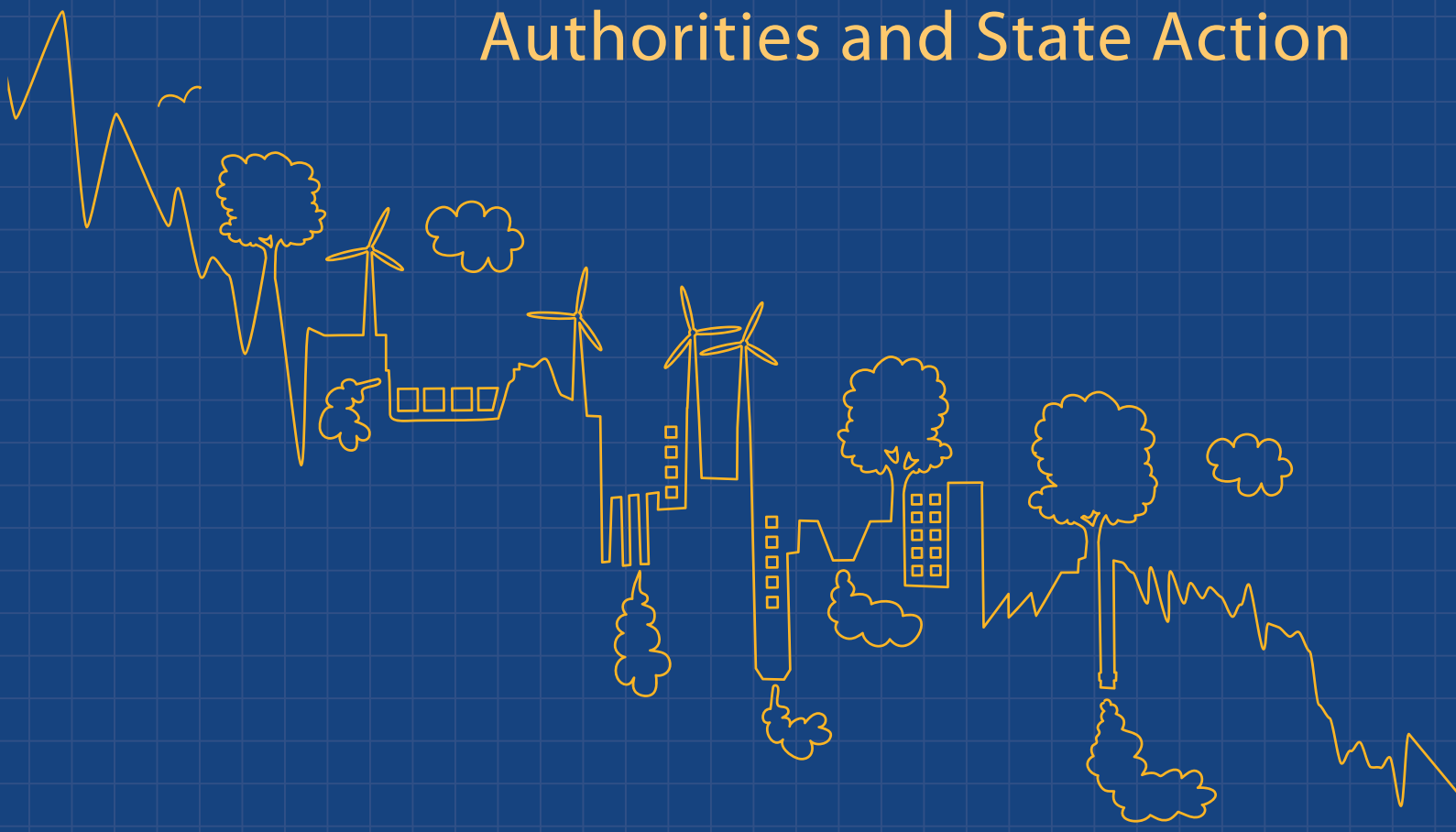
WORLD RESOURCES INSTITUTE

SUMMARY FOR POLICYMAKERS

Reducing Greenhouse Gas Emissions in the United States

Using Existing Federal Authorities and State Action



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I. Introduction

AS THE U.S. CONGRESS HAS STRUGGLED to pass comprehensive climate change legislation, observers in the United States and abroad have asked what greenhouse gas emissions reductions are possible under existing federal laws and through state action. Can the U.S. meet the Obama Administration's Copenhagen commitment to reduce greenhouse gas emissions in the range of 17 percent below 2005 levels by 2020 using the regulatory tools already available to federal agencies, together with announced actions at the state level? Even if congressional action is ultimately necessary to put the U.S. on a long-term low-carbon path and aid in the transition to a low-carbon economy, can federal agencies and state governments get the U.S. started down that path? To help answer these and related questions, the World Resources Institute (WRI) presents this analysis of potential reductions under existing federal authorities and announced state actions through 2030.

Set out below is a summary of the key findings of this peer-reviewed study. The aggregate range of potential federal reductions in key sectors is provided first, based on assessments from available literature on what is technically feasible, as well as the corresponding regulatory ambition required to achieve the technically feasible reductions. An explanation of how potential reductions were assessed for each sector and/or category of sources follows, including: (a) a description of the sector or category of sources affected; (b) a discussion of the regulatory policy or policies available to achieve reductions in the sector or category of sources; and (c) an explanation of how available studies were used to construct three potential reduction scenarios for each sector or category of sources.

The three potential reduction scenarios analyzed include a "Lackluster" scenario that aggregates reductions at the lower end of what is technically feasible and therefore represents low regulatory ambition; a "Middle-of-the-Road" scenario that combines reductions generally in the middle of the range considered technically feasible and corresponding to moderate regulatory ambition; and a "Go-Getter" scenario that adds up reductions that may be considered toward the higher end of what is technically feasible and corresponds to higher regulatory ambition. Readers can make their own judgment about which scenario they think is most plausible.

After assessing potential reductions through federal regulatory actions in key sectors, state-level reductions are considered. In contrast to the sector-by-sector, policy-by-policy approach used for the federal assessment, state-level reductions were quantified using economy-wide greenhouse gas reduction targets and regional cap-and-trade programs. See Box I. Similar to the federal analysis, however, reductions from state actions are reported as a range of possible reductions, with lower reductions projected if only legislated targets are implemented and states otherwise show lower ambition, and higher reductions projected if states follow through on announced goals and policies showing higher ambition. These state scenarios are also labeled "Lackluster," "Middle-of-the-Road," and "Go-Getter" to reflect the range of potential ambition and follow-through at the state level.

After the summary of key findings and more detailed discussion of the federal and state-level quantification efforts, the uncertainties underlying the emission reduction projections contained in this analysis are outlined.[1] Importantly, a detailed explication of the methods and assumptions is contained as an appendix to this paper. WRI intends to produce periodic revisions to this analysis of reductions to reflect new studies on the technical feasibility of reductions in various sectors, new actions by federal and state governments, and any identified improvements in methods.

1. The single biggest variable—the level of ambition applied by the federal administration and state governors and legislatures—is captured in the scenarios. Thus, if one assumes high ambition on the part of federal agencies, the Go-Getter Scenario will be most relevant. Conversely, if one assumes low ambition, the Lackluster Scenario will be most apt.

BOX 1. Analytical Steps to Assessing Potential Reductions at the Federal and State Levels

FEDERAL ANALYSIS	STATE-LEVEL ANALYSIS
(a) Review the 2008 U.S. greenhouse gas emissions inventory;	(a) Determine which states have greenhouse gas emissions reductions targets in legislation;
(b) Identify those sectors and/or categories of emissions sources where existing regulatory authorities can be applied to achieve reductions;	(b) Determine which states have greenhouse gas emissions reduction targets in executive orders;
(c) Based on available technical studies, consider the range of possible reductions in each sector and/or category of emissions sources;	(c) Determine which states have announced their participation in regional initiatives to design and implement cap-and-trade programs to reduce greenhouse gas emissions;
(d) Model three levels of emissions reductions corresponding to different levels of regulatory ambition in each sector and/or category of sources for which reliable quantitative information is available; and	(d) Model three levels of emissions reductions, one assuming only states with legislative targets follow through to reduce emissions; a second assuming states with legislative and executive targets follow through; and a third assuming states with targets and announced cap-and-trade initiatives follow through; and
(e) Present aggregate results as three reduction scenarios based on the range technically feasible and the corresponding range of regulatory ambition: lower ("Lackluster"), moderate ("Middle-of-the-Road") and higher ("Go-Getter").	(e) Present aggregate results as three reduction scenarios.

II. Summary of Key Findings

WRI'S ANALYSIS OF POTENTIAL GREENHOUSE gas emissions reductions by federal and state governments suggests a range of potential outcomes is possible. On the federal level, whether reductions are achieved at the lower end or upper end of the range shown in Figure 1 depends on the extent to which the Obama Administration and subsequent administrations use existing regulatory authority to go after reductions shown to be technically possible in the literature.[2] On the state level, whether reductions are realized at the lower or upper end of the range projected in Figure 2 depends similarly on the continued resolve by governors and legislative leaders in the 25 states counted as having taken actions. The findings set out here represent an assessment of what is possible given available inputs for some key sectors. It does not include potential emissions reductions achievable through federal policies to reduce vehicle miles traveled, management of agricultural lands and forests, new federal investments in areas such as energy efficiency, renewable energy infrastructure, or other areas that could yield reductions, nor new federal legislation of any kind. Key findings are summarized below.

