STATE OF NEW MEXICO
BEFORE THE ENVIRONMENTAL IMPROVEMENT BOARD

IN THE MATTER OF PROPOSED REGULATION
20.2.350 NMAC – *GREENHOUSE GAS CAP-AND-TRADE PROVISIONS*

No. EIB 10-04 (R)

DIRECT TESTIMONY OF SANDRA ELY

I. INTRODUCTION

When compared to traditional forms of regulating air pollutants, cap-and-trade provides flexibility to choose the most economically efficient means for achieving greenhouse gas (GHG) emission reductions. As you have heard, the Department's proposed cap-and-trade program is technically practicable and economically reasonable, and the attendant benefits for climate change, air quality, public health, and the growing green economy can and should be realized in New Mexico.

The proposed program is also consistent with the WCI regional cap-and-trade design, and therefore will allow New Mexico allowances to be traded on the regional market. The WCI design acknowledges that individual jurisdictions may select their own allowance distribution method. The Department's proposal to distribute free allowances to New Mexico sources includes a number of important features. First, the allocation method maintains the state emissions budget while steadily reducing GHG emissions. Second, the allocation method accounts for new emissions and new sources in the state. Third, the allocation method provides predictability for existing sources because distribution is based on historic emissions and production rates. Fourth, the allocation

method minimizes the cost to industry. The Department's proposal also gives industry ample time to prepare for the program since the first compliance obligation is not until 2015. Should equally effective federal legislation be enacted, the Department's proposed rule will sunset.

II. STAKEHOLDER ARGUMENTS

Since 2007, industry representatives have expressed concerns about New Mexico's participation in a regional GHG cap-and-trade program. The Department has listened to those concerns, studied them closely, and made changes to the program and the rulemaking process, whenever possible. You have already heard testimony that the proposed program is economically and technically feasible. In my testimony, I will focus on the other policy arguments that we have heard from stakeholders.

A. THE PROCESS WAS RUSHED AND STAKEHOLDER CONCERNS WERE NOT ADDRESSED.

The stakeholder process for this rule was reasonable and appropriate, and exceeded the statutory requirements for rulemaking. The initial recommendation to develop a regional GHG cap-and-trade program came from the Climate Change Advisory Group (CCAG), whose members represented a wide range of interests. The CCAG unanimously endorsed the recommendation for a cap-and-trade program. Throughout the CCAG process, the public was fully informed, and invited to attend meetings and provide comment.

The WCI regional design was developed with extensive stakeholder input. In conjunction with regional stakeholder events, the Department held a series of public meetings to inform New Mexicans and get feedback on the development of the Design

Recommendations for the Regional Cap-and-Trade Program. NMED-Ely Exhibit 1. At each of these meetings, there was discussion about potential WCI options, and the public was provided with web addresses for additional sources of information. While all these meetings took place in Santa Fe, each was accessible telephonically and each had PowerPoint slides available to the public before and after the meeting. The primary mechanism for meeting notification was electronic mail, and the Department maintained an electronic mail notification list with more than 850 people. Further, as the WCI produced papers and analyses, it held stakeholder meetings and conference calls to get public comment, and maintained a website developed specifically to inform the public and provide an opportunity for feedback. NMED-Ely Exhibit 2.

The Department also made a concerted effort to inform the public about the state's climate change work. Over the past three years, representatives from the Governor's Office and the Department have given several presentations to audiences including tribal entities, industrial sources, nonprofit organizations, legislative committees, and environmental groups.

Finally, the Department provided a full stakeholder process for the proposed rule that went beyond the statutory requirements. In March 2010, the Department issued a draft paper on proposed options for the cap-and-trade program entitled *"Greenhouse Gas Emissions Allowances and Trading in New Mexico"*. NMED-Weaver Exhibit 1. The paper was announced and posted on the Department's website for several weeks where the public could provide written comment. NMED- Ely Exhibit 3. The Department also held a series of meetings with interested stakeholders including, representatives from

affected industries, to get comments on the paper and specific recommendations on the allowance distribution options.

