

## 4.5 EMISSIONS OF TROPOSPHERIC OZONE PRECURSORS AND BLACK CARBON

### 4.5.1 ABATEMENT TECHNOLOGIES FOR EMISSIONS OF TROPOSPHERIC OZONE PRECURSORS AND BLACK CARBON

#### Technology Description



(Above) Reflective roofing technology is an effective way to reduce temperatures in cities, leading to GHG reductions and tropospheric ozone concentrations, (Source: Sarnafil)

(Left) Available options to reduce open biomass burning include changing the frequency and conditions of prescribed burning and reducing open waste burning. (Photo: *National Geographic*, presented by T. Bond, 2002)

The role of black carbon (soot), organic carbon and tropospheric ozone in climate change is still evolving and additional research is needed to characterize emission sources, atmospheric concentrations, net climatic effects at global and regional scales, and technological responses. It is likely that activities to reduce tropospheric ozone precursors and black carbon (BC) will have large public health and local air quality benefits, in addition to their role in mitigating climate change. Abatement technologies in this area include:

- *Transportation control technologies* - Tropospheric ozone and particulate matter (PM) emissions, of which BC is a component, resulting from motor U.S. vehicles have long been targeted because of their health and environmental consequences. Thus, vehicle manufacturers have developed increasingly effective control technologies to abate ozone precursors (especially nitrogen oxides or NO<sub>x</sub>) and emissions of PM, in response to stricter engine and emission standards. Aside from emission controls, increasing fuel efficiency also reduces ozone precursors and BC.
- *Temperature reduction in cities* - Heat islands form as cities replace natural vegetation with pavement for roads, buildings, and other structures. There are several measures available to reduce the urban heat island effect that can decrease ambient air temperatures, energy use for cooling purposes, GHG emissions, and ozone concentrations. (Related information can be found in the technology profile “Urban Heat Island Technologies” under “Buildings”).
- *Biomass burning* - Important sources of BC and organic carbon (OC) aerosols in the United States include combustion of not only fossil fuels but also biomass burning. Available options to reduce open biomass burning include changing the frequency and conditions of prescribed burning and reducing open waste burning.

#### System Concepts

- *Transportation control technologies* - For on-road and non-road vehicles and equipment, future abatement technologies primarily involve sophisticated computer engine controls and treatment of exhaust emissions. Reduced fuel consumption and vehicle use also reduce ozone precursors and black carbon emissions.

- *Temperature reduction in cities* - Reduced temperatures reduce the need for summertime cooling energy, decrease biogenic volatile organic carbon emissions and evaporative losses from mobile and stationary sources, and reduce photochemical reaction rates, which may reduce ozone production.
- Assess the importance of *biomass burning*, including agricultural, prescribed, and wild fires.

### **Representative Technologies**

- *Transportation control technologies* include advanced tailpipe NO<sub>x</sub> controls (including NO<sub>x</sub> adsorbers), PM filters (traps) for diesel engines (including catalyzed traps capable of passive regeneration), and hybrid and fuel cell vehicles.
- Representative technologies for *temperature reduction in cities* include:
  - Strategically planted shade trees
  - Reflective roofs: There are more than 200 Energy Star™ roof products, including coatings and single-ply materials, tiles, shingles and membranes. Energy savings with reflective roofs range as high as 32% during peak demand (summer average of 15%).
  - Reflective paving materials: There are several reflective pavement applications being developed, including new pavement and resurfacing applications, asphalt, concrete and other material types. White-topping is becoming increasingly popular.
- Alternatives to *biomass burning* include prescribed burning programs (which are directed at minimizing wildfires), and regulation or banning of open burning (such as in land clearing).