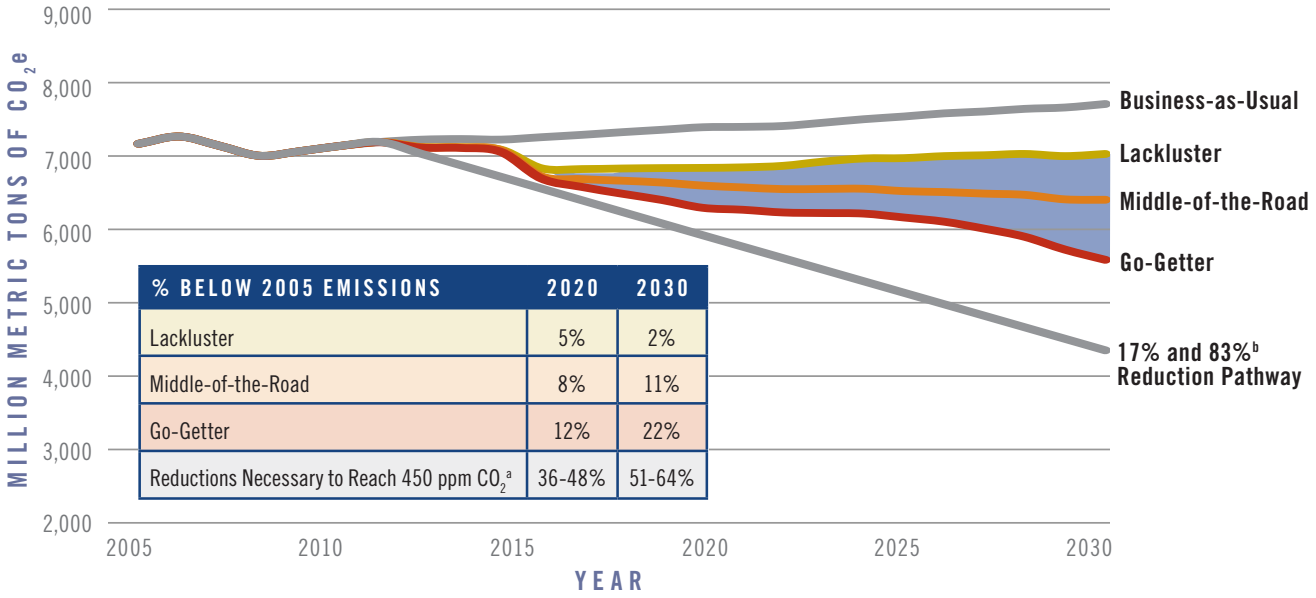
- If federal agencies and states pursue the path of "go getters" and move strongly to achieve the reductions published literature suggests are technically feasible in the sectors analyzed, the U.S. could achieve significant reductions in greenhouse gas emissions, which approach but fall short of President Obama's Copenhagen pledge to reduce emissions 17 percent below 2005 levels by 2020.

- If, however, federal agencies fail to capitalize on available reduction opportunities and states fall short on their announced plans to reduce emissions, middle-of-the-road or lackluster reductions will result, falling far short of the 17 percent reduction by 2020 goal.

- Longer-term reductions post-2020 are less certain under all analyzed scenarios, primarily due to uncertainty about how quickly aging power plants will be replaced and the transportation sector can be transformed. Regulatory policies can drive technology, but without knowing what technological

2. There are of course other uncertainties and variables at play that could affect the extent of reductions. Key risks and uncertainties are outlined below and in the appendix to this report.

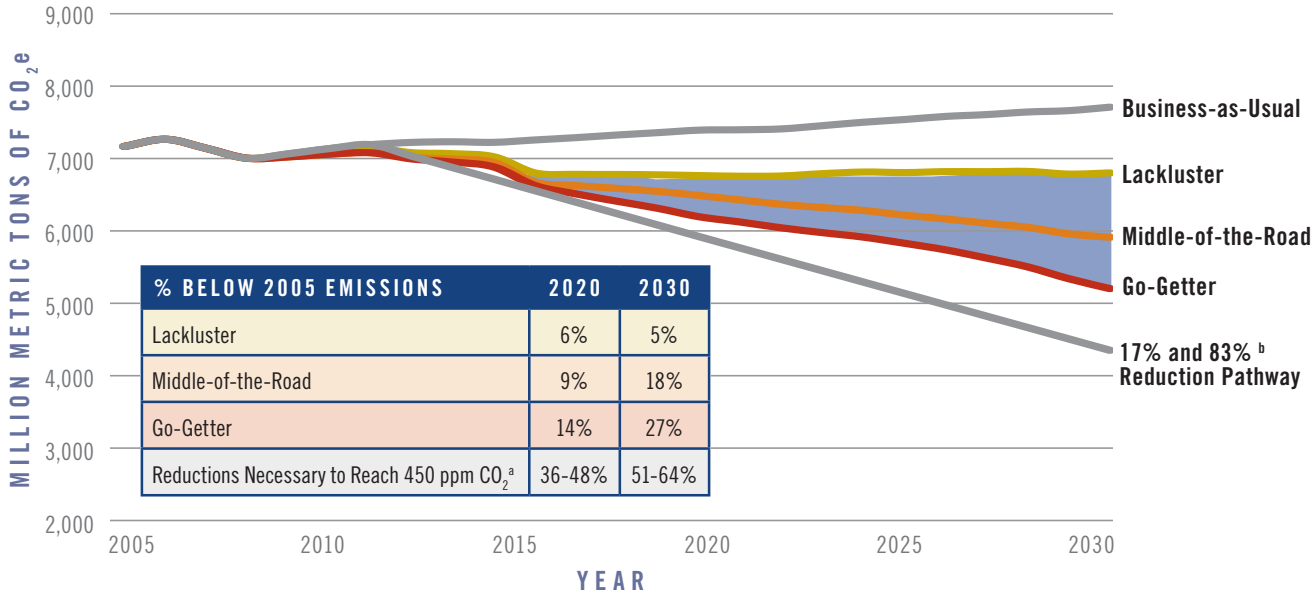
FIGURE 1. Projected U.S. Emissions under Different Federal Regulatory Scenarios



% BELOW 2005 EMISSIONS	2020	2030
Lackluster	5%	2%
Middle-of-the-Road	8%	11%
Go-Getter	12%	22%
Reductions Necessary to Reach 450 ppm CO_2[a]	36-48%	51-64%

Figure 1 provides aggregate results from the federal sector-by-sector, policy-by-policy analysis laid out more fully in subsequent sections of the report. The regulatory actions specific to each of the Lackluster, Middle-of-the-Road and Go-Getter Scenarios modeled are described in the next section of this paper and in specific detail in the assumptions and methodology section in the Appendix.

FIGURE 2. Projected U.S. Emissions under Different Federal Regulatory Scenarios and State Scenarios



% BELOW 2005 EMISSIONS	2020	2030
Lackluster	6%	5%
Middle-of-the-Road	9%	18%
Go-Getter	14%	27%
Reductions Necessary to Reach 450 ppm CO_2[a]	36-48%	51-64%

Figure 2 depicts the additional reductions achievable when three state-level scenarios are added to the federal policy scenarios.

a. The Intergovernmental Panel on Climate Change's (IPCC's) Fourth Assessment Report (2007) suggests that industrialized countries need to collectively reduce emissions between 25 and 40 percent below 1990 levels by 2020 and 80 to 95 percent below 1990 levels by 2050 to keep global average temperatures from increasing more than 2 degrees Celsius. This target does not necessarily represent any particular country's share.

b. The U.S. pledge in Copenhagen calls for reductions in 2020 "in the range of 17% [below 2005 levels], in conformity with anticipated U.S. energy and climate legislation." The U.S. submission notes that the ultimate goal of pending legislation is to reduce emissions by 83% in 2050.

FIGURE 3. **Projected U.S. Emissions in 2020 by Sector under Different Federal Regulatory Scenarios**

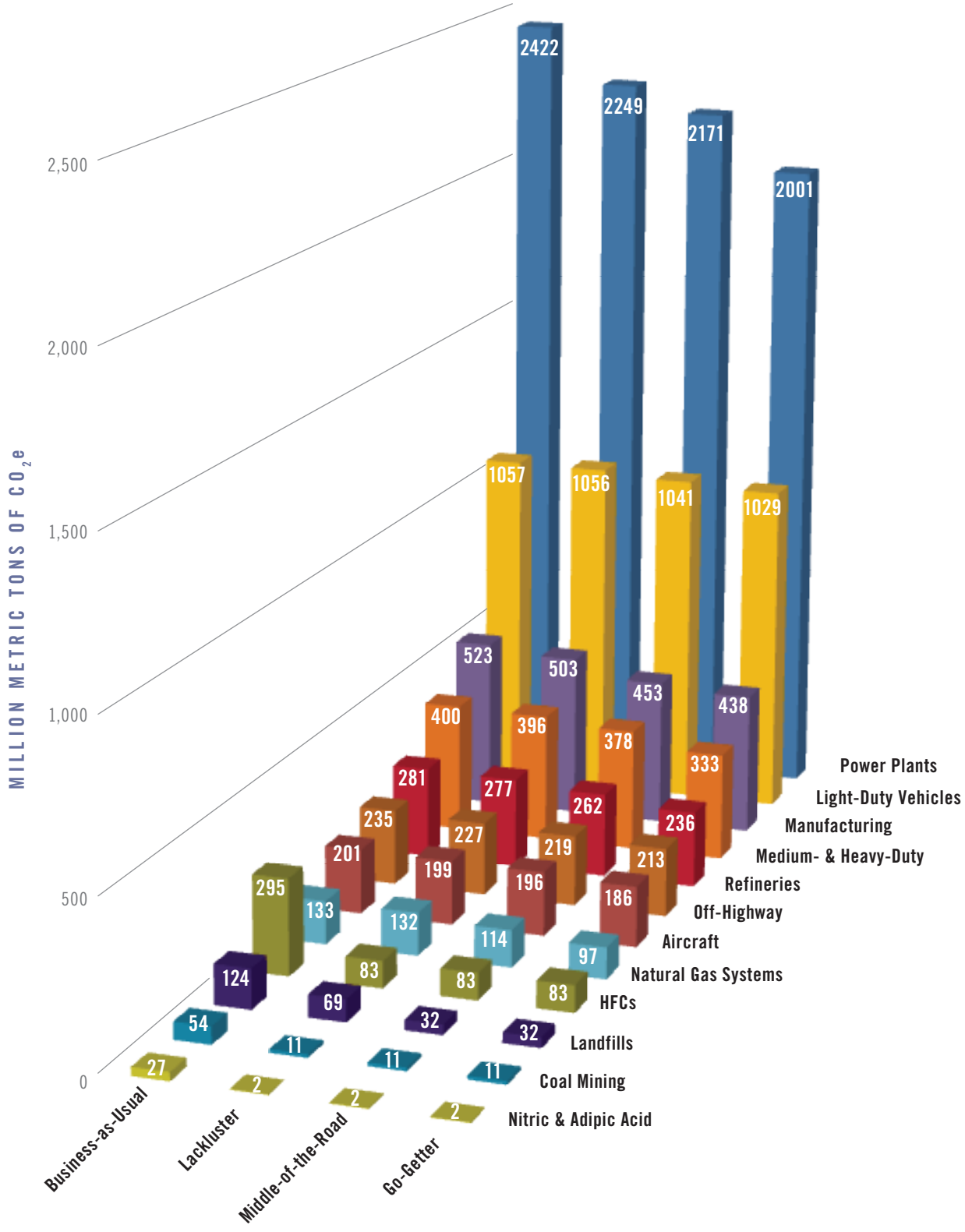


Figure 3 depicts the emissions under the three federal regulatory scenarios by sector or category of sources through 2020. The bars across the back represent the business-as-usual emissions. Emissions under the Lackluster, Middle-of-the-Road and Go-Getter Scenarios are then shown in the bars in front of the business-as-usual emissions.

