

Valuation of Environmental Impacts of Acidification and Eutrophication

a NewExt project
Co-funded by the EC DG Research (5th framework)

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DIEM USER WORKSHOP
Prague, 16 February 2004



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Impacts well covered by ExternE

Impact category	airborne pollutants					
	NO _x	SO ₂	PM	NH ₃	VOC	Green-house gasses
Human health	✓ Nitrates (sec PM) ozone	✓ direct, sulphates (sec PM)	✓	✓ nitrates sulphates (sec PM)	✓ via ozone	partial
Crops	✓ via ozone	✓ direct	-	-	✓ via ozone	partial
Materials, buildings	-	✓ direct	<i>included in SO₂ impacts</i>	-	-	partial
Ecosystems	ACID EUTRO	ACID	-	ACID EUTRO	via ozone	-
Amenity	-	-	-	-	-	-



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Framework

NewExt : New Elements for the Assessment of External Costs from Energy Technologies

Goal : *Improve assessment of externalities by providing new methodological elements for integration into the existing EU external cost accounting framework*

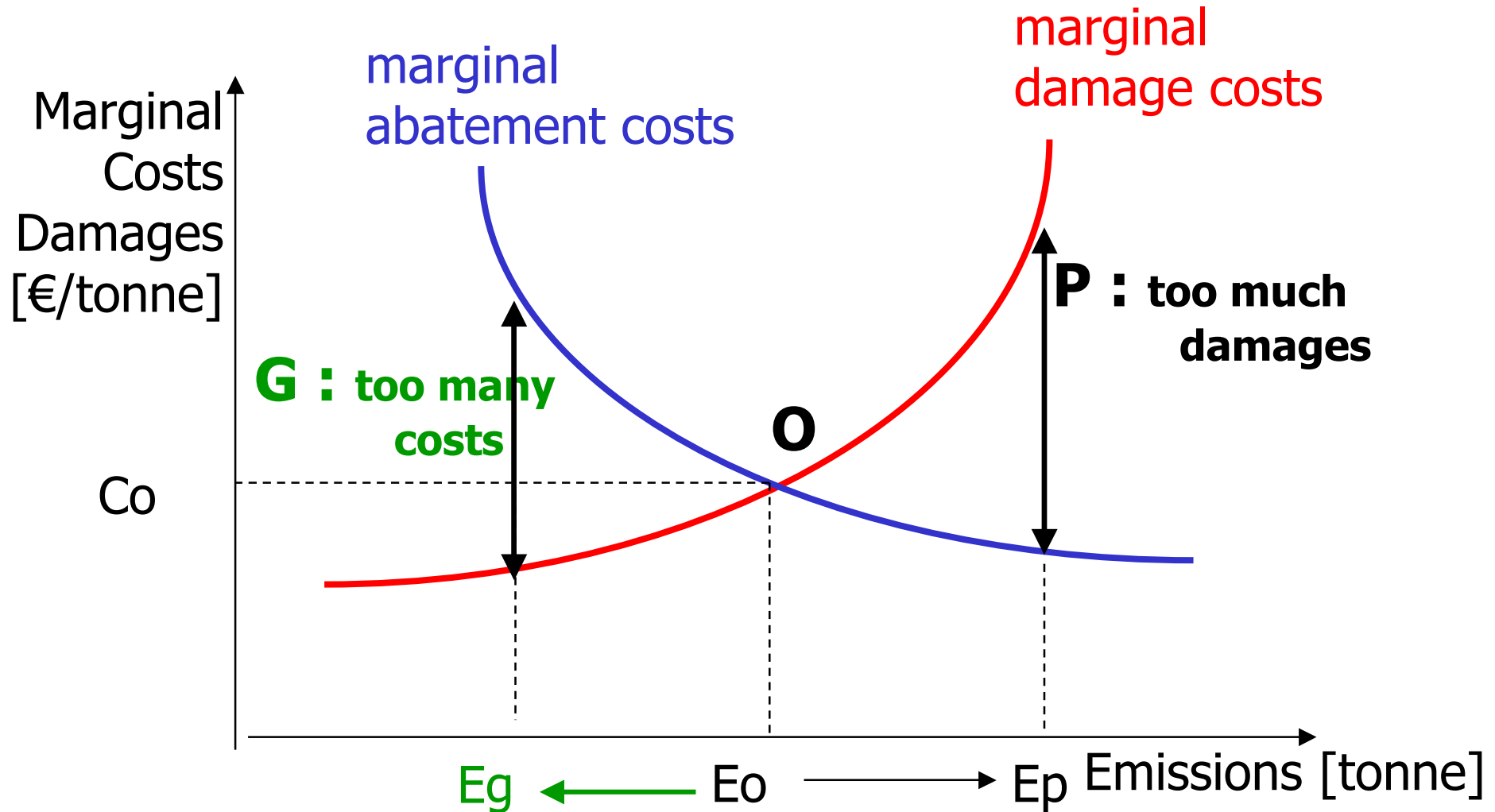
Work package 3 : Valuation of impact on ecosystems by the standard-price approach



