

Electricity, Heat, Mobility: Sector integration in the future energy system

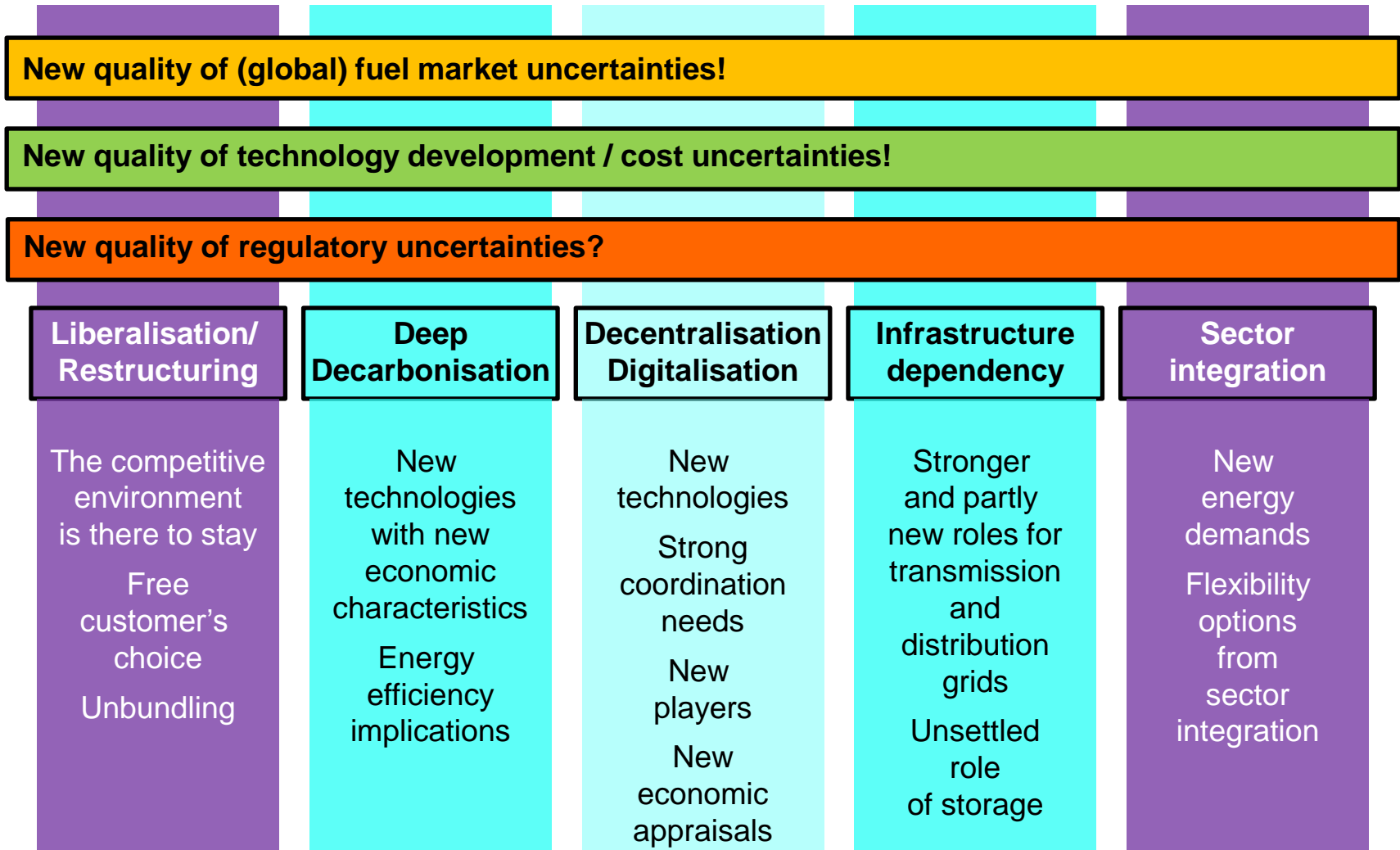
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» Security of Supply in a European Context «

