

# **Multi-Pollutant Strategies & Integrated Assessment**

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U.S. Environmental Protection Agency**

# Overview

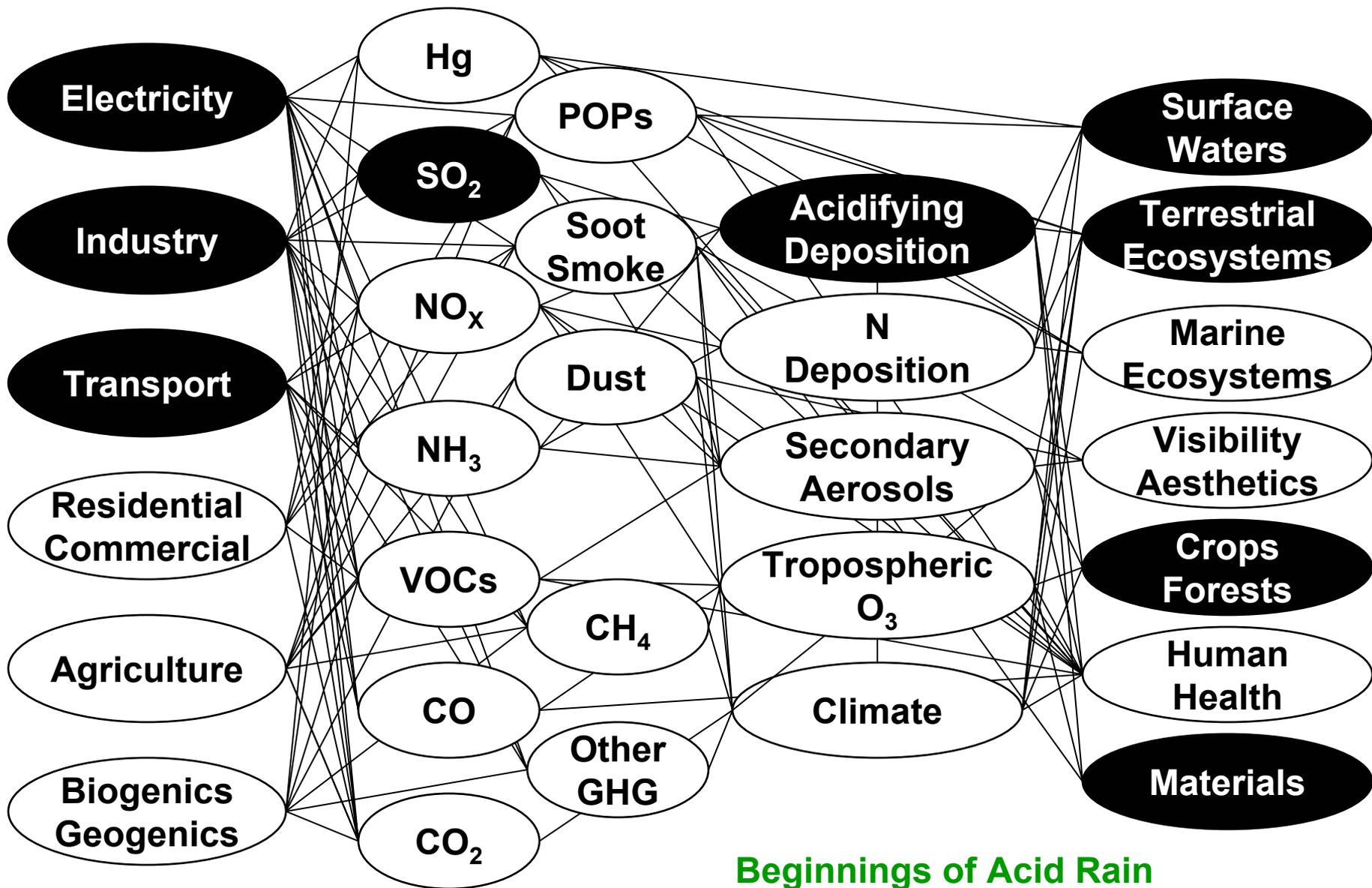
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- **Making the Linkages:**
  - Where have we been?
  - What are we doing now (at least at USEPA)?
  - What's possible?
- **Multi-Attribute v. Multi-Objective Frameworks**
- **Some Issues and Implications**

