Energy Economics: The Case of Emission Markets

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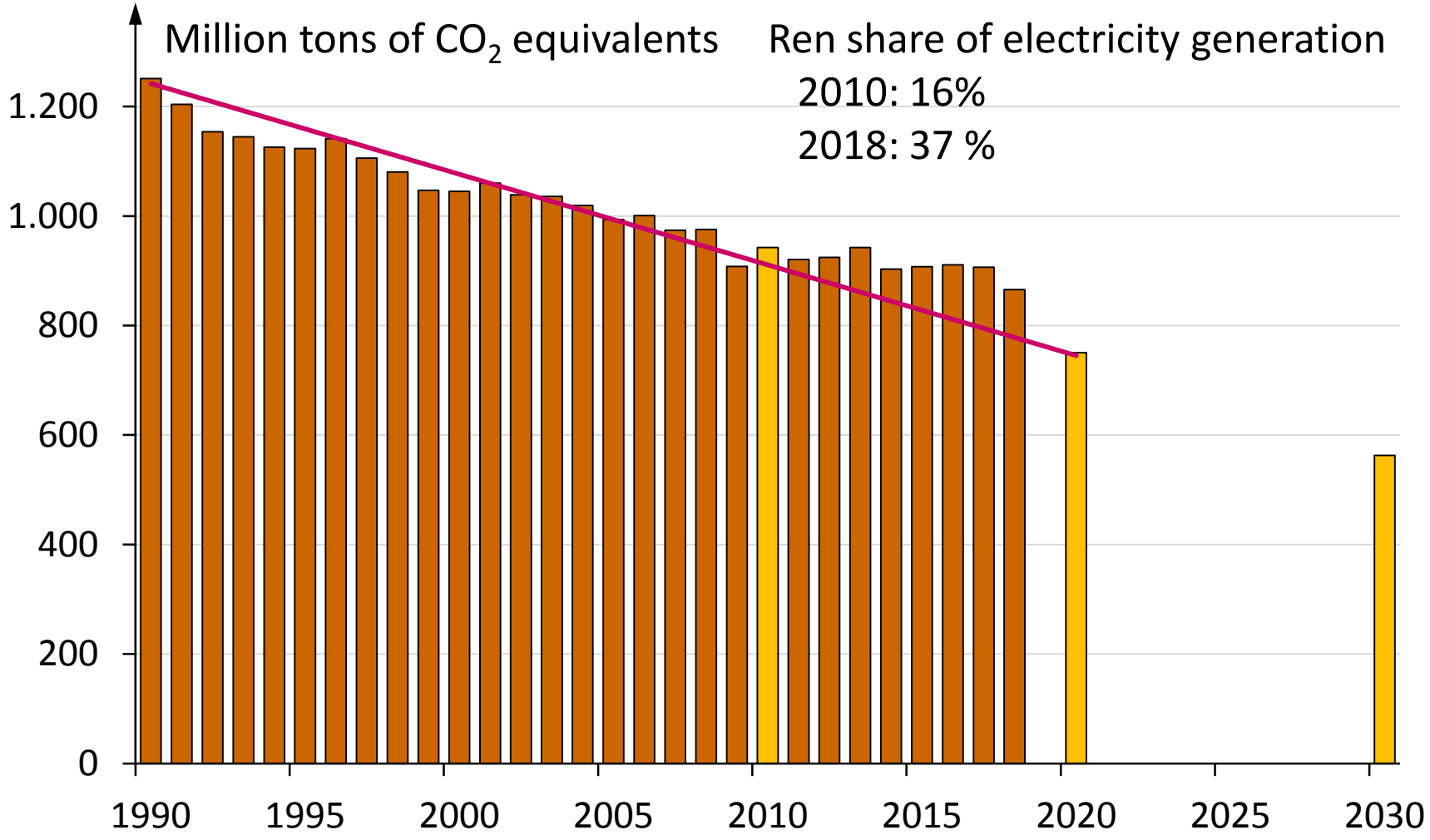
Greenhouse Gas Emissions in Germany



My Content Today

- Why Markets for Emissions?
  - Externalities, Pareto optimum and the role of regulators
- How to organize the Pareto optimum? Control of volumes or prices?
- How to organize emission markets: Uniform or heterogeneous approach with respect to energy uses?
- How to organize emission markets: Uniform or heterogeneous approach with respect to countries?
  - Avoiding carbon leakage through import tariffs or free allocation of emission rights
- The case of the European Trading System ETS
  - Gradual shift from volume control to price control

Definitions

- Emissions: Substances exhausted into the atmosphere, the hydrosphere etc., also noise, tremor, odour, contamination, and radiation
- Immissions: distribution, transformation and metamorphosis of the emitted substances in the receiving ecosphere
- Damages: Impacts of immissions that are somehow negatively valued by humans
- External effects: Impacts of economic activities on outsiders without compensation. In the case of damages, these impacts are “negative external effects”; if the impacts represent advantages, they are called “positive external effects”
- External cost: Negative external effects expressed in monetary units

