The modern Clean Air Act (CAA) came into being in 1970, and although significant changes were made to it in 1977 and 1990, the basic structure of the Act has remained the same. Significant additions since 1970 include provisions addressing acid rain, chlorofluorocarbons (CFCs), indoor air, and chemical safety. In 2007, the Supreme Court confirmed the authority of the Environmental Protection Agency (EPA) to regulate greenhouse gases to mitigate climate disruption. The CAA regulates both stationary and mobile sources of pollution, taking into account the relative contributions of each to specific air pollution problems, and the relative capacity of different kinds of sources within each category to reduce their emissions. The recognition that sources using newer technology might be able to achieve greater emission reductions than older sources with older technology led to the Act’s distinction, in both its stationary and mobile source provisions, between new and existing sources. Although driven by equity considerations regarding the relative financial and technical burdens of pollution reduction, this approach has unwittingly discouraged modernization or replacement of facilities and has resulted in the operation of older facilities, especially in the field of energy, beyond their expected useful life. For new sources within each industrial sector, there was recognition of the need for uniformity and also for encouraging technological innovation through the technology-forcing capability inherent in stringent standards.

**CLEAN AIR ACT**

The 1970 CAA directed the EPA to set air quality criteria for pollutants that are emitted to the air “from numerous or diverse stationary or mobile sources” and “may reasonably be anticipated to endanger public health or welfare” (Section 109[a][1][A] and [B]), and to establish primary ambient air quality standards for those pollutants that protect public health with an adequate margin of safety (Section 109[b][1]). As interpreted by the courts and supported by congressional history, these standards are to be established without consideration of economic or technological feasibility. In addition, secondary ambient air quality standards are to be established to protect the public welfare within a reasonable time (Section 109[b][2]). The EPA has issued, and revised, ambient air quality standards for a relatively small number of these so-called criteria pollutants.

The CAA assigns key roles to both the federal government and the states in controlling exposure to the criteria pollutants in the ambient air. While ambient air quality (concentration) standards are established by the federal government, these ambient standards (identified below) are to be attained through (1) emission limitations placed on individual existing polluters through permits issued by state government as a part of their state implementation plans (SIPs; Section 110); (2) nationwide emission limitations for new sources, established by the EPA and known as New Source Performance Standards (Section 111); and (3) a combination of federal and state restrictions on mobile sources. Emission standards, in contrast with ambient concentration standards, are expressed as an emissions rate (milligrams emitted per 100 kg of product, per hour, per day, per week, per quarter, per year, per British thermal unit (BTU), per passenger mile, or per other unit of measurement).

The CAA does not establish ambient standards for hazardous air pollutants, but rather requires compliance with nationwide emission limitations set by the EPA (Section 112). Hazardous air pollutants are those recognized as extraordinarily toxic and eventually regarded as non- or low-threshold
pollutants. Initially, these were to be regulated to protect public health with an ample margin of safety and, as with the primary ambient standards for criteria pollutants, emission standards for hazardous air pollutants were to be established without consideration of economic burden. The reliance on federal emission standards reflected congressional concern with “hot spots” of localized intense pollution, and also with intermittent versus continuous versus sudden and accidental releases of harmful substances. These pollutants, Congress determined, were sufficiently dangerous to preclude any reliance on atmospheric dispersion and mixing as a means of reducing their ambient concentrations. Moreover, ambient concentration standards were considered impractical and of little relevance for the sporadic and idiosyncratic sources of hazardous air pollutants. For all these reasons, uniform federal emission standards were considered necessary. (Note, however, that California did establish an ambient standard as a complement to the federal emission limitation on vinyl chloride.)

