turning knowledge into practice

Use of Black Carbon and Organic Carbon Inventories for Projections and Mitigation Analysis

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What is Black Carbon (BC)?

- BC is emitted from incomplete combustion of fossil fuels
- BC is thought to cause warming by absorbing radiation in the atmosphere and by reducing snow albedo
- BC ≈ Elemental Carbon (EC)
- Organic carbon (OC) is always co-emitted but BC:OC ratio varies by fuel type and combustion efficiency

What is Organic Carbon (OC)?

- OC is emitted from incomplete combustion of biomass; BC is co-emitted

- OC is thought to cause cooling by reflecting incoming sunlight
- OC ≈ Primary Organic Aerosol (POA)

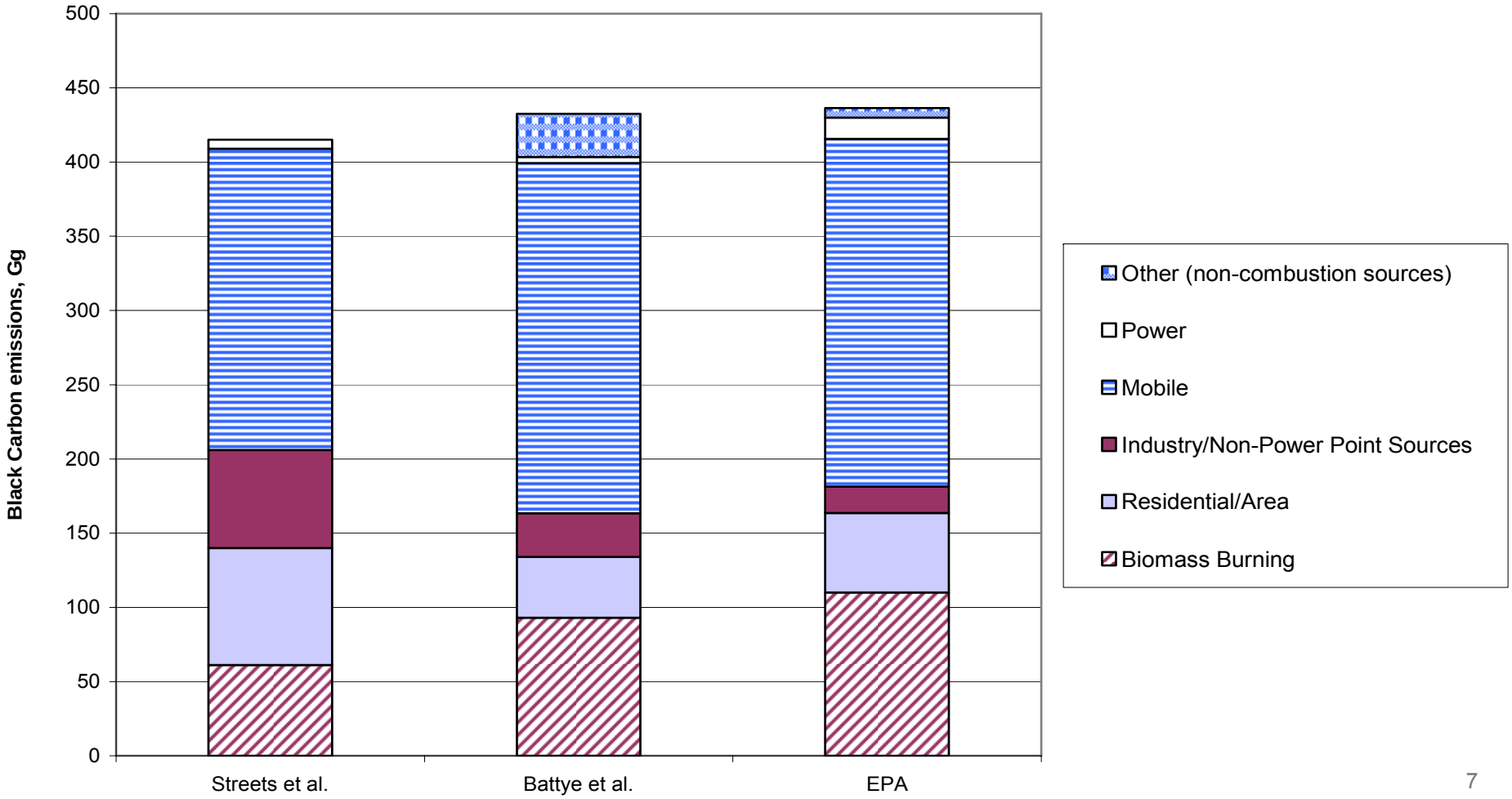
Project Objectives

- Identify existing and forthcoming air quality regulations and their future impacts on BC and OC
- Perform a BC and OC mitigation assessment for the United States, emphasizing transportation and open biomass burning (i.e., wildfires, prescribed fires, agricultural waste burning)
- Identify mitigation measures that go beyond current regulations
  - Estimate emission reductions
  - Estimate costs
  - Develop marginal cost curves
- Inform global BC and OC modeling efforts on long-term emission and mitigation scenarios