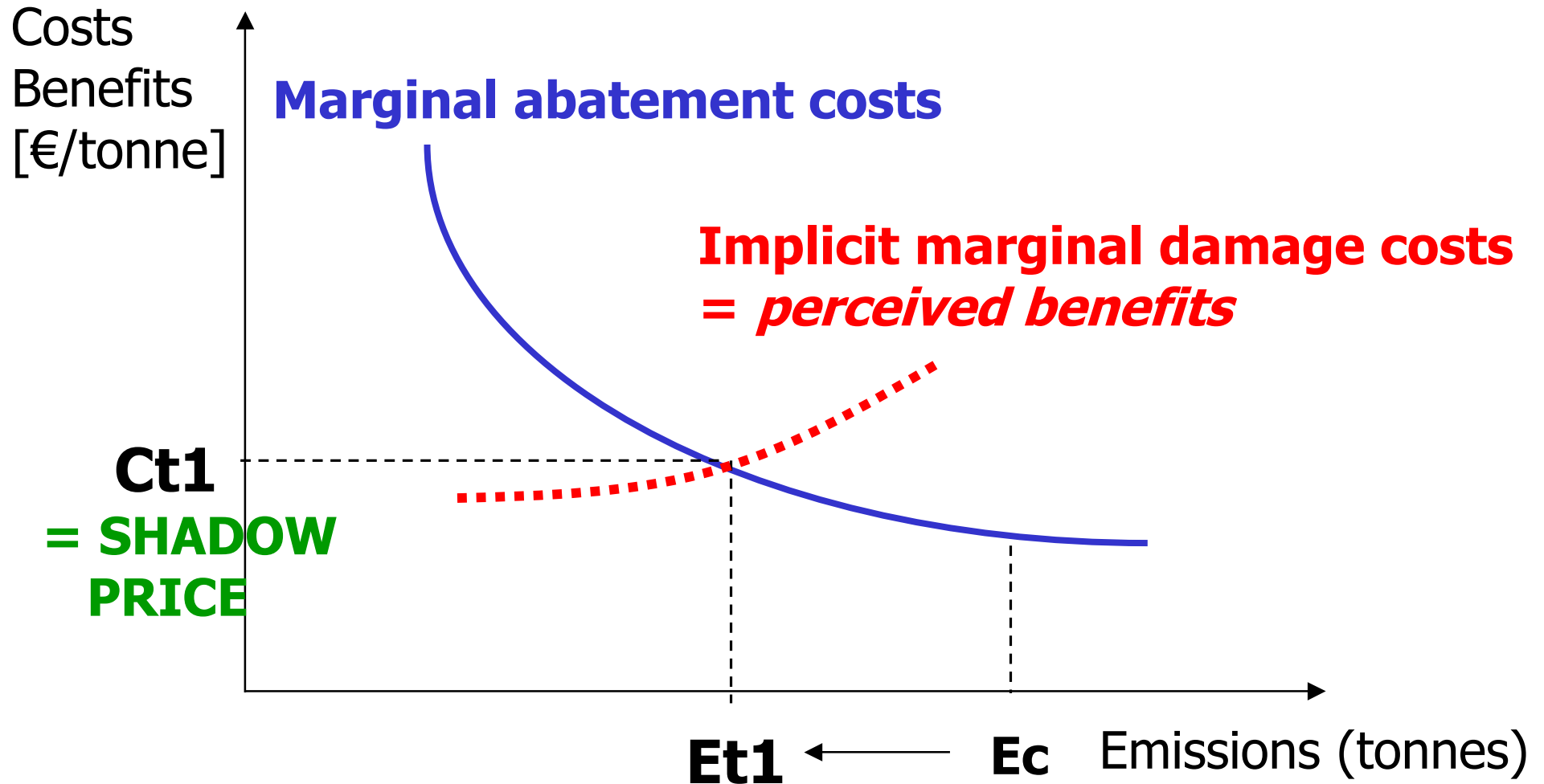
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Theoretical framework



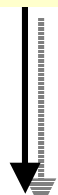
Standard Price approach



OUR APPROACH

Emissions technology / location

STEP 1



Marginal impacts : Exceedance of critical loads (in ha ecosystem protected / ton emission)

STEP 3



Valuation : **SHADOW PRICE of impact on ecosystems** (in €/tonne emission)

STEP 2

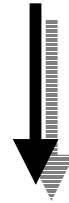
WTP for protection of ecosystems : *determined by the standard-price approach*

(In €/ha protected)



STEP 1 : Determination of physical impacts

EMISSIONS : estimated tonnes of SO₂, NO_x emitted for a certain fuel cycle / energy technology [ktonne] in a certain country



Krewitt et al. (2001)
EMEP

IMPACTS : Marginal impacts of SO₂ and NO_x emissions in a particular country on the total area of ecosystems in the EU15 [ha/tonne].

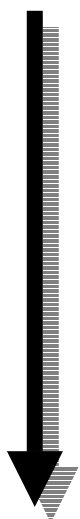


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STEP 2 : DETERMINATION OF WTP by standard-price approach

EMISSION REDUCTION TARGETS for year 2010



- ❖ European BAU scenario for 2010, calculated in the RAINS model by IIASA (**REF**)
- ❖ UN-ECE Gothenburg Protocol of LRTAP convention of 1999 (**PRO**)
- ❖ Proposal and directive 2001/81/EC on National Emission Ceilings of 2001 (**NEC_i** and **NEC_f**)

Willingness To Pay per hectare ecosystem protected [EUR/ha*y]



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UN-ECE Gothenburg Protocol on Long Range Transboundary Air Pollution (1999)

- ❖ *Multi-effect Multi-pollutant* protocol :
 - ❖ Effects of acidification and eutrophication on ecosystems (SO_2 , NO_x , and NH_3 emissions)
 - ❖ Effects of ground-level Ozone on ecosystems and human health (NO_x and VOC emissions)
 - ❖ Thus : **not only represents targets for improvement of ecosystem health!**



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UN-ECE Gothenburg Protocol (PRO) *cont.*

- ❖ Mentions additional benefits : effects of SO₂ on materials, effects of SO₂ and NO_x on human health by secondary particles (aerosols)
- ❖ Goal : 50 % less unprotected ecosystems against acidification and eutrophication all over Europe
- ❖ Compromise EU15 countries, other European countries, USA, Canada



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European NEC directive 2001/81/EC (2001)

Initial NEC proposal (NEC_i) by EC in 1999:

- ❖ Also *multi-effect multi-pollutant* policy target
- ❖ Based on scientific research to meet LT goals in 2020 (no exceedance CL = all ecosystems protected)
- ❖ In favor of NGOs and European Parliament's env. Committee
- ❖ NEC_i was found to be too ambitious, rejected by Member States



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EU NEC directive *cont.*

Agreed NEC directive (NEC_f) (2001):

