The New Emission Trading System on Diffuse Emission in the European Policy Mix

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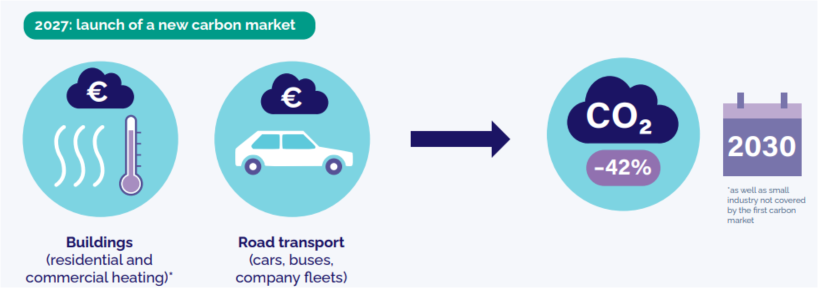
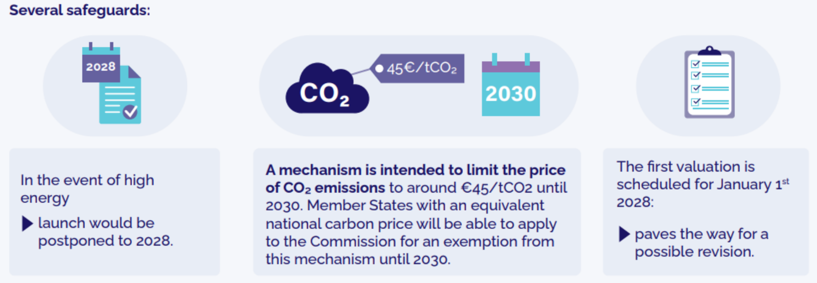
A new Emission Trading System on diffuse emissions

- Part of the EU's plan for carbon neutrality by 2050.
- Initiated by the European Commission in the 2018 Green Deal.



Characteristics Inspired by ETS1

- Allowances based on 2024 emission levels, decreasing annually.
- Reduction rate: 5% annually.
- No risk of leakage: 100% auctioned permits.



Several safeguards:

In the event of high energy

▶ launch would be postponed to 2028.

A mechanism is intended to limit the price of CO_2 emissions to around €45/tCO2 until 2030. Member States with an equivalent national carbon price will be able to apply to the Commission for an exemption from this mechanism until 2030.

The first valuation is scheduled for January 1st 2028:

▶ paves the way for a possible revision.

Market Stability Reserve (MSR) - 2027

Key Points:

- Starts with 600M allowances (in addition to cap)
- Purpose Stabilize prices by adjusting allowances.

Triggers:

- If Total Allowances in Circulation $<$ 210M: Release 100M allowances.
- If Total Allowances in Circulation $>$ 440M: Store 100M allowances in MSR2.
- Price $>$ €45/t (2 months): Release up to 40M allowances.
- Rapid price increase: 50M (2x price), 150M (3x price).

Limitations:

- Max 150M allowances/year.
- Delays in activating measures.

Risk of High Prices in ETS2

Price Estimates for 2030 (without complementary policies):

- €180/t (France, Germany, Poland) Jon Stenning et al. 2021.
- €174/t (France, Spain, Poland) Maj et al. 2021.
- €297/t (EU-wide) Rickels et al. 2023.
- €275/t (REMIND EU model) Pietzcker et al. 2021.

Price Estimates for 2030 (with complementary policies):

- Range: €175/t to €360/t Abrell et al. 2024.
- Price reductions with complementary policies: €71/t (PRIMES model) Günther et al. 2024.

Interaction with Effort Sharing Regulation-ESR

Key Points:

- Link to ESR: Same sectoral targets, but national budgets Abrell et al. 2024.
- New waterbed Effect: ETS2 and Annual Emission Allocations (AEA) prices should add up to a unified carbon price Görlach et al. 2022.

