Environment Center
Charles University
in Prague

Economic Rationale for Regulation:
Environmental externalities, abatement costs and market-based instruments

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Presentation outline

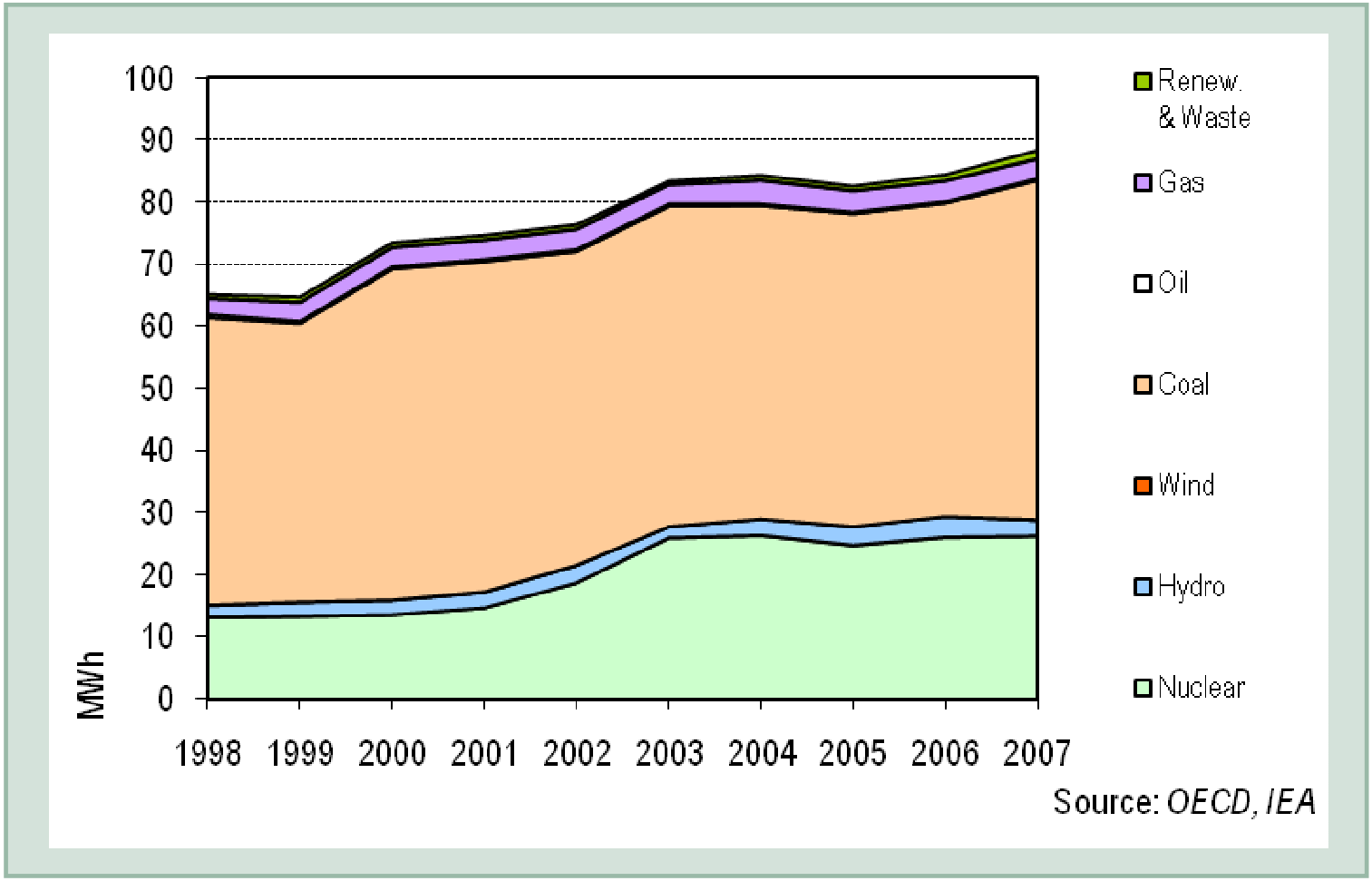
- energy sector
- theoretical fundamentals of optimal environmental taxation
- quantification of external costs
- abatement costs
- internalisation using market-based instruments

Drivers and challenges

Energy sector under continuous influence from EU

- opening of energy market
- vertical dis-bundling (generation, transmission, distribution)
- harmonised taxation of energy
- emission trading scheme
- promotion of renewable energy sources
- security of energy supply

Gross Electricity Production 1998-2007



Optimal environmental taxation theory

- externalities renders ineffective the market price mechanism that otherwise secures socially optimal (Pareto efficient) resource allocation
- presence of the externality could be avoided by making its external effect 'internal' → (voluntary) internalisation through
  - private negotiation
  - creation of market (Coase)
- but transaction costs matter

Optimal environmental taxation theory (2)

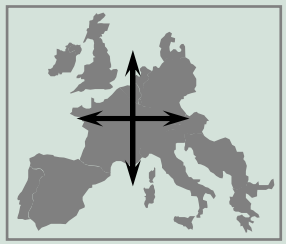
- regulation of market by introducing taxes (subsidies)
  - optimization at the point where reduction of **additional damage equals to additional increase in abatement costs**
  - **Pigouvian tax** (subsidy) – tax rate equals to marginal external costs
  - but this holds only in first best setting with no need for tax revenues (→ Ramsey's inverse elasticity rule)
  - Sandmo – **optimal pollution tax** consist of **revenue-raising part** (Ramsey) and **externality correcting part** (Pigou) weighted by marginal cost of public funds