# Sources

# Pollutants

# Receptors

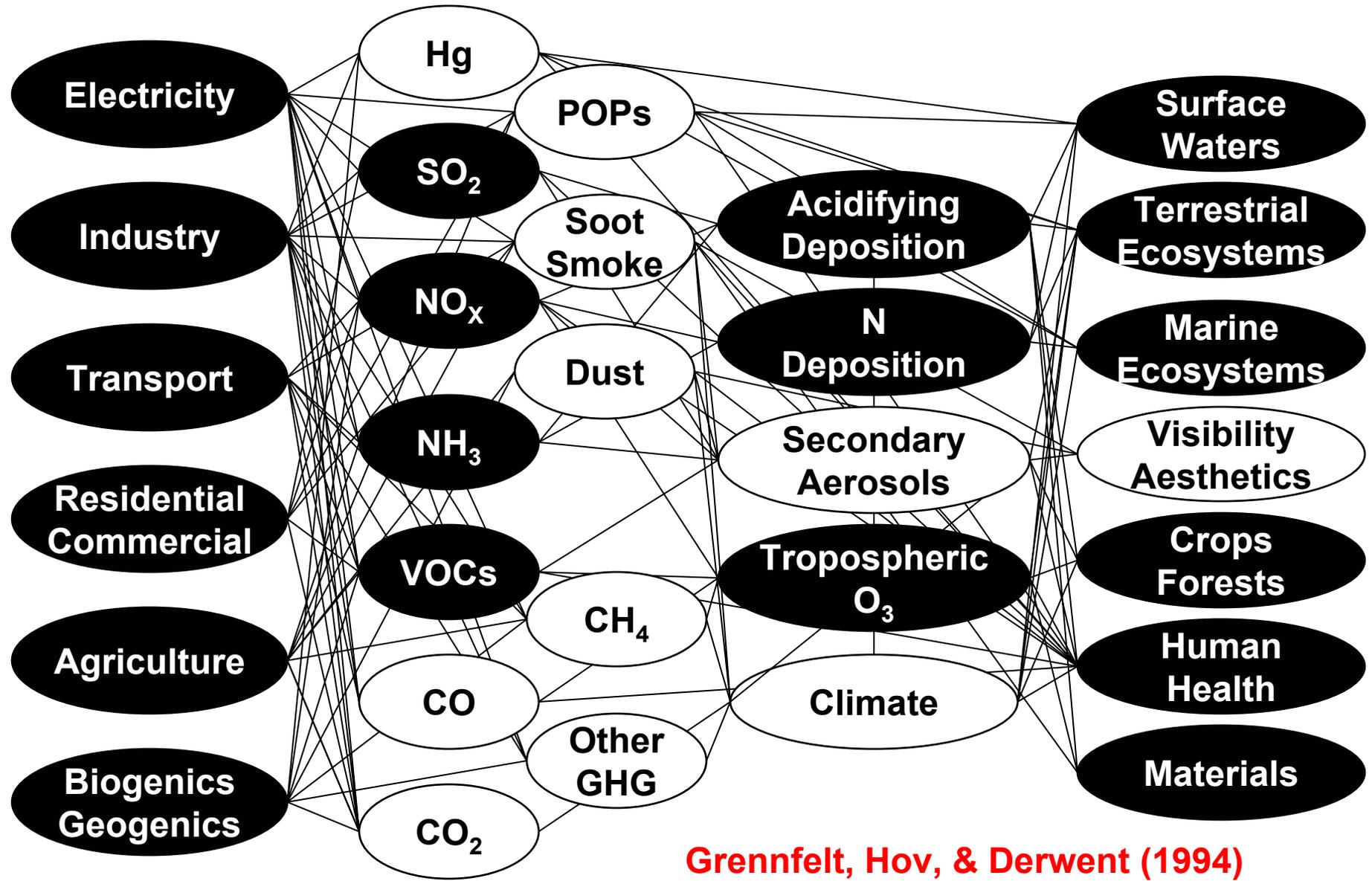


Beginnings of Acid Rain

# Sources

# Pollutants

# Receptors

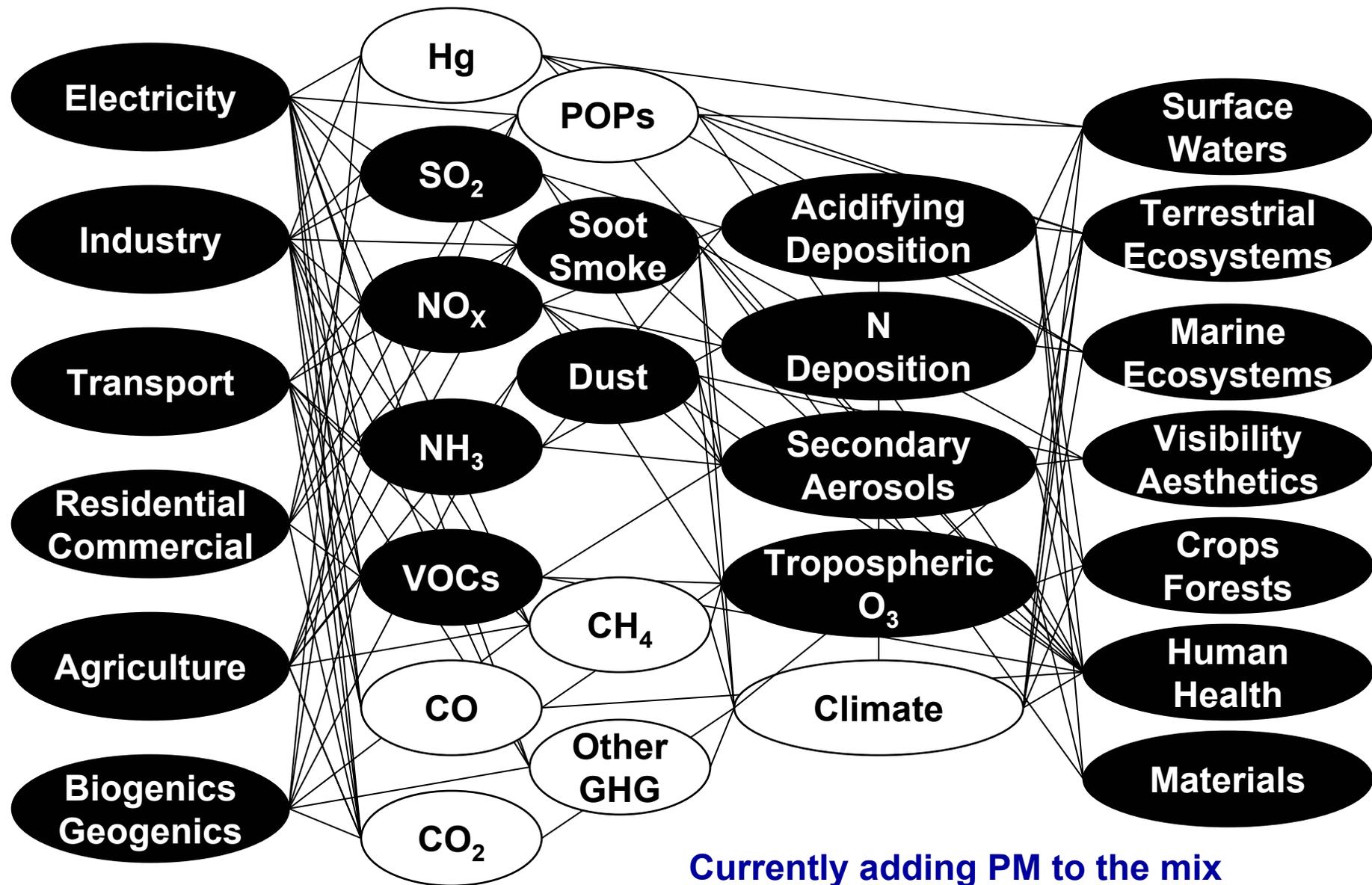


**Grennfelt, Hov, & Derwent (1994)**  
**Ambio, 23:425-433**