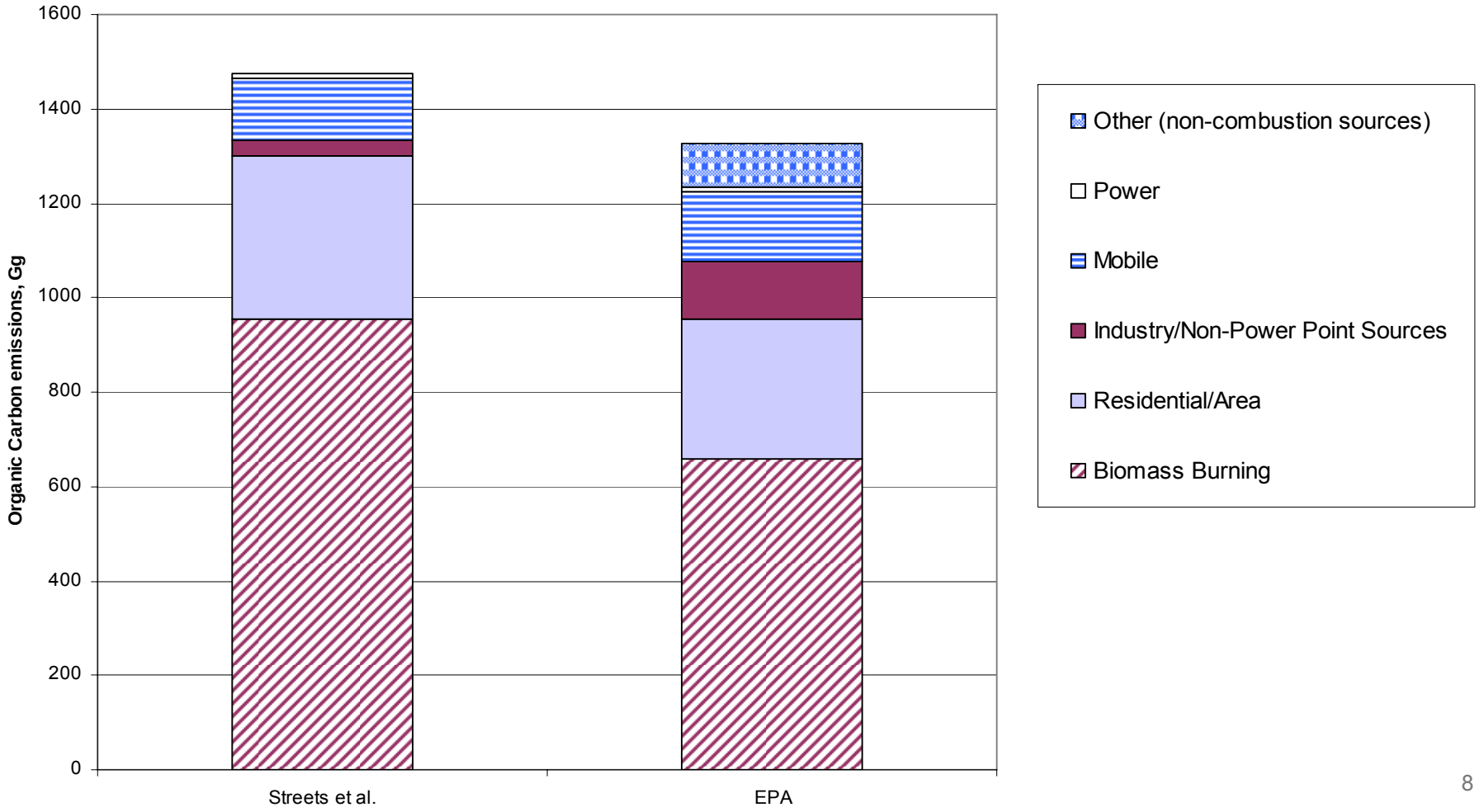
Sources for U.S. Emissions Circa 2000

- **Bond et al. & Streets et al.**
  - 1996 (and global projections for 2030 and 2050)
- **Battye et al.**
  - 2000
- **EPA OAQPS ($PM_{2.5}$ NAAQS Regulatory Impact Assessment)**