Types of Damages

- Economic damages in the narrow sense: destruction of physical assets that cause income losses, cleanup and repair costs
- Human life and health: number of concerned persons, number of years of life lost, duration and degree of medical treatment
- Environmental damages as far as not yet captured by category "economic damages"
- Quality of life: exposure to noise and vibration, but also fear of catastrophes, reduced autonomy and self-fulfillment
- Social institutions that are temporarily prevented from normal functioning (civil protection, health system, …): number of days times number of concerned persons

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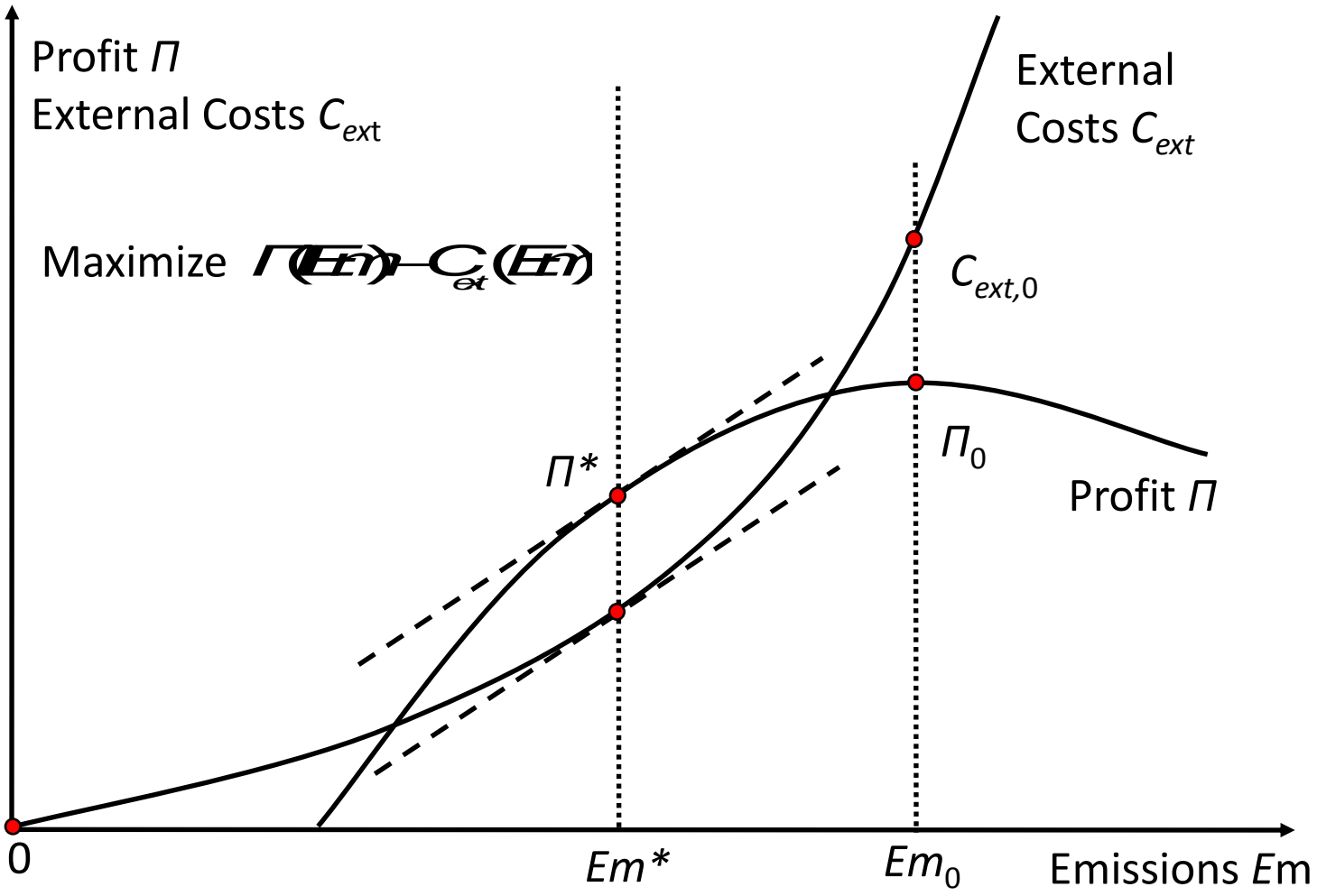
Optimal Emmision Levels



External Costs and Market Failure

- No Pareto-Optimum: Some agent can be better off without that the situation of any other agents are deteriored
- Coase-Theorem: Negotiations between polluters and victims could lead to the Pareto-optimum, but negotiations may not be possible due to
  - Multitude of polluters and victims
  - unclear cause-effect relationships
  - high transaction costs (costs of using the market)

→ Market Failure

Strategies to Correct Market Failure

- Define emission standards and norms (e.g. mandatory emission controls, ban of certain technologies)

