

NOx Abatement, REP Experience in Sweden

Gbg April 2011

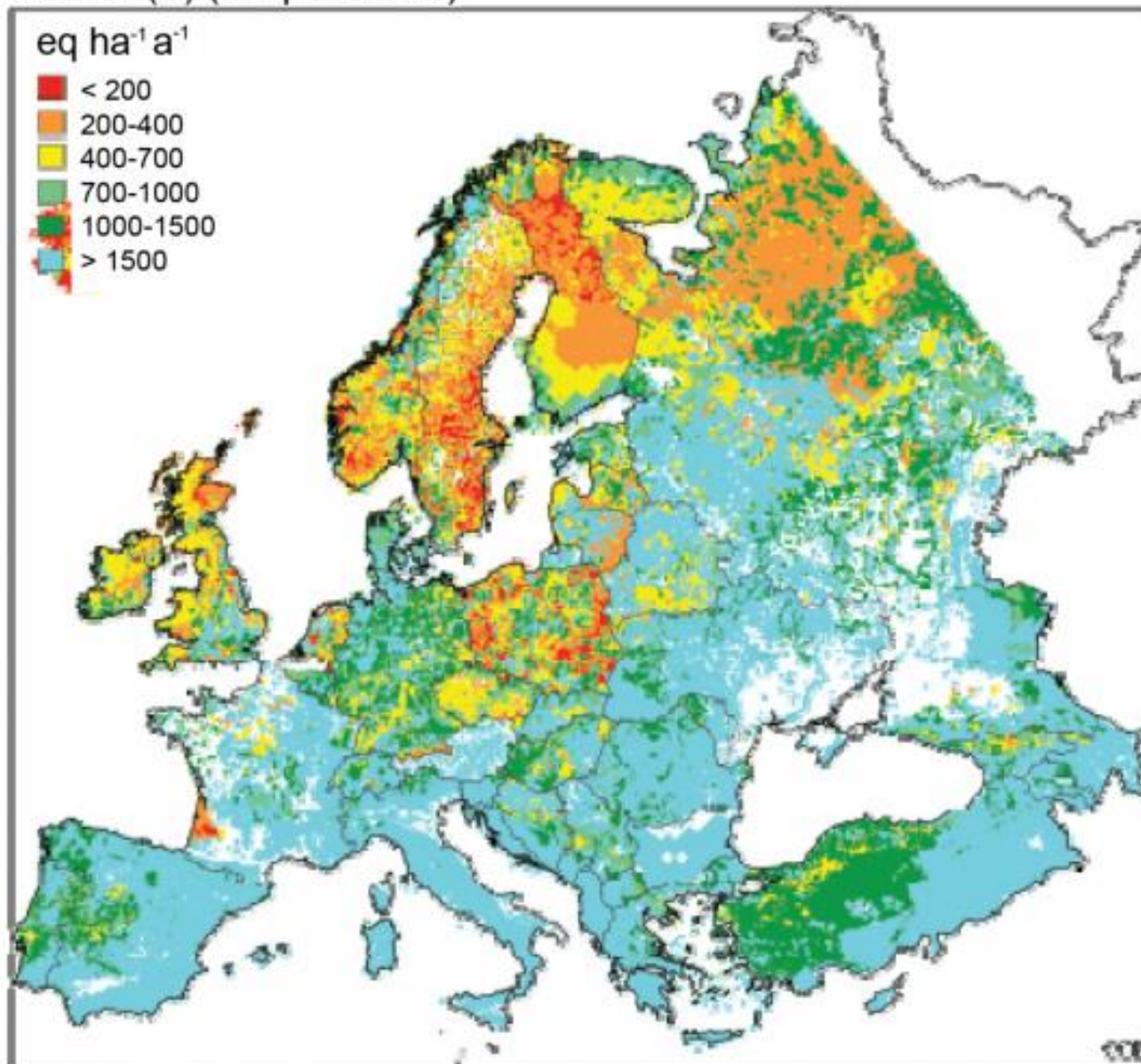
Thomas Sterner

Swedish Acid Policy

- Sweden (+Norway...) most affected
- Sensitivity of ecosystems extreme ← low buffering cap. of granite
- Highest Sulfur taxes in the World
- Sulfur is $>€3/\text{kg S}$
- (This is $€1.5 / \text{kg SO}_2$)
- France: $€ 0.3$
- US Permits $€ 0.1$

Sensitivity of ecosystems to pH

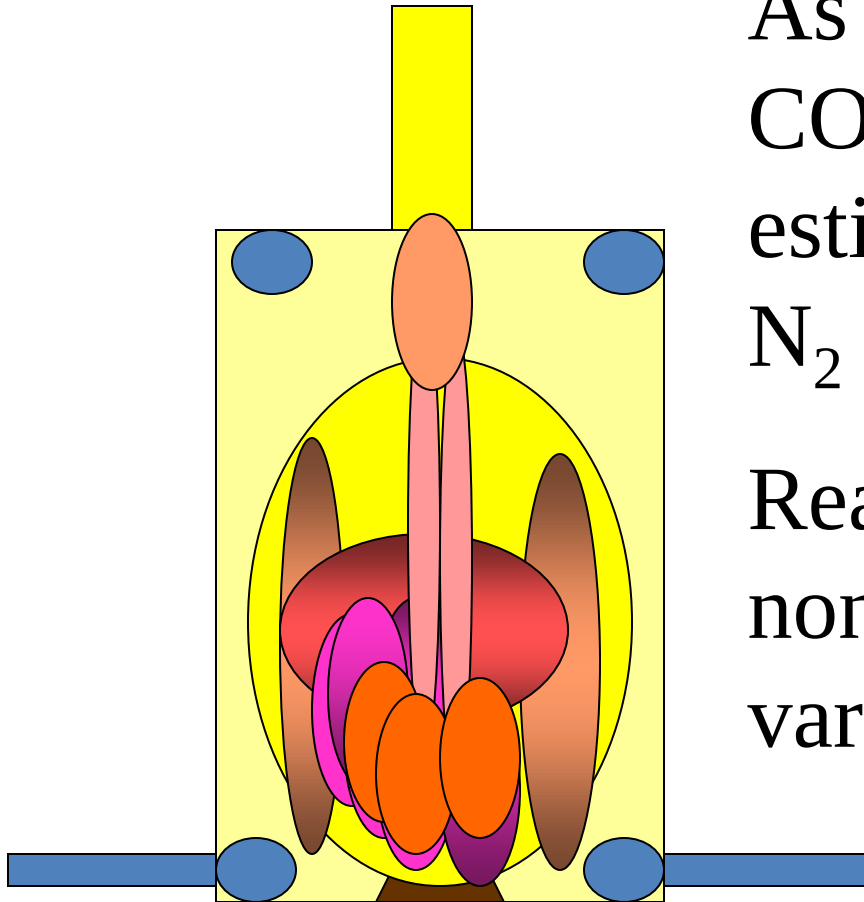
CLmax (S) (5th percentile)



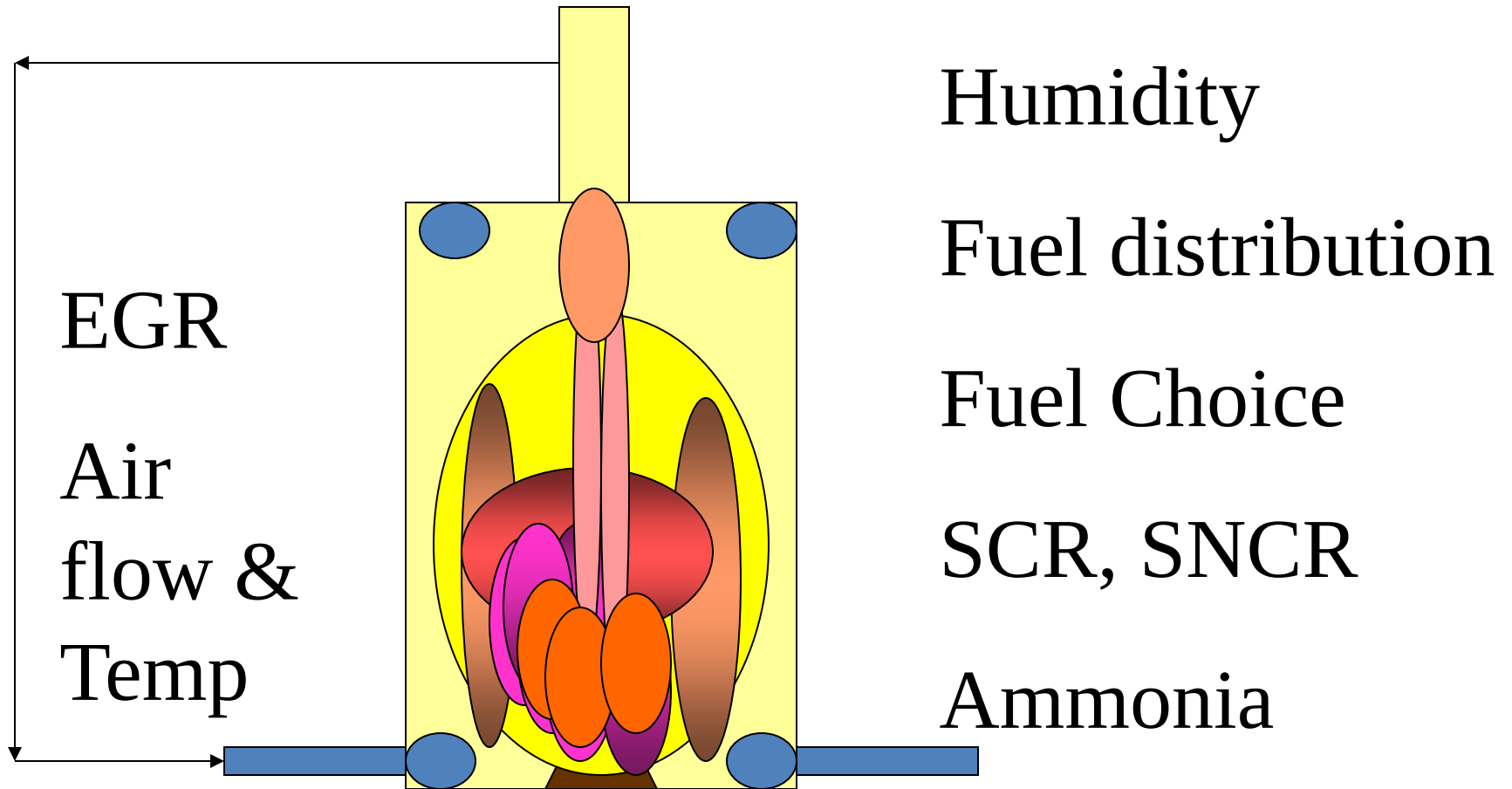
Technicalities of NO_x

As distinct from SO_x
CO₂, NO_x not easy to
estimate. Formed by
N₂ and O₂ in air.

