SectorStrategies

# Measuring Construction Industry

## *Environmental Performance*

September 2007

# Contents

# Introduction

As EPA seeks new and better ways to pursue its mission, the measurement of environmental progress has become even more important. Through the Sector Strategies Program in the Office of Policy, Economics, and Innovation, EPA works together with many sectors to reduce their environmental impacts in cost-effective ways and to share information with the public. By engaging a broad range of stakeholders in the process, EPA hopes to promote a culture of understanding and environmental stewardship. For the construction sector, EPA Sector Strategies formed a partnership with the Associated General Contractors of America (AGC) to work together to improve the environmental performance of the construction industry.

Tracking the environmental performance of the construction sector in particular presents some unique challenges including: the large number of construction firms (and even larger number of construction sites); the prevalence of small businesses; and the lack of centralized data (federal or state) on environmental measures for this non-manufacturing sector. Often-used sector environmental performance measures and data sources are either not applicable to or not available for the construction sector—for example, chemical releases from the Toxics Release Inventory, or the details of air permits. Instead, this sector's environmental footprint includes areas such as sediment and contaminants in stormwater runoff, disposal of debris, and air emissions from nonroad equipment—all areas not well covered by EPA databases. Data on some of the topics of interest for construction are available from sources such as at the state-level, however, even using these data present challenges: the data collection can be infrequent within a state and inconsistent across states.

To address these challenges, this report provides recommendations on possible measures of environmental performance for the construction sector.[1] The information is this report will help EPA select the most meaningful measures for construction, and will be of interest to other government agencies working with construction, as well as other construction industry stakeholders.

Note that throughout the report only available data were investigated; new information collection efforts are not proposed. Currently, AGC is in the process of surveying its members on their environmental practices related to green buildings, diesel retrofits of equipment, construction debris, and environmental management systems. Their survey is expected to be recurring, which may make it possible to use the survey data to analyze trends over time. As this effort is currently underway and information from it has not yet been made publicly available, the data could not be included in this report.

As the impacts of construction are of concern to multiple EPA programs and offices, a team representing all of the EPA programs with a focus on the construction industry was assembled,

[1] Note that this report focuses on the construction phase of the built environment; it does not address activities prior to construction such as siting of buildings, the selection of materials, or post-construction activities (e.g., building operation).

with leadership provided by the Sector Strategies Program. This team worked together to choose the environmental topic areas where measurement was needed. This report provides background information for each of these topic areas relevant to the construction sector, recommends measures, and also describes other measures considered. The topic areas are:

- Normalizing Data
- Green Building Practices
- Construction and Demolition Debris Management
- Diesel Air Emissions
- Stormwater Compliance
- Energy Use and Greenhouse Gas Emissions

# Normalizing Data

## Background

This report frequently refers to "normalized" data when presenting trends over time. Normalizing means adjusting the actual annual numbers (e.g., count of Notices of Intent, gallons of fuel consumed) to account for changes in the sector's output over the same time period. For example, if the gallons of fuel consumed increased steadily over time, this could be due to an increase in construction activity, rather than an indication of reduced fuel efficiency. Without accounting for the increase in construction activity, the graph would show an upward trend. After adjusting for the increase in construction activity (i.e., after normalizing the data), the rate of increase would be reduced.

## Recommended Measures

**McGraw-Hill Construction.** Current and historical data on the "Value of Construction" and the number of projects in the residential, non-residential building, and engineering (roads, bridges, dams, airports, water and sewers, etc) subsectors are available from McGraw-Hill Construction. These data are updated quarterly, and 2006 is the most current complete year of data available. Data are available by state. The data do not distinguish between projects based on their acreage or, for residential projects, the number of dwelling units (e.g., one project could have 50 dwelling units). For non-residential and non-building projects, the number of projects includes the number of unique project types. For example, if a site includes constructing a hospital and a parking garage, that would be counted as two projects. Because the McGraw-Hill custom report covers the construction sector more comprehensively than the Census data, it is included in this report as the recommended measure.

## Other Measures Considered

**U.S. Census Bureau.** U.S. Census tracks the national dollar value of construction put in place on a monthly basis by the type of construction (e.g., construction for residential, commercial, lodging) through 2005. However, these data are not readily available at the state level. The Census Bureau does provide state-specific data on the dollar value for private non-residential construction put in place. A report costing $200 includes annual data from 1993 through 2005 by state, but these data exclude public construction, residential construction, power, communication, and railroad construction.[1]

Census data are also available for the annual number and valuation of privately owned housing units authorized by building permits, by state, for 1980-2005.[2] These data, also referred to as construction starts or housing starts, are of limited value as a normalizing measure for the construction sector as a whole, in that they cover only the residential subsector of construction.

# Green Building Practices

## Background

Stakeholders throughout the construction sector are increasingly promoting practices aimed at reducing the environmental impact of construction activities. Green building actually encompasses numerous environmental topics, but this report focuses on measuring performance only during the construction phase of the built environment; it does not address activities prior to construction such as design, siting of buildings, specification of materials, or operation of structures.

Several different types of rating or certification systems are now available to assess green buildings. From a measurement perspective, the program with the most data available is the Leadership in Energy and Environmental Design (LEED) Green Building Rating System™. LEED, which was developed by members of the U.S. Green Building Council (USGBC), is a set of voluntary standards for designing, constructing, and operating high-performance green buildings. First released in 2000 as a green building rating system for new commercial construction, LEED has expanded since then to cover additional aspects of building construction and operation, including existing building operations and maintenance, commercial interiors projects, and core and shell development projects. LEED certification distinguishes building projects that have demonstrated a commitment to green building by meeting performance standards. Tracking the construction sector's contributions to LEED certification provides a possible indicator of the sector's shift toward operations that are more environmentally sustainable.

Currently, AGC is in the process of surveying its members on their practices related to green buildings, among other environmental topics. Their survey is expected to be recurring, which may make it possible to use the survey data to analyze trends over time. As this effort is currently underway and information from it has not yet been made publicly available, the data could not be included in this report.

## Recommended Measures

**LEED-NC Credits Related to Construction Activity.** Construction practices play a key role in a building's LEED certification. Projects must meet prerequisites to qualify for certification. One of these prerequisites is specifically construction-related, requiring a site-specific plan to reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust generation. In addition to the prerequisites, projects receive points for each performance benchmark (credit) that they meet within each of five categories: sustainable sites; water efficiency; energy and atmosphere; materials and resources, which include credits for recycling and salvaging construction and demolition debris; and indoor environmental quality.[3] A project's point total, as assessed by an independent certifier, determines whether it will receive certification, and dictates its level of certification. Levels of certification range from "Certified" for projects receiving at least 26 points, to "Platinum" for projects earning 51 points or more.

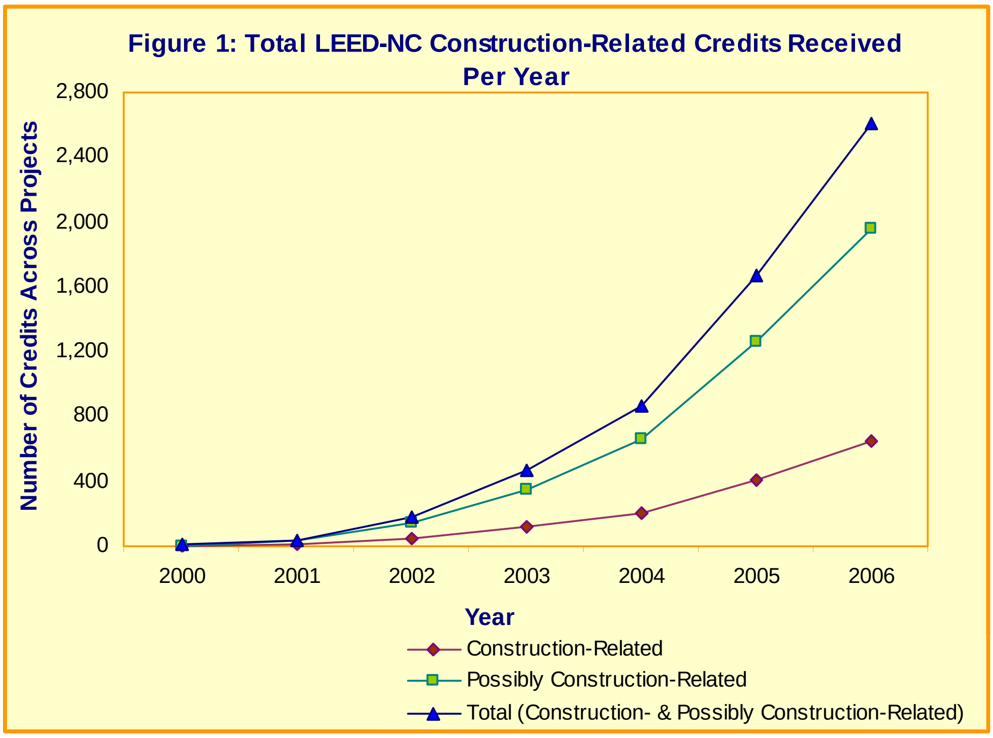
Although the USGBC defines the credits or criterion by the intent, requirements, strategies, and technologies associated with each, it is not always obvious which criteria are associated with decision-making at the construction contractor level. This report assigns each criterion to one of three categories: 1) not construction-related, 2) construction-related, or 3) possibly construction-related. Table 1 lists the specific criteria assigned to each category based on the criteria for *LEED-NC: Green Building Rating System for New Construction and Major Renovations* (version 2.2). In order to obtain credits, a project must first meet certain prerequisites for each category. Though projects must complete the prerequisites before acquiring credits, the prerequisites themselves do not add to the total number of credits (and are thus not presented in the graph of total LEED credits). Figure 1 displays the number of credits received between 2000 and 2006 by all certified projects for all construction-related and possibly construction-related criteria combined.

**Table 1: Categories with Construction-Related Prerequisites and Credits**

| | |
|---|---|
| **Construction-Related Prerequisite** | |
| **Sustainable Sites** | |
| **Construction Activity Pollution Prevention** | Reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation. |
| **Criteria Flagged as Construction-Related or Possibly Construction-Related** | |
| **Construction-Related** | |
| **Materials & Resources** | |
| **Construction Waste Management,** Divert 50% from Disposal | Divert construction, demolition and land-clearing debris from disposal in landfills and incinerators. Direct recyclable recovered resources back to the manufacturing process. Direct reusable materials to appropriate sites. |
| **Construction Waste Management,** Divert 75% from Disposal | Divert construction and demolition debris from disposal in landfills and incinerators. Direct recyclable recovered resources back to the manufacturing process. Direct reusable materials to appropriate sites. |
| **Indoor Environmental Quality** | |
| **Construction IAQ Management Plan,** During Construction | Reduce indoor air quality problems resulting from the construction/renovation process in order to help sustain the comfort and well-being of construction workers and building occupants. |
| **Construction IAQ Management Plan,** Before Occupancy | Reduce indoor air quality problems resulting from the construction/renovation process in order to help sustain the comfort and well-being of construction workers and building occupants. |
| **Possibly Construction-Related** | |
| **Sustainable Sites** | |
| **Stormwater Design,** Quantity Control | Limit disruption of natural water hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff, and eliminating contaminants. |
| **Stormwater Design,** Quality Control | Limit disruption and pollution of natural water flows by managing stormwater runoff. |
| **Site Development,** Protect or Restore Habitat | Conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity. |

