Current status and future potential of the multi-pollutant approach to air pollution control in Japan, China, and South Korea

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Worsening Air Pollution in East Asia

- Transboundary
- Domestic

Need to Link to Climate Change (Cobenefits & Cost Effectiveness)

Increasing Complexity: Secondary Pollutants (PM2.5 & Ozone) composed of primary pollutants

How can international (regional) cooperation help?

Lessons from LRTAP in Europe? (Convention on Long Range Transboundary Air Pollution)
- Legally binding treaty
- Multi-pollutant Multi-effect approach (MPME)

Main functions of MPME:
- Address secondary pollutants like ozone (addresses multiple pollutants and complexity)
- Address multiple effects (environment & health)
- Improve cost effectiveness of reduction measures

This presentation focuses on MPME

Discussed at Tripartite Environment Ministers Meeting
Secondary Pollutants & Primary Pollutants

Primary Pollutant

NOx

VOCs (Volatile Organic Compounds)

Secondary Pollutant

Ozone

Secondary Pollutant

PM2.5 is also a secondary pollutant

It is more effective to regulate secondary pollutants based on primary components (rather than simply regulate secondary pollutants)
Research Questions

1. What is the potential for using MPME in East Asia (with different conditions than Europe)?

2. What are the main components of MPME?

3. To what extent are China, Japan, Korea already implementing MPME?

4. What kinds of capacities, institutions, administrative mechanisms are necessary for implementation?

5. How can international (regional) cooperation assist?

Rationale:
- Concept is complex & confusing
- Typical interpretation based on LRTAP
- Hard to compare to other countries

Methodology:
- Inductive approach
- Analyzed cases of LRTAP, US, China, Japan, Korea, Thailand

Methodology:
- Policy documents
- Interviews with experts and government officials
OUTLINE

1. MPME Concept
2. Country Examples
3. MPME Steps and Regional Cooperation
Concept map of the Multi-pollutant Multi-effect (MPME) approach in the Gothenburg Protocol of LRTAP

Multiple (Primary) Pollutants
- SO₂
- NOₓ
- NH₃
- VOCs

Multiple Effects
- ACIDIFICATION
- EUTROPHICATION
- GROUND-LEVEL OZONE
- SURFACE WATERS
- TERRESTRIAL ECOSYSTEMS
- MARINE ECOSYSTEMS
- YIELD LOSSES (crops and forests)
- HUMAN HEALTH
- MATERIALS

Integrated Modeling (RAINS => GAINS) / EMEP Monitoring
- Interactions among pollutants
- Effects of pollutants
- Reduction technologies
- Reduction costs
- Transboundary movement

MPME Elements
A. System of Scientific Analysis
B. Target Concept & Rationale
C. Recommendations for targets

Source: LRTAP Secretariat 1999, revised 2002
MPME’s Role in the LRTAP/Gothenburg Protocol

**MPME as a system of scientific analysis**

**MPME Role: Support Negotiations**
- Informs target setting
- Cost-benefit optimization
- Target concept, principles
- Scientific justification

**GOTHENBURG PROTOCOL**
- Legally binding treaty
- Reduction targets informed (recommended) by MPME
- But actual targets are decided politically
- Countries have different targets
- Targets are cost optimized

**Negotiations for Revision of Gothenburg Protocol**
- How to incorporate new pollutants (e.g. PM2.5)
- How to incorporate climate change?

**Note:**
Gothenburg/MPME is an integrated approach, but not comprehensive (still room for more)

Example of adding new pollutants, new effects

Can conduct analysis without linking to a treaty

MPME as a science policy interface
Multi-Pollutant and Multi-Effect dimensions can be distinguished

Need to distinguish:

a) scientific aspects

b) policy aspects

MPME is a scientific decision tool to inform policy & target setting
## Transition from a Single Pollutant to a Multi-Pollutant Approach

### Scientific Aspect of MP Approach
- Focus on secondary pollutants (PM, ozone)
- Analyzing interactions among primary pollutants
- (Not just increasing quantity of pollutants addressed)

### Control Strategy

<table>
<thead>
<tr>
<th>Control Strategy</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single Pollutant Control</strong></td>
<td></td>
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</tr>
<tr>
<td>Phase 1 (S1)</td>
<td>Managing one or more primary pollutants individually</td>
<td>Direct toxicants (NO2, Sulfur, VOC, Heavy Metals), precursors for simple secondary pollutants (NOx and Sulfur for acid control)</td>
</tr>
<tr>
<td>Phase 2 (S2)</td>
<td>Managing complex secondary pollutants through one primary pollutant</td>
<td>VOC or NOx for Ozone control</td>
</tr>
<tr>
<td><strong>Multi Pollutant Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase 1 (M1)</td>
<td>Managing a secondary pollutant through multiple primary pollutants</td>
<td>VOC and NOx for Ozone control, Sulfur for PM2.5 control</td>
</tr>
<tr>
<td>Phase 2 (M2)</td>
<td>Managing multiple secondary pollutants and toxicants in an integrated way</td>
<td>Simultaneous Ozone and PM management</td>
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</tbody>
</table>

