Carl-Philipp Anke, ***Hannes Hobbie,*** Steffi Misconel, Dominik Möst
Faculty of Business and Economics
Chair of Energy Economics

Interactions between International and National Carbon Mitigation Policies

1st IAEE Online Conference // 7 June 2021

Energy Policy 144 (2020) 111647

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Coal phase-outs and carbon prices: Interactions between EU emission trading and national carbon mitigation policies

Carl-Philipp Anke *, Hannes Hobbie, Steffi Schreiber, Dominik Möst

Chair of Energy Economics, TU Dresden, Germany

ARTICLE INFO

Keywords:
Carbon emissions
Renewable energies
Coal phase-out
EU ETS
Energy systems analysis

ABSTRACT

The European Union Emission Trading System (EU ETS) constitutes the core instrument of the European Union climate protection policy. It limits greenhouse gas emissions of its member states and aims at facilitating an efficient allocation of emission reduction across national borders. Accompanying this policy at the European level, individual member states have introduced national mitigation policies, including renewable energy (RES) expansion measures or coal phase-outs.

This study examines to what extent national policies affect the effectiveness of the EU ETS and to what degree the impact is reflected in prices for European Union Allowances (EUA). To investigate this question, a fundamental optimization model of the European electricity markets is deployed and model endogenous EUA prices are derived with a set of future market scenarios. Overall findings indicate that fundamental market forces strongly affect EUA prices. Furthermore, national policies play a critical role: The expansion of RES does not affect the capacity of the EU ETS to provide sufficient price signals for the desired level of decarbonization but a coal phase-out has a strong price-suppressing effect. A withdrawal of certificates can reestablish the effectiveness of the EU ETS but prices can rise drastically when overestimating the necessary amount.

1. Introduction

Starting in 2005, the EU Emissions Trading Scheme (EU ETS) sets an aggregate CO_2 emission cap for specific energy-intensive installations within the EU. About 45% of the EU's total CO_2 emissions are covered by this instrument (European Commission, 2016) and industries from different sectors such as power, chemicals, oil refineries, etc. fall under this regulation. The implemented cap and trade system for carbon allowances is Europe's key policy to reduce carbon emissions. It limits the overall level of emissions and in so doing aims to efficiently allocate carbon mitigation measures across member states. In order to achieve a continuous decarbonization of the regulated sectors the emission cap is subject to an annual reduction rate. This triggers a growing implementation of climate protection measures (e.g. energy efficiency), otherwise companies would come under considerably economic pressure from rising carbon prices. Besides this European instrument for the reduction of greenhouse gas emissions, EU member states have itself deployed further environmental policy measures and regulatory instruments at a national level. Such measures include, among others, phasing-out coal-based power production, support schemes for the expansion of renewable energy sources (RES), policies to improve energy efficiency as well as the introduction of carbon taxes.

While these measures lead to a reduction of carbon emissions at a national level, a lower demand for emission allowances arises with which carbon prices decline. In turn, carbon emissions increase again at a different location unless the overall emission cap is adjusted to account for these developments. This effect is often referred to as the 'waterbed effect' (see Rosendahl (2019)). Until now, carbon prices stayed at a low to moderate level which indicates that regulators considered this effect already at the time the annual reduction rate was set. With the latest developments around climate change, however, an increasing number of EU countries have revised their energy strategies and committed themselves to phase-out further coal-based energy installations.

As coal and lignite are connected to high shares of greenhouse gas emissions regulated by the EU ETS,[1] these developments raise serious concerns that the EU ETS could become ineffective without a dynamic means of adjusting the volume of emissions allowances accordingly.

This study contributes to the existing research by investigating the market implications from the co-existence of national and international policies for climate protection. The central objective pursued in this work is the evaluation of the capability of the EU ETS to incentivize

* Corresponding author.
E-mail address: carl-philipp.anke@tu-dresden.de (C.-P. Anke).