Price control

- Emission taxes (Pigou-Tax). By taxing emissions, the government puts a price on them; accordingly the externality becomes internalized
- Standard Price Approach (BAUMOL, OATES 1988): Government sets an emission standard and implements it through
  - appropriate emission taxes

Volume control

  - defining the number of tradable emission allowances distributed through auctions …
  - … or through a free allocation to polluters (grandfathering, benchmarking)

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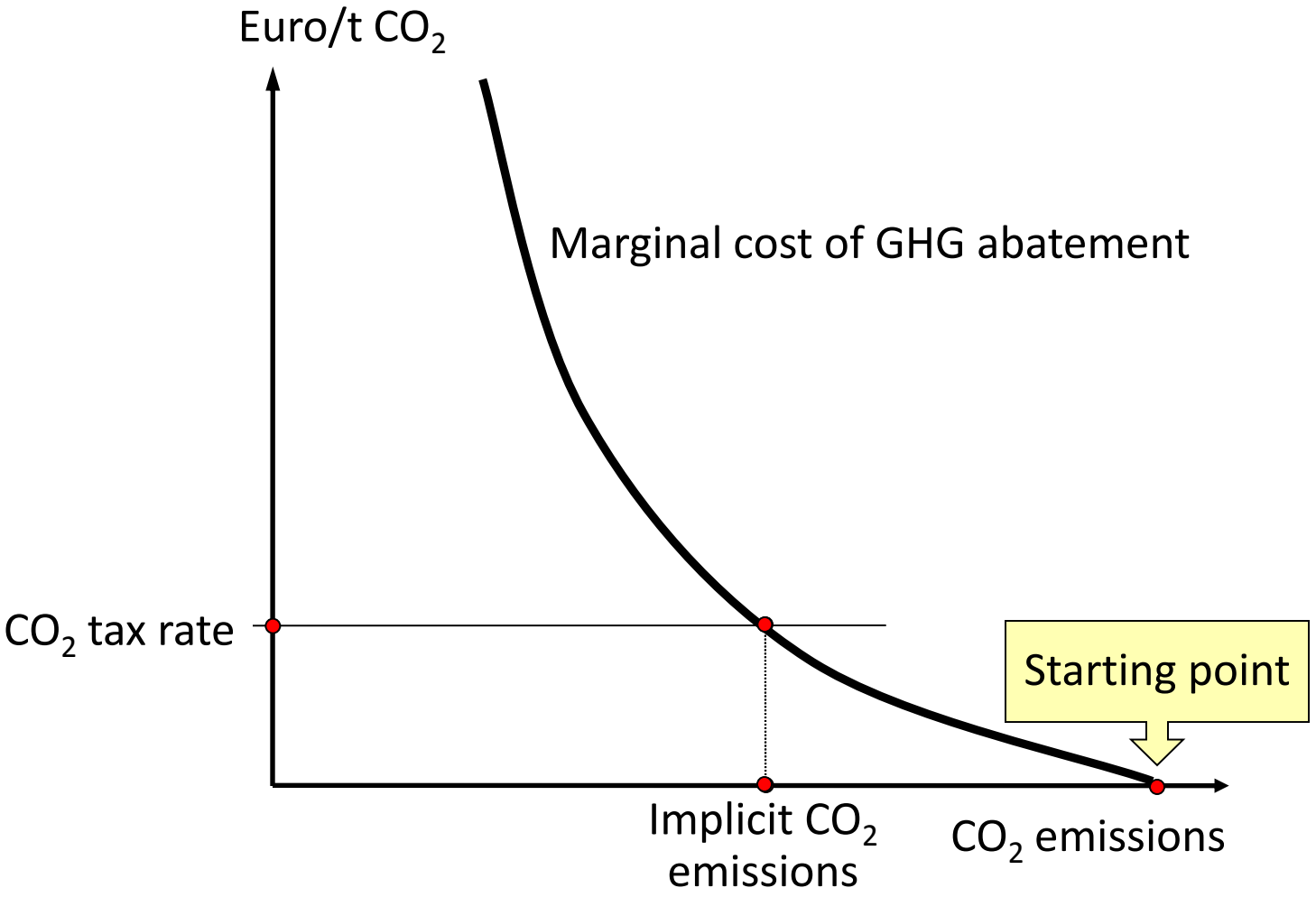
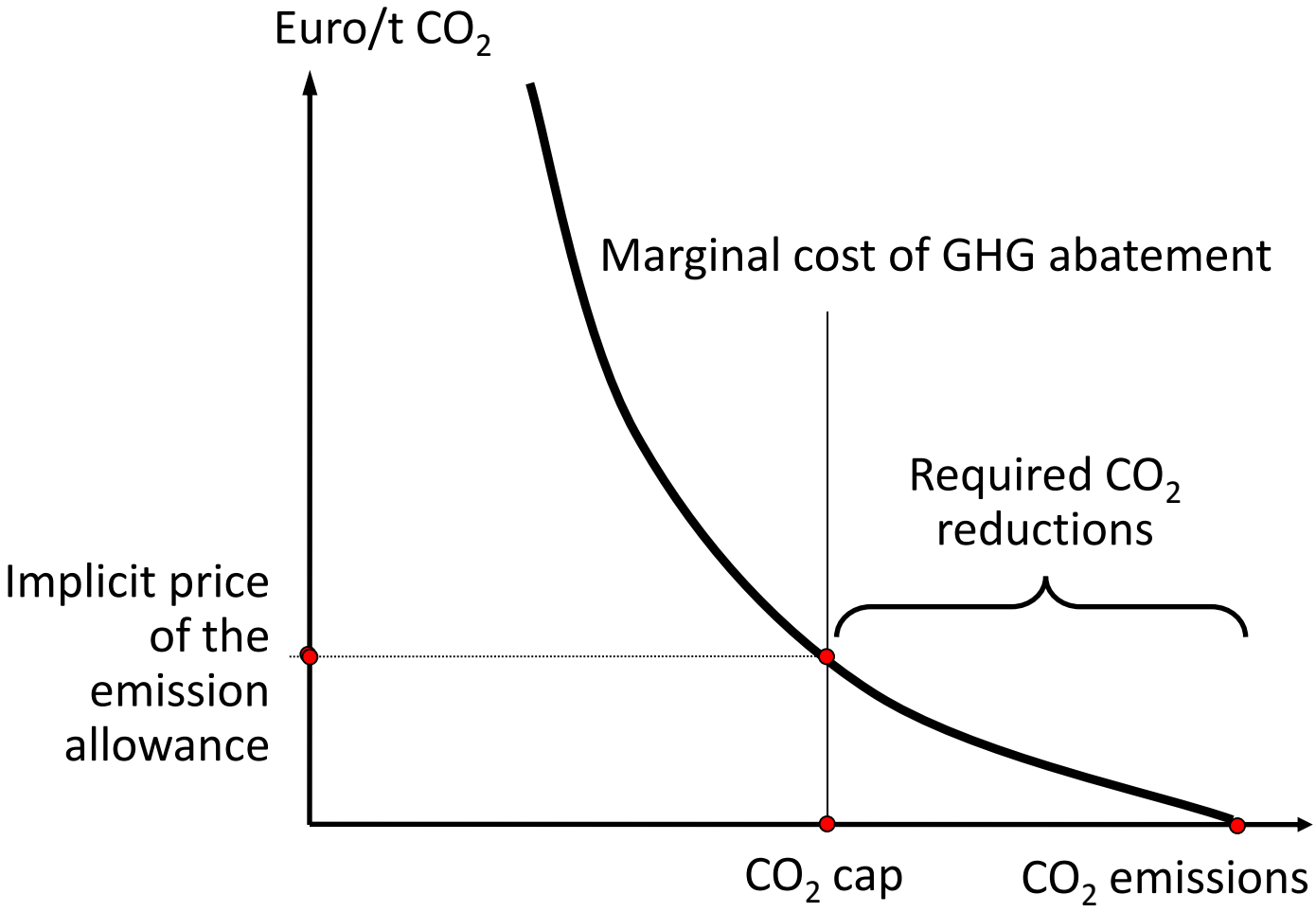
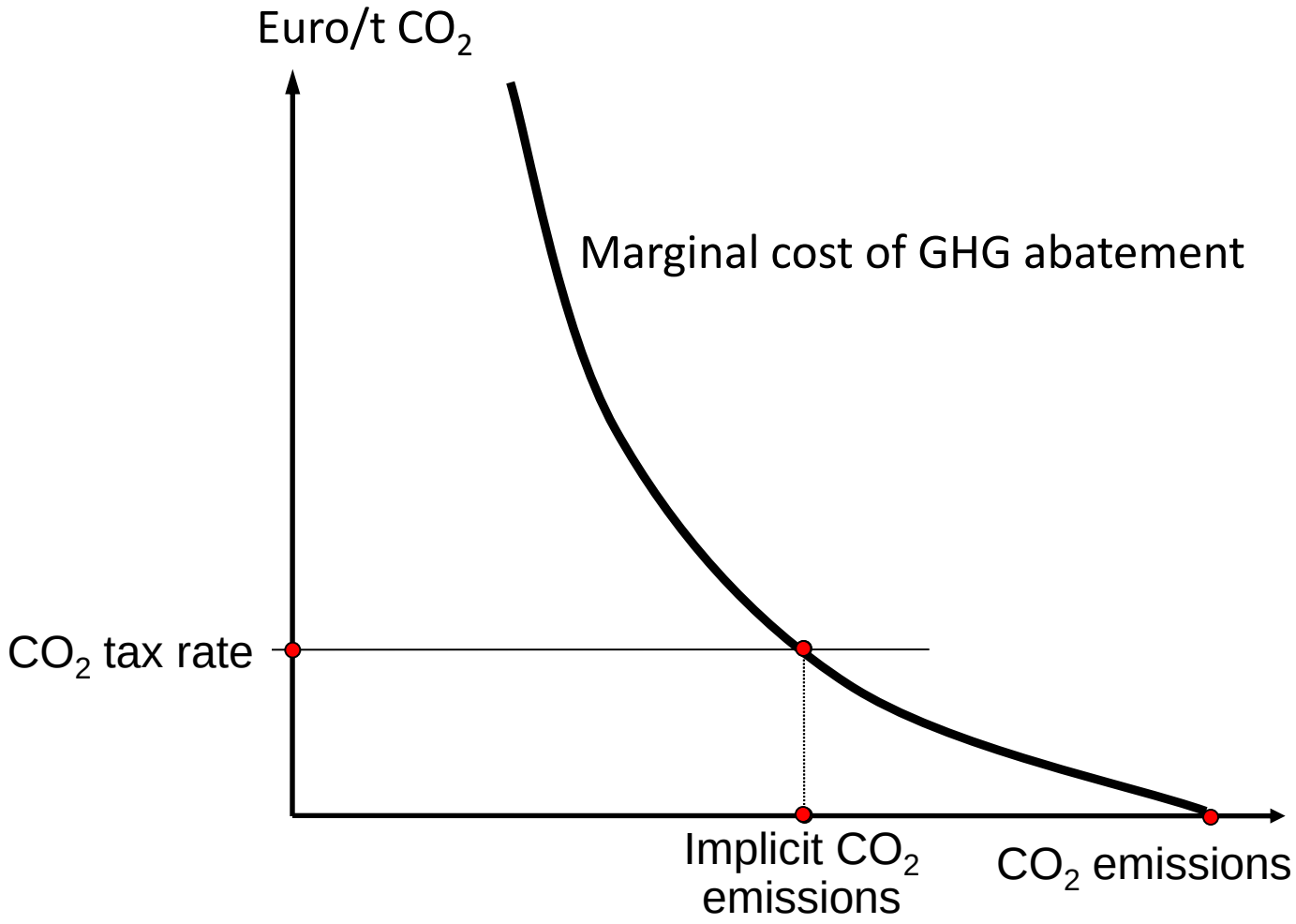
CO_2 Abatement Costs and a CO_2 Tax