### Policy focus:
- Focus on secondary pollutants (PM, ozone) by managing components
- MP is not a list of several pollutants regulated separately
## Multi-Effects Concept

<table>
<thead>
<tr>
<th></th>
<th>Multi-Effects (ME)</th>
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</thead>
</table>
| **Scientific Analysis**  | • Analysis of several effects  
                          | • Complex integrated modeling  
                          | • Needs considerable scientific capability |
| **Link to Policy, Regulation** | • Extent to which effects are considered in setting targets  
                           | • Considering several effects |
| **Comparison with “single” effects** | • Even analysis of single effects is not easy  
                            | • Single-effect analysis foundation needed to analyze multiple effects |
## Progression of MP & ME Implementation in LRTAP

<table>
<thead>
<tr>
<th>Multi-effects → Multi-pollutants ↓</th>
<th>Effects Supported</th>
<th>Effect-based</th>
<th>Multi-effects</th>
<th>Climate</th>
<th>Risk-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 Direct toxicant or acid component (1)</td>
<td>LRTAP Sulfur Protocol (1985)</td>
<td>LRTAP Sulfur Revision (1994)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2 O3 or PM Component (1)</td>
<td></td>
<td>LRTAP VOC Protocol (1991)</td>
<td>LRTAP NOx Revision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1 O3 or PM Component (2)</td>
<td></td>
<td></td>
<td>Gothenburg Protocol (1999)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M2 O3, PM, Acid, component, toxicant, etc. (2+)</td>
<td></td>
<td></td>
<td></td>
<td>Gothenburg Revision (2012)</td>
<td></td>
</tr>
</tbody>
</table>

Multi-pollutant and multi-effect aspects progress in parallel in LRTAP.
### Main Arguments

#### Conventional Thinking
- MPME is an integrated approach.
- MPME is closely linked to a legally binding treaty (LRTAP).
- Therefore, MPME may not be feasible in East Asia.

#### Main Results
- MPME consists of several components.
- MPME is a system of scientific analysis, not a treaty.
- MPME assists decision making about targets (sci./policy link).
- MPME improves effectiveness, lowers costs.
- Can set targets without MPME, but will be less effective.
- Components can be separated and implemented in steps.
- China, Japan, Korea, already moving towards MPME steps (can be used domestically, not just for international treaties).
- Less developed countries can also begin steps.

### International cooperation can be helpful without a treaty
- Focus can be on information sharing & capacity building.
- Can use MPME in E. Asia as a scientific system w/o a treaty.
- Scientific epistemic community can promote MPME.
2. COUNTRY EXAMPLES
### US Case

<table>
<thead>
<tr>
<th>US typically uses a single pollutant approach.</th>
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<tbody>
<tr>
<td>US legal &amp; regulatory framework is not suited to MPME.</td>
</tr>
<tr>
<td>US has domestic transboundary air pollution issues (also international transboundary issues with Canada).</td>
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<tr>
<td>However, USEPA has been trying to develop &amp; implement MPME in a stepwise approach since the 1990s.</td>
</tr>
<tr>
<td>US has been promoting MPME-type research on multiple effects</td>
</tr>
<tr>
<td>US calls it a “Multi-pollutant” approach, but its efforts include effects.</td>
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<tr>
<td>Some pilot projects and voluntary initiatives with states &amp; companies (since MPME can reduce costs).</td>
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**MPME can be implemented:**
- In steps
- In a voluntary context (cost motivation)

**Notes:**
- **MPME as scientific analysis**
- **EPA uses a different name**
- **Legally binding approach may be helpful, but not necessary**
- **Cost incentive is important for voluntary action**
POLICY ASPECTS

- China regulates multiple pollutants
- Secondary pollutants now regulated (PM2.5, O3)
- Concept: co-control (climate & air)
- Government promotes scientific analysis
- Analysis of interactions and effects not directly used in policy
- Targets, standards are based on technological feasibility, economic considerations, other countries
- Regional management plan for domestic transboundary air pollution (future domestic LRTAP?)

SCIENTIFIC ANALYSIS

- China (including a few major cities) has some capability to analyze effects and interactions, but not enough to implement nationwide
- Research on air-climate cobenefits
- Research on health impacts
- Increased monitoring (incl. PM2.5)

Implications

- China is already moving towards a domestic MPME
- Development of MPME in China can be further encouraged
China: Regional Air Pollution Management

12th Five Year Plan On The Prevention And Control Of Air Pollution In Key Regions

- Address regional transboundary pollution (from Beijing Olympics, etc.)
- Designates key regions and city clusters
- Sets up coordination mechanisms
- Additional pollutants (PM2.5, Ozone, VOCs)
- Stronger targets & implementation measures
  - (e.g. stronger EIA, tech. requirements, industrial adjustment, key projects, etc.)