Reaction very
nonlinear in T which
varies in furnace.

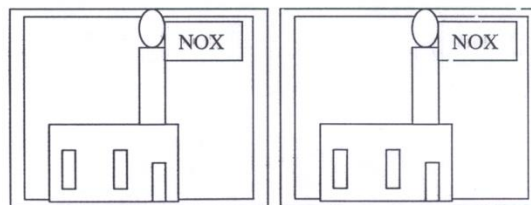
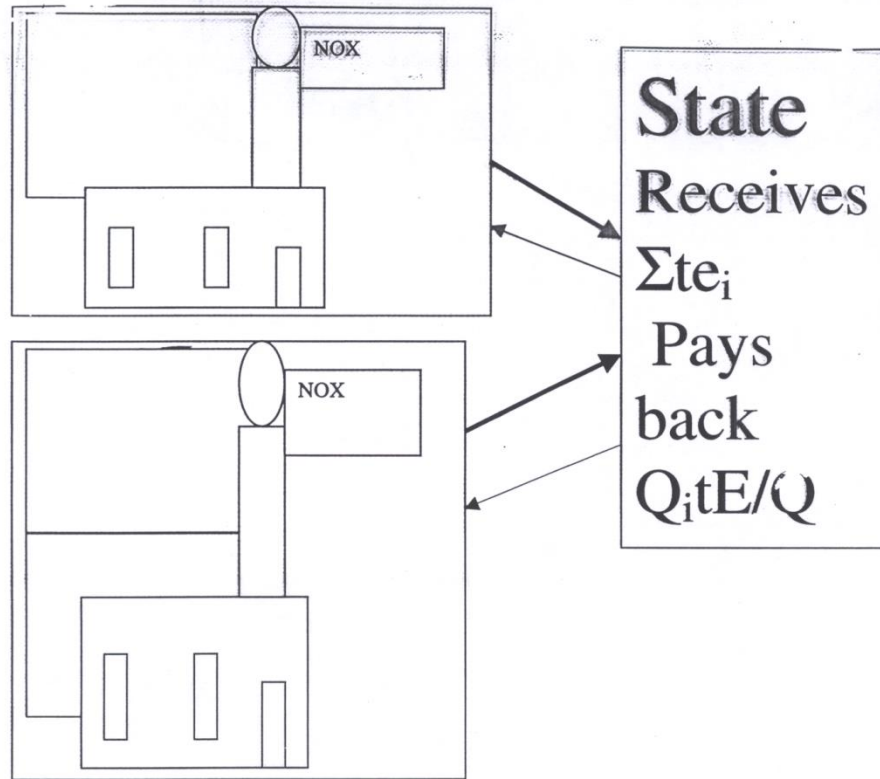


Abatement of Nox



The role of measurement

- many case studies
- Engineers “try” measures
- Could not calculate effect.
- Finetuning crucial
- Measurement necessary for plant engineers



Small companies too small to warrant monitoring, measurement and other costs.

Administration REP: 0,5%

	Verksamhet	Produktionsenhet	NOX	MWh	FEE	REFUND	Net Fee		Panntyp
7	Kraft- och	Panna 3	123421	593335	4936840	5532128	-595288		Brännare
7	Kraft- och	Panna 4	411219	2338216	16448760	21801023	-5352263		Brännare
8	Massa- oc	Barkpanna	103440	274082	4137600	2555482	1582118		Roster
9	Massa- oc	SMW	129394	466200	5175760	4346749	829011		Brännare
10	Kemiindus	Heater 3	21227	54668	849080	509713	339367		Brännare
10	Kemiindus	Ångpanna	24292	74090	971680	690799	280881		Brännare
11	Kemiindus	Panna 3	37976	204991	1519040	1911292	-392252		Brännare
12	Kraft- och	HVP 2844	29251	129964	1170040	1211756	-41716		Roster
12	Kraft- och	HVP 3344	19476	110656	779040	1031733	-252693		CFB
13	Avfallsförbr	P1	38494	60373	1539760	562905	976855		CFB
13	Avfallsförbr	P2	31262	51737	1250480	482385	768095		
14	Avfallsförbr	P6	41387	82562	1655480	769790	885690		Rörlig roste
19	Kraft- och	HVCB2	33628	155008	1345120	1445261	-100141		Brännare
32	Avfallsförbr	P1	78790	241099	3151600	2247955	903645		Rörlig roste
32	Avfallsförbr	P4	59554	416740	2382160	3885594	-1503434		Rörlig roste
			SUMS	5253721	47312440	48984565	0		
				Refund:	9,005511				
				SEK/MWh					

REP

- Each company pays 5 €/kg
- Money refunded to same industries
- ***Don't get back what you paid!***
- Refund= output share in total fees
- Much like a tax: Lets explore differences
- Tax has 4 effects: Techn./ Price/ Budgetary
- (and tax interaction)

Economics of REPs (comp. Tax)

$$Pq_i - c_i(q_i, a_i) - Te_i(q_i, a_i) + \sigma_i T[\Sigma_i e_i(q_i, a_i)]$$

q output, c prod cost, a abat. Te charge,
 σ share and $\sigma T \Sigma e$ is the refund.

$$c'_a = -Te'_a (1 - \sigma_i)$$

$$P = c'_q + Te'_q (1 - \sigma_i) - T(E/Q)(1 - \sigma_i)$$

Conclusions

- Abat. Incentives same
- Average payment 0 --> no output effect nor revenue recycling effect.

No effect on competitiveness, targetting of subsectors easier.

Inoptimal because marginal firms are not driven out of business

- However Acceptability higher --> Fee T higher

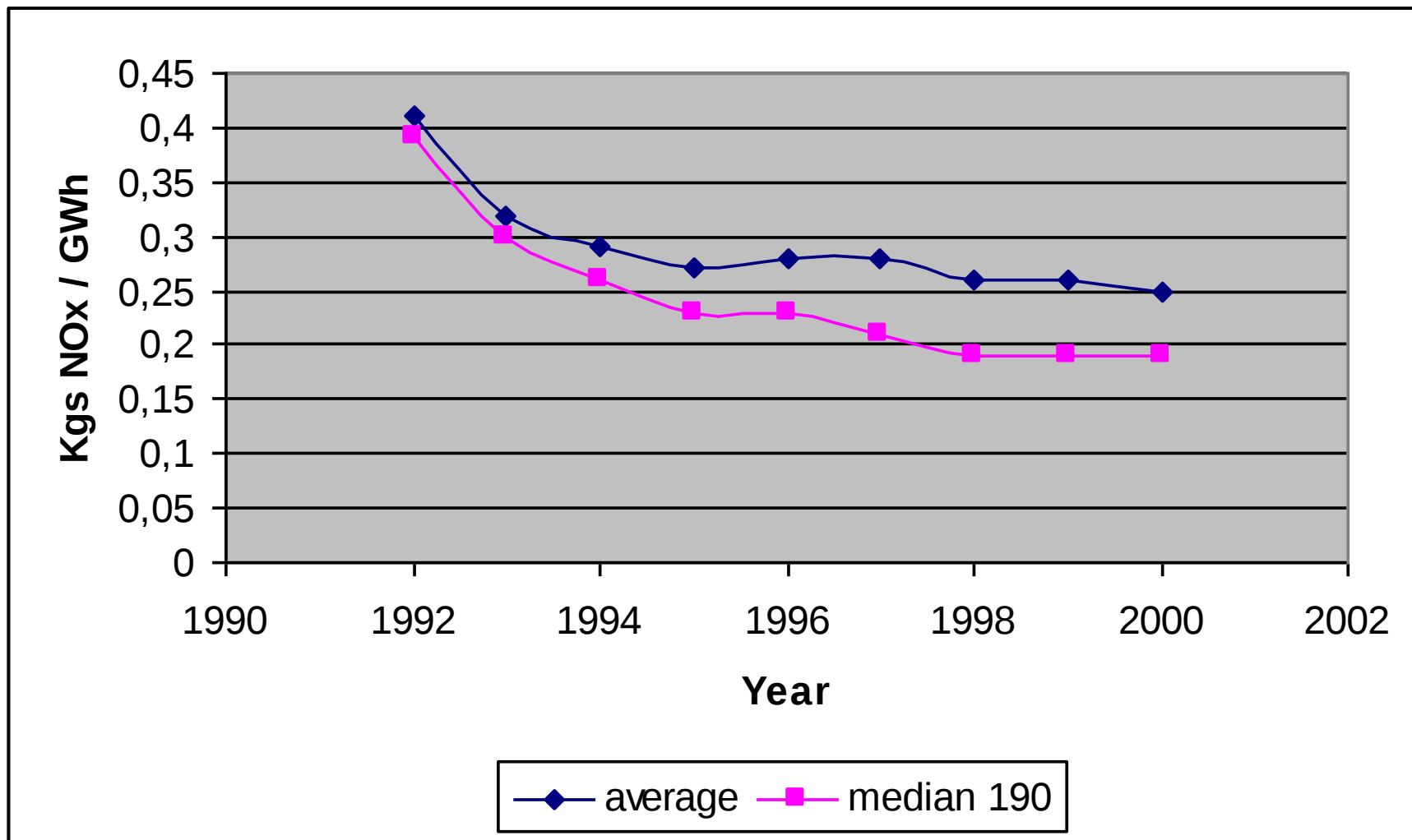
PROPERTIES OF REP

- Similar to tax on excess pollution
- Or tax-subsidy
- Useful when output effect **not** wanted
- Small open economy (competitiveness issues)
- Targeting of only some industries
- Compact lobby of powerful polluters
- Oligopoly (see Requate and Gersbach)