  - 2001 (and U.S. projections for 2015 and 2020)

U.S. BC Inventories Comparison (circa 2000)



U.S. OC Inventories Comparison (circa 2000)



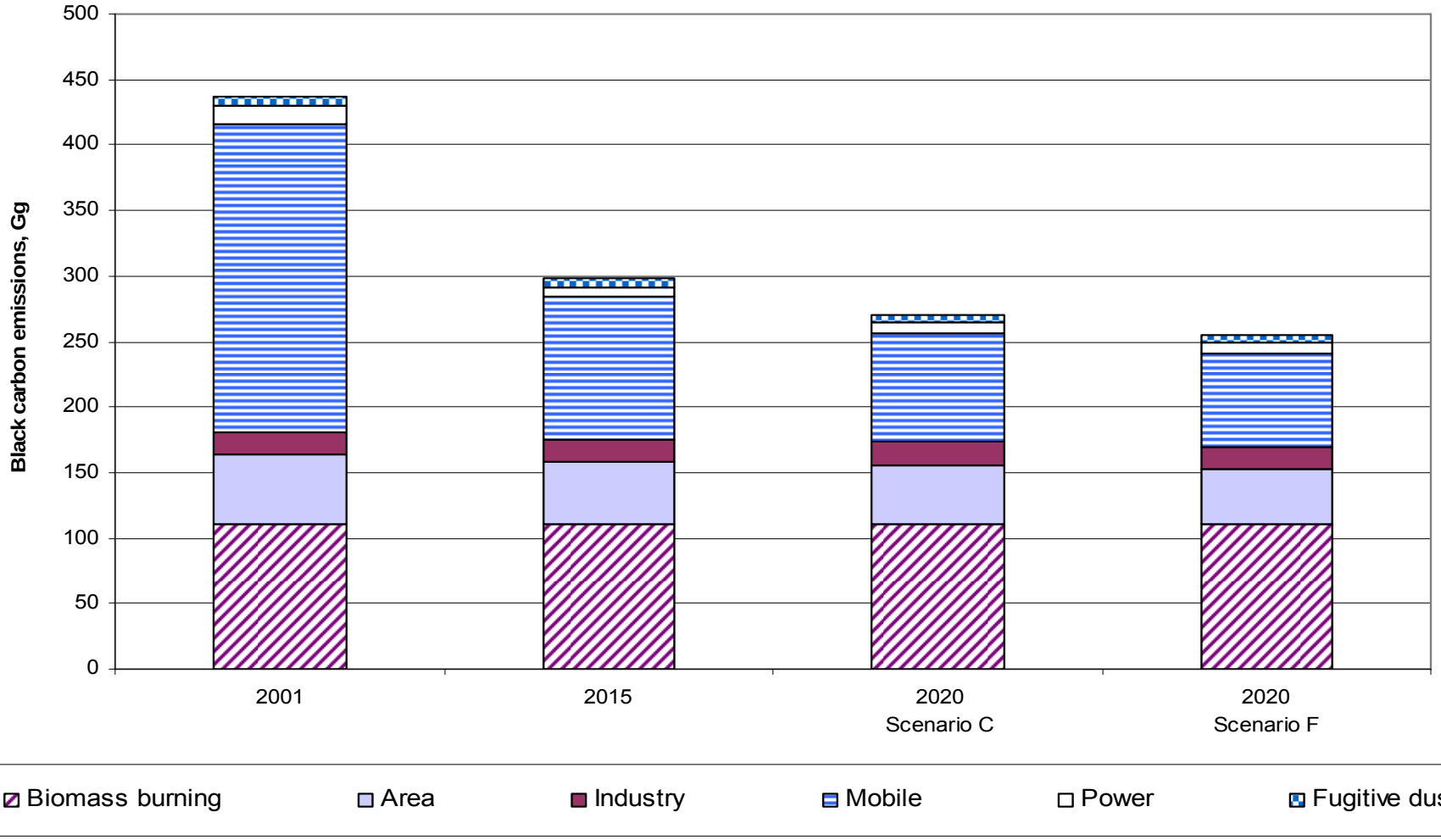
Key regulations and their effects on BC/OC emissions