### **Technology Status/Applications**

- *Transportation control technologies* - Heavy-duty diesel engine manufacturers are pursuing advanced NO<sub>x</sub> controls and particulate matter filters to meet stringent 2004 and 2007 emission standards for highway trucks and buses and 2010 standards for nonroad diesel construction, agricultural and industrial equipment. In addition, hybrid and fuel cell alternatives are under development.
- Technology status for *temperature reduction in cities*
  - Shade Trees - Nationally, there are numerous tree-planting programs. Some utilities have partnered with urban forestry groups to encourage residential shade tree planting to reduce energy consumption from air conditioning. Further, several communities have implemented shade tree ordinances.
  - Reflective Roofs - A few states (e.g., Georgia and Florida) have incorporated reflective roofs into their state energy codes. Some states (e.g., California) and communities have reflective roof incentive programs. Reflective roofs are given credit in several environmental rating programs including the U.S. Green Building Council's LEED (Leadership in Energy and Environment) rating system.
  - Reflective Pavements - Some communities are installing alternative pavement parking lots and alleys – mainly using porous pavement technologies. White-topping is also becoming increasingly popular.

## **Current Research, Development, and Demonstration**

### **RD&D Goals**

- *Transportation technologies* - Cost-effective NO<sub>x</sub> and PM black carbon engine and vehicle controls, especially for diesel engines, hybrid-diesel, and gasoline drive trains for medium- and heavy-duty vehicles.
- *Temperature reduction in cities* - Understand and quantify the impacts that heat island reduction measures have on local meteorology, energy use, GHG emissions, and air quality; develop an application, based on geographic information systems, that predicts heat island outcomes from different development scenarios.
- *Basic research* is needed to better understand the joint role of BC and OC in climate change, including establishing linkages between air pollution and climate change by enhancing modeling capabilities; designing integrated emissions control strategies to benefit climate, regional and local air quality simultaneously.

### **RD&D Challenges**

- *Temperature reduction in cities* - The interaction between meteorological, land surface, and emission-specific parameters are not fully understood.
- *Biomass burning* - To design integrated emissions control strategies to benefit global climate and regional and local air quality simultaneously and improve current wildfire research to be address black carbon and organic carbon.

**RD&D Activities**

- Better understanding of the role of ozone and black and organic carbon in climate change
- *Transportation control technologies* - Transfer of onroad diesel emission control technology to nonroad applications has begun with the nonroad diesel rule issued in 2004; development of in-use emission measurement techniques; gasoline vehicle particulate matter (inc. black carbon) characterization; develop retrofit emission control technology, and develop understanding of role of reducing fuel consumption and vehicle use on non-CO<sub>2</sub> GHGs, and further development of hybrid, hydrogen internal combustion, and fuel cell technologies to a range of vehicle applications.
- *Transportation control technologies* - Current focus of industry and EPA research is on developing and demonstrating effective, compact, and durable advanced NO<sub>x</sub> and particulate matter control systems.
- *Temperature reduction in cities* - Tulane University and Lawrence Berkeley National Lab (LBNL) are modeling the impacts of heat island reduction measures on local meteorology in seven U.S. domains; LBNL is analyzing the urban fabric (surface composition) in several cities; and several groups in California are examining net benefits from trees.

**Recent Progress**

- *Transportation control technologies* - In 2000, stringent passenger car/light truck/sport utility vehicle standards were established to result in historically low levels of per-vehicle emissions of NO<sub>x</sub> beginning in 2004. In 2001, stringent heavy truck and bus standards are resulting in creative technological approaches to difficult NO<sub>x</sub> and particulate matter standards. In 2004, standards similar to the bus and truck standards were established for nonroad diesel applications, and industry is pursuing similar technological approaches for NO<sub>x</sub> and PM control.
- *Biomass burning* - EPA began monitoring of black carbon as part of the IMPROVE network in 1988 (110 monitoring sites). EPA also developed new source performance standards for residential wood heaters (promoting complete combustion and reducing particulate emissions). Open burning (including land clearing) in many parts of the country has been regulated or banned in order to minimize emissions and help achieve national ambient air quality standards for particulate matter and ozone.

**Commercialization and Deployment Activities**

- *Transportation control technologies* - All new passenger cars, light trucks, and sport utility vehicles will have highly sophisticated emission controls after 2004. Manufacturers of heavy-duty engines have significant demonstration experience with particulate filter technologies, especially on urban buses. Commercialization of hybrid light- and heavy-duty vehicles is underway or beginning.
- *Temperature reduction in cities* - Reflective roofing and paving technologies may be broadly applicable to U.S. cities, but benefits will vary. In addition, several reflective roof programs (e.g., California's Cool Savings Program) require use of Energy Star<sup>TM</sup> Roof Products.