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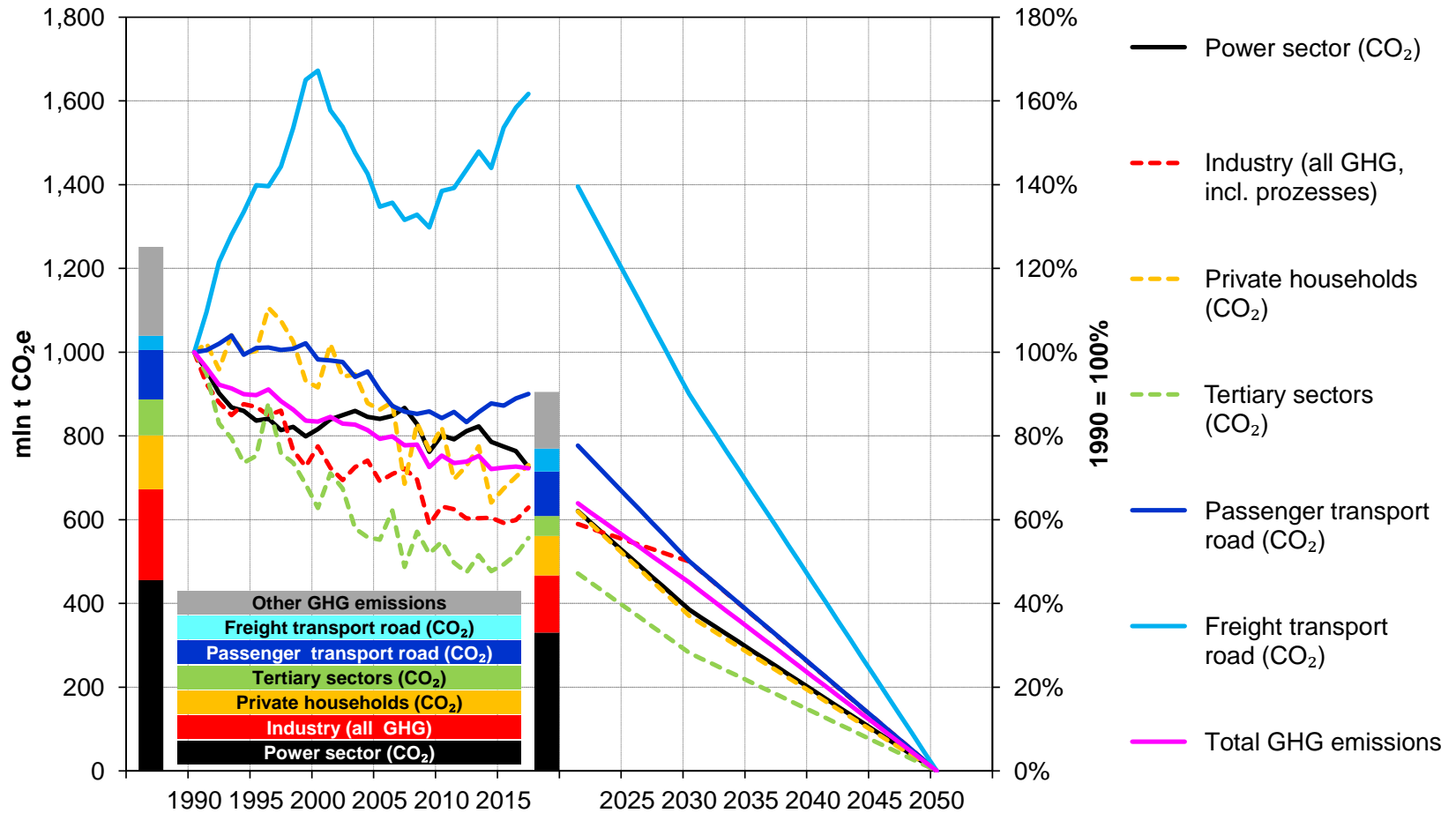
Energy transformation at the intersection of different megatrends

Sector integration is one of them



Total and sectoral GHG emissions in Germany

A bumpy road towards the new paradigm of climate neutrality



German (and European) energy and climate policy

The importance of medium and long-term strategies (1)

Climate neutrality is the new long-term target for Europe and Germany

What did we learn from the modelling exercises so far?