[1] In 2018 coal and lignite fired power plants emitted 75% of Germany's greenhouse gas emission related to power generation (UBA, 2020).

https://doi.org/10.1016/j.enpol.2020.111647
Received 13 January 2020; Received in revised form 7 April 2020; Accepted 21 May 2020

- This work was carried out during 2019-2020 and already handed in to the last year's IAEE conference
- In the meantime, an improved version was submitted to and accepted for publication at the Energy Policy Journal
- Results I am showing today refer widely to our paper on *Coal phase-outs and carbon prices*
- However, findings are still relevant for several market design issues and upcoming research

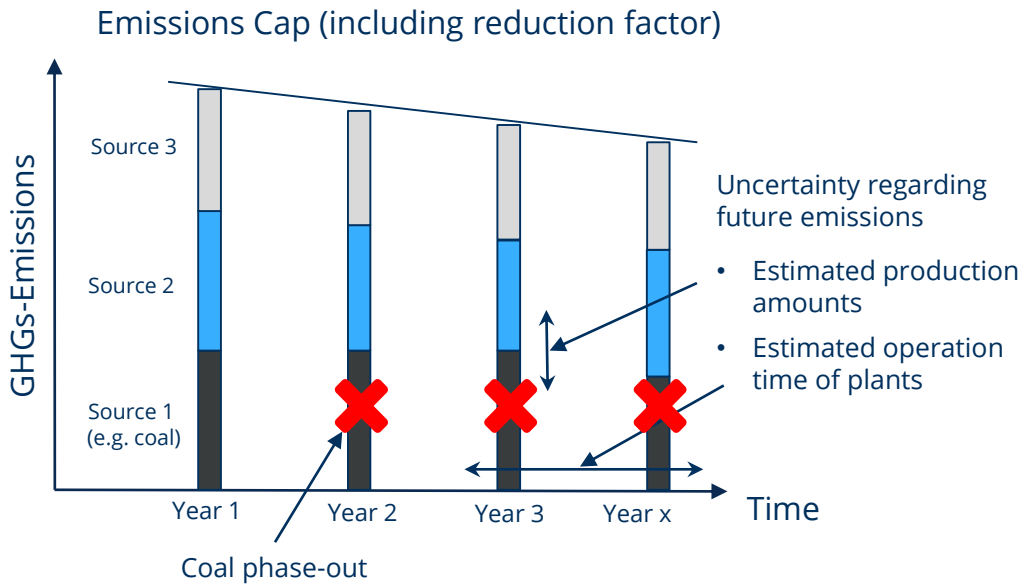
Short summary: National policies play a critical role regarding an effective functioning of the EU ETS

- The EU ETS constitutes the core instrument of the European Union climate protection policy
- Accompanying this policy at the European level, individual member states have introduced national mitigation policies, including renewable energy expansion measures or coal phase-outs
- This study applies a fundamental market model to examine to what extent national policies affect the effectiveness of the EU ETS and to what degree the impact is reflected in EUA prices
- Findings indicate that renewable expansion does not affect the capacity of the EU ETS to provide sufficient price signals for the desired decarbonisation but coal phase-outs have a strong price-suppressing effect

Illustrative look on environmental policies and interactions with EU ETS

Various instruments/developments have an influence on CO2 emissions and thus on the need for CO2 certificates

- Renewable expansion dynamics
- Development of electricity demand (sector-coupling, crisis, e.g. Covid, ...)
- Energy efficiency measures
- Coal phase-outs
- Increasing recognition of international emission rights (Clean Development Mechanism, Joint Implementation)



National developments and mitigation policies create uncertainty in designing an effective EU ETS

The EU ETS has been continuously adjusted to changing market environments to stabilise EUA prices

Phase 1 (2005-2007)

- Introduction of the EU ETS
- Free allocation of certificates

Phase 2 (2008-2012)

- Reduction of CO2 allowances by **6.5%** (compared to 2005)
- National allocation plans
- Clean-Development-Mechanism, Joint-Implementation Projects

Phase 3 (2013-2020)

