CITY OF

HAYWARD

HEART OF THE BAY

CITY COUNCIL SUSTAINABILITY COMMITTEE MEETING

Hayward City Hall – Conference Room 2A

777 B Street, Hayward, CA 94541-5007

January 17, 2008

4:30 p.m. – 6:00 p.m.

AGENDA

I. Call to Order

II. Roll Call

III. Public Comments: *(Note: For matters not otherwise listed on the agenda. The Committee welcomes public comments under this section, but is prohibited by State Law from discussing items not listed on the agenda. Items brought up under this section will be taken under consideration and referred to staff for follow-up as appropriate. Speakers will be limited to 5 minutes each; organizations represented by more than one speaker are limited to 5 minutes per organization. All public comments are limited to this time period on the Agenda.)*

IV. Adoption of Committee 2008 Schedule

V. Adoption of Sustainability Committee Mission Statement, and Goals and Objectives

VI. Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?
Presentation by Council Member Bill Quirk

VII. Summary of the City of Hayward Greenhouse Gas Emissions Inventory
Presentation by Erik Pearson, Senior Planner

VIII. Finance Department - Equipment Management Division
Presentation by, Scott Estes, Equipment Manager

IX. Next Meeting: Wednesday, February 6, 2008 - Connection between Transit-Oriented Development and Sustainability.

Adjournment

Assistance will be provided to those requiring accommodations for disabilities in compliance with the Americans with Disabilities Act of 1990. Please request the accommodation at least 48 hours in advance of the meeting by contacting Katy Ramirez at 510/583-4234 or by calling the TDD line for those with speech and hearing disabilities at 510/247-3340.

Department of Community and Economic Development

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Tel: 510/583-4250 Fax: 510/583-3650

City Council Sustainability Committee
2008 Meeting Schedule

Monthly on Third Thursdays from 4:00 pm to 5:30 pm

January 17
February 21
March 20
April 17
May 15
June 19
July 17
September 18
October 16
November 13
December 18

Sustainability Committee Mission Statement and Goals and Objectives

Mission: Make Hayward a more sustainable community in order to ameliorate negative impacts of climate change.

Goals: Adoption of policies and standards that would have a positive impact on a sustainable Hayward community.

Objectives

1) Require the use of alternative energy resources when possible.
2) Reduce the use of energy through conservation.
3) Assure that all new construction and remodels will be GreenPoint rated and/or LEED certified (or will comply with Green Building and Bay Friendly Landscape standards).
4) Reduce green house gas (GHG) emissions.
5) Require reduction in waste generation.
6) Encourage transit-oriented development.
7) Support sustainability measures in all aspects of City business.

CITY OF
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DATE: January 17, 2008

TO: Mayor and City Council Sustainability Committee

FROM: Director of Community and Economic Development Department

SUBJECT: Summary of Baseline Greenhouse Gas Emissions Inventory Report

RECOMMENDATION:

That the Committee read and comment on this report.

SUMMARY:

This report summarizes the Baseline Greenhouse Gas Emissions Inventory Report. The Inventory found that Hayward's emissions totaled 764,530 tons of equivalent carbon dioxide gases in 2005, which is in line with other cities of comparable size.

DISCUSSION:

It is important to clarify some concepts that are used when speaking about climate change. The concept of "carbon footprint" is comprised of the direct/primary footprint and the indirect/secondary footprint.

> The **primary footprint** is a measure of direct emissions of CO_2 from the burning of fossil fuels, including energy consumption and transportation.
>
> The **secondary footprint** is a measure of the indirect CO_2 emissions from the whole lifecycle of products. The secondary footprint includes such things as estimates of how far food is shipped to point of consumption. The secondary footprint is quite vast and difficult to estimate.

Because the overall carbon footprint of a city is difficult to measure, the City's greenhouse gas emissions inventory focuses on the primary footprint.

<u>Community Scale Emissions Inventory</u>
As a participant in the Alameda County Climate Protection Project, the City of Hayward has partnered with ICLEI (originally known as International Council for Local Environmental Initiatives) to complete its initial Baseline Greenhouse Gas Emissions Inventory Report. Using 2005

as a base year, the report provides a breakdown of greenhouse gas emissions in the City. The baseline analysis provides emissions data from residential, commercial, industrial, transportation, and waste sectors. The information can be used to help the City adopt an emissions reduction target and reduction plan of action.

Information was collected from a variety of sources. PG&E was consulted for community electricity and natural gas data. The Metropolitan Transportation Commission (MTC), Bay Area Air Quality Management District (BAAQMD), and Bay Area Rapid Transit (BART) served as sources of transportation data. Solid waste data was gathered from StopWaste.org, Waste Management, Inc., Alameda County Industries, Republic Services, Inc., and the US EPA.

The Community Inventory represents all energy used and waste produced within the City of Hayward. This means that, even though the electricity used by Hayward's residents is produced elsewhere, the energy and emissions associated with it appears in Hayward's inventory. Emissions are reported in terms of eCO2 (equivalent carbon dioxide). This notation allows for the comparison of different greenhouse gases. For example, methane is twenty-one times more powerful than carbon dioxide in its capacity to trap heat; therefore one ton of methane is quantified in the report as 21 tons of eCO2.

The power sources that make up a utility's electricity generation mix have a significant impact on a city's greenhouse gas emissions. In quantifying emissions, calculations were used to account for the sources of power that Pacific Gas & Electric transmits to the City of Hayward. For example, a coal-fired power plant releases 1.3 tons of eCO2 per megawatt-hour of electricity generated versus 0.7 tons for gas turbines and 0 tons for renewable sources such as solar, wind, or hydroelectric power.

