Greenhouse Gas Emissions and the Industrial Sector: Policies, Programs and Opportunities for Energy-Efficiency

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ABSTRACT

According to prevailing scientific opinion, greenhouse gas (GHG) emissions are contributing to the changing of the Earth's climate. The daily conversion of fossil fuels to usable forms of energy—namely heat, steam, and electricity—produces as a byproduct, high levels of CO_2, which is the most prominent of GHGs. Due to the strong link between conventional energy generation and GHGs, managing energy production and consumption are considered paramount to confronting issues of global climate change.

The industrial sector consumes about one third of primary energy in the United States (U.S.). In 2007, U.S. energy consumption by the industrial sector (including agriculture and mining) totaled 32.77 quads and released 35.8 percent of GHG emissions (EIA, 2009). Though the overall U.S. industrial energy intensity (energy use per dollar of value added to GDP) has declined since 1993, structural changes account for a large portion of the improvement, with efficiency improvements a smaller factor. Significant opportunities exist for cost-effective energy savings—including the deployment of new, clean technologies—which must play a leading role in further reducing energy intensity and thus GHG emissions within the sector.

Federal, regional, and state programs, policies, and initiatives have evolved to promote GHG emissions reduction, energy-efficient technologies, and best energy management practices within industry. This paper reviews the most relevant of these programs, policies and initiatives and highlights their impacts on energy efficiency improvement and GHG emissions reduction in the industrial sector. The paper also suggests additional policy ideas and measures that could maximize energy efficiency and GHG emissions reduction.

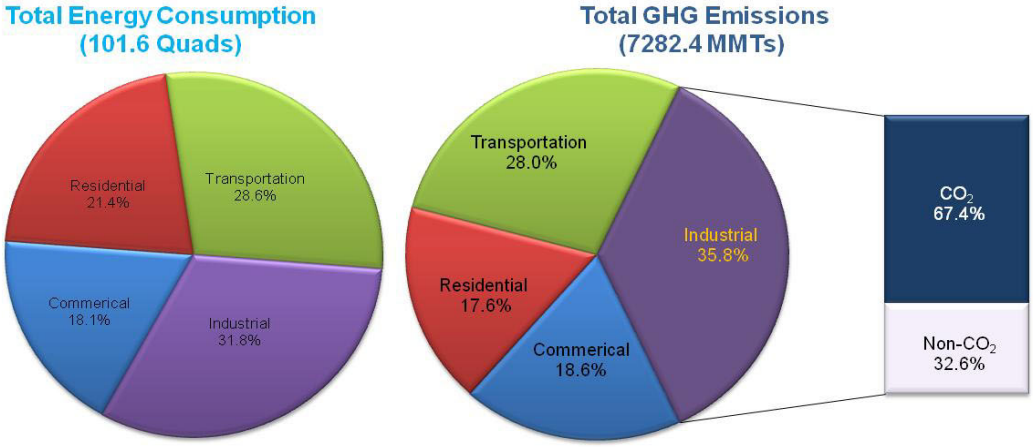
Introduction

According to prevailing scientific opinion, greenhouse gas (GHG) emissions are contributing to the changing of the Earth's climate. The daily conversion of fossil fuels to usable forms of energy—namely heat, steam, and electricity—produces as a byproduct, high levels of CO_2, which is the most prominent of GHGs. Due to the strong link between conventional energy generation and GHGs, transforming our current energy production and management practices is paramount to confronting issues of global climate change. Even though overall energy intensity in the industrial sector has improved over the past decade, the U.S. and China combine to account for about one-half of the total GHG emissions worldwide.