- the technologies for reaching the 2030 targets are available
- the technology options for reaching the 2050 targets are either available or at least visible in the innovation pipeline
 - energy efficiency and electrification: -XX €/MWh ... +XX €/MWh
 - electricity from renewables: 35 €/MWh + 45 €/MWh integration & backup costs (= 50...100 €/t CO₂), limit probably at 800 TWh
 - hydrogen: economic benchmark is (imported) blue hydrogen (natural gas + steam reforming + CCS): 40...80 €/MWh (= 100...300 €/t CO₂), significant imports of blue/green hydrogen (e.g. 500 TWh?)
 - many other (smaller) options will also be needed for climate-neutrality (e.g. industrial process emissions, agriculture)

Sector integration in the energy system transformation

A closer look beyond the headlines (1)

Decarbonizing the energy system towards climate neutrality requires

- for all sectors the optimal level of energy efficiency (efficiency first!)
- for all sectors CO₂-neutral energy carriers in the long term, in the medium term low-carbon energies
- for some sectors (e.g. industrial processes) other options (e.g. CCS)

CO₂-neutral energy carriers in a sustainable energy system

- CO₂-neutral final energy carriers
 - electricity
 - fuels
 - heat
- renewable primary energy carriers
 - hydro – limited potential
 - wind – restrictions on land availability (in Germany)
 - solar – restrictions on land availability (in Germany)
 - biomass – restrictions on land availability and sustainability
- nuclear: not an option (in Germany and many other places)

Sector integration in the energy system transformation

A closer look beyond the headlines (2)

CO₂-neutral final energy carriers

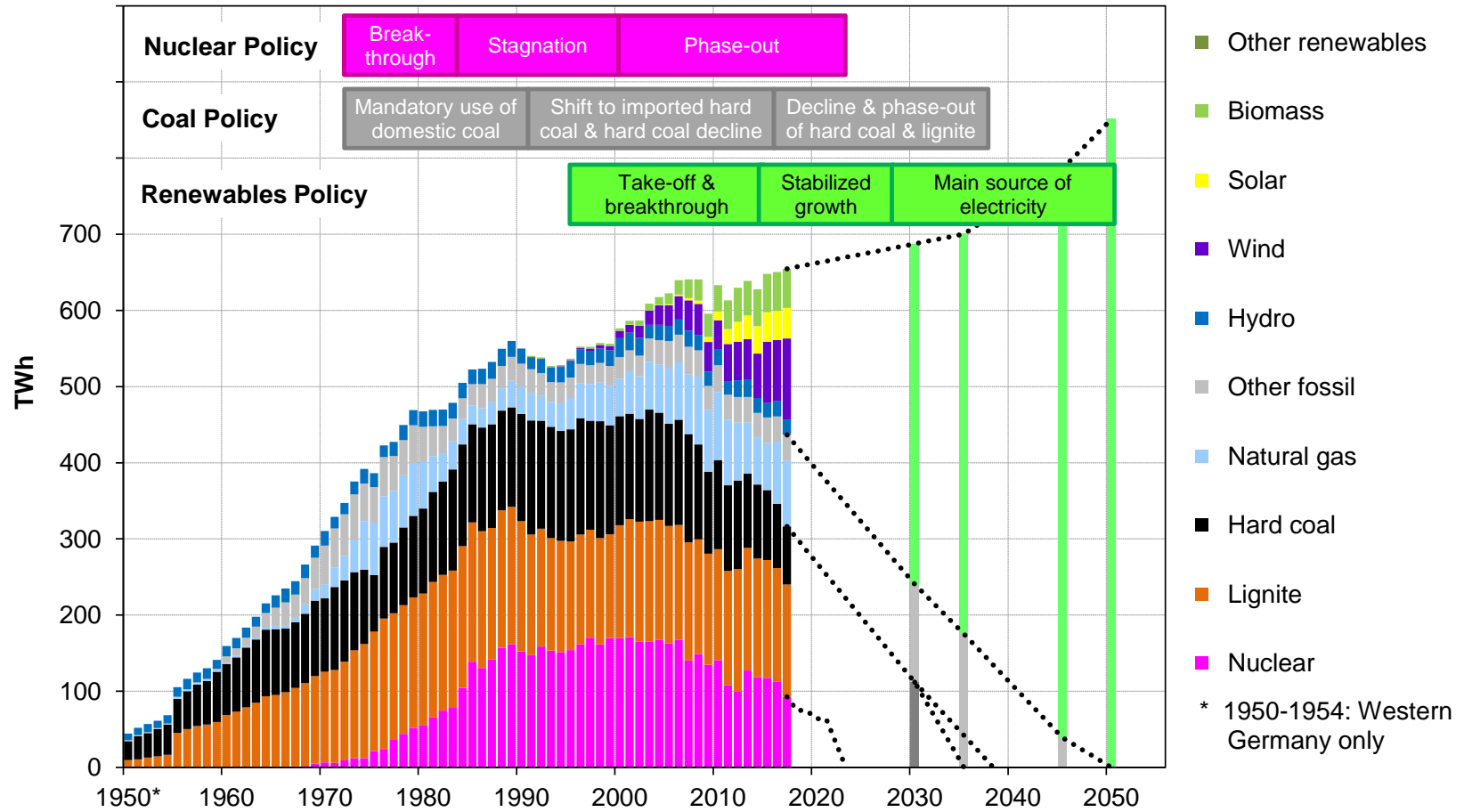
- direct use of biomass with significantly limited potential
- direct solar-thermal energy with significantly limited potential
- direct use of electricity with large potential, but not for all sectors (some industrial processes, aviation & other long-distance transport)
- indirect use of electricity with large potential
 - domestic CO₂-free electricity supplies for production of electricity based fuels (e-fuels) are limited domestically
 - international trade with CO₂-neutral e-fuels (and not only e-fuels) will play a significant role
 - is there a role for novel fuels beyond hydrogen (DAC?!)?