# Sources

# Pollutants

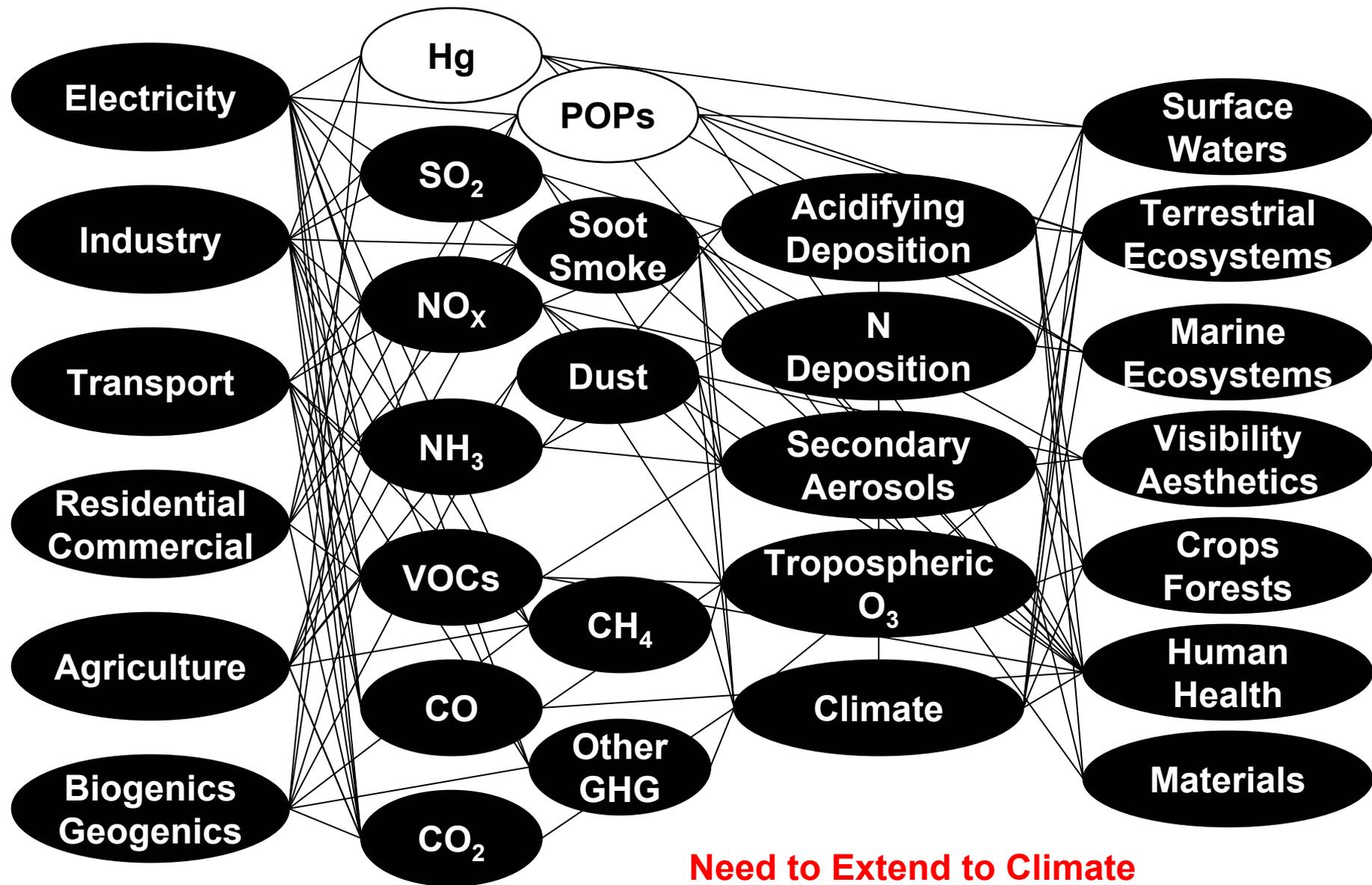
# Receptors



# Sources

# Pollutants

# Receptors

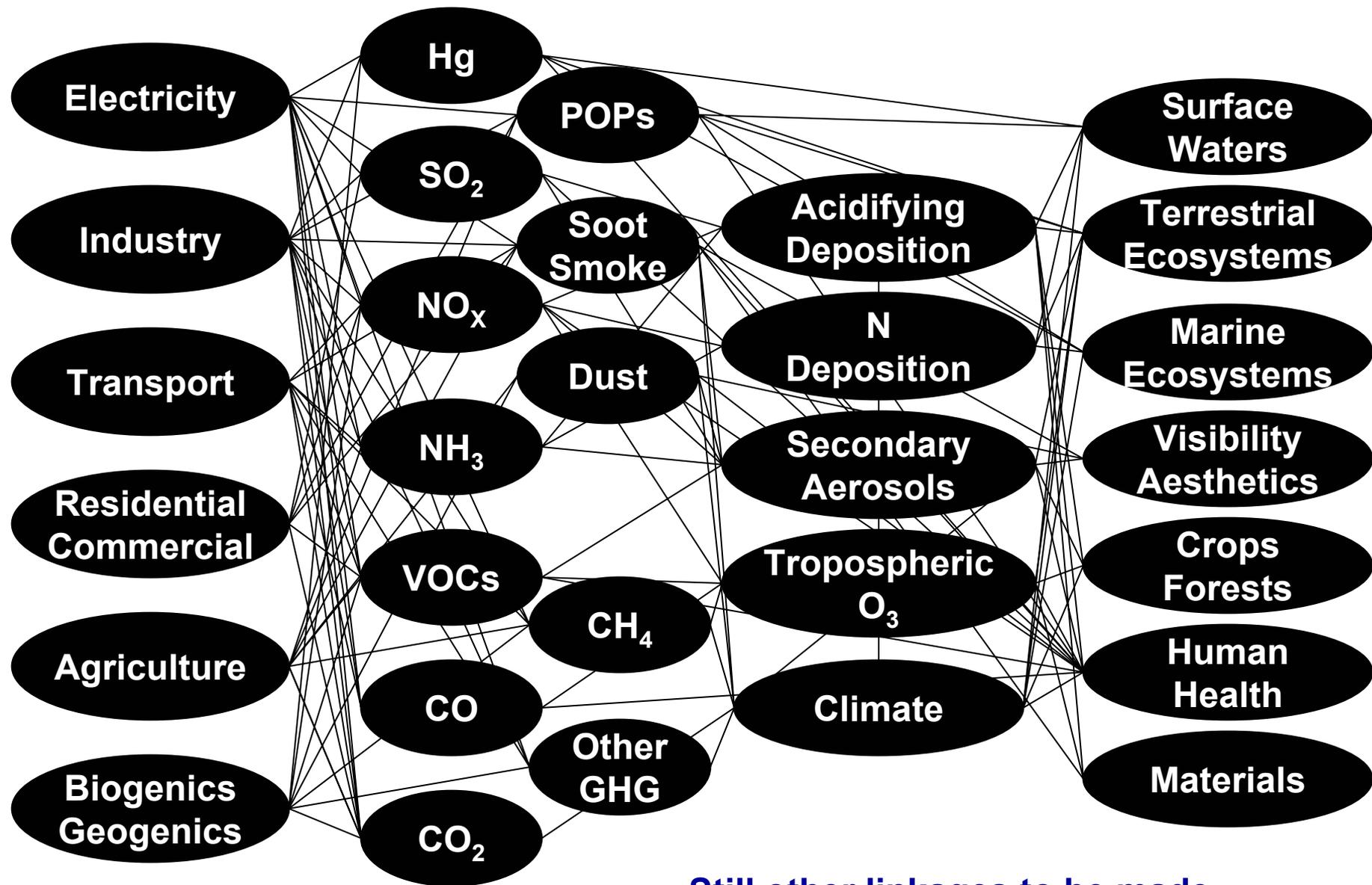


**Need to Extend to Climate and Global Air Quality**

# Sources

# Pollutants

# Receptors



Still other linkages to be made

