Environmental Assessment

Fachbereich 2 Informatik und Ingenieurwissenschaften

Electricity generation in Germany

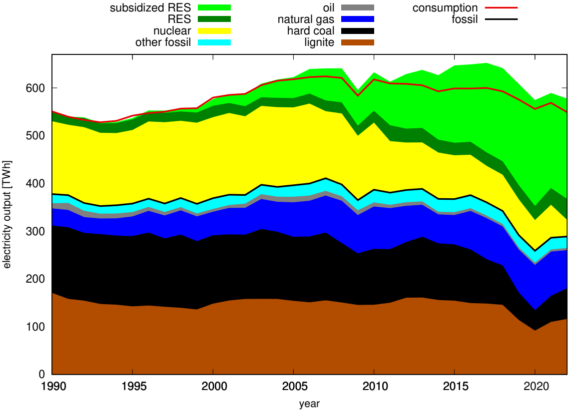

Figure: Stacked area chart illustrating the development of gross electricity generation in Germany between 1990 and 2021 with respect to input sources. The difference between gross electricity generation and consumption (red line) corresponds to the electricity export; eigene Darstellung auf der Grundlage von Daten, die von Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen e.V) (2018), Information Platform of the German Transmission System Operators (Informationsplattform der deutschen Übertragungsnetzbetreiber – netztransparenz.de) (2018)

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Necessary data for ETS assessment

- https://ag-energiebilanzen.de/en/data-and-facts/energy-balance-2000-to-2030/
- https://unfccc.int/ghg-inventories-annex-i-parties/2023

→ better: https://www.umweltbundesamt.de/dokument/co2-ef-liste-1990-2021-korrigiert

- https://ag-energiebilanzen.de/wp-content/uploads/2023/10/STRERZ_Abgabe-09-2023.xlsx
- https://www.netztransparenz.de/en/Renewable-energies-and-levies/EEG/EEG-billing/EEG

Regression of emission intensities

How a reasonable equation considering the time trend, fuel and allowance prices for emission intensities could look like?

$$\ln(e_i) = b + a_t \cdot (i - 2000) + a_p \cdot p_{i,ratio} + \epsilon \quad (1)$$

- b as axis intercept
- ϵ as error term
- $p_{i,ratio}$ corresponds to the price ratio between hard coal and gas $(p_{i,coal}/p_{i,gas})$
- $p_{i,coal}$ and $p_{i,gas}$ consist of pure fuel prices $\tilde{p}_{i,coal}$ and $\tilde{p}_{i,gas}$ plus a respective surcharge $\Delta p_{i,coal}^{ets}$ and $\Delta p_{i,gas}^{ets}$ stemming from the EU ETS

Regression of emission intensities

	results
R^2	0.842
$\bar{R}^2$	0.818

Table: General statistical analysis of the linear regression with R^2 as coefficient of determination, $\bar{R}^2$ as adjusted coefficient of determination.

	a_t	a_p	b
	-0.0051	-0.0777	6.7440
s	0.0010	0.0310	0.0144
R^2	0.766	0.505	

Table: Statistical analysis of coefficients a_t, a_p, b with s as standard error and R^2 as coefficient of determination resulting from a correlation test for a_i and a_p separately.

ETS assessment – exercise

- Calculate the regression parameters using data for the years 2000 – 2015
- Calibrate the axis intercept so that it equals the average of the years 2000 – 2002 if possible
- Calculate the expectation value of the emission intensities of the counterfactual scenario
- Calculate the expectation value of the absolute emission abatement

Development of emission intensities

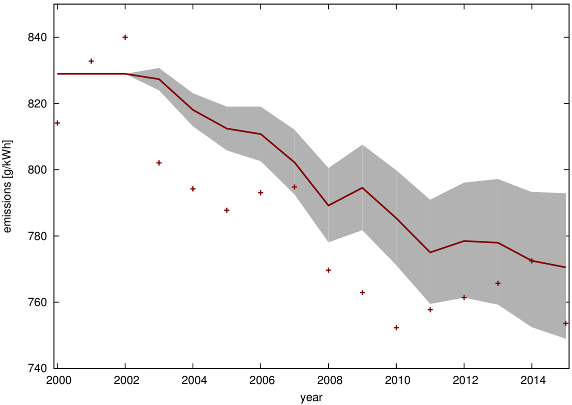

Figure: Counterfactual development of emission intensities and real development of emission intensities. The shaded area corresponds to the confidence interval of the time trend. The solid line within the shaded area is the counterfactual scenario using the mean a_t.

Emission reduction induced by the EU ETS

	intensity reduction [g/kWh]			CO_2 reduction [Mt]		
year	lower limit	mean	upper limit	lower limit	mean	upper limit
2005	18.1	24.7	31.3	7.5	10.2	13.0
2006	9.5	17.7	26.0	4.0	7.4	10.9
2007	[-2.3]	7.4	17.3	[-1.0]	3.2	7.5
2008	8.4	19.5	30.9	3.6	8.2	13.0
2009	18.8	31.6	44.7	7.3	12.2	17.2
2010	18.9	33.1	47.6	7.7	13.5	19.5
2011	1.7	17.3	33.2	0.7	6.9	13.3
2012	[-0.1]	17.1	34.7	0.0	7.0	14.3
2013	[-6.4]	12.3	31.5	[-2.7]	5.1	13.1
2014	[-20.0]	0.1	20.8	[-7.9]	0.0	8.2
2015	[-4.6]	16.9	39.2	[-1.8]	6.6	15.4

Table: CO_2 and intensity reduction in the German electricity sector induced by the EU ETS. Negative values (in brackets) mean an intensity respectively CO_2 increase compared to the counterfactual scenario. This might happen due to tactical behavior.