In April 2009, the Environmental Protection Agency (EPA) issued a proposed "endangerment finding", which states that GHG emissions are harmful to public health and welfare and must be reduced and regulated under existing provisions of the Clean Air Act. This action by EPA may have an influence on actions taken by the U.S. Congress toward climate change legislation as an alternative to EPA-imposed regulation. The industrial sector consumes more energy and emits more GHGs than any other U.S. sector and would be significantly impacted by GHG regulation. Total energy consumption by the industrial sector was 31.8

percent (32.77 quads) of a U.S. total of 101.6 Quads in 2007, while industrial GHG emissions accounted for 35.8 percent of all domestic GHG emissions (see Figure 1). Of industrial CO_2 emissions, 53 percent were released directly from fossil fuel use for steam and/or heat in industrial processes; the balance of CO_2 emissions were generated indirectly from purchased electricity for motors, electric furnaces, ovens, lighting, and other facility uses (EIA, 2009). Some leading industrial companies have already turned to energy efficiency as a primary and cost-effective means for reducing GHG emissions (EPA, 2008a; Galitsky & Worrell, 2003).

Figure 1. Total Energy Consumption and GHG Emissions by Sector in 2007



Note: Over 60% of non-CO_2 industrial GHG emissions come from agricultural sources such as methane and nitrous oxide.

Due to the large amounts of energy required to create the products needed for today's global economy, the industrial sector has far greater energy intensity [EI] (BTU per dollar of value added to GDP) than other U.S. economic sectors. The "heavy manufacturing" subsectors including chemicals, forest products, petroleum refining, steel and iron, cement, and glass are particularly energy intensive, and thus, produce substantial GHG emissions. Though the overall U.S. industrial energy intensity has declined since 1993, the changes are mostly structural and due to factors unrelated to efficiency improvements.

Opportunities for enhancing energy efficiency in the industrial sector remain abundant. Highlighted by a recent McKinsey study (Creyts & Derkach et al., 2007), the deployment of low-cost measures such as improved management practices and CO_2 abatement technologies in the industrial sector—measures classified as having an implementation cost averaging less than $50 per ton CO_2 equivalent (CO_2e) mitigated—represents a GHG reduction opportunity of 600 to 800 million metric tons of CO_2e equivalent by 2030. These management practices and technologies are economically viable and commercially available today and include increasing combined heat and power (CHP) capacity, enhancing the efficiency of steam production, improvements to pumping, compressed air, fan, and processing heating systems, and the use of advanced process controls for energy management. Barriers to adoption of energy efficiency technologies do exist, including imperfections in the organizational decision making process, a lack of reliable information, limited access to capital, or undertrained personnel (Worrell & Price, 2001). Although many energy efficient technologies have become available in the marketplace, in many cases, the research, development and deployment of these technologies would not have occurred,

or likely would have occurred more slowly, without regulatory and financial support from government—even for cost-effective technologies. Due to this circumstance, federal, regional and state government programs and policies continue to be an important "backbone" to promote energy efficient technologies in industry.

In the U.S., there are at least 65 active federal programs, policies and initiatives that in some way promote energy efficiency and GHG emissions reduction in industry (DOE, 2009d). Many states are taking the lead on emissions reduction by developing climate change action plans and other initiatives. 23 states, representing a total of 52 percent of U.S. GDP (BEA, 2008), are active members of a regional cap-and-trade program to reduce GHG emissions either for an individual sector or for the entire state economy.

Selected Federal, Regional and State Programs and Policies

Long before GHG emissions became recognized as a concern, several key legislative actions dating back to the 1970s focused on energy efficiency, conservation and renewable energy, such as the Energy Policy and Conservation Act of 1975, the National Energy Conservation Policy Act of 1978 (NECPA), and the Public Utility Regulatory Practices Act (PURPA) of 1978. Other major national legislation included the National Appliance Energy Conservation Act of 1987, the Energy Policy Act of 1992, the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007, and most recently the American Recovery and Reinvestment Act of 2009. The cumulative effect of these policies, as well as market-driven technology and behavioral change, has played a role in reducing energy intensity economy-wide and consequently, slowed growth in GHG emissions (Pew Center, 2004; Aldy & Pizer, 2009).

Many current federal programs, activities, and legislative actions exist that in some way relate to industrial sector GHG emissions. Table 1 lists the most active and most relevant federal programs, along with the key regional initiatives.

Federal Level

American Recovery and Reinvestment Act of 2009 (ARRA). ARRA is the single largest federal investment in the economy in U.S. history. The stimulus provides more than $25 billion specified for energy efficiency and billions more which can be directly or indirectly applied to energy efficiency projects. The stimulus funds are being distributed primarily to states and municipalities through major grant programs and to individuals through rebates, tax credits and other means. Below are the major components of the stimulus package that are likely to impact energy efficiency programs in the industrial sector.