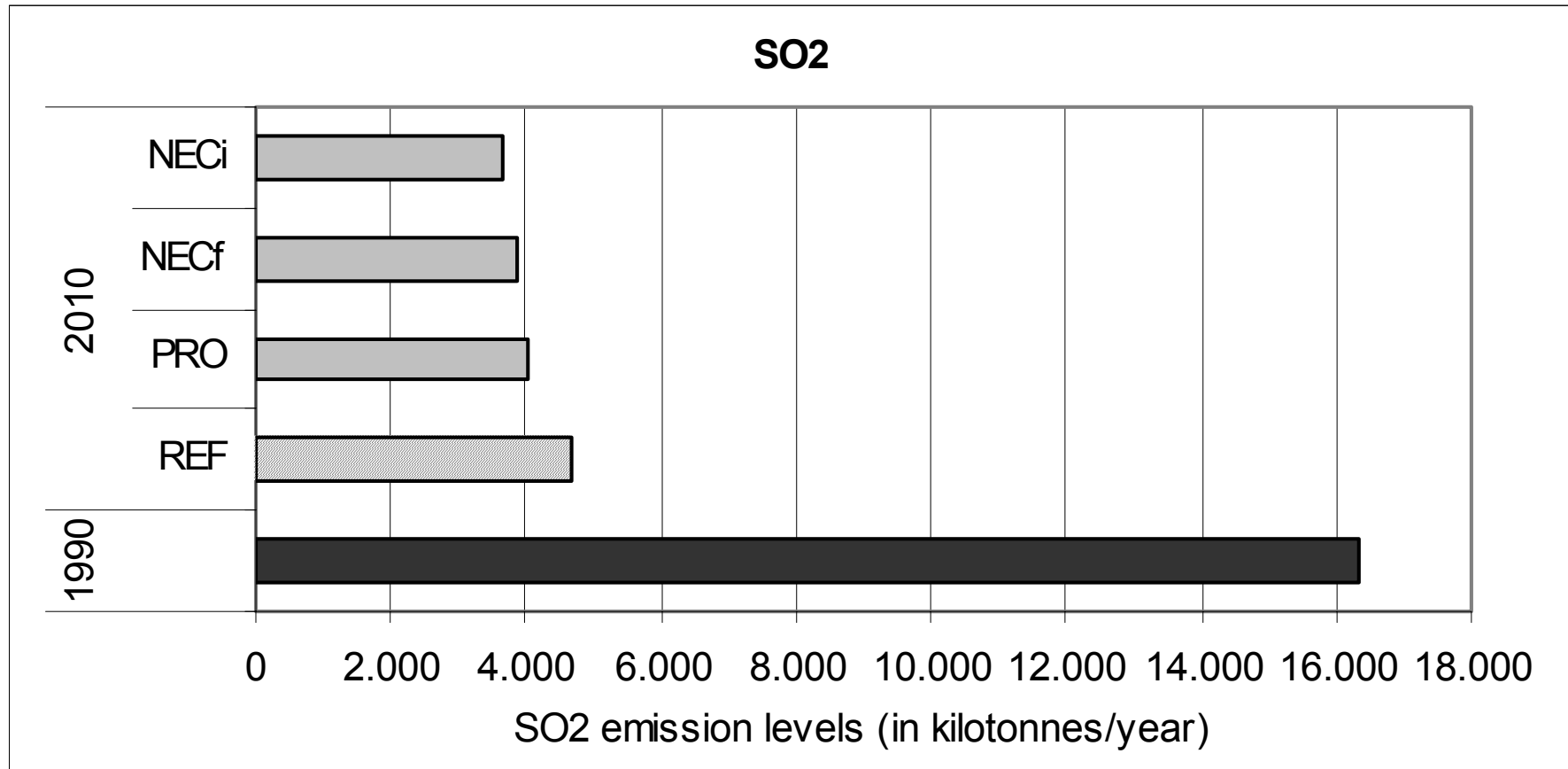
- ❖ NEC_f just slightly more ambitious than PRO
- ❖ Also mentions additional health effects by the abatement of secondary particles but less explicit as PRO



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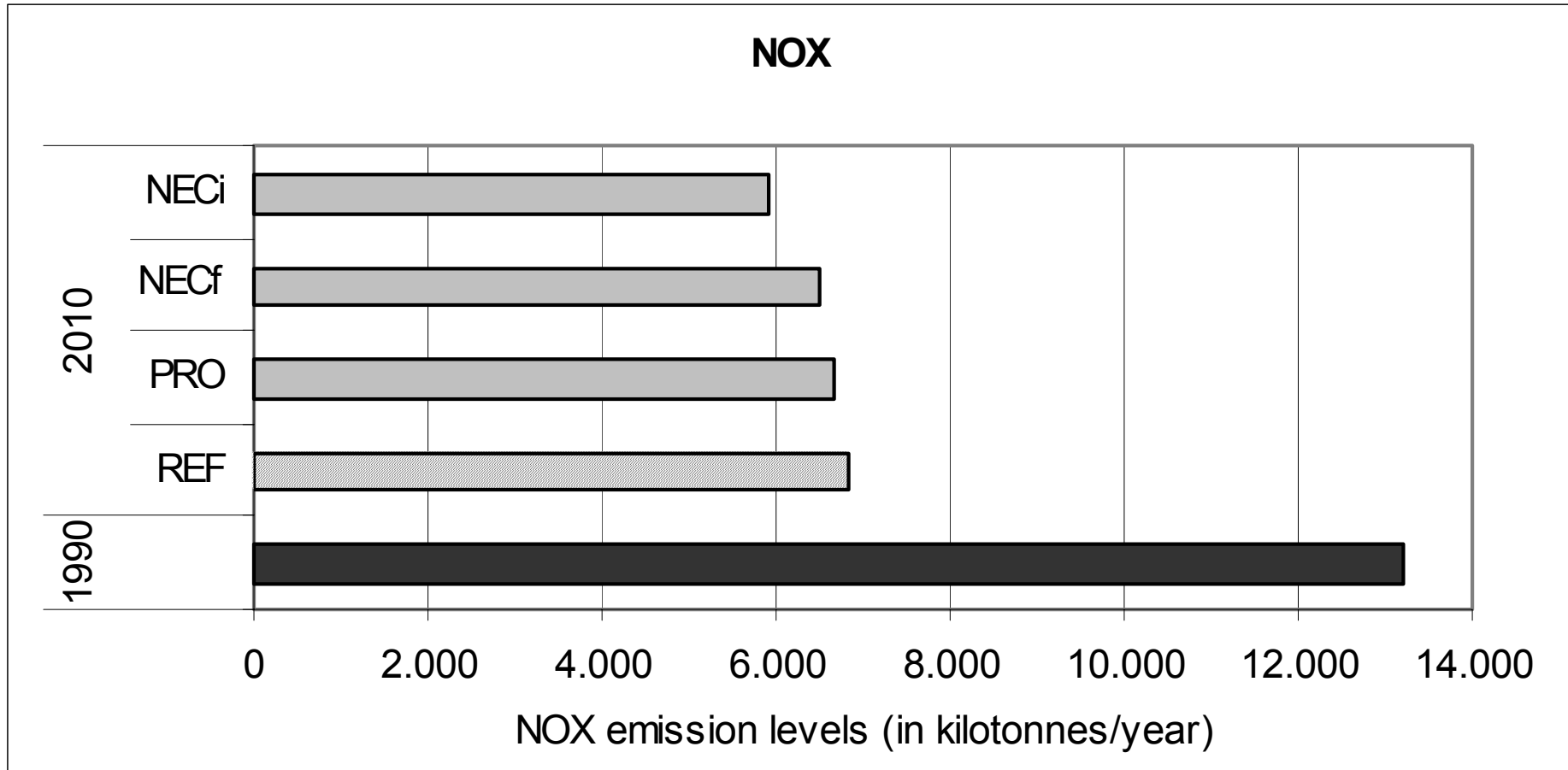
SO₂ : ca. 71-78% reduction 1990-2010