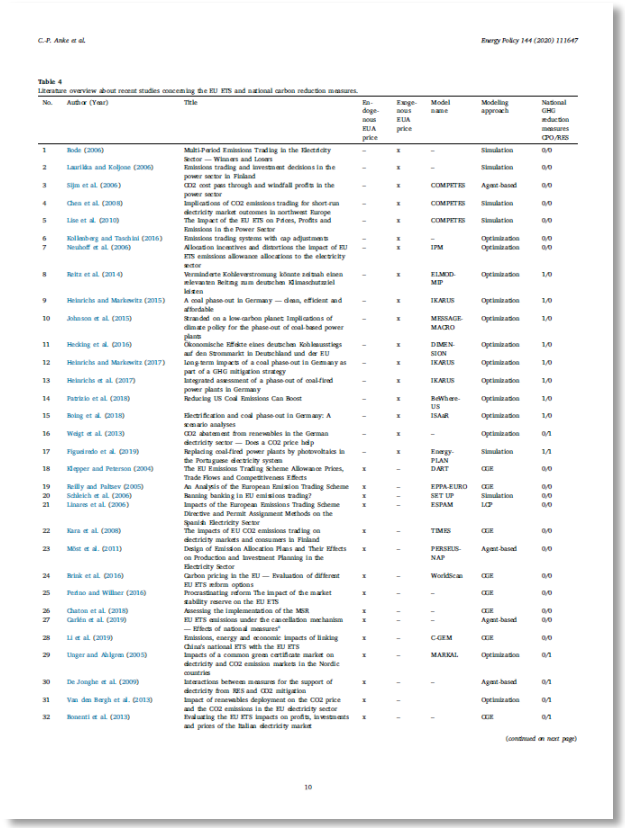
- Annual linear reduction of CO2 allowances by **1.74%**
- European cap
- Increased auctioning
- Backloading and Market stability reserve

Phase 4 (2021-2030)

- Annual linear reduction of CO2 allowances by **2.20%**
- Cancelling of certificates from MSR

Literature investigating both RES expansion and coal phase-outs under consideration of model-endogenous CO2-prices is scarce

Literature sources



C.-P. Anke et al. Energy Policy 144 (2020) 111647

Table 4
Literature overview about recent studies concerning the EU ETS and national carbon reduction measures.

No.	Author (Year)	Title	En-doge-nous EUA price	Exoge-nous EUA price	Model name	Modelling approach	National GHG reduction measures CPO/RES
1	Bode (2006)	Multi-Period Emissions Trading in the Electricity Sector — Winners and Losers	–	x	–	Simulation	0/0
2	Laurikka and Koljonen (2006)	Emissions trading and investment decisions in the power sector in Finland	–	x	–	Simulation	0/0
3	Sijm et al. (2006)	CO2 cost pass through and windfall profits in the power sector	–	x	COMPETES	Agent-based	0/0
4	Chen et al. (2008)	Implications of CO2 emissions trading for short-run electricity market outcomes in northwest Europe	–	x	COMPETES	Simulation	0/0
5	Lise et al. (2010)	The Impact of the EU ETS on Prices, Profits and Emissions in the Power Sector	–	x	COMPETES	Simulation	0/0
6	Kollenberg and Taschini (2016)	Emissions trading systems with cap adjustments	–	x	–	Optimization	0/0
7	Neuhoff et al. (2006)	Allocation incentives and distortions the impact of EU ETS emissions allowance allocations to the electricity sector	–	x	IPM	Optimization	0/0
8	Reitz et al. (2014)	Verminderte Kohleverstromung könnte zeitnah einen relevanten Beitrag zum deutschen Klimaschutzziel leisten	–	x	ELMOD-MIP	Optimization	1/0
9	Heinrichs and Markewitz (2015)	A coal phase-out in Germany — clean, efficient and affordable	–	x	IKARUS	Optimization	1/0
10	Johnson et al. (2015)	Stranded on a low-carbon planet: Implications of climate policy for the phase-out of coal-based power plants	–	x	MESSAGE-MACRO	Optimization	1/0
11	Hecking et al. (2016)	Ökonomische Effekte eines deutschen Kohleausstiegs auf den Strommarkt in Deutschland und der EU	–	x	DIMEN-SION	Optimization	1/0
12	Heinrichs and Markewitz (2017)	Long-term impacts of a coal phase-out in Germany as part of a GHG mitigation strategy	–	x	IKARUS	Optimization	1/0
13	Heinrichs et al. (2017)	Integrated assessment of a phase-out of coal-fired power plants in Germany	–	x	IKARUS	Optimization	1/0
14	Patrizio et al. (2018)	Reducing US Coal Emissions Can Boost	–	x	BeWhere-US	Optimization	1/0
15	Reisg et al. (2018)	Electrification and coal phase-out in Germany: A scenario analyses	–	x	ISAaR	Optimization	1/0
16	Weigt et al. (2013)	CO2 abatement from renewables in the German electricity sector — Does a CO2 price help	–	x	–	Optimization	0/1
17	Figueiredo et al. (2019)	Replacing coal-fired power plants by photovoltaics in the Portuguese electricity system	–	x	Energy-PLAN	Simulation	1/1
18	Klepper and Peterson (2004)	The EU Emissions Trading Scheme Allowance Prices, Trade Flows and Competitiveness Effects	x	–	DART	CGE	0/0
19	Reilly and Paltsev (2005)	An Analysis of the European Emission Trading Scheme	x	–	EPPA-EURO	CGE	0/0
20	Schleich et al. (2006)	Banning banking in EU emissions trading?	x	–	SET UP	Simulation	0/0
21	Linares et al. (2006)	Impacts of the European Emissions Trading Scheme Directive and Permit Assignment Methods on the Spanish Electricity Sector	x	–	ESPAM	LCP	0/0
22	Kara et al. (2008)	The impacts of EU CO2 emissions trading on electricity markets and consumers in Finland	x	–	TIMES	CGE	0/0
23	Möst et al. (2011)	Design of Emission Allocation Plans and Their Effects on Production and Investment Planning in the Electricity Sector	x	–	PERSEUS-NAP	Agent-based	0/0
24	Brink et al. (2016)	Carbon pricing in the EU — Evaluation of different EU ETS reform options	x	–	Worldscan	CGE	0/0
25	Perino and Willner (2016)	Procrastinating reform The impact of the market stability reserve on the EU ETS	x	–	–	CGE	0/0
26	Chatzo et al. (2018)	Assessing the implementation of the MSR	x	–	–	CGE	0/0
27	Gerlin et al. (2019)	EU ETS emissions under the cancellation mechanism — Effects of national measures'	x	–	–	Agent-based	0/0
28	Li et al. (2019)	Emissions, energy and economic impacts of linking China's national ETS with the EU ETS	x	–	C-GEM	CGE	0/0
29	Unger and Ahlgren (2005)	Impacts of a common green certificate market on electricity and CO2 emission markets in the Nordic countries	x	–	MARKAL	Optimization	0/1
30	De Jonghe et al. (2009)	Interactions between measures for the support of electricity from RES and CO2 mitigation	x	–	–	Agent-based	0/1
31	Van den Bergh et al. (2013)	Impact of renewables deployment on the CO2 price and the CO2 emissions in the EU electricity sector	x	–		Optimization	0/1
32	Rosenti et al. (2013)	Evaluating the EU ETS impacts on profits, investments and prices of the Italian electricity market	x	–	–	CGE	0/1

