Development of Mid-Century Anthropogenic Emissions Inventory in Support of Regional Air Quality Modeling under Influence of Climate Change

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NESCAUM

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Georgia Institute of Technology

EPA EI Conference, May, 2005, New Orleans
Overview
Purpose of work

* Develop 2050 EI
  - Target year: Year 2050, Annual
  - Format: SMOKE-ready
  - Sector: Anthropogenic only
  - Geographical domain: US/CAN/MX
  - Projection approach:
    Two stage approach if any national projection is available

* In support of modeling
  - Not creating new future energy/emissions scenario
Uncertain Future (Global CO2 & SO2)

Source: IPCC
Basic strategy
Future year EI development

- Try to get the best available future EI data possible
- Fill-up gaps from near/certain future to distant/uncertain future

Example: Use EPA projection until 2020 and use IPCC scenario from 2020-2050
## Inter-comparison of Future EI development

<table>
<thead>
<tr>
<th>Name</th>
<th>Base Year</th>
<th>Future Years</th>
<th>Geographical Domain</th>
<th>Scenario</th>
<th>Source sectors</th>
<th>Chemical species</th>
<th>Model</th>
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<td>OTB/OTW</td>
<td>EGUs &amp; non-EGUs</td>
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<td>2040/10yrs</td>
<td>38 States + DC</td>
<td>OTB/OTW/BWC/BB</td>
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<td>~2100/yr</td>
<td>World (17 regions)</td>
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<td>~2029+/3yrs</td>
<td>Units(EGUs), States(NE), Country</td>
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- **Pros**
- **Cons**
- **Both**

**RIVM** : Netherlands’s National Institute for Public Health and the Environment

**IMAGE** : Integrated Model to Assess the Global Environment
Selected Method & Data
Near Future EI (EPA CAIR)

- Base Case
  - Current controls except CAIR

- Control Case (Clean Air Interstate Rule)*
  - The same as base case except for EGUs

- Based on 1999 NEI
- Pollutant: NOx, CO, NMVOC, SO2, NH3, PM10, PM2.5
- Available as SMOKE/IDA format

* CAIR region: AL, AR, CT, DE, DC, FL, GA, IL, IN, IA, KY, LA, MD, MA, MI, MN, MS, MO, NJ, NY, NC, OH, PA, SC, TN, TX, VA, WV, WI
Distant Future EI (RIVM IMAGE)

IMAGE: A dynamic integrated assessment modeling framework for global change

WorldScan (economy model), and PHOENIX (population model) feed the basic information on economic and demographic developments for 17 world regions into three linked subsystems (EIS, TES, and AOS*).

* EIS (Energy-Industry System), TES (Terrestrial Environment System), AOS (Atmospheric Ocean System)
Project emissions

- US -

- **Step #1 : Use national projection data available for the near future**
  - Use EPA CAIR Modeling EI
    (Point/Area/Nonroad, from Y2001 to Y2020)
  - Use RPO SIP Modeling EI
    (Mobile, from Y2002 to Y2018)

- **Step #2 : Get growth data for the distant future and develop cross-reference**
  - Use IMAGE model (IPCC SRES, A1B)
  - From Y2020(Y2018 for mobile activity) to Y2050
  - X-Ref : Sectors/Fuels combination to SCCs

- **Step #3 : Apply growth factors using cross-reference**
  - Use in-house Fortran software
  - From Y2020(Y2018 for mobile activity) to Y2050
Project emissions
- CANADA/ MEXICO -

- **Step #1 : Use national projection data available for the near future or update base year inventory**
  - Use Y2020 Environmental Canada Future EI (Area/Mobile)
  - Use Y2002 Point source inventory (NYSDEC) scaled with Y2000 by-state point source summary from Environment Canada
  - Update base year Mexico inventory (BRAVO) using Mexico NEI for 6 US-Mexico Border states

- **Step #2 : Get simple growth data for the future and apply them**
  - Use IMAGE model (IPCC SRES, A1B)
  - From Y2020 to Y2050 (CAN, Area/Mobile)
  - From Y2000 to Y2050 (CAN, Point)
  - From Y1999 to Y2050 (MX, All)
Result
Developing cross-reference (CAIR and IMAGE)

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5000+ SCCs
Growth (IMAGE – A1B)

SO2(as S)

NOx(as N)
Growth (IMAGE – A1B)
Growth (IMAGE - A1B)