CO_2 Abatement Costs and CO_2 Cap



Unknown CO_2 Abatement Costs and CO_2 Tax



Some Theory *[Source Sachverstaendigenrat 2019]*

- Theory of emission control under uncertainty:
  - If the marginal costs of emission reduction increase strongly with the achieved reduction, price volatility of a Cap & Trade system would be large. In this situation most economists prefer price instead of volume control.
  - If the atmosphere is close to a (known) tipping point so that small additional emissions would cause huge damages, most economists prefer volume control if this would keep the emissions below the tipping point.

- Weitzman, Martin L. (1974), “Prices vs. Quantities,” Review of Economic Studies, 41: 477–91

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CO_2 Emission Factors and Power Generation

	Fuel specific emissions	Assumed generation efficiency	Specific emissions of power generation
	t CO_2/MWh H_i	Percent	t CO_2/MWh$_{el}$
Lignite	0.39	42	0.929
Hard coal	0.33	45	0.733
Heavy oil	0.28	38	0.737
Heating oil	0.27	40	0.675
Natural gas	0.20	57	0.351

H_i = lower heating value (*Brennwert*)

CO_2 Emission Factors and Fuel Prices

	Fuel specific emissions		Assumed wholesale fuel price	Implicit price increase at 100 €/t CO_2
	kg CO_2/GJ H_i	kg CO_2/kWh H_i	Ct/kWh H_i	Percent
Hard coal	92	0.33	1.5	220
Natural gas	55	0.20	2.2	91
	kg CO_2/GJ H_i	kg CO_2/l	Ct/l	Percent
Gasoline	74	2.37	1.40	17
Diesel	74	2.65	1.30	20

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Marginal Cost Pricing in Competitive Markets

Profit $\Pi = p \cdot Q - C_f - c_v \cdot Q$

p	Power price [Euro/MWh]
Q	Generation (Quantity) [MWh]
c_v	Variable unit cost [Euro/MWh]
C_f	Fixed costs [Euro]

Profit maximizing under atomistic competition:

$$\frac{d\Pi}{dQ} = p\frac{dQ}{dQ} + Q\underbrace{\frac{dp}{dQ}}_{=0} - \underbrace{\frac{dC_f}{dQ}}_{=0} - \frac{d(c_v \cdot Q)}{dQ} = 0 \quad \longrightarrow \quad p = \frac{dC}{dQ} = c_v$$

Ask price at a uniform price auction market must exceed the marginal costs, otherwise no offer

Components of marginal costs of power generation:

- Fuel costs (coal, natural gas, …)
- Startup and shutdown costs

Marginal Cost Pricing under Emission Caps

$$\Pi(Q, Em) = p \cdot Q - C(Q, Em) - p_{em} \cdot \left(Em - g(\overline{Em}) \right)$$

