Environmental Health Impacts of European Policies for Mitigation of Climate Change – a Case Study for Integrated Health Assessment Using the INTARESE/HEIMTSA Methodology

USTUTT, THL, CERTH, JRC, TNO, IOM, UBath, CUEC, ENPC, RIVM, IC, NILU, ETH-Z, UM-ICIS, INERIS, met.no, MSC-East, UU, UoM, AUTH
The Policy Question:

What are the (negative or positive) impacts of
a) EU mitigation options (policies and resulting measures) to reduce greenhouse gas emissions
b) EU adaptation options (policies and resulting measures) to reduce impacts of climate change on human health worldwide?
Main activity areas:

- Energy supply and demand
- Transport
- Agriculture
- Waste
- Buildings and Urban Development

Main Pressures causing env. health impacts:

PM$_{10}$, PM$_{2.5}$, incl. secondary PM$_x$, ozone, noise, pesticides, PCBs, dioxins/furanes, heat;

indoor: PM$_{2.5}$, PM$_{10}$, ETS, radon, mould, formaldehyde
The Full Chain Approach

Variables
- Future Activities
- Emissions Releases
- Concentration, Level, Deposition
- Exposure, Dose, Intake

Models
- Scenario development
- Emission modelling
- Stack height, spatial planning
- Education, advise
- Policy interventions
- Impact modelling
- Aggregation valuation

Policy interventions
- Medication, prevention

Metabolism
- Exposure and intake modelling
- Exposure-response-relationships
- Health impacts

Emission modelling
- Emission factors
- Meteorology
- Population, Diet, Time-activity
- DALYs pdfs costs

Scenario development
- Changes in behaviour, activity
- Emission reduction and control
- Stack height, spatial planning
- Education, advise
- Exposure and intake modelling
- Impact modelling
- Aggregation valuation

Policy interventions
- Medication, prevention

Aggregation valuation
- Unit values

Health impacts
- Damage to ecosystems, materials

DALYs pdfs costs
‘Business as usual’ or reference scenario:

Activities and emission factors follow trend and include agreed policies, however no climate change mitigation measures after 2012;

Some adaptation measures included;

Worldwide GHG emissions and climate change according to IPCC A1B scenario
450 ppm or 2° scenario (climate protection scenario):
Embedded in a worldwide emission scenario aiming at not exceeding 2° temperature increase:
Reduction of EU GHG emissions by 20% 1990-2020 and 71% 1990-2050
Climate according to IPCC B1
Constraints:
Share of renewable energy on final energy consumption > 20% 2020, > 40% 2050
At least 10% biofuels in transport fuels 2020
Minimum market shares for electric and hybrid cars
Continuation of national policies of subsidizing renewable energies (e.g. PV)
Emission trading system continues: -31.5 % 2005-2020, then -1.74 % p.a.
### General assumptions

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GDP [10^{12}\ \text{€}_{2007}]</strong></td>
<td>11,7</td>
<td>17,8</td>
<td>24,4</td>
</tr>
<tr>
<td><strong>GDP</strong></td>
<td>Average annual growth 2010 - 2050: 1.7%, Regional differences among countries</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Oil price [\text{US\$}_{2007}/\text{bbl}]</strong></td>
<td>78</td>
<td>100</td>
<td>109</td>
</tr>
<tr>
<td><strong>Other assumptions</strong></td>
<td>Additional nuclear power in countries according to current national policy</td>
<td></td>
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</tbody>
</table>
Scenario generation:

- **Energy supply:**
  Minimizing energy service supply costs while observing constraints (e.g. maximum CO2 emissions): use of TIMES

- **Transport:**
  Simulation using a stock-activity-emission factor data base, partly data from TREMOVE

- **Agriculture:**
  use of scenarios from the IMAGE model for food production,
Final energy consumption by fuel (EU27)