# Examples of “Integrated Assessments”

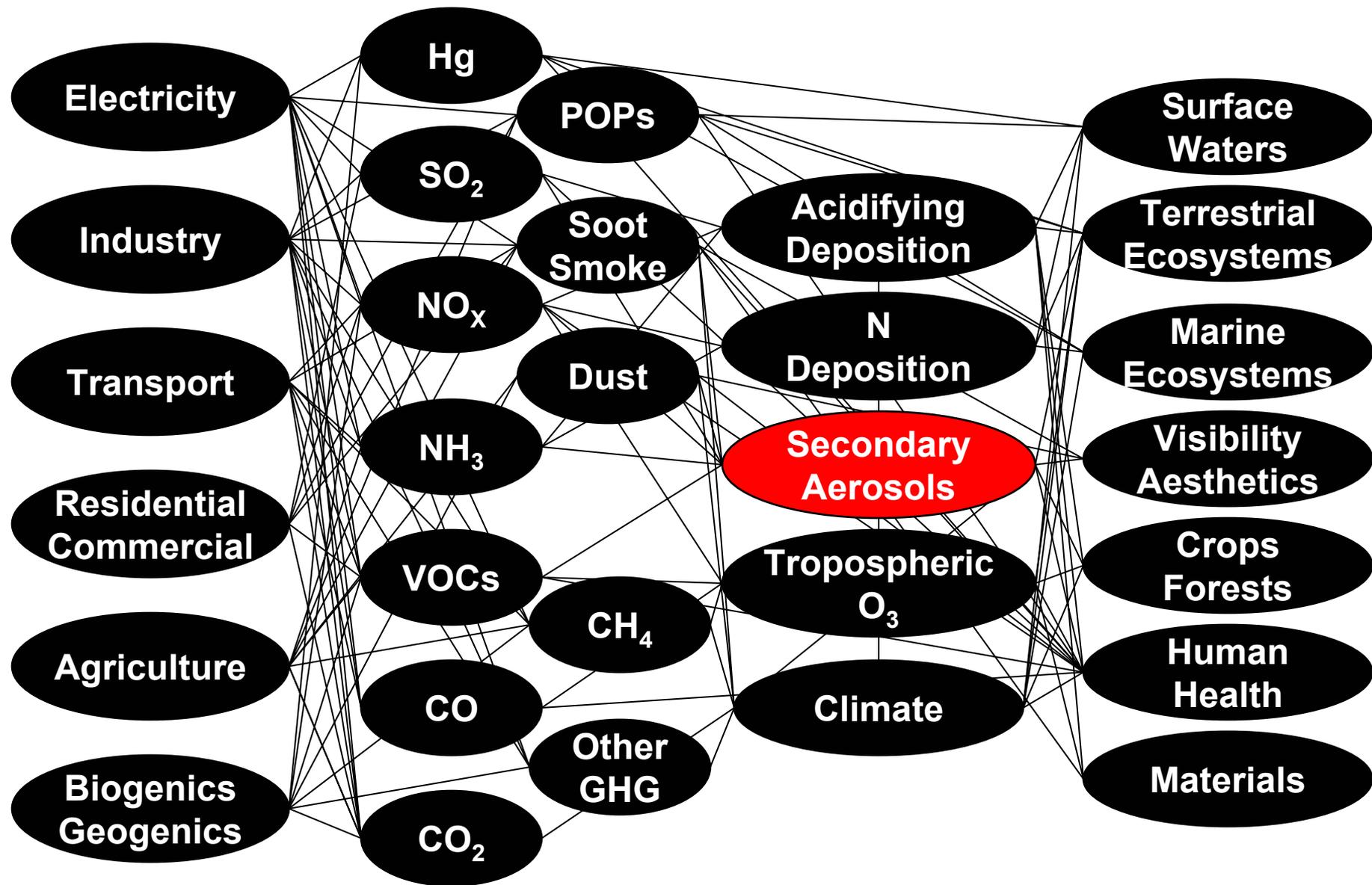
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- **Multi-Attribute**
  - **Multi-Pollutant Strategies for the Electricity Sector**