- Clean Air Nonroad Diesel Rule
  - Significant BC reduction
- Clean Air Highway Diesel Rule (2007 Highway Rule)
  - Significant BC reduction
- Clean Air Interstate Rule (CAIR)
  - Insignificant impact on BC or OC
- PM2.5 NAAQS
  - Insignificant impact on nationwide BC or OC

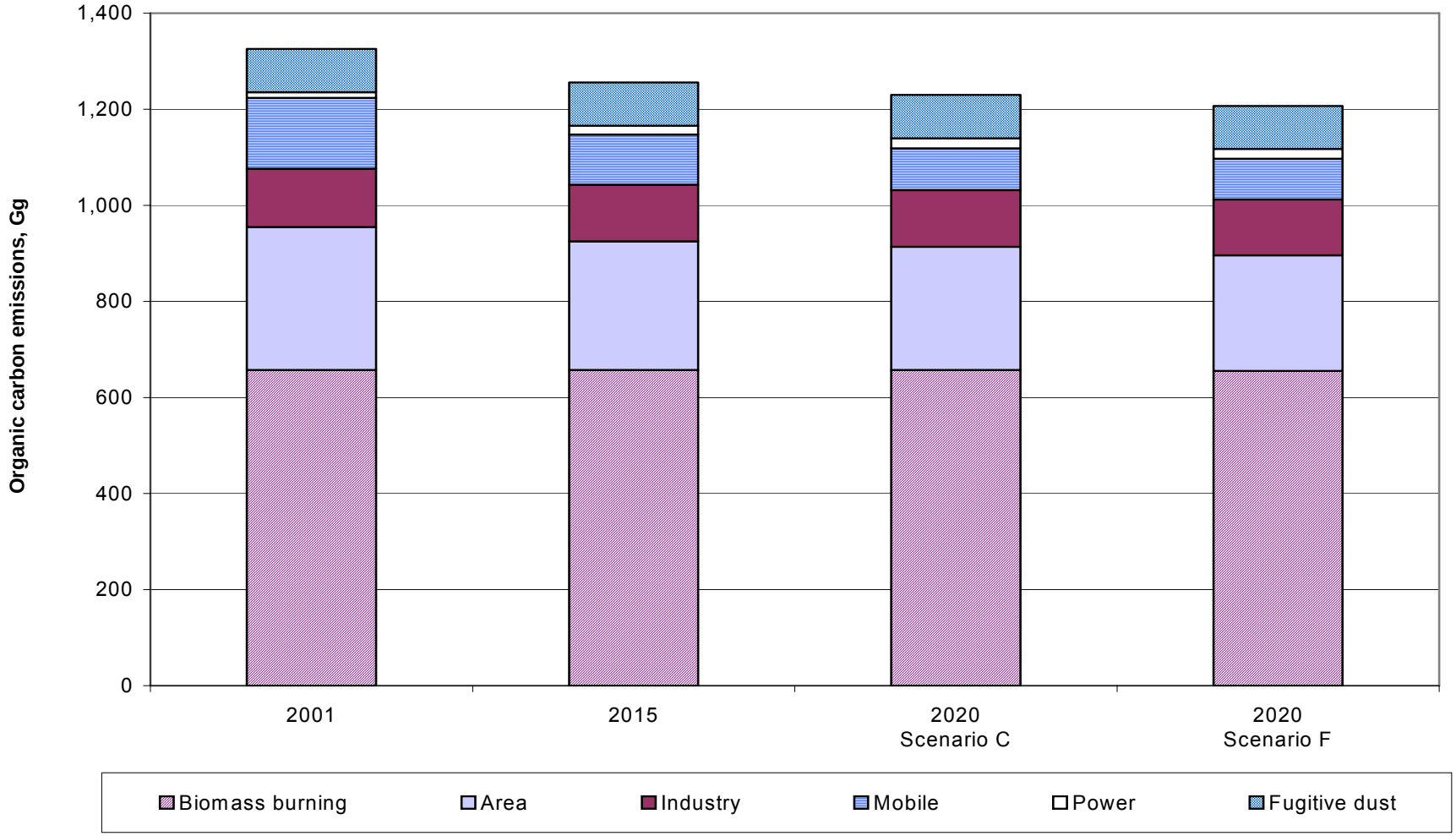
$PM_{2.5}$ NAAQS Regulatory Impact Assessment projections

