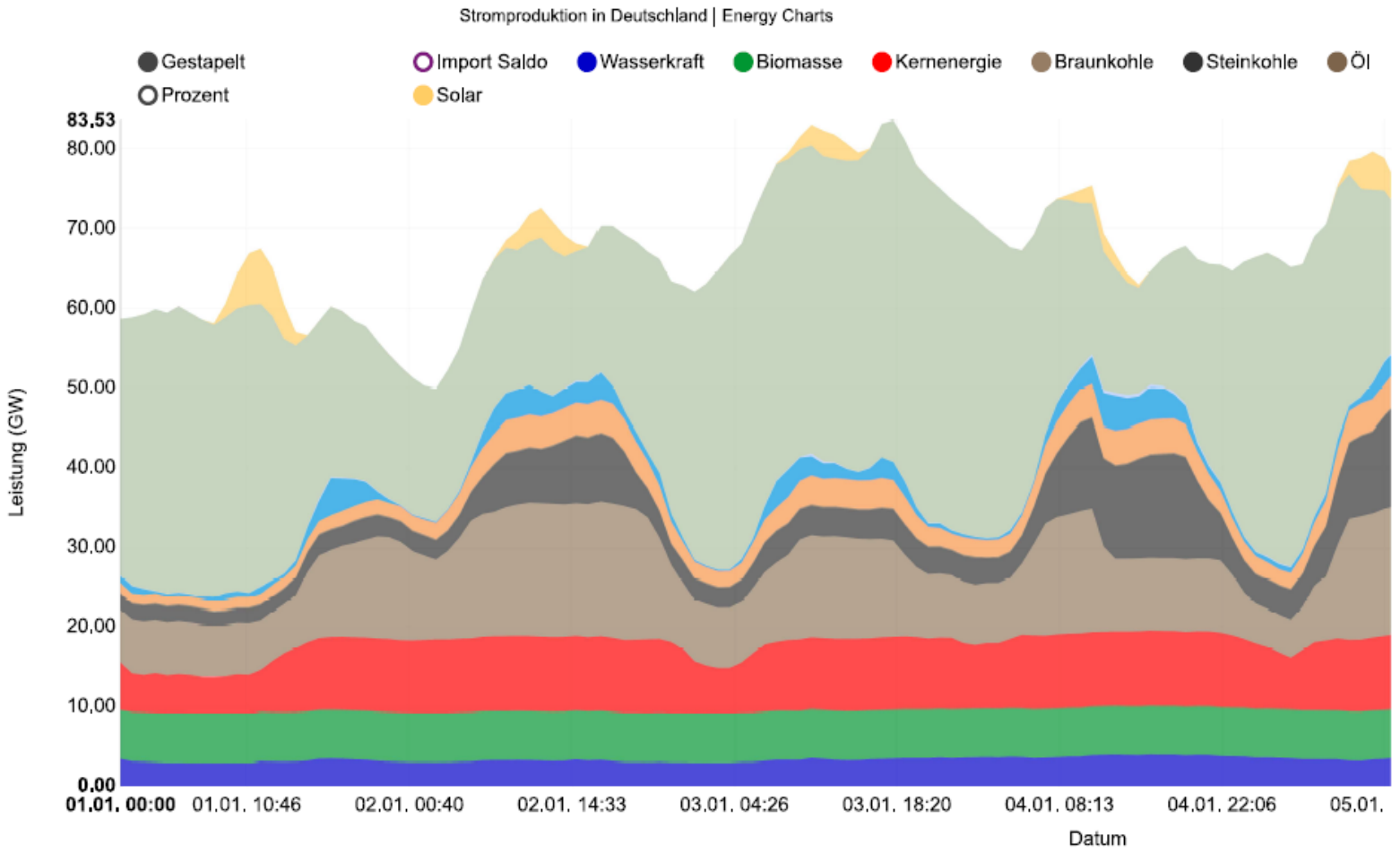
- Renewables ca 5%, constrained to waste from paper and pulp
- 50% of process heat > 500 degrees C
- Gas easy to handle at all temperatures
- Still 20% coal
- CHP potential for gas

