Structured, Science-based Environmental Policy Making: The Case of Air Pollution in Europe

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International Institute for Applied Systems Analysis (IIASA)

- International and independent research organization
- Located 20 km south of Vienna in Austria
- Founded during the Cold War (1972) on neutral soil
- 24 Members (typically Nat’l Academies of Sciences):
  - USA, China, India, Brazil, Russia, UK, Germany, Indonesia, South Africa, Japan, Australia, Pakistan, + 12
- Policy-oriented systems analysis of:
  - Climate and Energy
  - Food and Water
  - Poverty and Equity
- 250 international researchers
Suppose we could extend your life expectancy by one month.

How much would you be willing to pay for this, every year from now until the end of your life?

The new EU directive on air pollution (adopted on 7 Oct 2015 by the EU parliament) can achieve this at $8/yr per person.
Why environmental policy? (and how science can help crafting it)

Two theories of intervention:
- To correct 'market failures' (Public interest theory)
- Avoid intransparent and 'irrational' decision making influenced by particular interest groups (Public choice theory)
Human health impacts

EU in 2005
Loss in statistical life expectancy due to PM2.5 pollution:

8.4 months
(355 million life years lost)

EU in 2005
Cases of premature deaths attributable to ground-level ozone

26,400 cases

Acidification

EU in 2005
Forest area with acid deposition above their critical loads
12.5%

Freshwater catchment areas with acid deposition exceeding critical loads for acidification
18,000 km²

EU in 2005
Ecosystem areas with excess nitrogen deposition
1,150,000 km²

Eutrophication
The causal chain:
Where policy targets are set

- **Human Activities**: Emission standards for technologies
- **Emissions**: Emission caps
- **Concentrations**: Ambient air quality standards
- **Impacts**: Loss of life Environmental quality

- Energy policy
- Agriculture policy
- Etc.
Principles of the GAINS model:

• Multi-pollutant, multi-effect integrated assessment model

Greenhouse gas – Air pollution INteractions and Synergies

- Emission factors
- Control technologies
- Activities
- Mitigation strategies
- Cost optimization
- Impacts
- Impact indicators
- Concentrations
- Dispersion, atmospheric chemistry
- Targets
GAINS model: some specifications

Emissions module
• 43 countries in Europe
• 10 pollutants + 6 GHGs
• 1990-2050 – 5yr-steps
• >1,000 emission source types per country
• 3-8 mitigation options per source
• Technology costs
• Technology constraints

Impacts
• Impacts:
  – Mortality PM2.5
  – Mortality ozone
  – Eutrophication
  – Acidification
• Spatial resolution: 28 km x 28 km

Freely accessible web interface:
http://gains.iiasa.ac.at/models/index.html
Fine Particulate Matter
< 2.5 micrometer diameter (PM2.5)

Primary particles
• Directly emitted from
  – Fly ash (coal burning)
  – Incomplete combustion
  – Industrial processes
  – Dust
  – Sea salt
  – Sand
  – Re-suspension

Secondary matter
• Formation in chemical and physical processes from emissions of:
  – Primary particles
  – Sulfur dioxide (SO$_2$)
  – Nitrous Oxides (NOx)
  – Ammonia (NH$_3$)
  – Volatile organics (VOC)
# The Matrix

<table>
<thead>
<tr>
<th>Health impacts:</th>
<th>PM (Loss in life expectancy)</th>
<th>O₃ (Premature mortality)</th>
<th>Vegetation damage:</th>
<th>O₃ (AOT40/fluxes)</th>
<th>Acidification (Excess of critical loads)</th>
<th>Eutrophication (Excess of critical loads)</th>
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<td>PM</td>
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Who is responsible for emissions? (multiple stakeholders)

EU28 in 2010
The 7-phase process

1. Bilateral consultations with Member States
2. Assessment of current policies
Assessment of current policies

**Figure 4.5: SO$_2$ emissions of the EU-27 by SNAP sector**
Assessment of current policies

Emissions

- SO\textsubscript{2}
- NO\textsubscript{x}
- PM\textsubscript{2.5}
- NH\textsubscript{3}
- VOC

Loss in life expectancy

- 2000
- 2030 Baseline

In Figure 4.11: Decrease in SO\textsubscript{2} emissions from industrial processes, 2000–2030. Figure 4.12: Transport-related emissions as a percentage of total SO\textsubscript{2} emissions.