(continued on next page)

10

Classification of literature

European ETS

	none	CPO **or** RES extension	CPO **and** RES extension	
Endogenous EUA Prices	[18]-[28]		[29]-[35]	**Research gap**
	Σ 11	Σ 0	Σ 9	Σ 1
Exogenous EUA Prices	[1]-[7]	[8]-[15]	[16]	[17]
	Σ 7	Σ 8	Σ 1	Σ 1

National CO2 mitigation measures

ELTRAMOD derives endogenous power and EUA prices for the European electricity markets

MODEL INPUT

TECHNO-ECONOMIC DATA

- Technology specific power plant characteristics
- Economic parameter
- European transmission capacity (NTC)
- No congestion within one market zone (copper plate)

SUPPLY SIDE

- 17 conv. generation technologies
- Hourly RES generation profiles
- (CO_2 emissions cap)

DEMAND SIDE

- Hourly electricity demand per country
- Must-run requirements for CHP

LINEAR OPTIMIZATION

Target function:
Cost minimal dispatch of fixed capacities

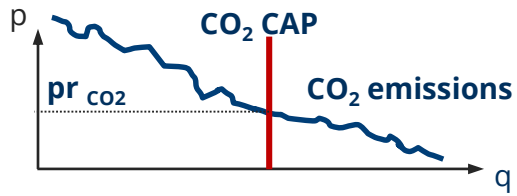
$$Min \sum_{t} TOTAL\ SYSTEM\ COSTS \quad t \in T\ [8760\ h]$$

Countries with block-wise power plant representation

Countries with technology-specific aggregated power plants representation

Existing lines

MODEL ENDOGENOUS CO2 PRICE CALCULATION



CO_2 BALANCE:

$$\sum_{t,p} \frac{Gen \cdot CO2\ emission\ factor}{efficiency} < CO_2\ CAP \quad t \in T\ [8760\ h],\ p \in P$$