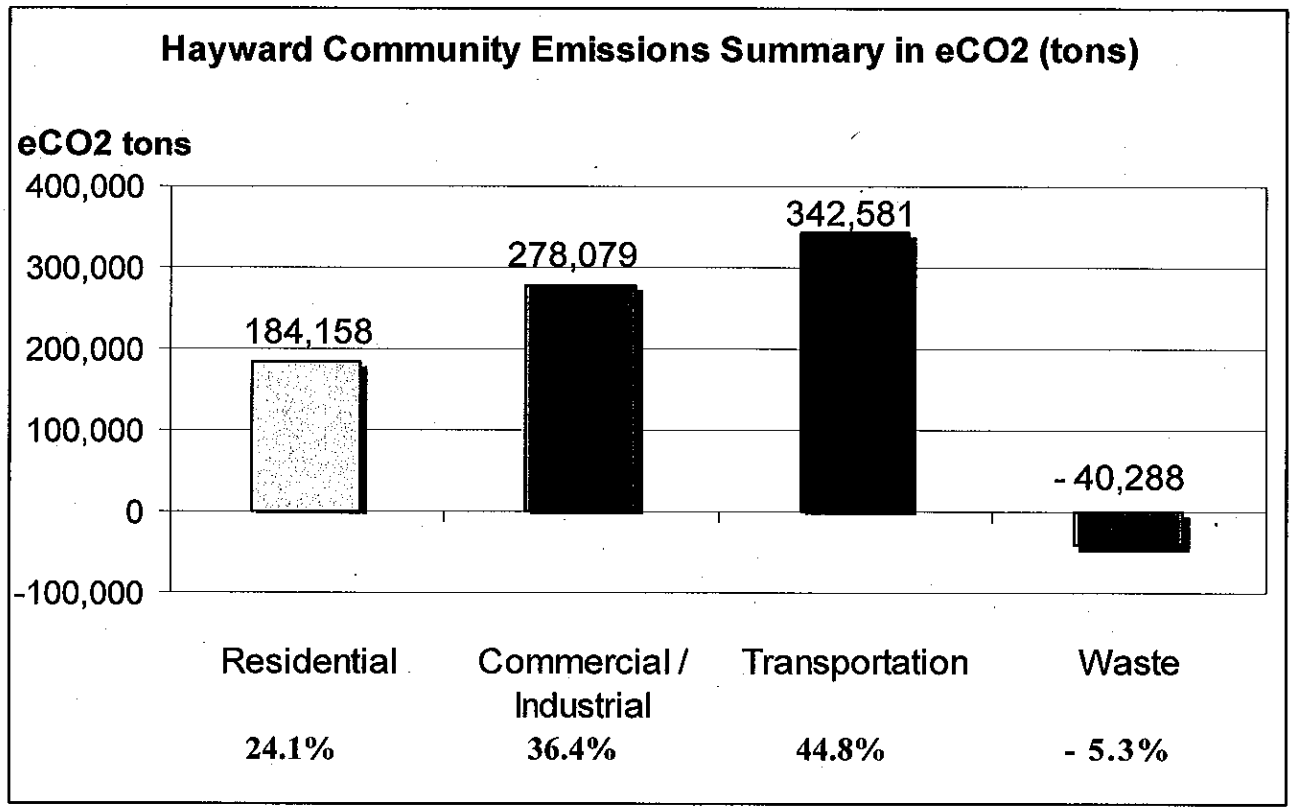
In the base year 2005, the City of Hayward emitted approximately 764,530 tons of eCO2 from all sectors combined. The residential sector represents 24.1%; the commercial and industrial sector represents 36.4%; and the transportation sector represents 44.8%. Burning fossil fuels in vehicles and for energy use in buildings is the major contributor to Hayward's greenhouse gas emissions. Fuel consumption in the transportation sector is the single biggest source of emissions. Stationary energy use, which is comprised of residential and commercial/industrial sectors, represents 60.5% of total greenhouse gas emissions.

Solid waste emissions were calculated to be slightly negative, - 5.3%, due to the estimate that more than 74.5% of the methane produced from Hayward's solid waste is believed to be recovered – methane is either captured perpetually under the liner of the landfill or captured and then flared. These numbers however may be problematic due to questions which have arisen from recent studies of the US EPA's estimates for the amount of methane that is actually captured by methane recovery systems at landfills. Many hypothesize that numbers are overestimated, and that much more of the potent greenhouse gas is actually escaping from landfills into the atmosphere. The ICLEI software is designed to follow EPA guidelines and the tool will be updated appropriately when those guidelines change.

It is important to keep in mind that although landfills are equipped to capture methane, the benefits gained from recycling and the associated reduction in upstream energy use far outweigh sending waste to a landfill. Recycling reduces CO_2 emissions because manufacturing products with

recovered materials avoids emissions from the energy that would have been used during extraction, transporting and processing of virgin raw materials. Recycling paper also conserves forests, which contribute to carbon sequestration.