First order optimality conditions

$$\frac{\partial C}{\partial Em} = -p_{em} \qquad p = \frac{\partial C}{\partial Q} + p_{em} \cdot \frac{Em}{Q}$$

Em	Total emissions of a facility [t CO_2]
$g(Em)$	Free allocation of EUA [t CO_2]
C	Cost function [Euro]
p	Power price [Euro/MW]
p_{em}	Emission price [Euro/t CO_2]
Π	Profit [Euro]
Q	Output [MWh]

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EU Emission Trading System (ETS)

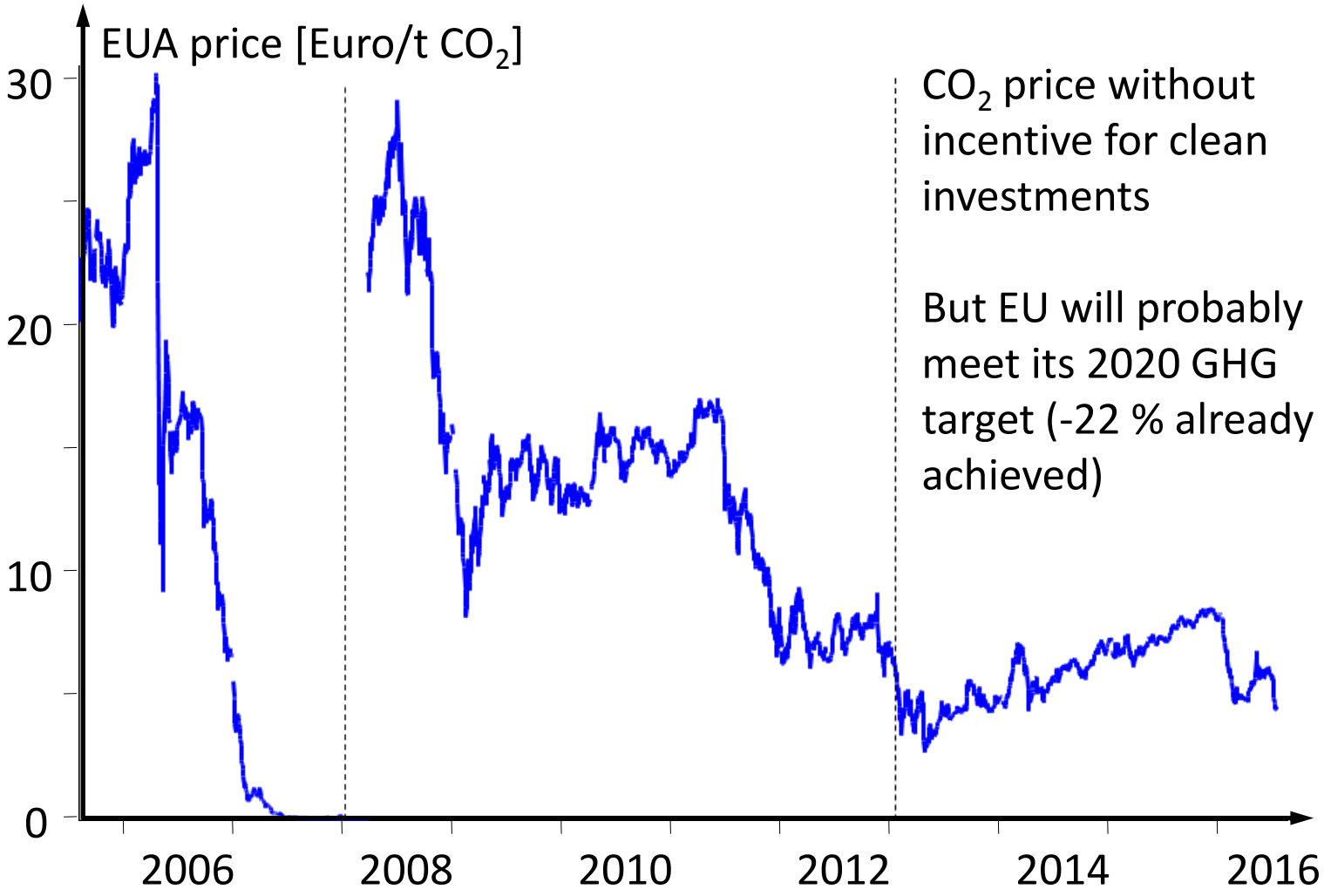
- For introducing an European CO_2 tax, an unanimous vote of all EU member states is required. But a majority vote is sufficient for introducing an ETS system

- Mandatory "CO_2 Cap and Trade" system since 2005 with trading periods of 3 to 10 years for
  - Installations of power, refinery, steel, glass, cement industries (2071 million t CO_2 emissions in 2005)
  - airline business (since 2011)

- Almost free allocation of emission rights in the first two trading periods 2005/7 and 2008/12 → Windfall profits