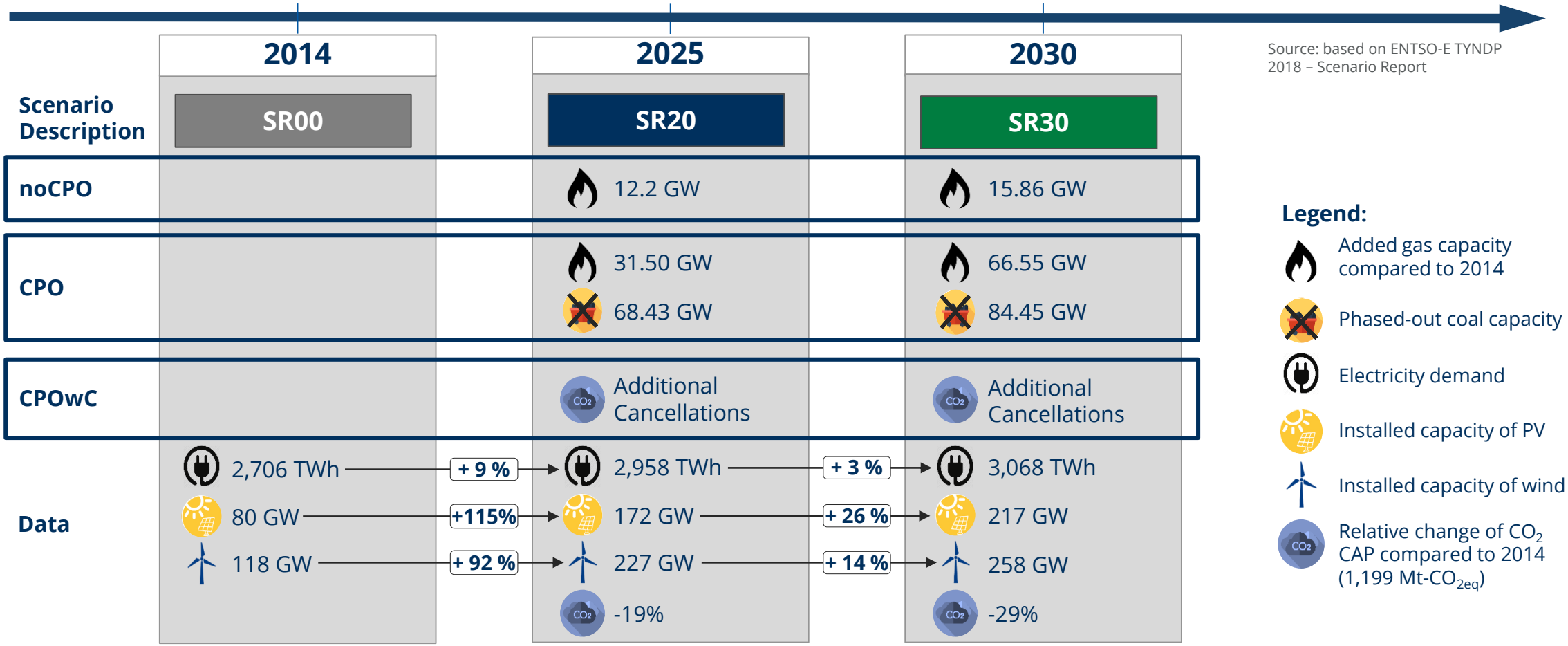
CO_2 BALANCE . Marginal = pr CO_2

CO2 EMISSION ALLOWANCE PRICE

FURTHER MODEL OUPUT

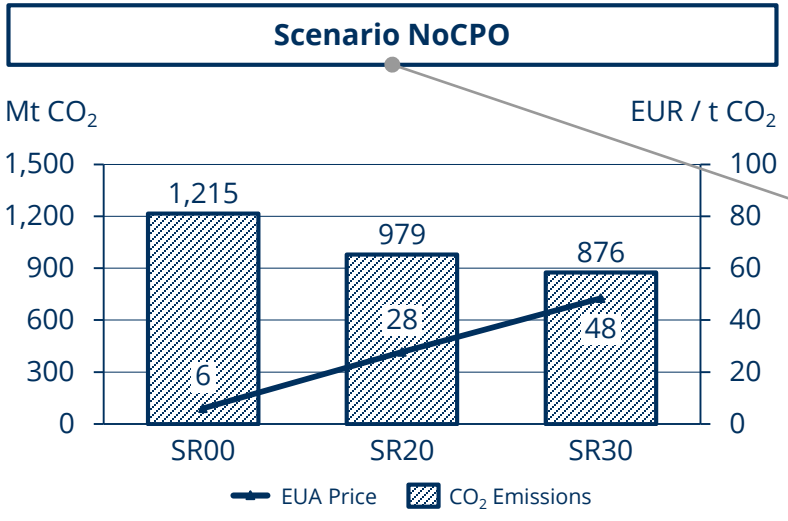
- Power plant dispatch
- Export-import flows
- Integrated/curtailed RES
- Electricity prices