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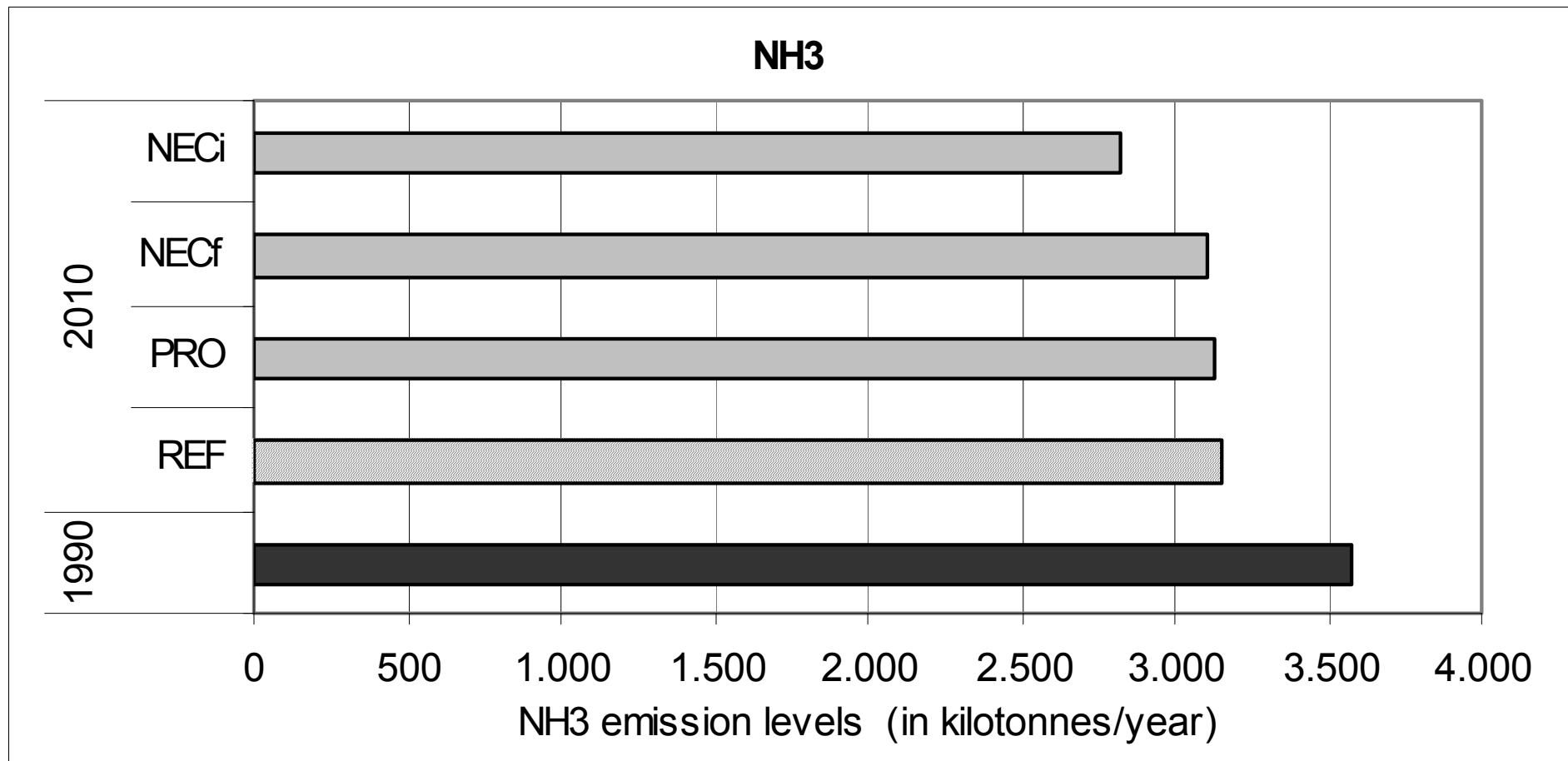
NO_x : ca. 48-55% reduction 1990-2010



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NH_3 : ca. 12 – 21% reduction 1990-2010



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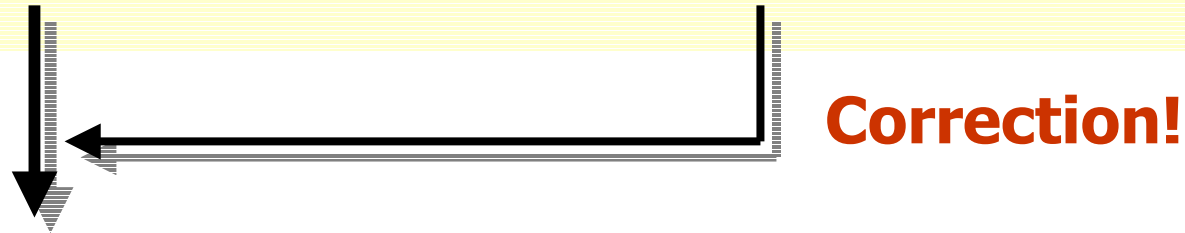
POLICY TARGETS : PRO, NEC_i , NEC_f (compared to REF)

COSTS

Abatement cost of sum of $SO_2 + NO_x + NH_3$ emissions for the whole of EU15 [€/year]

BENEFITS

Quantified benefits for O_3 , health, agriculture and building materials [€/year]



WILLINGNESS TO PAY FOR ACIDIFICATION AND EUTROPHICATION

Abatement costs to protect ecosystems against acidification and eutrophication. Range of WTP determined by targets determined by REF, PRO and NEC [€/year].