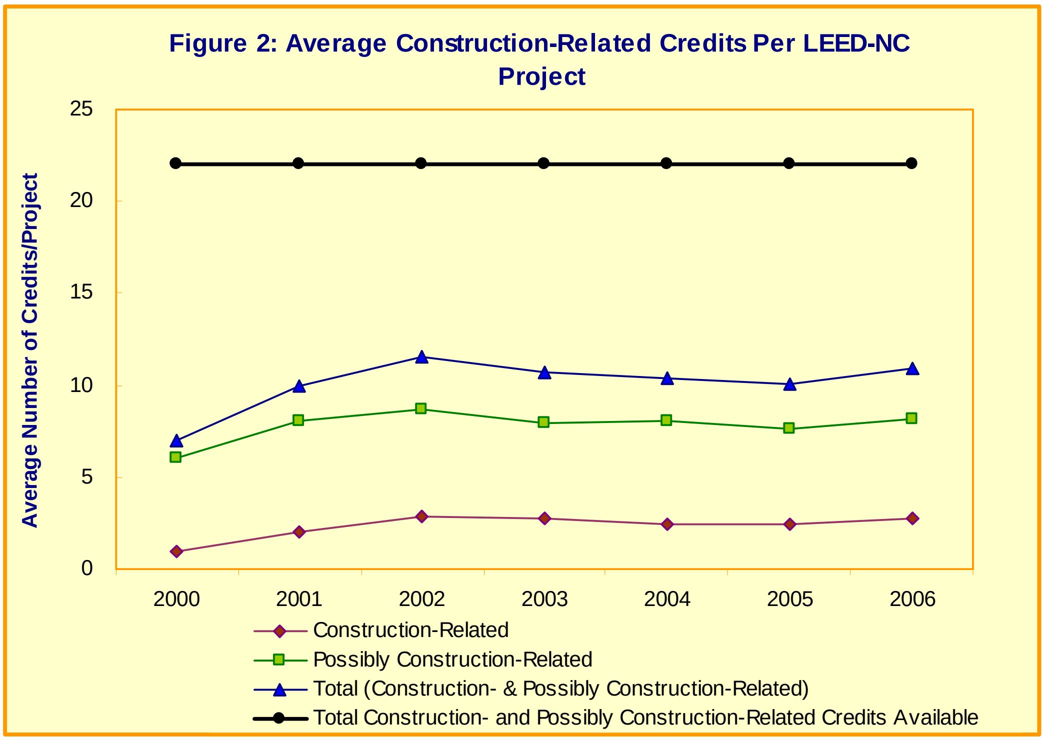
| Materials & Resources | |
|---|---|
| **Building Reuse,** Maintain 75% of Existing Walls, Floors & Roof | Extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport. |
| **Building Reuse,** Maintain 95% of Existing Walls, Floors & Roof | Extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport. |
| **Building Reuse,** Maintain 50% of Interior Non-Structural Elements | Extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport. |
| **Materials Reuse,** 5% of total value of materials used | Reuse building materials and products in order to reduce demand for virgin materials and to reduce waste, thereby reducing impacts associated with the extraction and processing of virgin resources. |
| **Materials Reuse,** 10% of total value of materials used | Reuse building materials and products in order to reduce demand for virgin materials and to reduce waste, thereby reducing impacts associated with the extraction and processing of virgin resources. |
| **Recycled Content,** 10% (post-consumer + ½ pre-consumer) | Increase demand for building products that incorporate recycled content materials, thereby reducing impacts resulting from extraction and processing of virgin materials. |
| **Recycled Content,** 20% (post-consumer + ½ pre-consumer) | Increase demand for building products that incorporate recycled content materials, thereby reducing the impacts resulting from extraction and processing of virgin materials. |
| **Regional Materials,** 10% Extracted, Processed & Manufactured Regionally | Increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation. |
| **Regional Materials,** 20% Extracted, Processed & Manufactured Regionally | Increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation. |
| **Rapidly Renewable Materials,** 2.5% of total value of materials and products | Reduce the use and depletion of finite raw materials and long-cycle renewable materials by replacing them with rapidly renewable materials. |
| **Certified Wood,** 50% of wood-based materials and products | Encourage environmentally responsible forest management. |
| **Indoor Environmental Quality** | |
| **Low-Emitting Materials,** Adhesives & Sealants | Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants. |
| **Low-Emitting Materials,** Paints & Coatings | Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants. |
| **Low-Emitting Materials,** Carpet Systems | Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants. |
| **Low-Emitting Materials,** Composite Wood & Agrifiber Products | Reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants. |

Source: USGBC. *LEED-NC: Green Building Rating System for New Construction and Major Renovations*. v2.2. 2005.




Source: USGBC. 2007. *LEED-NC v2 Certified Projects*. June 2007;
USGBC. 2005. *LEED-NC: Green Building Rating System for New Construction and Major Renovations*. Version 2.2. October 2005.

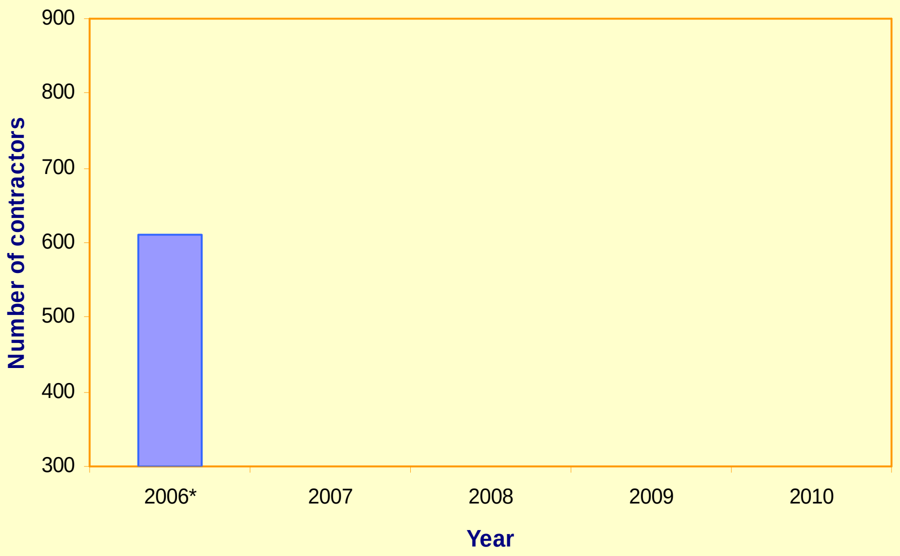
The growth in construction-related credits earned closely tracks the overall increase in LEED certified projects, as would be expected. To show the trend in construction contractors' contributions on a per project basis, Figure 2 depicts the average number of construction-related credits received per project in each year. A total of 22 credits are defined as either "construction-related" or "possibly construction-related." An increase over time in the average number of these credits received per project would indicate an increasing contribution of the construction sector in achieving green building certifications. As presented in the graph below, the average number of construction-related credits received per project increased between 2000 and 2002, and has remained relatively constant since then with approximately 11 credits per project.




Source: USGBC. 2007. *LEED-NC v2 Certified Projects*. June 2007.
USGBC. 2005. *LEED-NC: Green Building Rating System for New Construction and Major Renovations*. Version 2.2. October 2005.

**Construction Contractors with Professional LEED Accreditation.** In addition to the building certification process, the USGBC administers a program whereby individuals can earn LEED Professional Accreditation. Of the 25,700 LEED Accredited Professionals listed in the USGBC's directory, 610 of them selected "General Contractor" as their area of practice.[4] 2006 was the first year that the USGBC tracked the affiliation of LEED Accredited Professionals. Tracking the year-to-year change in the number of construction contractors who receive accreditation could provide an indicator of the trend in the green building knowledge of professionals and trades people in the sector. A change in the number of LEED Accredited Professional contractors is an indirect measure of the construction sector's investment in the requisite human infrastructure needed to expand green building practices. As the database is populated in the coming years, the trend in contractors receiving LEED accreditation could be tracked, as shown in Figure 3.

**Figure 3: LEED Accredited Professional General Contractors**



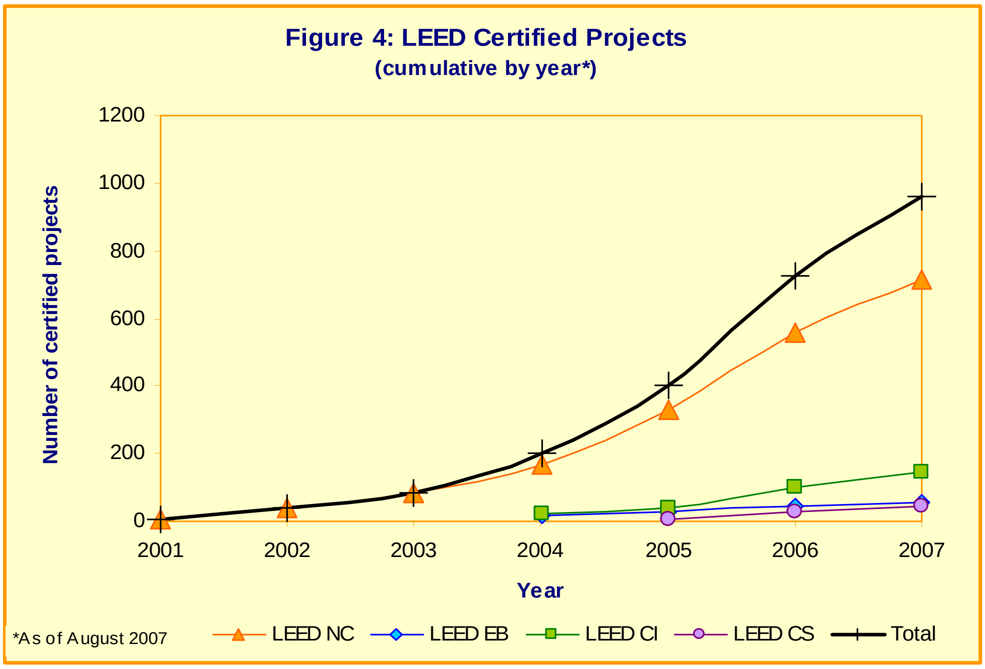

* First year of data collection

Source: USGBC Accredited Professionals database
http://www.usgbc.org/LEED/AP/ViewAll.aspx?CategoryID=1306&CMSPageID=1585

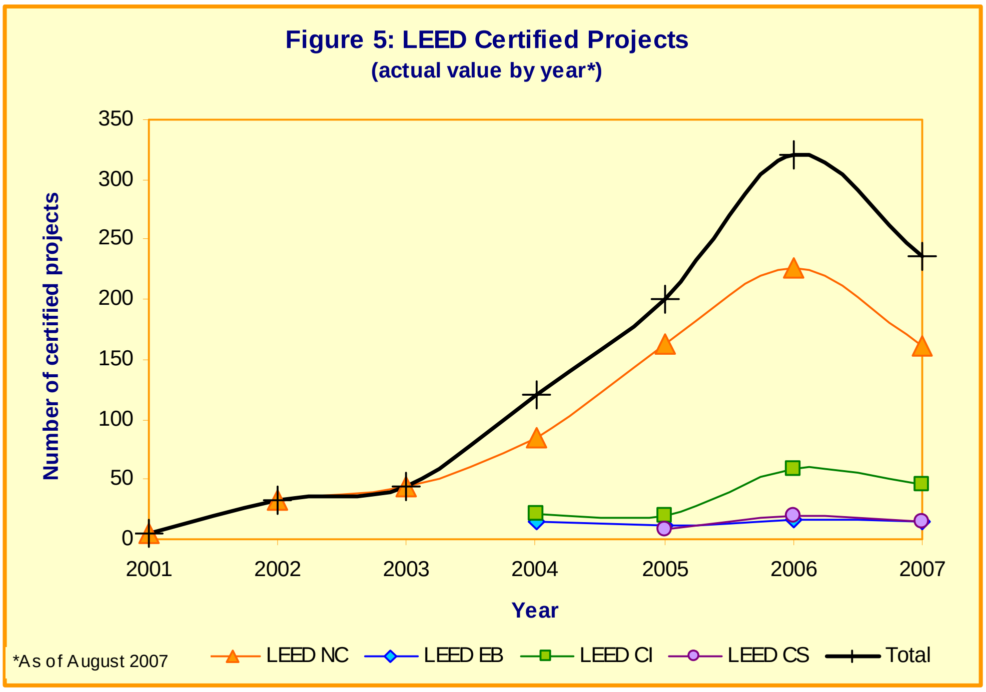
## Other Measures Considered ...............................................................................