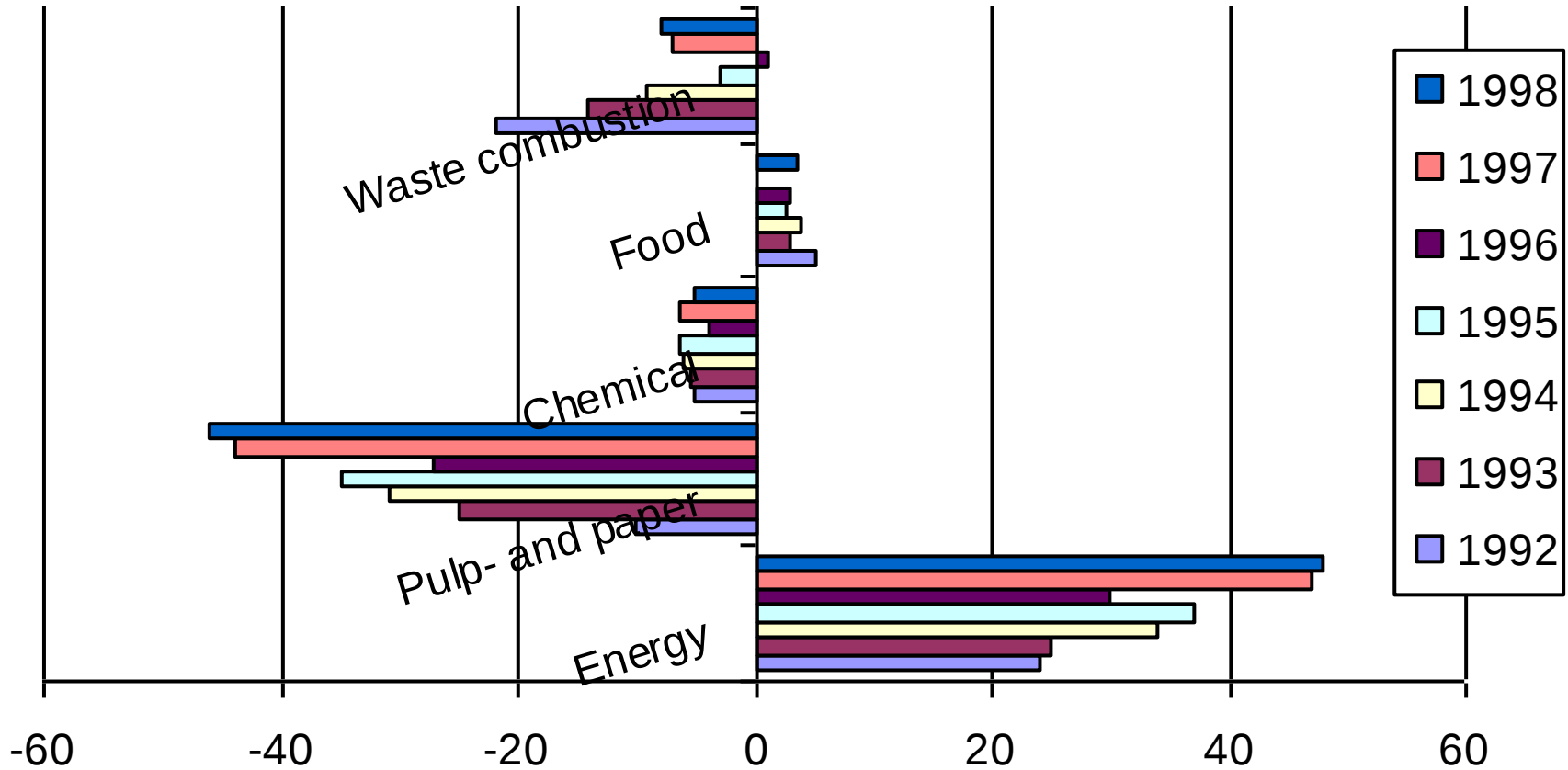
Political Economy arguments

- Fredrikson & Sterner (Econ Letters)
- “clean” firms lobby for higher tax
- Lobby for lower taxes weakened

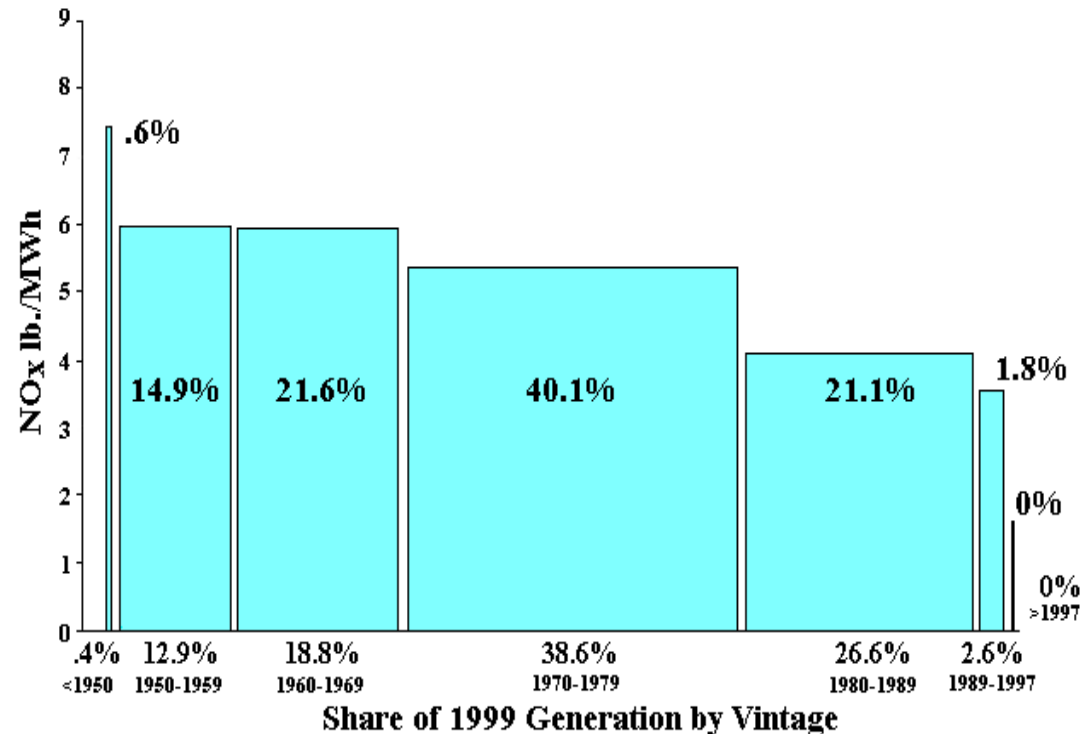
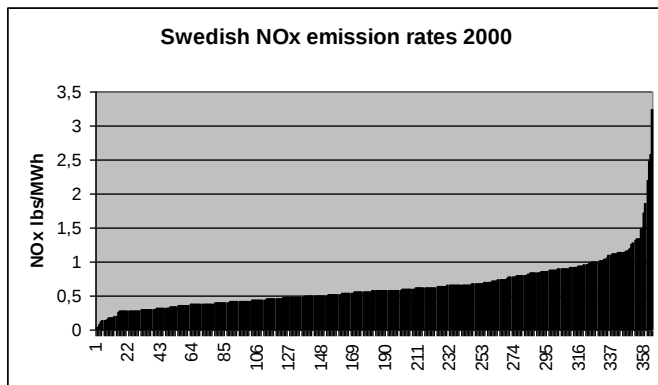
Lower emission coefficients



