CPB Netherlands Bureau for Economic
Policy Analysis

Integrated Assessment: Air & Climate Policies are Complements

by

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Research Global / Regional Interactions Climate and Air Pollution Policies

- climate change and health impacts of energy related $PM_{2.5}$

Bollen, J, van der Zwaan, B, Brink, C, and Eerens, H. (2009), Local Air Pollution and Global Climate Change: A Combined Cost-Benefit Analysis, Resource and Energy Economics, Vol. 31, Issue 3, August 2009, pp. 161-181.

- +energy security

Bollen J., van der Zwaan, B., Hers, S. (2010), An Integrated Assessment of Climate Change, Air Pollution, and Energy Security Policy, Energy Policy, Vol. 38, Issue 8, pp. 4021-4030.

- + Emissions of PM_{10}, SO_2, NO_x, NH_3, VOC

  + Concentrations of $PM_{2.5}$ (+ secondary aerosols), strat. O_3,

  + Decomposing GHG climate sensitivity in trop. O_3 & GHG's

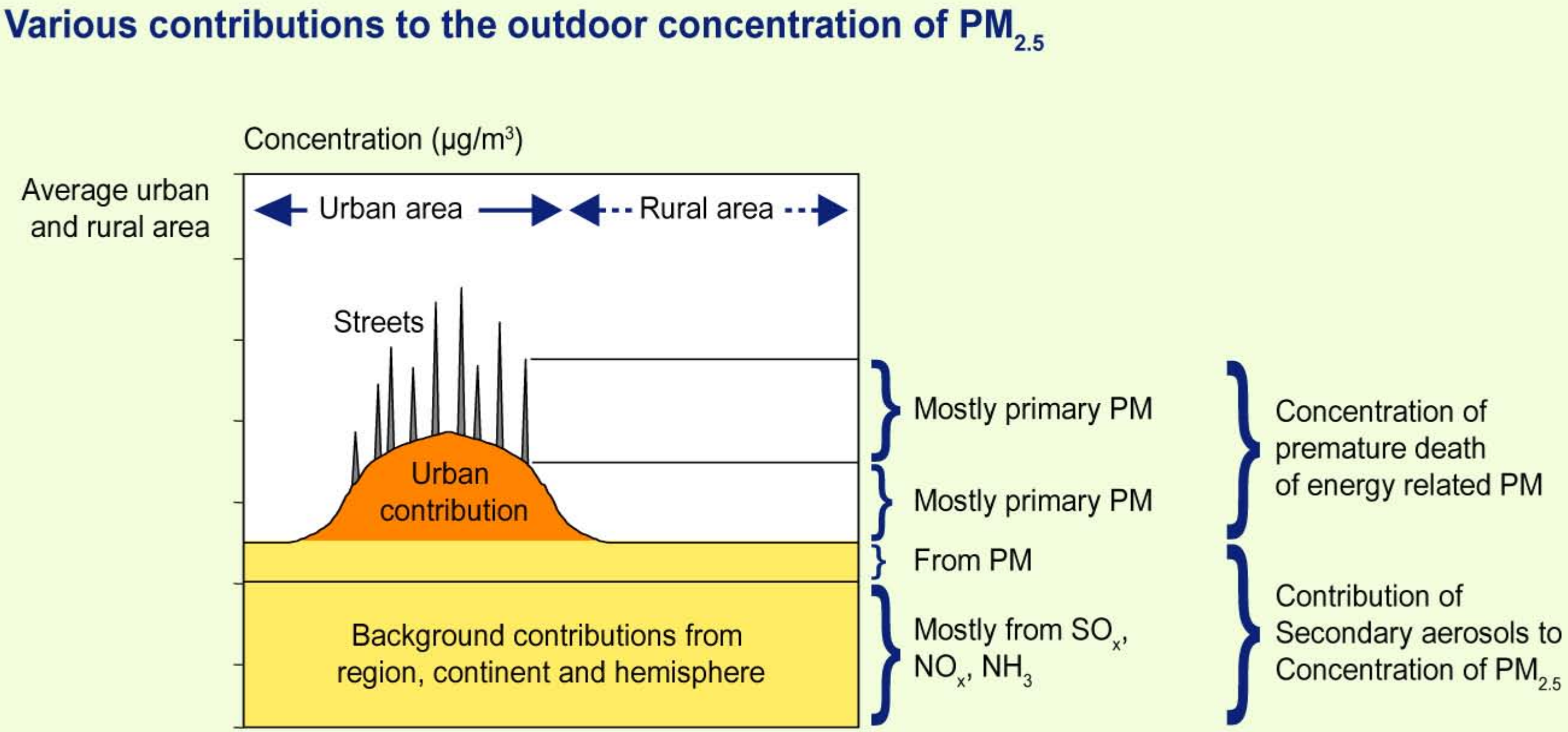
Bollen, J., Guay, B., Jamet, S., Corfee-Morlot, J. (2009), Co-benefits of Climate Change Mitigation Policies: Literature Review and New Results, OECD Economics Department Working Paper No. 693, OECD Economics Department Working Paper No. 693, OECD.

75% of ΔT of Climate Policies through Air Policies

Policy Relevance

- Less free-rider incentives
- Restructure Non-Electric Energy
- Focus R&D also on Non-Electric Energy

Valuing Air Pollution (no Spikes)



Various contributions to the outdoor concentration of $PM_{2.5}$

- weighted sum SO_x, NO_x, NH_3, $PM_{2.5}$ (de Leeuw, 2002)
- concentrations → premature deaths (Pope et al, 2002)
- 1 mn €/premature death in EU, income elasticity 1 (Viscusi&Aldy, 2003)