Methodology for calculation of external costs

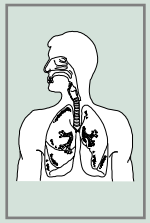
Impact-Pathway Approach

EMISSIONS

TRANSPORT & CHEMICAL TRANSFORMATION

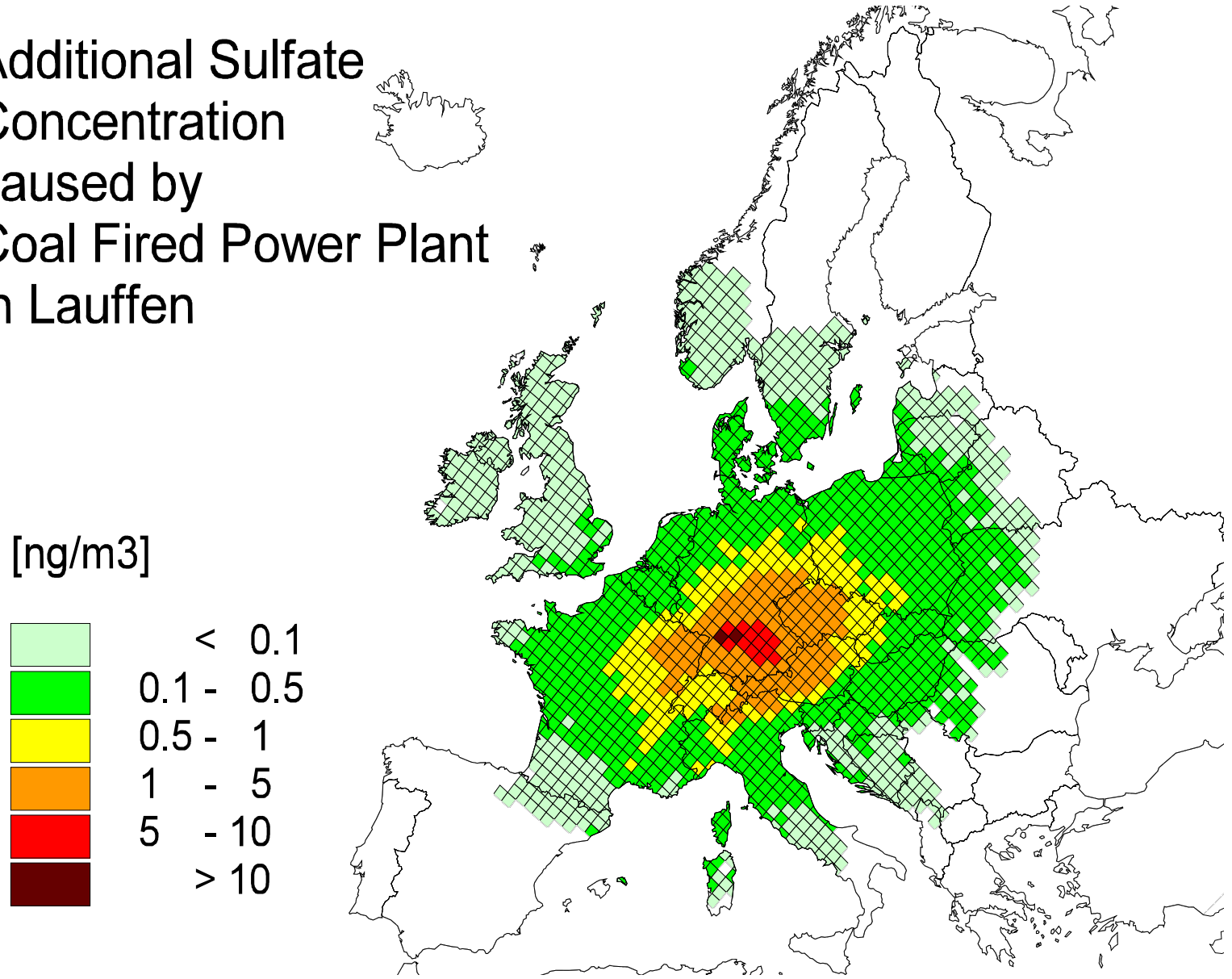


PHYSICAL IMPACTS

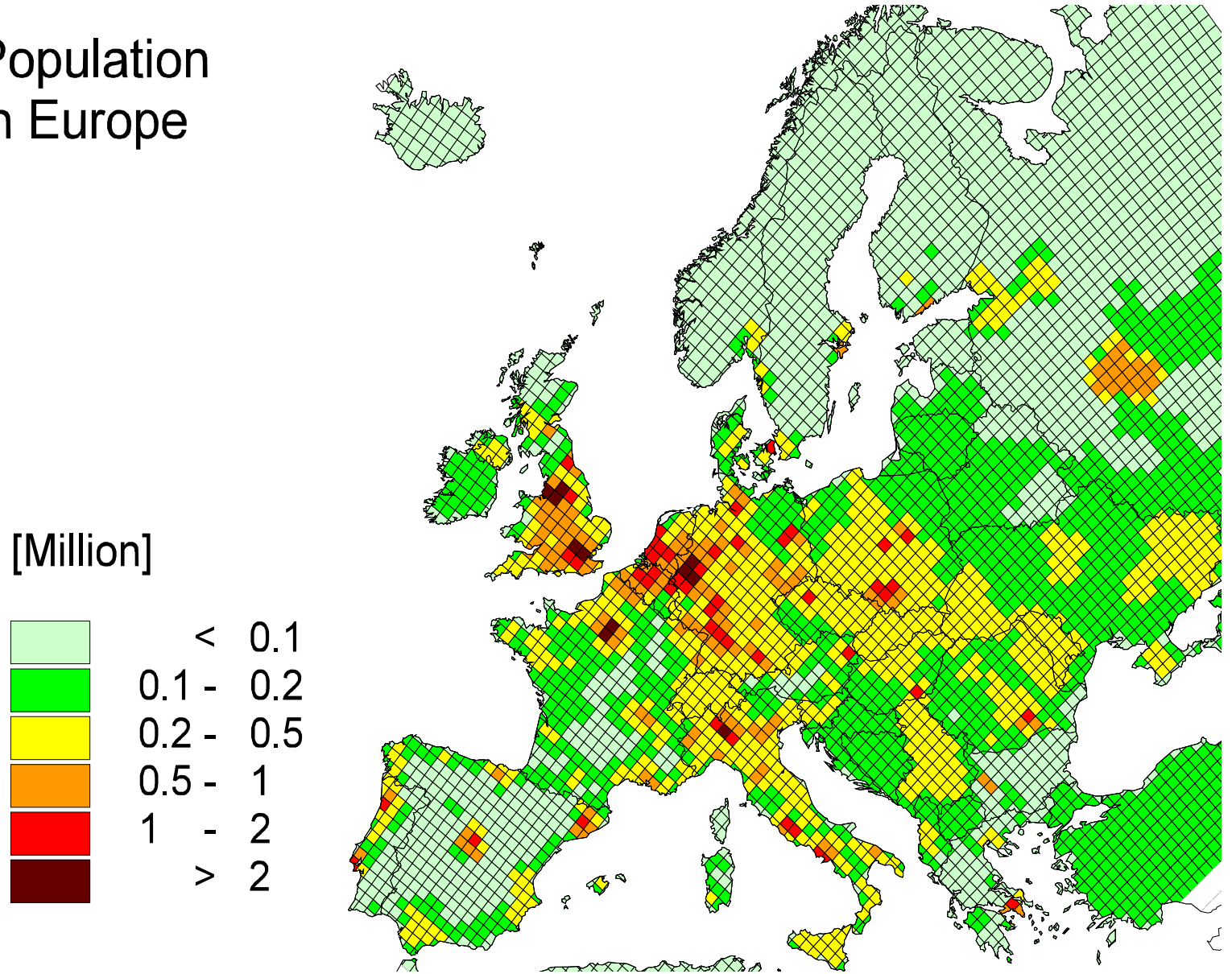


MONETARY VALUATION

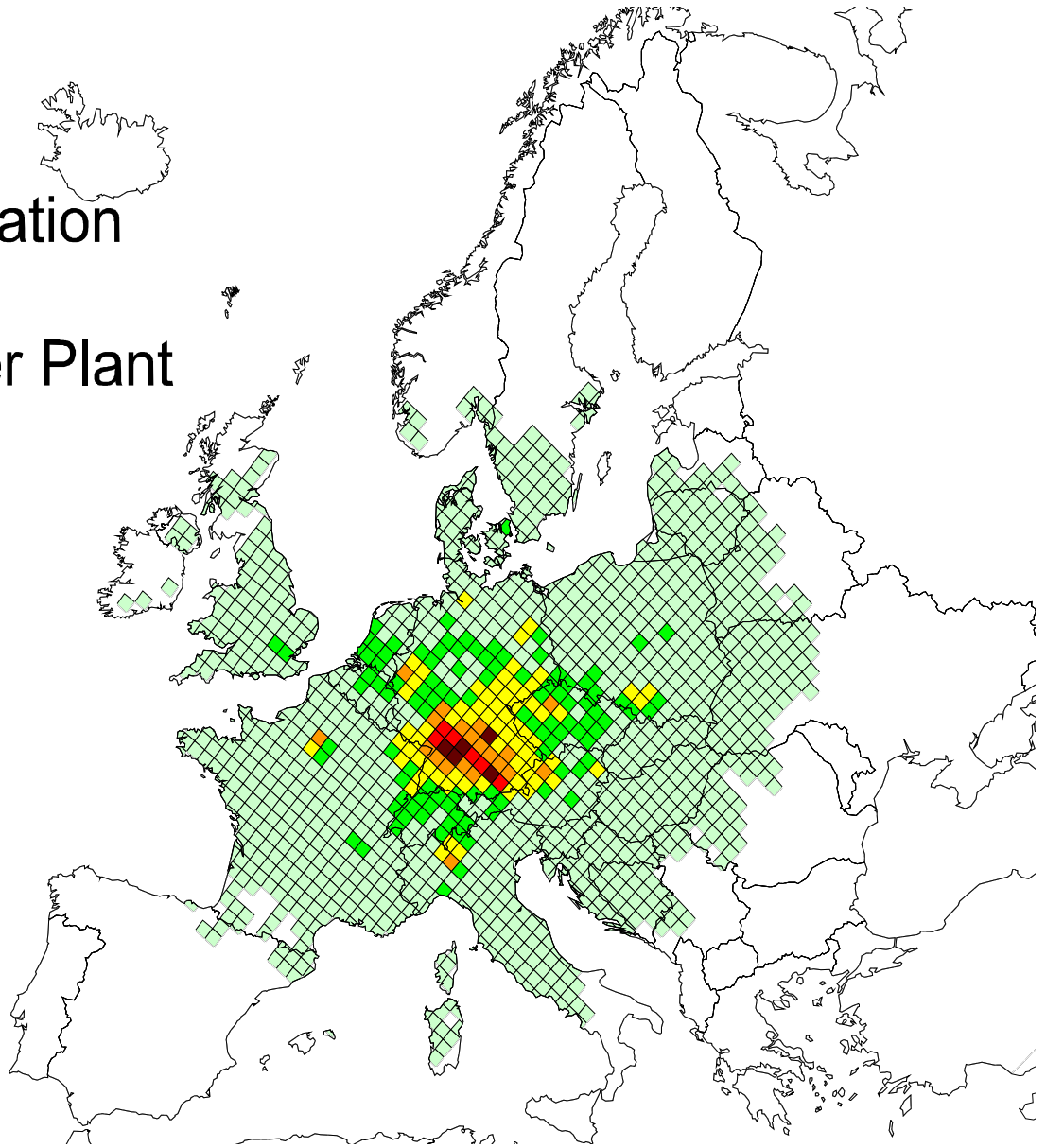
Additional Sulfate Concentration caused by Coal Fired Power Plant in Lauffen



Population in Europe



Life Time Lost caused by Sulfate concentration due to Coal Fired Power Plant in Lauffen



Input data

technology data	emissions	other
Flue gas parameters	SO_2, NO_x, PM10, PM2.5, NH_3, NMVOC	Land-use change
Location	Cd, As, Cr, Ni, Hg, Pb, Cr-VI, CH_2O, dioxins	
Building properties	CO_2, CH_4, N_2O	
	radio-nuclides	