- Declining number of CO_2 Allowances (EUA), whereby the annual decline rates correspond to the EU GHG targets for 2020 and 2030

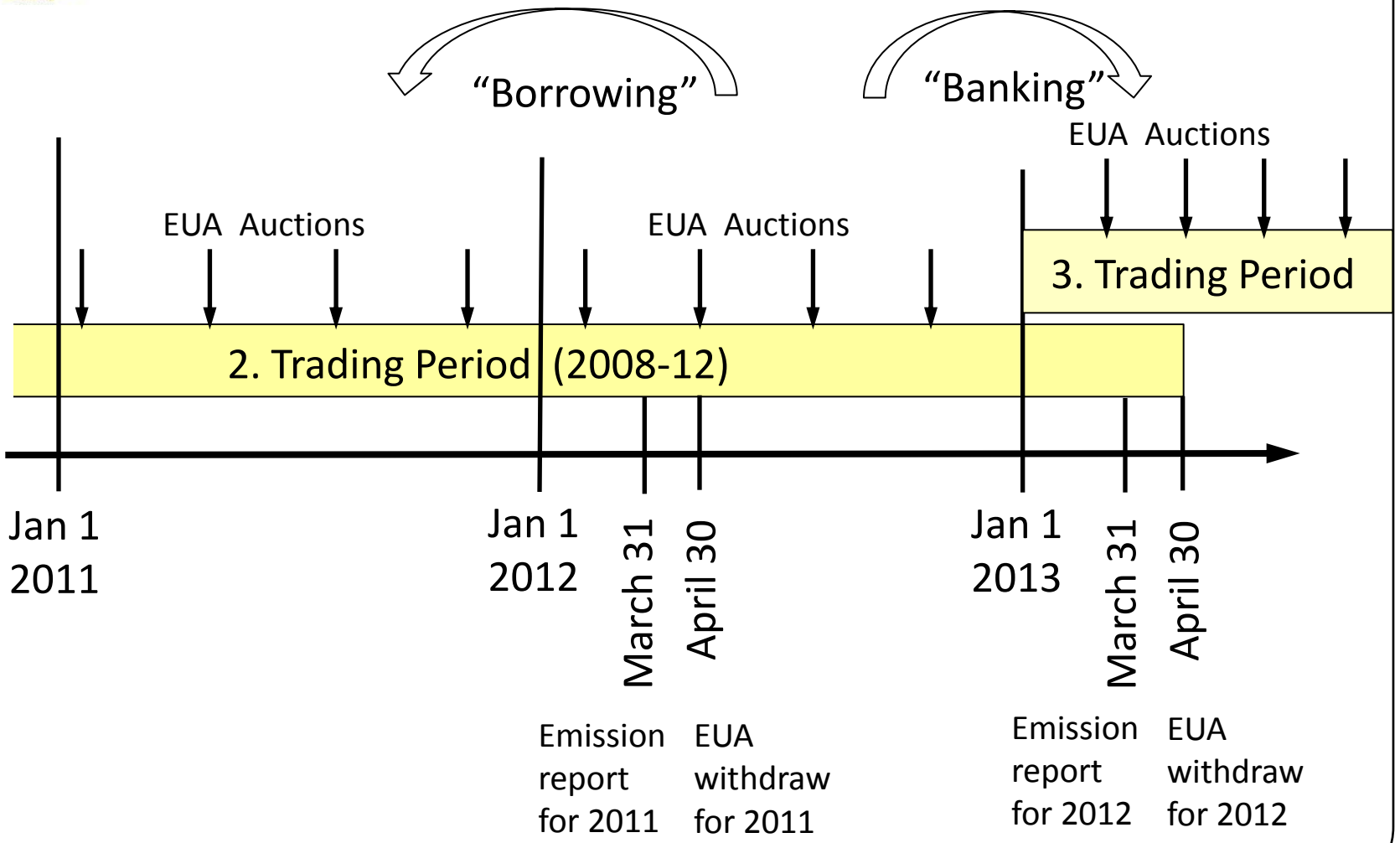
CO_2 Price of the European ETS



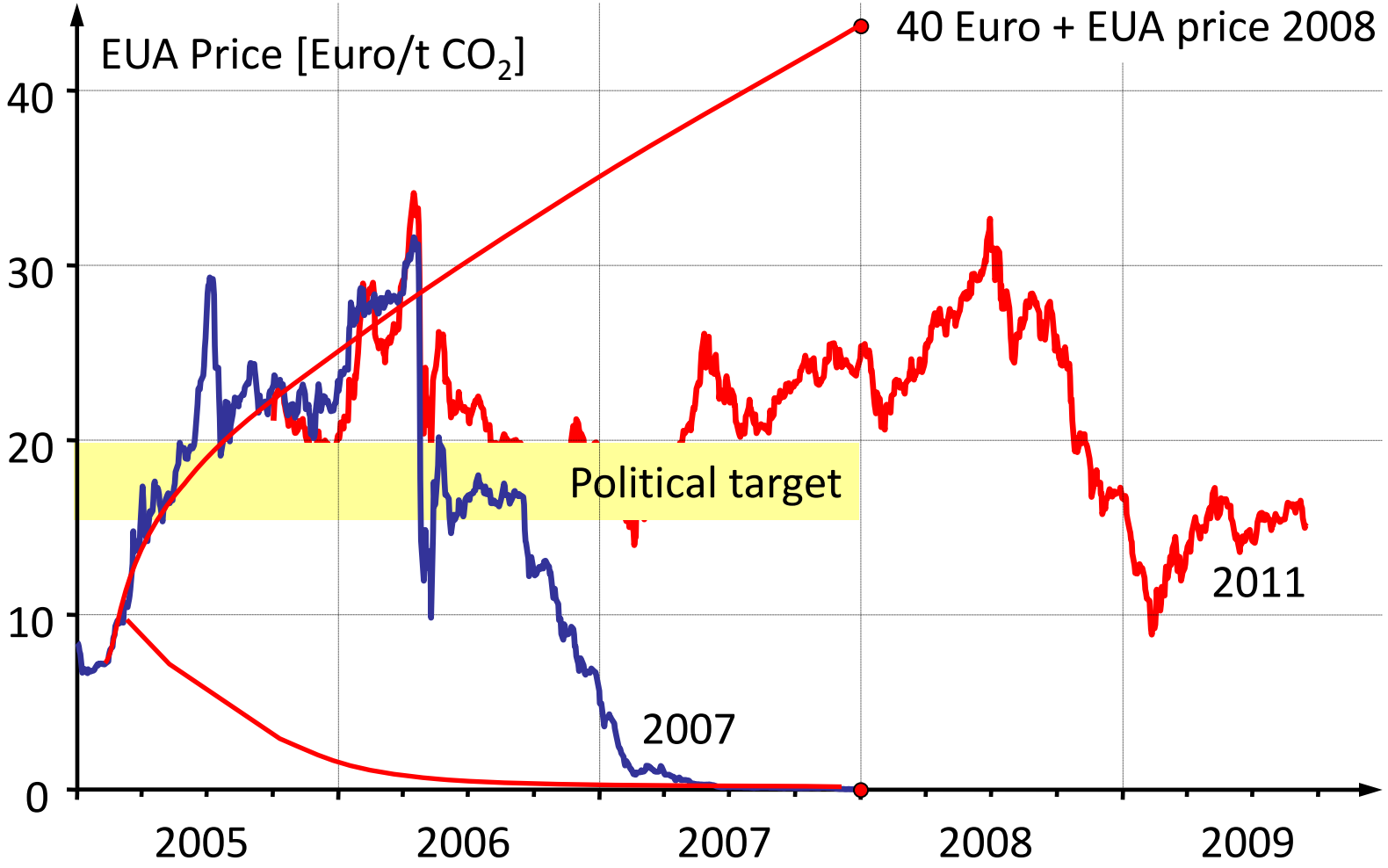
CO_2 price without incentive for clean investments

But EU will probably meet its 2020 GHG target (-22 % already achieved)

Actions Along the Time Axis



Price of European Union Allowances (EUA)



Assessment of the European Cap-and-Trade

- EUA price is not determined by marginal abatment costs but on the expectations of the ETS market at the end of the trading period
- The CO_2-price of a cap & trade system is
  - either low at the end of the trading period (it market is long and cap is not exceeded)
  - or equivalent to the penalty defined by the regulator (100 Euro/t plus EUA price of the next trading period)
- ETS prices of 40-70 Euro/t are not realistic under the original cap-and-trade system
- ETS prices beyond 100 Euro/t are politically infeasible (international competitiveness of the European industry, carbon leakages)

EU-2030 Framework on Climate & Energy

- Introduction of a market stability reserve within the current trading period
- It triggers adjustments to annual auction volumes in situations where the **total number of allowances** in circulation is outside a predefined range:
  - Reducing allowances from future auction volumes if the EU ETS surplus exceeds **833 million allowances**
  - Adding allowances to future auction volumes provided the EU ETS surplus is **below 400 million allowances**
- Under certain conditions the emission allowances in the market stability reserve are deleted forever

EU-Decisions 9 November 2017

[source: www.consilium.europa.eu]

- Linear Reduction Factor (LRF) of emission allowances 2.2% can be subject to change in the light of implementing the Paris Agreement
- Cancellation from the MSR: As from 2023, allowances in MSR above the total number of allowances auctioned during the previous year should no longer be valid
- Auction share: 57% at the outset, but flexible
- New Entrants Reserve: 370 Mt
- Voluntary cancellation of allowances due to closure of electricity generation: Member states may cancel allowances to counteract the impact of closing down electricity generation up to the average verified emissions over the last five years upon preceding the closure

CO_2 Prices on the European Emission Market

Grazie!

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