Main characteristics MERGE

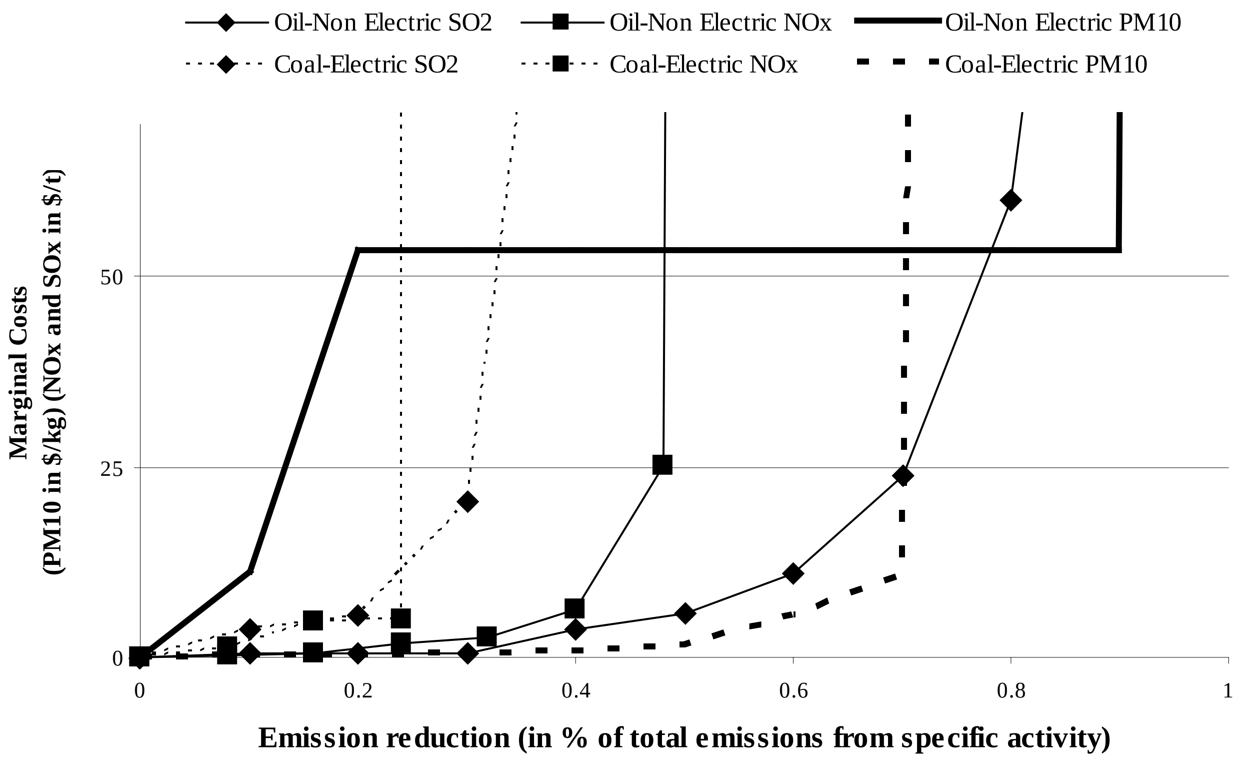
- Intertemporal Optimization Welfare
- 9 regions, Pareto-efficiency
- top-down production, bottom-up energy perspective
- Fossil Fuel depletion
- RD and two-factor learning

- end-of-pipe mitigation options included

Technology Costs & Emissions Coefficients in Europe

Electricity Sector						
		Cost	Emission coefficients			
Date of availability	Technology	Cost in 2000 $/GJ	CO_2 t/GJ	SO_2 t/GJ	No_x t/GJ	$PM_{2.5}$ t/GJ
Available	Coal direct use	2.5	0.024	0.34	0.22	0.12
Available	Oil at alternative costs	3.0-5.3	0.02	0.15	0.035	0.017
Available	Coal at alternative costs	2.0-4.3	0.014	0	0.35	0
Available	Renewable	6	0	0	0	0.011
2010	Carbon free technology	14↓6	0	0	0	0
Non-Electricity Sector						
Date of availability	Technology	Cost in 2000 Mills/kWh	CO_2 Bn t/TWH	SO_2 Mt/TWh	Nox Mt/TWh	PM Mt/TWh
Available	Hydroelectric and geothermal	40	0	0	0	0
Available	Existing nuclear	50	0	0	0	0
Available	Existing gas fired	36	0.14	0	0.26	0
Available	Existing oil fired	38	0.21	1.87	0.40	0.01
Available	Existing coal-fired	20	0.25	0.99	0.42	0.01
2010	New gas-fired	13	0.09	0	0.23	0
2020	Advanced gas-fired +CCS	30	0	0	0	0
2010	New coal-fired	41	0.2	0	0.35!!!	0
2050	Advanced coal-fired +CCS	56	0.01	0.029	0.01	0
2030	Integr. gas.+ comb.cycle+CCS	62	0.02	0.04	0.23	0
2010	Carbon free technology	100↓5	0	0	0	0

Abatement Cost Curves: OECD Europe



MACC's move: Technological progress: →→

Income growth: ↑↑

Valuation of air pollution (1 of 4)

$$PM_{t,r} = PM\left(G_{t,r}, Y_{t,r}\right) = \frac{0.06G_{t,r}}{0.06G_{t,r}+1} P_{t,r} c_{t,r} \left(1.06 \frac{\left(Y/P\right)_{t,r}}{\left(Y/P\right)_{0,W}}\right)$$

with G is the anthropogenic $PM_{2.5}$ concentration, P the region’s population of the region, and c the crude death rate, and Y the BBP. The risk of death thus increases log-linearly with the concentration of $PM_{2.5}$ The crude death rate is assumed to increase by 12% on average and by 8% in OECD regions in 2050 relative to 2000.

Valuation of air pollution (2 of 4)

$$PM_{t,r} = PM\left(G_{t,r}, Y_{t,r}\right) = \frac{0.06G_{t,r}}{0.06G_{t,r}+1} P_{t,r} c_{t,r} \left(1.06 \frac{\left(Y/P\right)_{t,r}}{\left(Y/P\right)_{0,W}}\right)$$

$$G_{t,r} = \sum_{c\in C} H_{c,t,r} + \min\left(H_{NH_3,t,r}, \frac{18}{72} H_{NO_x,t,r} + \frac{36}{96} H_{SO_x,t,r}\right)$$

With c the index of substances SO_2, NO_x, and PM_{10} and *H* the substance-specific contribution to the regional yearly $PM_{2.5}$ concentration. The last term accounts for the fact that the secondary aerosol formation from ammonia can only contribute $PM_{2.5}$ concentration though chemical reactions with NO_3^- or SO_4^{2-}. The weights express the sum of the atomic weights of the different elements contributing to NO_3^- or SO_4^{2-}. In the presence of ammonia, secondary aerosols often take the form of ammonium salts; i.e. ammonium sulfate and ammonium nitrate (both can be dry or in aqueous solution); in the absence of ammonia, secondary compounds take an acidic form as sulfuric acid (liquid aerosol droplets) and nitric acid (atmospheric gas).