Distribution of net fees



Comparison em. Coeff Sweden/US

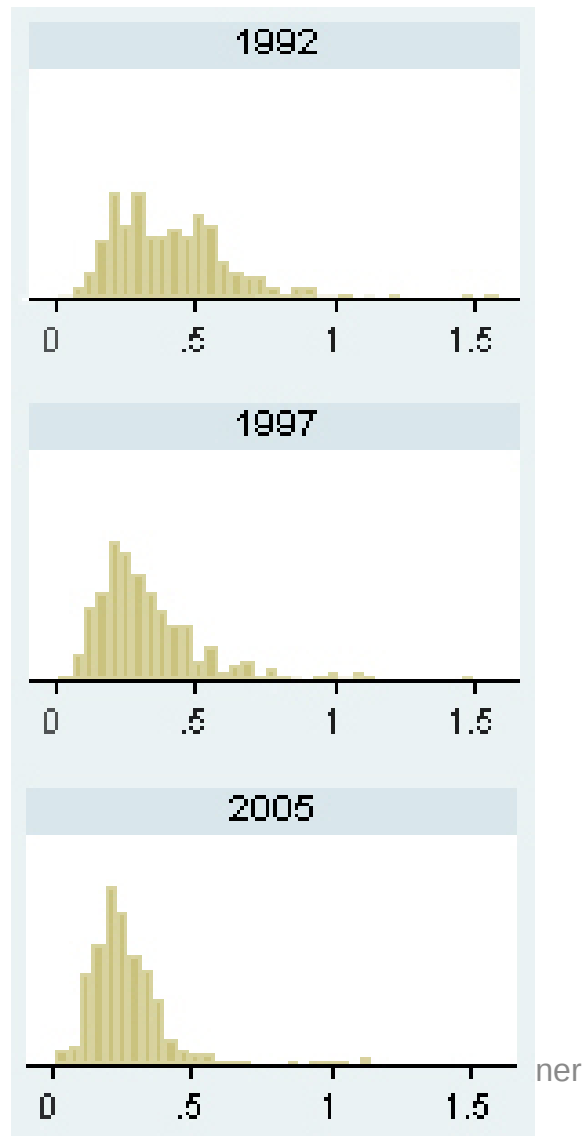


NB A possible correction factor would be 90/40 for efficiency

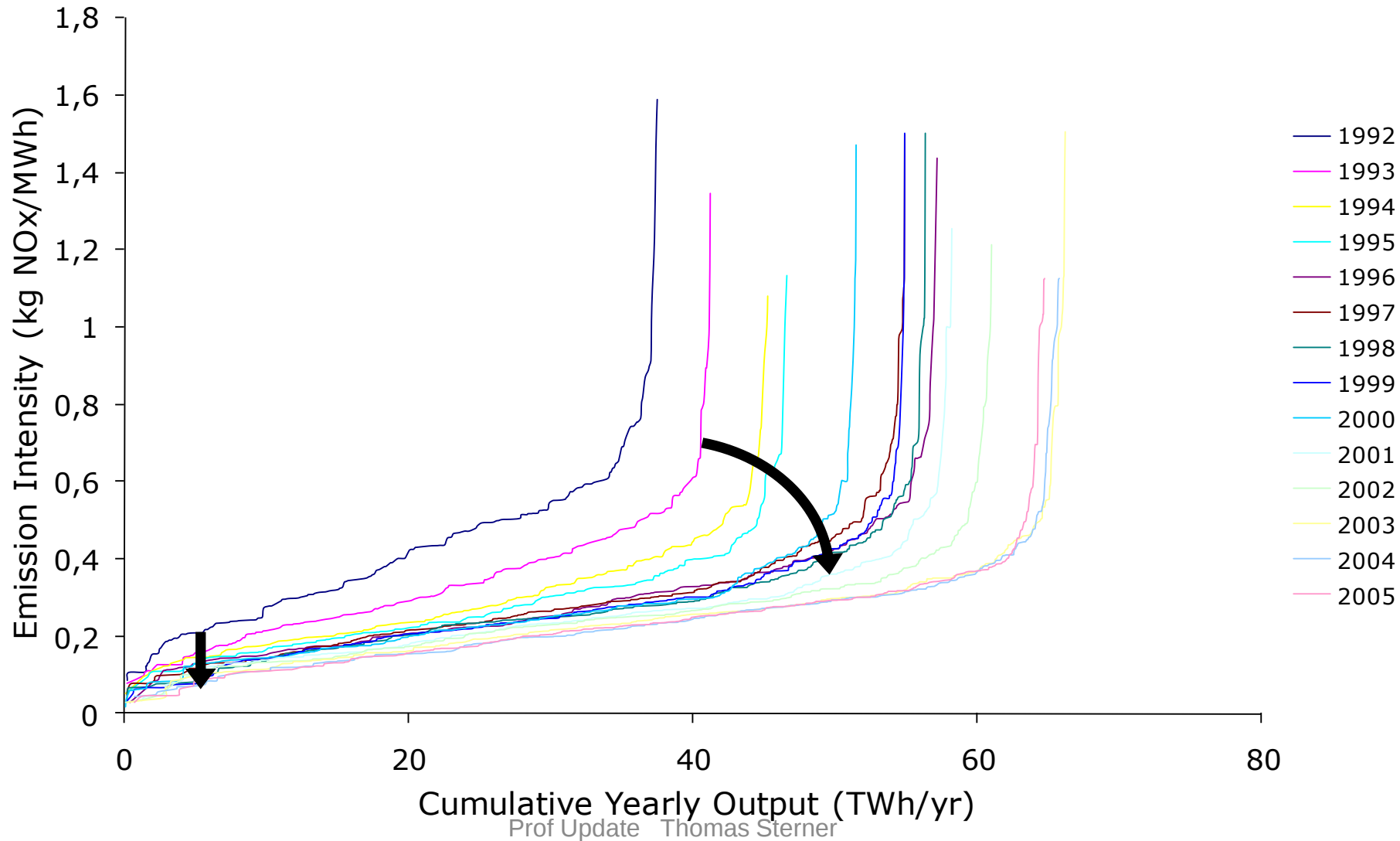
NOX

- *“The Swedish retrofitted unit, in contrast, demonstrates that NO_x levels well below the Swedish standard (and also below the German or United States standards) are achievable. ... The Swedish regulatory system, incorporating an economic incentive, clearly motivates [the Swedish plant] to achieve minimal NO_x rates rather than just comply with the applicable emission standard.” [p. 37].*