- Others (Methanol, Hydrogen, GtL, CtL)
- Waste
- Renewables
- Heat
- Electricity
- Gas
- Petroleum products
- Coal
Net Electricity Generation (EU27)
Total land requirement for energy crop production EU
for comparison: arable land for food 1 Mio km² + grassland 0,5 km²
PM2.5-Emissions by Source Category for EU 29

PM2.5-Emissions EU 27+NO+CH

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th>2030</th>
<th>2050</th>
</tr>
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<tbody>
<tr>
<td>BAU</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Climate Scenario</td>
<td></td>
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</tbody>
</table>

**Source Categories:***
- Waste management
- Transport
- Solvent and other product use (Firework, Smoke)
- Small and Medium Combustion Plants
- Industry
- Energy
- Agriculture
NH₃-Emissions by Source Category for EU 29

NH₃-Emissions EU 27+NO+CH

- Waste management
- Transport
- Small and Medium Combustion Plants
- Industry
- Energy
- Agriculture

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2020</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAU Climate</td>
<td>3100</td>
<td>3400</td>
<td>3500</td>
</tr>
<tr>
<td>BAU Scenario</td>
<td>3200</td>
<td>3500</td>
<td>3600</td>
</tr>
<tr>
<td>BAU Climate</td>
<td>3300</td>
<td>3600</td>
<td>3700</td>
</tr>
<tr>
<td>BAU Scenario</td>
<td>3400</td>
<td>3700</td>
<td>3800</td>
</tr>
</tbody>
</table>
NO\textsubscript{x}-Emissions by Source Category for EU 29
SO$_2$-Emissions by Source Category for EU 29

![SO$_2$-Emissions EU 27+NO+CH chart]

- **BAU**: Baseline scenario
- **Climate Scenario**: Scenario with climate action
- **kt**: Kilogram of carbon equivalent

**Key Categories**:
- Waste management
- Transport
- Small and Medium Combustion Plants
- Industry
- Energy
- Agriculture

**Years**:
- 2020
- 2030
- 2050
From emissions to concentrations/levels/intake/exposures

Used models:

- Outdoor air: EMEP, Polyphemus, Chimere, ECOSENSE (parametrized), MSC-EAST (POPs, pesticides)
- New tool for assessing local impacts of pesticide application
- Urban increment: new ‘urban increment estimation tool’
- Multimedia to food: new multimedia models dynamiCROP (pesticides), PANGEA (POP)
- Noise: new noise upscaling model
- Indoor: Steady state mass balance model with homogenous mixing
- Exposure: new LAMA model
Personal exposure – Results (in $\mu g/m^3$)

Average PM2.5 exposure over EU-30 per subgroup for the six scenarios

![Graph showing average PM2.5 exposure over EU-30 per subgroup for the six scenarios.](image-url)
DALYs due to all stressors for 2020 Climate scenario (log scale)

1 If no additional measures to improve air exchange rate in buildings are implemented.
2 Results from the Exiopol project.
DALYs due to outdoor air pollutants
Air pollutants – sensitivity analysis

<table>
<thead>
<tr>
<th></th>
<th>Variant 1</th>
<th>Variant 2</th>
<th>Variant 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPM2.5</td>
<td>1</td>
<td>* 1.5</td>
<td>* 1.75</td>
</tr>
<tr>
<td>nitrates</td>
<td>1</td>
<td>* 0.5</td>
<td>* 0.25</td>
</tr>
<tr>
<td>sulphates</td>
<td>1</td>
<td>* 0.6</td>
<td>* 0.25</td>
</tr>
<tr>
<td>PPMcoarse</td>
<td>1</td>
<td>* 1</td>
<td>* 1</td>
</tr>
<tr>
<td>nitratescoarse</td>
<td>1</td>
<td>* 0.5</td>
<td>* 0.25</td>
</tr>
</tbody>
</table>

Weighing scheme for different fractions of particulate matter.