Valuation of air pollution (3 of 4)

With u the exogenous time series of the proportion of people living in urban areas in year t in region r, $\Delta E_{s,t,r}$ the growth of emissions of substance s at time t compared to the year 2000, and the substance-specific coefficient α in urban or rural areas to translate regional emission increases to the regional yearly average concentration of $PM_{2.5}$.

$$\begin{aligned} H_{s,t,r} &= u_{t,r}\left(C_{s,t,r,urb} + C_{s,t,r,rur}\right) + \left(1 - u_{t,r}\right)\left(C_{s,t,r,rur}\right) \\ &= u_{t,r}C_{s,t,r,urb} + C_{s,t,r,rur} \\ &= \Delta E_{s,t,r}\left(u_{t,r}\alpha_{s,r,urb} + \alpha_{s,r,rur}\right) \end{aligned}$$

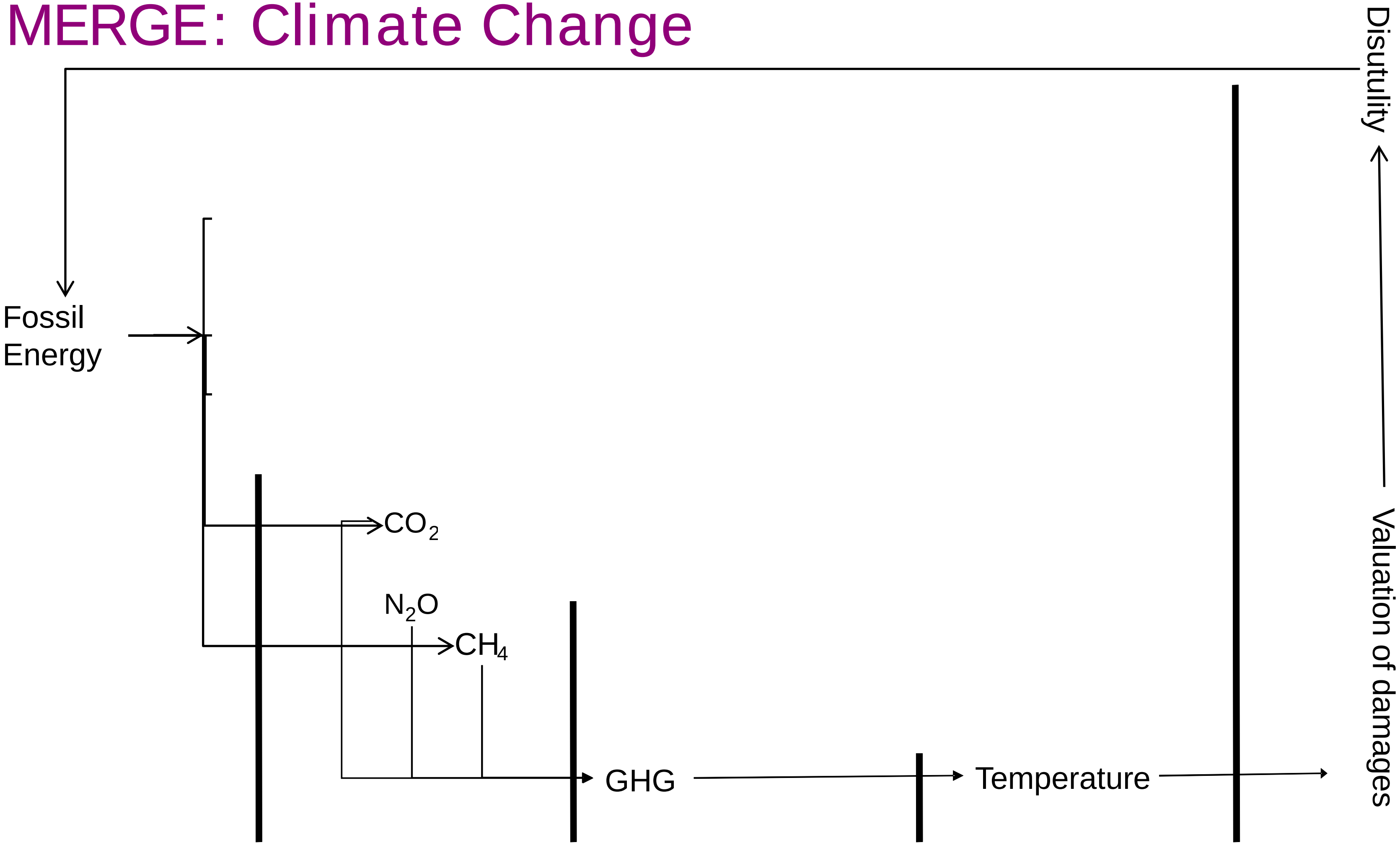
Valuation of air pollution (4 of 4)

$$PM_{t,r} = PM\left(G_{t,r}, Y_{t,r}\right) = \frac{0.06G_{t,r}}{0.06G_{t,r}+1} P_{t,r} c_{t,r} \left(1.06 \frac{\left(Y/P\right)_{t,r}}{\left(Y/P\right)_{0,W}}\right)$$