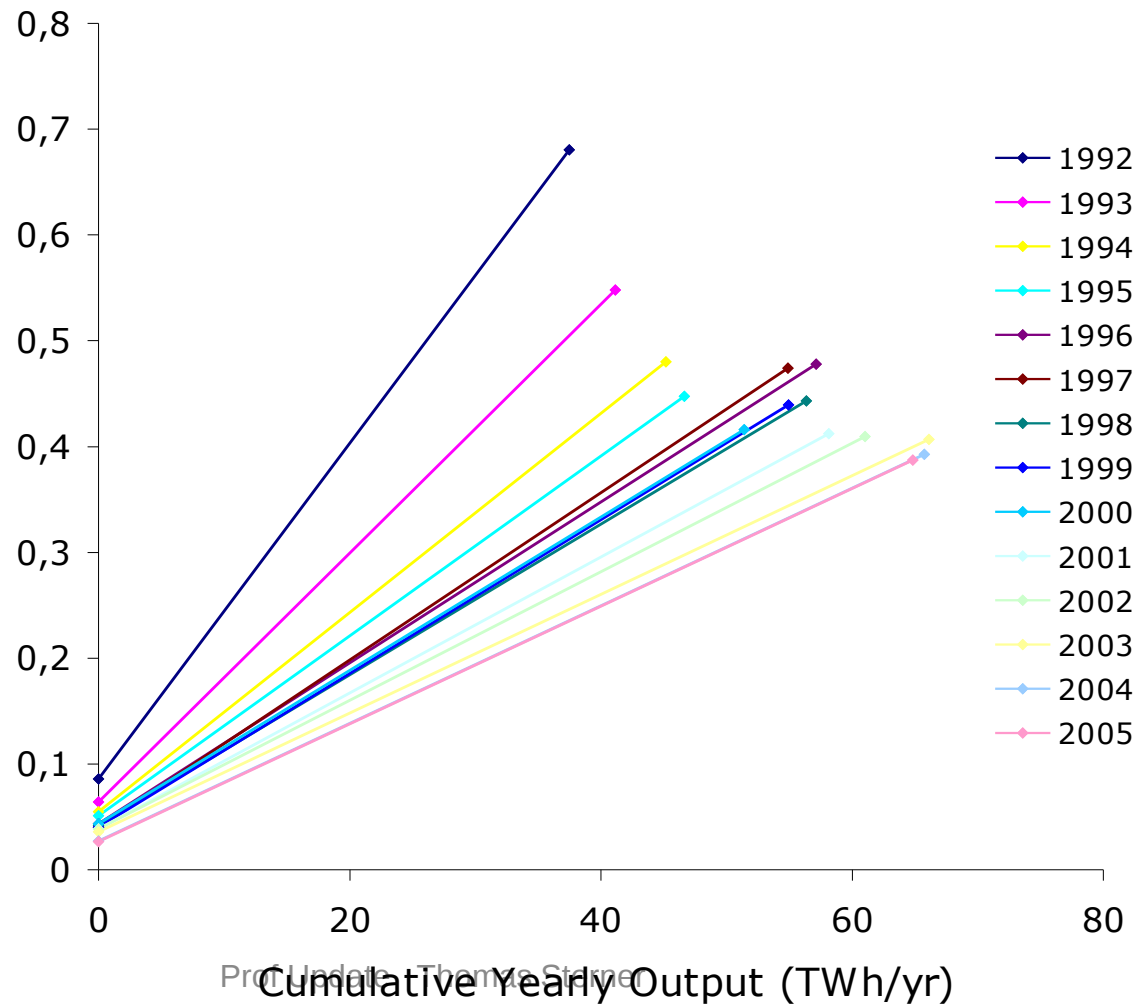
Emission coeff distributions



Emission histograms

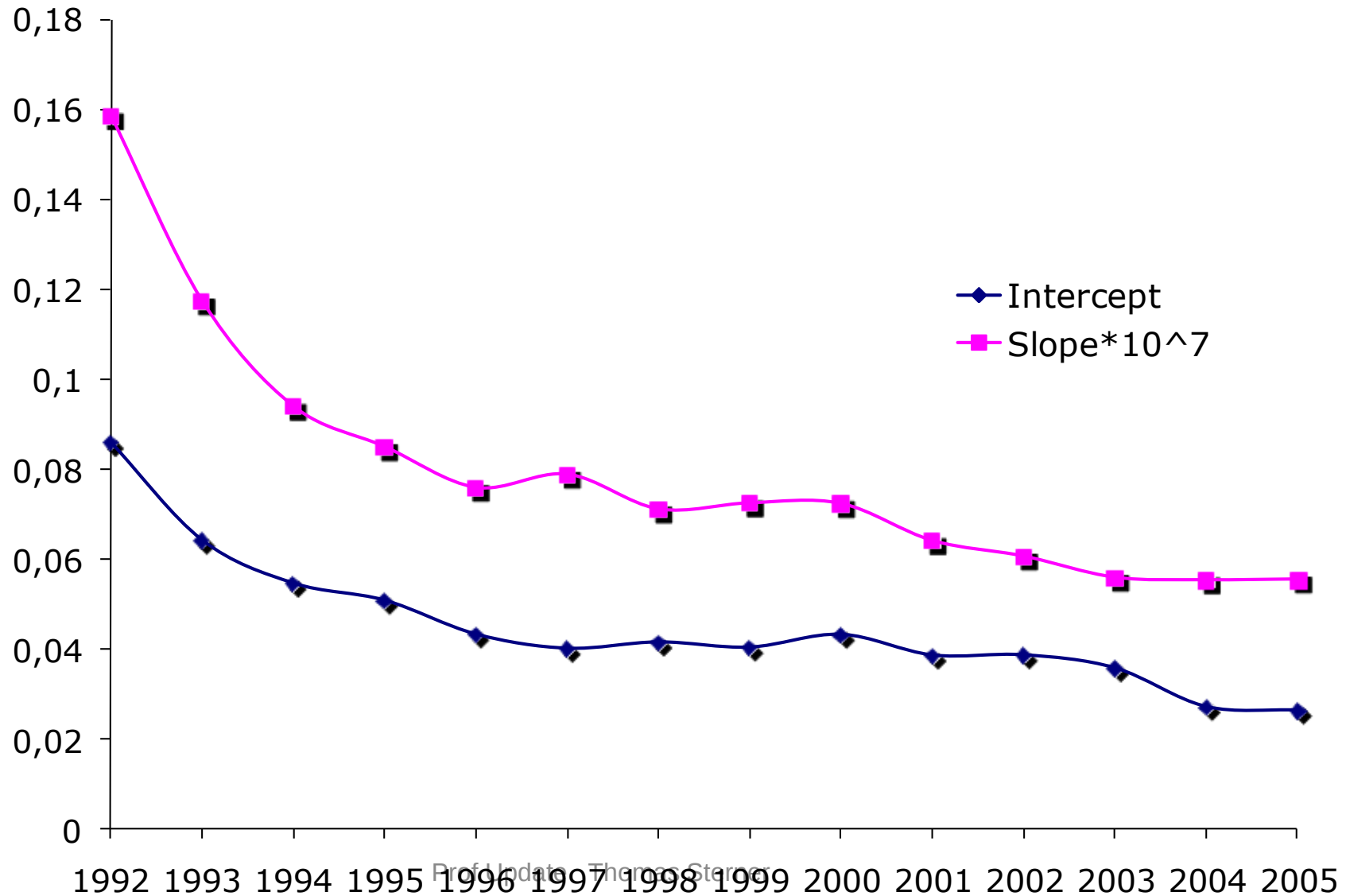


Innovation and Diffusion

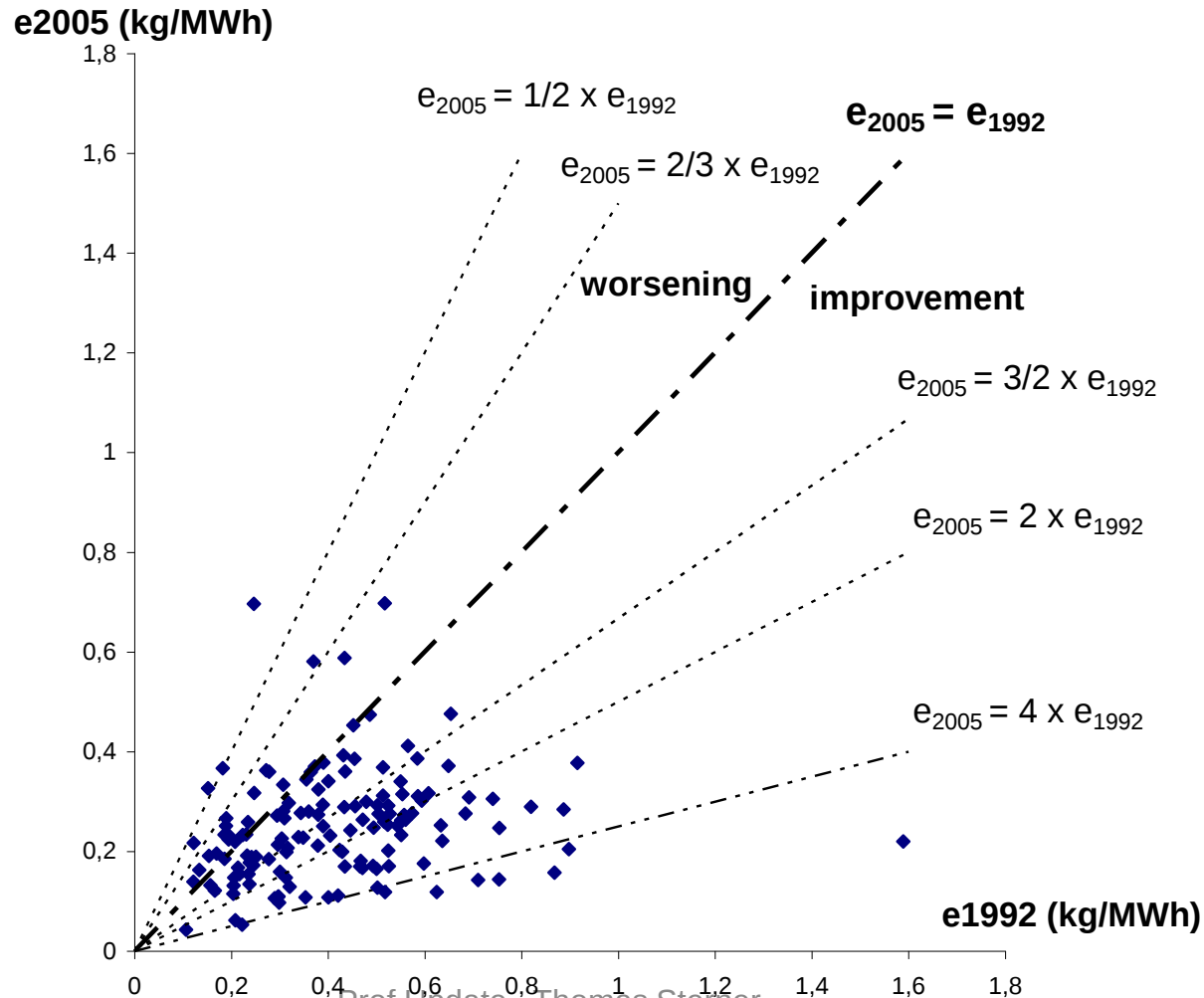


Innov/Diffusion

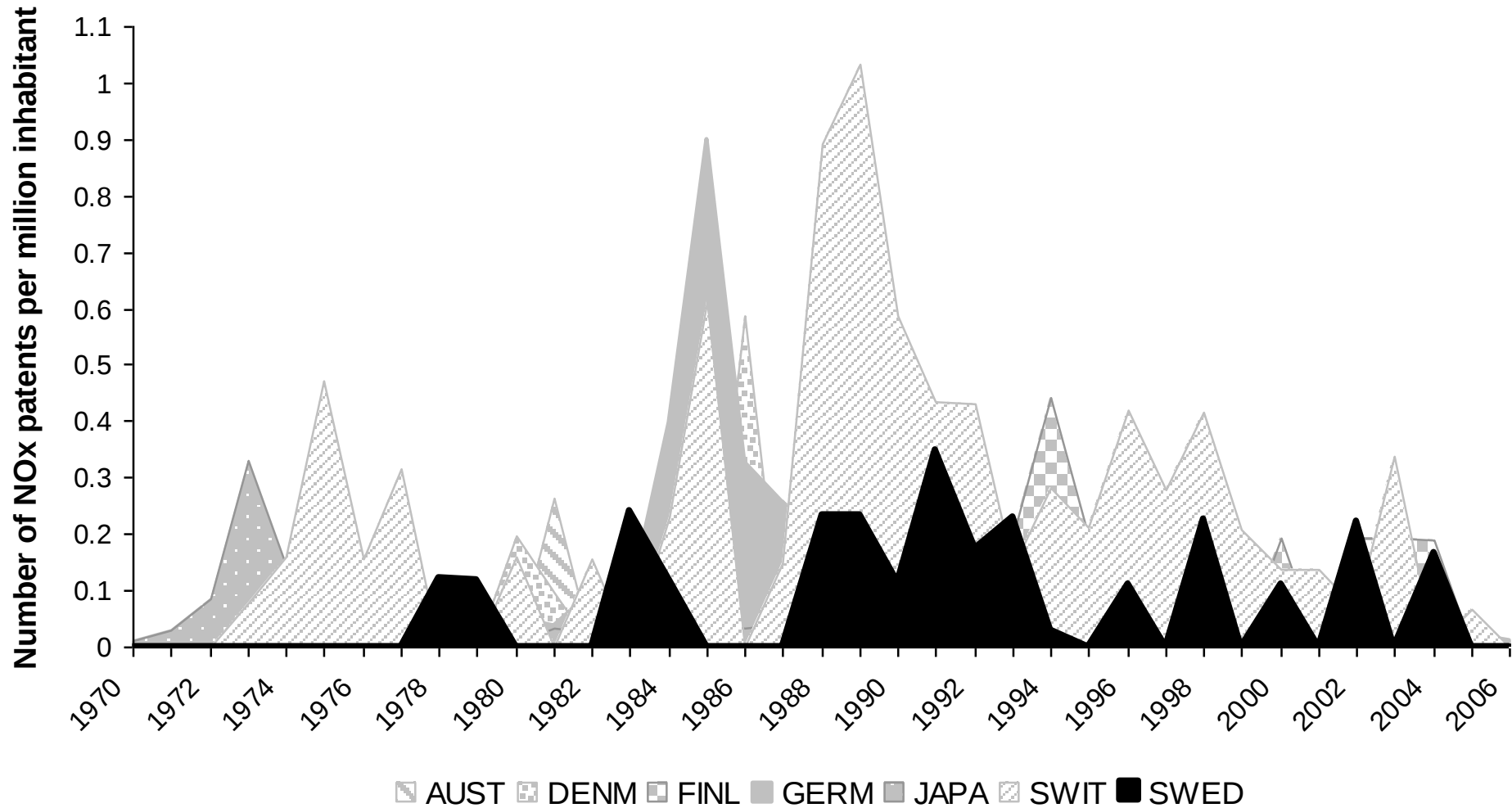
kg NO_x/MWh



Individual plant behaviour



Patents / Mcap.