Table 1. Comparison of Selected Federal, Regional and State Programs

	Key Features	Time Frame
ARRA of 2009	• SEP: $3.1 billion • ARPA-E: $400 million • Applied Research, Development, Demonstration, and Deployment: $2.5 billion	2009-2010
EISA of 2007	• Promotes CHP, R&D • Grants for waste energy recovery	2008-2012
EPACT-05	• No less than 2.5% annual reduction of energy intensity in industry • Up to 2.5cent/kWh production tax credit for advanced power system technology • Up to $1.8 / sq ft to industrial buildings	2006-2012 2006-2013
Climate VISION	• Reduces 18% GHG intensity below 2002 levels by 2012 in 13 trade groups and associations	2002-2012
Save Energy Now	• Provides energy assessments, technical materials, software tools and trainings	2007-2017
Industries of the Future	• Management of R&D for innovative energy saving technologies and processes • Cross-cutting technologies	ongoing
Energy Star for Industry	• Guides corporate level energy management, issues Energy Star Label for 4 Sectors out of 10 Sectors	2000-ongoing
Regional Greenhouse Gas Initiative	• Reduces 10% CO_2 emissions below 2009 levels by 2018 for power sector only	2005-ongoing
Western Climate Initiative	• 15% regional GHG reduction by 2020, relative to 2005 levels • Covers power sector, combustion at industrial and commercial facilities, industry process and transportation	2007-ongoing
Midwestern GHG Reduction Accord	• 15-25% reduction below 2005 levels by 2020; and 60-80% reduction by 2050 • Covers manufacturing, agriculture, and commercial sectors	2007-ongoing
Climate Change Action Plans	• Reduction targets vary by state (30 states completed, 7 in progress as of 2008) • cover all economic sectors	ongoing
Energy Efficiency Resource Standard	• Varied goals in 18 states with EERS • Reducing electrical energy and peak load	ongoing

- The **State Energy Program (SEP)**, with total funding of $3.1 billion, will allocate a percentage of funding to support commercial and industrial energy audits.
- **Advanced Research Projects Agency- Energy (ARPA-E)**, with total funding of $400 million, will perform research and development of next generation energy-efficient, renewable and GHG emission reduction technologies.
- **Applied Research, Development, Demonstration, and Deployment**, with total appropriations of $2.5 billion will support a number of programs in the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE), including $50 million dedicated "to increase the energy efficiency of information and communication technologies and improve standards".
- **Advanced Energy Investment Credit**, with up to $2.3 billion in tax credits, establishes a new 30 percent investment tax credit for the manufacturers of "advanced energy

property," including technologies advancing the production of renewable energy, energy storage, energy conservation, efficient transmission and distribution of technology, and carbon capture and sequestration.

- Finally, the ARRA legislation provides grants to businesses instead of tax credits for **specified energy property** placed in service during 2009 or 2010, including combined heat and power (CHP) systems, geothermal heat pumps, fuel cells and micro-turbines (ASE, 2009b).

Energy Independence and Security Act of 2007 (EISA). Several sections of EISA are relevant to the industrial sector. Most of these authorized programs remain unfunded, however.

- Section 375 authorizes continuation of the Regional Application Centers (RACs) to encourage deployment of CHP systems and other clean energy technologies.
- Section 451 authorizes research, development and demonstration (RD&D) of new processes, technologies, and operating practices and techniques for equipment and processes used by the energy-intensive industries. Section 451 also directs EPA to calculate the total quantities of potentially recoverable waste energy from industrial sources on site, both by state and nationally. The authorization includes cost-shared grants for feasibility studies (EPA, 2008a).
- Section 452 authorizes a recoverable waste energy inventory program to improve energy efficiency in the form of electricity, useful thermal energy, or other energy-related products (Sissine, 2007). This program provides incentive grants to owners who produce electricity or incremental useful thermal energy through waste energy recovery.
- Section 471 of EISA authorizes $1 billion for implementing or improving sustainable energy infrastructure at facilities that produce electricity from renewable sources, CHP, waste heat recycling, or renewable sources of thermal energy.
- Title VI authorizes funding for accelerated R&D of renewable technologies, and RD&D on advanced manufacturing processes and materials.