**LEED Certified Projects.** The trend in LEED certified projects was considered as a potential measure of the construction industry's green building practices, however, it is possible for a building to achieve the points required for LEED certification without employing any green construction practices beyond the prerequisites. Tracking the change in the number of buildings certified over time, therefore, gives an inconclusive indication of the construction sector's contributions to LEED certification, and thus is not included as a recommended measure.

Figures 4 and 5 show trends in the number of LEED certified projects as of August 2007. Figure 4 shows the cumulative number of LEED certified projects, by project type. The total number of certified buildings increased from 5 in 2002 to 960 through August 2007. Figure 5 shows the annual number of LEED certified projects (this graph is not cumulative). In 2002, five buildings received LEED certification, and in 2006, 236 buildings received certification. For both graphs, note that data for 2007 are included for January through August only. Also note that during this time period, additional options for LEED certification became available, such as for existing buildings, that weren't available in 2002. The total number of LEED New Construction projects is shown by certification level in Table 2.




NC = New Construction, EB = Existing Buildings, CI = Commercial Interiors, CS = Core & Shell
Source: Personal communication with Kurt Steiner, U.S. Green Building Council. August 2007.




NC = New Construction, EB = Existing Buildings, CI = Commercial Interiors, CS = Core & Shell
Source: Personal communication with Kurt Steiner, U.S. Green Building Council. August 2007.

**Table 2: Total LEED Certified New Construction Projects in the United States**

| Level | Score | LEED Certifications at This Level* |
|---|---|---|
| Certified | 26-32 | 250 |
| Silver | 33-38 | 199 |
| Gold | 39-51 | 149 |
| Platinum | ≥ 51 | 22 |

*As of August 1, 2007

### Additional Green Building Standards.

**Green Globes™** provides another program for rating green buildings in the United States. The Green Building Initiative (GBI) brought Green Globes™—an online rating system for commercial structures developed by BOMA Canada's Green Go Plus program—to the U.S. market in 2004. The Green Globes system rates commercial buildings based on their environmental performance in seven areas: project management, site, energy, water, resources, emissions, and indoor environment. Projects that achieve 35% or more of the total points available to them receive a rating of one or more Green Globes:

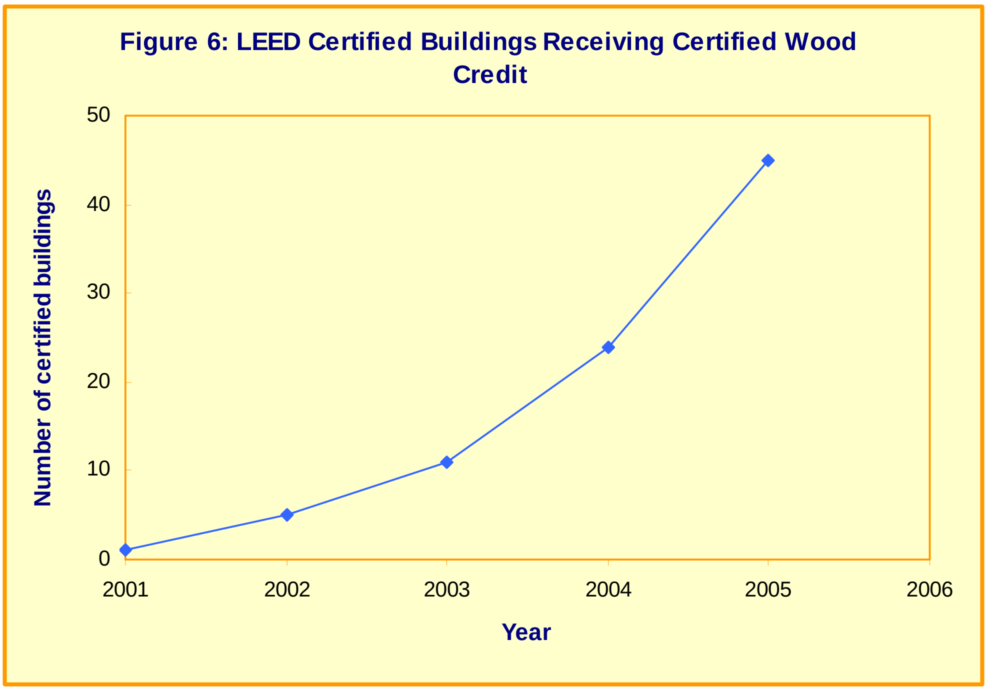
- Projects achieving 35-54% of the total points receive one Green Globe.
- Projects achieving 55-69% of the total points receive two Green Globes.
- Projects achieving 70-84% of the total points receive three Green Globes.
- Projects achieving 85-100% of the total points receive four Green Globes.

To date, eight projects in the U.S. have been awarded Green Globes: one project received four Green Globes, one received three Green Globes, and six projects received two Green Globes. Given that this program is relatively new to the U.S. market, and that it currently has so few U.S. awards, the data on the specific construction-related points that the award buildings received have not been incorporated into this report at this time.

**The Standard Project Committee 189 (SPC 189)** of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is establishing minimum standards for the design of high-performance green buildings. The standards apply to new commercial buildings and major renovation projects and addresses sustainability, water use and energy efficiency, the building's impacts on the atmosphere, materials and resources, and indoor environmental quality. The provisions of this standard do not apply to low-rise residential buildings, manufactured houses, and buildings that do not use either electricity or fossil fuel. Using USGBC's LEED® Green Building Rating System as a key resource, the standard will be an ANSI-accredited standard that can be incorporated into building code. It is anticipated that the standard will eventually become a prerequisite within LEED.[5]

**Green Home Building.** The National Association of Home Builders (NAHB) published its Model Green Home Building Guidelines in 2005. Intended as a toolkit for residential builders and local home builders associations, these guidelines address lot preparation and design; resource efficiency; energy efficiency; water efficiency/conservation; occupancy comfort and indoor environmental quality; and operation, maintenance, and education.[6] The NAHB Web site states that "by the end of 2007, more than half of NAHB's members, who build more than 80 percent of the homes in [the United States], will be incorporating green practices into the development, design and construction of new homes."[7] Apart from this claim, the NAHB does not provide any metrics that would be useful for tracking trends in green building practices among residential builders.

**Use of Environmentally Preferable Products.** Tracking trends in the construction sector's use of environmentally preferable products (e.g., low VOC paint or FSC certified wood products) is another area of interest to EPA. Construction contractors usually have a limited influence on the types of materials that are used in buildings, so use of environmentally preferable products is not a recommended measure in this report. One measure that was considered was the use of certified wood products. Projects pursuing LEED Certification can receive one credit for using Forest Stewardship Council (FSC) certified wood. In order to receive this credit, a minimum of 50% of the project's wood-based building components (i.e., structural framing and general dimensional framing, flooring, sub-flooring, wood doors, and finishes) must be certified in accordance with the Forest Stewardship Council's (FSC) Principles & Criteria of Forest Stewardship. These apply to the management of forests used for the production of wood products.[8] FSC tracks the number of LEED certified projects that have received the certified wood credit, as shown Figure 6.[9] Construction contractors have limited influence on whether or not certified wood is used; therefore, this metric was not recommended as a measure of the environmental performance of the construction sector.




Source: Miller, K. Forest Stewardship Council, Washington, DC. Personal communication, December, 2006.

## Construction and Demolition Debris Management

### Background

Construction and demolition (C&D) debris is produced when new structures are built and when existing structures are renovated or demolished. C&D debris is a significant contributor to the nation's solid waste.  Most of this debris is disposed of, such as in landfills, rather than recycled. EPA and the construction sector share a focus on reducing the impact of C&D debris on the environment, so a national measure of C&D debris generation and management would be a valuable metric. Currently, there is no centralized, national source for information on quantities of C&D debris generated or recycled.

Currently, AGC is in the process of surveying its members on their practices related to C&D debris management, among other environmental topics. Their survey is expected to be recurring, which may make it possible to use the survey data to analyze trends over time. As this effort is currently underway and information from it has not yet been made publicly available, the data could not be included in this report.

The following section uses several terms that are similar but not equivalent. In general, the term *generation* refers to the amount of waste produced, whereas *disposal* refers only to waste that is not recycled or reused (in many cases, this is also referred to as *landfilled* waste). *Recycled* waste refers to any waste that has undergone processing so that it may be used again (in some instances, this may include the direct reuse of materials and composting). Some states also refer to *source reduction* quantities, which are input materials that are not used and therefore do not become waste.

### Recommended Measures

**Trends in C&D Debris Recycling Rates at the State Level.** One approach for estimating the quantity of C&D debris generated annually in the U.S. is to use state-level C&D debris data, normalized for changes in state-level construction activity. It should be noted, however, that C&D debris measurement practices differ significantly among states so that a national trend cannot be projected.

A number of states including California,[10] Florida,[11] Iowa,[12] Maryland,[13] Missouri,[14] Virginia,[15] Wisconsin, Massachusetts, and Washington track the amount of C&D debris disposed of, but only Florida, Maryland, Virginia, Massachusetts, and Washington publish the data regularly. Among these five states, there are several inconsistencies in the data they present, including:

- Florida, Maryland, and Massachusetts are the only states identified that regularly collect data for C&D debris disposal and recycling.
- Virginia tracks only the amount of C&D debris that is landfilled or recycled at permitted facilities.
- Maryland and Virginia C&D debris data are currently available through 2005.

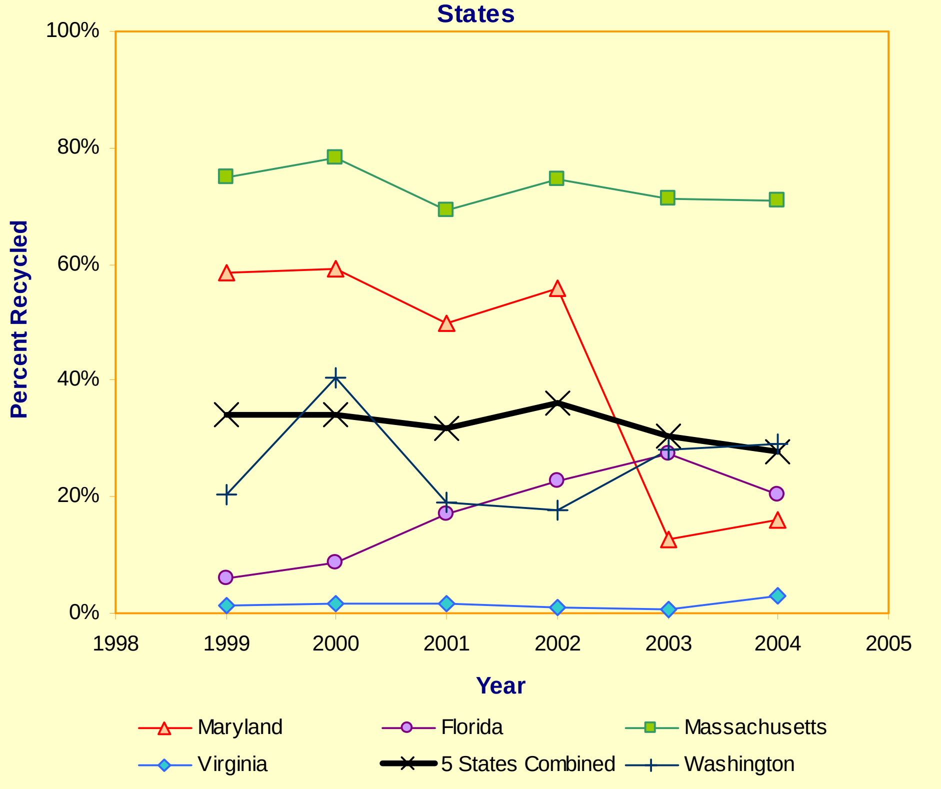
- Florida and Massachusetts C&D debris data are currently available only through 2004.
- Washington tracks the amount of C&D recycled annually by conducting mandatory surveys; however, waste handlers do not face any penalty for not returning the survey. Though Washington tracks waste landfilled annually, the data only includes the demolition and inert materials categories.