After considering this public input, the Department issued a draft rule for additional public comment, and held an open house to explain the rule and get additional comment. The rule then was updated to incorporate these public comments and to provide greater clarity. NMED-Ely Exhibit 4. The Department then requested a hearing that would occur more than 60 days after the publication date of the public notice. This process satisfied the applicable statutory and regulatory requirements.

B. GLOBAL WARMING HAS NOT BEEN PROVEN.

There is overwhelming scientific evidence that climate change is real, that the average global temperature is increasing, and that human activity is at least partly to blame. In February 2007, the Intergovernmental Panel on Climate Change (IPCC), a United Nations body charged with assessing the scientific record on global warming, concluded that the evidence of global warming is "unequivocal" and stated, with near certainty, that human activities are responsible for most of the observed increase in global average temperatures since the mid-20th century. NMED-Ely Exhibit 5. These findings are supported by the National Academy of Sciences (NAS), one of our most respected scientific bodies. In its 2008 report, *Understanding and Responding to Climate Change*, NAS stated, "The scientific understanding of climate change is now sufficiently clear to begin taking steps to prepare for climate change and to slow it. Human actions over the next few decades will have a major influence on the magnitude and rate of future warming." NMED-Ely Exhibit 6.

There are few certainties in science, and credible scientists, like those in the IPCC, often speak in terms of probability rather than absolutes. Unfortunately, climate doubters have seized on the language of probability to foster the perception that the science is not sufficiently clear to take decisive action on climate change. Fortunately, most of the public understands the need for action. Polls show that the majority of Americans and New Mexicans believe that the earth is warming as a result of human activity, and want the federal and state governments to implement policies to address it. NMED-Ely Exhibits 7 and 8.

C. THE PROGRAM WILL NOT HAVE A MEASURABLE IMPACT ON CLIMATE CHANGE.

The proposed cap-and-trade rule is critical to achieving Governor Richardson's effort to reduce GHG emissions in New Mexico. Nonetheless, it is obvious that New Mexico - which accounts for less than 2 percent of U.S. GHG emissions - will not fix the problem by itself. Although the Department's proposed rule - standing alone - will not stop global warming or even have a discernible effect on temperatures in New Mexico, it will contribute to the solution, and perhaps reduce the risk as we approach the tipping point, beyond which the experts believe that global warming will become more rapid and out of control. In addition, it would be irresponsible not to do what is possible and demonstrate leadership in the effort.

It should not be forgotten that New Mexico is working to reduce emissions with other jurisdictions in the WCI. The emissions within the WCI region are significant. The combined annual GHG emissions are a little more than one billion metric tons of carbon dioxide equivalent. With approximately the same amount of emissions as Germany, the

WCI is the seventh largest source of GHG emissions on the planet. By starting the program soon, we can have a significant impact on regional emissions and galvanize the federal government to take action.

D. NEW MEXICO SHOULD NOT IMPLEMENT A STATE-ONLY CAP-AND-TRADE PROGRAM.

The CCAG recommended that New Mexico participate in a national or regional GHG cap-and-trade program, and the Department has never considered a state-only approach. Regional cap-and-trade programs perform better and cost less than state-only efforts. For these reasons, New Mexico will implement a cap-and-trade program only when there are sufficient North American trading partners to make the program efficient and cost-effective. Specifically, the Department proposes to implement the cap-and-trade rule only after other jurisdictions have initiated programs containing a minimum of 100 million metric tons of carbon dioxide equivalent.

It should be noted that the WCI is not the only regional effort to cap and reduce GHG emissions. As you heard from Mr. Litz, there are two other regional programs in the U.S. The Regional Greenhouse Gas Initiative in the northeastern U.S. is already up and running, while the Midwest Accord has developed rules to guide its member states and provinces. Altogether, more than half the states in the nation have implemented or are considering a GHG cap-and-trade program. The regions are in discussions to link their programs so that allowances can be traded across the regions.

E. THE DEPARTMENT SHOULD WAIT FOR FEDERAL LEGISLATION.

Industry would like New Mexico to wait until the federal government takes action, but no one can say when that will happen or what action will be taken. Meanwhile, New Mexico loses precious time to implement policies to reduce GHG emissions. Moreover, by taking action now, New Mexico is better able to influence and prepare for federal legislation if and when it does occur. In fact, the Department supports an effective national program, and has proposed a sunset provision when the federal government establishes such a program.