## Industrial heat consumption in TWh




Source: Agora Energiewende (Feb. 2017): Changing Heat Supply 2030

# Eleanor in January 2018: testing the power system



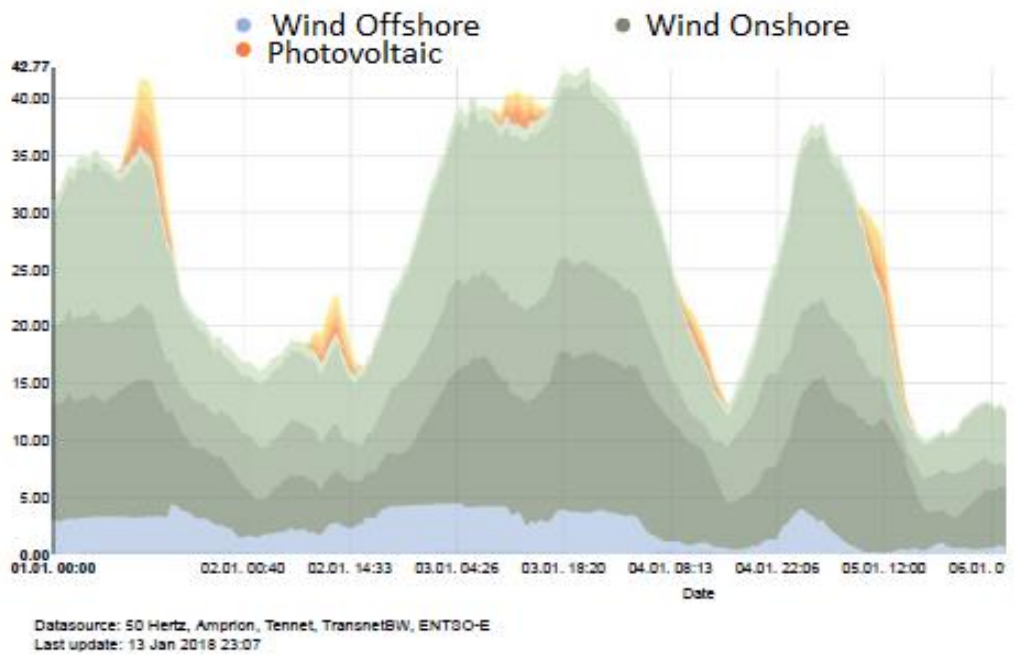

Nettoerzeugung von Kraftwerken zur öffentlichen Stromversorgung.
Datenquelle: 50 Hertz, Amprion, Tennet, TransnetBW, EEX
letztes Update: 24 Jan 2018 09:29

# Challenges posed by wind and PV

## Challenges of intermittence

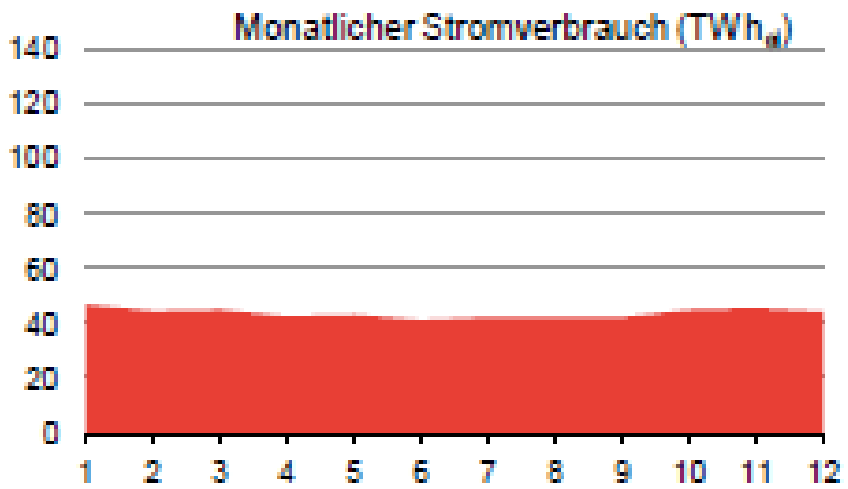
- High volatility (during storms): all thermal in load following: 2-3 GW/h
- Strong wind / PV > low demand: cut REN or export surplus + must-run thermal (1 Jan 2018)
- Low wind in dark winter: dispatchable power must cover all peak load! (2nd half of Jan 2017)
- High ./. low wind: 200 h/a x 50 GW = 10 TWh (aluminium: 8 GWh/a)
- Export / import as a buffer, how long?

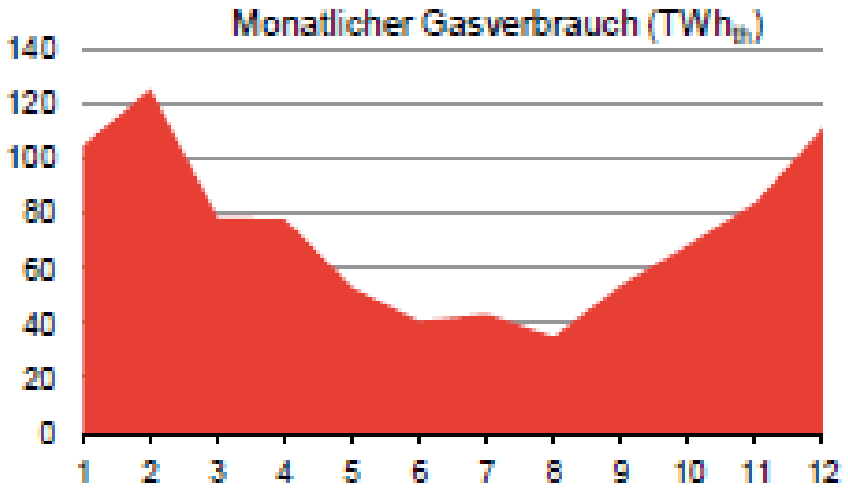
## Wind, PV during 1-6 Jan 2018 (Eleanor)