Figure 4.13: Comparison of NO\textsubscript{x} emissions among different sectors, 2000–2030.

Figure 4.14: Changes in PM\textsubscript{2.5} emissions from various sources, 2000–2030.

Figure 4.15: Reduction in NH\textsubscript{3} emissions from agricultural processes, 2000–2030.

Figure 4.16: Decline in VOC emissions from industrial transport, 2000–2030.
The 7-phase process

1. Bilateral consultations with Member States
2. Assessment of current policies
3. Assessment of reduction potentials
Scope for reducing, e.g. future PM2.5 emissions

![Graph showing PM2.5 emissions by sector and year]

Figure 3.3: PM2.5 emissions of the TSAP 2013 Baseline; Current legislation (CLE) and Maximum Technically Feasible Reductions (MTFR), EU-28
3.3.2 Health impacts from ground-level ozone

The TSAP 2013 Baseline suggests for 2025 approximately 18,000 cases of premature deaths from exposure to ground-level ozone in the EU-28 (Figure 3.11). This is safely below the 10% reduction target (25,000 cases) that was established by the 2005 Thematic Strategy on Air Pollution for 2020 relative to 2000, mainly due to more optimistic expectations on the development of hemispheric background ozone levels.

Additional emission reduction measures within the EU-28 could save another 2,800 cases of premature deaths.

The spatial pattern of the health-relevant SOMO35 indicator, and how this will be influenced by the different emission reduction scenarios, is presented in Figure 3.10.

Figure 3.9: Years of life lost (YOLLs) due to exposure to fine particulate matter, EU-28

Figure 3.10: Years of Life Lost (YOLL)
The 7-phase process

1. Bilateral consultations with Member States
2. Assessment of current policies
3. Assessment of reduction potentials
4. Target setting options + ambition levels
Target setting approaches

1. **Human Activities**
   - Energy policy
   - Agriculture policy
   - Etc.

2. **Emissions**
   - Emission caps
   - Emission standards for technologies

3. **Concentrations**
   - Ambient air quality standards

4. **Impacts**
   - Loss of life
   - Environmental quality
Choosing a target level: Marginal costs and marginal benefits

Figure 4.2: Marginal emission control costs and marginal health benefits in 2025
The 7-phase process

1. Bilateral consultations with Member States
2. Assessment of current policies
3. Assessment of reduction potentials
4. Target setting options + ambition levels
5. Proposal by the Commission
Key elements of adopted proposal

- 67% gap closure on PM-health indicator in 2030
  - life expectancy -> + ~ 1 month
  - Resulting emission ceilings for 5 pollutants in 28 Member States
- Co-effects on other indicators
  - Avoided 1,000 ozone-related deaths per year
  - 20,000 km² forests protected from acidification
  - 140,000 km² ecosystems protected from eutrophication
- 3.3 billion Euros/yr
  - 0.021% of GDP in 2030 (0.001%-0.176% across MSs)
  - $8 per person per year
The 7-phase process

1. Bilateral consultations with Member States
2. Assessment of current policies
3. Assessment of reduction potentials
4. Target setting options + ambition levels
5. Proposal by the Commission
6. Bilateral consultations + sensitivity studies
7. Additional analyses for EU parliament

Adoption by EU parliament and Council of Ministers
Structured, science-based decision making

• A multi-stage (multi-year) process
  – Multi-way iterative communication

• Integrated assessment methods
  – Interdisciplinary (multidisciplinary + integration)
  – Independent scientific institution(s)
  – Open source data and information
  – Identification of win-win strategies

• Clear communication of principles:
  – cost-effectiveness and (cost < benefits)
  – equity

• Clear distinction between:
  – Peer-reviewed evidence-focussed science
  – Expert judgements
  – Value judgements by stakeholders
Conclusions

Structured, science-based decision making

– allows a systematic assessment of different options in collective action problems
– can result in cost-effective environmental policy
– can enhance trust that new regulation is rational, efficient, and overall beneficial
Example:
cost-optimal distribution of PM2.5 reduction measures

Figure 4.7: Further reductions of PM2.5 emissions (beyond the baseline) of the B7 scenario, relative to baseline emissions