In the early stages of the implementation of the stationary source provisions of the Clean Air Act (approximately 1970–1975), the EPA focused on (1) the ambient air quality standards for criteria pollutants; and (2) emission standards for new sources of criteria pollutants and for all sources emitting any of seven regulated hazardous air pollutants (discussed below). Initially, prior advisory ambient standards for criteria pollutants carbon monoxide (CO), sulfur dioxide (SO2), oxides of nitrogen (NOX), large particulate matter, and photochemical oxidants were made mandatory. In 1979, the standard for photochemical oxidants was narrowed to cover only ground-level ozone and was relaxed from 0.08 parts per million (ppm) to 0.12 ppm averaged over a one-hour period. The standard for coarse particulate matter—inhalable particulates up to 10 microns in diameter (PM10)—was adopted in 1987. In 1997 and again in 2008, the ozone standard was further revised to 0.08 ppm and 0.075 ppm, respectively, but the 2008 standard has been put on hold pending further revisions. Also in 1997, the particulate standard was altered to place more stringent requirements on smaller (less than 2.5 microns) respirable particles (PM2.5), with a twenty-four-hour limit of 65 micrograms per cubic meter of air (μg/m3). In 2006, the PM2.5 limit was further lowered to 35 μg/m3. Further revisions are under consideration. A standard for a sixth criteria pollutant, airborne lead, was promulgated in 1978, and in 2008 EPA lowered the permissible airborne concentration by one order of magnitude, from 1.5 micrograms per cubic meter of air (μg/m3) to 0.15 μg/m3. (Current primary air quality standards set under Section 109 are found in the table below.) In June 2010, EPA replaced the daily and annual sulfur dioxide standards with an hourly standard of 75 parts per billion (0.075 ppm.).

As noted, Congress also directed the EPA to set emission standards for “hazardous air pollutants.” As originally written, Section 112 of the Act specified that all such standards should be set at a level

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Standard</th>
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</thead>
<tbody>
<tr>
<td>Carbon Monoxide</td>
<td>Primary (1970) – 35 ppm averaged over 1 hr and 9.0 averaged over 8 hrs; Secondary – none.</td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>PM10: Primary and Secondary (1970) – 150 μg/m³ averaged over 24 hrs, with no more than one expected exceedance per calendar year; also, 50 μg/m³ or less for the expected annual arithmetic mean concentration.</td>
</tr>
<tr>
<td>PM2.5</td>
<td>Primary (2006) – 35 μg/m³ averaged over 24 hrs</td>
</tr>
<tr>
<td>Ozone</td>
<td>Primary (1997) – 0.08 ppm averaged over 8 hrs</td>
</tr>
<tr>
<td>Nitrogen Dioxide</td>
<td>Primary (1970) – 100 μg/m³ (0.053 ppm) as an annual arithmetic mean concentration</td>
</tr>
<tr>
<td>Sulfur Oxides</td>
<td>Primary (2010) – hourly standard of 75 parts per billion; prior daily and annual standards revoked</td>
</tr>
<tr>
<td>Lead</td>
<td>Primary and Secondary (2008) – 0.15 μg/m³ arithmetic average over a calendar quarter</td>
</tr>
</tbody>
</table>
that protects public health with an “ample margin of safety.” It is likely that this phraseology reflected an early assumption that although hazardous pollutants were very dangerous, they exhibit a finite threshold (a nonzero level of exposure below which no harm would occur). As the 1970s progressed, however, there was a growing recognition that this assumption might be wrong, and that for many hazardous pollutants there was no level of exposure (at least at levels within the limits of detection) below which one could confidently predict that no harmful or irreversible effects (especially cancer or birth defects) would occur.

This presented an implementation challenge for the EPA. Arguably, given its mandate to protect public health with an ample margin of safety, the agency was required to ban the emission of several hazardous substances. This would, as a practical matter, essentially ban the use of these substances in many industries. Seeking to avoid this result, the EPA adopted a policy of setting Section 112 emission standards at the level that could be achieved by current technology. The standard-setting process was slow and had to be forced by litigation; only a few substances were regulated, and it took four to seven years to establish a final standard for each of these substances. Had the EPA continued to set standards for more substances, and had it used the technological-feasibility approach to spur the development of cleaner technology, the environmental community may well have been content to allow the implementation of Section 112 to proceed in this fashion. When the setting of new Section 112 standards all but stalled during the Ronald Reagan administration, however, the National Resources Defense Council, an environmental group, decided to press the issue in court.