Source: 50 Hertz, Amprion, Tennet, TransnetBW, ENTSO-E

# Monthly consumption and storage volume: power vs. gas (2012,TWh)




Strom-Speichervolumen in Deutschland: 0,04 TWh$_{el}$

Source: Frontier Economics on the basis of ENTSO-E, IEA and the German Bundestag (2017)

# Lessons from Germany for global decarbonisation

- If renewables and energy efficiency do not reach Germany's decarbonisation targets (with € 20 bln support per year), they are unlikely to work globally to reach PA targets
- Germany's Energy Strategy – if it worked - would use up 1.5% of the carbon budget (for 2 degrees) by 2050 compared to 1% of global population
- Countries differ, but seasonal and annual variations of REN production generally apply in moderate zones, so does competition of producing energy biomass with food production
- Do not equate renewables with carbon free energy, renewables are sustainable, the point is about a carbon free energy supply first
- Only adding decarbonised hydrocarbons has the potential to reach the PA targets in time (within the carbon budget)
- Renewables alone will not reach the global decarbonisation target in time
- It is essential to complement renewables by other GHG-free energy. Known processes applied on a large scale are needed.
- Decarbonising natural gas to $H_2$ through a reforming process upstream is a good start

# Benefits of decarbonizing natural gas upstream

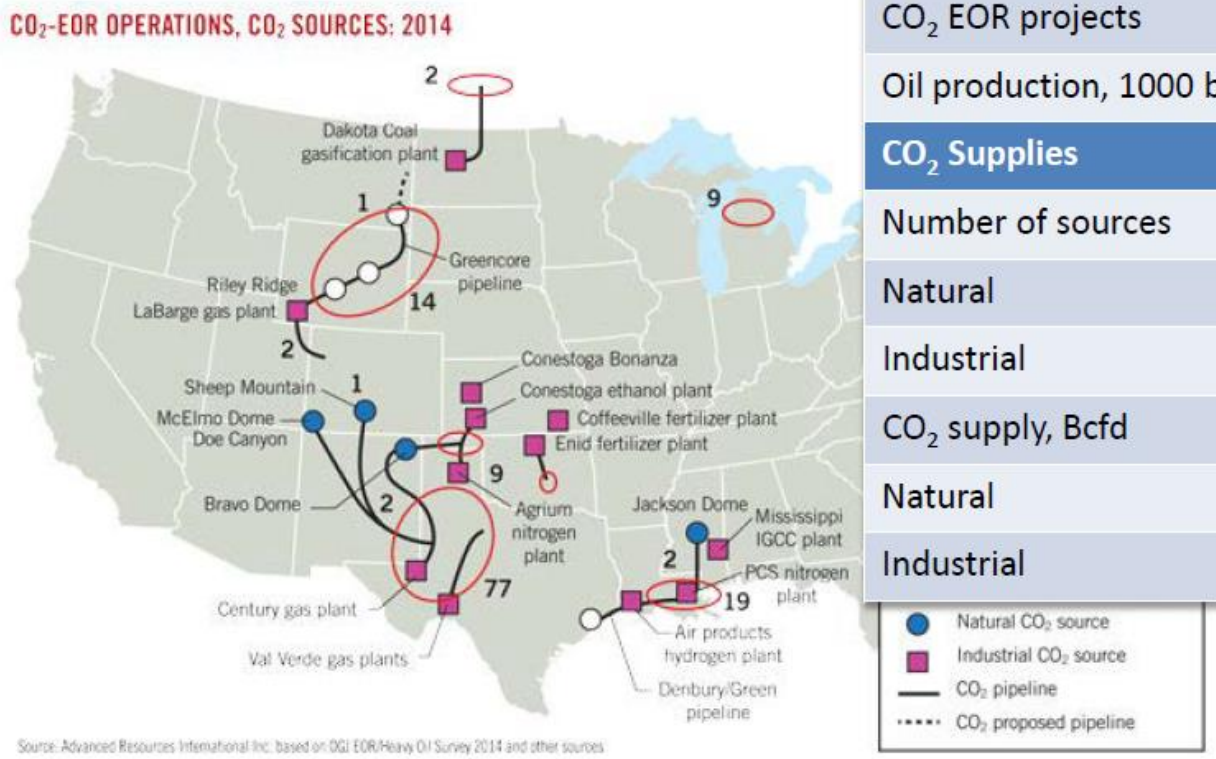
T**o achieve PA targets:**

- Time is of the essence
- Natural gas (and other hydrocarbons) can become important part of de carbonized world (a competitive solution fuel)
- Reforming of natural gas is wide  spread; NEW: reforming upstream, disposal of CO2 in structure near production (possibly EOR); no need for long CO 2 pipelines, no discussion in populated areas