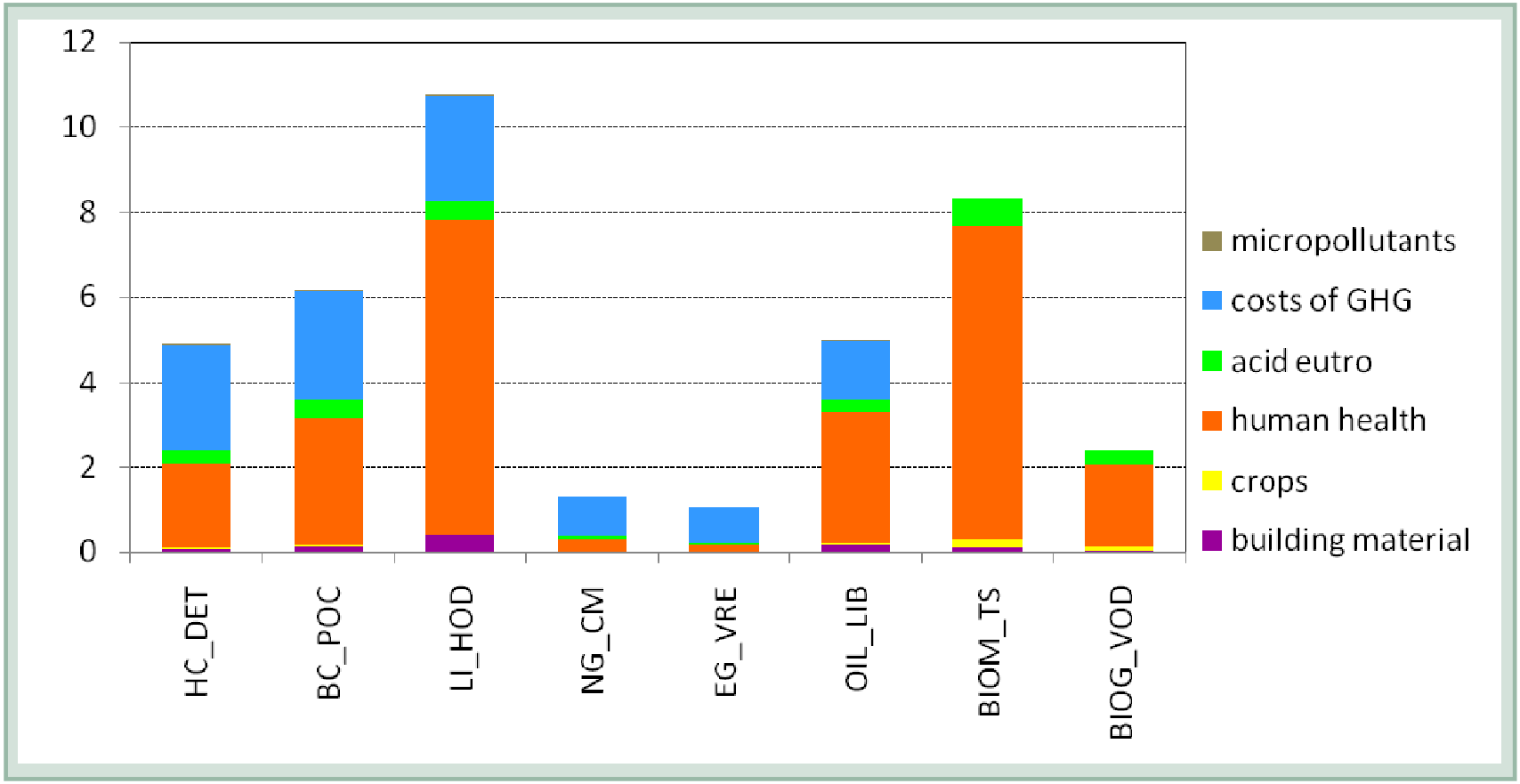
Output data

- Concentration levels of primary and secondary particles and ozone
- Receptor exposure (i.e. population, crops, building materials)
- Physical impacts resulting from exposure to airborne pollutants
- (Damage) costs due to impacts on human health, crops, building materials, ecosystems and due to climate change

Technologies assessed

facility	fuel	instal. capacity (MWel)	electricity production (GWh/a)
Dětmarovice	coal/lignite	800	2 502
Hodonín	lignite/biomass	105	303
Tušimice II	lignite	800	4 758
Červený Mlýn	natural gas	95	242
Vřesová - PPC	energo gas/NG	370	1 781
Teplárna Liberec	HFO/NG	12	30
Trhové Sviny	biomass	0,6	1,063
Vodňany	biogas	0,142	0,8207

Marginal external costs (in €c/kWh)



➔ range of external costs between 1.08 and 10.8 €c/kWh

External cost estimates (3)

- highest for lignite fired power plants
- lowest for natural gas fired power plants
- costs mainly driven by climate change impacts and human health effects (esp. mortality)
- substantial uncertainties
  - climate impacts – estimates based on abatement costs (vs. damage costs)
  - health impacts – mortality valuation (value statistical life vs. life year lost)