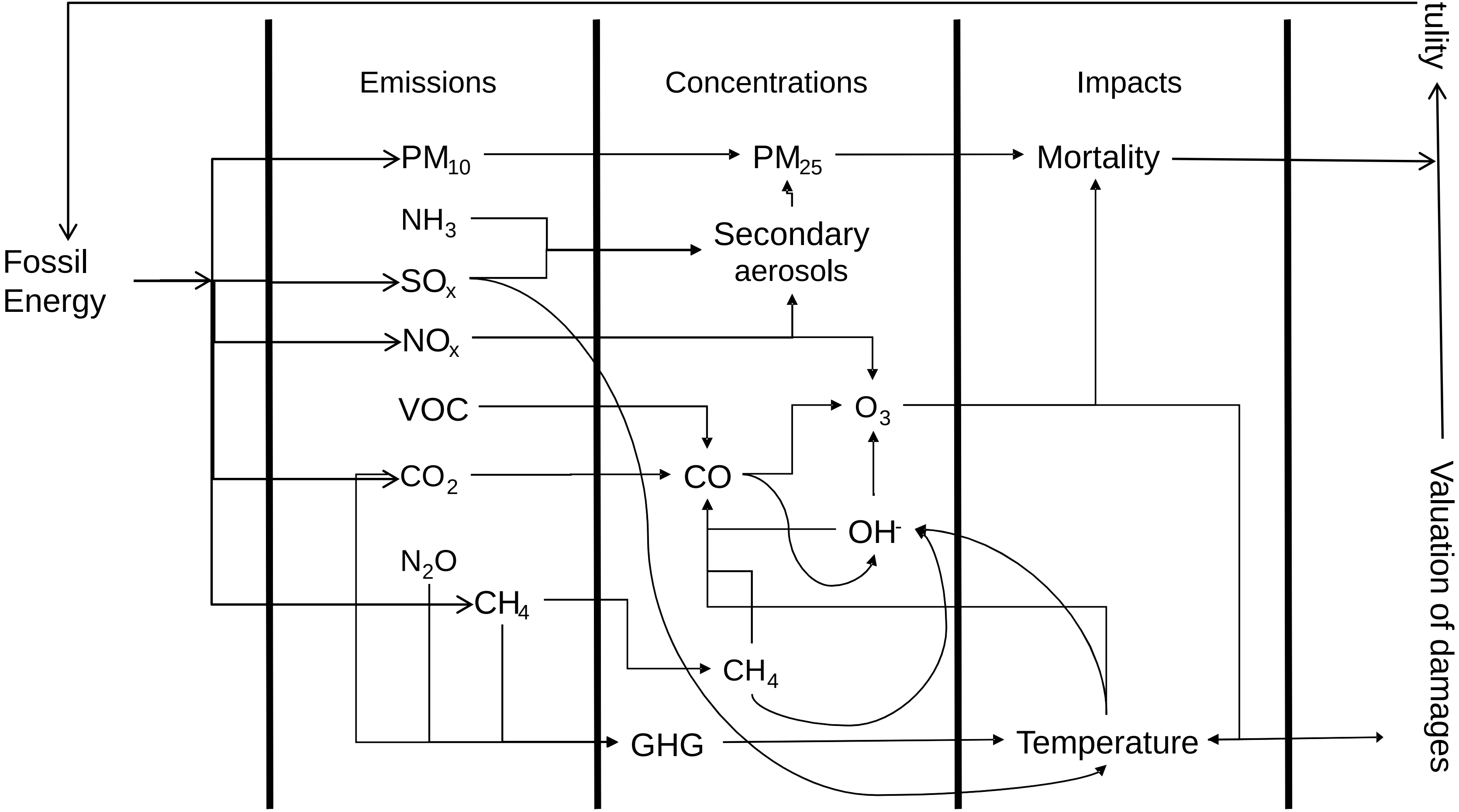
$$G_{t,r} = \sum_{c \in C} H_{c,t,r} + \min\left(H_{NH_3,t,r}, \frac{18}{72} H_{NO_x,t,r} + \frac{36}{96} H_{SO_x,t,r}\right)$$

$$\begin{aligned} H_{s,t,r} &= u_{t,r}\left(C_{s,t,r,urb} + C_{s,t,r,rur}\right) + \left(1 - u_{t,r}\right)\left(C_{s,t,r,rur}\right) \\ &= u_{t,r} C_{s,t,r,urb} + C_{s,t,r,rur} \\ &= \Delta E_{s,t,r}\left(u_{t,r}\alpha_{s,r,urb} + \alpha_{s,r,rur}\right) \end{aligned}$$

MERGE: Climate Change



MERGE: CBA on Climate Change & Air Pollution



Policy Scenarios in Cost-Benefit Mode

Disutility Climate

Consumption

Negishi

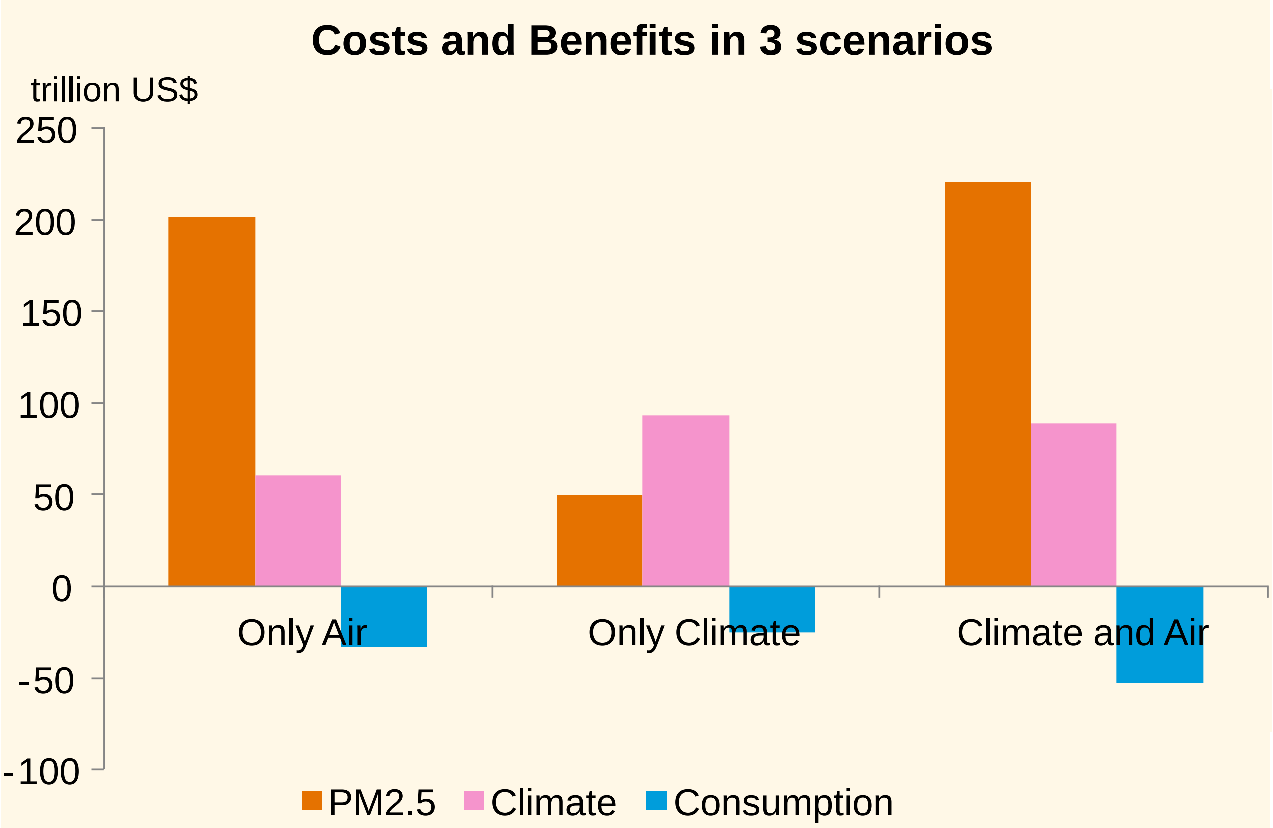
$$\sum_r n_r \sum_t u_{t,r} \log\left(E_{t,r} F_{t,r} C_{t,r}\right)$$