**Impact on industry**

- Keeps value of resources, infrastructure , adding options for new sales in traffic segment (fuel cell use cars, locomotives and ships)
- Duration: as long as gas resource can be exploited competitive with renewables
- Becomes a competitor for (electric) renewables with different pros / cons, new competitive environment for industry
- Resource owning countries sell energy contained in natural gas as H2  (some energy losses as local heat), plus selling CO2 storage room  => carbon free H2 as higher value product

# U.S. $CO_2$ EOR Projects

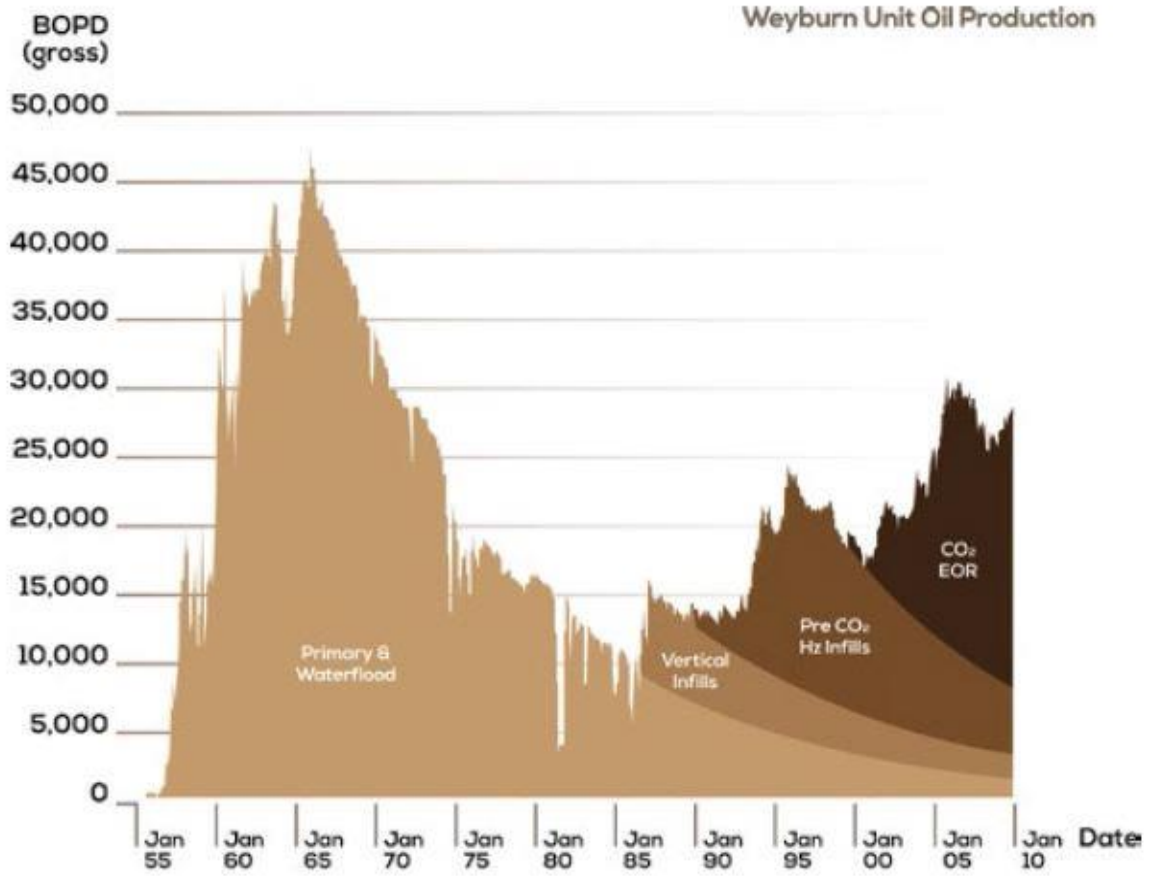



| Oil Production, 2014 | |
|---|---|
| $CO_2$ EOR projects | 136 |
| Oil production, 1000 b/d | 300 |
| **$CO_2$ Supplies** | |
| Number of sources | 17 |
| Natural | 5 |
| Industrial | 12 |
| $CO_2$ supply, Bcfd | 3.5 |
| Natural | 2.8 |
| Industrial | 0.7 |

