



Centre for
Energy,
Environment
and Health

Economic optimization of the Danish energy systems

- through minimization of direct costs as well as indirect costs related to air born pollution and anthropogenic climate change.

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CEEH is sponsored by the Danish Council for Strategic Research and runs over 5 years beginning in January 2007.



Main output

Economically optimized future energy systems for parts of Northern Europe at different time horizons.

Global externality costs related to the local emissions are included in the optimization process. Considered so far: health and global climate.

Plus a large number of bi-products

Inputs



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Main input:

- Economic growth
- Global energy prizes

Additional inputs:

- State of the art energy technology catalogue
- Population and health data, local demography (including future assumptions)
- IPCC scenario for global/hemispheric particle emissions according to scenario A1B.
- Global/hemispheric/regional weather evolution in year 2000.
- Global “climate cost” of one kilogram of CO₂ emission.
- IPCC scenario for physical climate changes according to scenario A1B.

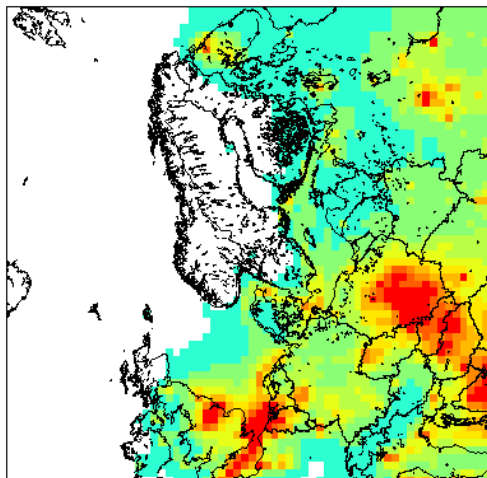


Interdisciplinary effort

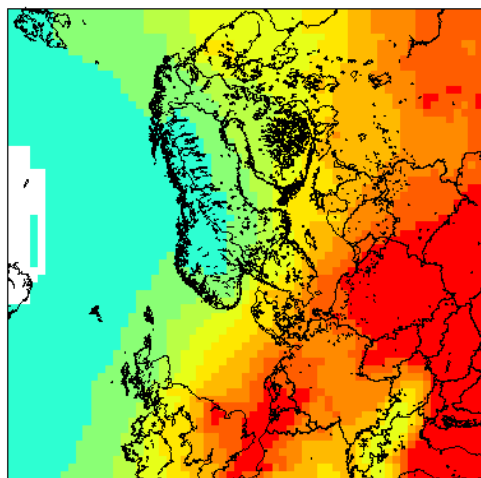
- Atmospheric Science (UoC, DMI, DMU/AU)
- Toxicology (AU, DMU)
- Epidemiology (NIPH/SDU, AU)
- Public health economy (DMU, CAST/SDU)
- Energy and system analysis (RISØ, DMU/AU, DMI)