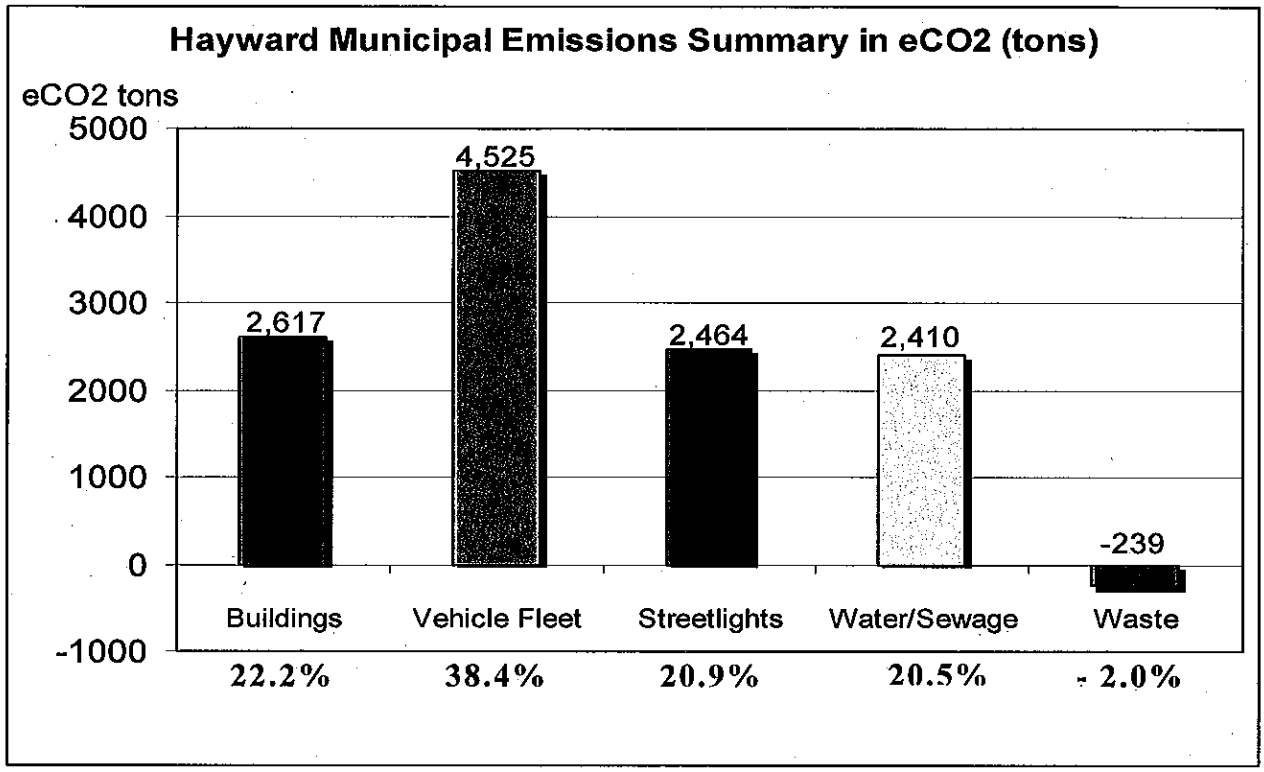
For comparison, the City of Palo Alto emitted approximately 803,414 tons of eCO2 in 2005 and the City of San Mateo emitted approximately 689,072 tons of eCO2 in 2006. The City of Palo Alto adopted a Climate Action Plan in December 2007, setting both near and long term emission reduction targets. For more detail and data from additional jurisdictions, see Exhibit A (attached).



Municipal Operations Emissions Inventory

In order for the City of Hayward to demonstrate a leadership role in curtailing its own emissions, an analysis of emissions from municipal operations has been included in the report. Keeping in mind that these numbers are already reflected in the Community Inventory, municipal government emissions represent 1.5% (11,777 tons of eCO_2) of overall emissions for the City of Hayward. The city's vehicle fleet accounts for the largest percentage of emissions, 38.4%, while buildings account for 22.2% and streetlights account for 20.9%. Water and sewage account for 20.5% while solid waste is estimated to be -2%. Although the municipal government emissions represent a small percentage of community-wide emissions, by proactively reducing emissions generated by its own activities, the Hayward government can take a visible leadership role in the effort to address climate change. This is important for inspiring local action in Hayward as well as for inspiring action in other communities.

Conducting an emissions forecast is essential for setting an emissions reduction target, since the amount of greenhouse gas emissions Hayward pledges to reduce will be derived from the projected emissions. Based on the estimated 2005 baseline and a .68% population growth rate, given that no other changes are made, by the year 2020 the forecast is that the City of Hayward will produce 823,495 tons eCO_2.



The Baseline Greenhouse Gas Emissions Inventory Report offers a snap-shot of the City of Hayward's 2005 base year emissions. Using the report as a tool, the information can be used to help the city adopt an emissions reduction target and reduction plan of action.

NEXT STEPS:

On December 19, 2007 the Bay Area Air Quality Management District Board of Directors approved a $40,000 grant for the City of Hayward for the purpose of preparing a Climate Action Plan. Staff expects to present a formal agreement with the Air District to the City Council in early 2008 to receive the funds and begin the process of selecting a consultant to assist staff with this project. The Climate Action Plan, when adopted, will include an emissions reduction target as well as an implementation strategy. It is anticipated that the preparation of the Climate Action Plan will be a two year project with council adopting the plan December 2009.