EERC

*Source: Evolution of CO2 EOR and CCS in the United States* 7th IEA International CCS Regulatory Network International Energy Agency Paris, France April 22–23, 2015 John A. Harju Associate Director for Research

# EOR from CO2 injection at the Weyburn field (Canada)




Because the $CO_2$ is miscible with the oil a certain amount of $CO_2$ returns to the surface during oil production. The oil company at the Weyburn field separates this $CO_2$ from the oil mixture at the surface, and compresses and re-injects it along with the new $CO_2$ arriving from the United States.

source: What happens when $CO_2$ is stored underground? Q&A from the IEAGHG Weyburn-Midale $CO_2$ Monitoring and Storage Project

# Estimates of CO2 storage capacity in the Norwegian shelf
## by the Norwegian Petroleum Directorate (CO2 storage atlas Norwegian North Sea)

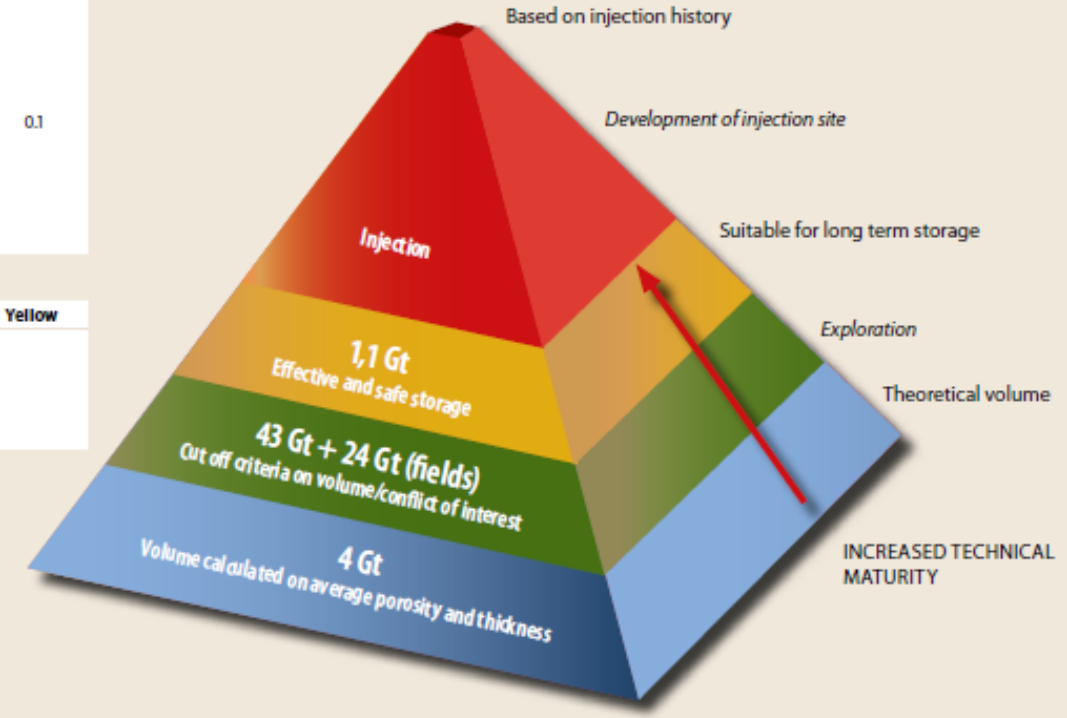
**Storage capacity in Gigatons and technical maturity**

**Aquifers**

| Basin/reservoir | Storage capacity | Maturity | | |
|---|---|---|---|---|
| | Total | Blue | Green | Yellow |
| Utsira and Skade | 15.8 | | 14.8 | 1 |
| Bryne/Sandnes southern parts | 13.6 | | 13.6 | |
| Sognefjord Delta east | 4.1 | | 4.1 | |
| Statfjordfm øst | 3.6 | | 3.6 | |
| Gassum | 2.9 | 2.9 | | |
| Bryne/Sandnes Farsund basin | 2.3 | | 2.3 | |
| Johansen and Cook | 1.8 | | 1.7 | 0.1 |
| Fiskebank | 1 | 1 | | |
| Hugin East | 0.1 | | 0.1 | |
| Stord basin, Jura | 0.1 | 0.1 | | |
| Stord basin , mounds | 0.05 | 0.05 | | |

**Field related**

| | | Blue | Green | Yellow |
|---|---|---|---|---|
| Abandoned fields | 3 | | 3 | |
| Fields in production 2030 | 4 | | 4 | |
| 2050 | 6 | | 6 | |
| Sognefjord delta including Troll | 14 | | 14 | |




Halland E.K., Johansen W.T., Riis F., 2012. CO2 Storage Atlas Norwegian North Sea, NPD report: http://npd.no/en/Publications/Reports/CO2-Storage-Atlas-/