F. THE DEPARTMENT SHOULD DEFER TO THE STATE LEGISLATURE.

The state legislature authorized the Board to adopt a cap-and-trade program in the Air Quality Control Act. In fact, the Board concluded in November of 2007 (when it adopted the clean car standards), and again in April of 2009 (when it rejected challenges to the New Energy Economy petition), that it had the authority adopt GHG regulations. The Board has a responsibility to regulate GHG pollutants until and unless the state legislature states otherwise.

G. THE PROGRAM WILL ADVERSELY AFFECT THE STATE'S ECONOMY.

Cap-and-trade is considered the least-cost option for achieving GHG emission reductions. Cost containment is one of the critical factors in choosing this program over a traditional command-and-control strategy that would require every source to reduce emissions. Nonetheless, the regulated community has expressed concern that a cap-and-trade program would impose significant costs. The Department has included many

provisions in the rule to mitigate these potential impacts, including the free distribution of allowances, the use of offset credits, and banking. Further, the Department's proposed method for distributing allowances is based in part on production to encourage businesses to stay in state. Finally, the Department's regional and state economic analyses demonstrate that the program will have a slightly positive impact on the state's economy.

H. AN ECONOMIC ANALYSIS SHOULD BE CONDUCTED BEFORE THE BOARD CONSIDERS A CAP AND TRADE PROGRAM.

As you heard from other witnesses, the Department has conducted economic analyses to guide the Board's decision to adopt a cap-and-trade program. These analyses show that the Department's proposal is likely to have a small positive impact on the regional and state economy.

Economic modeling provides insights about policy choices, not specific numbers. As stated in the Pew Center's paper on the topic, "Models are an invaluable tool in exploring alternative policy choices and for generating insights about how the economy might respond to different types and forms of regulation. They cannot, however, predict future events, nor can they produce precise projections of the consequences of a specific policy....As the climate policy debate evolves, it is increasingly important that stakeholders understand the strengths and limitation of economic models and look to them for broad insights, not absolute answers." NMED-Ely Exhibit 9.

The WCI completed an initial regional economic model in 2008, well before the Department proposed a cap-and-trade program. This model informed the development of the WCI design, on which the Department's proposal is based. The WCI updated the

model in July 2010, and the updated results are consistent with the findings of other regional modeling efforts.

The Department also conducted macroeconomic modeling to identify the program's effect on the state economy. That modeling showed a slightly positive impact on New Mexico, which is consistent with the results of similar analyses in other states.

H. THE PROGRAM IS TOO COMPLEX AND SUSCEPTIBLE TO GAMING.

Not being the first to design a cap-and-trade program has its benefits. Through the WCI, the Department has worked with representatives from existing programs to learn from their successes and mistakes. For example, as WCI developed its design, it consulted with experts from RGGI and the United Kingdom, and as the Department developed the proposed allocation methods it considered lessons learned by previous programs. As a result, the Department proposes to base allocations to existing facilities on three years' worth of data, including one year of third party-verified data, to avoid the over allocation of allowances, as well as provisions to correct over-allocations that may be later discovered. Finally, the Department will work with other jurisdictions to develop the trading system, including provisions to detect and deter market manipulation. NMED-Ely Exhibit 10.

II. CONCLUSION

After reviewing the details of the rule, it is important to step back and consider the context. Adopting these rules will put, for the first time ever, a price on GHGs in New Mexico. Putting a price on GHGs holds industry accountable for the environmental impacts of these pollutants, begins to level the playing field between fossil fuels and

renewable forms of energy, and spurs the development of a green energy economy.

The proposed cap-and-trade program presents a tremendous opportunity for New Mexico. Not only will the program reduce GHG emissions, but also will protect the public health by reducing the emissions of ozone-forming pollutants, fine particulates, and toxic air pollutants. Economically, the program will support development of New Mexico's clean energy economy, while having a slightly positive cost impact on the overall economy.

The cap-and-trade program is a priority for Governor Richardson, and an integral part of his strategy for reducing GHG emissions in New Mexico. New Mexico already has implemented or has begun to implement more than 40 of the CCAG's recommendations, and it is now time for the largest industrial sources to do their part.