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Correction :

Use of weight factors (0 or 1)

$$\begin{aligned}
 & \text{WTP}_{\text{ACID+EUTRO}} \\
 & = \\
 & \text{pTC} - \omega * \text{TB}_{\text{O}_3} \\
 & - \chi * \alpha * \text{TB}[\text{HH}]_{\text{secPM}} \\
 & - (\chi * \gamma * \text{TB}[\text{A}]_{\text{ACID}} + \psi * \theta * \text{TB}[\text{A}]_{\text{EUTRO}}) \\
 & - \chi * \delta * \text{TB}[\text{BM}]_{\text{ACID}}
 \end{aligned}$$

Perceived Abatement Costs

Total benefits ozone
(effects on health, agriculture, buildings)

Total benefits

- * Human Health (secondary PM)
- * Agricultural yields (acid&eutro)
- * Building Materials (acid)



ASSUMPTION :

pTC = TC : policy makers knew estimated total abatement costs from the technico-economic models (RAINS) during the negotiations + were believed as correct

WTP_{ACID+EUTRO}

=

$$\begin{aligned} & \text{pTC} - \omega * \text{TB}_{\text{O}_3} \\ & - \chi * \alpha * \text{TB}[\text{HH}]_{\text{secPM}} \\ & - (\chi * \gamma * \text{TB}[\text{A}]_{\text{ACID}} + \psi * \theta * \text{TB}[\text{A}]_{\text{EUTRO}}) \\ & - \chi * \delta * \text{TB}[\text{BM}]_{\text{ACID}} \end{aligned}$$



ASSUMPTION :

χ , ψ and $\omega = 1$: acidification, eutrophication and ground-level ozone perceived as equally important topics during negotiations

WTP_{ACID+EUTRO}

=

TC - ω *TB₀₃

- χ * α *TB[HH]_{secPM}

- (χ * γ *TB[A]_{ACID} + ψ * θ *TB[A]_{EUTRO})

- χ * δ *TB[BM]_{ACID}



ASSUMPTION:

$\alpha = 0$: human health by sec PM (SO_2 , NO_x) not deterministic role during the negotiations ;

γ , θ and $\delta = 1$: agriculture, building materials played an equal and deterministic role in the negotiations

WTP_{ACID+EUTRO}

=

TC - TB₀₃

- $1 * \alpha * \text{TB}[\text{HH}]_{\text{secPM}}$

- $(1 * \gamma * \text{TB}[\text{A}]_{\text{ACID}} + 1 * \theta * \text{TB}[\text{A}]_{\text{EUTRO}})$

- $1 * \delta * \text{TB}[\text{BM}]_{\text{ACID}}$

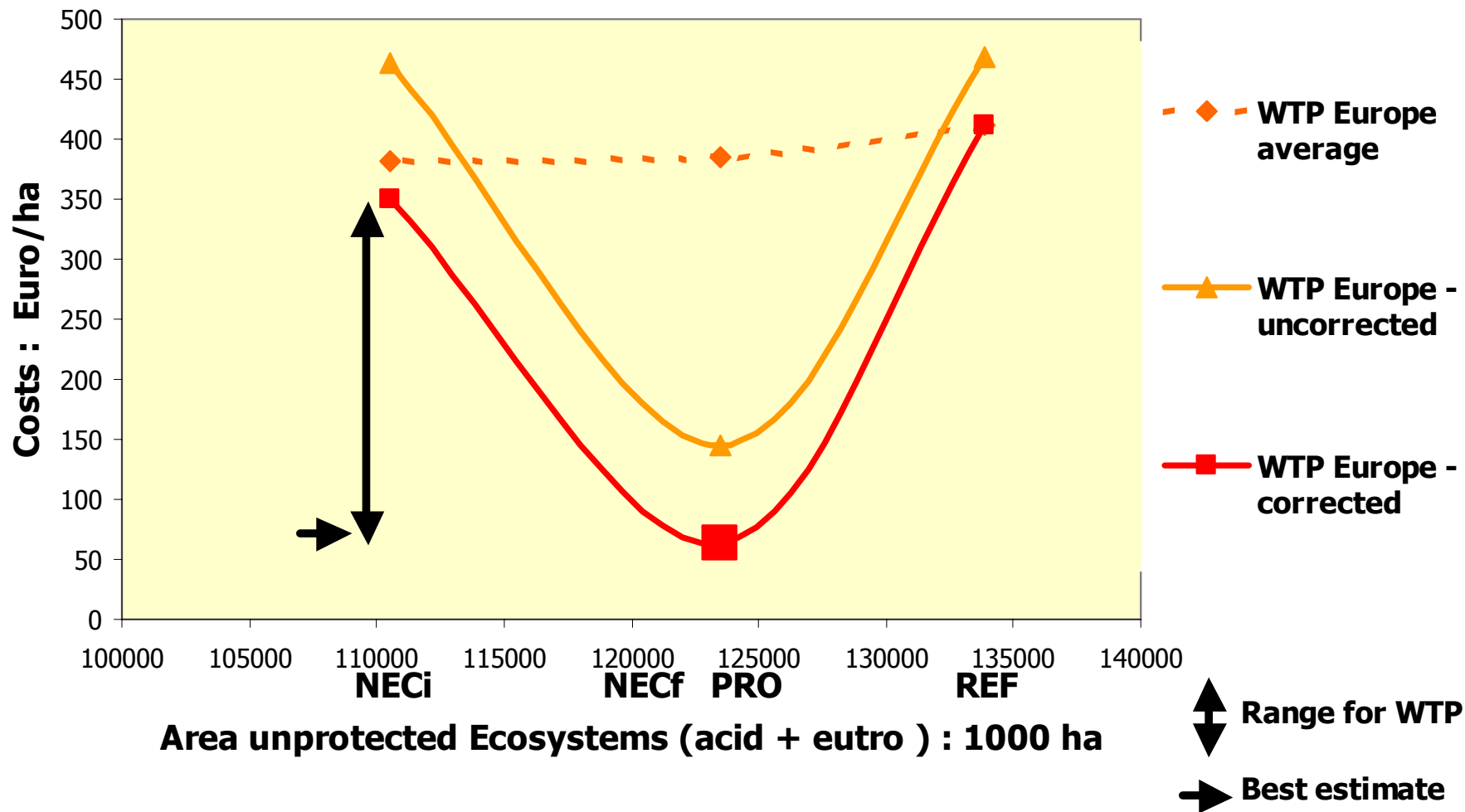


Formula Willingness-to-pay taking into account assumptions (first analysis)