Effects of national policies on the EU ETS are investigated based on a scenario analysis

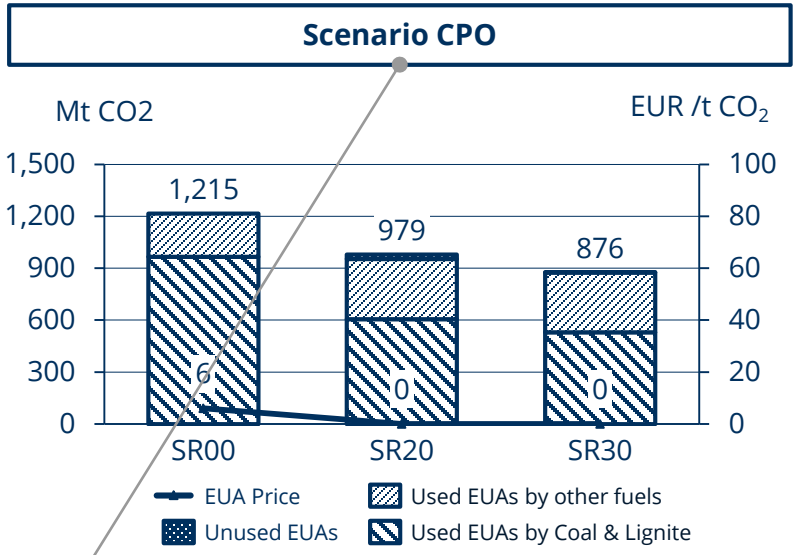


Coal phase-outs reduce the ability of the EU ETS to provide price signals for carbon mitigation

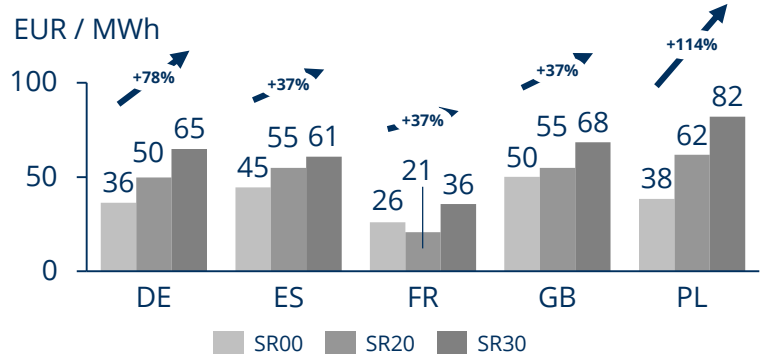
Carbon emissions & EUA prices



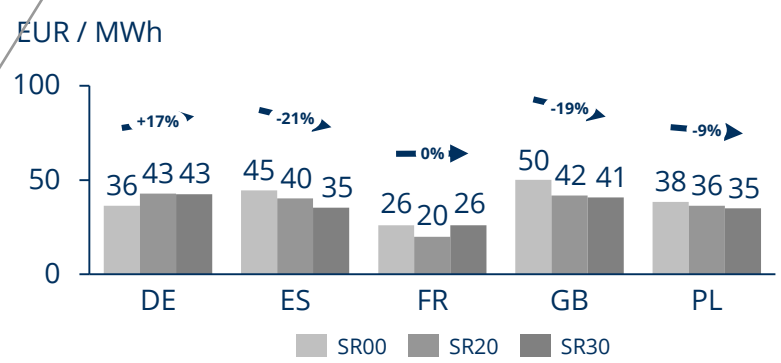
Under current design of the EU ETS, RES expansion does not drive down EUA prices