Prepared by:

Tiffany Roberts
Planning Intern

Recommended by:

Susan J. Daluddung, Ph.D.
Director of Community and Economic Development

Approved by:

Gregory T. Jones
City Manager

Exhibits:

Exhibit A – Emissions and Reduction Targets of other Jurisdictions

EXHIBIT A

Emissions and Reduction Targets of Bay Area Jurisdictions

Jurisdiction	Population	GHG Emissions (Metric Tons)	GHG Emissions (Imperial Tons)	Reduction Target
San Mateo	99,100	625,009 metric tons of eCO2 (2006)	689,072	Reduce greenhouse gas emissions each year, beginning with 2009 emissions being less than the 2006 baseline and then exceed the 2020 state target (emissions at 1990 level in 2020) and meet the 2050 state target (emissions at 80% below 1990 level).
San Francisco	795,800	9.1 Million tons (1990)	10,032,750	20% below 1990 levels by 2012 (goal adopted in 2002)
Palo Alto	75,500	728,720 metric tons eCO2 (2005)	803,414	Set greenhouse gas emissions reduction targets as follows: • A 5% reduction from 2005 City emissions levels by July 2009. This would equal a reduction of 3,266 metric tons CO_2e. • A 5% reduction in City and Community emissions by July 2012. This would equal a reduction of 39,702 metric tons of CO_2e. • A community-wide target of a 15% decrease from 2005 levels by 2020, equal to a reduction of 119,107 metric tons. Achieving this goal would enable Palo Alto to match the State of California's goal of 1990 emission levels by the year 2020 (statewide it is estimated that 2005 emissions were 15% higher than 1990 emissions). (CAP approved on 12/3/2007)
Santa Rosa	154,212	36,334 (01/02)	40,058	Set target of 20% of 2000 levels by 2010
Berkeley	102,743	634,798 metric tons eCO2 (2005)	699,865	• Ultimate target is an 80% reduction below 2000 baseline level of 696,498 eCO2 by 2050 • Interim target is a 33% reduction by 2020
Oakland	399,484	2,248,667 metric tons eCO2 (2005)	2,479,155	
Piedmont	10,952	59,092 metric tons eCO2 (2005)	65,149	No target has been set yet

Menlo Park	30,648	440,042 metric tons eCO2 (2005)	485,146	Target is currently under discussion
Albany	16,444	83,429 metric tons eCO2 (2005)	91,980	Target set to reduce greenhouse gas emissions 25% below 2004 levels by 2020
Fort Bragg	7,026 (2000)	138,824 (05/06 fiscal year)	153,053	

Executive summary

Consensus is growing among scientists, policy makers and business leaders that concerted action will be needed to address rising greenhouse gas (GHG) emissions. The discussion is now turning to the practical challenges of where and how emissions reductions can best be achieved, at what costs, and over what periods of time.

Starting in early 2007, a research team from McKinsey & Company worked with leading companies, industry experts, academics, and environmental NGOs to develop a detailed, consistent fact base estimating costs and potentials of different options to reduce or prevent GHG emissions within the United States over a 25-year period. The team analyzed more than 250 options, encompassing efficiency gains, shifts to lower-carbon energy sources, and expanded carbon sinks.

THE CENTRAL CONCLUSION OF THIS PROJECT

The United States could reduce greenhouse gas emissions in 2030 by 3.0 to 4.5 gigatons of CO_2e using tested approaches and high-potential emerging technologies.[1] *These reductions would involve pursuing a wide array of abatement options available at marginal costs less than $50 per ton, with the average net cost to the economy being far lower if the nation can capture sizable gains from energy efficiency. Achieving these reductions at the lowest cost to the economy, however, will require strong, coordinated, economy-wide action that begins in the near future.*

Although our research suggests the net cost of achieving these levels of GHG abatement could be quite low on a societal basis, issues of timing and allocation would likely lead various stakeholders to perceive the costs very differently – particularly during the transition to a lower carbon economy. Costs will tend to concentrate more in some sectors than others, and involve "real" up-front outlays that would be offset by "avoided" future outlays. Given the timing of investments relative to savings, the economy might well encounter periods of significant visible costs, with the costs and benefits shared unequally among stakeholders. Nonetheless, a

1 CO_2e, or "carbon dioxide equivalent," is a standardized measure of GHG emissions designed to account for the differing global warming potentials of GHGs. Emissions are measured in metric tons CO_2e per year, i.e., millions of tons (megatons) or billions of tons (gigatons). All emissions values in this report are per-year CO_2e amounts, unless specifically noted otherwise. To be consistent with U.S. government forecasts, the team used the 100-year global warming potentials listed in the Intergovernmental Panel on Climate Change's Second Assessment Report (1995).

concerted, nationwide effort to reduce GHG emissions would almost certainly stimulate economic forces and create business opportunities that we cannot foresee today and that may accelerate the rate of abatement the nation can achieve, thereby reducing the overall cost.

We hope that the fact base provided in this report will help policymakers, business leaders, academics and other interested parties make better informed decisions and develop economically sensible strategies to address the nation's rising GHG emissions.

RISING EMISSIONS POSE AN INCREASING CHALLENGE

Annual GHG emissions in the U.S. are projected to rise from 7.2 gigatons CO_2e in 2005 to 9.7 gigatons in 2030 – an increase of 35 percent – according to an analysis of U.S. government reference forecasts.[2] The main drivers of projected emissions growth are:

- Continued expansion of the U.S. economy
- Rapid growth in the buildings-and-appliances and transportation sectors, driven by a population increase of 70 million and rising personal consumption
- Increased use of carbon-based power in the electric-power generation portfolio, driven by projected construction of new coal-fired power plants without carbon capture and storage (CCS) technology.

Growth in emissions would be accompanied by a gradual decrease in the absorption of carbon by U.S. forests and agricultural lands. After rising for 50 years, carbon absorption is forecast to decline from 1.1 gigatons in 2005 to 1.0 gigatons in 2030.

On this path – with emissions rising and carbon absorption starting to decline – U.S. emissions in 2030 would exceed GHG reduction targets contained in economy-wide climate-change bills currently before Congress by 3.5 to 5.2 gigatons.[3]

2 The research team used the "reference" scenario in the U.S. Energy Information Administration's Annual Energy Outlook 2007 report as the foundation of its emissions reference case for emissions through 2030, supplementing that with data from Environmental Protection Agency and Department of Agriculture sources: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005; Global Anthropogenic non-CO_2 Greenhouse Gas Emissions: 1990-2020; Global Mitigation of non-CO_2 Greenhouse Gases; and Forest Service RMRS-GTR-59 (2000). Our analyses excluded HCFCs, which are being retired under the Montreal Protocol.