Agricultural Production

Surrogates for NH3 for OTH sector

Surrogates for PM species

BC+EC

-Streets et al. (2004)
Spatial Distribution of Emissions (SO2)

2001

2020

2050

Chart:
- SO2
- Area
- Nonroad
- Onroad

SO2 (Total, TPY):
- 8000 - 76000
- 76000 - 265000
- 265000 - 421000
- 421000 - 738000
- 738000 - 1582000

Millions TPY

2001

2020

2050

Pnt  Area  Nonroad  Onroad
Spatial Distribution of Emissions (NOx)

2001

2020

2050

Bar Chart

- P_nox
- A_nox
- N_nox
- M_nox

NOx (Total TMY)

- 0
- 5
- 10
- 15
- 20
- 25

Millions TMY

- 0
- 5
- 10
- 15
- 20
- 25

Area

Nonroad

Onroad

Legend

Pnt
Spatial Distribution of Emissions (PM2.5)

2001

2020

2050

Chart
- P_pm25
- A_pm25
- N_pm25
- M_pm25

PM2.5 (Total, TPY)
- 2000 - 18000
- 18000 - 37000
- 37000 - 61000
- 61000 - 96000
- 96000 - 156000

Chart
- P_pm25
- A_pm25
- N_pm25
- M_pm25

PM2.5 (Total, TPY)
- 2000 - 18000
- 18000 - 37000
- 37000 - 61000
- 61000 - 96000
- 96000 - 156000

Bar chart showing emissions in 2001, 2020, and 2050 with different categories:
- P
- Area
- Nonroad
- Onroad
Future Emissions (CANADA)
Future Emissions (Mexico)

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Mobile source (VMT vs. Emission)

In spite of VMT increase, emission (CO) decrease dramatically because of controls for the future years. Much less effect of controls after 2018.

Three SMOKE/ M6 runs (2002/2018/2050) for MANE-VU states

VMT increases (about 1%/year) for the future years (Y2050 = Y2018 yet)
Conclusion

- US emissions in the future (Y2050) are estimated to decrease by 2.5 times (NOx) to 25% (PM2.5)
- Canadian EI shows decrease of gaseous pollutants but increase of particle emissions because of fugitive dust
- For Mexico, emissions of NOx, SO2, NH3, and VOC are estimated to increase but CO, PM10, and PM2.5 will decrease
- For US onroad mobile source, post 2018 emissions will not decrease significantly without activity change or even increase with just VMT growth. The IMAGE model, however, projects decrease of this source sector.
On-going work

- Air quality modeling using CMAQ-DDM for three cases
  - Base year emissions with base year meteorology
  - Base year emissions with future year (2050) meteorology
  - Future year (2050) emissions with future year (2050) meteorology
Thank you for your attention!
Mobile source (VMT vs. Emission)

National emissions of VOCs from light-duty vehicles expected to remain flat post 2015 and begin to rise post 2020.

NOx to remain flat post 2020 and begin to rise sometime post 2030.

Source: US EPA, Tier 2 Regulatory Impact Analysis; NRDC, 2005
Combining two futures (CAIR and IMAGE)

- Calculate combined factor of growth/control from EPA base year (2001) vs. future year (2020) emissions inventory
- Calculate growth factor for Y2020-Y2050 (A1B) from IMAGE
- Calculate growth factor for Y2001-Y2050 for Canada/Mexico from IMAGE

RPO 2018 Activity data (On-road mobile)

- Use EPA 2020 CAIR-case inventory

- Compare EPA CAIR vs. IMAGE for Y2001-Y2020
- Develop SCC to IMAGE fuel/sector x-reference

- Check/apply growth factors to 2020 EPA CAIR EI to get 2050 EI
- Update cross-references

- SMOKE/M6-ready activity data for 2050
Combining two futures
(CAIR and IMAGE)

• EPA CAIR inventories for year-2001 and year-2020 were processed with SMKINVENV and SMKREPORT to ensure consistency in data formatting and generate emissions summary by each SCCs.

• Emissions from IMAGE and other research [Streets et. al., 2004] were estimated for USA/Canada/Mexico and for Y2001/Y2020/Y2050 to get growth factors for these periods.

• The cross-references from US Source Classification Code (SCC) to IMAGE sector/fuel combination were developed.
Developing cross-reference
(CAIR and IMAGE)

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CAIR

5000+ US SCCs