FIGURE 4. **Projected U.S. Emissions in 2030 by Sector under Different Federal Regulatory Scenarios**

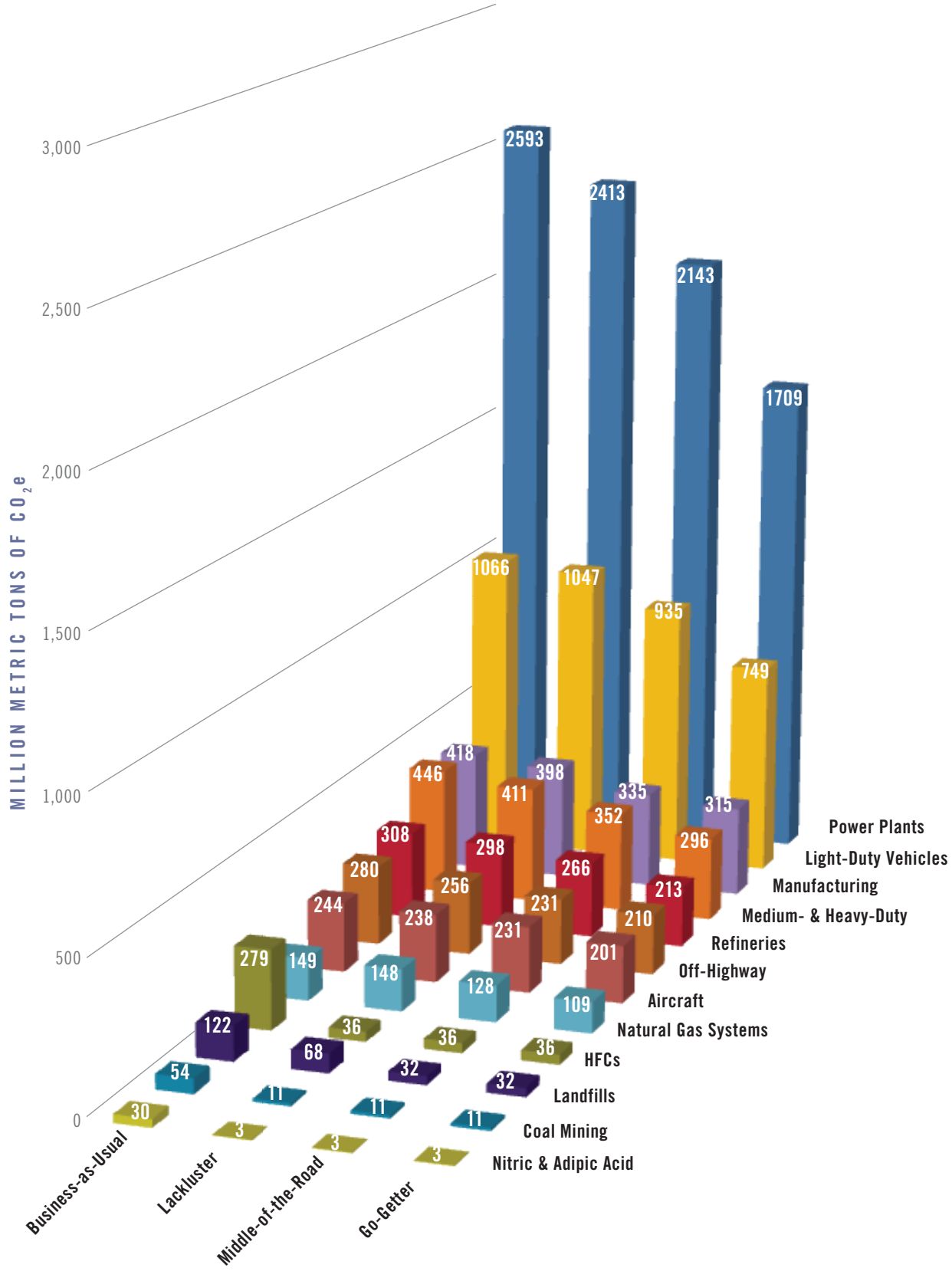


Figure 4 depicts the emissions under the three federal regulatory scenarios by sector or category of sources through 2030. The bars across the back represent the business-as-usual emissions. Emissions under the Lackluster, Middle-of-the-Road and Go-Getter Scenarios are then shown in the bars in front of the business-as-usual emissions.

advances will happen and when, it is difficult to project the tightening of regulatory standards.[3]

- All scenarios under current federal authority and announced state plans show the United States far off the pace of reductions the IPCC suggests are necessary by mid-century to prevent average global temperatures from increasing more than 2 degrees Celsius.[4]

- While the results of the analysis suggest that existing federal regulatory tools can be used effectively to reduce emissions alongside state actions, it is clear that the federal government and states will need to achieve reductions beyond those identified in even the most ambitious regulatory scenario if the United States is to meet its Copenhagen commitment. Some of these reductions might be found in regulatory policies not analyzed here, such as agricultural and forest lands management (approximately 7 percent of the U.S. inventory) or transportation planning (approximately 27 percent). Implementation of other environmental policies that encourage high-emitting sectors to modernize could also yield more reductions, such as mercury, sulfur dioxide, ozone and ash disposal regulations affecting aging coal plants.

- Among the existing federal regulatory tools most useful to achieve reductions are the mobile source and New Source Performance Standard provisions of the Clean Air Act, as well as the existing authority under Title VI of the Act to reduce hydrofluorocarbons. The vehicle fuel efficiency authority of the Department of Transportation is also important. State action that contributes reductions beyond federal regulatory policies will likewise be essential to meeting reduction goals.

- As outlined in Table 1, the analysis shows that a significant portion of the reductions can be achieved in non-energy emissions. It is expected that these

3. It is important to note that the uncertainty about future reductions relates to our ability to project into the future. It does not mean deeper reductions would not occur through existing regulatory policies, but rather that projecting those reductions is not possible given current knowledge.
4. The Intergovernmental Panel on Climate Change's (IPCC's) Fourth Assessment Report (2007) suggests that industrialized countries need to collectively reduce emissions between 25 and 40 percent below 1990 levels by 2020 and 80 to 95 percent below 1990 levels by 2050 to keep global average temperatures from increasing more than 2 degrees Celsius. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm. The U.S. pledge in Copenhagen calls for reductions that put the United States at 3 percent below 1990 levels in 2020. Specifically, the U.S. pledge reads, "In the range of 17%, in conformity with anticipated U.S. energy and climate legislation, recognizing that the final target will be reported to the Secretariat in light of enacted legislation." http://unfccc.int/files/meetings/application/pdf/unitedstatescphaccord_app.1.pdf.

FIGURE 5. Projected U.S. Emissions under Different State Scenarios

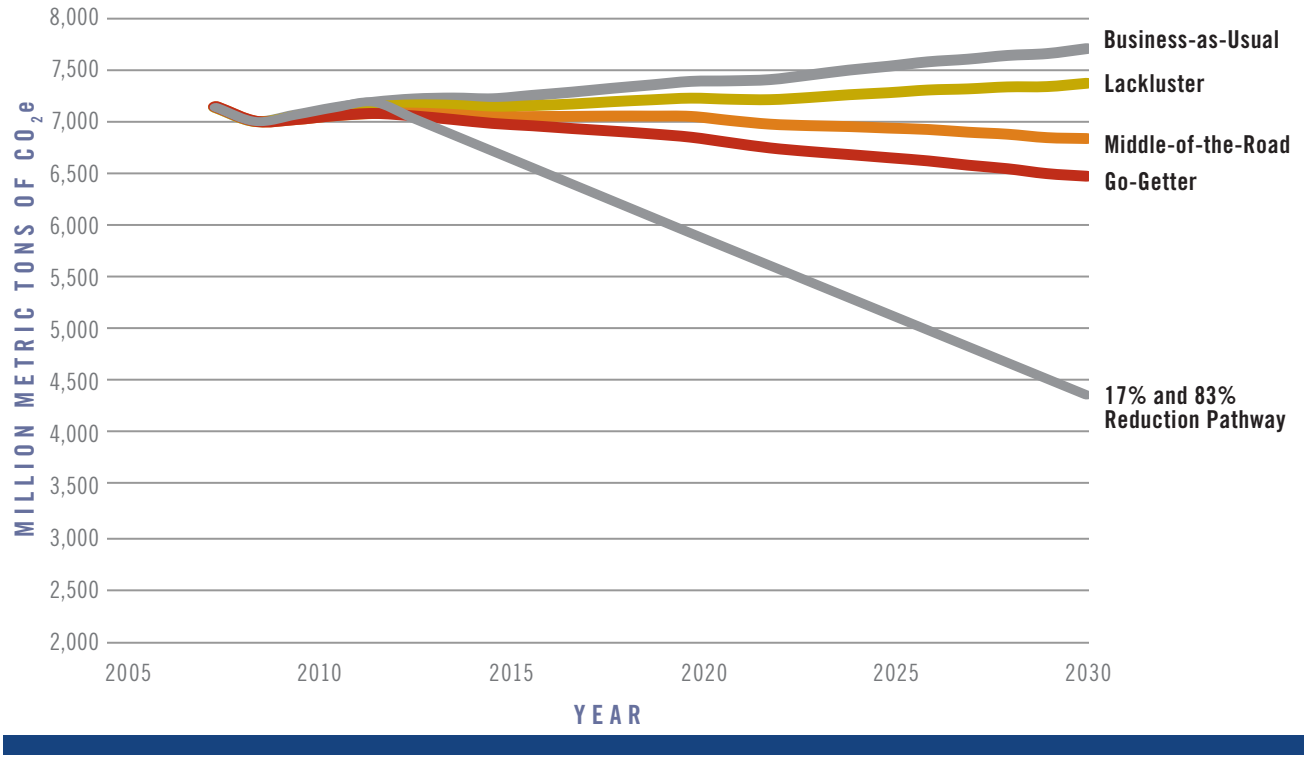


Figure 5 shows the Lackluster, Middle-of-the-Road, and Go-Getter Scenarios for state action without considering federal actions.

non-energy reductions can be accomplished without energy price increases.

- It is likely that the U.S. Congress and states will need to step up to augment existing regulatory tools, especially if the United States is to gear up to reduce emissions by the approximately 80 to 95 percent needed by 2050 to ward off the most deleterious effects of climate change.

III. The Federal Scenarios: Will the Overall Effort be Lackluster, Middle-of-the-Road, or Go-Getter?

TO PROJECT POTENTIAL REDUCTIONS THROUGH federal action, WRI: (a) examined the 2008 U.S. greenhouse gas emissions inventory to identify key sectors or categories of sources contributing to overall emissions; (b) conducted a review of existing regulatory authorities to determine what specific actions can be used to achieve reductions; (c) reviewed available literature to decide what range of reductions are technically feasible in key sectors; (d) modeled three levels of emissions reductions in each sector or category of sources corresponding to different levels of regulatory ambition against expected business-as-usual emissions;[5] and (e) aggregated the results as three reduction scenarios based on the range of technically feasible reductions and the corresponding levels of regulatory ambition necessary to achieve the reductions.