_National Resources Defense Council v. Environmental Protection Agency_, decided by the District of Columbia Circuit Court of Appeals in 1987, complicated the EPA’s approach to regulating hazardous air pollutants by ruling that the EPA must determine an acceptable (usually nonzero) risk level for a hazardous air pollutant prior to setting a Section 112 standard for that pollutant. In reaction to this case and to revitalize the moribund standard-setting process, Congress amended Section 112 in 1990 to specify a two-tiered approach: the use of technology-based standards initially, with residual risks to be addressed (at a later date) by health-based standards. In addition, Congress listed 189 substances that must be regulated as hazardous air pollutants, and directed the EPA to add other substances to the list if they “present or may present… a threat of adverse human effects (including, but not limited to, substances which are known to be or may be reasonably anticipated to be, carcinogenic, mutagenic, teratogenic, neurotoxic, which cause reproductive dysfunction, or which are acutely or chronically toxic) or adverse environmental effects whether through ambient concentration, bioaccumulation, deposition or otherwise.” The EPA was directed to set “maximum achievable control technology” (MACT) technology-based standards over a ten-year period for categories of major stationary sources (defined as those emitting more than ten tons per year of any single hazardous pollutant or more than twenty-five tons combined). MACT standards must require the maximum feasible degree of reduction (including a prohibition on emissions, where achievable) but must reflect the cost of achieving emissions reduction and any non-air and environmental impact and energy requirements. MACT standards for new sources must be at least as stringent as those met by the best-performing similar source, and MACT standards for existing sources must be at least as stringent as those met by the average of the best-performing 12 percent of similar sources. For categories of smaller (so-called area) stationary sources, the EPA is authorized to set standards that are less restrictive than the MACT standard, based either on “generally achievable control technology” (GACT) or on the use of specified management practices. For pollutants with an identifiable health threshold, the EPA is authorized to forgo the technology-based approach and to instead set health-based standards that ensure an ample margin of safety, essentially the original mandate of the 1970 CAA. Finally, the EPA is obligated to issue a report on the residual risk to health that remained after the adoption of the
technology-based standards, which it did in 2004. If no new legislation recommended by that report is enacted by 2012, the EPA must issue such additional regulations as are necessary to “protect public health with an ample margin of safety” in general and, specifically for carcinogens, must ensure that lifetime exposure risks are less than one in one million. The EPA has made substantial progress in establishing MACT and GACT standards, but has just begun the task of developing risk- or health-based approaches. The 1990 amendments to the CAA also placed an increased emphasis on toxic air pollutants emitted by mobile sources, and in 2007 the EPA issued a Mobile Source Air Toxics rule designed to lower benzene concentrations in gasoline and restrict automotive emissions of benzene and a number of other toxic substances.

Sudden and Accidental Release of Chemicals and Chemical Accidents. Although the first congressional response to the concern generated by the deadly industrial accident in Bhopal, India, was the Emergency Planning and Community Right to Know Act of 1986, the chemical safety provisions of that law are focused almost solely on chemical accident mitigation and not on accident prevention. A much greater potential for a direct focus on accident prevention can be found in the 1990 amendments to the Clean Air Act.

As amended in 1990, Section 112 of the Clean Air Act directs the EPA to develop regulations regarding the prevention and detection of accidental chemical releases and to publish a list of at least one hundred chemical substances (with associated threshold quantities) to be covered by the regulations. The regulations must include requirements for the development of risk-management plans (RMPs) by facilities using any of the regulated substances in amounts above the relevant threshold. These RMPs must include a hazard assessment, an accident prevention program, and an emergency release program. The EPA promulgated regulations setting forth requirements for the RMPs in 1996. This RMP rule, which is estimated to affect some 66,000 facilities, requires a hazard assessment (involving an offsite consequence analysis including worst-case risk scenarios and compilation of a five-year accident history), a prevention program to address the hazards identified, and an emergency response program.

In addition, Section 112(r) of the revised Clean Air Act imposes a general duty on all owners and operators of stationary sources, regardless of the particular identity or quantity of the chemicals used on site, to:

- identify hazards that may result from [accidental chemical] releases using appropriate hazard assessment techniques,
- design and maintain a safe facility taking such steps as are necessary to prevent releases, and
- minimize the consequences of accidental releases which do occur.