In addition to these states, other states may also have some supplementary information, although not necessarily data that are suitable for a trend analysis. For example, Ohio has 2003 data on the amount of C&D debris processed at C&D facilities, as well as 2006 data on the amount of C&D debris disposed at both C&D and MSW facilities. These Ohio data sources are problematic for two reasons: the 2003 data exclude a large portion of generated C&D material, and data were only collected for two years. Iowa, Missouri, Wisconsin, and Oregon also have limited data with similar issues. Table 3 summarizes data availability and limitations in the states investigated for this report.

| Table 3: C&D Debris Data Availability by State | | |
|---|---|---|
| **State** | **Data Availability** | **Data Limitations** |
| California | Total Generated and Diverted by Year | C&D debris data are not updated in regular intervals. |
| Connecticut | Connecticut does not report annual amounts of C&D disposed or recycled. | |
| Florida | C&D Collected and Recycled 1997-2004 | |
| Iowa | Does not track C&D recycling or disposal. Iowa has data on the amount of C&D landfilled in 1998 and 2005. | |
| Maryland | Tracks total tons of C&D debris managed and recycled from 1999 to 2005 at permitted refuse disposal facilities. | |
| Massachusetts | Tracks total tons of C&D debris generated, disposed of, and diverted from 1998 to 2004. | |
| Missouri | Missouri does not track C&D debris generation regularly. Has a waste characterization report from the late 1990s. Missouri suggests applying the percentage of C&D debris from that study to the 2005 disposal tonnage. | This method assumes that total waste disposal changes equally across all sectors. |
| New York | New York does track disposal and recycling data to some extent. Data were not included due to reporting inconsistencies and completeness. | Does not include waste that is exported or does not go to disposal facilities. Annual report data may be incomplete. |
| Ohio | Sent data from 2003 on C&D debris at C&D disposal facilities. Also sent 2006 data on C&D debris disposal at C&D and MSW facilities. | 2003 data does not include C&D debris not going to C&D facilities (a large underestimate). 2006 data does not include recycling. |
| Oregon | Does not separate disposal numbers into C&D. For disposal and recycling, data is listed by material type. May be able to provide an indication on C&D material. | Material types listed do not include inert material such as concrete. |
| Texas | Texas has tracked C&D disposal information from 2001 to 2005 for permitted and registered facilities. Texas does not track recycling. | |
| Virginia | Tracks C&D material received and recycled at permitted facilities. | This does not include waste that does not go to permitted facilities (captive waste management). This results in a large underestimate of total recycling. |
| Washington | Washington tracked annual C&D diversion from 1999 to 2005. Disposal data are also available but only in "demolition" and "inert materials" categories. | Diversion data is based on voluntary survey results. Disposal data are not presented specifically for C&D. |
| Wisconsin | Wisconsin only has some C&D debris numbers from a waste-sort in 2002 at MSW facilities. Does not track recycling. | |
| Sources: All information obtained from state environmental department websites or personal communications.[16] | | |

Trends in C&D debris recycling are presented in Figure 7 for five states: Florida, Maryland, Massachusetts, Virginia, and Washington (with the aforementioned caveats). The "5 States Combined" line shows the average percent C&D debris recycled by aggregating the five states' tons recycled and dividing by the aggregated tons generated to calculate the percentage of material recycled. The percentage of C&D debris that is recycled in these states combined has remained relatively steady over the six years examined, fluctuating between 28% and 36%. These data are presented as state-specific examples, not as a quantitative indicator of a national trend in C&D debris recycling. Further research, beyond the scope of this report, is needed to better understand the drivers that cause the vastly different recycling rates among the states presented and within states. For example, Massachusetts' high recycling rate may be the result of the state's mandatory C&D debris recycling requirements for several materials.

Figure 7: Generated C&D Debris That Is Recycled in Five States




Sources: http://www.mde.state.md.us/Programs/LandPrograms/Recycling/publications/index.asp - recycling;[17] http://www.dep.state.fl.us/waste/categories/recycling/pages/03_data.htm;[18] MA DEP, 2004;[19] 2006;[20] Virginia DEQ;[21] Washington Department of Ecology, 2006.[22]

## Other Measures Considered ........................................................................................

### National C&D Debris Trends for Building-Related and Road and Highway Construction.

For EPA's Office of Solid Waste, Franklin Associates developed a methodology to estimate the quantity of C&D debris generated in the United States in 2003 from the construction, demolition, and renovation of residential and nonresidential buildings.[23] As a preliminary estimate, this study calculated that 164 million tons of building-related C&D debris was generated in the United States in 2003.[24] Of that quantity, approximately 40% was recycled, and the remainder was disposed of.[25] The methodology for this study combined national Census Bureau data on construction industry activities (e.g., construction permits and construction value) with point source waste assessment data (i.e., waste sampling and weighing at a variety of construction and demolition sites) to generate a national estimate of building-related wastes. Findings are presented in the draft report, *Characterization of Building-Related Construction and Demolition Debris Materials in the United States*, expected to be final later in 2007. Considerable uncertainty is associated with the estimates presented in this study because the methodology relied on data from a limited number of waste assessments from new construction sites (293 residential, 12 nonresidential), the majority of which could now be considered outdated. For example, only 8 of the 293 studies were conducted after 1997, and the most recent study was conducted in 2000. Furthermore, the estimation of demolition debris was based on data from the demolition of five residential buildings and 27 nonresidential buildings. Additionally, reviewers of the study's methodology expressed concern that the Census Bureau undercounts the number of construction permits issued. In the future, if point source waste assessments were conducted more systematically, at regular intervals, and with a larger sample size representative of nationwide building construction and demolition, this could become a potential method for estimating changes in C&D debris practices nationwide. Currently, this study could provide an overview of national C&D trends by comparing the 2003 findings to those presented in a similar report published by EPA in 1996.

A method similar to the Franklin Associates method was developed for EPA's Office of Solid Waste to assess the quantity of C&D debris generated in the United States from road construction.[26] This methodology used road statistics published by the Federal Highway Administration (FHWA) to determine the number of lane-miles in the U.S. in 12-foot lane widths. By combining the area measurement with assumptions (obtained from literature and industry experts) about pavement type, maintenance time frames, reconstruction and resurfacing depths, and weight factors, this methodology was used to estimate road C&D debris generation on a tons per year basis. The preliminary estimate of road-related C&D debris generation was 167 million tons, of which 88% was recycled and the remainder was disposed of.[27] Similar to the building-related C&D debris assessment, this study is not updated regularly and is therefore of limited value for reporting trends in road and highway C&D debris generation.

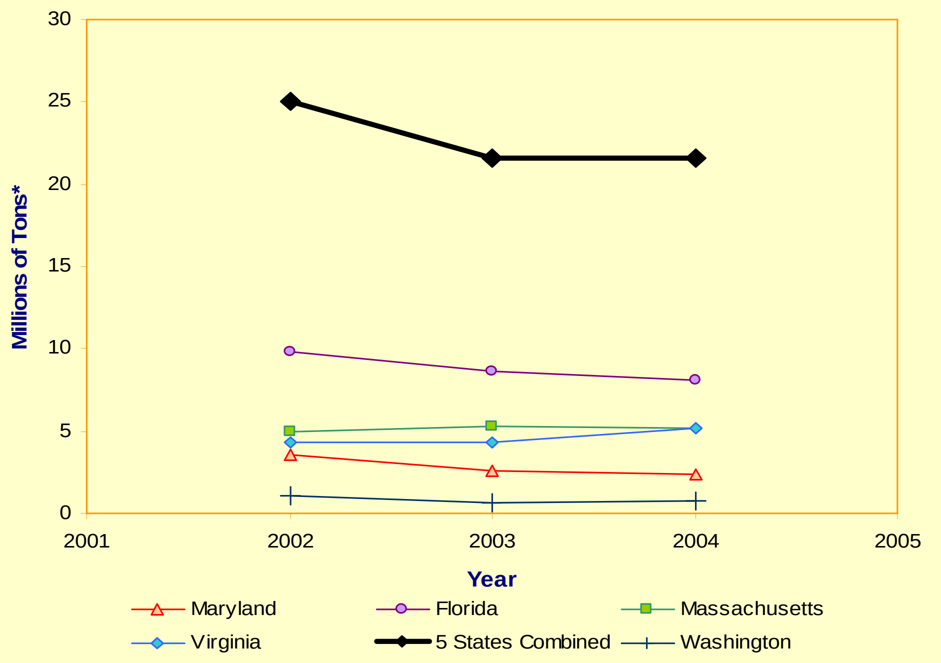
### National Surveys

Both the Construction Materials Recycling Association (CMRA) and the National Demolition Association (NDA) have conducted national surveys to gauge levels of recycling activity. In 1997 and 2004, the CMRA surveyed its members and developed estimates of total C&D waste processed and recycled. The CMRA survey estimated that national C&D recycling by C&D

processing plants was at 197 million tons in 2004, up from 96 million tons in 1997.[28] However, the CMRA currently does not have any plans for a future survey. NDA conducted its surveys in 1995 and 2005. The survey results reflect the amount of demolition debris generated and recycled by NDA members, nationwide. In 2005, NDA members who responded to the survey reported an aggregated demolition debris generation total of nearly 16 million tons and a demolition debris recycling total of over 11.5 million tons.[29] Using a statistical model, NDA extrapolated from the survey results to develop a national demolition waste generation number for all demolition activity (NDA members and non-members). Although NDA estimates the national amount of demolition debris generated, it does not include a national estimate of demolition recycling.[30]

**Trends in C&D Debris Generation at the State Level.** In addition to examining state-level recycling data, an analysis of trends in state-level C&D debris generation was also considered as a possible measure. After normalizing generation data for changes in state-level construction activity, inferences could be drawn about the level of materials reuse activity in each state. For example, if the normalized quantity of debris generated in a particular state decreased over time, it might suggest that C&D debris reuse was increasing in that state. Data for five states are shown in Figure 8.

**Figure 8: Amount of C&D Debris Generated**




* Normalized by value of construction from McGraw-Hill Construction.

Sources: http://www.mde.state.md.us/Programs/LandPrograms/Recycling/publications/index.asp - recycling;[31] http://www.dep.state.fl.us/waste/categories/recycling/pages/03_data.htm;[32] MA DEP, 2004;[33] 2006;[34] Virginia DEQ;[35] Washington Department of Ecology, 2006;[36] and McGraw-Hill Construction, *U.S. Total Construction Value*.

This approach has several data limitations and caveats. First, although more states regularly track C&D generation than track recycling, few were identified that had accessible data collected at regular intervals. Second, the McGraw-Hill data does not include information specific to demolition or renovation activities; normalizing disposal data for overall construction activity that may not include demolition or renovation could generate misleading results. Third, as with the recycling data, each state defines C&D disposal differently and has varying methods for collecting and measuring disposal information. These disparities make developing an aggregated year-to-year percentage change problematic. For these reasons, it does not seem likely that recommending a measurement of trends in C&D debris disposal data will add value to this report.

# Diesel Air Emissions

## Background

Most construction vehicles are powered by diesel engines. Diesel engines are also used frequently in other kinds of equipment found at construction sites, such as generators and compressors. Diesel air emissions are a focus for EPA because diesel exhaust (from all sources) is one of the largest sources of fine particulate matter in the U.S., and this exhaust also contains ozone-forming nitrogen oxides and other air pollutants.

In 2003, EPA proposed new emission standards for new nonroad diesel engines. These engine standards will begin to take effect in the 2008 model year, so significant reductions in air emissions are expected in 2008 and beyond. To help reduce emissions from the existing fleet of nonroad engines, innovative programs at both the federal and state level encourage retrofits of engines currently in use. For example, EPA's National Clean Diesel Campaign (NCDC) awards grants for projects designed to demonstrate effective emissions reduction strategies for diesel-powered vehicles, including construction equipment.

Currently, AGC is in the process of surveying its members on their diesel retrofit activities, among other environmental topics. Their survey is expected to be recurring, which may make it possible to use the survey data to analyze trends over time. As this effort is currently underway and information from it has not yet been made publicly available, the data could not be included in this report.