# Sources

# Pollutants

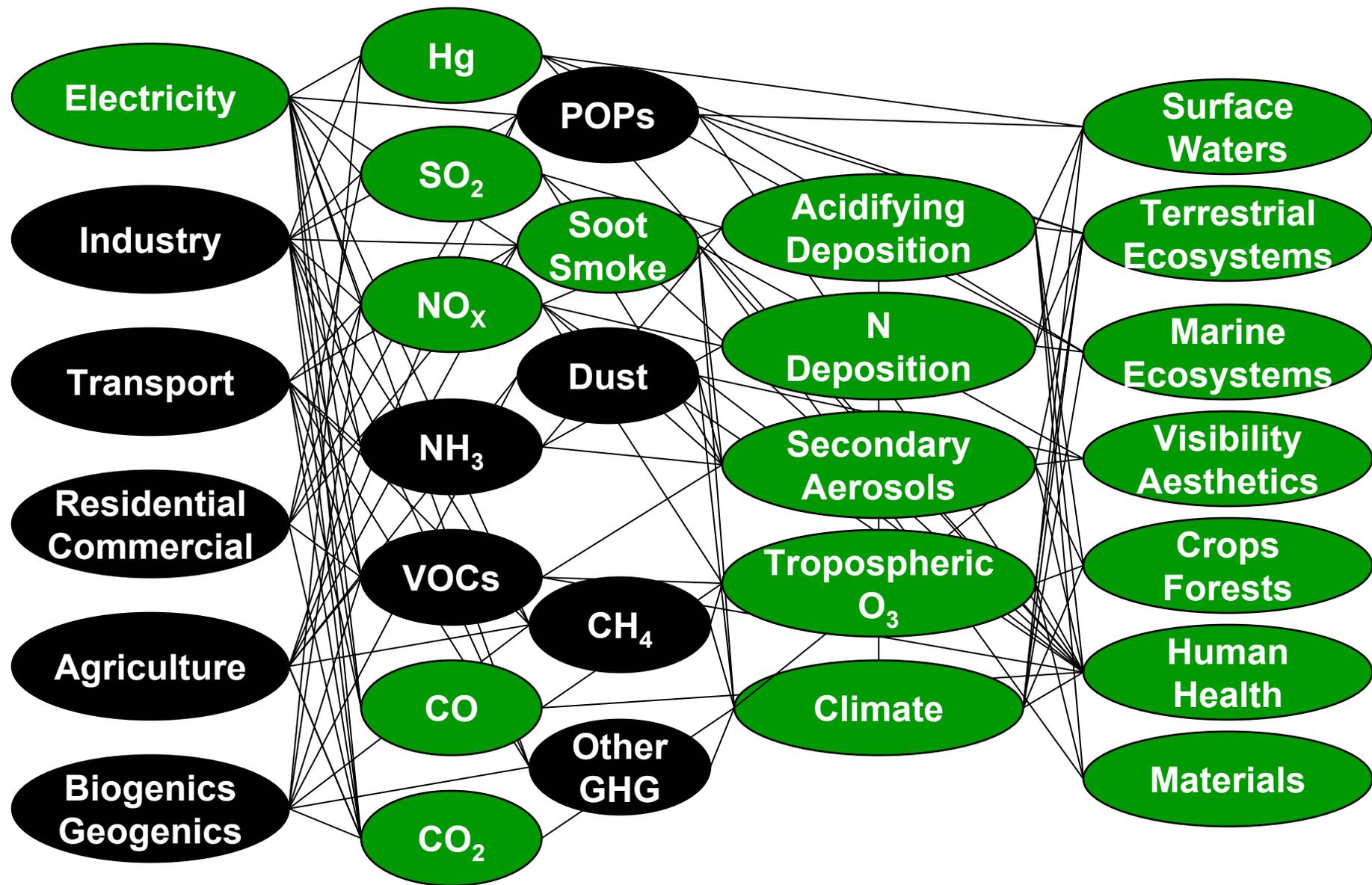
# Receptors



# Sources

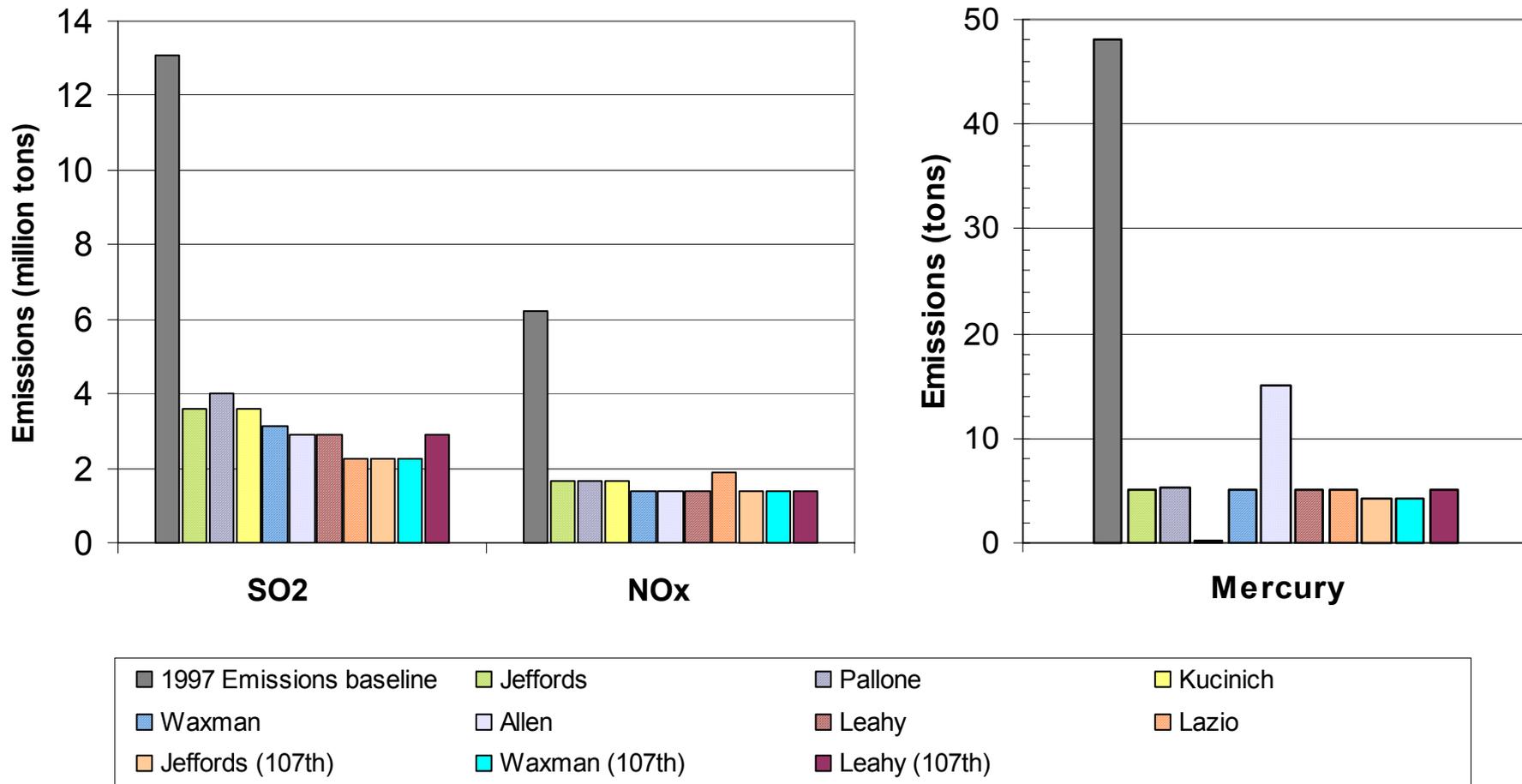
# Pollutants

# Receptors



# Multi-Pollutant Utility Legislation

Levels proposed in the 106<sup>th</sup> and 107<sup>th</sup> Congress



Graphic does not include a bill introduced by Sen. Allen in the 107<sup>th</sup> Congress