# Comparison / competition seen from an importing country: electric renewables vs. decarbonised gas

## Electric renewables

### Pros

- Wind, PV existing solution
- Sustainable in the long term
- Low variable costs
- Domestic
  - No import costs
  - No resource rent transfer
  - No import dependence

### Challenges

- Volumes not high enough
- Intermittence
- No battery solution
- Not always customer-friendly

## Decarbonised gas

### Pros

- Additional carbon-free solution
- Easy to store, transport
- More customer-friendly
- Use of existing resources
- Use of existing infrastructure, appliances
- Continuity of the role of resource owners
- Potential use in traffic, e.g. fuel cell cars

### Challenges

- Need to create a market for $H_2$
- Transition issues
- Resource rent transfer
- Import dependence

# Potential for co-operation

Topics for joined or shared research:

- Market for energy molecules (CH4 or H2) vs for electric power
- Use of Hydrogen
  - Potential market development
  - Blending and separating H2 and CH4
  - Use of existing infrastructure / equipment
- Ways to decarbonize natural gas
- How to dispose of C, CO2 (experience EU, Nor, US, Rus)

Conceptual discussion on trading de carbonized gas

Thank you for your attention!

# GHG Emissions Germany by sector in 2016 (Mio t CO2)

Tabelle 6: Energiebedingte $CO_2$-Emissionen aus Verbrennungsprozessen nach Sektoren und Energieträgern in Deutschland 2016 (ohne Biomasse)

| | Verbrennungsprozesse insgesamt | Energiesektor | Industrie | Verkehr | Haushalte und GHD |
|---|---|---|---|---|---|
| | Mio. t $CO_2$ | | | | |
| Flüssige Brennstoffe | 252,1 | 18,4 | 17,3 | 163,37 | 47,1 |
| Feste Brennstoffe | 310,4 | 258,4 | 48,8 | 0,03 | 3,1 |
| Gasförmige Brennstoffe | 168,2 | 34,8 | 53,2 | 1,65 | 77,5 |
| Andere fossile Brennstoffe | 21,0 | 15,0 | 6,1 | 0,00 | 0,0 |
| **Insgesamt** | **751,7** | **326,5** | **125,3** | **165,0** | **127,7** |
| | Anteile in % | | | | |
| Flüssige Brennstoffe | 33,5 | 5,6 | 13,8 | 99,0 | 36,9 |
| Feste Brennstoffe | 41,3 | 79,1 | 38,9 | 0,0 | 2,4 |
| Gasförmige Brennstoffe | 22,4 | 10,6 | 42,4 | 1,0 | 60,7 |
| Andere fossile Brennstoffe | 2,8 | 4,6 | 4,8 | 0,0 | 0,0 |
| **Insgesamt** | 100,0 | 100,0 | 100,0 | 100,0 | 100,0 |

Quelle: Eigene Darstellung auf Basis von UBA (2018b)

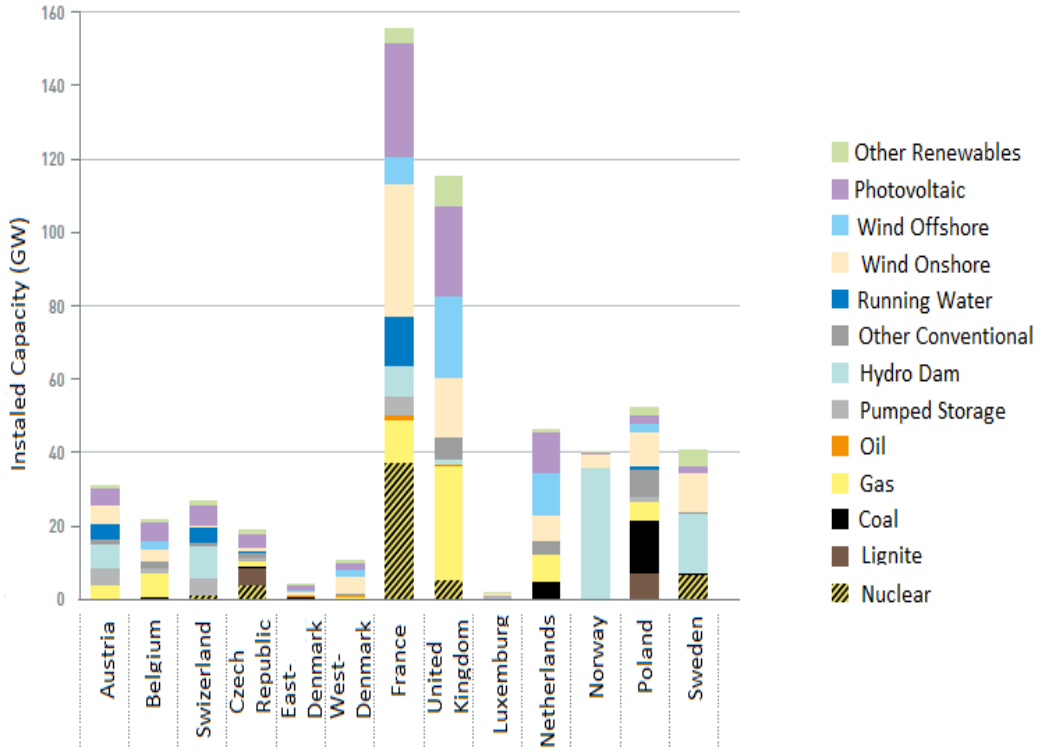
Source: Stellungnahme zum sechsten Monitoring-Bericht der Bundesregierung für das Berichtsjahr 2016