Energy Policy Act of 2005 (EPACT-05). Section 106 authorizes DOE to enter into voluntary agreements with industrial firms that consume significant amounts of energy to reduce the energy intensity of their production activities. The Act set a goal of 2.5 percent annual reduction of energy intensity in the manufacturing sector from 2007 to 2016. In response, DOE has developed requirements, a model agreement for industry partners, and a recognition program. The voluntary goals and recognition program will be launched in 2009 as the Save Energy Now Leaders initiative. Other provisions of EPACT-05 relevant to the industrial sector are as follows:

- Section 1224 provides production tax credits up to 2.5 cent/kWh for advanced power technologies (fuel cells, turbines, hybrid power systems) invested in industry through 2012.
- Section 1331 allows tax deductions for commercial building energy efficiency upgrades, including manufacturing facilities and manufacturers' office spaces and labs. The deduction of $\$1.80/ft^2$ applies to spaces that achieve a total energy reduction of 50 percent or more, however a partial deduction is available for investments that reduce energy use in lighting, HVAC systems, or the building envelope. Section 1331 is funded, and the incentive was recently extended through 2013.

- Section 911 authorizes funding for advanced technology R&D for energy intensive industries and R&D support for advanced controls for motor systems. (DOE, 2009a).

Climate VISION Initiative. Launched in 2003 and managed by DOE in partnership with EPA, the U.S. Department of Agriculture and the Department of Transportation, the Climate VISION Initiative focuses on trade groups and aims to reduce GHG intensity in industrial operations. Climate VISION targets an 18% reduction in industrial GHG emissions from 2002 levels by 2012. As of February 2009, the Climate VISION initiative had 13 industry trade associations and groups committed to help meet this target by seeking to improve energy efficiency and reduce GHG intensity in their sectors (Climate VISION, 2009). DOE estimates that Climate VISION participants account for at least 40 percent of U.S. greenhouse gas emissions. Each trade group participating in the Climate VISION Initiative has developed a plan for measuring and reporting emissions. The federal agencies have no means of tracking trade groups' progress in completing the steps in their plans and no written policy on what to do about groups that are not progressing as expected. The emissions reduction goals established by Climate VISION partners vary in how reductions are measured and the time periods covered, among other things. Trade associations have been an important resource to industry providing education, outreach, and technical assistance to members on energy efficiency and GHG emissions topics.

Save Energy Now. Save Energy Now is an initiative of DOE's Industrial Technologies Program (ITP). Through Save Energy Now, ITP helps industrial plants operate more efficiently and profitably by identifying ways to reduce energy use in key industrial process systems. Small industrial facilities qualify to apply for a free energy assessment conducted by faculty members and students at the DOE's university-based Industrial Assessment Centers. Large industrial energy users are eligible for a no-cost Energy Savings Assessment conducted by DOE-qualified energy experts. ITP also provides industrial plants access to a variety of resources, including technical and best practice materials, software tools, and training. As of May 2009, 2,135 assessments[1] have been completed over the past three years. Of these, over 1,950 plants reported identified energy savings opportunities of over $1.25 billion. Implemented measures have saved over $200 million per year. DOE assessments to date have identified potential CO_2 emissions reductions of 10.5 million metric tons (DOE, 2009b) through energy efficiency measures.

Industries of the Future. ITP has managed research and development (R&D) for innovative energy savings technologies and processes for many years. This includes subsector-specific R&D for the energy-intensive subsectors (known as the Industries of the Future program), and cross-cutting R&D in areas common to many industrial processes. Cross-cutting examples include research into combustion technology, sensors and controls, distributed generation, and nanomanufacturing.

Energy Star for Industry. Energy Star for Industry, an EPA initiative, provides tools that guide organizations on developing and refining their own corporate energy management program. To participate, members must commit to reducing their operational energy consumption and GHG emissions. A benchmarking system developed under the program is employed by participants to evaluate the performance of their individual plants against a distribution of the energy performance of U.S. peers. The benchmark is used to determine which facilities warrant the

[1] IAC assessments for small and medium enterprises are included.