Annual mean concentrations for the year 2000

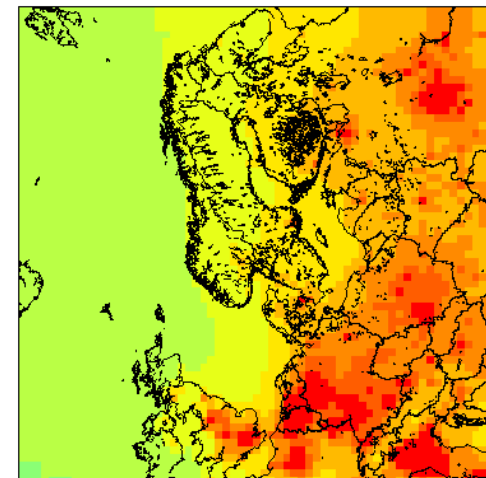
SO₂



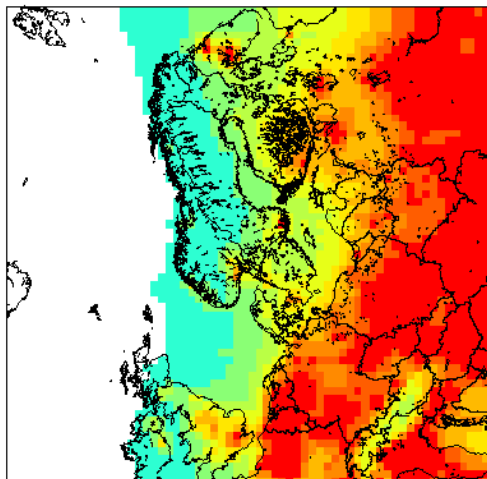
SO₄



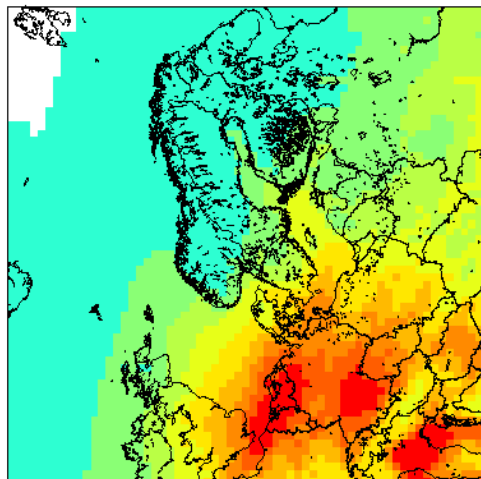
CO



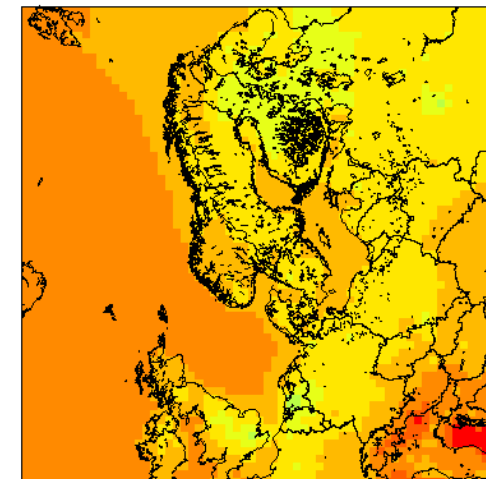
PM_{2.5}



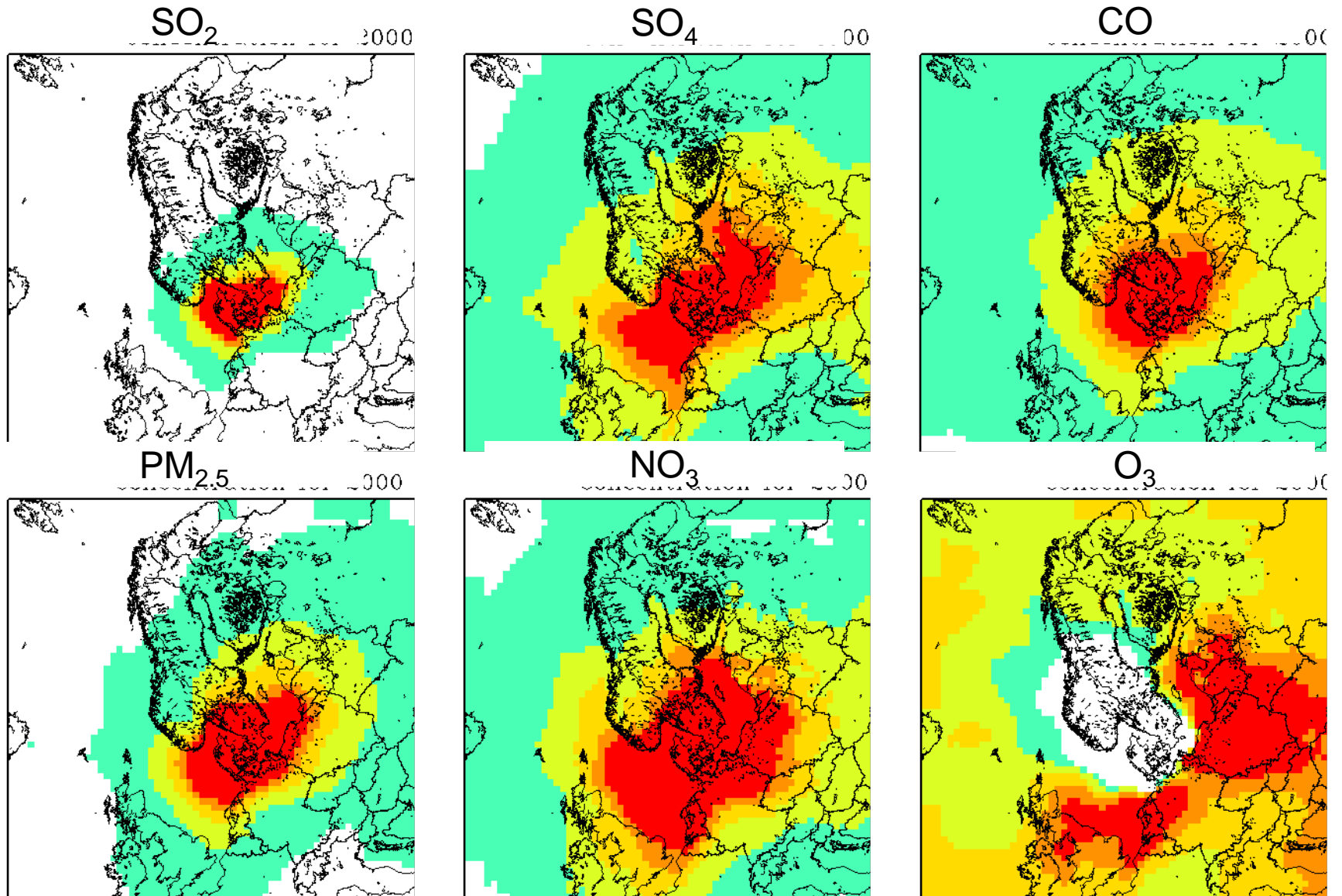
NO₃



O₃



Delta functions for the year 2000





Effects included in EVA

Response	Component	
Befolkningsdel		
Acute mortality (deaths)	SO ₂ , O ₃	All
Respiratory hospital admissions (cases)	SO ₂ , PM _{2.5} , NO ₃ , SO ₄	All
Congestive heart failure (cases)	CO, PM _{2.5} , NO ₃ , SO ₄	> 65
Cerebrovascular hospital admission (cases)	PM _{2.5} , NO ₃ , SO ₄	All
Chronic mortality (years of life lost)	PM _{2.5} , NO ₃ , SO ₄ , Dioxin	All
Bronchodilator use (cases)	PM _{2.5} , NO ₃ , SO ₄	Asthma
Cough (days)	PM _{2.5} , NO ₃ , SO ₄	Asthma
Lower respiratory symptoms (days)	PM _{2.5} , NO ₃ , SO ₄	Asthma
Chronic bronchitis (cases)	PM _{2.5} , NO ₃ , SO ₄	> 16
Restricted activity days (days)	PM _{2.5} , NO ₃ , SO ₄	> 16
Lung cancer (cases)	PM _{2.5} , NO ₃ , SO ₄	> 16
Infant mortality (cases)	PM _{2.5} , NO ₃ , SO ₄	Baby
Loss of IQ-points (points)	Bb	Baby
Loss of IQ-points (points)	Hg	Embryo