## Recommended Measures

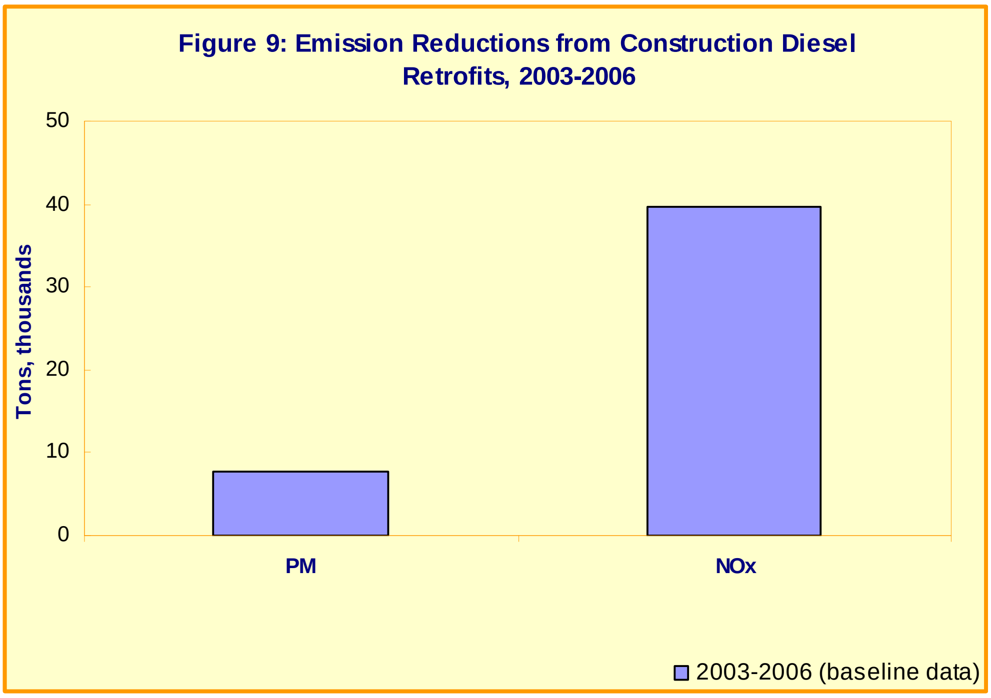
**Emissions Reductions from Diesel Retrofits.** EPA's regional offices track emission reductions from the EPA-funded projects and from retrofit projects funded by non-EPA sources. The data are then uploaded quarterly to the National Clean Diesel Campaign (NCDC) database. The national database uses an equation that incorporates the type of equipment retrofitted, the horsepower and model year of the retrofitted equipment, the year in which the retrofit occurs, and the number of vehicles retrofitted in order to estimate the reductions in particulate matter (PM), carbon monoxide (CO), nitrogen oxide (NOx) and hydrocarbon (HC) emissions from the projects.

This database could be used to measure the year-to-year change in emission reductions associated with voluntary diesel retrofits, which are primarily particulate matter (PM) and nitrous oxide (NOx). Baseline data indicate 7,793 tons of PM emissions and 39,747 of tons of NOx emissions were eliminated through diesel retrofits from 2003 through 2006. Data through 2006 are shown in Figure 9, with the following limitations:

- There is no requirement to report diesel retrofit activities to EPA; therefore, this database provides a lower-end estimate of total emission reductions from construction equipment.
- Emission reductions are not estimated for all of the projects tracked by the database because complete information (i.e., type of vehicle retrofitted, number of vehicles

retrofitted, or horsepower of vehicles retrofitted) is only available for 40 of the 85 tracked projects.

- As additional data become available for projects already in the NCDC database, it is possible that estimated emission reductions could change, even if the number of retrofit projects does not change.
- Only baseline data are currently available. At the end of 2007, an additional data point will be available to show the annual change from the 2003 – 2007 combined data as compared to the 2003 – 2006 combined data.




Note: Eighty-five projects are included in the NCDC database, but emission reduction data are available for only forty of the projects; therefore, this graph reflects emission reductions from those forty projects only.
Source: Went, J. USEPA Office of Transportation and Air Quality. Personal communication, August 2007.

## Other Measures Considered ............................................................................

**Criteria Air Pollutant Emissions.** EPA's Emission Factor and Inventory Group (EFIG) in the Office of Air Quality Planning and Standards (OAQPS) prepares a national inventory of the criteria air pollutant (CAP) emissions, based on input from numerous state, tribal, and local air pollution control agencies as well as EPA-generated and industry-submitted data. This inventory, called the National Emissions Inventory (NEI), is updated every three years and includes emissions of carbon monoxide, nitrous oxides, particulate matter, and sulfur dioxide. Non-road mobile sources in NEI include emissions from the operation of construction equipment, such as tractors, generators, excavators, rubber tire loaders, and off-highway trucks. However, the published NEI data combine emission estimates from *construction equipment* with emission estimates from *mining equipment*. Therefore, emission estimates from *construction equipment* alone are not readily available.

**Emission Reductions from State Retrofit Programs.** At the state level, the two most significant engine emissions reduction programs are in California and Texas. These programs provide financial incentives for reducing NOx and PM emissions from a variety of sources, including construction equipment.[37,38]

The Texas Emissions Reductions Program (TERP) awards funds through a competitive process. It provides grants to equipment owners to make voluntary equipment changes (i.e., new purchases, replacements, re-powers, and retrofits) that reduce emissions of NOx. TERP awards funding based on the dollar amount requested by the applicant as compared to the NOx reductions expected from their proposed project (i.e., lowest dollars per ton of NOx reduced).[39] For funded projects, TERP tracks the associated NOx reductions. Data are presented for on-road and nonroad projects; however, nonroad includes other applications in addition to construction (e.g., agriculture, irrigation, mining). Without specific knowledge of each project, emissions reductions specific to the construction sector cannot be tracked.

California's Carl Moyer Program has been funding engine emissions reductions projects since 1998. The program provides funds on an incentive-basis for the incremental cost of cleaner-than-required engines and equipment. Data are available for the first six years (1998-2004) of the Carl Moyer Program, and show that 322 construction equipment-related engines have been re-powered or retrofitted. These projects have achieved NOx emission reductions of 892 tons/year and PM emission reductions of 47 tons/year.[40]

## Stormwater Compliance

### Background

Since the early 1990s, EPA has regulated construction activity disturbing five or more acres of land and discharging stormwater to surface waters (Phase I). EPA and authorized states establish general National Pollutant Discharge Elimination System (NPDES) permits, which codify specific site management practices and reporting requirements for construction sites disturbing five acres or more. The promulgation of the Phase II rule in 2003 reduced the threshold for permit coverage to one acre of disturbance. Obtaining coverage under a state or EPA Construction General Permit (CGP) requires developing a stormwater pollution prevention plan (SWPPP) describing how the operator will minimize erosion, contain sediment and other construction-related pollutants, and control runoff volume and speed. Before starting land disturbance, the operator develops a SWPPP and submits a "Notice of Intent" (NOI) form, which is an application for permit coverage.

Stormwater is one of the most significant environmental issues for this sector, and is a focus for both EPA and construction trade associations. Given this emphasis on stormwater management, a measure of trends in this area is needed, however, tracking trends in stormwater compliance has been challenging for several reasons. Data on the quantities of sediment or contaminants entering waterways from construction sites is not available, as there are no practical site-specific techniques to measure this. Data on site-specific stormwater management practices could potentially be used to estimate runoff prevented, but are not available because SWPPPs are not submitted to the permitting authority. Alternatively, data are available on the number of NOIs submitted. This metric does not give a direct environmental measure (e.g., tons of sediment in site runoff), but it does provide an indication of the number of sites that are aware of the requirements and likely have developed and implemented a SWPPP.

### Measures Recommended

#### Nationally Representative Trends in NOIs Submitted

The trend in NOI submissions is the only national information available on construction stormwater compliance. When adjusted to account for changes in construction activity, such as the number of projects per state per year, the count of annual NOIs over time could indicate whether compliance with the NPDES requirement to obtain permit coverage is increasing or decreasing.

The primary challenge in tracking the trend in NOI submissions is that there is no data source available that tracks the number of construction sites subject to stormwater requirements. While the McGraw-Hill data track the number of projects by project type, they do not track the number of construction sites. One site that requires one NOI may be listed in the McGraw-Hill data as two or more projects. For example, a construction site where a roadway and a pipeline are being constructed would be listed as two projects (because they are two different types of construction) in the McGraw-Hill count of projects, but may only require one NOI. Further complicating the ability to track NOI trends is that individual construction sites may obtain more than one NOI when different owner/operators are responsible for different stages of the project. Additionally, stormwater permits are typically issued at the state-level. All but five states are authorized to issue NPDES permits. Among the authorized states, the information on NOIs varies. Most states collect basic site information through the NOIs submitted, such as owner/operator name, site address, date of construction start and end, and, in some cases, site acreage.

### NOI Data Sources Available for Tracking Trends in NOIs Submitted

**Data Source for States Where EPA is the Permitting Authority.** In the five states where EPA rather than the state is the permitting authority, NOIs are submitted through the EPA's centralized NOI Processing Center. These five states are: Alaska, Idaho, Massachusetts, New Hampshire, and New Mexico. The NOI Processing Center's information is expected to be the most consistent source among all states for tracking the trend in the number of NOIs submitted, and could show how NOI submittals are changing as contractors increasingly become aware of the requirements. Since July 2003, the NOI Processing Center has collected NOIs electronically (known as the eNOI). Prior to the eNOI, NOIs were submitted to EPA on paper. Submissions dating back to 1997 have been entered into a database (separate from eNOI) and are available from EPA's NOI Processing Center. These data, however, are not considered as reliable as the post-2003 eNOI data that includes both paper and electronic submissions. Based on this reduced data reliability, NOIs submitted prior to 2003 are not included in the recommended presentation.

In addition to providing a count of NOIs submitted annually, eNOI data include information on the acreage disturbed, allowing a separate examination of trends for sites greater than five acres (as a proxy for those sites covered under Phase I) and sites less than five acres (as a proxy for Phase II sites). U.S. territories (except the U.S. Virgin Islands) and Indian Country must submit NOIs directly to EPA as well. Counts of these NOIs are not presented here due to the difficulty of obtaining normalizing data for each of these areas.

**Data Sources for Authorized States.** The data maintained on NOIs vary among authorized states. Even a basic metric such as the number of NOIs per year can be challenging to compile, because states' information management protocols and systems vary in what information is collected on NOIs, how many years records are retained, and whether data are maintained electronically or on paper. Based on the research conducted as background in developing this report, it appears that most states track NOIs electronically, however, several data inconsistencies among states were identified, including:

- Not all states track the acreage of the sites obtaining NOIs.
- Some states' NOI data are maintained by individual counties or districts.
- States differ in how they define construction activity requiring an NOI (e.g., requiring sites less than one acre to obtain coverage, requiring pit excavation activities to obtain coverage under the CGP).

## Method Used for Developing a National Trend in NOIs Submitted

**Sampling Approach.** By combining data from authorized states with data from states where EPA is the permitting authority, a nationally representative trend in NOIs was developed. This analysis required obtaining data from states identified through a sampling plan developed to account for the variation in state-level construction activity that influences the number of NOIs received per state. The details of the sampling approach used are included in the Appendix. As described in the sampling approach, using probability sampling techniques allows the use of design-based estimation methods, so that the results are nationally representative. First, the five states where EPA is the permitting authority were included in the sample for their completeness and quality of data; however, these states accounted for only 4% of the national total value of construction in 2006. Next, the size distribution of the states was examined (based on value of construction). The three largest states (California, Florida, and Texas) accounted for 29% of the national total value of construction in 2006, and were therefore included in the sample with certainty. The remaining states were sorted based on their EPA Regions. From this sampling frame, 12 states were drawn using value of construction in 2006 as the measure of size. The resulting sample included a total of 20 states (5 states where EPA is the permitting authority + 3 largest states + 12 randomly selected states).

**Data Collection.** Based on the sampling plan, NOI data were accessed from the states identified, either through data retrieval from the state website or by contacting state stormwater coordinators. The number of NOIs submitted by each state was normalized by the annual value of construction in the state. Table 4 presents the contribution of each state to the total number of NOIs in the sample in 2006. Table 5 outlines the quality of data collected from the sample of 20 states.