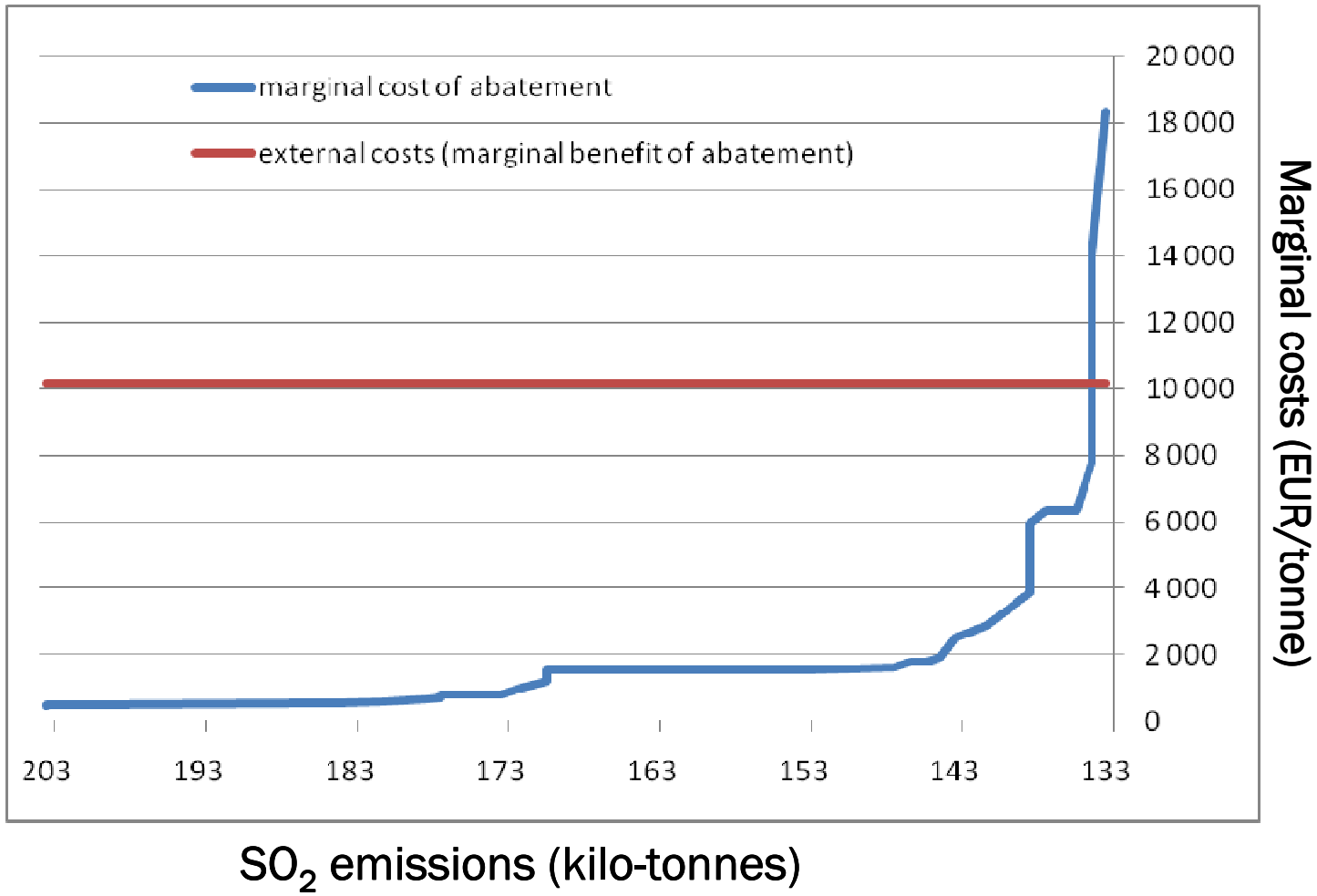
Abatement costs

- emission control costs computed by the **GAINS** model (*Greenhouse Gas and Air Pollution Interactions and Synergies*)
- integrated assessment model dealing with costs and potentials for air pollution control and greenhouse gas mitigation
- emission inventories, emission projections and control costs for **SO_2, NO_X, VOC, PM, NH_3, GHG**
- developed by **IIASA** (the International Institute for Applied Systems Analysis)
- web: http://gains.iiasa.ac.at/index.php/gains-europe

Abatement costs (2)

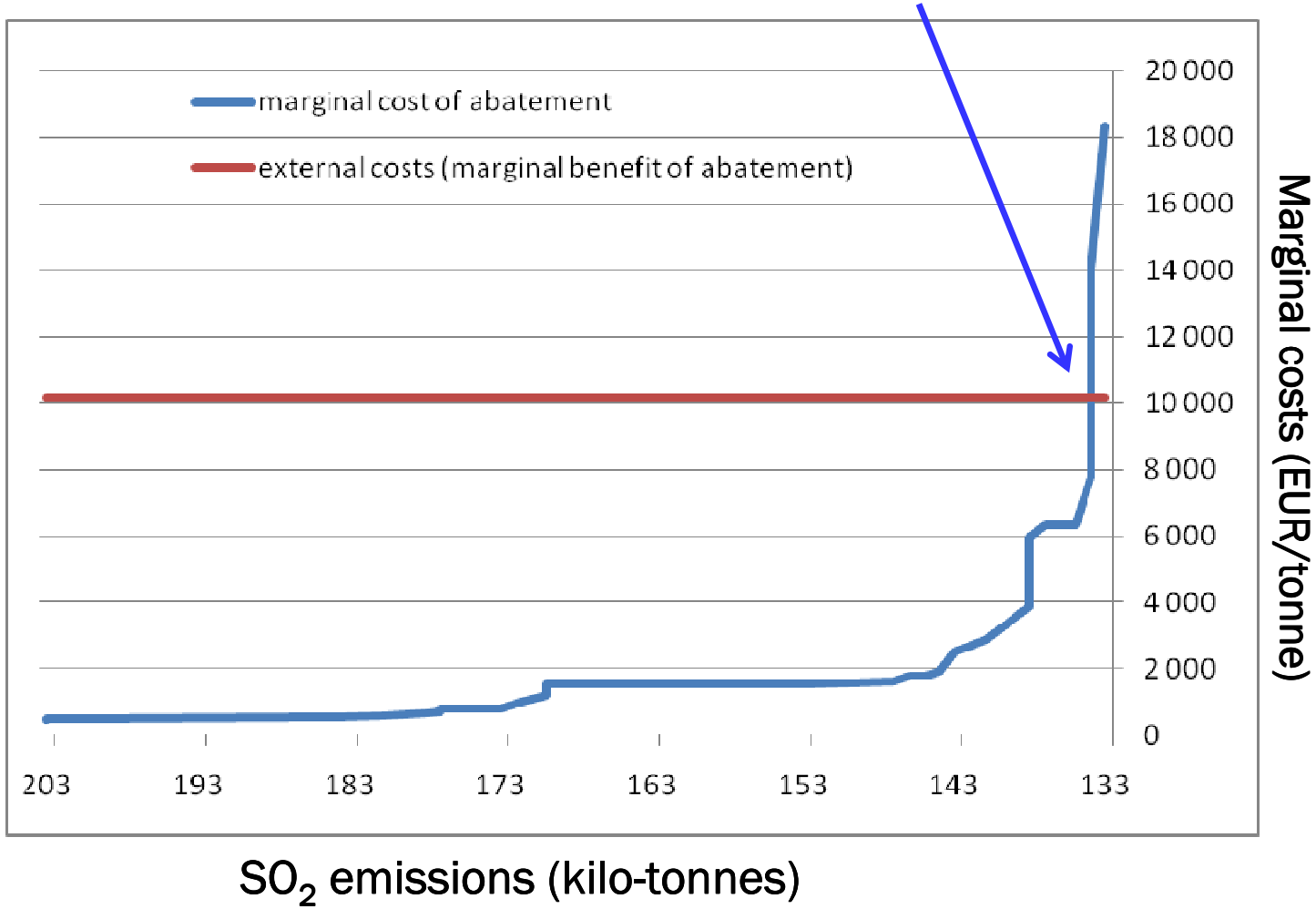
- Marginal abatement cost curve for SO_2, NO_X and $PM_{2.5}$
- expenditures on emission controls are differentiated to:
  - Investment costs (annualized over the technical lifetime of the plant, we used interest rate 4%)
  - Fixed operating costs (maintenance and administrative overhead),
  - Variable operating costs (additional labour demand, increased energy demand, sorbent material demand, by-products/waste disposal)
- emission control costs for „National projections 2006“ (scenario based on revision of the NEC directive for 2020)
- reduction objectives for 2020:
  - SO_2 by 77% compared to 2000, NO_X by 58%, $PM_{2.5}$ by 46%