Disparities:

- Poorer countries exceed targets due to ETS2, wealthier countries rely on ESR Haywood et al. 2023.
- Southern/Eastern Europe as net sellers of ETS2 permits Rickels et al. 2023.

Importance of Complementary Policies:

- Limit inequalities and ensure ESR goals Günther et al. 2024.
- Example: California WCI shows 80% reliance on complementary policies Cullenward et al. 2016.

The Social Climate Fund

Launched in 2026

Aim: to help vulnerable households

Part of the revenue will fuel a new **Social Climate Fund**

€65 billion

Budget 2026-2032

Member States must develop specific plans (Social Climate Plans) and submit them to the Commission by 2025 for assessment and validation.

Social compensation measures (energy bills support) or green investments (renovation subsidies).

Impact on Households and Inequalities

Key Concerns:

- Inequalities: Higher cost burden for the poorer Hübler et al. 2024. Significant concerns between and within countries Jacobs et al. 2022.
- Climate Social Fund (CSF): Redistributes revenue from 150M allowances, **may be insufficient** for full progressive redistribution Gore 2022.

Sector-Specific Effects of ETS2:

- Transport: Reduces regressivity of existing taxes Jacobs et al. 2022.
- Buildings: Redistribution struggles to offset costs for poorest tenants George et al. 2023.

Complementary Policies:

- Necessary to mitigate inequalities Görlach et al. 2022 and improve social acceptability Braungardt et al. 2021.

Literature Gaps

- Few academic studies focus on the ETS2 market, and even fewer use a microeconomic framework.
- Unclear interaction between ETS1 and ETS2.
- Limited analysis on ETS2's long-term social and economic impacts.
- Insufficient exploration of complementary policies to lower ETS2 prices.

Research Questions

- How will ETS2 influence household decarbonization choices?
- How will ETS2 interact with ETS1?

Methodology

Based on Eichner and Pethig (2019):

- Productive sector based on fossil fuel,
- Climate regulations with emission quotas,
- Substitution between carbonized and clean technologies.

Our Contributions:

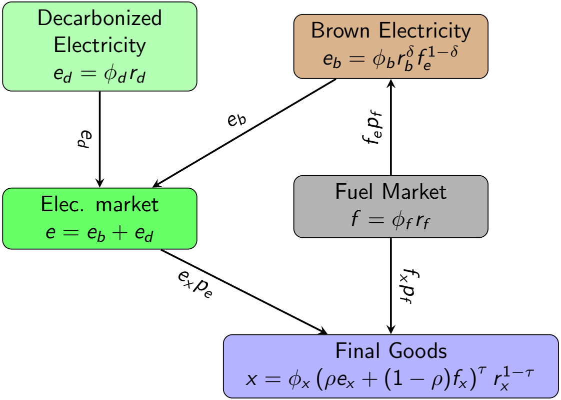
- Endogenous fossil fuel production.
- Broader quotas across all sectors, integrating national policies.
- Final energy demand added, with substitution between electricity and fossil fuels.

Comparison with Model Extensions:

- Cournot competition between fuel and electricity producers.
- Two-country model, reflecting consumer and policy differences.
- Resistance to change: households' reluctance to shift to electricity.

The Production Side

▸ Technologies ▸ Assumptions Production



Decarbonized Electricity
$e_d = \phi_d r_d$

Brown Electricity
$e_b = \phi_b r_b^{\delta} f_e^{1-\delta}$

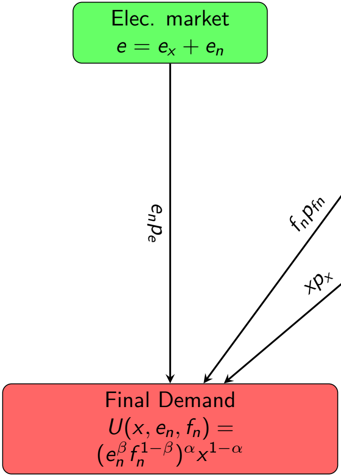
Elec. market
$e = e_b + e_d$

Fuel Market
$f = \phi_f r_f$

Final Goods
$x = \phi_x \left(\rho e_x + (1-\rho) f_x\right)^{\tau} r_x^{1-\tau}$