Energy Star designation. The ENERGY STAR plant designation is currently available to just five subsectors – auto assembly, cement, corn refining, petroleum refining, and pharmaceutical manufacturing. However, Energy Star for Industry currently has "Industrial Focuses" on ten subsectors: automobile assembly, food processing, cement, corn refining, glass, petrochemicals, petroleum refining, pharmaceutical manufacturing, iron and steel, and pulp and paper (EPA, 2008b). EPA has developed industry-specific tools and resources for these ten subsectors, and energy managers from facilities in these subsectors meet occasionally for best practices sharing.

Regional Level

Regional Greenhouse Gas Initiative (RGGI). RGGI was created in December 2005 by Northeastern and Mid-Atlantic states to reduce carbon dioxide emissions. It is the first mandatory, market-based effort to reduce greenhouse gas emissions in the United States. RGGI currently focuses on GHG emissions reduction by power plants in participating states. RGGI requires utilities to report and reduce their CO_2 emissions starting in 2009, with a goal of 10% emissions reductions by 2018. RGGI's first auction in 2008 produced an emission allowance price of $3.07, and will auction 188 million metric tons of CO_2 per year ($mmtCO_2/yr$) in allowances between 2009 and 2014. All funds raised from RGGI auctions will be reinvested into energy efficiency and renewable energy technologies and programs to benefit all economic sectors (residential, commercial, industrial and transportation) in each state**.** After the cap-and-trade program for power plants is implemented, participating states may consider expanding the program to other emission sources. Participating states include: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. RGGI's ten states represent about 10 percent of total U.S. emissions, totaling roughly 650 million metric tons CO_2 equivalent per year (RGGI, 2009).

Western Climate Initiative (WCI). Initiated in February 2007, WCI is developing a regional climate registry and GHG emissions tracking system along with a cap-and-trade program covering the power industry, combustion at industrial and commercial facilities, industrial process emission sources, and transportation fuel among others. WCI has established a regional goal of reducing GHG emissions 15 percent below 2005 levels by 2020. Currently, seven states in the United States and four provinces of Canada are members of WCI. Participating states are Arizona, California, Montana, New Mexico, Oregon, Utah and Washington; British Columbia, Manitoba, Ontario and Quebec are participating Canadian territories. There are 14 active observing members to the WCI. WCI's seven U.S. members represent approximately 12 percent of total U.S. emissions, roughly 850 million metric tons CO_2 equivalent per year (Nunu, 2009).

Midwestern GHG Reduction Accord (Midwestern Accord). The Midwestern GHG Reduction Accord was created in 2007 as the third regional initiative to address climate change. The Midwestern Accord plans to construct a regional cap-and-trade system for GHG emissions as well as promote renewable energy and clean energy in the region's manufacturing, agriculture and service sectors. The Midwestern Accord aims to reduce GHG emissions 15 to 25 percent below 2005 levels by 2020 and 60 to 80 percent by 2050 (Midwestern Accord, 2007). Currently, six states (Iowa, Illinois, Kansas, Michigan, Minnesota, and Wisconsin) in the U.S. plus the Canadian province of Manitoba are members of the Midwestern Accord. Observing states

include Indiana, Ohio and South Dakota. The participating states represent about 13 percent of U.S. emissions, roughly 917 million metric tons CO_2 equivalent per year (Nunu, 2009).

As demonstrated by these evolving regional initiatives, states are more comfortable tackling climate change issues collectively. Despite an influx of regional action, many states maintain the "wait and see" approach. Regional initiatives have effectively verified state interest in climate action, although a unified federal GHG cap-and-trade policy would likely be more influential in compelling industry to employ energy-efficient and low GHG-intensive technologies. The federal American Clean Energy and Security Act of 2009, currently being debated in the U.S. House of Representatives, could potentially resolve this issue.