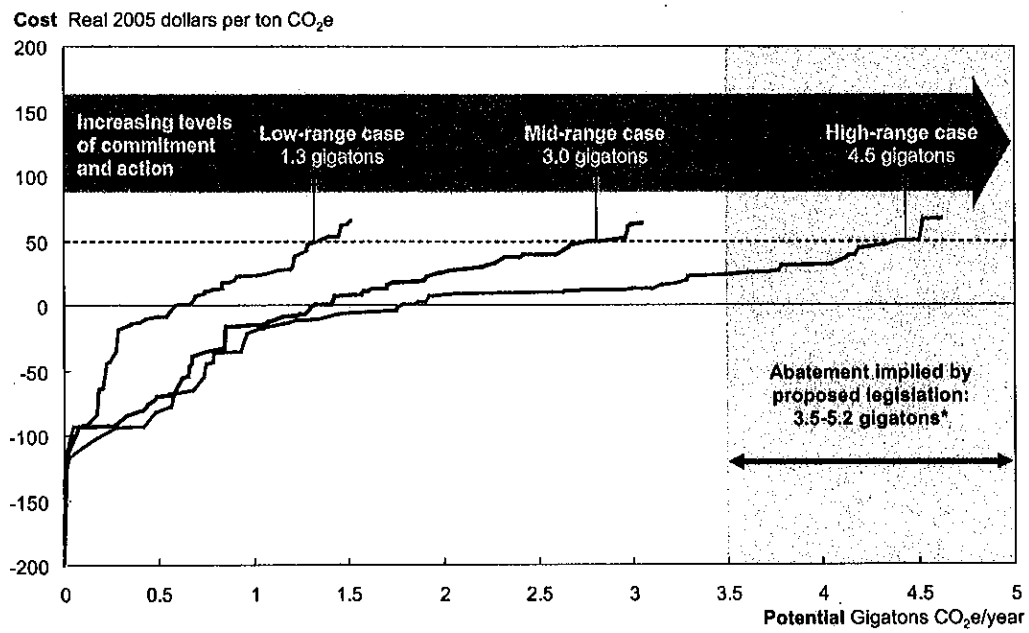
3 The research team defined an illustrative range of GHG reduction targets relative to the emissions reference case using a sampling of legislation that had been introduced in Congress at the time this report was written. The team focused on bills that address global warming and/or climate change on an economy-wide basis and contain quantifiable reduction targets. Use of these possible targets as reference points should not be construed as an endorsement of those targets nor the policy approaches contained in any particular legislative initiative.

SIGNIFICANT POTENTIAL TO REDUCE U.S. EMISSIONS

We analyzed resource costs and abatement potentials for more than 250 opportunities to reduce or prevent GHG emissions.[4] We projected a range of three outcomes for each option and, for analytical purposes, integrated the values into three abatement supply curves. The supply curves are not optimized scenarios, rather they represent different approximations of national commitment (e.g., degree of incentives, investments, regulatory reforms, and urgency for action) and different rates for innovation, learning, and adoption of various technologies. We have called the three curves "cases": the low-range case involves incremental departures from current (i.e., reference case) practices; the mid-range case involves concerted action across the economy; and the high-range case involves urgent national mobilization. In this way, the cases illustrate an envelope of abatement potential for the United States by 2030 (Exhibit A).[5]

Exhibit A

U.S. GREENHOUSE GAS ABATEMENT POTENTIALS – 2030



* Based on bills introduced in Congress that address climate change and/or GHG emissions on an economy-wide basis and have quantifiable targets; targets calculated off the 2030 U.S. GHG emissions of 9.7 gigatons CO_2e/year (reference case)

Source: McKinsey analysis

4 The cost of an abatement option reflects its resource (or techno-engineering) costs – i.e., capital, operating, and maintenance costs – offset by any energy savings associated with abating 1 ton of CO_2e per year using this option, with the costs/savings levelized over the lifetime of the option using a 7-percent real discount rate. We excluded transaction costs, communication/information costs, taxes, tariffs, and/or subsidies. We also have not assumed a "price for carbon" (e.g., a carbon cap or tax) that might emerge as a result of legislation, nor any impact on the economy of such a carbon price. Hence, the per-ton abatement cost does not necessarily reflect the total cost of implementing that option.

5 Only the high-range case reaches the target levels of GHG abatement (3.5 to 5.2 gigatons in 2030) suggested by our sampling of proposed federal legislation that addresses climate change on an economy-wide basis. For this reason, we focus most of our abatement analysis on the upper part of the envelope, from 3.0 gigatons (mid-range case) to 4.5 gigatons (high-range case).

Relying on tested approaches and high-potential emerging technologies, the U.S. could reduce annual GHG emissions by as much as 3.0 gigatons in the mid-range case to 4.5 gigatons in the high-range case by 2030. These reductions from reference case projections would bring U.S. emissions down 7 to 28 percent below 2005 levels, and could be made at a marginal cost less than $50 per ton,[6] while maintaining comparable levels of consumer utility.[7]

We made no assumptions about specific policy approaches that might be taken – e.g., a carbon cap or tax, mandates, or incentives – nor responses in consumer demand that might result. Nonetheless, unlocking the full abatement potential portrayed in our mid- and high-range curves would require strong stimuli and policy interventions of some sort. *Without a forceful and coordinated set of actions, it is unlikely that even the most economically beneficial options would materialize at the magnitudes and costs estimated here.*

Our analysis also found that:

- **Abatement opportunities are highly fragmented and widely spread across the economy (Exhibit B).** The largest option (CCS for a coal-fired power plant) offers less than 11 percent of total abatement potential. The largest sector (power generation) only accounts for approximately one-third of total potential.