Utility discount factor

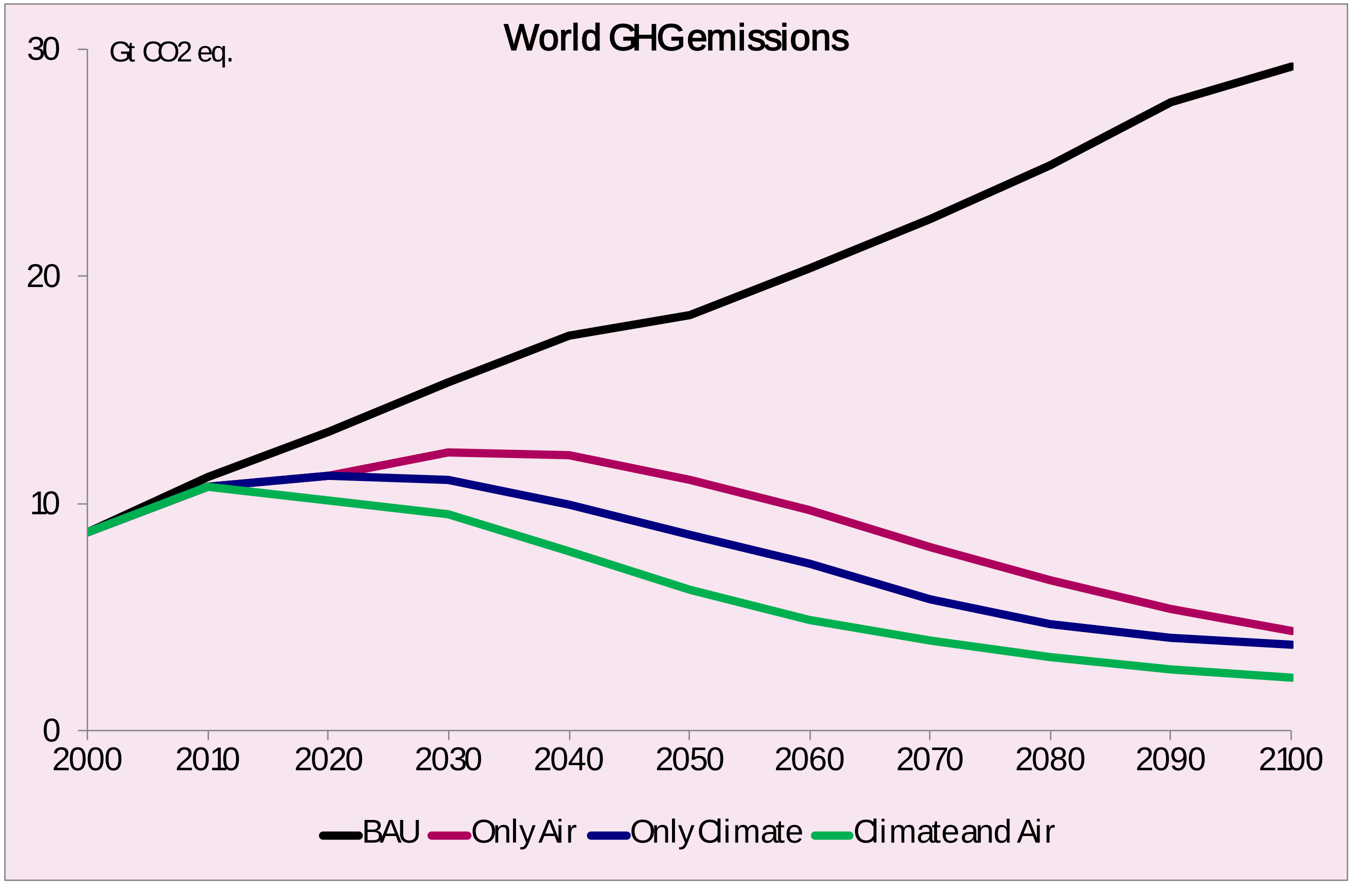
Disutility air pollution

- Policy variants optimally address externalities
  - Only Climate Change
  - Only Air Pollution
  - Both Climate Change and Air Pollution

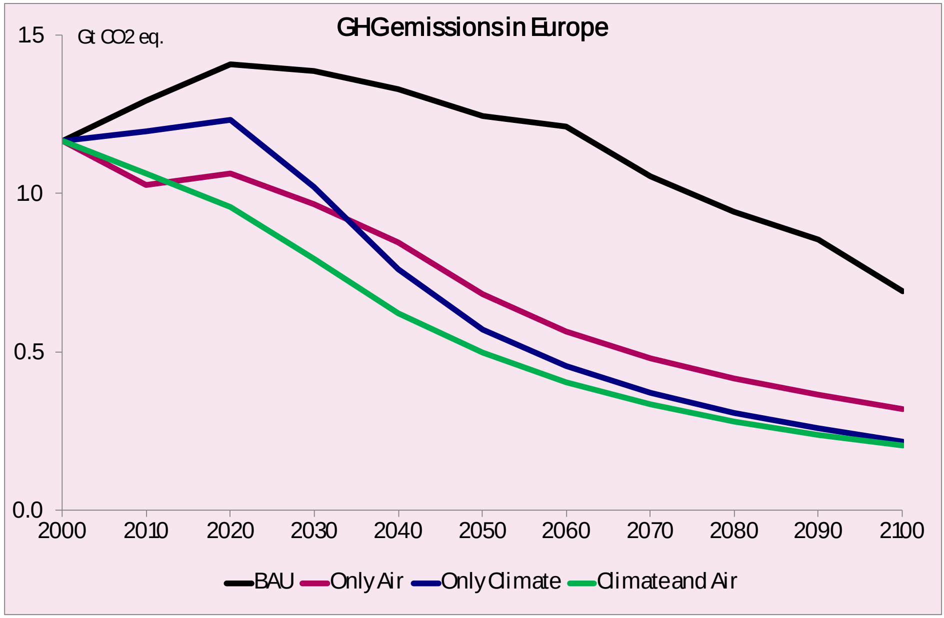
Air Pollution 1st, Climate Change 2nd Issue
Co-benefits significant for any mitigation strategy