Analysis

- Good policies on paper / difficult to implement
- Sets up a coordination structure
- (But coordination may be difficult)
- Originates from Beijing Olympics w/modeling
- Modeling/MPME analysis could be incorporated
- Could become domestic LRTAP
Japan Case

Need for multi-pollutant approach not widely recognized until recently
Transition motivated by low attainment of EQS for photochemical oxidants

Single pollutant Phase 1
Japan used historically (1970s =>)

Single pollutant Phase 2
VOC emission reduction policy to address SPM & oxidants (2004)

Multi pollutant Phase 1
NA

Multi pollutant Phase 2
Follow-up scheme to the VOC policy (2012)

Policy Implications

- Based on a policy mix of legal control & voluntary action plans.
- Policy target overachieved (44.1% reduction from 2000-2010 instead of 30%).
- Still attainment of photochemical oxidant’s EQS remains extremely low.

- Panel recommended new committee to address not only VOC, but also photochemical oxidants & PM2.5.
- Consideration: the complex linkages among VOC, photochemical oxidants and PM2.5, need for data on VOC emissions & effectiveness in emission reduction, and need to reduce business costs.

- Need for further research on chemical reaction
- Need more accurate modeling & integrated assessment systems to improve analysis of effectiveness of reduction policies of precursors
South Korea Case

- Risk based management concept introduced in 1980s
  - Research mainly on single pollutants & basic risk assessment
  - Research results not generally accepted by policymakers
  - Integrated MPME perspective is needed to incorporate results into policy

- MPME concept is not used in Korea, but similar efforts have been made or are underway
  - Secondary pollutants addressed in policies related to Seoul (2003, 2005) (NOX, SOX, VOC, PM10)
  - Korean policies are moving in the direction of risk based comprehensive systemic management, including toxicology
  - Discussions on integrated management which includes air environment, energy, climate (and considering state of the economy, possibility of employment creation) (E.g. Green growth policies linking air & climate)
  - Focus of PM is shifting from PM10 to PM 2.5
  - NIER & IIASA collaboration on integrated climate & air to develop GAINS Korea from 2013
## Comparison of Single/Multi-Pollutant Transition Status in Case Study Countries

<table>
<thead>
<tr>
<th>Phase</th>
<th>Japan</th>
<th>China</th>
<th>South Korea</th>
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<tbody>
<tr>
<td><strong>Single Pollutant</strong></td>
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<tr>
<td><strong>Phase 1</strong></td>
<td>Initial policy (regulating several pollutant)</td>
<td>Initial policy</td>
<td>Initial policy</td>
</tr>
<tr>
<td><strong>Phase 2</strong></td>
<td>VOC for ozone &amp; PM10</td>
<td>Policy transition? Capital region</td>
<td></td>
</tr>
<tr>
<td><strong>Multi Pollutant</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Phase 1</strong></td>
<td>NA</td>
<td>Policy transition?</td>
<td>PM 2015 Management Plan: NOx &amp; VOC for PM2.5</td>
</tr>
<tr>
<td><strong>Phase 2</strong></td>
<td>Transition to integrated ozone, PM2.5 &amp; VOC discussion</td>
<td>Research &amp; policy trend (regional management)</td>
<td>Policy in transition to risk-based management</td>
</tr>
</tbody>
</table>

Note: This table was not included in the paper.
Capacity for MPME

Key Foundation: Scientific Capacity (Many developing countries lack)

Scientific
- Analytical capability (human resources)
- Multidisciplinary cooperation
- Monitoring capability

Administrative
- Officials need some technical understanding
- Ability to coordinate between departments
- Legal framework that allows differentiated targets

International cooperation
- Means for international cooperation among scientists
- Mechanism for information sharing
- Means for scientists to communicate with policymakers
Main Ideas

- MPME can be introduced in a stepwise manner
- Range of possible focuses for pollutants & effects
- Focus first on scientific analysis, then incorporate into policy (variable scientific support for an influence on targets)
- Targets: range of possible magnitudes, types, principles

Scientific Analysis

- Start with studies & models
- Focus on interactions & effects
- Less emphasis on transboundary aspects

Policy

- Start with domestic policy framework
- International cooperation can use various models
- International cooperation can be voluntary
- May recommend differentiated targets
3. MPME STEPS AND REGIONAL COOPERATION
MPME Steps and Choices: Countries with Underdeveloped Capacity

Start with basic capacity development (science and policy).

Reduction policies for secondary pollutants (PM2.5, ozone) may be needed before sufficient domestic MPME science & policy capacity exists:

- Countries can adopt policy frameworks & targets developed by others (without conducting extensive domestic analysis).
- Targets can be based on technological or economic feasibility (rather than analysis of effects or interactions among pollutants).

International cooperation:

- Can emphasize capacity building initially
- Transboundary aspects need not be emphasized initially

However, MPME is needed to increase effectiveness & reduce costs.
MPME and Regional Cooperation

MPME may be a good focus for the international cooperation framework and science policy interface.

Focus on scientific aspects & capacity building at first, but also start on a path to reach agreement on reductions later.

Not necessary to link with a legally binding agreement/treaty.

This will help countries implement unilateral domestic policies (countries are already moving in this direction).

Emphasize cost savings and co-benefit aspects.

EANET already covers monitoring
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