**Table 4: Contribution by State of NOIs Included in the Nationally Representative Sample (2006)**

| State | Percent of 2006 NOIs |
|---|---|
| TX | 20.5% |
| CA | 19.2% |
| FL | 10.4% |
| AL | 8.1% |
| MN | 6.1% |
| PA | 4.8% |
| NM | 4.2% |
| IL | 4.0% |
| NY | 3.6% |
| SC | 2.8% |
| MO | 2.7% |
| UT | 2.4% |
| ID | 2.1% |
| NV | 1.9% |
| MA | 1.6% |
| KY | 1.5% |
| AK | 1.2% |
| NH | 1.2% |
| AR | 1.2% |
| CT | 0.4% |

NOTE: CT data include only NOIs for projects greater than 5 acres, 2006 South Carolina are incomplete.
Sources: EPA Office of Water eNOI database for AK, ID, MA, NH, NM., Stormwater program data from AL, AR, CA, CT, FL, IL, KY, MN, MO, NV, NY, PA, SC, TX and UT.

| Table 5: Availability and Completeness of Data From EPA Permitted and Authorized States | | |
|---|---|---|
| **State Surveyed** | **Overall** | **Acreage** |
| Alaska* | Complete | Occasional incomplete records. |
| Alabama | Complete | No acreage data available. |
| Arkansas | Occasional incomplete records. | Occasional incomplete records. |
| California | Complete | Occasional incomplete records. |
| Connecticut | Data unavailable for projects below 5 acres. | All projects greater than 5 acres. |
| Florida | Complete | Complete |
| Idaho* | Complete | Occasional incomplete records. |
| Illinois | Complete | Occasional incomplete records. |
| Kentucky | Occasional incomplete records. | No acreage data available. |
| Massachusetts* | Complete | Occasional incomplete records. |
| Minnesota | Complete | Occasional incomplete records. |
| Missouri | Complete | No acreage data available. |
| New Hampshire* | Complete | Occasional incomplete records. |
| New Mexico* | Complete | Occasional incomplete records. |
| Nevada | Complete | Complete |
| New York | Data unavailable for January and February 2003. | No acreage data available for 2003. Complete for 2004-2006. |
| Pennsylvania | Complete | Occasional incomplete records. |
| South Carolina | Data unavailable for coastal counties for several months in 2006. | Occasional incomplete records for 2003-2005. No acreage data available for 2006. |
| Texas | Complete | Occasional incomplete records. |
| Utah | Occasional incomplete records. | Complete |

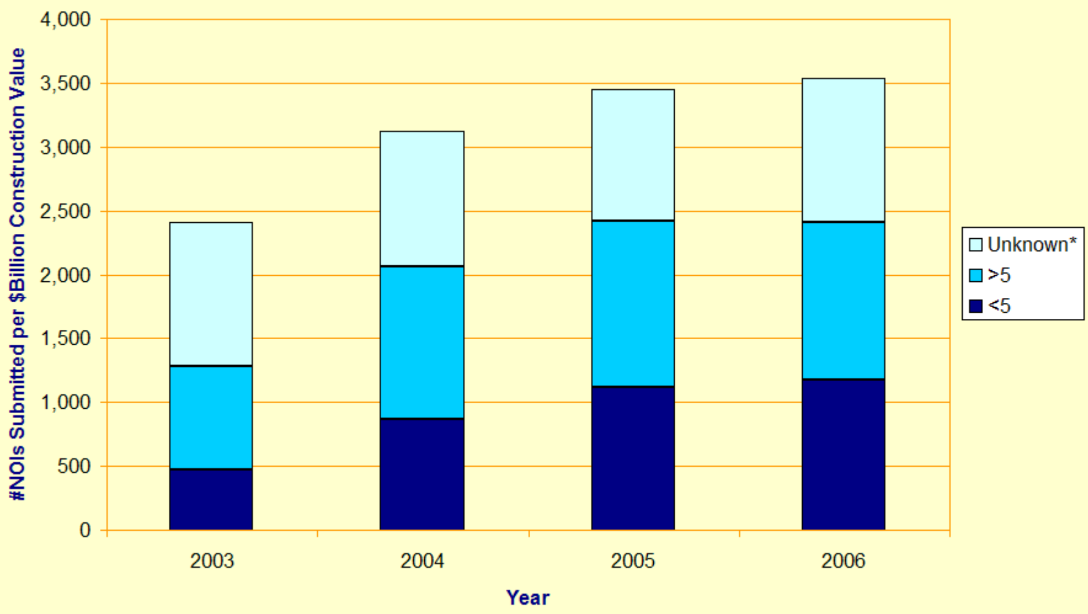
* EPA is the permitting authority.
Sources: EPA Office of Water eNOI database for AK, ID, MA, NH, NM. Stormwater program data from AL, AR, CA, CT, FL, IL, KY, MN, MO, NV, NY, PA, SC, TX, and UT.

## Trends in NOI Submissions

**National Trend in NOIs Submitted, by Acreage Disturbed, Normalized by Value of Construction.** Figure 10 shows the nationally-representative trend in NOI submissions, based on the sample of 20 states. The data were adjusted to account for the changes in construction activity, as measured by the state-specific annual construction value. From 2003 to 2006, NOI submissions, normalized by the state-specific value of construction, increased by 45%.

Note that the trend may be impacted because states' Phase II regulations took effect at different times. Some states did not develop a permit for construction sites that are one to five acres in size by the March 2003 deadline, as required by EPA's Phase II rule. After a state implements the Phase II permit requirements, the number of NOIs submitted in that state would be expected to increase significantly. If a state implemented the Phase II permit in 2004, for example, the number of NOI submissions in 2004 would be expected to be considerably greater than the number submitted in 2003. This increase, however, would reflect the expansion of permit coverage to the smaller sites rather than an increase in the percent of covered sites obtaining an NOI.

**Figure 10: Nationally Representative Trend in NOI Submissions, by Acreage Disturbed, Based on a Sample of 20 States**




* Acreage was unknown for at least one NOI submitted in MA, AK, NH, NM, ID, AL, AR, CA, CT, IL, KY, MN, MO, NY, PA, SC, and TX. Acreage data were not available for AL, KY, MO, NY in 2003, and SC in 2006.
NOTE: 2003 New York data and 2006 South Carolina data are incomplete.
Sources: EPA Office of Water eNOI database for AK, ID, MA, NH, NM, Stormwater program data from AL, AR, CA, CT, FL, IL, KY, MN, MO, NV, NY, PA, SC, TX, and UT. 2003 – 2006 data on construction value from McGraw-Hill Construction, *U.S. Total Construction Value.*

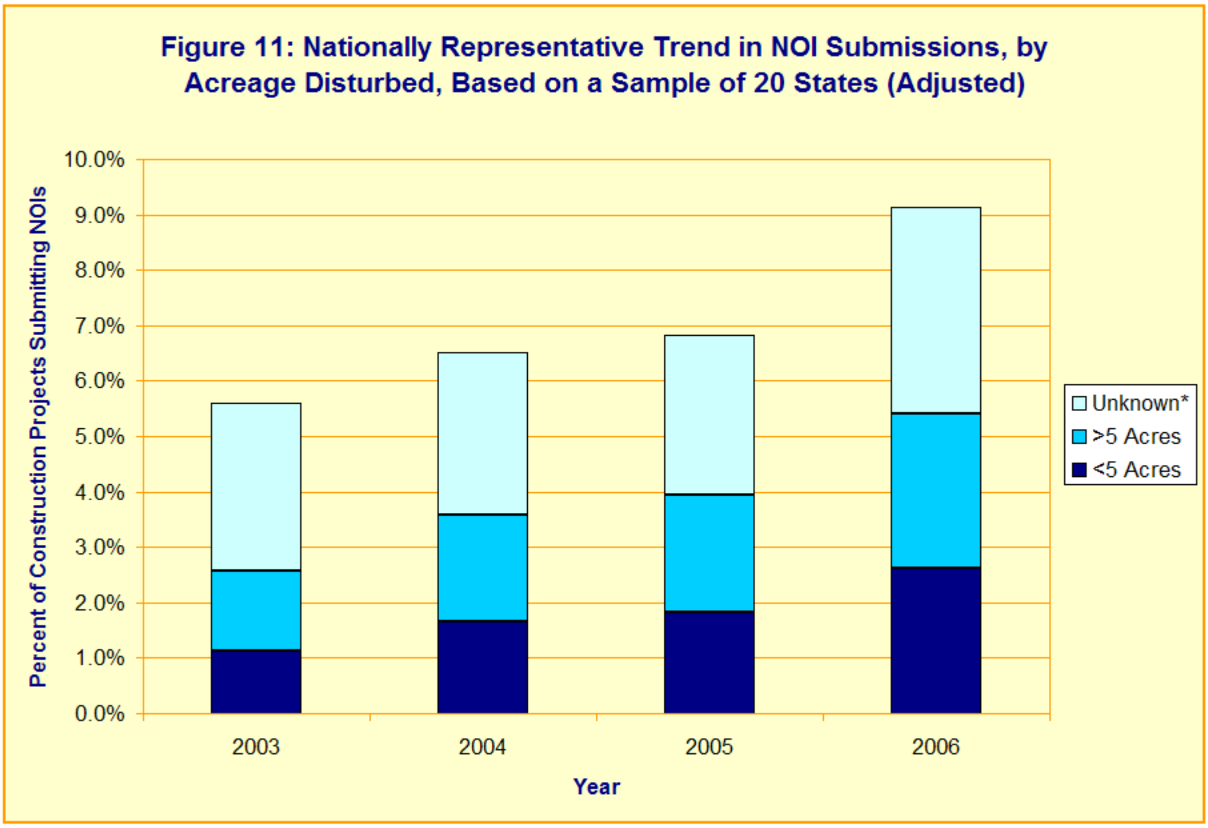
**National Trend in NOIs Submitted by Acreage Disturbed, Normalized by Number of Construction Projects.** As an alternative to tracking the trend in NOI submissions per dollar of construction value, the trend in NOI submissions per construction project could be examined as an indication of trends in obtaining permit coverage. If the number of NOIs submitted increases at a greater rate than construction activity (as measured by number of projects), this would indicate improving permit coverage rates. The data presented in Figure 11 indicate: The Number of NOIs Submitted/The Number of Projects in the McGraw-Hill Database.

This method does not indicate the percentage of sites in compliance with the NOI submission requirement because there is no data source available that tracks the number of NOIs required. The McGraw-Hill data on the number of construction projects for certain types of projects (specifically, non-residential and non-building projects) count the number of individual project *types*, which does not correspond to the number of NOIs required. One construction site that requires one NOI may be included in the project count as multiple construction projects. For example, a hospital and a parking garage for the hospital may be constructed together, under a single contract, but in the McGraw-Hill data, these are two different types of projects and would be considered as two different projects in the count of the number of projects. They may, however, require only one NOI. Data are not available to adjust the number of projects to account for this situation, where activities at a single site are counted as multiple projects. Without this adjustment, the number of projects is overestimated.