<i>Health effects (response)</i>	<i>Exposure-response function</i>	<i>Valuation Euros (2006-prices)</i>
MORBIDITY (Particulate matter)		
Chronic Bronchitis	8.2E-5 cases/μgm^{-3} (adults)	52,962 per case
Restricted activity days	8.4E-4 days/μgm^{-3} (adults)	131 per day
Hospital admissions		
<i>- respiratory</i>	3.46E-6 cases/μgm^{-3}	7,931 per case
<i>- cerebrovascular</i>	8.42E-6 cases/μgm^{-3}	10,047 per case
Congestive heart failure	3.09E-5 cases/μgm^{-3}	16,409 per case
Lung cancer	1.26E-5 cases/μgm^{-3}	21,152 per case
Asthma children (7.6 % < 16 years)		
<i>- bronchodilator use</i>	1.29E-1 cases/μgm^{-3}	23 per case
<i>- cough</i>	4.46E-1 days/μgm^{-3}	59 per day
<i>- lower respiratory symptoms</i>	1.01E-1 days/μgm^{-3}	16 per day
Asthma adults (5.9 % > 15 years)		
<i>- bronchodilator use</i>	2.72E-1 cases/μgm^{-3}	23 per case
<i>- cough</i>	2.8E-1 days/μgm^{-3}	59 per day
<i>- lower respiratory symptoms</i>	1.01E-1 days/μgm^{-3}	16 per day
MORTALITY		
Acute mortality (SO₂)	7.85E-6 cases/μgm^{-3}	2,111,888 per case
Chronic mortality (PM)	1.138E-3 YOLL/μgm^{-3} (>30 years)	77,199 per YOLL
Infant mortality (PM)	4.68E-5 cases/μgm^{-3} (> 9 months)	3,167,832 per case
Acute mortality (O₃)	3.27E-6*SOMO35 cases/μgm^{-3}	2,111,888 per case