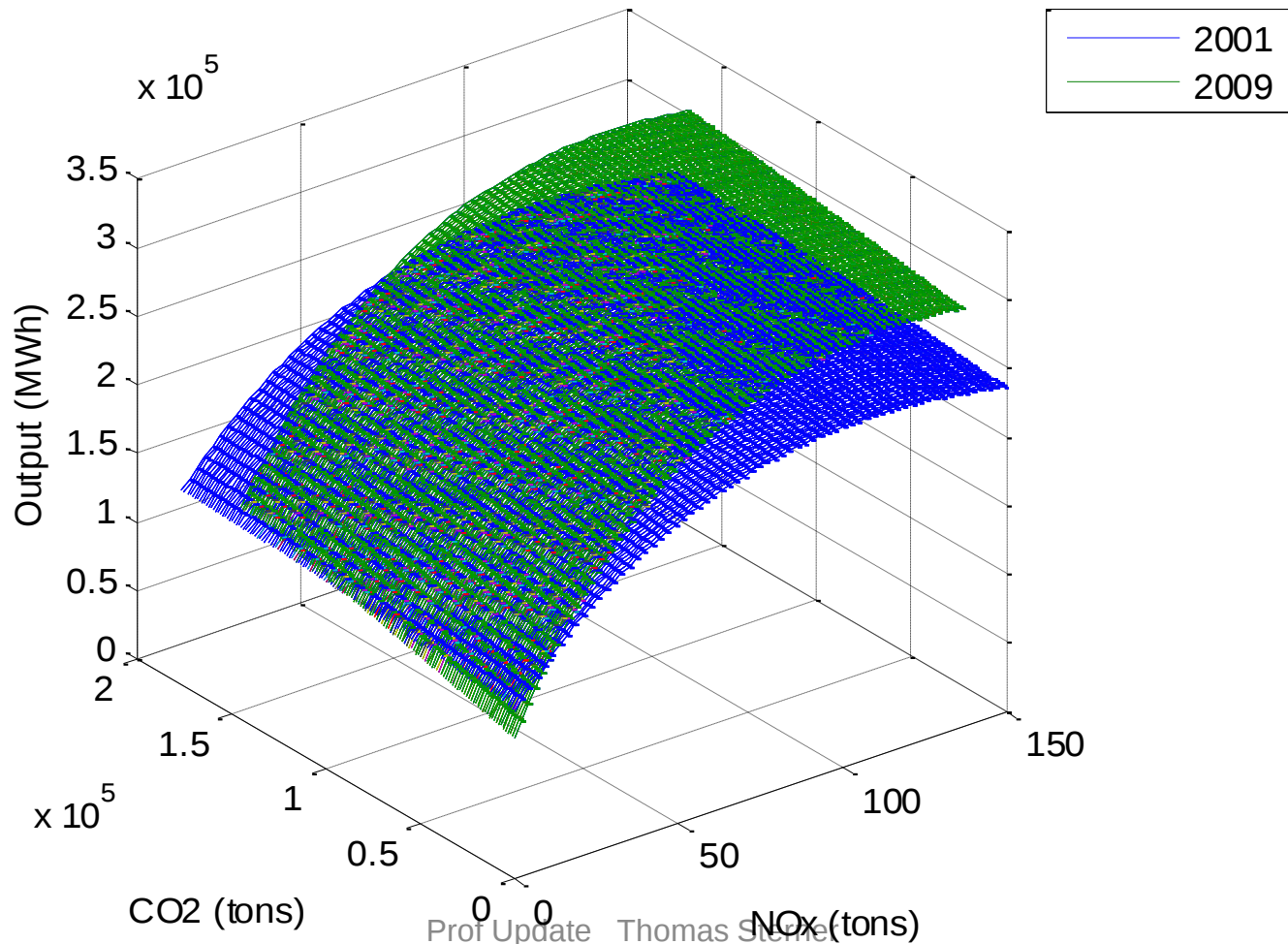
Some Conclusions

- Importance of Monitoring
- + High Price Signal
- Targetting of subsets of plants
- Refunding (or free permits).
- Creates incentives for monitoring (for clean pl)
- Sacrifice output and revenue effects but get acceptability. Also dynamic effects on techn.

The Norwegian NO_x Fund

- Gothenburg Protocol: Norway must reduce NO_x emissions <156 kt/yr by 2010 (179 in 2008).
- Tax 2007: 16,14 NOK/kg NO_x from
- Propulsion machinery > 750 kW,
- motors, boilers and turbines >10 MW
- flares on offshore installations.
- *1/1 2008 NO_x Fund (run by the business) Firms in Fund exempted from tax.*

Complement/substitution Nox-CO2



Norway's NO_x Fund

- -11 NOK /kg NO_x for offshore oil and gas industry
- 4 NOK /kg NO_x for other industries.

After application, Fund finances a share (max 75%) of NO_x-reducing investments.

The Fund is committed to facilitate abatement of 30 mill kg 2008 – 2011.

Daglig leder Geir Høiby i NOx-fondet har hittil mottatt 66 søknader om støtte



Mainly Ships, oil riggs...

Recent - Google Drive x ostfondue 2012 x Copy of ostfondue 2012 x The NOx Fund x

← → ↻ <https://www.nho.no/Prosjekter-og-programmer/NOx-fondet/The-NOx-fund/> ☆ 🔍 ☰

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The NOx Fund

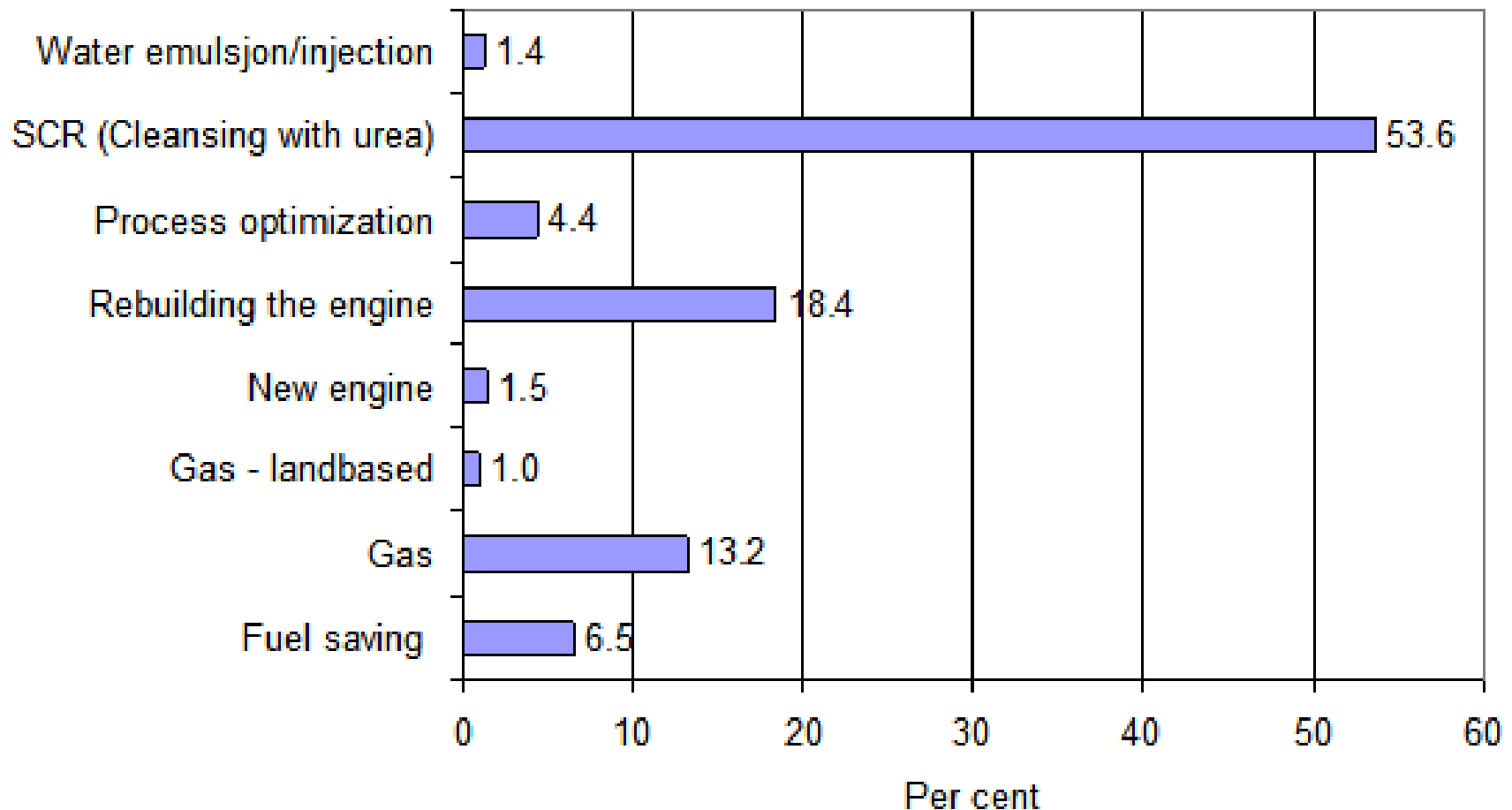
Reduced NOx emissions are the primary objective of the Environmental Agreement relating to NOx and the Business Sector's NOx Fund. The Fund is a cooperative effort where Participant enterprises may apply for financial support for NOx reducing measures. Payments made to the Fund shall replace the governmental NOx tax for Participant enterprises. The NOx fund is established by 15 cooperating business organisations.

SV N M S B A O S U

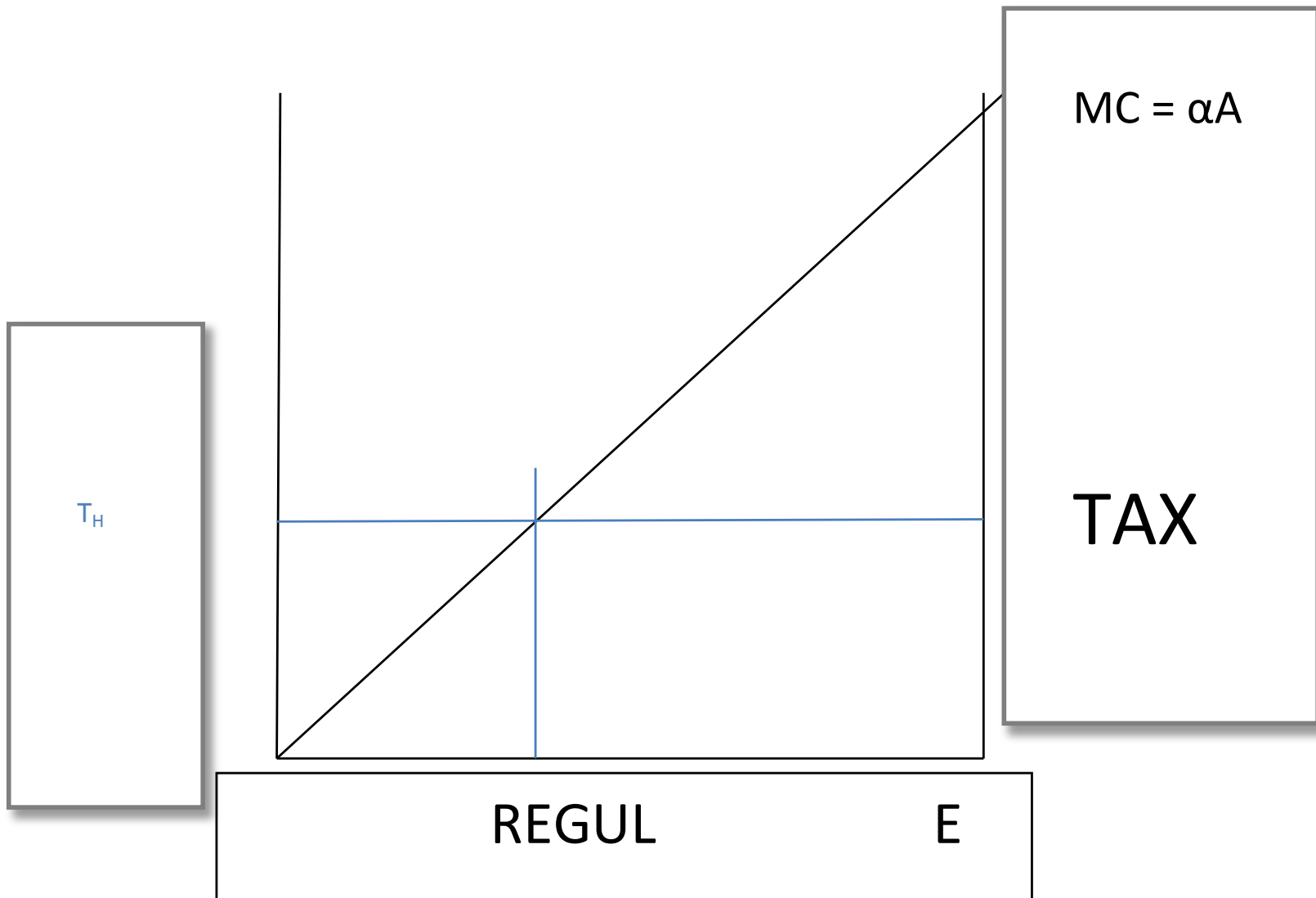
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Main Investments