ETS assessment – exercise

- Calculate the regression parameters using data for the years 1995 – 2021.
- Calculate the expectation value for each year and illustrate it together with the observed values.
- Calculate the counterfactual scenario and illustrate it in the graph from the previous task.

Development of emission intensities

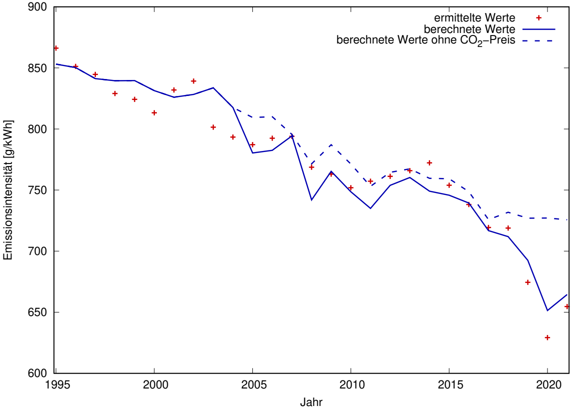

Figure: Development of real and calculated emission intensities in the German electricity sector between 1995 – 2021 together with counterfactual scenario without ETS; own illustration.

ETS assessment – exercise

- Calculate the absolute emission reduction based on the expectation value the emission intensity in the counterfactual scenario.
- Calculate the emission reduction induced by subsidized RES assuming a loss of 10 % for standby of fossil power plants.

Comparison of CO_2 reductions

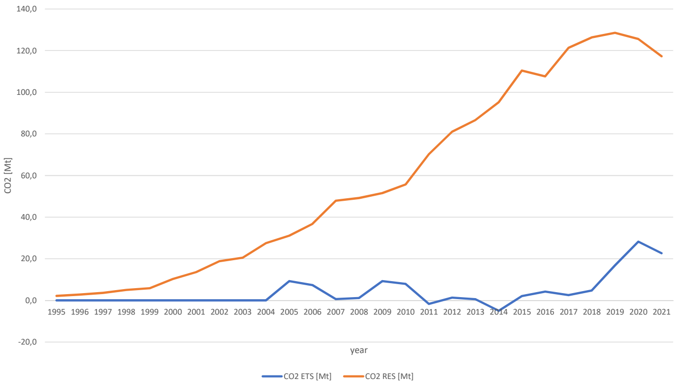

Figure: Development of CO_2 reduction assigned to the ETS and subsidies for RES from 1995 – 2021. The reduction assigned to the ETS is based on the counterfactual scenario developed above. The reduction assigned to subsidized RES is based on the product of emission intensity and electricity generated by RES with a discount of 10 % for fossil power plants on standby.

EUA price development after 2015

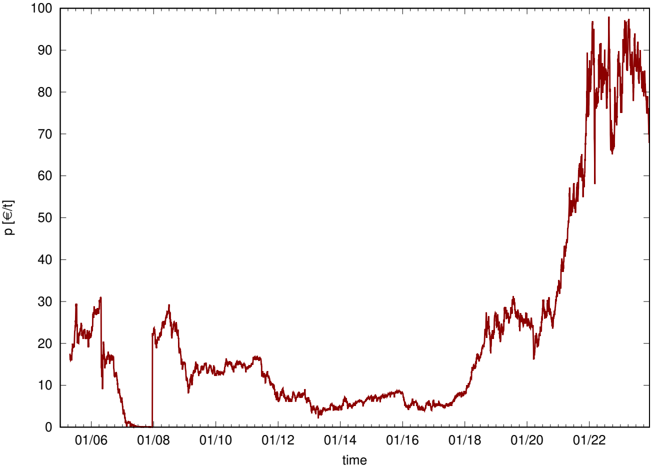

Figure: Development of the allowance price of the EU ETS between April 25, 2005 and December 6, 2023. Own illustration based on investing.com (2023).

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EUA price erosion

- De Perthuis and Trotignon (2014) identify three main reasons for price erosion

→ oversupply caused by the possibility to credit emission reductions outside the EU towards the EU ETS

→ lower demand economic crisis of 2008

→ *lower demand induced by overlapping regulations (e.g. promotion of renewable energy)*

- introduction of the so-called market stability reserve in 2015 → delayed auctioning of excessive EUAs
- agreement on November 9, 2017 that excessive EUAs above a certain threshold value are deleted

References

De Perthuis, C. and Trotignon, R. (2014). Governance of CO_2 markets: Lessons from the EU ETS. *Energy Policy*, **75**, 100 – 106.

Information Platform of the German Transmission System Operators (Informationsplattform der deutschen Übertragungsnetzbetreiber – netztransparenz.de) (2018). EEG-Jahresabrechnungen. Available at: https://www.netztransparenz.de/EEG/Jahresabrechnungen, accessed April 1, 2018.

investing.com (2023). Commodity prices. Avaialable at: https://www.investing.com/currencies/xbr-usd-historical-data, accessed January 8, 2023.

Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen e.V) (2018). Bruttostromerzeugung in Deutschland ab 1990 nach Energieträgern. Available at: https://ag-energiebilanzen.de/index.php?article_id=29&fileName=20171221_brd_stromerzeugung1990-2017.xlsx, accessed September 4, 2018.