- 2001 base case
- Scenario C
  - 2020 base case with CAIR/CAMR/CAVR
- Scenario F
  - 2020 15/35 (projection to 2020 with controls estimated to attain an annual standard of 15 μg/m^3 and a daily standard of 35 μg/m^3)

U.S. BC Inventory Projections to 2020



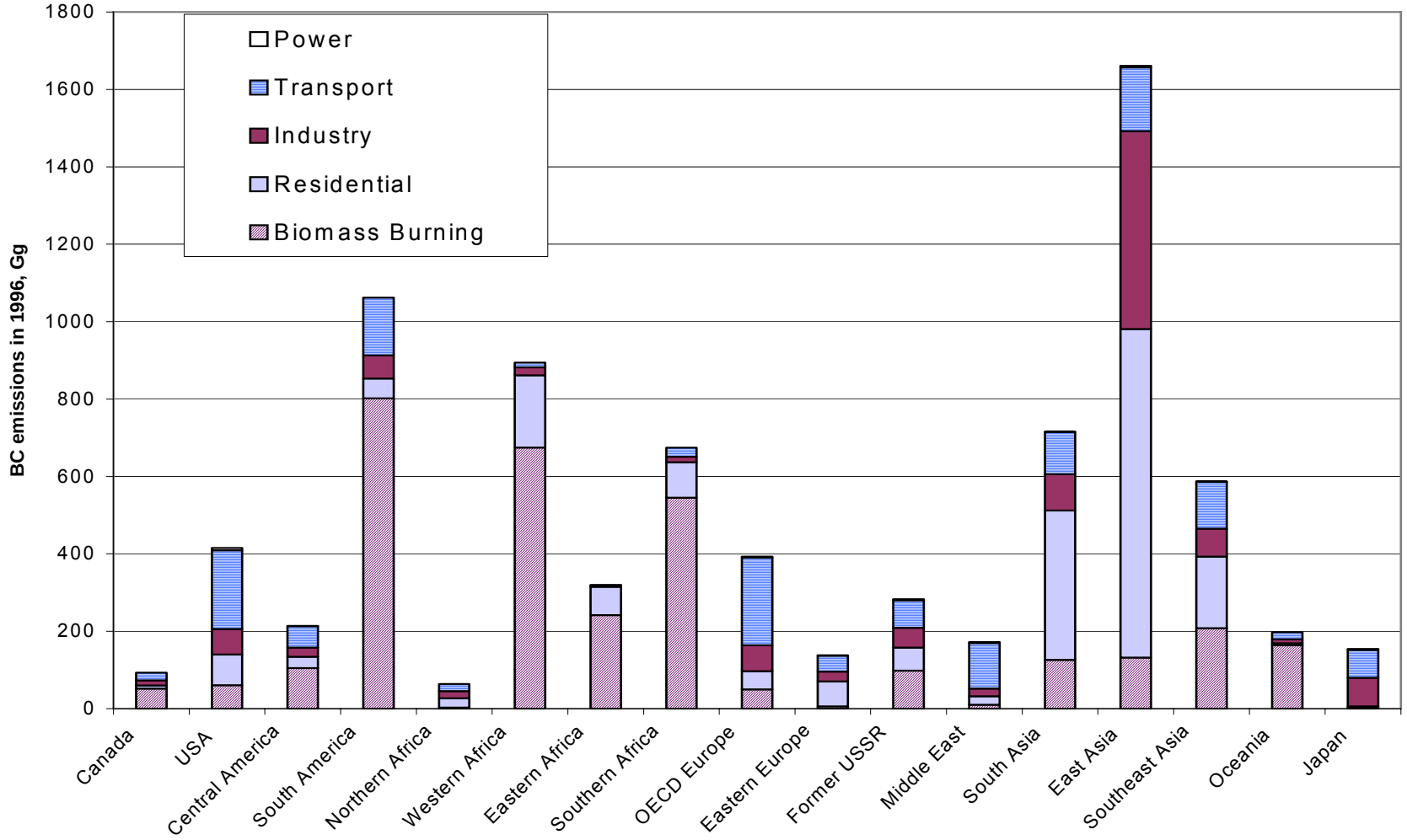
U.S. OC Inventory Projections to 2020



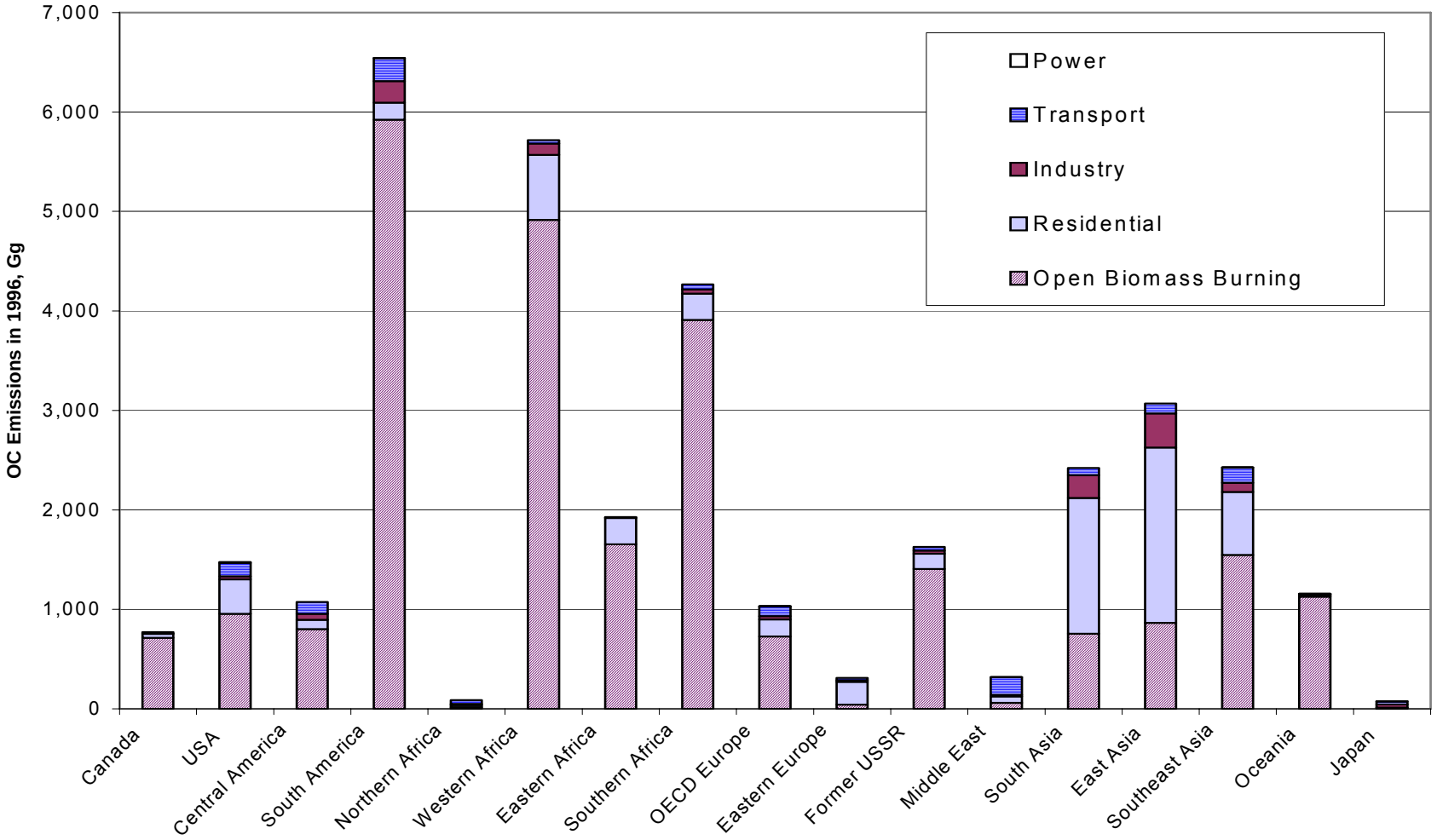
Findings for U.S. Inventories

- Generally good agreement for U.S. inventories, circa 2000
  - BC: 415 to 436 Gg
  - OC: 1,467 and 1,326 Gg
- EPA projections to 2020 (from PM2.5 NAAQS Regulatory Impact Assessment)
  - BC: 42% reduction
  - OC: 9% reduction
- Various diesel rules significantly reduce BC
- Open biomass burning emissions assumed constant; limited OC reductions

Global BC Inventory - 1996



Global OC Inventory - 1996



Findings: U.S. Versus Global Inventories, Circa 2000