$$\begin{aligned} & \mathbf{WTP}_{\text{ACID+EUTRO}} \\ & = \\ & \mathbf{TC - TB_{O_3}} \\ & \mathbf{- (TB[A]_{\text{ACID}} + TB[A]_{\text{EUTRO}})} \\ & \mathbf{- TB[BM]_{\text{ACID}}} \end{aligned}$$



Ref, PRO, NECf & NECi : "marginal" and average costs per ha protected



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CONCLUSION **STEP 2** : Willingness-To-Pay

- ❖ Range WTP/hectare :
 - ❖ NEC_f and PRO down limit, good proxy for WTP, NEC_i upper limit for WTP
 - ❖ **100 to 350 €/ha*year** (for ecosystems protected all over Europe)

- ❖ Within this range, best estimate around **100 €/ha**, to be applied to total area of ecosystems protected all over Europe.



STEP 3 : *an example of application*

Emissions technology / location

STEP 1

Marginal impacts : Krewitt *et al.* (2001)

STEP 3

Valuation : **SHADOW PRICE**
of impact of acidification and
eutrophication on ecosystems per
tonne SO₂ and NO_x emitted
[EUR/tonne*year]

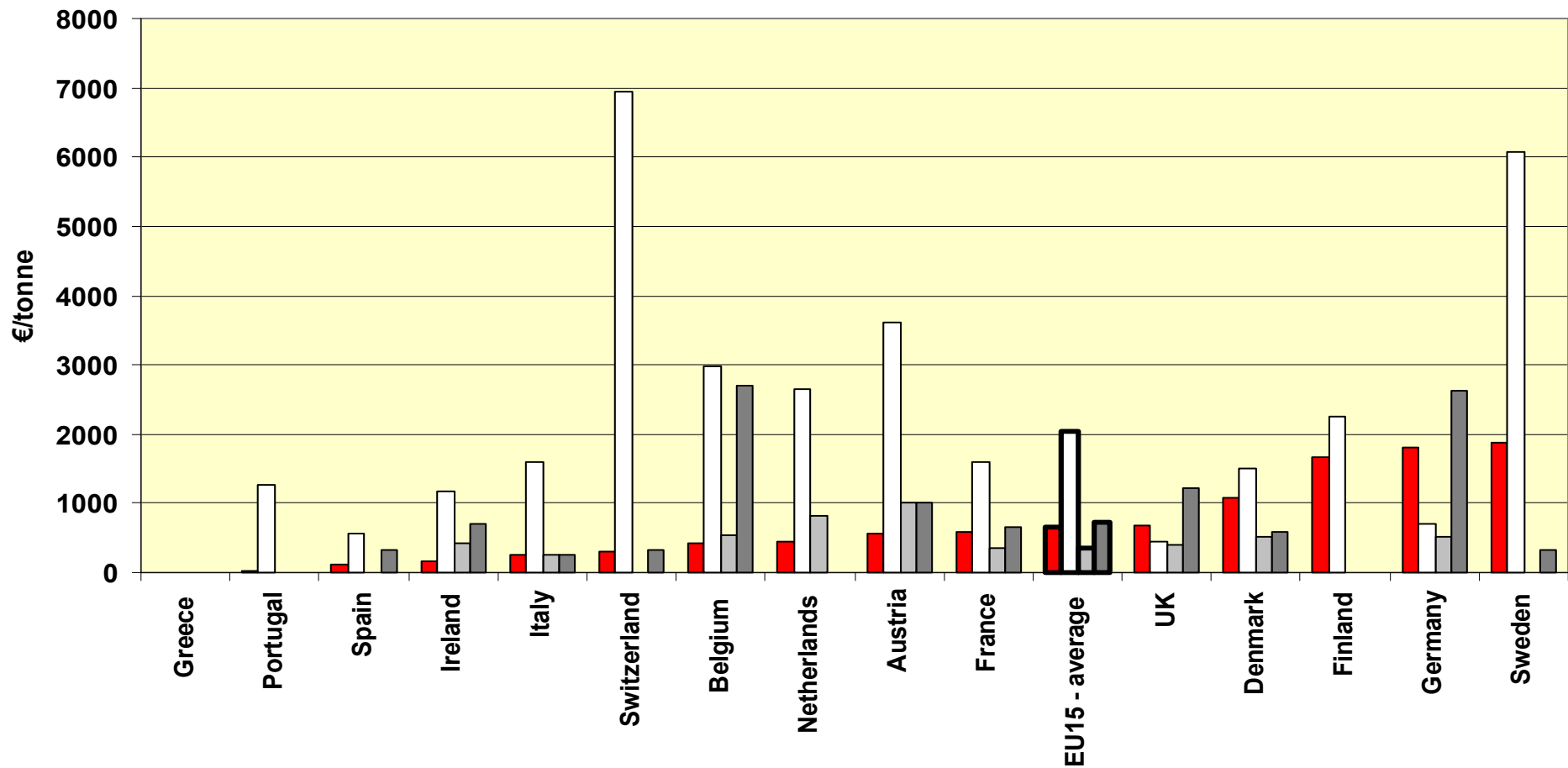
STEP 2

WTP for protection
of ecosystems -
EU15 and Europe
perspective : 100€/ha
[€/ha protected]



Shadow prices 2010 vs abatement costs for SO2

- SHADOW PRICE (WTP: 350€/ha)
- Abatement cost (REF-1990)
- ▒ Abatement cost (PRO-REF)
- Abatement cost (NECi-PRO)