State Level

States are currently responsible for implementing national energy efficiency and clean air policies, and play an important role given their authority over utilities, land use, transportation, taxation, and other policy areas affecting the environment. Following is an overview of the most relevant state-led programs and policies, including climate change action plans and energy efficiency resources standards.

Climate Change Action Plans. A growing number of states are undertaking the development of initiatives to reduce GHG emissions. According to EPA (EPA, 2009b), Climate Change Action Plans (CCAPs) help states identify and evaluate feasible and effective policies to reduce their GHG emissions through a combination of public and private sector policies and programs. The initial step in development of a CCAP is conducting a GHG inventory. As of August 2008, 46 states had completed GHG inventories, with one state actively engaged in the inventory process; 32 states had completed CCAPs while six states were in the process of creating their plans. Due to regional concentrations of industrial activity within the U.S., states have employed various tactics to address their respective sets of challenges in addressing emissions reductions. For instance, states hosting a large industrial base tend to measure progress by efficiency gains, where service-heavy states may be quicker to measure absolute emissions. Following are two examples of effective CCAPs.

California's CCAP has targeted reducing GHG emissions to 2000 levels by 2010, to 1990 levels by 2020 and 80 percent below 1990 levels by 2050. In support, the California legislature took steps to help the state realize these goals by enacting Assembly Bill 32, also known as the Global Warming Solutions Act in 2007. This act requires the California Air Resources Board (CARB) to develop regulations and market mechanisms to reduce California's GHG emissions to those levels targeted by the state (CARB, 2008). As part of broader requirements, major GHG emitters[2] will be required to report their emissions under AB 32 beginning in 2009.

New York's CCAP is seeking to reduce GHG emissions to five percent below 1990 levels by 2010 and ten percent below 1990 levels by 2020. To supplement emission reduction targets, the New York State Energy Research and Development Authority (NYSERDA) released the New York State Energy Plan in 2002 (EPA, 2009c), although the plan provided no emissions or energy reduction goals specific to the industrial sector.

[2] The industrial sectors that are required to report their emissions to CARB are as follows: cement plants; petroleum refineries (with >25,000 Metric Tons (MT) CO_2 in a calendar year); hydrogen plants (with >25,000 MT CO_2 in a calendar year); electricity generating facilities and cogeneration facilities (with > 1 MW and >25,000 MT CO_2 in a calendar year); electricity retail providers and marketers; and other industrial facilities referred to as "general stationary combustion facilities" (>25,000 MT CO_2 in a calendar year).

Energy Efficiency Resource Standards. An energy efficiency resource standard (EERS) is a mechanism which encourages utilities to more efficiently generate and deliver electricity and natural gas, and to promote end-user energy efficiency improvements. As of April 2009, eighteen states have an EERS in place (FERC, 2009). A national EERS was recently introduced by Rep. Ed Markey (D-MA) in H.R. 889, titled the American Clean Energy and Security Act of 2009. The standard would require savings rising to 15% of electricity and 10% of natural gas by 2020. Under EERS, utilities can achieve energy savings though a variety of means, including reducing end-use consumption, adjusting appliance standards and building codes, promoting combined heat and power at customer facilities, and reducing energy losses in energy distribution. Utilities can also purchase efficiency credits from end-users or third-party efficiency providers to meet their required reductions. States will be able to implement efficiency standards which are more aggressive than the federal EERS baseline (ASE, 2009a).

Not all industrial GHG emissions reduction initiatives are government-led. For example, the Business Roundtable, an association of Chief Executive Officers from leading U.S. companies, created Climate RESOLVE, an educational initiative for its member companies, designed to motivate companies to reduce their GHG emissions. Additionally, Superior Energy Performance is an initiative currently being formed (with federal-level support) to develop a voluntary certification program for industrial facilities, based around continual energy efficiency improvement via an energy management standard and the use of measurement and verification protocols. Additionally, a number of individual companies are setting their own goals and establishing their own ambitious programs for energy management and emissions reduction.

