OPERA:
AN INTEGRATED ASSESSMENT MODEL TO PLAN EFFECTIVE AIR QUALITY POLICIES

C. Carnevale, G. Finzi, R. Mansini, E. Pisoni, A. Visioli, M. Volta
DII, University of Brescia
RIAT - OPERA

RIAT

- JRC
- Beneficiaries
  - UNIVERSITY of BRESCIA
  - TERRARIA
- RIAT
- Lombardia

OPERA

- LIFE+
- Beneficiaries
  - ARPA-ER
  - UNIVERSITY of BRESCIA
  - TERRARIA
  - CNRS
    - JRC, RER, ASPA
- RIAT+
- Emilia Romagna, Alsace
IAM architecture

Input databases
- emission inventories and projections
- emission reduction measures:
  - technical measures
  - non-technical measures
  - costs
- Emission-concentration relationships (CTM simulations)

Decision model
- what-if analysis
- cost-benefit analysis
- cost-effective analysis
- multi-objective analysis

Deliverables
- efficient policies
- objective values
- post-processing:
  - ex-post analysis
  - sensitivity

Source-receptor models
Decision model approaches

- what-if analysis
- cost-benefit analysis
- cost-effective analysis
- multi-objective analysis
Decision model

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- multi-objective analysis

\[ \text{opt} \left[ J(x) \right] \]
\[ x \in \Theta \]

\( J(x) \) is the objective function to be optimized
\( x \) is the set of decision variables
\( \Theta \) is the set of feasible decisions
Decision model

Cost-benefit analysis:

\[ J(x) \] is a scalar function

all benefits and costs are monetized and assessed in a single function


Decision model

Cost-effective analysis

\[ J(x) \] is a scalar function

a single objective is optimized, while others required performances are included as constraints

RAINS/GAINS system, APD IIASA
Decision model

Multi-objective analysis:

\( J(x) \) is a vector

\( J(x) \) represents different and often conflicting objectives.

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Decision problem

\[
\min_x J(x) = \min_x \left[ \text{AQI}(x) \cdot \text{inC}(x) \right]
\]

\( x \in \mathcal{X} \)

Set of feasible decisions

Set of decision variables

Air Quality Index: PM10, PM2.5, Ozone, NOx

Internal Costs

Set of precursor emission reduction measures
AQI: Source-Receptor models

\[
\frac{\partial AQI(x)}{\partial x} = \frac{\partial AQI(x)}{\partial E} \cdot \frac{\partial E}{\partial x}
\]

- **Source-Receptor models**
  - S-R models identified processing CTM model simulations
  - Non linear processes
  - Local features
  - Design of experiments
## DoE: CTM simulations

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- C = CLE2010 + 10%
- A = MFR2020
- B = (CLE2015 + MFR2015)/2
Source-receptor models

- Input data: precursor emissions
- Target data: AQI
PM10: basecase

CHIMERE

S-R models

(µg/m³)
S-R models

Identification

Validation

corr=1.00
mse=0.13

corr=0.99
mse=0.72
Decision variables

Detailed approach

- Technical measures:
  - Actual technical measures spreading
  - Actual technical measures spreading and replacing

- Non technical measures

Lumped approach

- Technical measures:
  - Macrossector precursor emission reductions
Constraints

• Technical measures feasibility
• Technical and non technical measure mix
• National and European plan harmonization
• Emission reduction measures replacing
• Budget constraints due to ongoing or foreseeable AQ policies
**Problem formalization**

\[
\min_{X_{i,j,k,t}} J(X_{i,j,k,t}) = \min_{X_{i,j,k,t}} AQI(X_{i,j,k,t})
\]

\[
inC(X_{i,j,k,t}) \leq L \quad 0 \leq L \leq L
\]

If no technology replacement:
- to ensure the technology feasibility:
  \[
  X_{i,j,k,t}^{CLE} \leq X_{i,j,k,t} \leq \bar{X}_{i,j,k,t}^{CLE} \quad \forall i, j, k, t
  \]
- to ensure the emission conservation:
  \[
  \sum_{i,j,k} X_{i,j,k,t} \leq 1
  \]

If technology replacement:
- to ensure the technology feasibility:
  \[
  0 \leq X_{i,j,k,t} \leq \bar{X}_{i,j,k,t}^{CLE} \quad \forall i, j, k, t
  \]
- to ensure the emission conservation:
  \[
  \sum_{i,j,k} X_{i,j,k,t} \leq 1
  \]
- to ensure optimal reduced emissions > CLE
  \[
  \sum_{i,j,k} \text{eff}_{i,j,k,t,p} \cdot X_{i,j,k,t} \geq \sum_{i,j,k} \text{eff}_{i,j,k,t,p} \cdot X_{i,j,k,t}^{CLE} \quad \forall i,j,k,t
  \]
- to ensure no controlled emission in CLE remains without control
  \[
  \sum_{i,j,k} X_{i,j,k,t} \geq \sum_{i,j,k} X_{i,j,k,t}^{CLE}
  \]
Effective solutions

CLE 2020

AQI PM10 [μg/m³] vs. Cost over CLE [Meuro/year]
Problem options

- Seasonal air quality indexes
- Point and area emission sources
- Optimization domains
- Population exposure
- GHGs budget
System tests

- Emilia Romagna
- Alsazia
- Standard methodology for European regions
IAM architecture

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