TABLE 1. Reductions from Non-energy Emissions Sources as a Share of Total U.S. Reductions under Different Federal Regulatory Scenarios

% BELOW BASE CASE PROJECTIONS	2020	2030
Lackluster	60%	54%
Middle-of-the-Road	49%	32%
Go-Getter	37%	21%

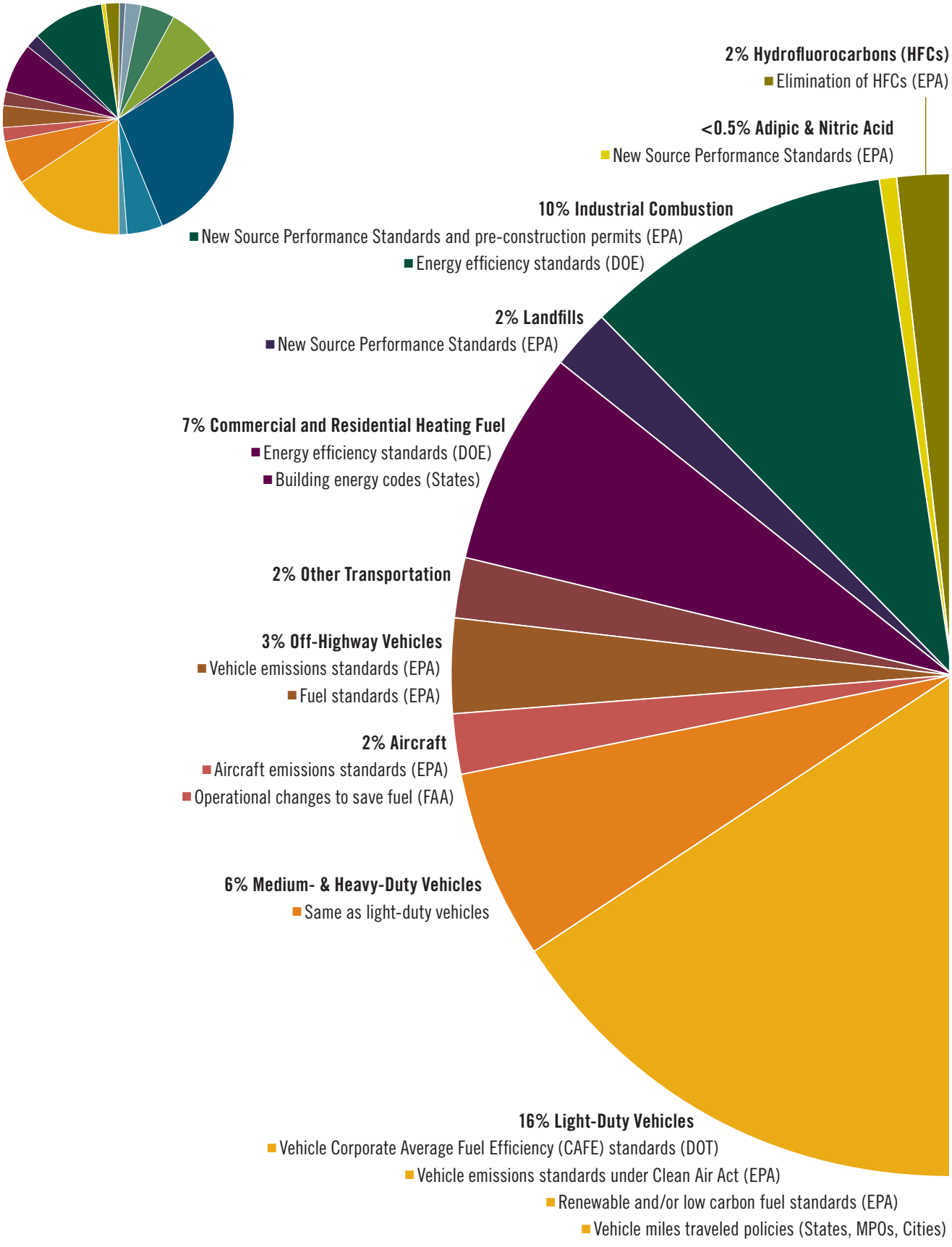
A. Emissions and Currently Available Regulatory Tools

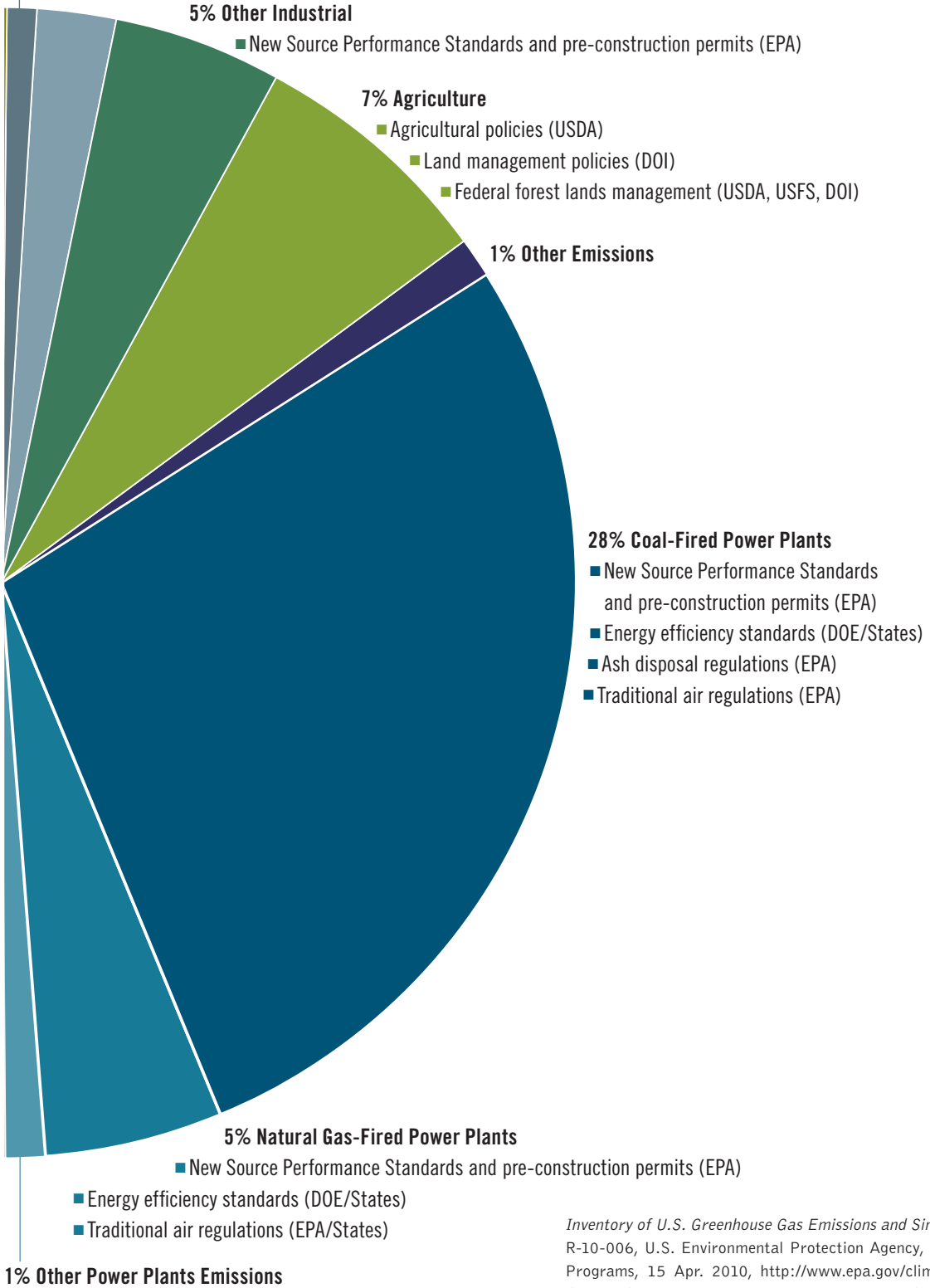
Figure 6 depicts the 2008 U.S. greenhouse gas emissions inventory separated by key sectors and categories of sources. For each sector or source category, existing regulatory authorities are listed that can be used to achieve emissions reductions. Given the fossil-fuel origins of most U.S. greenhouse gas emissions, the existing regulatory authorities of the U.S. Department of Energy (DOE), the U.S. Department of Transportation (DOT), and the U.S. Environmental Protection Agency (EPA) are prominent among available regulatory tools in terms of their ability to drive reductions.[6] Existing energy laws provide DOE with authority to regulate the energy efficiency of appliances and commercial equipment, for example, while DOT has authority to improve the fuel efficiency of vehicles. The federal Clean Air Act vests EPA and states with substantial authority to regulate emissions that present a danger to public health and the environment. Various other federal agencies have purview over other important areas, such as the U.S. Federal Aviation Administration's (FAA) oversight of air traffic, the U.S. Department of Agriculture's programs related to agricultural lands and practices, and the U.S. Bureau of Land Management's stewardship of public lands. Specific legal authorities are provided in the more detailed explanation of the regulatory policy tools set out below.

5. As described more fully in the appendix to this report, the Energy Information Agency's Annual Energy Outlook (AEO) for 2009 was used as business-as-usual for energy-related emissions, and EPA's ADAGE Model Reference Scenario, as developed for their analysis of HR 2454, the American Climate and Energy Security Act of 2009, was used for non-energy emissions.

6. For a discussion of U.S. EPA authority under the Clean Air Act, see *What to Expect from EPA: Regulation of Greenhouse Gas Emissions Under the Clean Air Act,* 40 Environmental Law Reporter 10480, Franz T. Litz and Nicholas M. Bianco, May 2010.

FIGURE 6. **U.S. Emissions by Sector and Corresponding Federal Authorities (2008)**

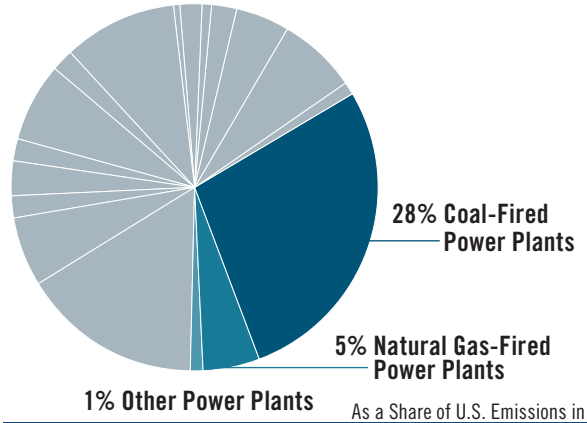




Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2008, 430-R-10-006, U.S. Environmental Protection Agency, Office of Atmospheric Programs, 15 Apr. 2010, http://www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010_Report.pdf.