e_b:	Brown elec.
e_d:	Decarb. elec.
e:	Elec. supply
f:	F. fuel supply
f_j:	Fossil fuel for j
e_x:	Elec for x
x:	Final goods
r_j:	input for j
p_j:	Price of j
ϕ_j:	Productivity of j

The Demand Side ▸ Demand



Elec. market
$e = e_x + e_n$

Fuel Market
$f = f_e + f_x + f_n$

Final Goods

$e_n p_e$

$f_n p_{fn}$

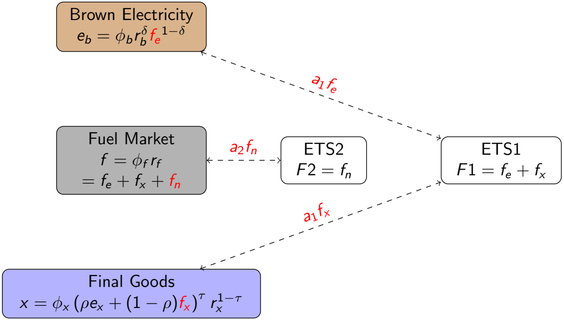
$x p_x$

Final Demand
$U(x, e_n, f_n) = (e_n^{\beta} f_n^{1-\beta})^{\alpha} x^{1-\alpha}$

e:	Elec. supply
f:	F. fuel supply
x:	Final goods
U:	Utility function
f_j:	Fossil fuel for j
e_j:	Elec for j
p_j:	Price of j

Climate Regulation

▸ Regulations



Brown Electricity
$e_b = \phi_b r_b^{\delta} f_e^{1-\delta}$

$a_1 f_e$

Fuel Market
$f = \phi_f r_f$
$= f_e + f_x + f_n$

$a_2 f_n$

ETS2
$F2 = f_n$

ETS1
$F1 = f_e + f_x$

$a_1 f_x$

Final Goods
$x = \phi_x \left(\rho e_x + (1-\rho) f_x\right)^{\tau} r_x^{1-\tau}$

F_j: Quota of ETS j
a_j: Carbon price of ETS j
f_j: Fossil fuel for j
f: F. fuel supply
x: Final goods
e_d: Brown elec

Productive Technologies ▸ Model

- 2 productive technologies for Electricity production

$$e = \phi_d r_d + \phi_b r_b^{\delta} f_e^{1-\delta}$$

- A Composite good production

$$x = X(e_x, f_x, r_x) = \phi_x \left(\rho e_x + (1-\rho) f_x\right)^{\tau} r_x^{1-\tau}$$

- A representative fossil fuel production
  (Can be representative of coal, gas, oil, independent on final uses)

$$f = \phi_f r_f$$

Climate Regulations ▸ Model

All fossil fuel used is capped, but with two different regulations:

- ETS 1: Caps and Targets electricity producers and Final good producers

$$F1 = f_e + f_x$$

- ETS 2: Caps fossil fuels final consumption but targets fossil fuel producers

$$F2 = f_n$$

➤ $f = f_n + f_e + f_x = F_1 + F_2 = F$

Demand

▸ Model

- The utility $U_(x_,e_n, f_n)$ is increasing with their consumption of final goods, x, and of energy services. For the latter, each agent can either consume fuel, f_n or electricity e_n
  - ➤ $U(x, e_n, f_n) = (e_n^{\beta} f_n^{1-\beta})^{\alpha} x^{1-\alpha}$
- It is assumed that consumers' original equipment enables them to purchase up to $\bar{e_n}$ of electricity at the price p_e. More electricity can only be acquired by paying a fixed cost K