To improve the trend estimate, several adjustments were made when examining the number of NOIs per construction project to get the percent of construction projects submitting NOIs:

- ***Adjustment to the number of NOIs submitted.*** Construction sites may have multiple operators that are required to obtain permit coverage, so the actual number of NOIs submitted could be higher than the total number of construction sites requiring permit coverage. Based on information from the eNOI database, it is assumed that 10% of NOIs are multiple submissions for the same site. Therefore, the number of NOIs was multiplied by 0.90 to account for the multiple submissions for a single project site.[41]
- ***Adjustment to the number of projects***. The number of projects includes sites less than one acre in size. For example, EPA estimated that 25% of sites were less than one acre in the 1999 Economic Analysis of the Final Phase II Storm Water Rule.[42] Therefore, the number of projects was multiplied by 0.75 to better estimate the number of projects requiring an NOI.
- ***Adjustment to the number of projects.*** EPA estimated that 15% of sites qualify for a waiver from stormwater program requirements; therefore, the number of projects was multiplied by 0.85 to better estimate the number of projects requiring an NOI.[43]

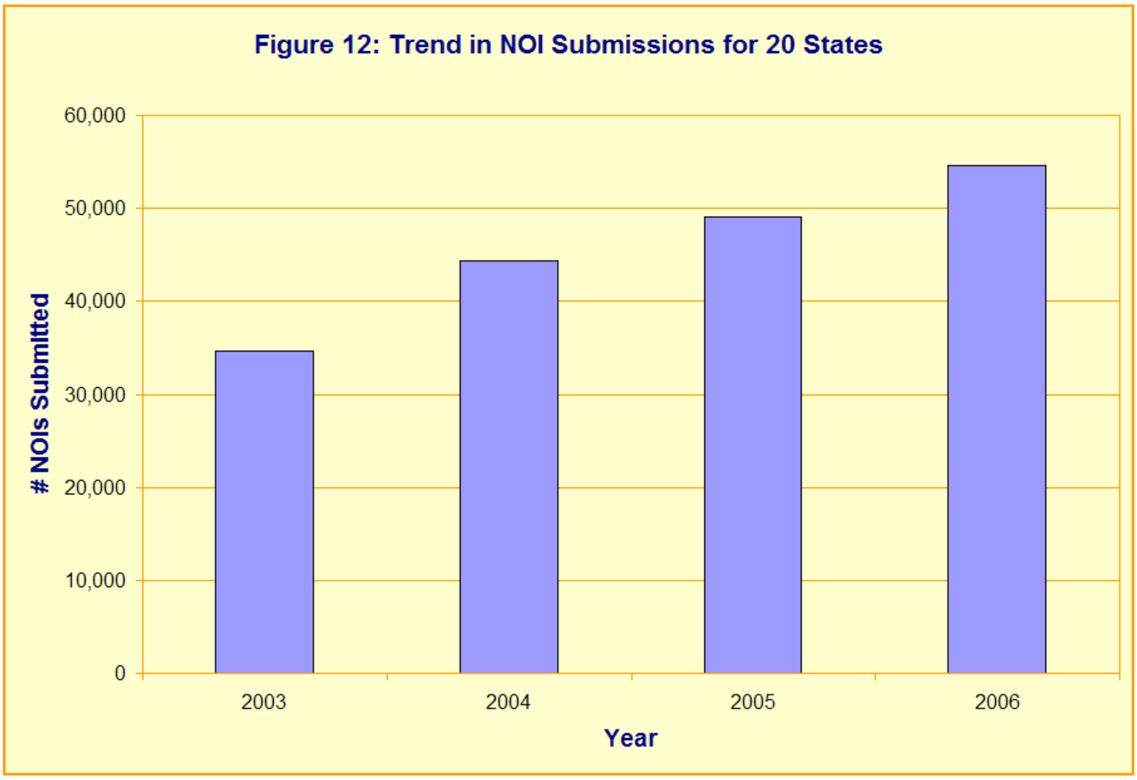
While these adjustments improve the metric, Figure 11 still does not indicate the percentage of sites in compliance with the NOI submission requirement. The denominator ("Number of Projects") still overestimates the number of projects requiring an NOI because a single construction site may be counted multiple times if it happens to include multiple project types. Instead, Figure 11 indicates the trend in NOI submissions, and shows that the percentage of construction projects with NOIs increased by 63% from 2003 to 2006.




NOTE1: Number of NOIs was adjusted to account for multiple submissions from a single site. Number of projects was adjusted to account for sites less than one acre and sites qualifying for a waiver.
NOTE 2: 2003 New York data and 2006 South Carolina data are incomplete.
NOTE 3: Because all projects do not require an NOI, this is not an indicator of percent of projects in compliance with the requirement to submit an NOI.
Sources: Number of projects from McGraw-Hill Construction - *US Total Construction Number of Projects by State*, 2005. Number of NOIs from eNOI for AK, ID, MA, NH, NM and from state-specific data files for AL, AR, CA, CT, FL, IL, KY, MN, MO, NV, NY, PA, SC, TX, and UT. Adjustment for multiple NOIs from EPA Office of Water, Water Permits Division, via December 15, 2006 email. Adjustment to estimate construction projects less than one acre from U.S. EPA, Economic Analysis of the Final Phase II Storm Water Rule, October 1999, page 3-7.

## Other Measures Considered ..........................................................................

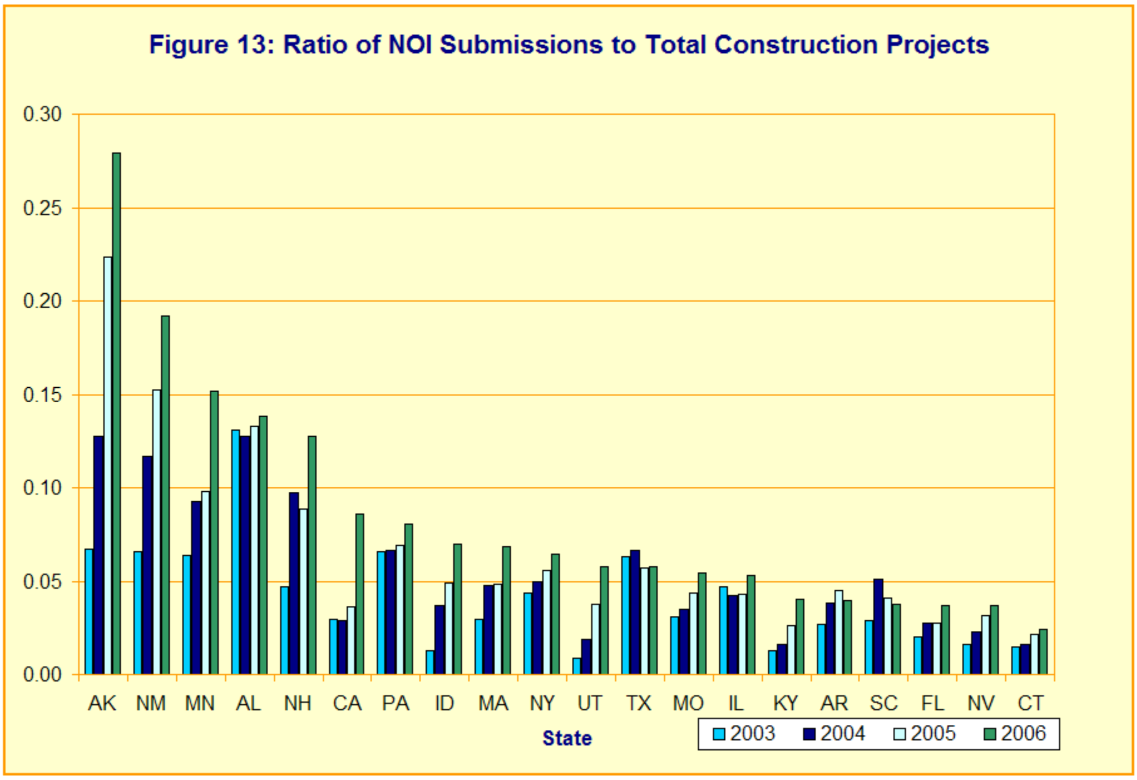
**National Trend in NOIs Submitted by Acreage Disturbed, Not Normalized.** Figure 12 displays the total number of NOIs submitted each year for the nationally representative sample of 20 states. It shows a 57% increase in NOI submissions from 2003 to 2006. Without normalizing the data, this measure does not account for changes in construction activity.




NOTE: 2003 New York data and 2006 South Carolina data are incomplete.
Sources: Number of NOIs from eNOI for AK, ID, MA, NH, NM. and from state-specific data files for AL, AR, CA, CT, FL, IL, KY, MN, MO, NV, NY, PA, SC, TX, and UT.

**Trend in Percentage of Construction Projects with NOIs Submitted, by State.** Using the McGraw-Hill data for number of construction projects per state per year, the number of NOIs per construction project could be calculated by state for 2003 - 2006. Although this ratio indicates the relative change over time in obtaining permit coverage, it does not serve as an indicator of the state-level permit coverage compliance rate for the same reasons as discussed in above for the recommended measures.

Figure 13 shows this measure for the sample of 20 states over a four-year period. For the 20 states in the sample, the ratio of NOI submissions to total construction projects ranged from 2% to 28%. The ratio increased from 2003 to 2006 for 19 states in 2006. Only Texas showed a declining ratio of NOI submissions to construction projects. The absolute number of NOIs submitted in Texas increased by 12% from 2003 to 2006, but during this same time period the number of construction projects in the state increased by 22%.




NOTE1: Number of construction projects includes projects less than one acre in size.
NOTE2: 2003 New York data and 2006 South Carolina data are incomplete.
Sources: Number of projects from McGraw-Hill Construction - *US Total Construction Number of Projects by State*. Number of NOIs from eNOI for AK, ID, MA, NH, NM. and from state-specific data files for AL, AR, CA, CT, FL, IL, KY, MN, MO, NV, NY, PA, SC, TX, and UT.

Although Figure 13 illustrates an increase in the number of sites that are aware of the requirements and likely have developed and implemented a SWPPP, it does not show a nationally representative trend. To show this trend on a national level, the measure shown in Figure 11 was developed.

### Trends in the Percentage of Stormwater Inspections Resulting in Violations or Actions.

**National Trends.** ICIS-NPDES is a modernized data system covering Clean Water Act compliance and enforcement that may provide a new measure in the future. Structurally, ICIS-NPDES contains expanded permit and compliance information for stormwater requirements and the stormwater permits, which were not available in the legacy Permit Compliance System. However, only states where EPA is the NPDES permitting authority and the states that directly entered their data into PCS are using ICIS-NPDES. Between now and the end of FY08, the states that are involved in batch uploads and hybrid data entry are expected to be in the new system. In addition, while states are not required to submit compliance information on minor NPDES permits to EPA, an increasing number of states do (http://www.epa.gov/echo/about_data.html). To the extent that ICIS-NDPES is populated by state programs providing information for stormwater permits, it would be possible to measure the percentage of inspections or inspected locations where violations are found or an enforcement action occurs. However, such a measure would not be representative of the sector as a whole because sites suspected of having issues (e.g., where a complaint was made) are more likely to be inspected, thus skewing the data.

**Quantitative Geographically-focused Analysis.** EPA staff identified several specific state, county, or local construction stormwater programs as having a particularly strong presence.[44] If strong programs could be identified that collect more-extensive data, metrics of interest to EPA such as percentage of construction stormwater inspections resulting in violations could potentially be examined. EPA contacts also mentioned municipal separate storm sewer systems (MS4s) as potential sources of additional information on construction stormwater. MS4s transport and discharge polluted stormwater runoff into local rivers and streams without treatment. To meet their EPA stormwater requirements, operators of regulated MS4s are required to develop and implement a program to control construction site runoff, including plan review, inspection, and enforcement. However, following a discussion of the quantitative geographically focused approach with EPA Headquarters and Region 3 staff, it was determined that sufficient and consistent data are currently not available to conduct a quantitative analysis. If MS4s could be identified that inspected all constructions sites, the bias associated with targeted inspections would be removed and a metric of the percentage of inspected sites with violations could be calculated. While the violation rate would be accurate for that particular MS4, it would only be applicable to a small geographic area and could not be considered nationally representative.

**Qualitative Geographically-focused Analysis.** Given that a quantitative, representative sampling approach to tracking trends in stormwater violations does not appear to be feasible, a qualitative approach could be considered as an alternative. This approach would involve purposeful sampling where data sources, such as selected MS4s, are strategically and purposefully selected. Potential sampling approaches include:

- ***Maximum variation sampling***. In this approach, the trends in violations could be compared between one or more strong MS4s and one or more MS4s that are considered to have a weak program related to construction activity. This approach is intended to show the range of construction stormwater activity among MS4s.