B. Building the Scenarios: The Sector-by-Sector Analysis

FIGURE 7. Power Plant Emissions



As a Share of U.S. Emissions in 2008

1. POWER PLANTS.

Representing approximately 34 percent of U.S. emissions in 2008, fossil-fuel-fired power plants represent a significant emissions reduction opportunity for DOE and EPA. There are currently no federal greenhouse gas emissions reduction requirements in force for power plants.[7] Emissions from power plants, however, can be reduced using the following federal regulatory authorities:

(a) Appliance and equipment efficiency standards under Department of Energy authority.[8] Based on available studies, the three scenarios modeled assume progressively greater reductions through appliance and equipment standards, ranging from 86 terawatt-hours (TWh) of annual savings in 2030 in the Lackluster Scenario to 234 TWh annual savings in 2030 under the Go-Getter Scenario.

(b) New Source Performance Standards (NSPS) under section 111 of the federal Clean Air Act.[9] Under section 111, EPA may prescribe emissions limitations based on the "best demonstrated technology" (BDT) for new and modified existing sources within source categories EPA determines cause or contribute significantly to air pollution that may reasonably be anticipated to endanger public health and welfare.[10] To determine BDT, EPA considers technological feasibility, cost, lead-time, and energy and non-air environmental impacts. In addition, for any source category EPA regulates on the federal level, EPA must also promulgate guidelines for the states to use in developing requirements for existing sources under section 111(d). In regulating existing sources, states must also take into account the remaining useful life of the existing units. The form of regulations imposed on existing sources is not tightly prescribed in the statute, and EPA has taken the position that states could implement cap-and-trade programs to reduce emissions from existing sources, though other measures are certainly permitted.[11] Table 2 specifies the three scenarios for coal- and natural gas–fired power plants under section 111. Given the range of alternatives for existing sources, we note that cap and trade is only one example of how EPA and the states may implement section 111(d), and we expect that similar emissions reductions could be achieved using alternative regulatory mechanisms.

(c) Best Available Control Technology (BACT) requirements for major new and modified existing sources of greenhouse gas emissions under Title I, Part C of the Clean Air Act. In 2011, EPA and the states will begin applying the Prevention of Significant Deterioration (PSD) pre-construction permitting program for new sources that emit 100,000 tons or more in carbon dioxide equivalent on an annual basis, and existing sources that increase emissions more than 75,000 tons on an annual basis.[12] In the permitting process, EPA applies the BACT standard in establishing emissions rates for covered facilities. Because determinations under BACT are source-specific, it can drive reductions beyond those achieved through NSPS. It is difficult to precisely estimate these additional benefits, and therefore we do not attempt to quantify

7. Federal permitting requirements for major new and modified plants will take effect January 1, 2011, under the Prevention of Significant Deterioration pre-construction permitting program. http://www.epa.gov/nsr/documents/20100413final.pdf (as of June 26, 2010). These requirements are discussed in section III(B)(1)(c). At the state level, a number of policies are included in the Energy Information Administration's business-as-usual emissions projection, including state renewable energy standards and the Regional Greenhouse Gas Initiative (RGGI).

8. DOE appliance and equipment standards have been issued over time and are revised periodically. For a list of the standards and links to more information on each, see http://www1.eere.energy.gov/buildings/appliance_standards/.

9. 42 U.S.C. § 7411.

10. See 40 CFR Part 60 and its subparts for the existing source categories EPA has designated.

11. It should be emphasized that the same statutory considerations related to the best demonstrated technology apply to establishment of a cap-and-trade program for existing sources. Thus, in setting a reduction target under a cap-and-trade program for existing sources, EPA and the states will consider technological feasibility, cost, lead-time, and energy and non-air environmental impacts, as well as the remaining useful lives of existing units.

12. 40 CFR Parts 51, 52, 70, and 71, http://www.epa.gov/nsr/documents/20100413final.pdf (as of June 26, 2010). The final rule suggests that the tonnage threshold for triggering permitting requirements may be reduced in the future.

TABLE 2. New Source Performance Standards for Power Plants by Scneario

	LACKLUSTER	MIDDLE-OF-THE-ROAD	GO-GETTER
Existing coal-fired plants	Emissions reductions consistent with 5% improvement in efficiency	Emissions reductions consistent with 7% improvement in efficiency	Emissions improvements across all electric generators result in sector-wide reductions consistent with what is demonstrated to be cost effective through published cap-and-trade modeling reports
New coal-fired plants [a]	Emissions reductions consistent with emissions rate equivalent to natural gas [b]	Emissions reductions consistent with CCS at 90% capture rate beginning in 2020	
Existing gas-fired plants	No reductions	No reductions	
New gas-fired plants	Emissions reductions consistent with ramp up to 70% efficiency by 2030	Emissions reductions consistent with efficiency ramp up similar to Lackluster Scenario, CCS at 90% capture rate beginning in 2020	

a. It is important to note that the AEO forecast does not predict many new coal plants through 2030. Therefore, the assumed regulatory approach to new coal plants does not produce significant reductions in the analysis.

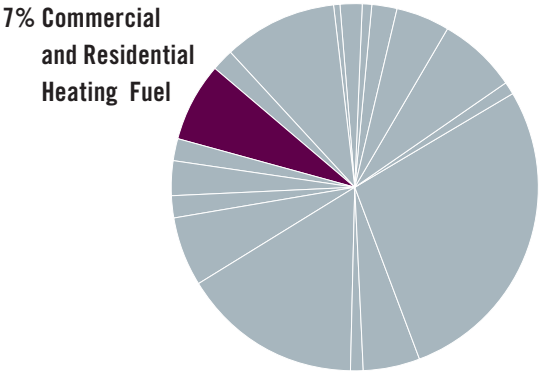
b. We note that the Clean Air Act requires performance standards be established in the form of an emissions rate. Our descriptions of particular abatement technologies or fuel choices are illustrative only.

these reductions. However, we do assume that in some instances emissions limitations are imposed on new plants sooner than NSPS requirements come into effect for a category of plants.

(d) New energy efficiency investments. The analysis does not include the emissions benefits from new federally funded energy efficiency investments in the future. The Annual Energy Outlook (AEO) emissions forecast used as the business-as-usual emissions trend in this analysis already includes the investments made by the federal government in the 2009 stimulus package. It is likely that any future similar investments could put substantial downward pressure on emissions, but given the uncertainty around federal spending in any given future year, we do not include reductions from any future investments.

(e) Pending non–greenhouse gas regulatory initiatives. Existing and pending regulatory initiatives unrelated to greenhouse gas emissions may place significant indirect downward pressure on greenhouse gas emissions. These include new coal ash disposal regulations, new fine particulate matter regulations, new sulfur dioxide and ozone regulations, and other Clean Air Act regulatory developments. The AEO2009 baseline does not reflect the increased unit turnover that may result from these pending measures or the corresponding emissions reductions, and we have not made any assumptions in this analysis about the indirect effects of regulatory programs that are not specifically greenhouse gas–focused. WRI may include this in future versions of this analysis.

FIGURE 8. Commercial & Residential Heating Emissions



As a Share of U.S. Emissions in 2008

2. RESIDENTIAL AND COMMERCIAL HEATING.

Residential and commercial heating accounted for approximately 7 percent of U.S. emissions in 2008. Emissions reductions are possible using the following federal regulatory authorities:

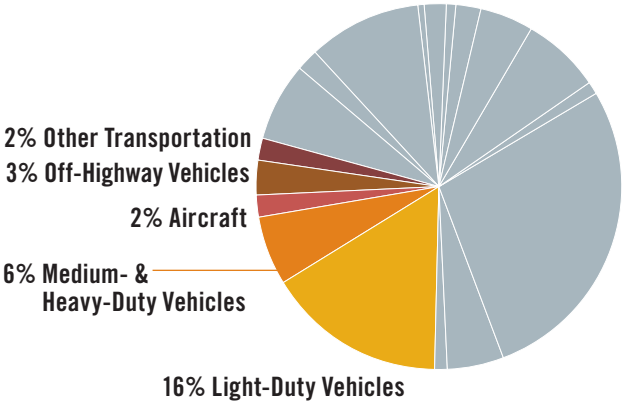
(a) Appliance and equipment efficiency standards under Department of Energy authority.[13] Based on our review of available studies, we assume for all scenarios that standards for residential and commercial appliances that combust fuel will reduce natural gas demand by 166 trillion British Thermal Units (TBtu) in 2020 and 347 TBtu in 2030, and could reduce oil demand by 2.3 TBtu in 2020 and 5.4 TBtu in 2030.

13. DOE appliance and equipment standards have been issued over time and are revised periodically. For a list of the standards and links to more information on each, see http://www1.eere.energy.gov/buildings/appliance_standards/.

(b) New energy efficiency investments. It should be noted that the analysis does not include the emissions benefits from new federally funded energy efficiency investments in the future. The AEO emissions forecast used as the business-as-usual emissions trend in this analysis already includes the investments made by the federal government in the 2009 stimulus package. It is likely that future similar investments could put substantial downward pressure on emissions, but given the uncertainty around federal spending in any given future year, we do not include reductions that would result from future investments.

(c) Building code standards: Improved building code standards will reduce emissions associated with residential and commercial heating. Existing federal programs can only encourage improvements to building codes, however, and cannot require them. Therefore, emissions reductions from improved building codes are not modeled here.

FIGURE 9. **Transportation Emissions**[14]



As a Share of U.S. Emissions in 2008

3. TRANSPORT VEHICLES.

Transportation emissions represented approximately 29 percent of U.S. emissions in 2008. At the federal level, regulatory policies have been most effective at reducing emissions through vehicle efficiency, vehicle emissions, and fuels requirements. The Energy Independence and Security Act of 2007, for example, raised vehicle efficiency standards for light duty vehicles to 35 mpg for model year 2020, a policy that is included in the business-as-usual emissions projection from the Energy Information Administration. The three scenarios assume additional actions to reduce emissions through federal regulatory policies, as explained below.

(a) Corporate Average Fuel Efficiency (CAFE) standards by the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA). The corporate average fuel efficiency (CAFE) regulations adopted in May 2010 will reduce greenhouse gas emissions by increasing CAFE standards for light-duty vehicles for model years 2012–2016.[15] These regulations were included in all three scenarios analyzed for light-duty vehicles, together with additional standards for the period 2017 and after, as detailed below.