$$\text{s.c. } R = I_{[\bar{e_n},\infty)}(e_n)K + p_e e_n + p_{fn} f_n + p_x x$$

Assumptions on Production ▸ Model

- **Assumption 1:** All productivity coefficients are constant and equal except for brown electricity:

$$\phi_d = \phi_f = \phi_x = \phi \quad \text{and} \quad \phi_b = z\phi$$

- **Assumption 2:** The price of the composite good taken as numeraire:

$$p_x = 1$$

➤ Profit functions simplified under these assumptions without loss of generalization.

Electricity Production Profit ▸ Main variables ▸ Model

$$\Pi_e = p_e \phi (r_d + z r_b^{\delta} f_e^{1-\delta}) - \bar{p}_r (r_d + r_b) - (p_f + a_1) f_e$$

- First-order conditions yield:

$$\begin{aligned} p_e &= \frac{\bar{p}_r}{\phi}, \\ &= \frac{\bar{p}_r}{\phi z \delta r_b^{\delta-1} f_e^{1-\delta}}, \\ &= \frac{p_f + a_1}{\phi z (1-\delta) r_b^{\delta} f_e^{-\delta}}. \end{aligned}$$

Fossil Fuel Production Profit

▸ Main variables ▸ Model

$$\Pi_f = p_f(\phi r_f - f_n) + (p_{fn} - a_2)f_n - \bar{p}_r r_f$$

- First-order conditions yield:

$$\begin{aligned} p_f &= \frac{\bar{p}_r}{\phi}, \\ p_{fn} &= \frac{\bar{p}_r}{\phi} + a_2, \\ \Rightarrow p_{fn} &= p_f + a_2. \end{aligned}$$

Final Goods Production Profit (with $p_x = 1$)

▸ Main variables ▸ Model

$$\Pi_x = \phi\left((\rho e_x + (1-\rho)f_x)^{\tau}\, r_x^{1-\tau}\right) - p_e e_x - (p_f + a_1)f_x - \bar{p}_r r_x$$

- First-order conditions yield:

$$\begin{aligned}
\bar{p}_r &= \phi(1-\tau)(\rho e_x + (1-\rho)f_x)^{\tau} r_x^{\tau},\\
p_e &= \phi\tau\rho(\rho e_x + (1-\rho)f_x)^{\tau-1} r_x^{1-\tau},\\
p_f + a_1 &= \phi\tau(1-\rho)(\rho e_x + (1-\rho)f_x)^{\tau-1} r_x^{1-\tau}.
\end{aligned}$$

Consumer's Problem

▸ Main variables ▸ Model

$$\mathcal{L}_c = (e_n^{\beta} f_n^{1-\beta})^{\alpha} x^{1-\alpha} + \lambda \left(R - I_{[\bar{e}_n,\infty)}(e_n) K - p_e e_n - p_{fn} f_n - p_x x \right)$$

- From the first-order conditions, we derive:

$$x = \frac{p_e}{p_x} \frac{(1-\alpha) e_n}{\alpha\beta},$$
$$f_n = \frac{p_e}{p_{fn}} \frac{(1-\beta) e_n}{\beta},$$
$$e_n = \frac{p_{fn}}{p_e} \frac{\beta f_n}{1-\beta}.$$

Total Demand Functions ▸ Main variables ▸ Model

- Substituting back in the budget constraint, final demand functions derived:

$$
\begin{aligned}
x &= (1-\alpha)(R - I_{[\bar{e}_n,\infty)}(e_n)K), \\
f_n &= \frac{\alpha(1-\beta)(R - I_{[\bar{e}_n,\infty)}(e_n)K)}{p_{fn}}, \\
e_n &= \frac{\alpha\beta(R - I_{[\bar{e}_n,\infty)}(e_n)K)}{p_e}.
\end{aligned}
$$