- **Almost 40 percent of abatement could be achieved at "negative" marginal costs,** meaning that investing in these options would generate positive economic returns over their lifecycle. The cumulative savings created by these negative-cost options could substantially offset (on a societal basis) the additional spending required for the options with positive marginal costs. Unlocking the negative cost options would require overcoming persistent barriers to market efficiency, such as mismatches between who pays the cost of an option and who gains the benefit (e.g., the homebuilder versus homeowner), lack of information about the impact of individual decisions, and consumer desire for rapid payback (typically 2 to 3 years) when incremental up-front investment is required.

- **Abatement potentials, costs, and mix vary across geographies.** Total abatement available at less than $50 per ton ranges from 330 megatons in the Northeast to 1,130 megatons in the South (mid-range case). These potentials are roughly

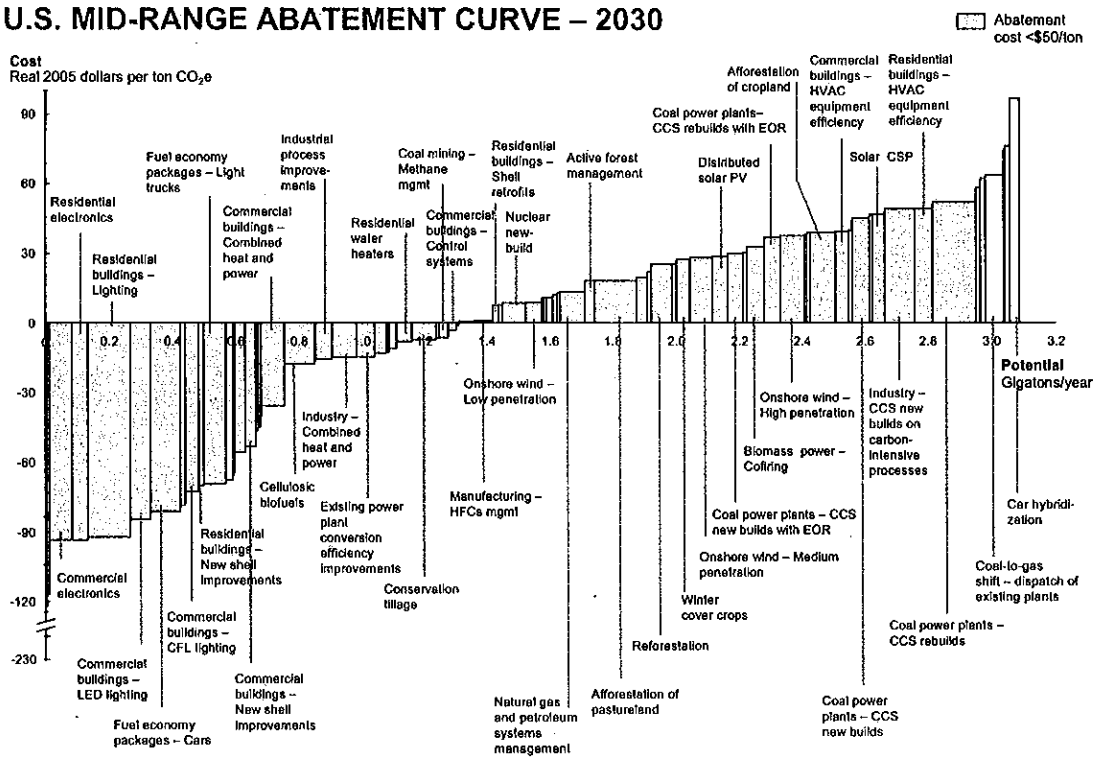
6 The team set an analytical boundary at $50 per ton in marginal cost after considering consumer affordability and the estimated long-term cost for adding carbon capture and storage to an existing coal-fired power plant, a solution that, if successfully deployed, would likely set an important benchmark for emission-control costs. Abatement costs are expressed in 2005 real dollars. The team examined a number of options with marginal costs between $50 and $100 per ton, but did not attempt a comprehensive survey of options in this range. For simplicity of expression in this report, we refer to the threshold with the phrase "below $50 per ton."

7 By "consumer utility" we mean functionality or usefulness for people, including level of comfort; in this context, holding consumer utility constant would imply, e.g., no change in thermostat settings or appliance use; no downsizing of vehicles, homes, or commercial space; traveling the same mileage annually relative to levels assumed in the government reference case. In a strict economic sense, maintaining constant consumer utility assumes a constant economic surplus for the consumer while delivering against a common benefit. We have not attempted to calculate potential changes in utility that might result from energy price changes associated with pursuing the options outlined in our abatement curve.

proportional to total GHG emissions from the regions, but there are significant variations relative to GDP and population.

Exhibit B

U.S. MID-RANGE ABATEMENT CURVE – 2030



Source: McKinsey analysis

Reducing GHG emissions would require capital spending increases and a change in investment patterns relative to the government reference case. For example, the incremental capital costs associated with capturing the 3.0 gigatons of abatement in our mid-range case would average approximately $50 billion annually through 2030. Cumulative net new investment through 2030 would be $1.1 trillion, or roughly 1.5 percent of the $77 trillion in real investment the U.S. economy is expected to make over this period. This number would be higher if our projected savings from energy efficiency gains do not materialize and/or if the nation chooses to achieve emissions reductions by mandating higher-cost options. These incremental investments would be highly concentrated in the power and transportation sectors; if pursued, they would likely put upward pressure on electricity prices and vehicle costs. Policymakers and legislators would need to weigh these added costs against the energy efficiency savings, opportunities for technological advances, and other societal benefits.