Abatement costs – SO_2

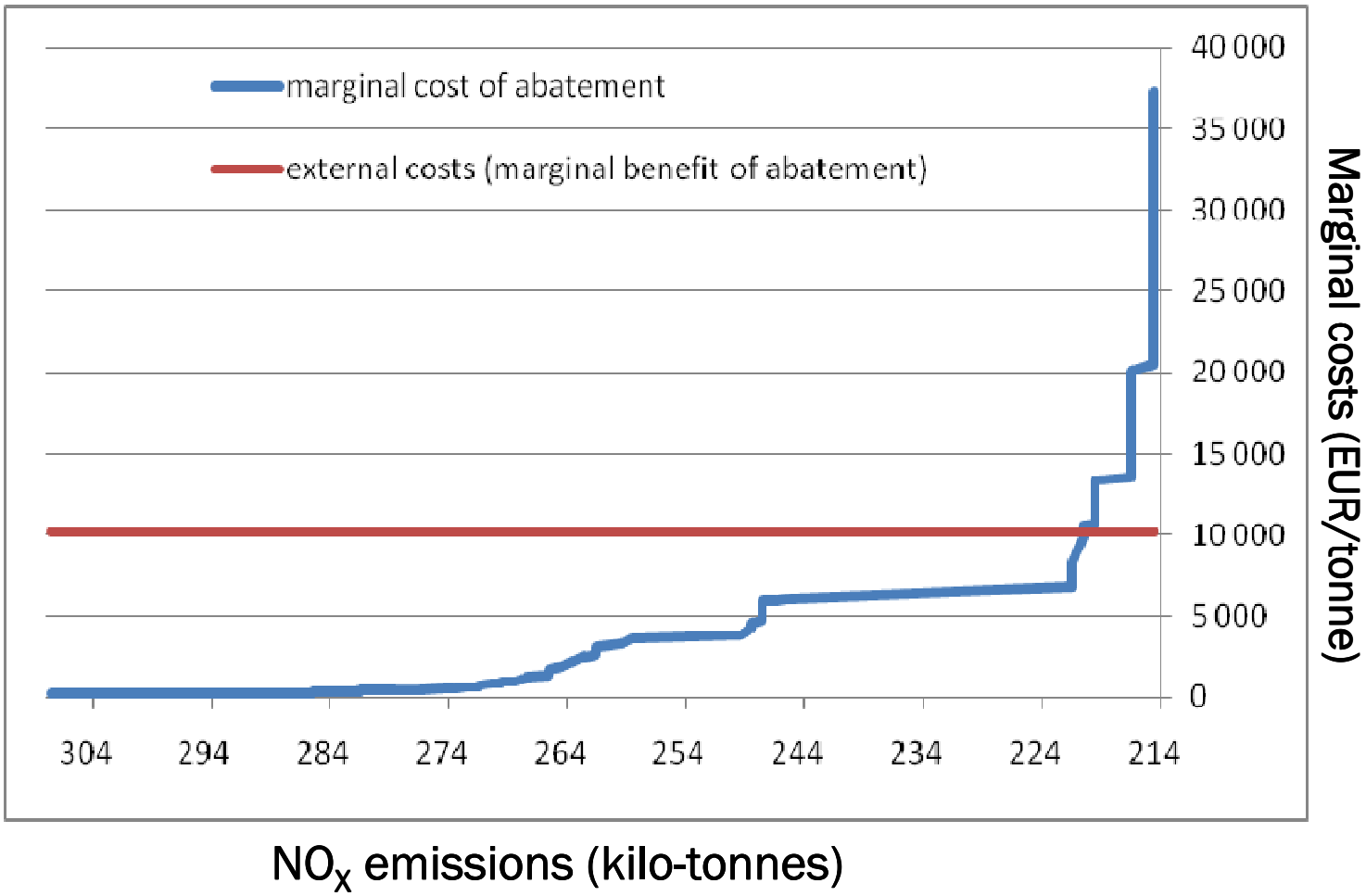


Abatement costs – SO_2

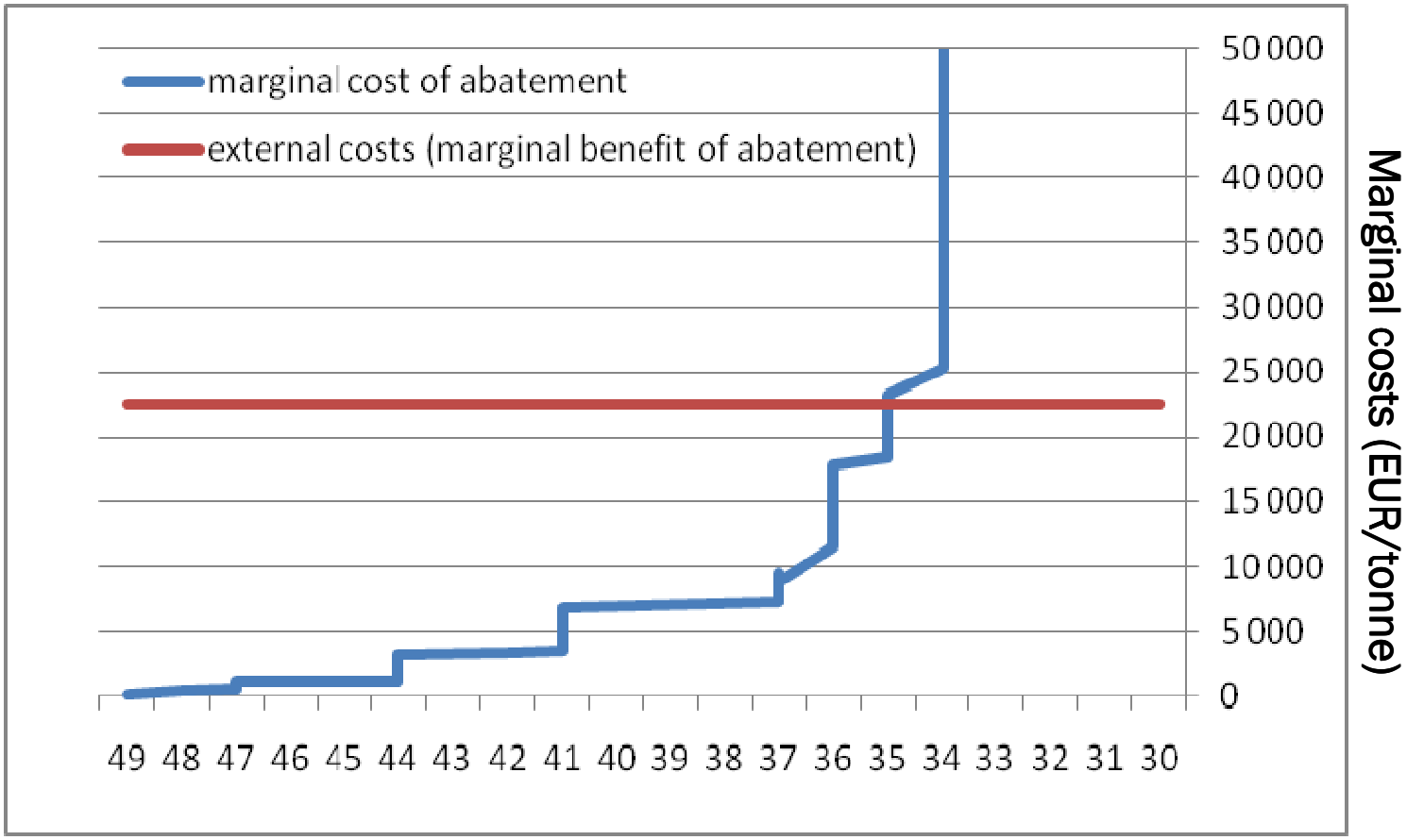
at ~10,000€ /t damage equals to additional increase in abatement costs



Abatement costs – NO_x



Abatement costs – $PM_{2.5}$



Internalisation

- comparison between external costs and environmental taxes