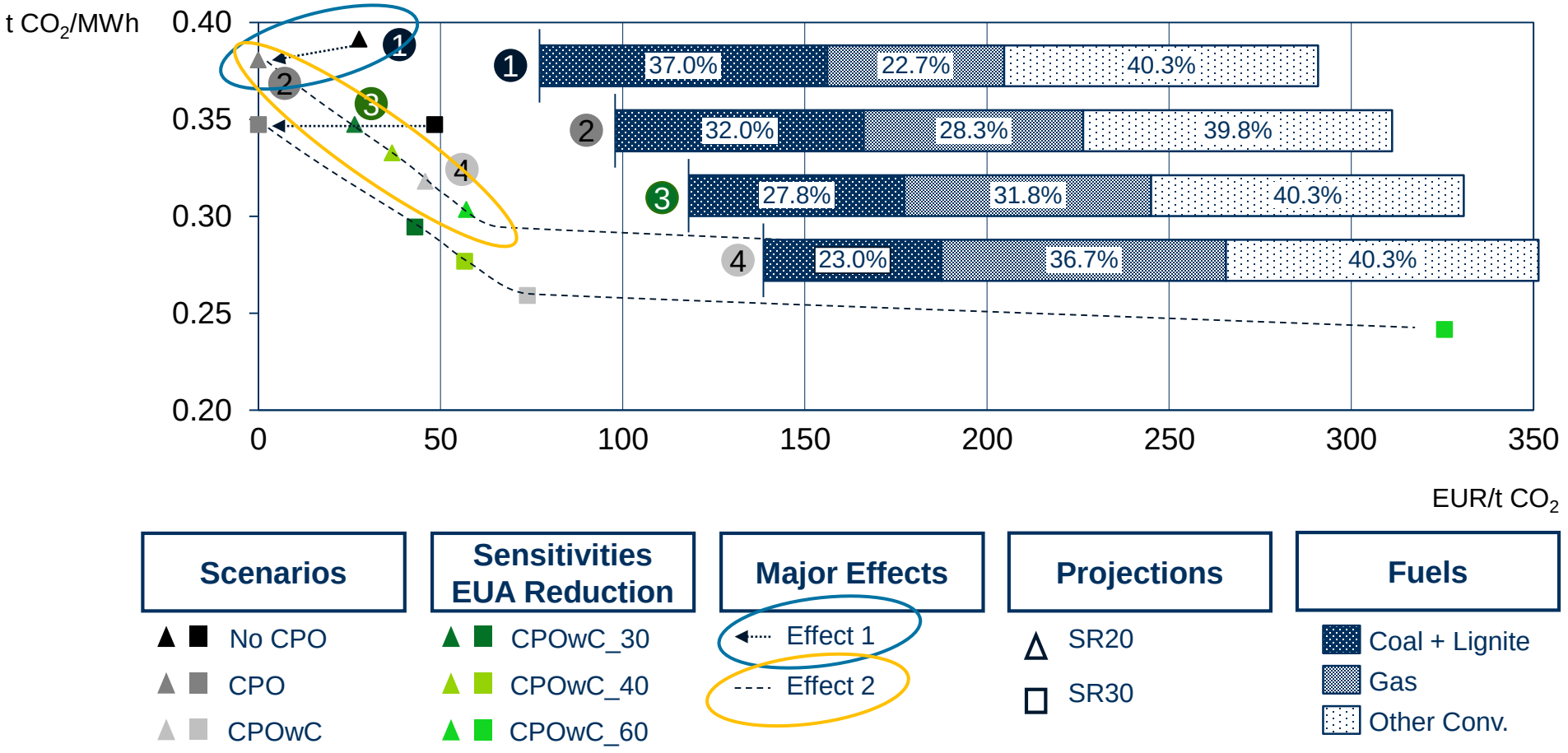
Power prices



Coal phase-outs undermine the effectiveness of the EU ETS in incentivising carbon mitigation based on price signals



A cancellation of EUAs can restore the capability of the EU ETS to incentivise carbon mitigation



Better coordination of national mitigation strategies and EU environmental policies necessary

- **EUA prices are strongly affected by fundamental market forces**
  - RES deployment strategies
  - Coal phase-out
  - Reduction of CO2 emission cap
- **National carbon mitigation policies can thwart the ability of the EU ETS to generate price signals for carbon mitigation**
  - The expected RES expansion seems to have a minimal impact on the EU ETS
  - A coal phase-out entails a significant impact on the EU ETS and EUA lose all material value
- **A cancellation of EUAs can stabilize the EU ETS and its ability to provide market signals for carbon mitigation**
- **The determination of the amount of withdrawn EUAs need to be done carefully, as EUA prices react very sensitively**