Equilibrium Results

▸ Main variables ▸ Model

- At equilibrium, energy prices are equal:

$$p_f^* = p_e^* = \frac{\bar{p}_r}{\phi}$$

- Carbon prices on ETS1 and ETS2 differ:

$$a_1^* = \frac{\bar{p}_r}{\phi\rho} - \frac{2\bar{p}_r}{\phi} \neq a_2^* = \frac{\alpha(1-\beta)(R - I_{[\bar{e}_n,\infty)}(e_n^*)K)}{F_2} - \frac{\bar{p}_r}{\phi}$$

  - a_1 depends on productivity (ϕ) and the share of fossil fuels (ρ) in production.
  - a_2 depends on the energy price, substitutability, and quota F_2.

Contribution and Next steps

A first model on ETS2 with consumer integration

- Including demand side changes the results of the literature,
- Carbon prices on ETS 1 and ETS 2 are different,
- Constraint on the demand side investment may necessitate complementary policies.

Future developments

- Comparative statics,
- To compare the results with the extended model,
- Numerical illustration.

Discussion

Thank You

for your attention.

Happy to answer your questions!

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References I

Abrell, Jan et al. (Jan. 2024). "Optimal allocation of the EU carbon budget: A multi-model assessment". In: *Energy Strategy Reviews* 51, p. 101271.

Braungardt, Sibylle, Veit Bürger, and Benjamin Köhler (Jan. 2021). "Carbon Pricing and Complementary Policies—Consistency of the Policy Mix for Decarbonizing Buildings in Germany". en. In: *Energies* 14.21. Number: 21 Publisher: Multidisciplinary Digital Publishing Institute, p. 7143.

Cullenward, Danny and Andy Coghlan (June 2016). "Structural oversupply and credibility in California's carbon market". In: *The Electricity Journal* 29.5, pp. 7–14.

Eichner, Thomas and Rüdiger Pethig (May 2019). "EU-type carbon regulation and the waterbed effect of green energy promotion". en. In: *Energy Economics* 80, pp. 656–679.

References II

George, Jan Frederick et al. (June 2023). "The landlord-tenant dilemma: Distributional effects of carbon prices, redistribution and building modernisation policies in the German heating transition". en. In: *Applied Energy* 339, p. 120783.

Gore, Tim (2022). *Can Polluter Pays policies in the buildings and transport sectors be progressive?* en. Tech. rep. Institute for European Environmental Policy.

Görlach, Benjamin et al. (June 2022). *A Fair and Solidarity-based EU Emissions Trading System for Buildings and Road Transport*. Tech. rep. Porsdam: Ariadne.

Günther, Claudia et al. (2024). "Carbon prices on the rise? Shedding light on the emerging EU ETS2". en. In: *Working Paper SSRN Electronic Journal*.

References III

Haywood, Luke and Michael Jakob (Aug. 2023). “The role of the emissions trading scheme 2 in the policy mix to decarbonize road transport in the European Union”. In: *Transport Policy* 139, pp. 99–108.

Hübler, Michael et al. (Apr. 2024). “The distributional effects of CO 2 pricing at home and at the border on German income groups”. en. In: *Resource and Energy Economics* 77, p. 101435.

Jacobs, Leif, Lara Quack, and Mario Mechtel (Oct. 2022). “Distributional effects of carbon pricing by transport fuel taxation”. en. In: *Energy Economics* 114, p. 106290.

Jon Stenning et al. (2021). *Exploring the trade-offs in different paths to reduce transport and heating emissions in Europe*. Tech. rep. Cambridge, UK: Cambridge Econometrics.

Maj, M. et al. (2021). *Impact on Households of the Inclusion of Transport and Residential Buildings in the EU ETS*. Tech. rep. Warsaw: Polish Economic Institute, ERCST, Cambridge Economics.