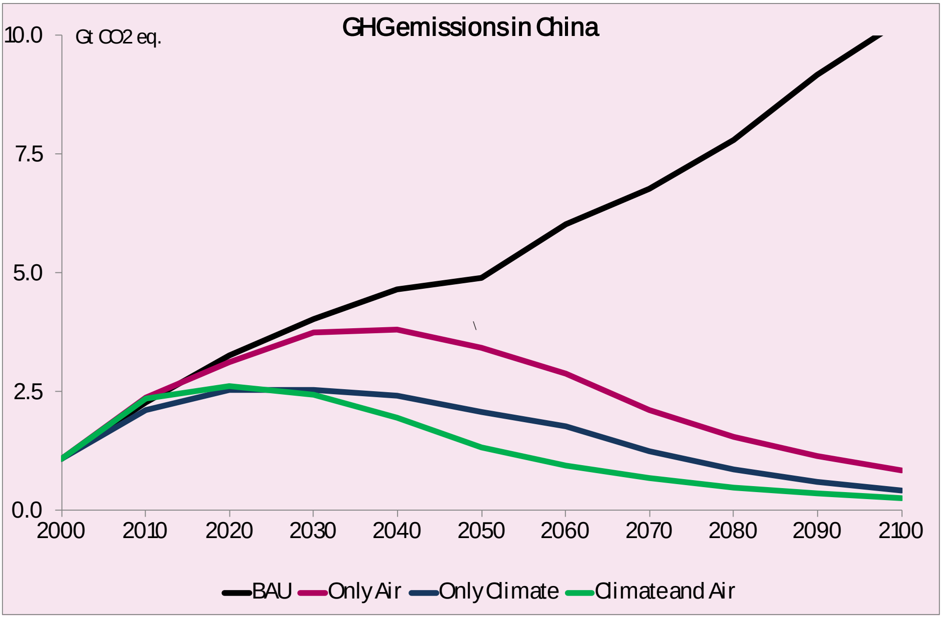


“Only Air” strategy yields significant global CO2 eq emission reductions!



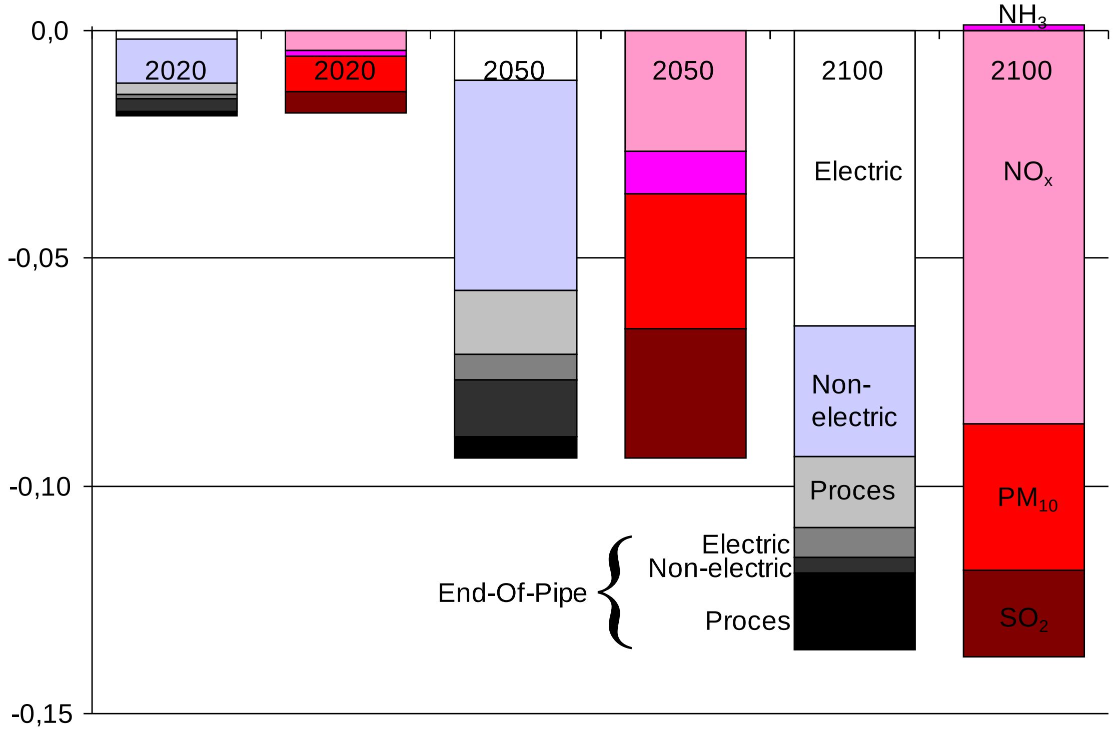
Strategies < EU-Roadmap, but “Only Air” also yields CO2 eq emission reductions