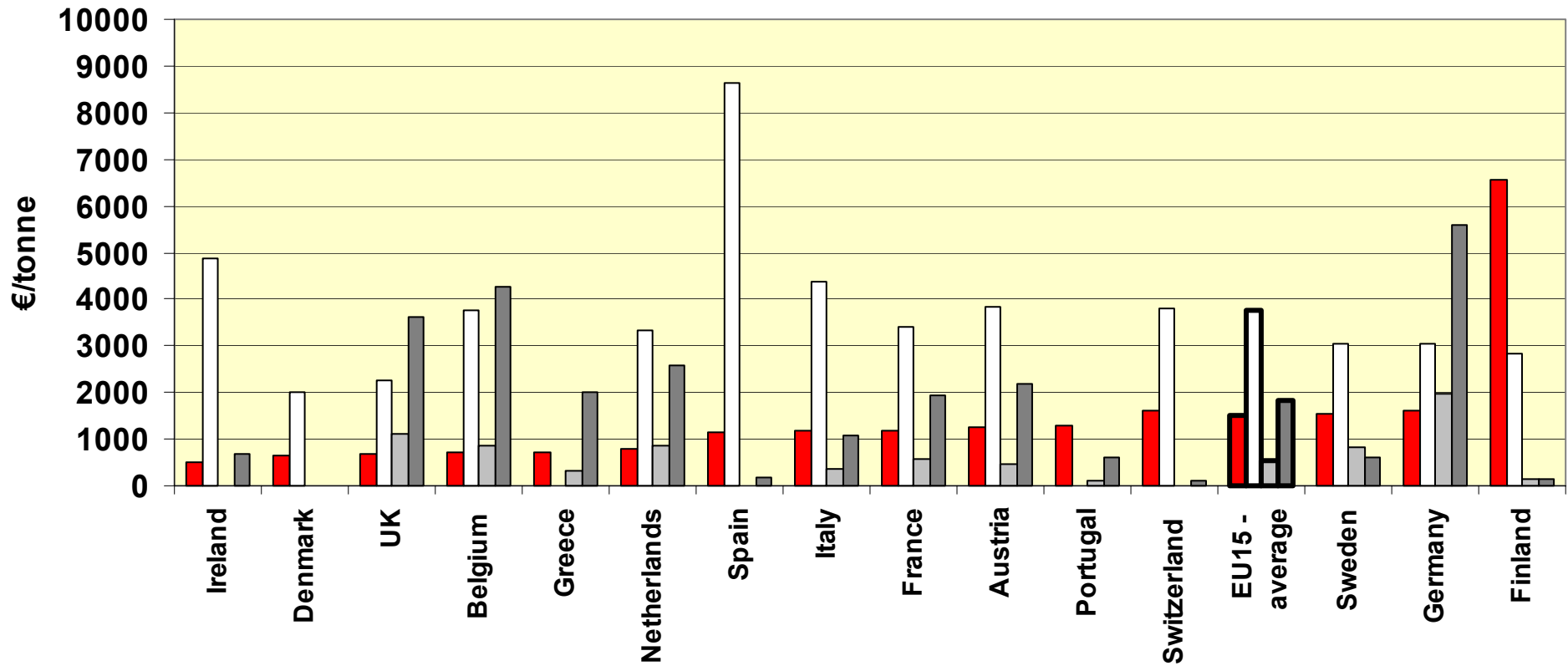


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Shadow prices 2010 vs abatement costs for NOX

- SHADOW PRICE (WTP: 350€/ha)
- Abatement cost (REF-1990)
- ▒ Abatement cost (PRO-REF)
- Abatement cost (NECi-PRO)



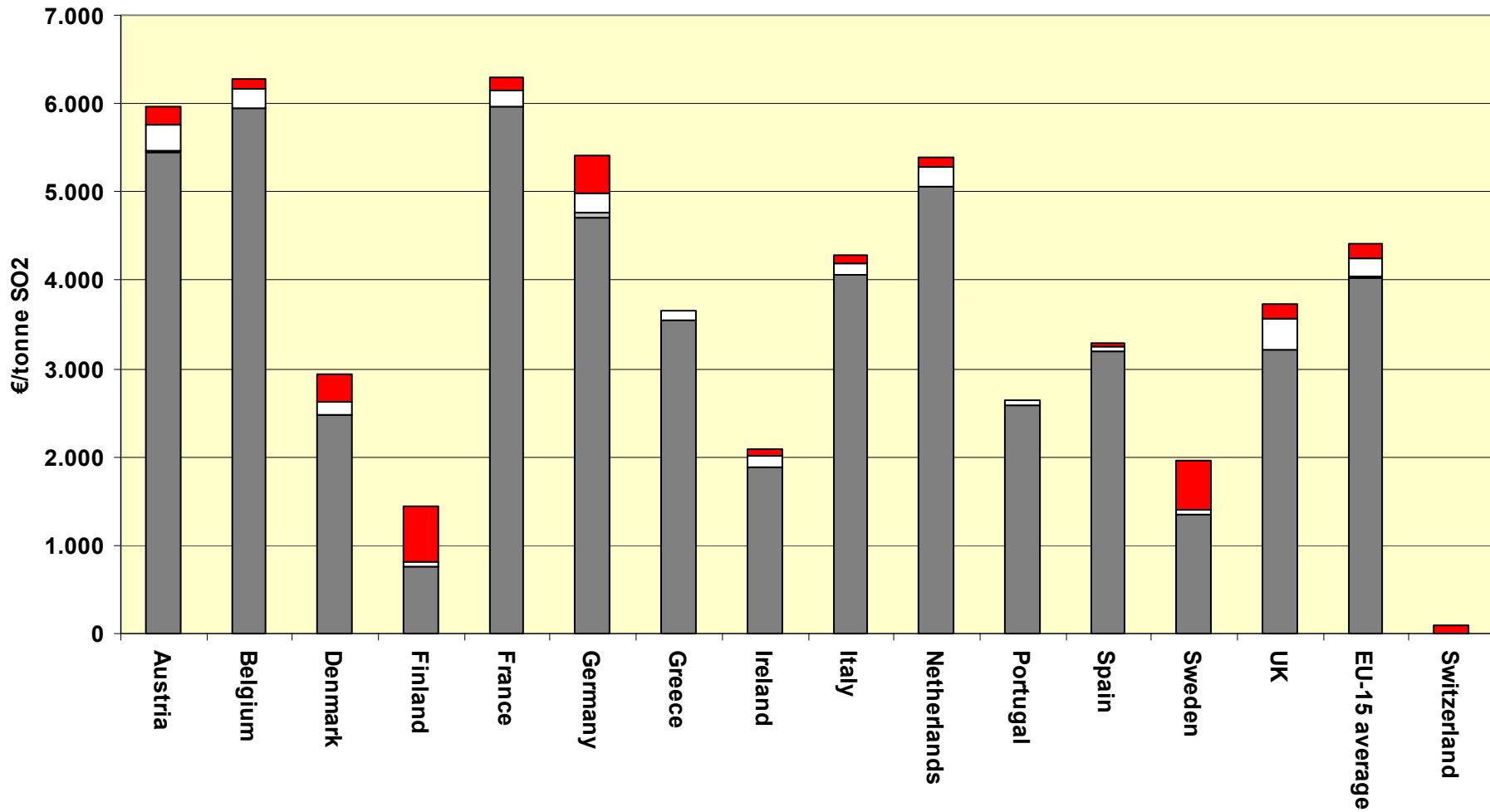
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Vlaamse
Instelling voor
Technologisch
Onderzoek