(b) Vehicle emissions standards by EPA under Title II of the Clean Air Act. In addition to the May 2010 light-duty vehicle emissions standards adopted jointly with DOT, EPA has the ability under Title II of the Clean Air Act to revise light-duty vehicle standards and to impose medium- and heavy-duty vehicle emissions standards to achieve additional greenhouse gas emissions reductions. In considering what additional actions were possible for light-duty vehicles, available studies were reviewed.[16]

As detailed in Table 3, improvements modeled in fuel efficiency through 2030 range from 204 grams per mile (or 40 mpg) in the Lackluster Scenario to 86 grams per mile in the Go-Getter Scenario. Consistent with the EPA "Analysis of the Transportation Sector," we assume that this is achieved through a 51 mpg CAFE standard, with additional benefits from air conditioning efficiency improvements and HFC emissions reductions, as well as a 30 percent market penetration rate for electric vehicles and 17 percent market penetration for plug-in hybrid electric vehicles.

For medium- and heavy-duty vehicles, studies suggest that modest improvements in fuel efficiency, or approximately a 2.5 percent improvement per year from 2014 to 2019, are readily attainable, with

14. Table A-105 of EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008 breaks down off-highway emissions into agricultural equipment (45.4 mmtCO2), construction & mining equipment (69.3 mmtCO2), and other sources (77.7 mmtCO2). For purposes of adjusting the EPA inventory, we assume that agricultural emissions come entirely from agricultural emissions. We also assume that construction and mining equipment come from industrial combustion emissions (the 1% of emissions depicted from coal mining are methane emissions, only). Because we cannot determine the relative contribution of each equipment type to the "other source" category, we split the emissions equally between residential, commercial, and industrial combustion emissions.

15. 75 Fed. Register 25324 (May 10, 2010).

16. Studies by the American Physical Society, Massachusetts Institute of Technology, and the EPA informed these scenarios. See discussion of assumptions and methodology in the appendix to this report.

a 0.75 percent annual rate of improvement from 2020 to 2030. Moderate improvements might be expected at double those rates, or 4.9 percent per year from 2014 to 2019 and 1.5 percent annually from 2020 to 2030. The upper ends of the potential, for all vehicles except tractor-trailers, are rates of 5.6 percent annually from 2014 to 2019 and 1 percent per year from 2020 to 2030.[17] The upper end of the potential for tractor-trailers is a doubling of fuel economy in 2017. The three scenarios are summarized in the table below.

(c) Emissions standards for off-highway mobile sources by EPA under Title II of the Clean Air Act. Off-highway sources represent just under 3 percent of total U.S. emissions and 10 percent of all vehicle emissions. For the Lackluster, Middle-of-the-Road, and Go-Getter scenarios, respectively, the analysis assumes new standards can achieve an additional 0.9 percent, 1.8 percent, and 2.4 percent annual improvement in the emissions rate for new equipment and engines from 2015 to 2030. These estimates are derived from EPA's "Analysis of the Transportation Sector."

(d) Aircraft emissions reductions. The FAA may make operational improvements in the air traffic control system that could achieve significant emissions reductions over time.[18] We draw our assumptions about operational improvements from EPA's "Analysis of the Transportation Sector" and the FAA's comments on that analysis. In its analysis, EPA suggests that sustained operational

17. Each of these scenarios corresponds to analyses published in available literature by reputable sources. For more information, see section VI of the Appendix.

18. We note that although EPA has authority to impose aircraft engine emissions standards under Title II of the Clean Air Act, the AEO business as usual emissions projectionsassume significant improvements in the emissions rate of aircraft through efficiency improvements without emissions standards. For this analysis, therefore, we did not project additional reductions through aircraft engine standards. This topic is discussed more fully in the methodology section in the Appendix.

TABLE 3. Vehicle Emissions, Efficiency Standards, & Operational Improvements

	LACKLUSTER SCENARIO	MIDDLE-OF-THE-ROAD SCENARIO	GO-GETTER SCENARIO
	May 2010 Joint EPA-DOT Standards: 35.5 mpg by model year 2016		
Light-duty vehicles	40 mpg by 2030 or 204 grams per mile; or CA + 17 states adopt 162 grams per mile (50 mpg)	50 mpg by 2030 or 162 grams per mile	86 grams per mile achieved through a 51 mpg CAFE standard, with additional benefits from A/C efficiency improvements and HFC emissions reductions, as well as a 30 percent market penetration rate for electric vehicles and 17 percent market penetration for plug-in hybrid electric vehicles
Medium- & heavy-duty vehicles	2.45 percent annual GHG emissions rate improvement each year from 2014 to 2019; +0.75 percent annually from 2020 to 2030	4.9 percent annual GHG emissions rate improvement each year from 2014 to 2019; +1.5 percent annual improvement from 2020 to 2030	5.6 percent annual GHG emissions rate improvement each year from 2014 to 2019; +1 percent annual improvement from 2020 to 2030 Tractor trailers reduce their emissions rate by 25 percent from 2014–2016, and halve it in 2017
Off-highway vehicles	0.9 percent annual improvement in the emissions rate for new equipment and engines from 2015 to 2030	1.8 percent annual improvement in the emissions rate for new equipment and engines from 2015 to 2030	2.4 percent annual improvement in the emissions rate for new equipment and engines from 2015 to 2030
Aviation emissions improvements	0.17 percent annual emissions reduction through 2030	0.4 percent annual emissions reduction through 2030	1.4 percent annual emissions reduction through 2030

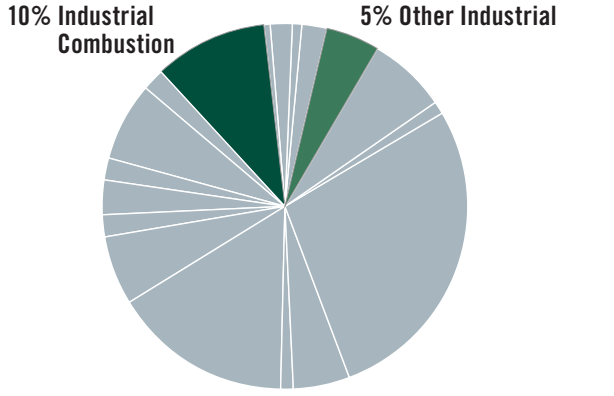
improvements reduce emissions by between 0.7 and 1.4 percent annually, so that by 2030 operational measures could produce reductions between 10 and 20 percent. EPA notes in its report, however, that the FAA considered operational improvements in the range of 0.17 to 0.4 percent per annum more appropriate. Because the FAA must implement the improvements, we modeled the upper and lower end of the FAA position for the Lackluster and Middle-of-the-Road Scenarios. For the Go-Getter Scenario, however, we assumed the FAA achieved 1.4 percent annually through 2030 as estimated by EPA. The specific reductions modeled are outlined in the transport scenario table below.

(e) Renewable fuel standard or a low carbon fuel standard. EPA has adopted a federal renewable fuel standard (RFS) as required by the Energy Independence and Security Act of 2007. The standard calls for an increase in renewable fuel supply to 36 billion gallons per year by 2022. The Energy Information Agency includes the RFS in the business-as-usual case in its 2009 Annual Energy Outlook (AE02009), which is also used as the business-as-usual case for this study. An improved RFS or a low-carbon fuel standard that targets improvements over the current federal RFS would produce emissions reductions beyond what actually occurs from the current standards. However, the AE02009 assumes there are no carbon dioxide emissions associated with the combustion of renewable fuel, and therefore greatly overstates the actual emissions benefits of the RFS. Review of available literature and consultation with experts in the field revealed that additional reductions beyond those included in the AE02009 baseline emissions projections are not likely, whether through further revision of the RFS or through adoption of a low-carbon fuel standard. As a result, we have not included any emission reduction benefits of a national low-carbon fuel standard in the scenarios.

(f) Emission standards for aircraft. Title II of the Clean Air Act allows EPA to prescribe emissions standards for aircraft engines. Those standards would be implemented and enforced by the Federal Aviation Administration. These standards were not included in the scenarios for a number of reasons. First, aircraft turnover rates are very slow and turnover occurs in a highly international market where the effect of domestic US regulatory policies can be somewhat muted. Second, the AE02009 already incorporates some improvement in commercial aircraft efficiency as a function of market forces.

(g) Emission standards for marine vessels. Marine vessels were not included in the analysis because of the difficulty in regulating vessels of international origin and a limited inventory information for the domestic fleet.[19] We note that EPA has identified a technical potential for reduction of 20 to 40 million metric tons of carbon equivalent in marine vessels, but these reductions have as yet not been coupled with any regulatory policy.[20]

FIGURE 10. Industrial Emissions



As a Share of U.S. Emissions in 2008

4. INDUSTRY.

Emissions from industrial facilities comprise 15 percent of the U.S. emissions inventory for 2008.

(a) New source performance standards under Clean Air Act section 111. As discussed under "Power Plants," the EPA may prescribe emissions limitations based on the "best demonstrated technology" (BDT) for new and modified existing sources within source categories it designates.[21] In addition, for greenhouse gases, where EPA adopts new source standards, it must also promulgate guidelines for the states to regulate existing sources within the same source categories

19. According to analysis by the Pew Center on Global Climate Change, international shipping accounts for 85 percent of U.S. marine emissions. "Marine Shipping Emissions Mitigation." Pew Center on Global Climate Change, Mar. 2010. http://www.pewclimate.org/technology/factsheet/MarineShipping.

20. *EPA Analysis of the Transportation Sector: Greenhouse Gas and Oil Reduction Scenarios.* U.S. Environmental Protection Agency, Mar. 2010. http://www.epa.gov/oms/climate/GHGtransportation-analysis03-18-2010.pdf.

21. 40 CFR Part 60.

TABLE 4. New Source Performance Standards for Industry by Scenario

	LACKLUSTER SCENARIO	MIDDLE-OF-THE-ROAD SCENARIO	GO-GETTER SCENARIO
Industrial combustion and cement kilns	10 percent improvement in emissions rate for new and existing boilers	Harness all cost-effective energy efficiency from combustion and processes for existing units	Harness all cost-effective energy efficiency from combustion and processes for existing units; all new units meet natural gas emissions rate
Refineries	1 percent one-time improvement in emissions rate	5 percent one-time improvement in emissions rate	10 percent one-time improvement in emissions rate

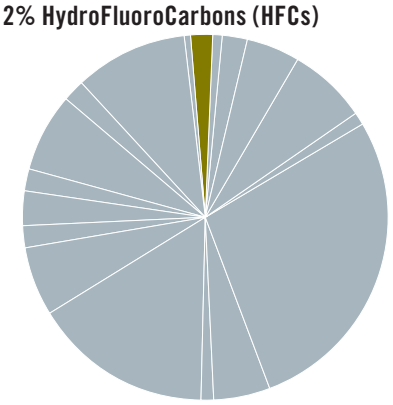
under section 111(d). States are then charged with following the prescribed guidelines, though they may implement alternative approaches that are equal to or more stringent than the federal guidelines. The form of regulations imposed on existing sources is not tightly prescribed in the statute. The NSPS regulatory policy is therefore likely to vary from source category to source category. Its application to industry subsectors is described below.