Sector integration is about direct and indirect use of electricity and the interactions between the supply and the demand system

- direct and indirect use of electricity for final demand
- direct and indirect use of the demand side as flexibility option in an electricity system dominated by variable supply options

The transformation of the German electricity system

The bigger picture at a glance



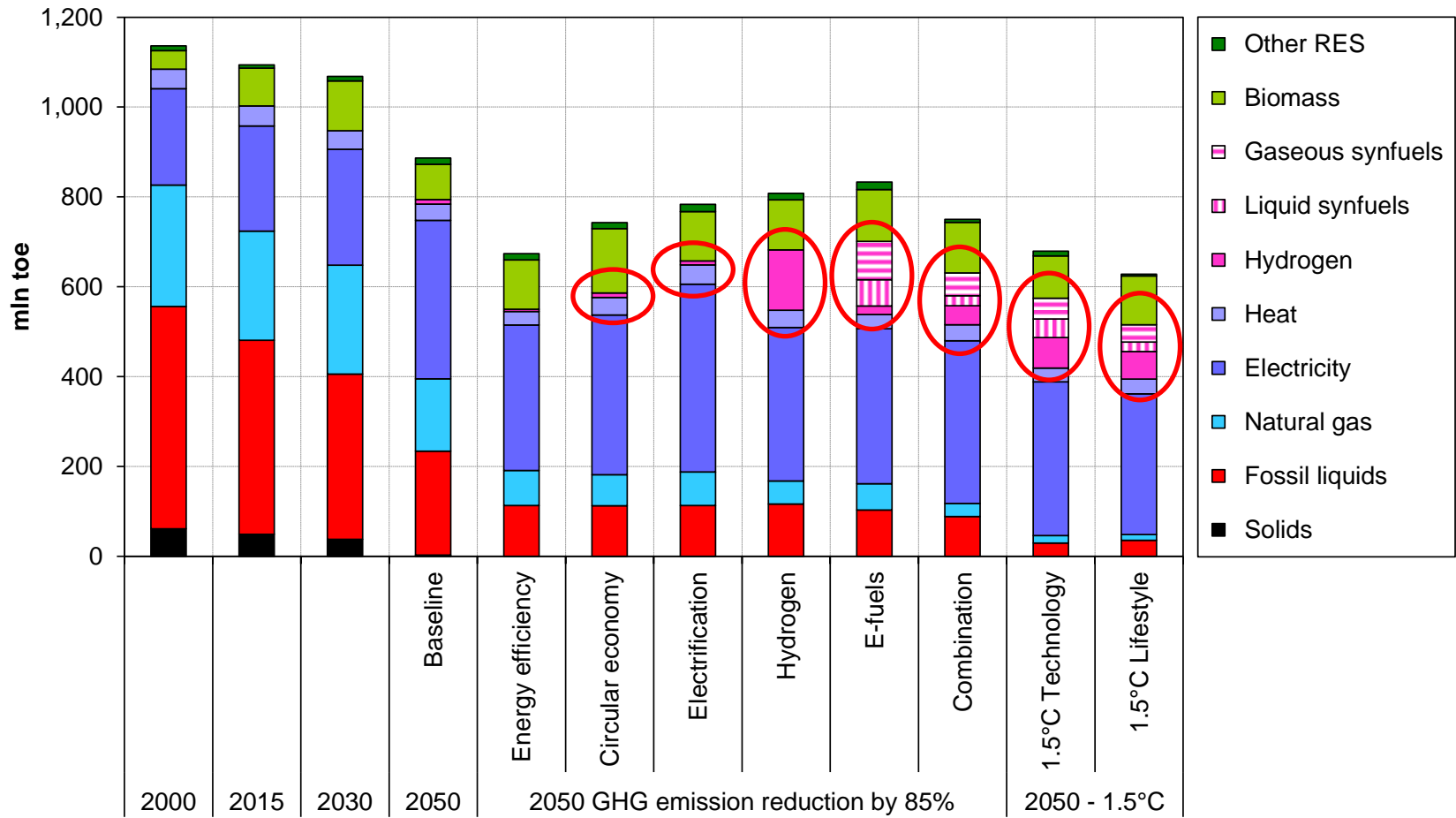
Sector integration based on electricity (and novel fuels)