Shadow prices SO₂ (2000) for impacts on ecosystems vs. ExternE estimates for external costs for other impact categories

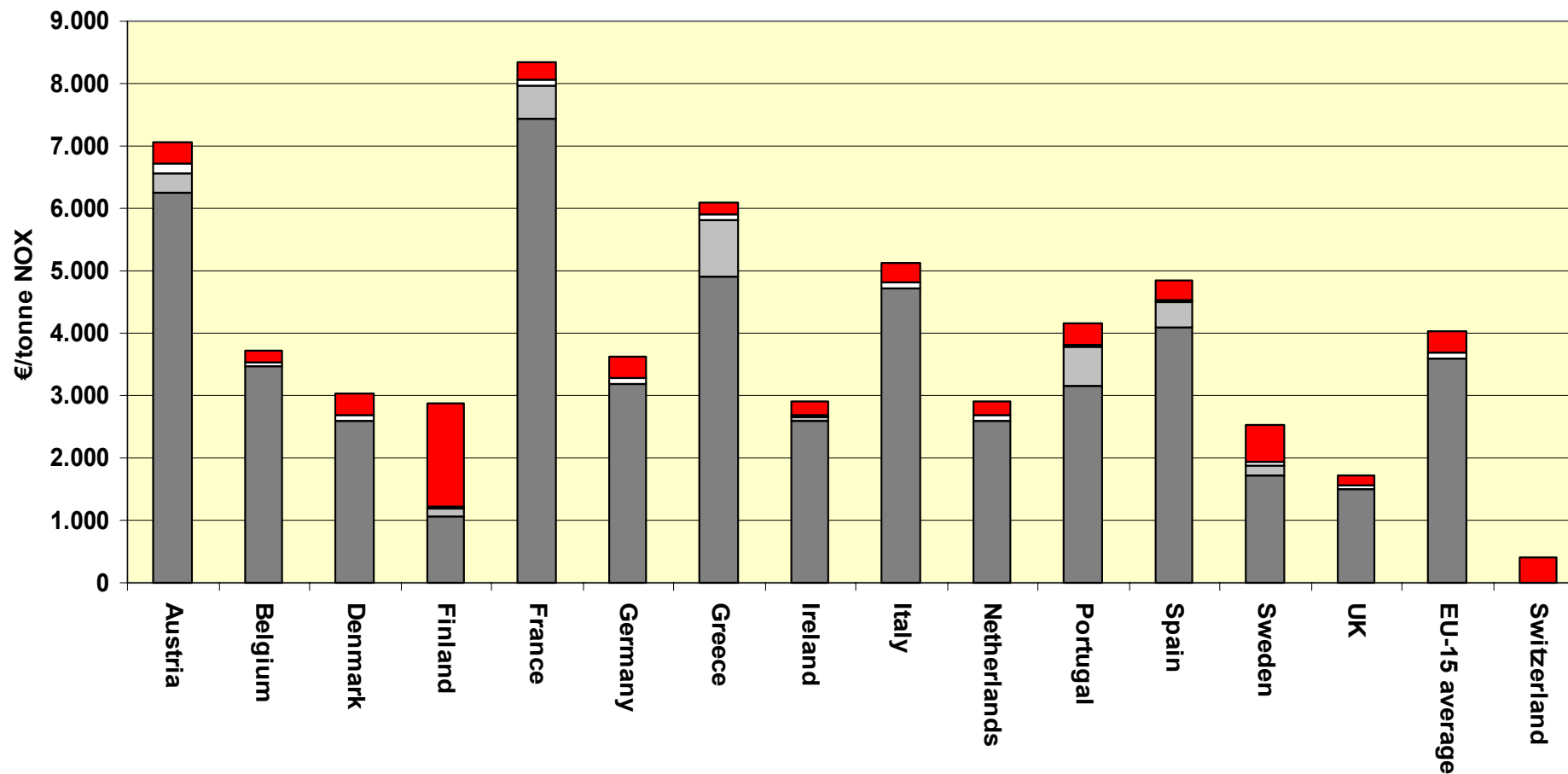
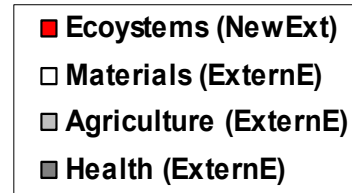
- Ecosystems (NewExt)
- Materials (ExternE)
- Agriculture (ExternE)
- Health (ExternE)



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Shadow prices NOX (2000) for impacts on ecosystems vs. ExternE estimates for external costs for other impact categories



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Conclusion **Step 3**

- ❖ **EU15 average** : shadow price for impacts on ecosystems result in relatively small increase in external costs for other impact categories (+4% SO₂, +10% NO_x)

- ❖ **Exceptions** : Finland and Sweden



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i REMARK !

- ❖ 'Second-best' method
- ❖ Valuation step different from ExternE
- ❖ Cannot be used for cost-benefit analysis or policy advices related to these emission reduction policies

- ❖ Useful data for comparison of energy technology and fuels : 'shadow prices' for a non-market scarcity



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