- **BC emitted mainly from transport in the U.S. and OECD Europe, but not so in developing countries**
  - **BC mainly from residential in China and India, and biomass burning in South America and Africa**
- **OC emitted mainly from open biomass burning in the U.S. and most of the world**
  - **However, residential is the largest OC source in China, India, and Eastern Europe**

Findings: U.S. Versus Global Trends to 2020-2030

- **Transportation**
  - U.S.: BC reduction of ~70% from 2001 to 2020
  - Global: BC increases by 7% to 77% (range across all Streets et al. emissions scenarios)
- **BC/OC ratio**
  - U.S.: 0.33 in 2001 to 0.21 in 2020
  - Global: 0.23 in 1996 to 0.22 to 0.25 in 2030 (range across all Streets et al. emissions scenarios)
- **Probable explanation**
  - Significant BC increases in developing countries (e.g., China and India)
- **Changing BC:OC ratio has warming/cooling implications**

Completing the Mitigation Assessment for the U.S.

- **Focus on transportation and open biomass burning**
- **Identify control options that go beyond measures used to generate 2020 PM2.5 NAAQS scenarios**
- **Determine emission reductions potential and associated costs, using AirControlNET where feasible**
- **Produce marginal cost curves**
- **Inform discussion about what role, if any, BC/OC mitigation measures should play in climate change strategies**

Thank You!

- **Contact me at bahner@rti.org**
- **Or Ben DeAngelo at deangelo.ben@epa.gov**
- **Additional references:**
  - Black Carbon Subgroup under Energy Modeling Forum (EMF)
    - www.stanford.edu/group/EMF/projects/projectemf22.htm
  - EPA's Climate Change Website
    - www.epa.gov/climatechange
  - EPA's Regulatory Impact Analysis for Revised NAAQS
    - www.epa.gov/ttnecas1/ria.html