and charges (or subsidies) levied upon emissions from electricity generation (or upon electricity consumption)

Internalisation (2)

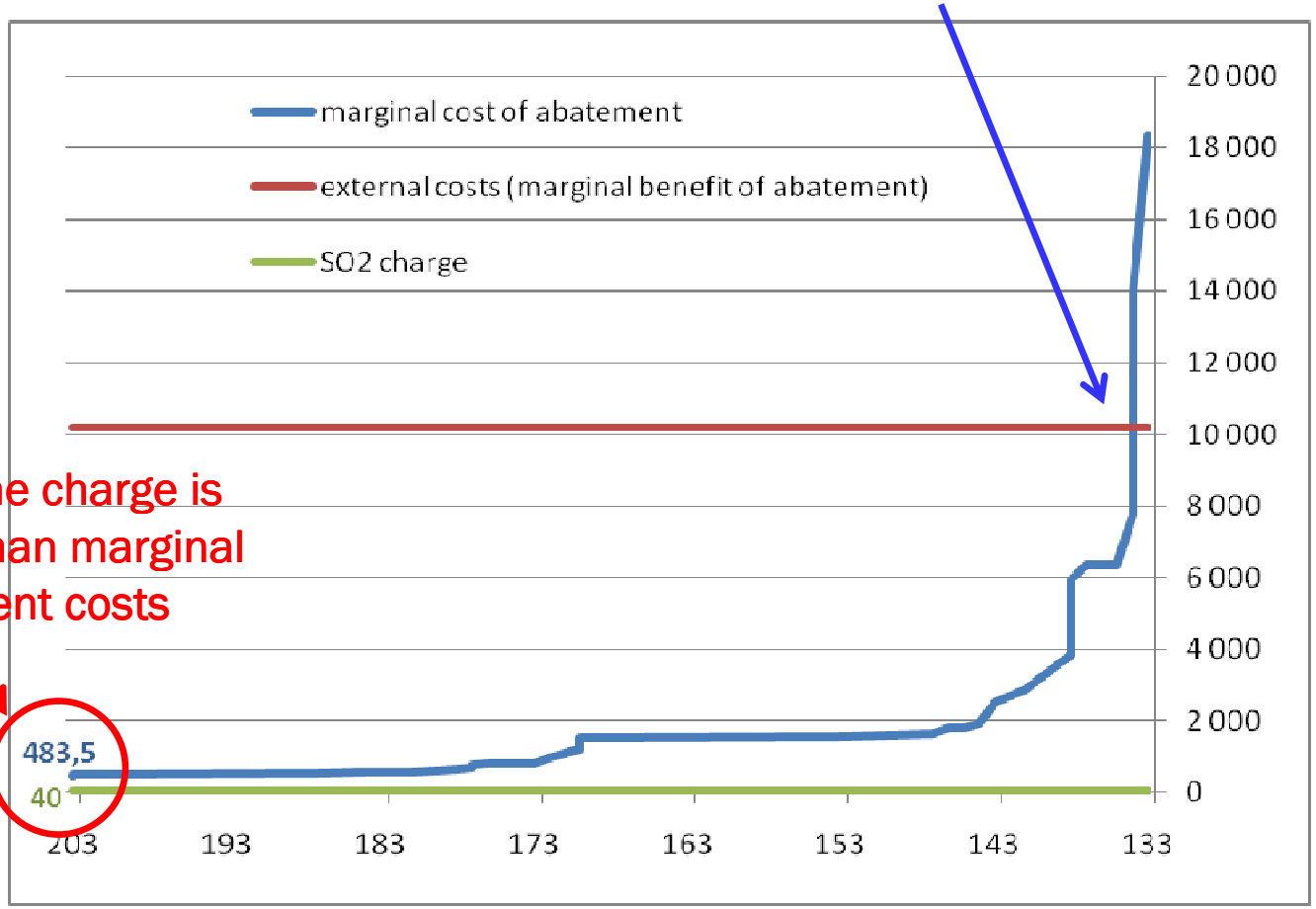
- emission charges set for a number of pollutants emitted to the atmosphere from stationary sources
- reduced rates when abatement technology installation commenced