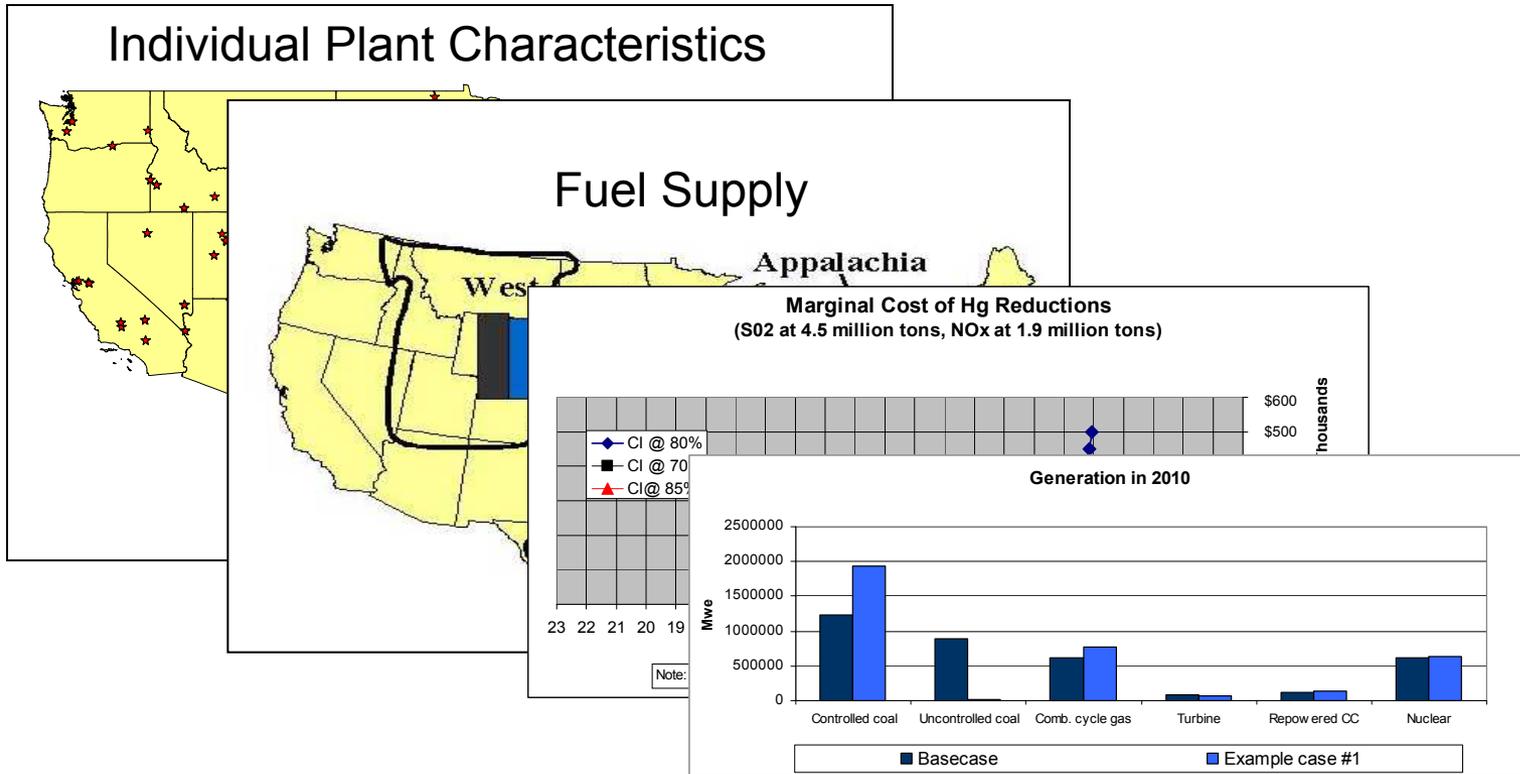
# Proposed Requirements for Electric Generating Units

	Actual Emissions in 2000	Clear Skies Initiative Emissions Caps		Total Reduction at Full Implementation
		<u>First Phase of Reductions</u>	<u>Second Phase of Reductions</u>	
<b>SO<sub>2</sub></b>	11.2 million tons	4.5 million tons in 2010*	3 million tons in 2018*	73%
<b>NO<sub>x</sub>**</b>	5.1 million tons	2.1 million tons in 2008*	1.7 million tons in 2018*	67%
<b>Mercury</b>	48 tons	26 tons in 2010	15 tons in 2018*	69%

\*Because sources can reduce emissions early, earn allowances for those actions, and use those allowances later, actual emission levels will be higher than the cap in the first years of these phases.

\*\*The NO<sub>x</sub> cap is divided between two zones with separate trading programs under each zone.

# Detailed Modeling of Electricity Sector ICF's Integrated Planning Model



# Detailed Cost/Benefit Analysis

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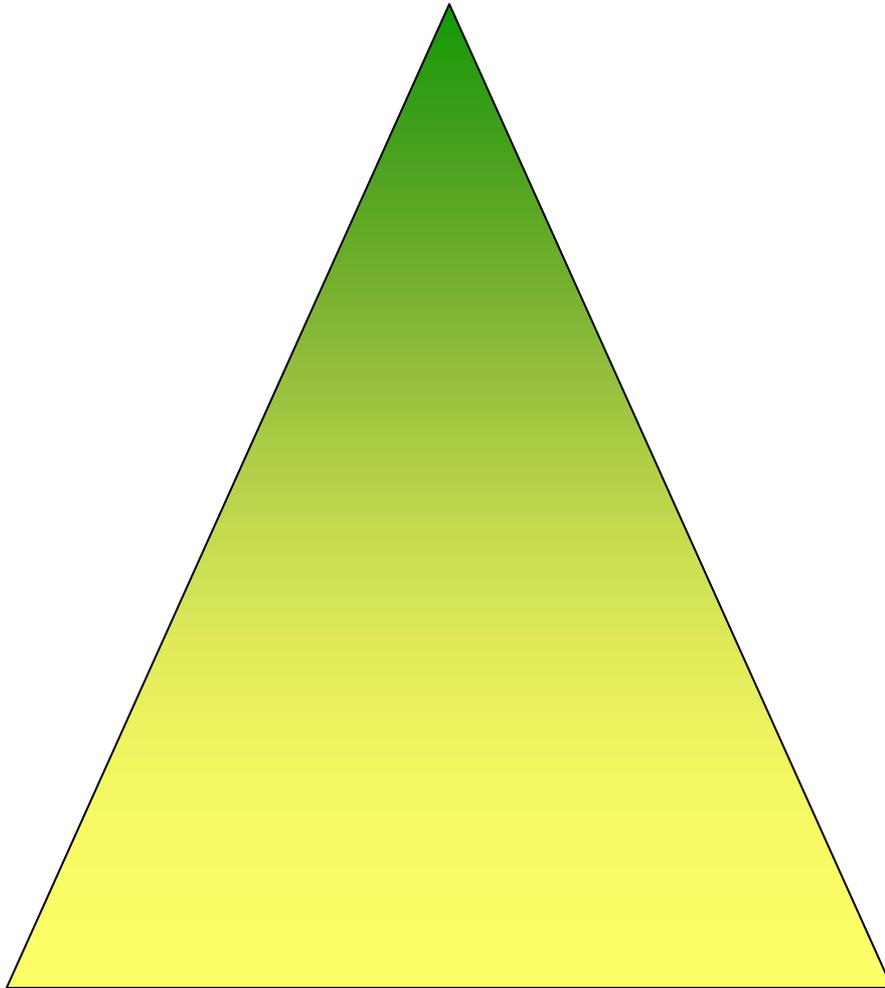
- $O_3$ ,  $PM_{10}$ ,  $PM_{2.5}$
- NAAQS Attainment
- Hg Deposition
- Eutrophication
- Visibility
- Change in ANC