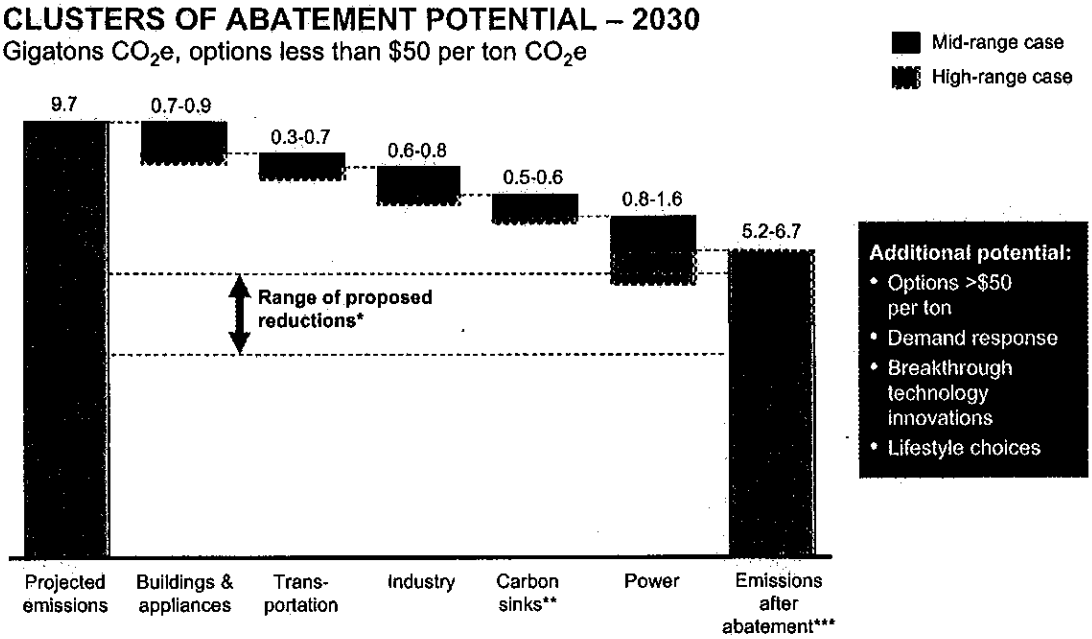
FIVE SECTORS OFFER CLUSTERS OF ABATEMENT POTENTIAL

Five clusters of initiatives, pursued in unison, could create substantial progress – 3.0 gigatons (mid-range case) to 4.5 gigatons (high-range case) of abatement per year – against proposed GHG-reduction targets for 2030 (Exhibit C). We will discuss these clusters in order, from least to highest average cost.

Exhibit C

CLUSTERS OF ABATEMENT POTENTIAL – 2030

Gigatons CO_2e, options less than $50 per ton CO_2e



* Based on bills introduced in Congress that address climate change and/or GHG emissions on an economy-wide basis and have quantifiable targets; targets calculated off the 2030 U.S. GHG emissions of 9.7 gigatons CO_2e/year (reference case)

** Including abatement in the agriculture sector

*** Adjusted for cumulative rounding errors

Source: U.S. EIA; EPA; USDA; McKinsey analysis

1. **Improving energy efficiency in buildings and appliances – 710 megatons (mid-range) to 870 megatons (high-range).** This large cluster of negative-cost options includes: lighting retrofits; improved heating, ventilation, air conditioning systems, building envelopes, and building control systems; higher performance for consumer and office electronics and appliances, among other options. While this category of abatement options would cost the least from a societal point of view, persistent barriers to market efficiency will need to be overcome.

2. **Increasing fuel efficiency in vehicles and reducing carbon intensity of transportation fuels – 340 megatons to 660 megatons.** Improved fuel efficiency could provide 240 megatons to 290 megatons of abatement: much of the benefit would come from fuel

economy packages (e.g., lightweighting, aerodynamics, turbocharging, drive-train efficiency, reductions in rolling resistance) and increased use of diesel for light-duty vehicles. Though the savings from fuel efficiency may offset the incremental cost of the abatement option over a vehicle's 12- to 15-year lifecycle, these options require up-front investment by automakers and thus higher vehicle costs for consumers. Lower-carbon fuels, such as cellulosic biofuels, could abate 100 megatons to 370 megatons of emissions, though this potential is highly dependent on innovation rates and near-term commercialization of these technologies. Plug-in hybrid vehicles offer longer-term potential if vehicle cost/performance improves and the nation moves to a lower-carbon electricity supply.

3. **Pursuing various options across energy-intensive portions of the industrial sector – 620 megatons to 770 megatons.** This potential is in addition to 470 megatons assumed in the government reference case. It involves a multitude of fragmented opportunities within specific industries (e.g., equipment upgrades, process changes) and across the sector (e.g., motor efficiency, combined heat and power applications). Despite offering direct bottom-line benefit, these options must compete for capital and, without clear incentives to control GHG emissions, may not receive funding.

4. **Expanding and enhancing carbon sinks – 440 megatons to 590 megatons.** Increasing forest stocks and improving soil management practices are relatively low-cost options. Capturing them would require linkages to carbon-offset mechanisms to access needed capital, plus improved monitoring and verification.