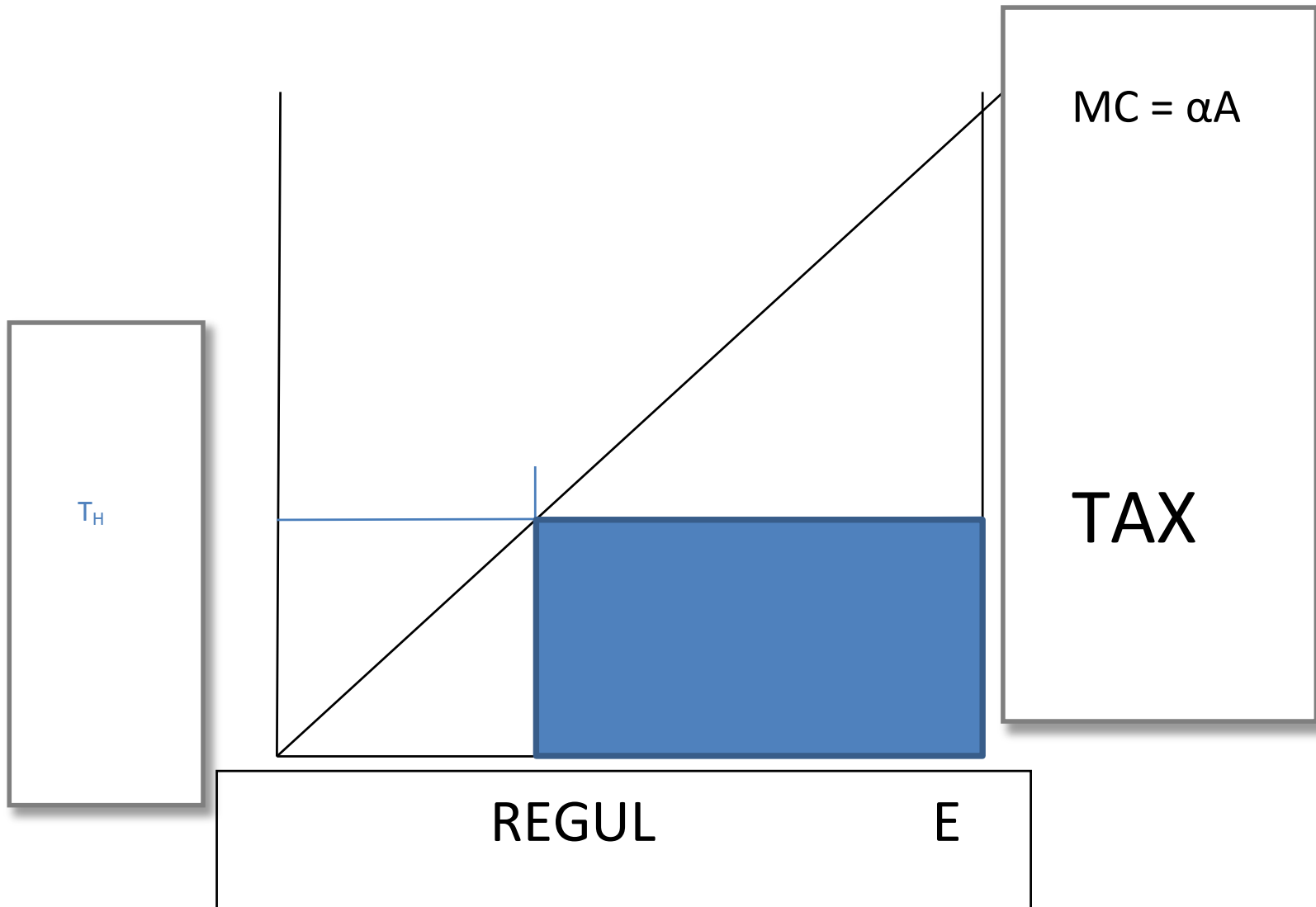
Type of investment - share of emission reduction