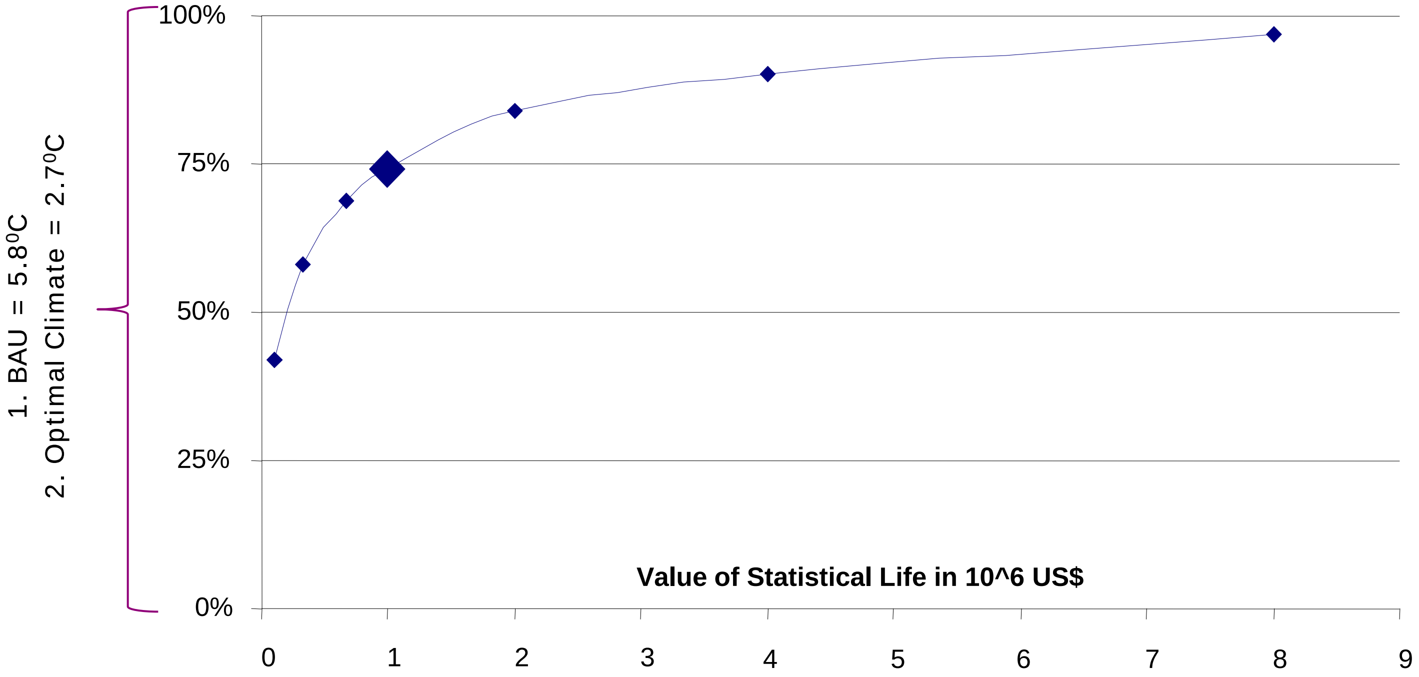


EOP options tackle only 33% and NO_x reductions 20-60% of Air pollution

Global Premature Deaths avoided from Only Air Pollution Policies decomposed to sources (% of population)