5. **Reducing the carbon intensity of electric power production – 800 megatons to 1,570 megatons.** This potential derives from a shift toward renewable energy sources (primarily wind and solar), additional nuclear capacity, improved efficiency of power plants, and eventual use of carbon capture and storage (CCS) technologies on coal-fired electricity generation. Options in the power sector were among the most capital-intensive ones evaluated. These options also tend to have the longest lead times, given bottlenecks in permitting, materials and equipment manufacturing, and design, engineering, and construction.

The theme of greater energy productivity pervades these clusters. Improving energy efficiency in the buildings-and-appliances and industrial sectors, for example, could (assuming substantial barriers can be addressed) offset some 85 percent of the projected incremental demand for electricity in 2030, largely negating the need for the incremental coal-fired power plants assumed in the government reference case. Similarly, improved vehicle efficiency could roughly offset the added mobility-related emissions of a growing population, while providing net economic gains.

NEED FOR STRONG, ECONOMY-WIDE APPROACHES

The U.S. will need to develop and implement a strong, coordinated program of economy-wide abatement actions in the near future, if it is to achieve emissions reductions proposed (in bills currently before Congress) for 2030 at the lowest cost to the economy.

We believe a comprehensive abatement program for the U.S. should be built on three principal actions:

1. **Stimulate action through a portfolio of strong, coordinated policies to capture GHG reductions efficiently across industry sectors and geographies.** These policies would need to support development of:

   - Visible, sustained signals to create greater certainty about the price of carbon and/or required emissions reductions; this will help encourage investment in options with long lead times and/or lifecycles

   - A coordinated economy-wide abatement program or set of programs. Because abatement options are highly fragmented and widely distributed across sectors and geographies, any approach that does not simultaneously unleash a full range of abatement options risks missing proposed 2030 reduction targets and/or driving up total cost to the economy

   - Exchange mechanisms (e.g., trading schemes, offsets, tax credits) to create fungibility across fragmented markets, create greater market transparency, and drive least-cost solutions

   - Verification, monitoring, management, and enforcement systems to ensure sustained abatement impact

   - Safeguards against "leakage" and transfer of GHG-emitting activities overseas.

2. **Pursue energy efficiency and negative-cost options quickly.** Many of the most economically attractive abatement options we analyzed are "time perishable": every year we delay producing energy-efficient commercial buildings, houses, motor vehicles, and so forth, the more negative-cost options we lose. The cost of building energy efficiency into an asset when it is created is typically a fraction of the cost of retrofitting it later, or retiring an asset before its useful life is over. In addition, an aggressive energy efficiency program would reduce demand for fossil fuels and the need for new power plants. These energy efficiency savings are not being captured today, however, suggesting that strong policy support and private sector innovation will be needed to address fundamental market barriers. Policy support might consist of standards, mandates and/or incentives to promote carbon-efficient buildings, appliances, and vehicles. Mechanisms to better align all stakeholders (e.g., end users, manufacturers, utilities, and supporting businesses) should also be considered.

3. **Accelerate development of a low-carbon energy infrastructure.** Transitioning to a lower-carbon economy will require significant changes in the country's energy infrastructure. To accelerate development of a lower-carbon energy infrastructure, the U.S. would need to:

   - **Encourage research and development of promising technologies and stimulate deployment.** Of the options we analyzed, some 25 percent (e.g., solar photovoltaics, plug-in hybrid electric vehicles, cellulosic biofuels, CCS) would require additional R&D investment and/or cost compression to achieve the learning rates and scale required to accelerate widespread adoption. This support might include gap-closing financial incentives (e.g., investment tax credits, feed-in tariffs, or direct subsidies) and/or industry or regulatory standards to help achieve scale economies as soon as possible.

   - **Streamline approval and permitting procedures.** Many energy infrastructure investments (e.g., nuclear power, transmission lines, and pipelines) have long lead times and can face substantial delays in getting necessary approvals. Permitting and approval delays can substantially increase the risk and cost to investors and, if not specifically addressed, may inhibit pursuit of these capital-intensive abatement options. Some emerging technologies, such as geologic storage of CO_2, currently have no defined approval and permitting process. Anticipating and addressing potential regulatory hurdles – e.g., siting, liability, and monitoring issues associated with permanently storing large amounts of CO_2 – and developing public and technical review processes to address those issues will be essential to avoid impeding the pursuit of these capital-intensive abatement options.

To address rising GHG emissions comprehensively, the nation would also need to consider abatement options outside the scope of this project. Additional reductions could be achieved by encouraging changes in consumer lifestyles and behaviors (e.g., driving habits, spending decisions) through measures such as price signals or education and awareness campaigns; they could also be achieved by pursuing abatement options with marginal costs greater than $50 per ton. Finally, we are confident that, in the years ahead, many new ideas and innovations not included in our analysis will emerge. These new technologies, products, processes, and methods could well offer additional abatement potential and lower overall costs.

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This project evaluated the costs and potentials of more than 250 abatement options available in the U.S. We did not examine economy-wide effects associated with abating greenhouse gases, such as shifts in employment, impact on existing or new industries, or changes in the global competitiveness of U.S. businesses. The project did not attempt to assess the benefits to society from reducing global warming. The report also did not attempt to address other societal benefits from abatement efforts, such as improved public health from reducing

atmospheric pollution or improving national energy security. Policymakers would undoubtedly want to weigh these factors – and possibly others – when developing comprehensive approaches for reducing GHG emissions in the U.S.

Creating comprehensive approaches will be challenging: they will need to combine durable policies and a slate of strong near-term actions that mobilize economic sectors and geographies across the U.S. The pursuit of GHG abatement, however, will undoubtedly stimulate new businesses and economic opportunities not covered by our cost-focused analysis.