- Monetized Health Benefits
  - Premature deaths
  - Chronic bronchitis
  - Hospital visits
  - Respiratory symptom days

**Control Technology Costs**  
**Impacts on Jobs**  
**Consumer Prices**

# Detailed Cost/Benefit Analysis

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Monetized

Quantified

Qualified

Identified

# Focus on Opportunities, Look Holistically

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- **Transport Sector**
  - Decoupling efficiency and emissions?
- **Open Biomass Burning**
  - differentiation between types of sources
  - management opportunities
- **Residential Coal & Biofuels**
- **Renewables & Energy Efficiency**
- **Integration Beyond AQ and Climate**

# Examples of “Integrated Assessments”

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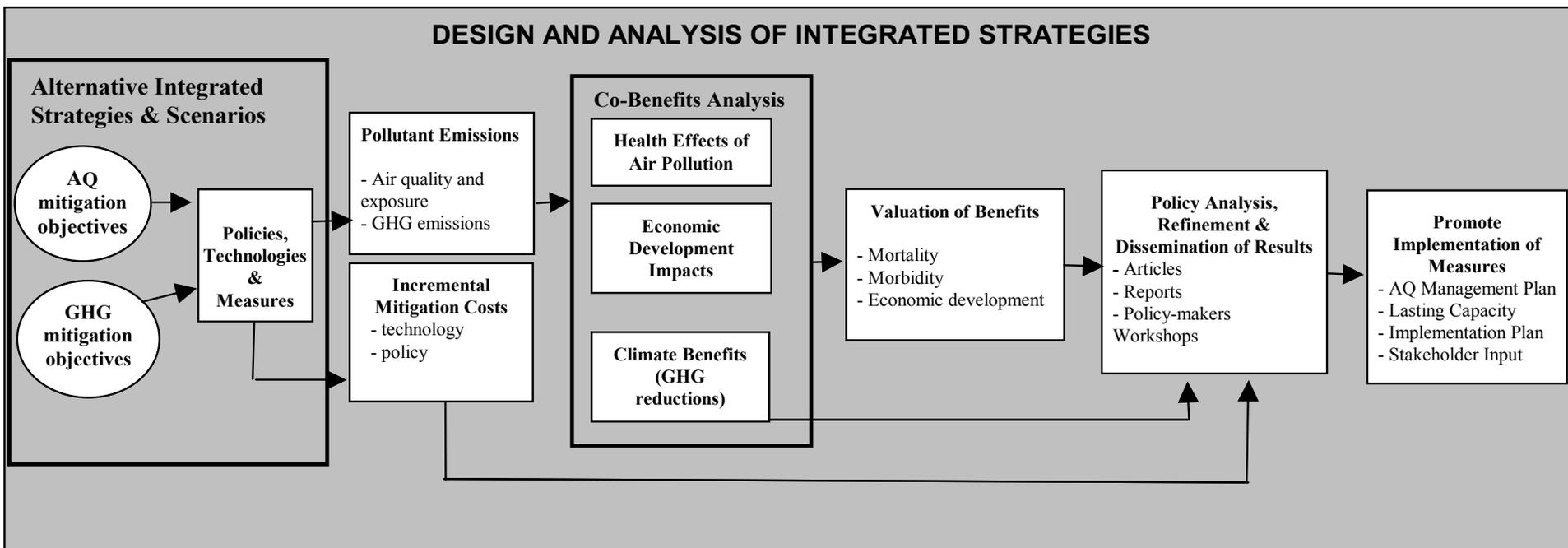
- **Multi-Attribute**

- **Multi-Pollutant Strategies for the Electricity Sector**
- **Integrated Environmental Strategies (IES) for Developing Countries**

**Began as the International Co-Controls Analysis Program (ICAP) with an emphasis on GHG reductions.**

**Now working on the design and implementation of integrated or harmonized GHG/AQ strategies in: Argentina, Chile, China, S. Korea, Brazil, Mexico, India, and S. Africa**

**<http://www.nrel.gov/icap>**



# IES Objectives

- Support and promote the analysis of environmental, public health, economic development and AQ/GHG mitigation benefits of integrated strategies
- Build permanent institutional & human capacity for that analysis
- Incorporate results into local policy initiatives (such as Air Pollution Reduction Plans)
- Engage *policy makers* in discussions that link research to policy and build support for integrated approaches
- Promote *implementation plans* for mitigation policies/programs

# **IES Program Accomplishments**

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- **Published AQ management plans with GHG benefits (Buenos Aires, Santiago, Shanghai, Seoul)**
- **Created lasting in-country capacity through training**
- **Collaborating with external donor groups (WHO, World Bank, UNEP)**

# **IES Program Accomplishments**

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- **Launched experts process on public health and AQ at ISEE and AWMA meetings**
- **Enabled south-south exchanges (ex: Chile and China)**
- **Increased visibility of IES efforts:**
  - **Special sessions at COPs**
  - **Publications in refereed journals**
  - **Media coverage**

# IES Contacts:

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- **EPA IES Program Manager:**  
**Katherine Sibold**  
**[sibold.katherine@epa.gov](mailto:sibold.katherine@epa.gov)**
- **NREL Technical Project Leader:**  
**Collin Green**  
**[collin\\_green@nrel.gov](mailto:collin_green@nrel.gov)**

# Examples of “Integrated Assessments”

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- **Multi-Attribute**
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  - **Integrated Environmental Strategies (IES) for Developing Countries**
  - **Air Quality - Climate Linkages**

# Intercontinental transport & Climatic effects of Air Pollutants (ICAP)

Carey Jang & Dennis Doll, EPA/OAR/OAQPS

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- Host a workshop and establish an expert advisory panel (December 2001)
- “Global Modeling of Air Pollution & Climate” (Harvard Univ., Jacob)
- “Global Radiative Forcing of Aerosols” (Stanford Univ., Jacobson)
- “Emission Inventories for Climate-Forcing Pollutants” (DOE/Argonne Lab, Streets)
- Project coordination and modeling protocol and reports drafting (MCNC-EMC, Hanna)

# *Phase 1 Progress*

## Workshop Summary & Panel Recommendations

### *PRIORITY QUESTIONS AND STRATEGIES FOR PHASE 2*

1. Intercontinental Transport - impact to US & other regions
  - Need improved global/regional emission inventories for O<sub>3</sub> and PM precursors partitioned by source sector
  - Need nested global and regional model
  - Need policy-relevant future emission projections
2. Climatic Effects of Air Pollutants - direct and indirect effects
  - Need global climate/chemistry model to estimate climate response for selected policy-relevant emission projections,
  - Develop approaches for quantifying direct and indirect climate responses on the perturbation of climate-forcing pollutants
3. How do U.S. & other regions emissions affect the ability of other countries to meet their air quality objectives?