Conclusions and Policy Recommendations

The federal government and individual state governments have adopted policies and initiated programs targeting energy efficiency and GHG emissions reduction in the industrial sector. Various programs and policies have different approaches, but share the same end-goals of emissions and energy intensity reduction in the industrial sector. At the federal level, some initiatives provide funding for industrial facilities to reduce their emissions via tax credit, rebates and subsidies, such as the ARRA, EISA, and EPACT-05 legislation. Other programs offer technical assistance, such as Energy Star for Industry and Save Energy Now. Still others, such as Climate VISION, rely on voluntary public-private partnerships to spur industrial efficiency improvements and emissions reductions. The regional cap-and-trade initiatives, Climate Change Action Plans and energy efficiency resource standards put certain areas of the country at the forefront of climate change policy.

Despite progress, there are additional opportunities that can catalyze measurable and lasting efficiency gains and emissions reductions. Many industrial firms are looking to adapt operations in response to climate change as well as to make their respective business models more sustainable. In fact, many organizations have already begun taking early steps in the process without mandates from the state or federal level. Meanwhile, as discussed above, a number of federal, regional and state programs and policies are in place providing additional incentives or regulation in the industrial sector. Nevertheless, some industrial firms continue to feel overburdened by the stringency or ambiguity of state, regional and federal requirements. A strong, unified national policy in the U.S. is necessary to realize significant GHG emissions reduction by all sectors, including industry. The following policy recommendations are considered key in reducing GHG emissions in the industrial sector: 1) construct a national climate program; 2) develop a single, national cap-and-trade mechanism; 3) enhance research

and development in energy efficiency and renewable energy; 4) raise awareness of the opportunities for energy efficiency and renewable energy.

Constructing a National Climate Program

The various programs, protocols, and reporting procedures in the current state, regional and federal programs and registries are likely to lead to confusion and conflicts, such as the double counting of emissions and extra labor requirements for reporting and compliance. A national climate program is a preferred solution by most industrial corporations. With a climate program at the federal level, a common framework for emissions reporting and management will provide long-term advantages to industry compliance and planning. On March 10, 2009, EPA announced a proposed rule (EPA-HQ-OAR-2008-0508) mandating all major sources of U.S. greenhouse gas emissions be cataloged in a national database (EPA, 2009a). One benefit from this kind of national reporting program would be that the emissions data will be collected in a consistent way, avoiding double counting and data mismatch.

Expanding the Cap-and-Trade Mechanism

A GHG cap-and-trade system can potentially reduce total GHG emissions cost-effectively through the power of the marketplace. With a national cap-and-trade system, participants are allotted permits equal to the maximum amount of GHGs they can emit under the cap. Companies may then buy additional emission permits from firms that have extra, unused emission allowances. The price of these credits would be determined by the supply and demand in the trading system. Cap-and-trade for GHG emissions already affects manufacturers in the European Union (EU) through the EU Emissions Trading System. The program has received mixed reviews, but the U.S. has the opportunity to apply lessons learned by the EU. In addition, the successful sulfur dioxide cap-and-trade program in the U.S. can be used as a model. That market-based program successfully controlled harmful acid rain in the U.S. in the 1990s.

Enhancing Research and Development in Energy-Efficiency and Renewable Energy

Federal support for industrial sector RD&D has diminished over the past few years. According to a recent peer review of DOE's Industrial Technologies Program, the "pipeline" of new research is running dry and an infusion of new funding is necessary for the manufacturing sector to continue to innovate and remain competitive globally. The United States spends less on research and development in energy efficiency and renewable energy than competing industrialized countries. The President's Committee of Advisors on Science and Technology (PCAST) concluded that continued and expanded investments in public- and private-sector R&D in energy efficiency and renewable energy would keep American companies and the U.S. economy competitive and growing sustainably over the next several decades. Increased R&D funding from the federal government is vital.

Raising Awareness

Energy efficiency has been recognized as the most cost-effective, quickest and cleanest way to reduce GHG emissions from all sectors. It is commonly acknowledged that energy efficiency is crucial to sustainable business growth. However, there are still many barriers to companies investing in energy efficiency and renewable energy projects, including limited awareness, perceived risks, limited capital resources, and other factors. Properly messaging the

size of the opportunities through energy efficiency and renewable energy is critical to developing a compelling business case for action, as is making the connection between energy efficiency and GHG emissions reduction.

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