(b) Industrial combustion and process efficiency. Table 4 presents the Lackluster, Middle-of-the-Road and Go-Getter Scenarios for industrial combustion and process efficiency. The reduction percentages are taken from the analyses EPA conducted as a basis for the Advanced Notice of Proposed Rulemaking (ANPR),[22] as well as a study done for the Department of Energy by the Interlaboratory Working Group.[23] The Middle-of-the-Road and Go-Getter Scenarios call for an approach that applies an output-based emissions limitation rather than the traditional emissions limitation applied solely at the combustion source. An output-based approach would allow industrial sources to improve efficiencies at a plant to improve their emissions rates, thereby capturing reductions that would otherwise be lost under the combustion-unit-only approach.

(c) Cement kilns. The modeled policy scenarios for cement are described in Table 4 and are identical to the scenarios chosen for industrial sources. They are also based on the same technical sources.

(d) Refineries. EPA's Advanced Notice of Proposed Rulemaking cited a range of 10 to 20 percent reductions for existing refineries. However, some efficiency improvements are already built into the baseline. Therefore, as outlined in the table below, this analysis assumed one-time improvements of 1 percent in the Lackluster Scenario, 5 percent in the Middle-of-the-Road Scenario, and 10 percent in the Go-Getter Scenario.

FIGURE 11. HFC Emissions



As a Share of U.S. Emissions in 2008

5. HFCs.

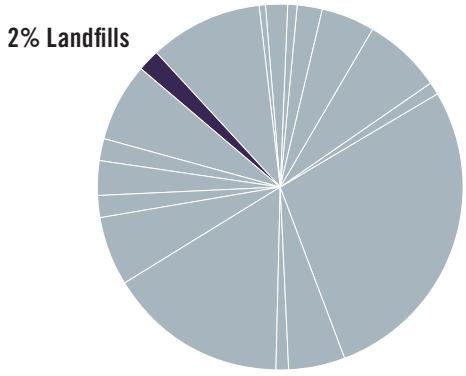
Hydrofluorocarbons (HFCs) made up just under 2 percent of the U.S. greenhouse gas inventory in 2008. If left uncontrolled, however, HFC emissions are projected to grow rapidly. EPA has existing authority to regulate HFC consumption under Title VI of the Clean Air Act and has proposed an international ramp-down schedule.[24] The scenarios modeled in this analysis are identical to that ramp-down schedule, and by 2033 would reduce emissions 85 percent below average emissions from 2004 to 2006.

22. Regulating Greenhouse Gas Emissions Under the Clean Air Act, 73 Federal Register § 147 (2008). http://www.epa.gov/climatechange/emissions/downloads/ANPRPreamble5.pdf.

23. *Scenarios for a Clean Energy Future*, Interlaboratory Working Group, ORNL/CON-476 and LBNL-44029, Nov. 2000.

24. *Analysis of HFC Production and Consumption Controls.* U.S. Environmental Protection Agency, Oct. 2009. http://www.epa.gov/ozone/downloads/HFCAnalysis.pdf.

FIGURE 12. Landfill Emissions

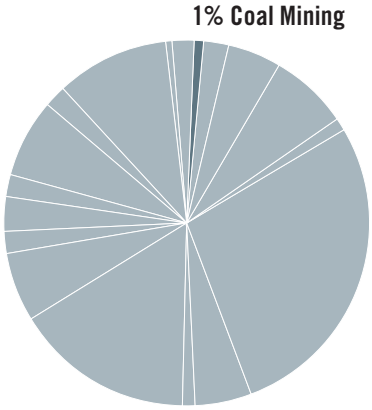


As a Share of U.S. Emissions in 2008

6. LANDFILLS.

Methane emissions from landfills represented just under 2 percent of total U.S. greenhouse gas emissions in 2008. Significant reductions from baseline emissions are possible through expanded New Source Performance Standards for landfills, implemented under section 111 of the Clean Air Act. Reduction scenarios were selected based on cost-per-ton calculations done for EPA in its analysis of federal climate change legislation. The Lackluster Scenario assumes a 44 percent decrease in emissions from the baseline, corresponding to a $5 per ton reduction cost. The Middle-of-the-Road and Go-Getter Scenarios assume a $20 and $61 per ton reduction cost, respectively, both of which result in a 74 percent reduction from baseline.

FIGURE 13. Coal Mine Emissions

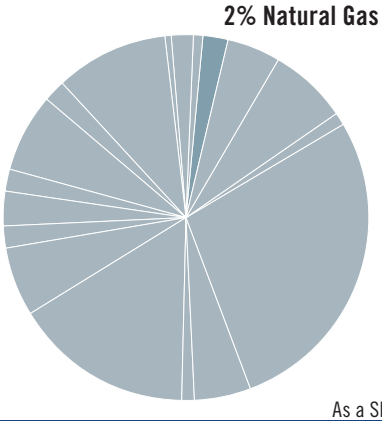


As a Share of U.S. Emissions in 2008

7. COAL MINES.

Methane emissions from coal mines represented 1 percent of total greenhouse gas emissions for the U.S. in 2008. EPA has authority to regulate coal mines as a source category under the New Source Performance Standard provisions of section 111 of the Clean Air Act. As discussed above, the EPA may prescribe emissions limitations based on the "best demonstrated technology" for new and modified existing sources within source categories it designates.[25] In addition, for greenhouse gases, where EPA regulates new sources, it must promulgate guidelines to the states to regulate existing sources within the same source category under section 111(d). States are then charged with following the prescribed guidelines, though some have taken the position that they may implement alternative requirements at the state level that are at least as stringent as the federal guidelines. The form of regulations imposed on existing sources is not tightly prescribed in the statute. For all three scenarios in this analysis, coal mines were assumed to reduce emissions by 86 percent from the baseline, consistent with EPA's analysis of federal climate change legislation and their Global Non-CO_2 Mitigation Analysis (and assuming $5, $20, and $61 cost per ton).

FIGURE 14. Emissions From Natural Gas Systems



As a Share of U.S. Emissions in 2008

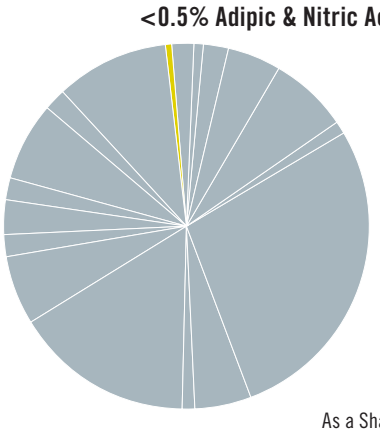
8. NATURAL GAS SYSTEMS.

Emissions from natural gas systems account for approximately 2 percent of total U.S. emissions in 2008. Similar to coal mines, EPA could regulate natural gas systems as a source category under the New Source Performance Standard provisions of section 111 of the Clean Air Act. They could require equipment changes and upgrades, changes in operational practices, and direct inspection and

25. 40 CFR Part 60.

maintenance. Achievable reductions for natural gas systems come from EPA's analysis of federal climate legislation and suggest that at $5, $20, and $61 per ton for CO_2e, emissions can be reduced by 9 percent, 14 percent, and 27 percent in 2030.

FIGURE 15. Adipic and Nitric Acid Emissions

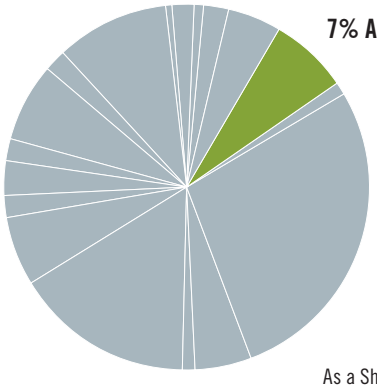


As a Share of U.S. Emissions in 2008

9. ADIPIC AND NITRIC ACID MANUFACTURING.

Nitric acid (HNO_3) is primarily used as a feedstock for synthetic fertilizer, though it is also used in the production of adipic acid and explosives. Adipic acid ($C_6H_{10}O_4$) is used in the production of nylon and as a flavor enhancer for certain foods. The manufacture of both compounds generates nitrous oxide (N_2O) as a byproduct, which according to the IPCC's Fourth Assessment has a global warming potential 298 times that of carbon dioxide over a 100-year timeframe.[26] N_2O emissions from the production of adipic and nitric acid manufacturing made up under one-half of 1 percent of total U.S. greenhouse gas emissions in 2008. Significant reductions from baseline emissions are possible through New Source Performance Standards for these manufacturing facilities, implemented under section 111 of the Clean Air Act. Reduction scenarios were selected based on cost per ton calculations done for EPA in its analysis of federal climate change legislation and are consistent with EPA's Global Non-CO_2 Mitigation Analysis.[27] All three scenarios in this analysis assume 96 percent and 89 percent reduction from baseline emissions for adipic and nitric acid manufacturing, respectively. These reduction levels correspond to carbon prices of $5 to $61 per ton for both types of manufacturing.

FIGURE 16. Agriculture Emissions



As a Share of U.S. Emissions in 2008

10. AGRICULTURE, FORESTRY AND LAND-USE EMISSIONS.

This category comprises about 7% of emissions in 2008. It is likely that the Forest Service (within the Department of Agriculture) could increase sequestration on federal forest lands. The Bureau of Land Management (within the Department of Interior) could potentially increase sequestration on some of the 264 million acres of public lands that they administer. The Department of Agriculture could also encourage practices that would reduce greenhouse gas or increase sequestration on farmland. Unfortunately, however, we could not identify any literature that has or would allow us to accurately quantify the magnitude of sequestration possible using existing regulatory policies without expanding program budgets. As a result, agriculture, forestry and land use emissions are not included in this analysis. Subsequent updates to this analysis may seek to address this gap.

26. *N_2O Emissions From Adipic Acid and Nitric Acid Production*, H. Mainhardt, ICF Incorporated, http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/3_2_Adipic_Acid_Nitric_Acid_Production.pdf; Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, S. Solomon, et al. (eds.), Cambridge University Press, http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html.

27. The American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. (2009); *Global Mitigation of Non-CO_2 Greenhouse Gases*, M. Gallaher, D. Ottinger, D. Godwin, and B. DeAngelo, Rep. no. 430-R-06-005, U.S. Environmental Protection Agency, Office of Atmospheric Programs, June 2006, http://www.epa.gov/climatechange/economics/downloads/GlobalMitigationFullReport.pdf.