Health-Cost Externalities for Europe and Denmark

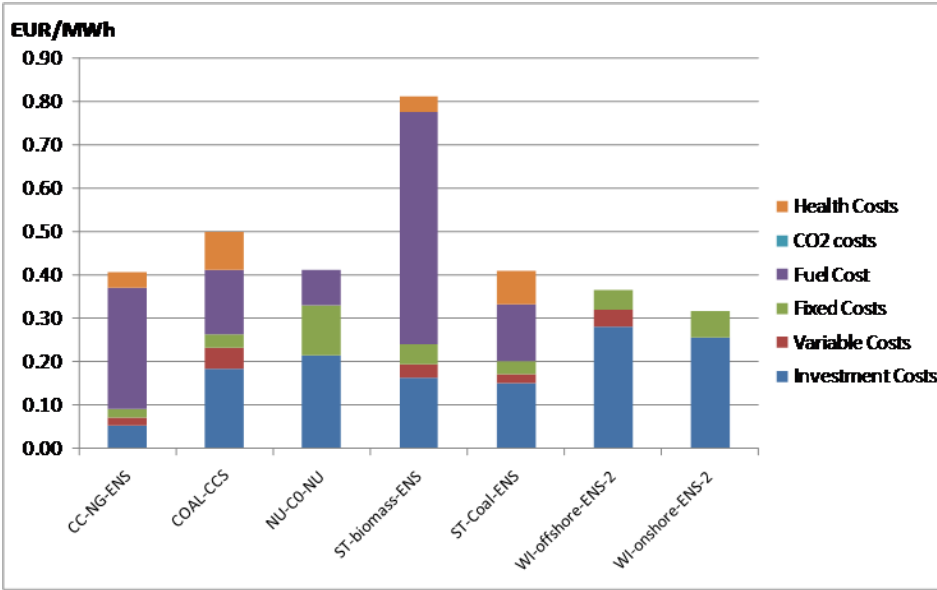
Total costs (Euros, 2006 prices)

	DK All emissions		DK Power plants		DK Road traffic		International BS+NS Ships	
	Total	Danish	Total	Danish	Total	Danish	Total	Danish
SO ₂	3.53E+07	1.52E+07	1.36E+07	3.95E+06	4.28E+06	1.86E+06	1.48E+09	1.45E+08
SO ₄	1.20E+09	9.20E+07	1.12E+08	9.21E+06	8.73E+06	3.07E+05	1.19E+10	3.48E+08
TotS SO₂+SO₄	1.24E+09	1.07E+08	1.25E+08	1.32E+07	1.30E+07	2.17E+06	1.34E+10	4.93E+08
O ₃	1.08E+08	4.34E+07	5.88E+06	1.20E+06	2.50E+07	3.31E+07	1.18E+09	2.14E+07
NO ₃	2.43E+09	3.20E+08	2.81E+08	1.87E+07	7.12E+08	9.92E+07	1.20E+10	3.40E+08
TotN (O₃+NO₃)	2.54E+09	2.77E+08	2.87E+08	1.75E+07	6.87E+08	6.61E+07	1.08E+10	3.18E+08
PM _{2.5}	3.21E+08	1.38E+08	7.83E+06	1.31E+06	6.19E+07	3.20E+07	-	-
CO	5.05E+05	1.57E+05	4.41E+03	4.98E+02	2.82E+05	1.01E+05	3.28E+04	1.93E+03
TOTAL	4.10E+09	5.22E+08	4.20E+08	3.20E+07	7.62E+08	1.00E+08	2.42E+10	8.10E+08