The merit order of options

- **Power-to-Heat (PtH), smart use of demand side & PtP storage options**
 - economically and environmentally the most attractive option
- **Power-to-chemicals (PtChem)**
 - ammonia, refineries, methanol (up to 50 TWh), key challenge: no sufficient price signal for fossil H₂
- **Power-to-hydrogen (PtHy)**
 - broad potential, key challenges: costs and infrastructure
 - alternative import option for CO₂-neutral H₂: electricity-based (“green”) H₂ and/or (“blue”) H₂ from fossil fuels & CCS?
- **Power-to-synthetic methane & Power-to-synthetic motor fuels (PtG/L)**
 - broad potential, use of existing infrastructures, key challenges: costs and availability of climate-neutral CO₂ (DAC as enabler?)
 - alternative import option for CO₂-neutral synthetic methane and/or CO₂-neutral synthetic motor fuels (“green” or “blue”)?

Long-term projections for the EU-28

Differently changing patterns of final energy demand



European Commission (2018)

Getting the prices right – or there will be no sector integration

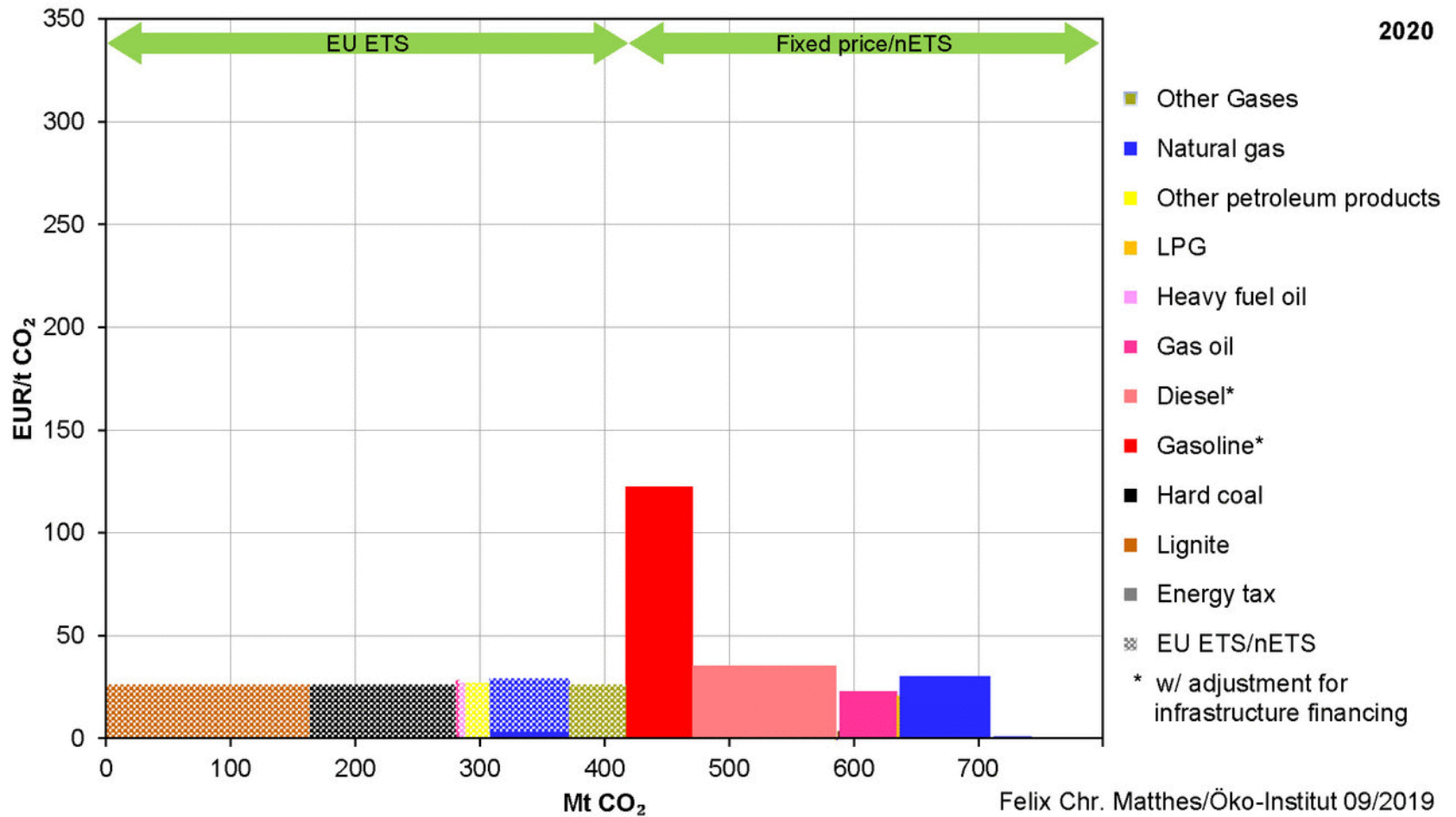
The bizarre German system of taxes, levies and surcharges

		Nominal	Implicit	Excl. infrastructure costs*		Excl. counter-
		tax rate	tax rate	€ 15b p.a.	€ 35b p.a.	factual invest**
		€ per unit	€ per t CO ₂	€ per t CO ₂	€ per t CO ₂	€ per t CO ₂
Gas oil	EUR/1.000 l	61.35	23.03			