IV. State Policy Scenarios

IN ADDITION TO THE FEDERAL ACTIONS analyzed by source category, this analysis seeks to quantify the reductions that might be expected under different state-level scenarios. States are pursuing a wide range of greenhouse gas mitigation policies, such as cap and trade, energy efficiency investments, renewable portfolio standards, smart-growth planning, low-carbon fuel standards, utility regulatory policy reforms, transit-oriented development, and many others. A bottom-up analysis of regulatory policies in all fifty states would require an analysis of existing legal authorities in each state, as well as the history in exercising existing state authorities. Such an extensive effort is beyond the scope of this study. Instead, state action is approached considering three top-down analytical frameworks designed to suggest the general range of state-level reductions that might be expected given the various activities carried out to date. Each scenario is described.

Lackluster Scenario: state reductions contained in state statutes. A number of states have enacted climate change legislation that calls for economy-wide reductions in greenhouse gas emissions. Those states include California, Connecticut, Hawaii, Maine, Maryland, Massachusetts, Minnesota, New Jersey, Oregon, and Washington, as depicted in Figure 17. For the Lackluster Scenario, state emissions reductions were assumed to include only the reductions called for in state legislation.

Middle-of-the-Road Scenario: state reductions called for in state statute and existing executive orders. In the absence of legislation calling for emissions reductions, governors in other states have issued executive orders establishing statewide greenhouse gas emissions reduction targets and timetables. For the Middle-of-the-Road Scenario, states with legislation or executive orders containing reduction targets are assumed to make the reductions called for in the legislation and executive orders. In general, state greenhouse gas reduction targets have been set through comprehensive greenhouse gas reduction planning that identifies policy measures that states can implement to achieve near-term targets.[28] States with legislation or executive orders are shown in Figure 18. It should be noted that while not all of the state laws and executive orders will result in the reductions assumed to occur, it is possible that additional reductions will occur in states without executive orders or laws. As such, the assumption that all executive orders are carried out is a moderate emissions reduction assumption.

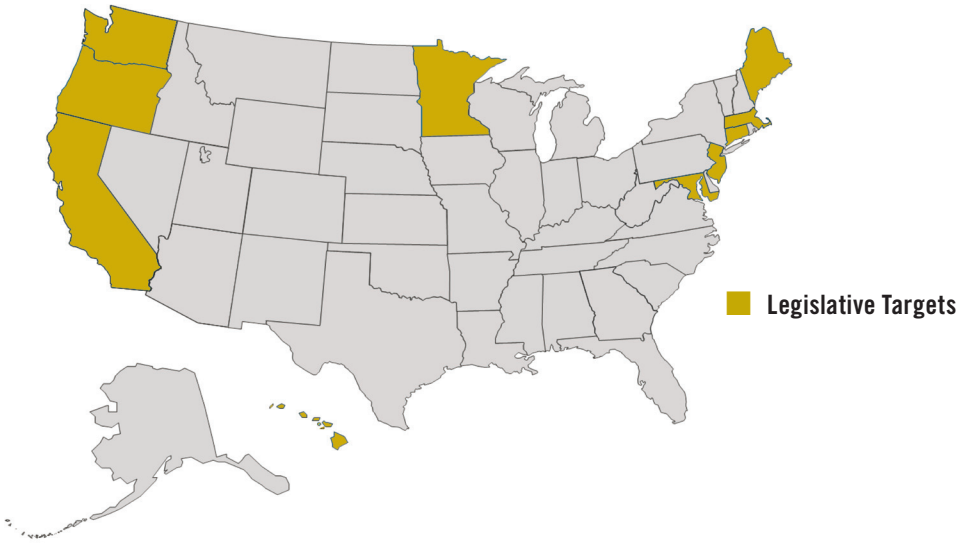
Go-Getter Scenario: state reductions from state statute, executive orders, and regional cap-and-trade programs. To project what might be expected if states and regions were to achieve higher emissions reductions, the Go-Getter Scenario assumes that state statutes, state executive orders, and regional cap-and-trade programs are all implemented to achieve their stated goals. States participating in regional cap-and-trade programs are depicted in Figure 19. While this scenario might be considered an upper bound in what might be expected from states, it is nevertheless a possibility, given that states with executive orders are likely to be progressive states on climate change issues. While some states will not follow through, other states that have previously not acted will step up and register reductions not contemplated by this analysis. Similarly, while the regional cap-and-trade programs are still to be implemented in a number of states, and it is likely some states will not follow through on their promise to cap emissions, the Go-Getter Scenario is a reasonable proxy for significant climate change action in states that represent about 40 percent of U.S. emissions.[29]

28. For a review of state climate change action plans, see the Web site for the Pew Center on Global Climate Change, http://www.pewclimate.org/states-regions.

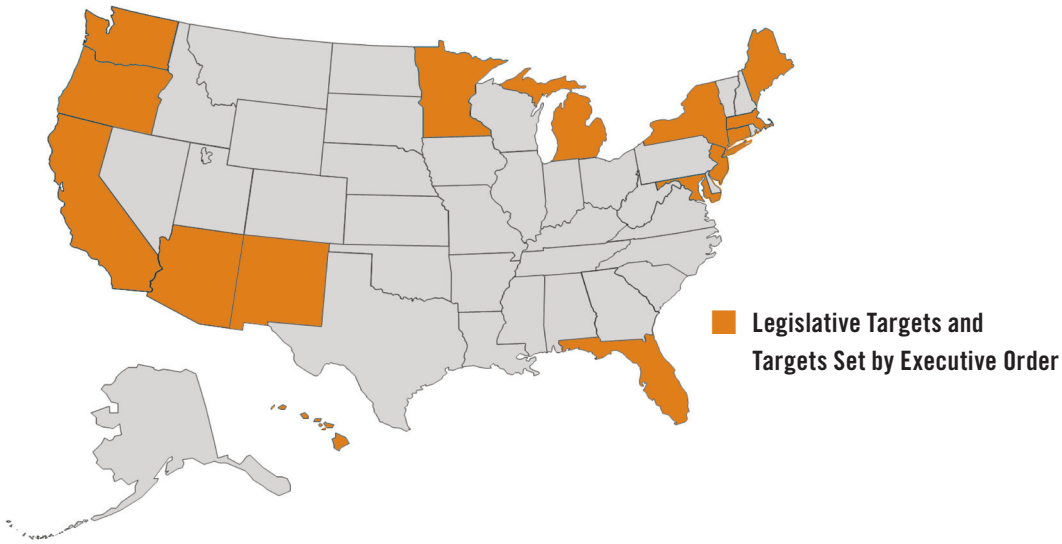
29. Note that because the Regional Greenhouse Gas Initiative (RGGI) is already operational in ten northeastern states, it is included in the business-as-usual projections.

FIGURE 17. State Scenarios

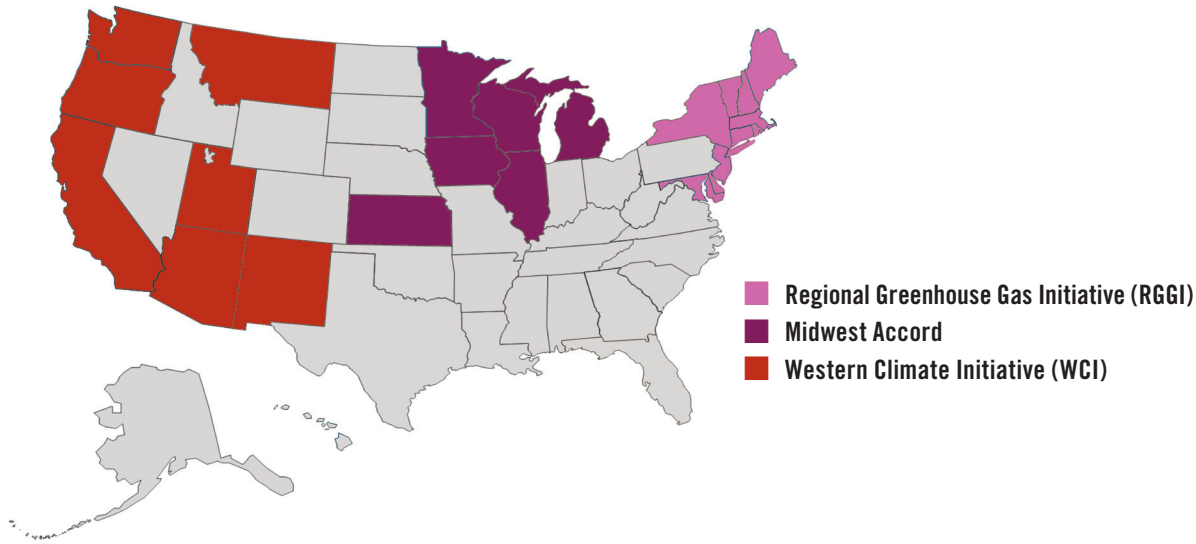
Lackluster Scenario: States with Reduction Targets Set by Legislation



Middle-of-the-Road Scenario: States with Mandatory Reduction Targets Set by Legislation or Executive Order



Go-Getter Scenario: States Part of Regional Cap-and-Trade Initiatives



BOX 2. Risks and Uncertainties

Uncertainties associated with the methods and results of this analysis include:

- **Uncertainties inherent in the models.** As with any modeling analysis of this sort, there is significant uncertainty in projecting the future. The analysis relies heavily on the Energy Information Administration's Annual Energy Outlook for 2009, which attempts to project energy and emissions trends into the future based a number of assumptions, including likely fuel costs, economic activity, and source turnover rates. All projections are only as good as the assumptions that go into them and the quality of the data modeled.

- **Regulatory impetus.** As the different scenarios suggest, a major uncertainty in the analysis is whether the federal administration will carry out the regulatory actions in a manner sufficient to achieve the reductions that available studies suggest are technically feasible. The Lackluster, Middle-of-the-Road and Go-Getter Scenarios stand for different levels of regulatory ambition. The Go-Getter Scenario, it should be emphasized, will require steadfast resolve on the part of the administration and the states.

- **Congressional action.** Federal agencies depend on the U.S. Congress for their budgets. In order to carry out a series of new regulatory actions, federal agencies will require sufficient resources through the annual budget process. In addition, it should be noted that existing authorities can be curtailed through new legislation.

- **Legal risk.** The assumptions made in this analysis were informed by sound legal analysis and vetted with legal experts in the field. Nevertheless, when federal agencies take new actions under existing statutes, the new actions are often challenged in federal court on the grounds that the agency has exceeded the authority originally granted to it in the statute. It is impossible to predict with any precision whether the challenges will be successful.

- **Technological development.** The results modeled depend in part on the development and deployment of new technologies over time. Indeed, many of the regulatory policies are technology based and must be revised by federal agencies as technology progresses. If technologies emerge rapidly, emissions reductions are more likely. Conversely, if technologies are slow to appear, emissions reductions will slow. This uncertainty is especially important further out into the future.

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