Thank you for your attention

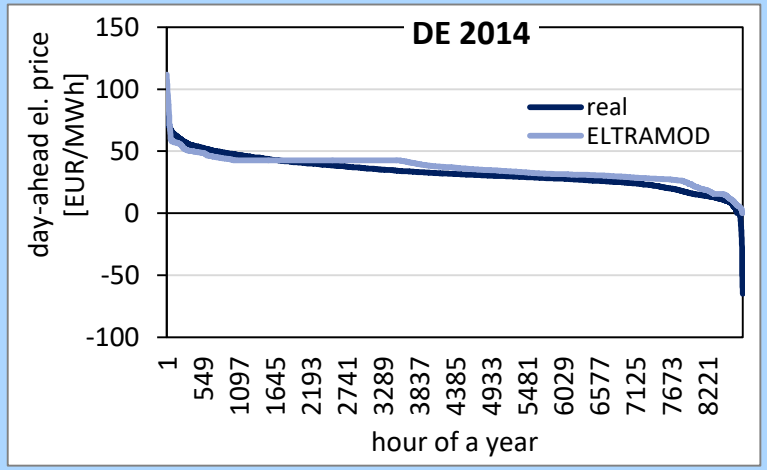
Hannes Hobbie

Tel.: +49 (0) 351/463-39894
Email: hannes.hobbie@tu-dresden.de
Web: ee2.biz

Chair of Energy Economics
Technische Universität Dresden
Münchner Platz 3
01069 Dresden

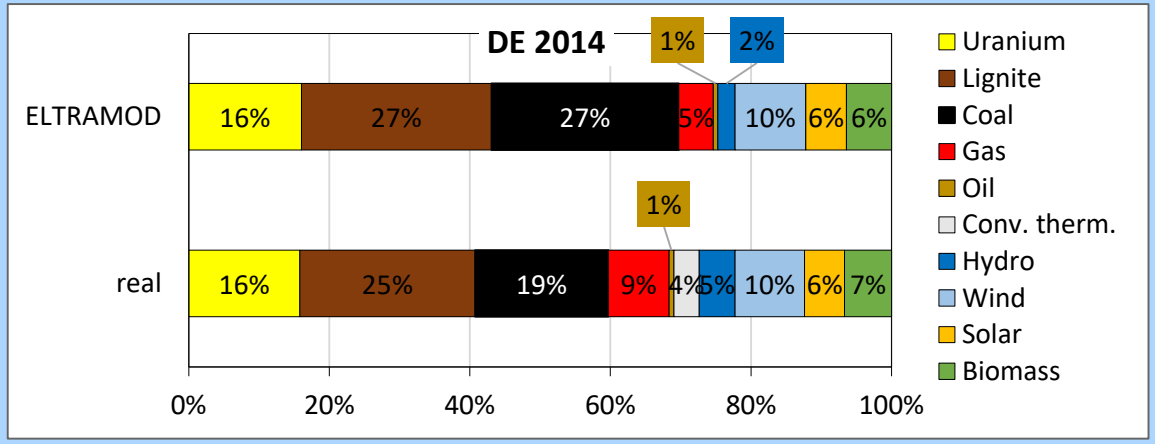
Back-up

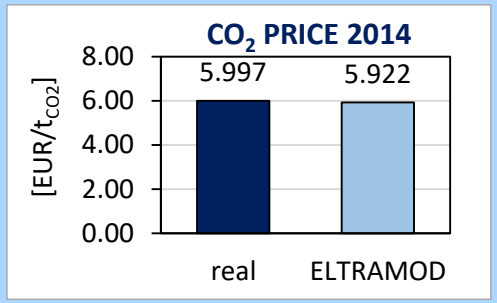
Model validity: ELTRAMOD explains historical market outcomes very well for 2014 based on fundamental input data



KPIs for GERMANY

EUR/MWh	
MAE sorted	4.80
MAE unsort.	6.31
RSME sorted	5.58
RSME unsort.	8.28
Price model	36.10
Price real	32.76





KPIs for a subset of core countries (AT, CZ, DE, HU, PL, SI, SK)

EUR/MWh	
MAE sorted	4.25
RSME sorted	5.90
Mean price model (compared to real price)	+3.4%

- **DE:** Good fit of power plant dispatch (slight overestimation of base load and peak prices)
- **Very good match of historical CO_2 price in 2014**
- **Core countries:** Good match of sorted price curves

Source: BNetzA, Monitoring Report 2015