The Board's adoption of the cap-and-trade program would be consistent with national trends. More than 50 percent of the states have adopted or are considering adopting a cap-and-trade program. In the absence of a meaningful federal effort, the states are creating a model for national action.

Anthropogenic emissions of GHG are changing the global climate with potential devastating consequences for New Mexico. Today, this Board can take concrete steps to address the problem. I urge you to do the right thing for New Mexico and the planet by adopting the Department's cap-and-trade rule.

NMED Western Climate Initiative Stakeholder Meetings

Date	Subject
8/14/07	WCI Overview
9/20/07	WCI Update
11/2/07	WCI Work Plan
3/7/08	WCI Design Options: Scope and Electricity (including status of Reporting)
4/9/08	Update on WCI Design Recommendations: Reporting, Allocations and Offsets
5/28/08	Overview and Status Of WCI Recommendations: Scope, Electricity, Reporting, Allocations, and Offsets
8/1/08	Draft Design Recommendations: Reporting, Electricity, Scope, Allocations and Offsets
10/31/08	Design Recommendations for the WCI Regional Cap-and-Trade Program

NMED Western Climate Initiative Presentations

Date	Subject	Location
4/25/07	New Mexico Climate Change Activities (including WCI)	Navajo EPA Conference
10/9/07	NMED Climate Change Initiatives (including WCI)	New Mexico Oil and Gas Association Annual Conference
4/11/08	New Mexico Climate Change Activities (including WCI)	New Mexico Public Health Association Conference
4/16/08	Western Climate Change Initiatives: Opportunities for Collaboration	National Tribal Environmental Conference: "One Earth, One People, One Environment"
4/17/08	Climate Change In The West	New Mexico Governor's Conference on Tourism
5/14/08	Western Climate Change Initiative Overview and Update	New Mexico Association of Commerce and Industry
11/5/08	New Mexico Climate Change Activities (including the WCI)	Sierra Club: Los Alamos
6/3/09	Western Climate Change Initiative Overview and Update	New Mexico Air and Waste Management Association
6/12/09	Western Climate Change Initiative Overview and Update	New Voice of Business
7/14/09	Western Climate Change Initiative Overview and	Public Service Company of New Mexico

NMED-ELY
EXHIBIT 1

	Update	
7/21/09	Western Climate Change Initiative Overview and Update	Energy in the Southwest
1/8/09	Western Climate Change Initiative Overview and Update	New Mexico Rural Electric Coops
3/26/09	Western Climate Change Initiative Overview and Update	ASC Federal Women's Program, Women's History Month
5/22/09	Western Climate Change Initiative Overview and Update	New Mexico Association of Commerce and Industry
6/17/09	New Mexico Climate Change Activities (including WCI)	New Mexico Society of Hazardous Materials Managers
9/8/09	NMED Climate Change Efforts	New Mexico Mining Association
9/16/09	New Mexico Climate Change Activities (including WCI)	New Mexico Air and Waste Management Association
10/23/09	New Mexico Climate Change Activities	New Mexico Infrastructure Conference
11/12/09	NMED Climate Change Activities (including WCI)	Radioactive and Hazardous Material Interim Legislative Committee

2010 NMED Cap-and-Trade Stakeholder Engagement

Date	**Subject**	**Stakeholders Involved**
3/16/10	Press Release Inviting Comment on Issues Paper	General Public
3/17/10	Email Inviting Comment on Issues Paper and State Greenhouse Gas Emissions Inventory	NMED Email Distribution List
3/18/10	Newspaper Article- Public Invited to Provide Comment on Issues Paper	Albuquerque Journal
4/5/10	Meeting	New Mexico Oil and Gas Association
4/5/10	Email Extending Comment Period on Issues Paper	NMED Email Distribution List
4/7/10	Meeting	Utilities Representatives
4/16/10	Meeting	Oil and Gas Representatives