<http://www.emc.mcnc.org/projects/GRO>

# Intercontinental Transport Workshops

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**Seattle, July 2000, Trans-Pacific**

**Palisades NY, June 2001, Trans-Atlantic**

**Bad Breisig, Germany, October 7-9, 2002**

**Transport Between Asia, Europe & NAmerica  
Ozone, Aerosols, Mercury**

**US/German Photochemistry Workshop, Oct 9-11**

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# Air Quality & Global Change

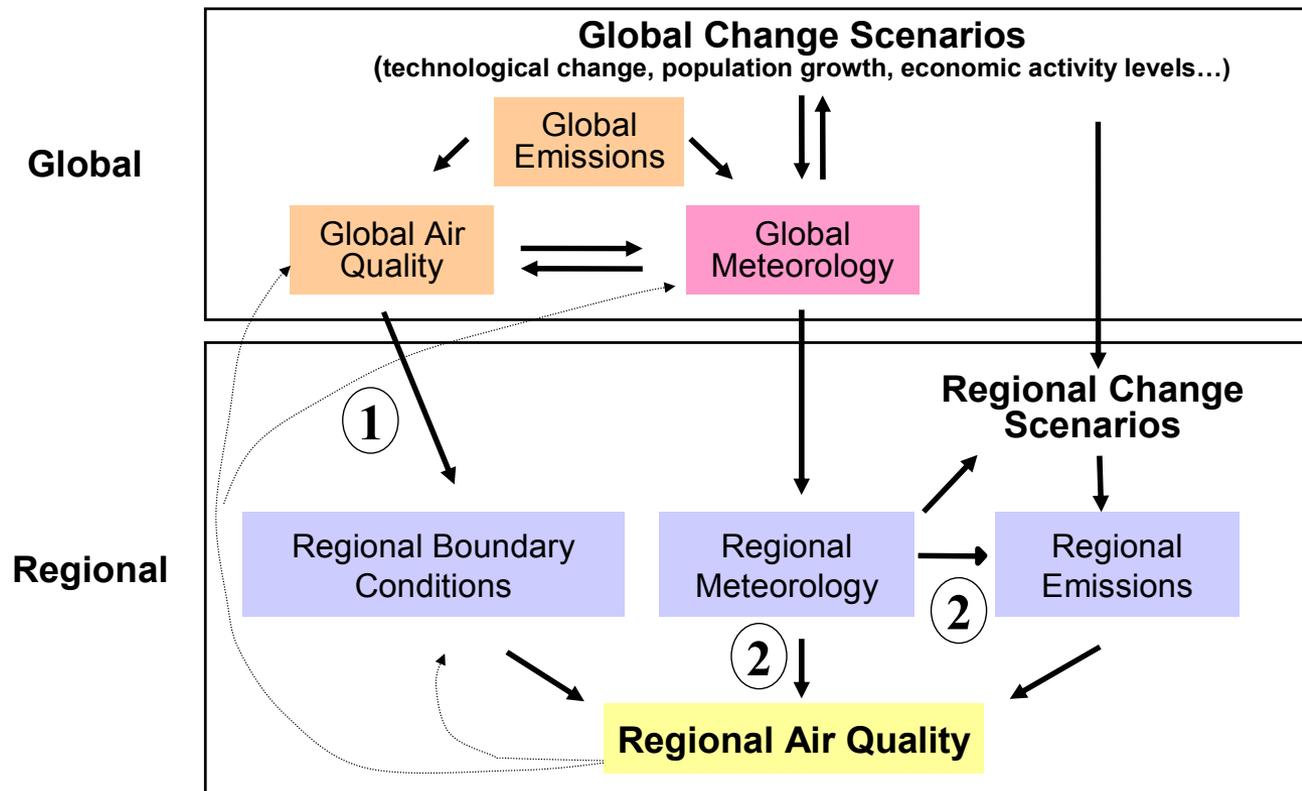
EPA's National Center for Environmental Research  
Science to Achieve Results (STAR) Program

<http://es.epa.gov/ncer/>

Request for Applications:

**Assessing the Consequences of Global Change for Air Quality: Global chemistry and sensitivity analysis**

Figure 1. Components of an Integrated Air Quality Assessment Framework



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- **Air Quality - Climate Linkages**

- **Multi-Objective**

- **RAINS Europe & Asia**

# Constrained Optimization in RAINS

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Source-Receptor Relationship

(Country Emissions to Concentration in Grid Cell)

Control Cost Curve

(Cost per Emission by Country and Sector)

Pollutant Critical Load

(Deposition or Concentration Threshold by Grid Cell)

Aspiration Level

(Achievement or Gap Closure to Critical Load)

# Constrained Optimization in RAINS

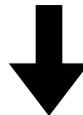
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(Country Emissions to Concentration in Grid Cell)

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(Achievement or Gap Closure to Critical Load)



Least Cost Strategy  
(Emissions by Country)

# Issues & Implications

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- **Bound the Effects, Feedbacks & Uncertainties**
  - **Need Direction? Relative Magnitude? Potential for Nonlinearities? Spatial Scale? Temporal Profile?**
  - **Will be used to make risk/risk tradeoffs.**
  - **Reduced Form Models: Where can we simplify?**

# Issues & Implications

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- **Bound the Effects, Feedbacks & Uncertainties**
- **Differentiation of Particles**
  - Mass is going to be a leading metric for some time
  - Identify implications for mass, number, species & size
  - Take advantage of emerging data
  - No Regrets?

# Issues & Implications

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- **Bound the Effects, Feedbacks & Uncertainties**
- **Differentiation of Particles**
- **Make Global Effects “Real”**
  - **Understand Regionality, Impacts on Local AQ, Cost of Achieving Goals**
  - **Need to Change Understanding of National Self Interests**
    - **Industrialized Countries: Local Impacts of Global Action**
    - **Developing Countries: Global Benefits of Local Action**