# Challenges posed by wind and PV

## Power exchange with neighbours?

- Export / import used to manage intermittence of wind and PV
- Most neighbours will also increase renewables (and intermittence) by 2030
- Closing nuclear by 2030 in DE, B, NL, part UK, part F
- Neighbouring grids swing to the tune of wind in Germany / NWE

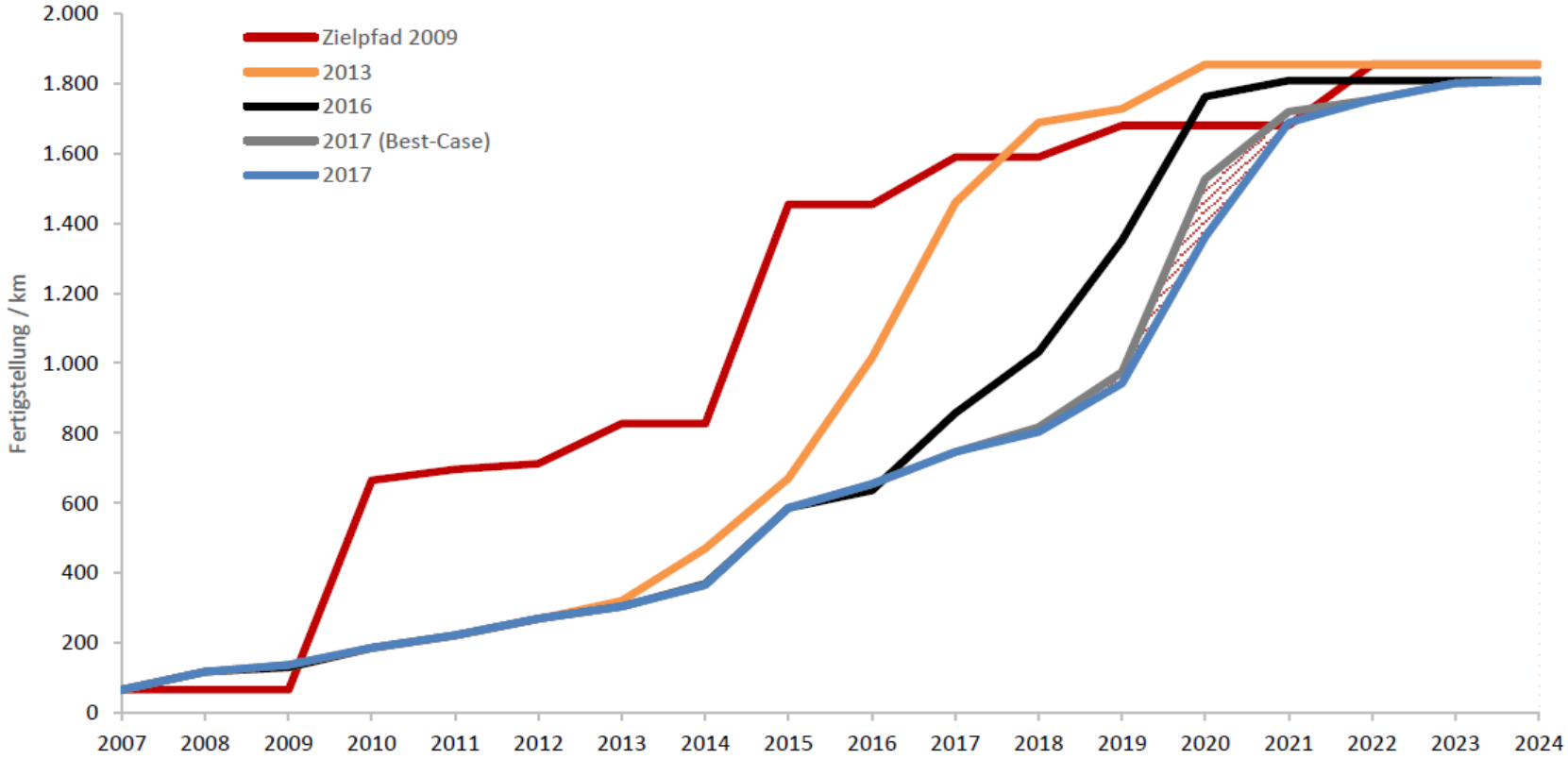
## Projected capacity 2030 in other EU counties