Air pollution charges

pollutant	CZK/tonne	EUR/tonne
particulates	3 000	120
SO2	1 000	40
NOx	800	32
NMVOC	2 000	80
heavy metals	20 000	801
CO	600	24
NH3	1 000	40
CH4	1 000	40
PAHs	20 000	801

Charge vs. abatement

at ~10,000€ /t damage equals to additional increase in abatement costs



at 40€/t the charge is 10x lower than marginal abatement costs

SO_2 emissions (kilo-tonnes)

Internalisation (3)

energy taxation

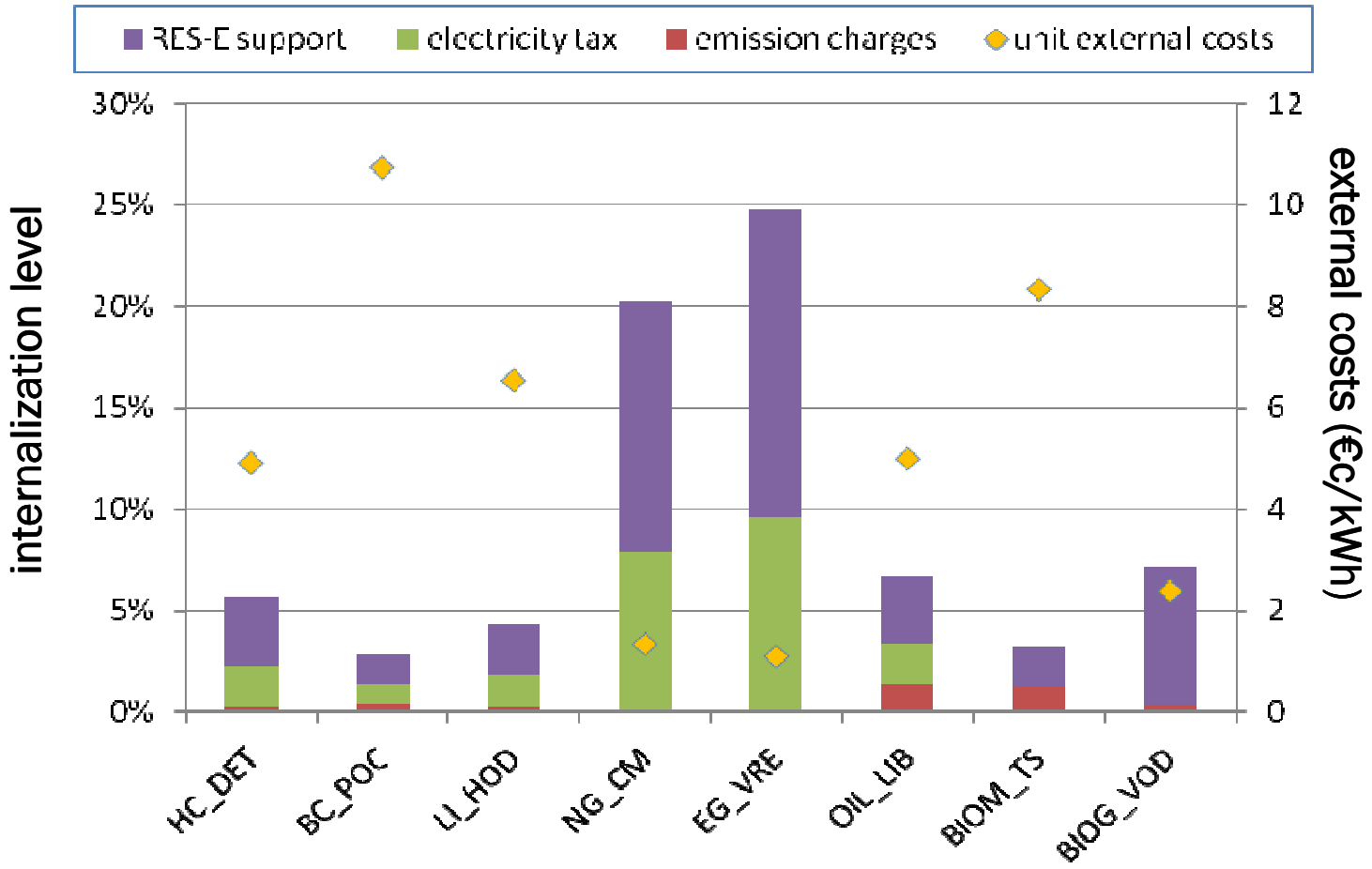
- minimum rates from Energy Taxation Directive
- electricity taxed as output, energy products used for electricity generation are exempted
- exemption for electricity produced from RES
- single rate of 28.3 CZK/MWh (1.028 EUR)

renewable energy promotion

- top-up for promotion of RES & CHP charged by distributors
- 1.63 EUR/MWh

Internalisation (4)

External costs and their internalisation



Internalisation (5)

- ➔ highest internalisation for energo-gas/NG generators but still below 25%
- ➔ relatively low internalisation for RES due to electricity tax exemption
- ➔ combined effect of lower unit external costs and flat rates (i.e. per kWh) of electricity tax and RES-E support charge

Concluding remarks

- level of internalization is generally low
  - current taxes and charges have too low rates → do not reap dynamic efficiency potential
  - no indexing of rates in time
  - lack of political will for increase in tax/charge (mainly due to competitiveness concerns)
- outdated technologies
  - gradual replacement will improve the situation
- fuel-mix composition
  - trade-off between domestic (dirty) resources and security of supply (natural gas)

Thank you for your attention!

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