Thus, firms are now under a general duty to anticipate, prevent, and mitigate accidental releases.

The amended Clean Air Act also directs each state to establish programs to provide small businesses with technical assistance in addressing chemical safety. These programs could provide information on alternative technologies, process changes, products, and methods of operation that help reduce emissions to air. However, the CAA provides no federal funding for these state programs, and they have not been uniformly implemented. Where they are established, linkage with state offices of technical assistance, especially those that provide guidance on pollution prevention, could be particularly beneficial.

Finally, the 1990 CAA amendments established an independent Chemical Safety and Hazard Investigation Board (CSHIB). The board is to investigate the causes of accidents, conduct research on prevention, and make recommendations for preventive approaches, much as the Air Transportation Safety Board does with regard to airplane safety.

Authority to Regulate Greenhouse Gases. As global climate change progresses and its detrimental impacts become clearer, it seems likely that reductions of global greenhouse gases (GHGs) will be necessary to stabilize the earth’s climate system. The transportation sector remains among the largest emitters of GHGs, contributing roughly 27 percent...
of such emissions in the United States and 21 percent worldwide.

During the Bill Clinton administration, the EPA determined that the Clean Air Act authorizes the regulation of carbon dioxide (CO2) emissions. In a landmark decision—Massachusetts, et al. v. Environmental Protection Agency (2007)—the US Supreme Court agreed. The EPA’s initial regulatory response was to issue a reporting rule for GHG emissions. Acting under its information-gathering authority in Clean Air Act Sections 114 (for stationary sources) and 208 (for mobile sources), the agency has imposed reporting requirements on a variety of stationary sources (including oil and gas facilities, refineries, chemical plants, pulp and paper plants, iron and steel plants, and industrial landfills) and on car and truck manufacturers.

In 2009, the EPA made a formal finding that greenhouse gas emissions from motor vehicles pose an endangerment to public health and welfare. Thus, in 2010 the EPA and the National Highway Traffic Safety Administration issued a joint rule specifying greenhouse gas emission standards and Corporate Average Fuel Economy (CAFE)—that is, fuel efficiency—standards for new passenger cars, light-duty trucks, and medium-duty passenger vehicles for model years 2012 through 2016. Under these standards, passenger cars and light-duty trucks would be required to meet an estimated combined average emissions level of 250 grams per mile of CO2 by the 2016 model year. The EPA’s “endangerment” finding also triggered a requirement that GHG emissions from “major emitting facilities” (stationary sources) be subject to emission regulation under the CAA (Section 165(a)[4]), and in 2010 the EPA promulgated the “Greenhouse Gas Tailoring Rule,” which takes a phased approach and limits the types of existing and new facilities that must reduce GHG emissions.

The fate of GHG regulations under the CAA is not yet settled, however. Scores of lawsuits have been filed challenging various aspects of these regulations, the EPA has delayed implementation of many of their provisions, and Congress has threatened to amend the CAA to prevent the EPA from regulating GHGs. The ultimate resolution, then, is likely to depend as much on political considerations as on legal ones.

[See also Environmental Protection Agency.]

Acknowledgment
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Bibliography

Nicholas A. Ashford and Charles C. Caldart

Climate Change
The international community has long been concerned about the state of the global climate, and about the possibly harmful impact of human activity on the delicate balance between people and their environment. The first Earth Day celebration, which launched the environmental movement in the United States, was held in April 1970, and as early as 1972 a 113-nation conference in Sweden launched the United Nations’s Environmental Program and its associated agency, the United Nations Environment Programme (UNEP). Though cooperation between nation-states is never easy to orchestrate, policy makers in the vast majority of such states have come to recognize the degree to which climate is the ultimate public good—the one dimension of the human condition in which the tragedy of the commons invites collective, rather than individual, regulation (on this, see Coates, 2011, pp. 107–108). That recognition manifested itself first in the signing, in 1988, of the Montreal Protocol on Substances That Deplete the Ozone Layer, and in the 1992 UN Earth Summit