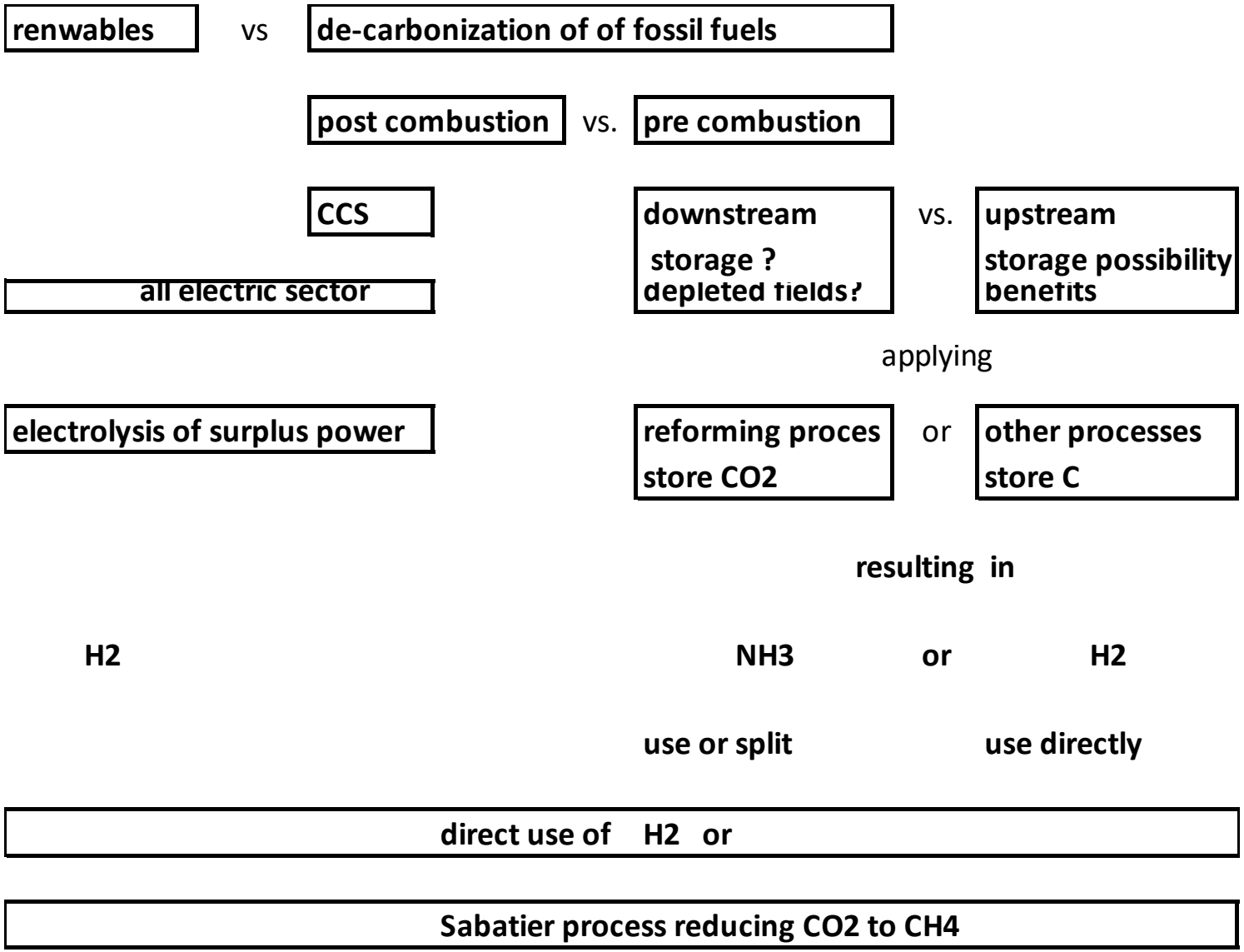

Source: ÜNB; (Jan 2018) Scenarios for the power grid development plan (NEP) for 2030 (draft 2019 version), p. 109

# Building of HV lines: Pathway 2009 and adoptions

**Abbildung 5: Ursprungspfad und allmählich angepasste Zielpfade des Netzausbaus nach EnLAG**




Quelle: Eigene Darstellung auf Basis von BNetzA/BKartA (2014, 2015) und BNetzA (2010, 2017c)

Source: Stellungnahme zum sechsten Monitoring-Bericht der Bundesregierung für das Berichtsjahr 2016

# Decision Tree