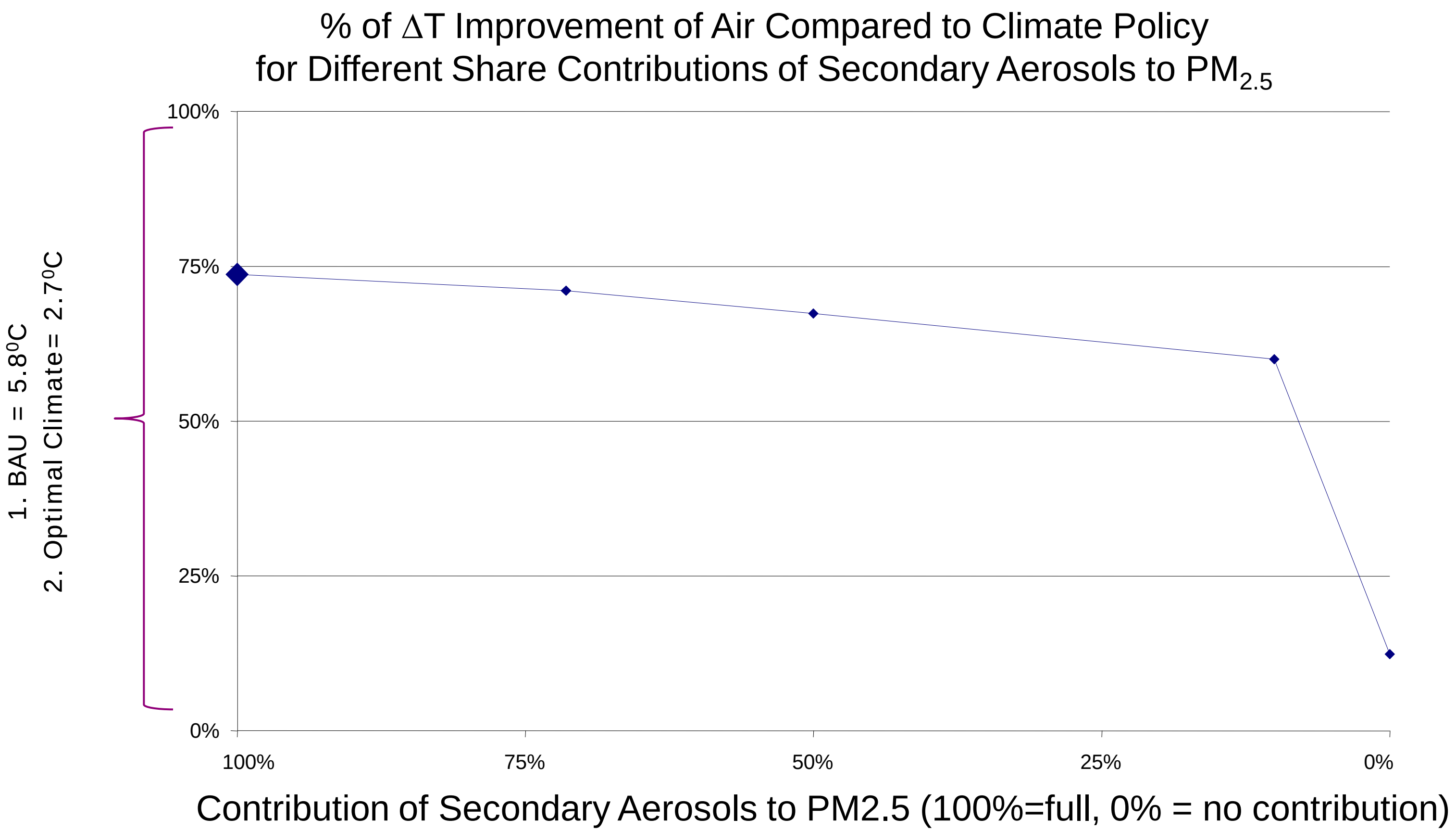


Stringent Air Pollution Policies → large climate change benefits

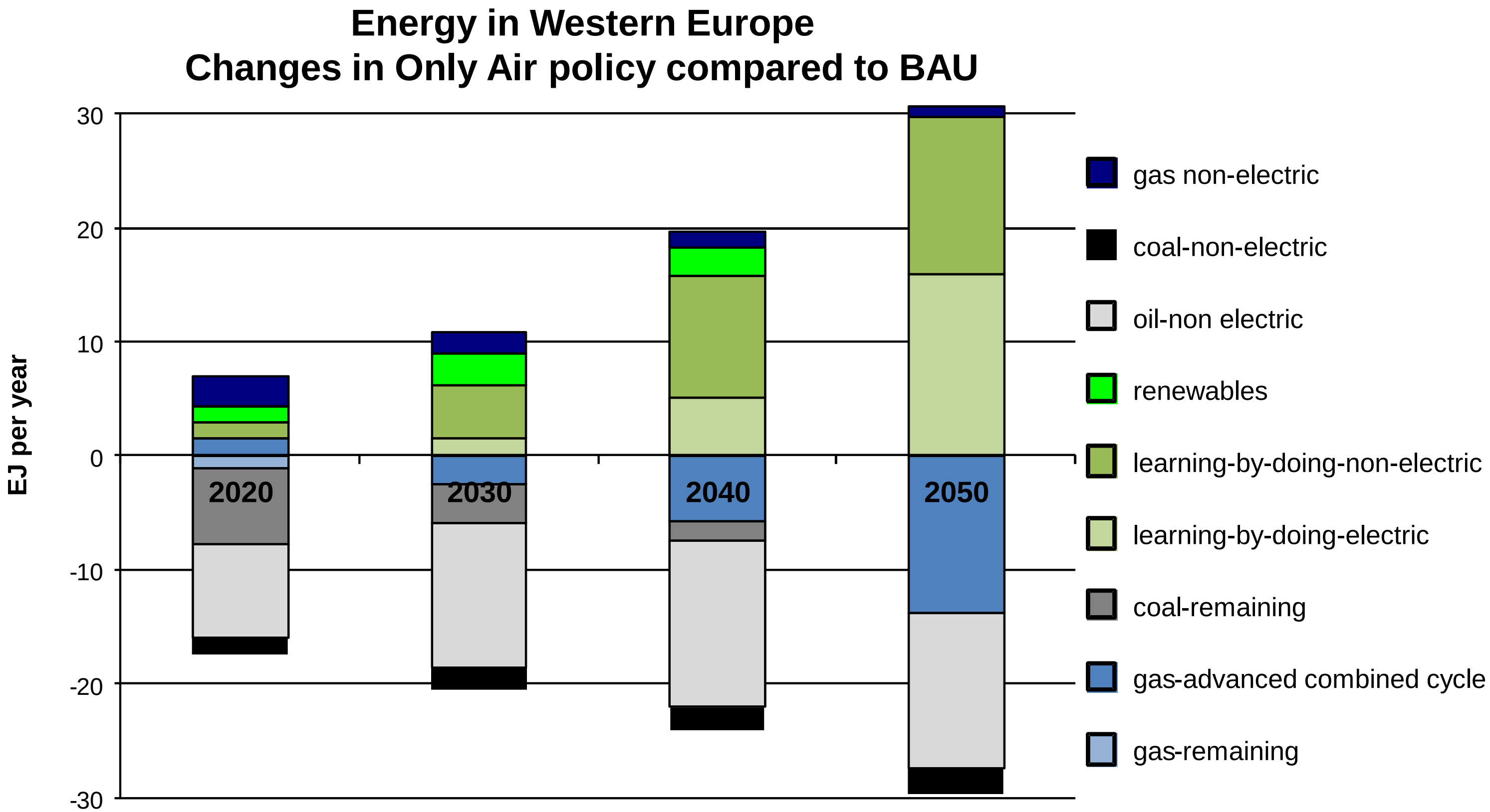


% of Temperature Improvement of Air compared to Climate Policy for different Values of Statistical Life in the base-year in EU

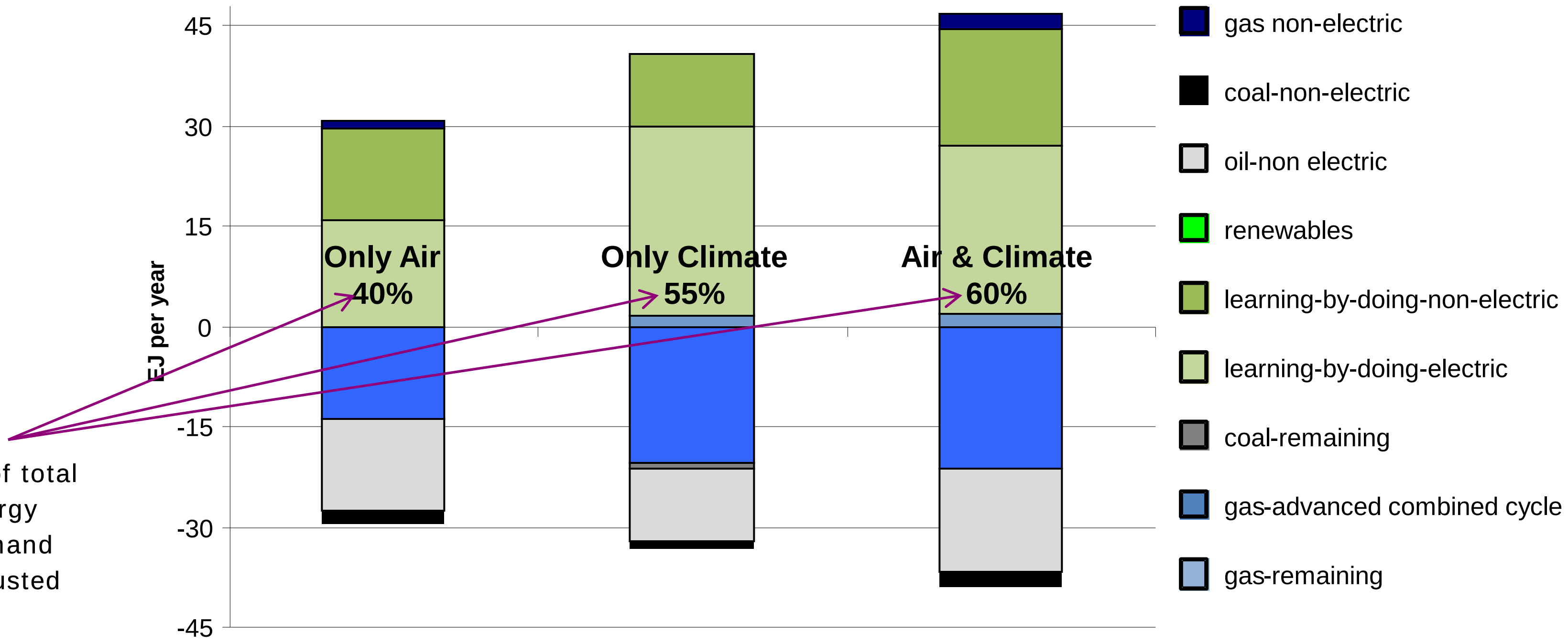
Climate Co-Benefits → 0, only if Secondary Aerosols to Air Pollution = 0!!



2020-2040: Learning Non-Electric markets, later in Electric markets (spillovers)



More Changes in Energy Markets & Learning in Electric in Climate Case



% of total energy demand adjusted

Air Policies are the primal, and generate large co-benefits to climate change, and involve

- EOP tackling 33% (potential is larger) & NOx reductions account 20-60% of the air pollution problem

- ΔTemperature = 40-100% of Climate Policy

- Climate Co-Benefit → 0, only if Secondary Aerosols to Air Pollution = 0!!

  no Nox contribution to air pollution

- Start learning Non-Electric markets, later in Electric markets