Heavy fuel oil (heating)	EUR/t	25.00	7.87			
Heavy fuel oil (power)	EUR/t	25.00	7.87			
Natural gas (heating)	EUR/MWh	5.50	30.23			
Natural gas (motor fuel)***	EUR/MWh	13.90	76.40	-26.00	-198.20	
LPG (heating)	EUR/100 l	6.06	20.56			
LPG (motor fuel)***	EUR/100 l	18.03	61.16	-11.37	-159.73	
Gasoline leaded***	EUR/1.000 l	721.00	315.90	279.79	134.93	
Gasoline unleaded***	EUR/1.000 l	654.50	286.76	253.99	122.49	
Diesel***	EUR/1.000 l	470.40	179.06	165.55	35.23	
Coal (non-power)	EUR/GJ	0.33	3.47			
Electricity ETS	EUR/EUA	15.82	15.82			
Electricity tax	EUR/MWh	20.50	22.78			
Electricity surcharges	EUR/MWh	75.55	83.94			53.54
Electricity total	EUR/MWh	111.87	122.54			92.14

Notes: Data as of 2018. - * Considering road infrastructure financing from motor vehicle tax (€ 8.7b) and truck toll (€ 3.1b). The lower range of infrastructure costs represents the annual investments and the upper range the annuity of total road system costs. - ** Considering a counterfactual investment of 36 €/MWh. - *** The implicit CO₂ tax rate for motor fuels covers also other significant transport externalities (other pollutants, noise, health impacts) which are less significant for other energies.

Getting the prices right – or there will be no sector integration

Why the German carbon pricing approach will have limited impacts



Thank you very much

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