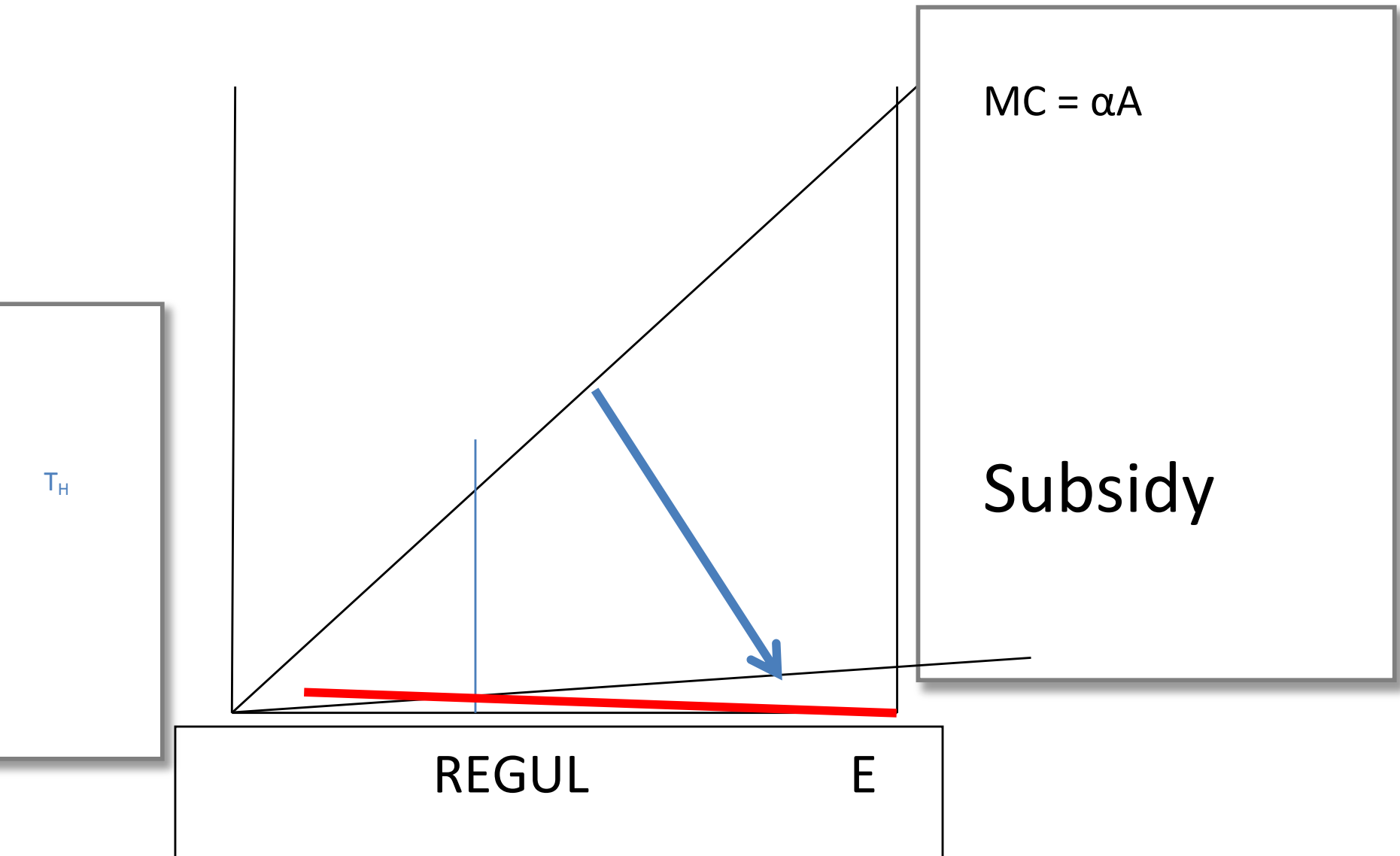
Policy Options Tax versus Q Regulation



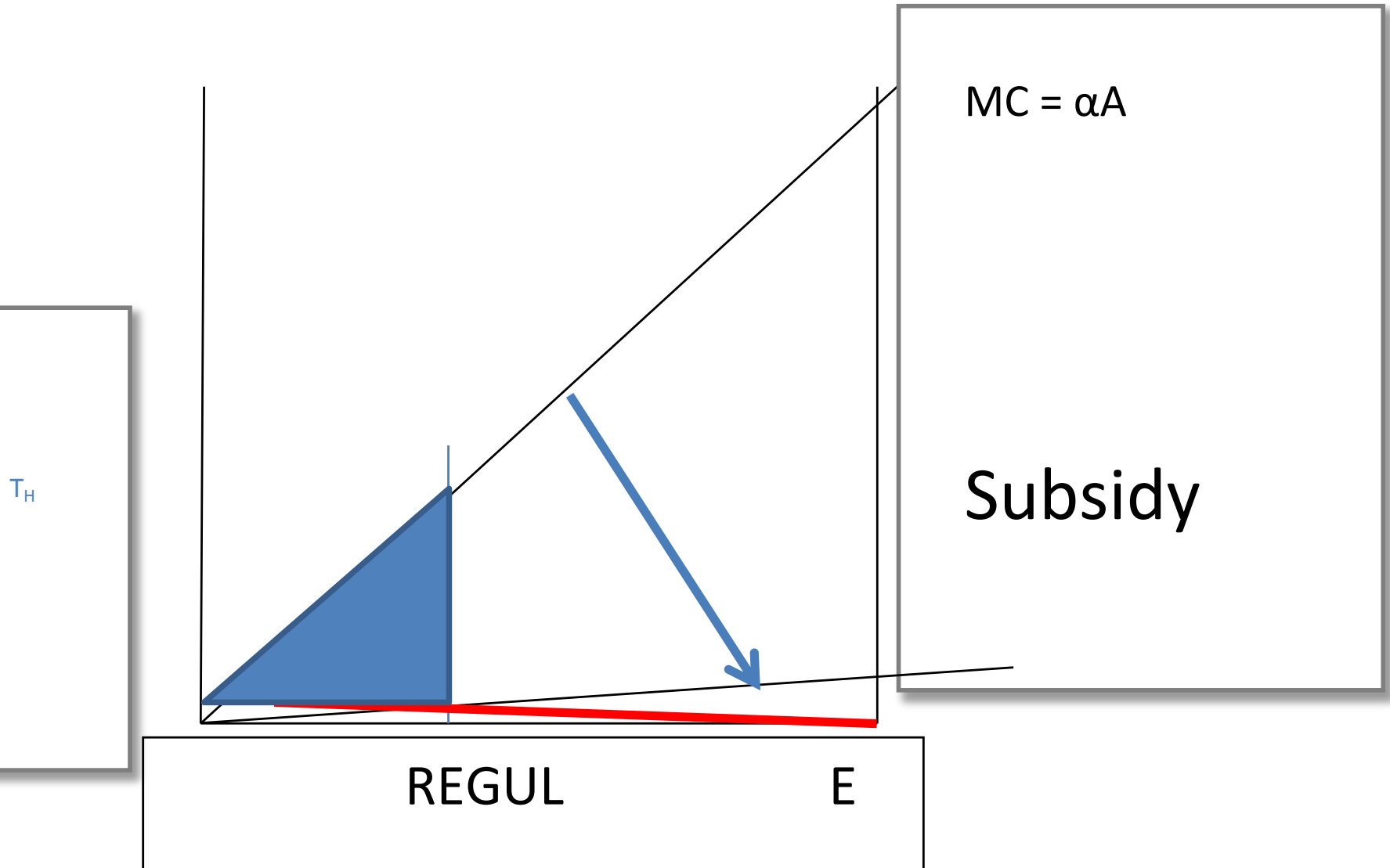
If high tax needed then big tax revenues (good or bad?)



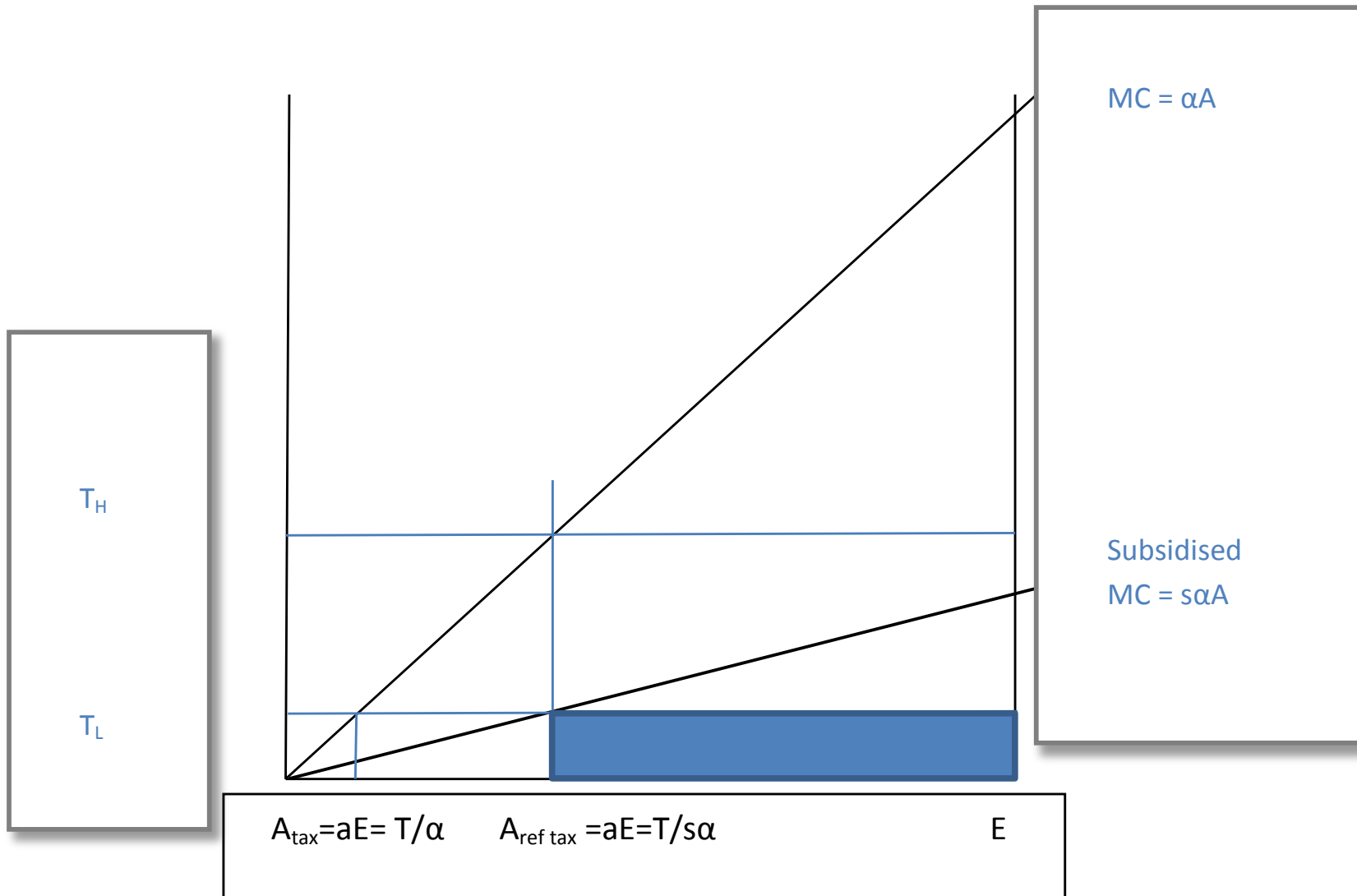
A subsidy could also work



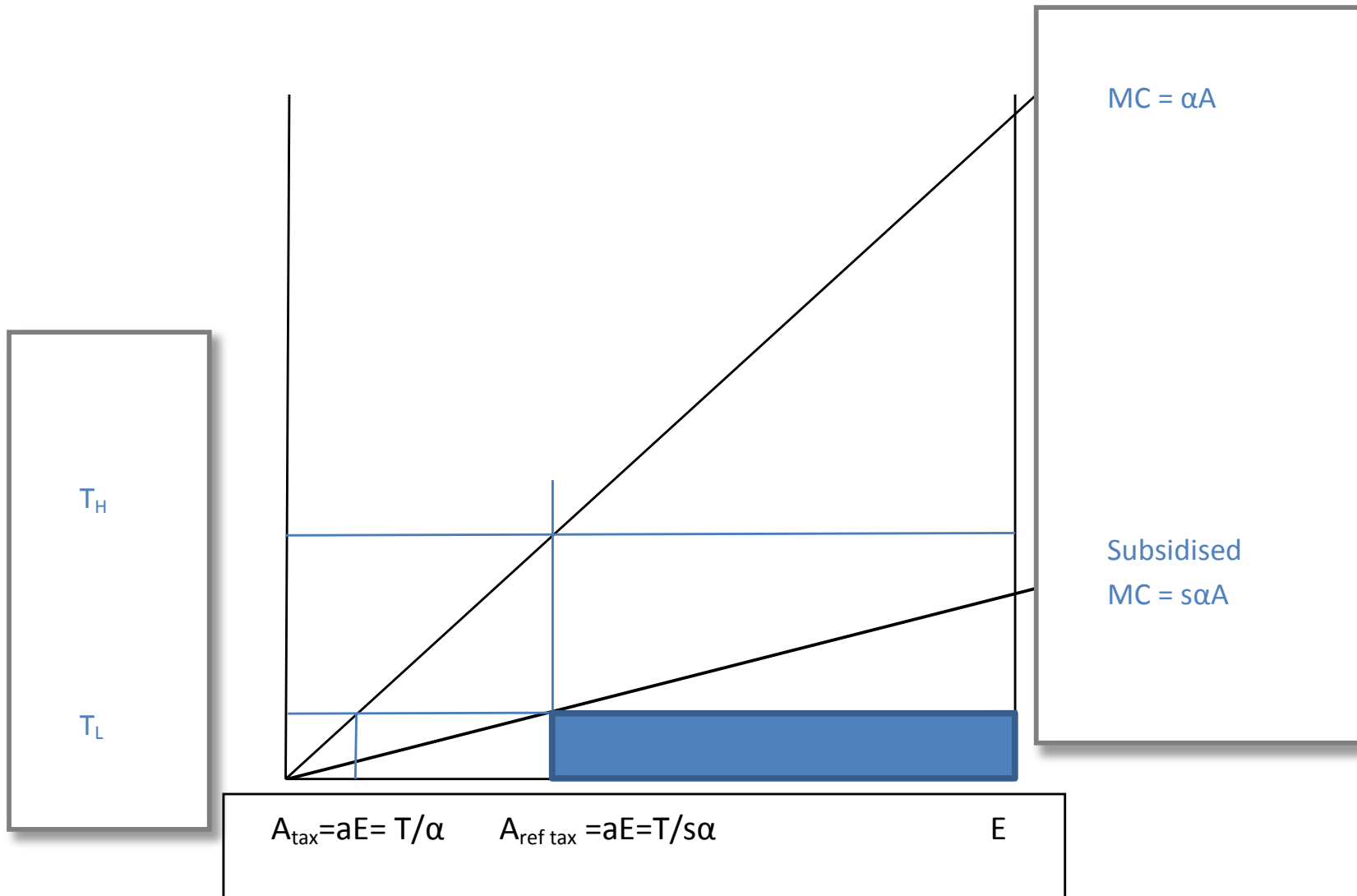
But is expensive...



Combined Tax Subsidy



Fees used to finance subsidy



Output based Refunding (OB):

$$\pi_i = p_i q_i - c_i(q_i) - A_i - te_i(q_i, A_i) + \sigma_i tE. \quad (1)$$

$$\sigma_i = \frac{q_i}{Q}. \quad (2)$$

EB $\pi_i = p_i q_i - c_i(q_i) - (1-s)A_i - te_i(q_i, A_i), \quad (8)$

problematic that s endogenous; (9) necessary for budget constraint:

$$s = \frac{tE}{A}, \quad (9)$$

MAC curves with varying subsidy%