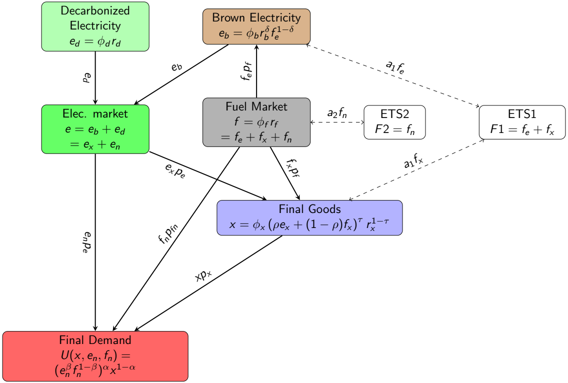
References IV

Pietzcker, Robert et al. (2021). *Notwendige CO2-Preise zum Erreichen des europäischen Klimaziels 2030*. de. Tech. rep. Artwork Size: 20 pages Medium: pdf. Potsdam Institute for Climate Impact Research, 20 pages.

Rickels, Wilfried et al. (2023). *Potential efficiency gains from the introduction of an emissions trading system for the buildings and road transport sectors in the European Union*. eng. Kiel Working Paper. Kiel.

A reference model inspired by Eichner et al.

▸ Elec ▸ Fossil Fuels ▸ Final Goods ▸ Utility ▸ Results



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Final Goods
$x = \phi_x \left(\rho e_x + (1-\rho) f_x\right)^{\tau} r_x^{1-\tau}$

Final Demand
$U(x, e_n, f_n) =$
$(e_n^{\beta} f_n^{1-\beta})^{\alpha} x^{1-\alpha}$

Schematic representation of the reference model

▸ Main variables

Main Variables

▸ Elec ▸ Fossil Fuels ▸ Final Goods ▸ Utility ▸ Method

e:	Electricity supply	f:	Fossil fuel supply	p_e:	Electricity price
e_d:	Decar. electricity	f_x:	Fossil fuel for final goods	p_f:	Fossil fuel price for production
e_b:	Brown electricity	f_n:	Fossil fuel for consumption	p_{fn}:	Fossil fuel price for consumption
r_d:	input - decarb. electricity	f_e:	Fossil fuel for elec	p_x:	Final goods price
r_b:	Input for brown electricity	e_x:	Elec for final goods	R:	Consumer income
r_f:	Input for fossil fuel production	e_n:	Elec for consumers	a_1:	Emission price on ETS1
r_x:	Input for final goods	x:	Total final goods	a_2:	Emission price on ETS2

Results: Work in Progress

▸ Results

$e^* =$		$f^* =$	$F = F_1 + F_2$
$e_d^* =$		$f_n^* =$	F_2
$e_b^* =$		$f_x^* =$	
$e_x^* =$		$f_e^* =$	
$e_n^* =$	$\frac{\phi\alpha\beta(R-I_{[\bar{e_n},\infty)}(e_n^*)K)}{\bar{p}_r}$	$x^* =$	$(1-\alpha)(R - I_{[\bar{e_n},\infty)}(e_n^*)K)$
$r_b^* =$		$r_x^* =$	$\frac{(1-\tau)(1-\alpha)(R-I_{[\bar{e_n},\infty)}(e_n^*)K)}{\bar{p}_r}$
$r_d^* =$		$r_f^* =$	
$p_e^* =$	$p_f^* = \frac{\bar{p}_r}{\phi}$	$p_{fn}^* =$	$p_f^* + a_2^* = \frac{\alpha(1-\beta)(R-I_{[\bar{e_n},\infty)}(e_n^*)K)}{F_2}$
$a_1^* =$	$\frac{\bar{p}_r}{\phi\rho} - \frac{2\bar{p}_r}{\phi}$	$a_2^* =$	$\frac{\alpha(1-\beta)(R-I_{[\bar{e_n},\infty)}(e_n^*)K)}{F_2} - \frac{\bar{p}_r}{\phi}$