Figure 8-1: DALYs due to outdoor air pollution: Approximate fractions of SIA, PPM and ozone according to different weighing schemes for sensitivity analysis.
Damage costs due to outdoor air pollutants

Damage costs in Million EUR\textsubscript{2010} due to air pollutants

- Ozone
- PPM 2.5
- PPM10
- Sulphates
- Nitrates 2.5
- Nitrates coarse

<table>
<thead>
<tr>
<th></th>
<th>BAU 2020</th>
<th>Policy 2020</th>
<th>BAU 2030</th>
<th>Policy 2030</th>
<th>BAU 2050</th>
<th>Policy 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damage costs in Million EUR\textsubscript{2010}</td>
<td></td>
<td></td>
<td></td>
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Differences: Policy – BAU (DALYs)

Million DALYs in EU29 (Policy - BAU)

Stressor groups

- Heat
- POPs, Pesticides
- Radon, Dampness, Formaldehyde
- Noise
- ETS (PM based)
- PPM
- SIA, ozone

2030
2050

Million DALYs
Insulation Scenario

Change (between insulation and BAU/Ref) in different metrics due to renovation (= *additional* DALYs and damage costs) (effects due to ETS might be overestimated)

<table>
<thead>
<tr>
<th>Stressor</th>
<th>DALYs</th>
<th>Damage costs (mio. EUR$_{2010}$)</th>
<th>Emissions of CO$_2$-equ (tons)</th>
<th>DALYs / kt CO$_2$-equ.</th>
<th>Damage costs EUR / t CO$_2$-equ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM from ETS</td>
<td>≈ 200,000</td>
<td>≈ 24,000</td>
<td>≈ 24,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>to 300,000</td>
<td>to 50,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radon</td>
<td>≈ 140,000</td>
<td>≈ 6,310</td>
<td>≈ 6,310</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>to 250,000</td>
<td>to 11,270</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dampness</td>
<td>≈ 35,000</td>
<td>≈ 1,580</td>
<td>≈ 1,580</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>to 60,000</td>
<td>to 2,700</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sum</td>
<td>≈ 560,000</td>
<td>≈ 47,000</td>
<td>-70,000,000</td>
<td>≈ 8</td>
<td>≈ 670</td>
</tr>
</tbody>
</table>
Agriculture 2030

Reduced cattle scenario:
(additional DALYs and damage costs)

<table>
<thead>
<tr>
<th>Policy vs. BAU</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided CO$_2$-equ. [kt]</td>
<td>13,000</td>
</tr>
<tr>
<td>Additional damage costs [million EUR$_{2010}$]</td>
<td>6,000</td>
</tr>
<tr>
<td>Add. EUR / t avoided CO$_2$-equ.</td>
<td>460</td>
</tr>
<tr>
<td>Add. mDALY / t avoided CO$_2$-equ.</td>
<td>8</td>
</tr>
</tbody>
</table>
Single measures traffic 2020

Avoided mDALYs / t CO₂-equ. 2020

- City toll
- Cycling in cities
- Fuel Tax
- PC toll
- Speed limit on motorways
- Tyre pressure monitoring system
- Green Wave
- Economic driving
- Gear shift indicator
Single measures 2020 electricity generation

Avoided mDALYs per ton avoided CO$_2$-equ.
Additional mDALYs per tonne of avoided CO₂-eq. emissions for heat generation using wood in comparison to the use of fossil fuels
Conclusions

i. The impact of most climate change mitigation policies on environmental human health is about as important as the climate change effects.

ii. Some policies, especially biomass burning and reducing air exchange rates in houses, cause quite high additional health impacts.

iii. The analysis allows a ranking of stressors in environmental media with regard to overall health impacts:
PM (and PM-based ETS) -> noise, radon -> ozone -> mould -> dioxins, heat waves, pesticides -> PCBs -> formaldehyde

iv. In general: relevant ‘side effects’ will change policy recommendations substantially, should thus be taken into account when making decisions and can be taken into account using the IEHIA methodology

More information: www.integrated-assessment.eu