- ***Criterion sampling.*** If weak MS4s cannot be identified, a criterion sampling approach could be used where all cases that meet some criterion are selected. For this analysis, the approach could involve an examination of the violation trends from MS4s that inspect all construction sites in the MS4. This approach eliminates the bias in examining violation data from areas conducting targeted inspections. Criterion sampling is intended to maximize the information presented on construction stormwater while keeping costs low.
- ***Typical case sampling.*** Typical case sampling is used to illustrate or highlight what is typical or average performance. This approach would be feasible if MS4 programs that are considered "typical" with respect to stormwater inspections at construction sites could be identified, such as through a review of annual reports, or by an EPA expert.

Once a sampling approach is selected, any available data on stormwater inspections of construction sites could be analyzed, such as the frequency of inspections and violations per inspection (delineated between first-time and repeat inspections for any given site). If sufficient information were available, the goal of the analysis would be to assess trends in the percentage of inspections resulting in violations. Data analysis would be supplemented with interviews of inspection and program management staff to gain insight into the drivers behind the trends observed. In some cases, such as that of weak MS4s in a maximum variation sample, data may not be available and the analysis would rely solely on the anecdotal interview information obtained. Findings would be presented in a case study format and would not be nationally representative.

# Energy Use and Greenhouse Gas Emissions

## Background

Energy is used in construction in several ways: on building sites to meet electricity needs, as fuels to power construction equipment, in offices, and by transport of materials to and from the site. In addition to reducing the air quality impacts of diesel emissions discussed earlier, reducing energy use could reduce costs and greenhouse gas emissions. Greenhouse gas emissions in the construction sector appear to come mostly from energy use.

## Recommended Measures

**Carbon Dioxide ($CO_2$) Emissions from Energy Consumption.** $CO_2$ emissions from construction were estimated based on data on purchases of distillate fuel, natural gas, and electricity from the U.S. Census Bureau's 2002 Economic Census Industry Series Report for Construction, and presented in a preliminary report prepared for EPA's Sector Strategies Division.[45] These Census data are updated every five years, and the 2002 report is the most recent data currently available. Spending on fuel was converted to consumption values, and purchased electricity was converted to electricity consumption using the cost of fuel and electricity, respectively, from the U.S. Department of Energy's State Energy Data Report published by the Energy Information Administration (EIA). Consumption values were converted to emissions using EIA's Electric Power Annual. Caveats related to this estimate include:

- Fossil fuel combustion and electricity emission estimates include only $CO_2$. Combustion activities also generate emissions of methane ($CH_4$) and nitrous oxide ($N_2O$), however such emissions have not been estimated.
- Electricity and fuel combustion emission estimates assume national average $CO_2$ emission factors.
- Regional differences in energy prices could not be accounted for; the method applies the national average costs of fuels and electricity to all construction energy purchases.
- The U.S. Census (2002) provides dollars spent on gasoline and diesel fuel as one lumped sum, which needed to be disaggregated to estimate non-$CO_2$ emissions. Because the Census data provided dollars spent by on- and off-highway fuel use, for the purpose of this calculation the emission estimates were based on the assumption that all off-highway fuel use was diesel and all on-highway use was motor gasoline.
- Trend data using this method are not currently available.

Table 6 presents the 2002 $CO_2$ emissions in units of teragrams of $CO_2$ equivalent (Tg $CO_2$ Eq.).

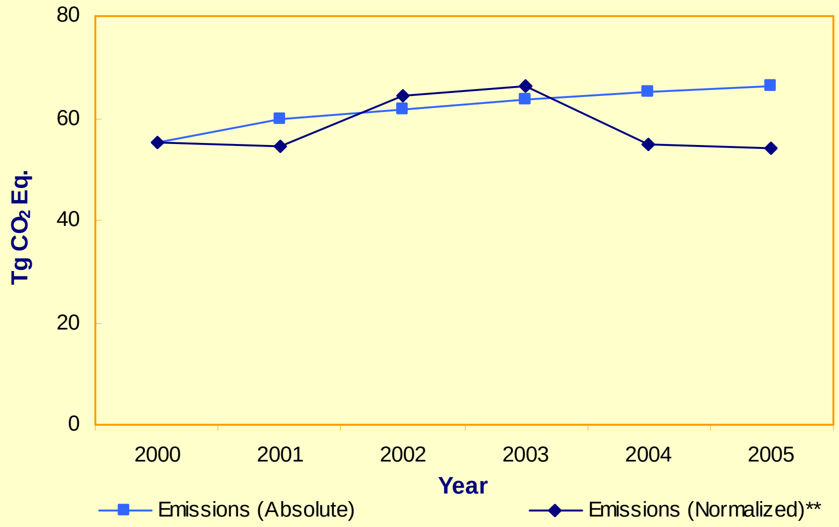
**Table 6: Carbon Dioxide Emissions from Construction, 2002**

| Source | Emissions, Tg $CO_2$ Eq. |
|---|---|
| Fossil Fuel Combustion | 84.7 |
| Electricity | 29.4 |
| **Total** | **114.1** |

**Trend in Greenhouse Gas Emissions from Nonroad Construction Equipment.** The *Inventory of U.S. Greenhouse Gas Emissions and Sinks* is published annually by EPA's Office of Atmospheric Program's Climate Change Division, to fulfill obligations stemming from the United Nations Framework Convention on Climate Change. The *Inventory* reports GHG emissions and sinks in the U.S. across multiple sources. Data specific to construction equipment are included for three greenhouse gases—carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) —and for total greenhouse gas emissions. These data include emissions resulting from gasoline and diesel fuel combustion by mobile construction equipment. Note that mobile construction equipment is defined in the *Inventory* as including both mobile construction and mining equipment. This report is published annually and could allow tracking of trends over time; however, it is focused on emissions resulting from non-road mobile sources, and does not include energy use associated with other aspects of construction such as electricity use and transport of materials to sites.

Annual GHG data specific to construction equipment are presented in Figure 14 in carbon dioxide equivalents with units of teragrams of $CO_2$ equivalent (Tg $CO_2$ Eq.). This measure uses global warming potential of each gas relative to $CO_2$. In 2005, these emissions represented 0.91% of the U.S. total anthropogenic GHG emissions.[46]

**Figure 14: Greenhouse Gas Emissions from Nonroad Construction Equipment***

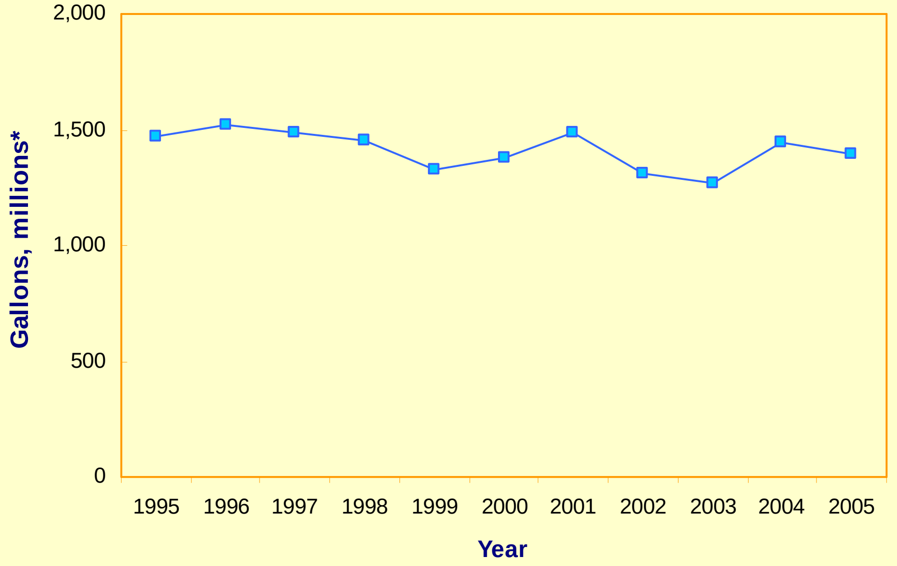



* Includes emissions from both construction and mining nonroad mobile equipment.
** Normalized based on national value of construction put in place from U.S. Census Bureau.

Note: Includes $CO_2$, $CH_4$, and $N_2O$ emissions.
Source: U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2005, EPA 430-R-07-002, Annex Table A-108, published April 2007. U.S. Census Bureau, Construction Spending (Value Put in Place), normalized based on national value of construction put in place (including private and public; residential and nonresidential) to a 2000 baseline year in 2000 dollars.

**Fuel Used by Construction Equipment.** Fuel oil sales data are available from the U.S. Energy Information Administration (EIA) of the U.S. Department of Energy (DOE), in the *Fuel Oil and Kerosene Sales* report.[47] This report includes data on annual off-highway distillate fuel oil sales for the construction industry, which is defined to consist of all facilities and equipment including earthmoving equipment, cranes, generators, air compressors, etc. EIA defines distillate fuel as the petroleum fractions produced in conventional distillation operations including No. 1, No. 2, and No. 4 fuel oils and diesel fuels.[48] EIA data are collected through surveys at the point of delivery or use, and are aggregated to determine national totals. This report is published annually and could allow tracking of trends over time; however, it is focused on off-highway distillate fuel use, and does not include energy use associated with other aspects of construction such as electricity use and transport of materials to sites. As an environmental measure, fuel sales could indicate trends in air emissions related to fuel consumption, as shown in Figure 15.

**Figure 15: Sales of Off-Highway Distillate Fuel Oil for Construction**




* Normalized based on national value of construction put in place from U.S. Census Bureau.

Source: Energy Information Administration, Fuel Oil and Kerosene Sales reports 1995-2005, Table 24. http://www.eia.doe.gov/oil_gas/petroleum/data_publications/fuel_oil_and_kerosene_sales/foks_historical.html and U.S. Census Bureau, Construction Spending (Value Put in Place), normalized based on national value of construction put in place (including private and public; residential and nonresidential) to a 1995 baseline year in 1995 dollars.

## Appendix: State Sampling Approach for NOIs

For a given calendar year, the submission of NOIs takes place at the state level, except for five states where the NOIs are submitted to EPA. It is expected that most states store the NOIs in an electronic format, but we do not currently know which specific states store the NOIs in hard copy format. Therefore, in the sampling approach discussed below we assume that all states and the District of Columbia are eligible for sample selection.

The specific sampling method that will be employed is called one-stage cluster sampling. In one-stage cluster sampling a sample of states (primary sampling units (PSU)) is drawn at the first stage of sampling. All NOIs for a given calendar year associated with each sample state (PSU) are then included in the sample of NOIs. Sampling variability is increased compared to a simple random sample of the same sample size of NOIs. A simple random sample of NOIs is however not possible, because a complete sampling frame of all NOIs in the U.S. cannot be assembled.

The sample of NOIs will be used in conjunction with state level and national data on the value of construction (from the U.S. Census Bureau's 2002 Economic Census) to examine year-to-year changes in the total number of NOIs. The use of a ratio estimator may be appropriate for examining change over time in the total number of NOIs in relation to the total value of construction. Sampling weights will be needed to adjust for unequal sampling probabilities.

Alaska, New Hampshire, Idaho, New Mexico, and Massachusetts are the five states for which the EPA directly collects NOIs. The completeness and quality of the NOIs for these states makes it advisable to include all of them in the state sample. These states however account for only 3.6% of the national total value of construction in 2006.

For the remaining 46 states and DC, a probability proportional to size (PPS) sample will be drawn. The measure of size for the PPS sample will be the total value of construction in 2006. We prefer to use the total number of NOIs, but this is not available for all states. In PPS sampling the largest states will be selected with certainty. We examined the size distribution of the states and determined that the three largest states account for 29.3% of the national total value of construction in 2006. The following three states will therefore be included in the sample with certainty: California, Florida, and Texas.

The remaining state sampling frame consists of 43 states. The sampling frame will be sorted by EPA region. A systematic PPS sample of 12 noncertainty states will then be drawn using value of construction in 2006 as the measure of size. This sampling approach will make it possible to estimate standard errors using a paired PSU variance estimation technique. We have used the current sampling frame to draw the sample of 12 states: Connecticut, New York, Pennsylvania, Alabama, Kentucky, South Carolina, Illinois, Minnesota, Arkansas, Missouri, Utah, and Nevada.

The entire sample consists of 20 states.

## Endnotes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