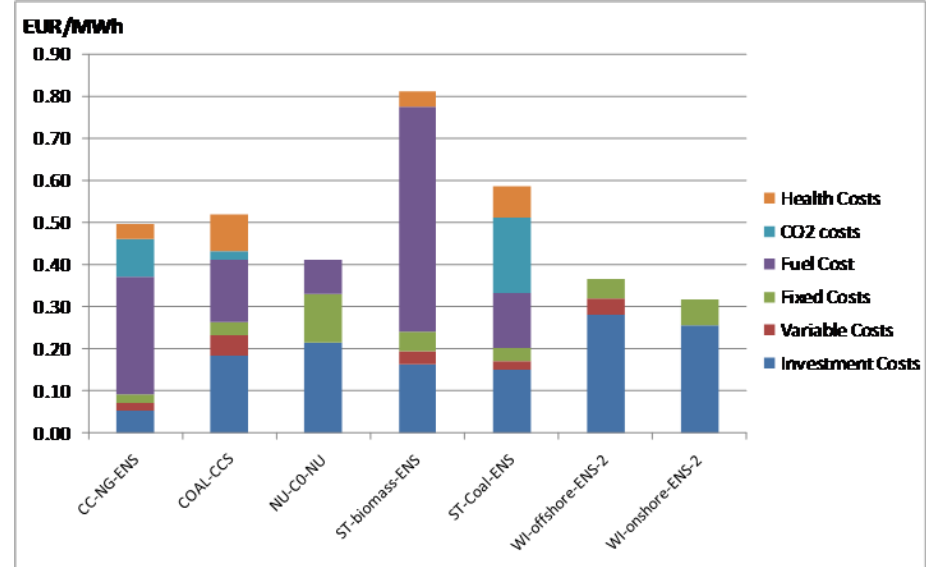


Power production prices in Euro per installed MWh

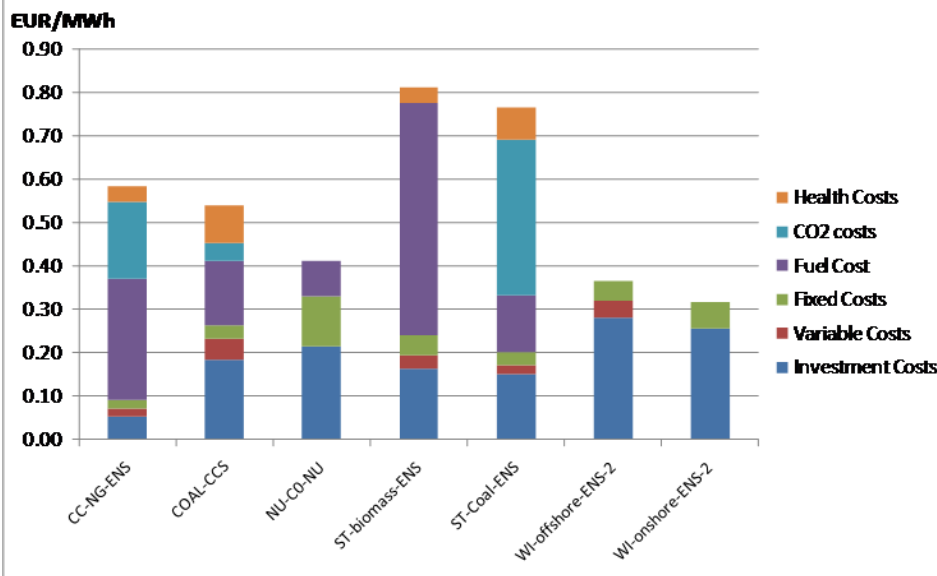
No additional CO2-price



CO2 price: 25€/tCO2



CO2 price: 50€/tCO2



All based on WEO2007 fuel prices



Balmorel simulations for year 2030

Case	SO₂, NO_x, CO and PM_{2.5} pricing	CO₂ price, Euro/t
Run1	no	0
Run2	yes	10
Run3	yes	25
Run4	yes	50
Run5	yes	0
Run6	no	50

CEEH model chain