4/23/10	Meeting	Non-Governmental Organizations
4/26/10	Newspaper Article-Public Invited to Provide Comment on Proposed Rule	Journal Business Outlook
5/17/10	Press Release Inviting Comment on Proposed Cap-and-Trade Program	General Public
5/17/10	Email Inviting Comment on Proposed Cap-and-Trade Program	NMED Email Distribution List
5/18/ 10	Email Inviting Comment on Proposed Cap-and-Trade Program	Western Climate Initiative Email Distribution List
5/19/10	Newspaper Article- Public Invited to Provide Comment on Proposed Rule; Open House Announced	Albuquerque Journal
518/10	Electronic Newspaper Article – Public Invited to Provide Comment on Proposed Rule	Daily Environment Report
5/13/10	Conference	Four Corners Oil and Gas Conference
5/25/10	Open House	General Public
6/4/10	Teleconference	Navajo Nation EPA
6/4/10	Press Release - Public Invited to Provide Comment on Proposed Rule	General Public
6/4/10	Email Inviting Comment on Proposed Cap-and-Trade Program	NMED Email Distribution List
6/17/10	Teleconference	Agricultural Interests
7/14/10	Conference	Energy in the Southwest

search...

MAILING LIST ♣ CONTACT

Western Climate Initiative

ABOUT THE WCI ♣ PROGRAM DESIGN ♣ EVENTS ♣ NEWS & UPDATES ♣ DOCUMENTS & RESOURCES

Upcoming Events

No current events.

<< JULY 2010 >>

Su	Mo	Tu	We	Th	Fr	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Welcome to the WCI website. The WCI is a collaboration of independent jurisdictions working together to identify, evaluate, and implement policies to tackle climate change at a regional level. This is a comprehensive effort to reduce greenhouse gas pollution, spur growth in new green technologies, help build a strong clean-energy economy, and reduce dependence on foreign oil. Click here to learn more about the WCI and the program design. For an overview of the WCI, download our brochure.

Partners and Observers

Click on the map for a detailed view

The WCI invites you to be involved. Follow the links above to participate in upcoming events, to provide comments, and to access WCI news and documents.

Read Current Newsletter | Submit Comments | Join Mailing List

Recent News

RSS Feed

- WCI Releases Updated Economic Analysis
- WCI Releases Consultant Study on the Potential for Leakage in the Eastern Electricity Sector
- WCI Submits Comments to EPA on Proposed Reporting for Oil and Gas Operations (Subpart W)
- WCI Proposes Harmonization of Its Reporting Requirements with EPA's Mandatory Reporting Rule
- WCI Releases White Paper on GHG-Reducing Complementary Policies
- New Mexico Releases Preliminary Draft Rule for Cap-and-Trade

New Mexico Climate Change Initiatives

Current Environment Department Initiatives

NEW Greenhouse Gas Cap and Trade Program - New Mexico regulations proposed or under development

- Proposed 20.2.350 NMAC - Greenhouse Gas Cap and Trade Provisions
- Greenhouse Gas Emissions Reporting and Verification

NEW Proposed Tailoring Rule Amendments to 20.2.70 and 20.2.74 NMAC

NMED has prepared draft amendments to 20.2.70 NMAC - Operating Permits and 20.2.74 NMAC - Permits-Prevention of Significant Deterioration (PSD) for public comment. These amendments reflect the language from the U.S. EPA's Prevention of Significant Deterioration/Title V Greenhouse Gas Tailoring Rule, issued on May 13, 2010. The EPA rule sets thresholds for greenhouse gas emissions that define when permits under the New Source Review PSD and Title V Operating Permit programs are required for new and existing facilities. NMED proposes these amendments in order to maintain its authority to issue PSD and Title V permits under the State Implementation Plan (SIP).

A public meeting will be held at the Air Quality Bureau office, 1301 Siler Road, Bldg. B, Santa Fe, NM 87507, on July 15, 2010 from 1:30 - 3:30 PM. For more information or to submit comments on these proposed rules, please contact Kerwin Singleton, at kerwin.singleton@state.nm.us, or 505-476-4350.

- Proposed Rule 20.2.70 - Tailoring Rule
- Proposed Rule 20.2.74 - Tailoring Rule

New Mexico is a founding member of the Western Climate Initiative.

The Climate Master™ Program has come to New Mexico! Click here for additional information.

Background Information on New Mexico Climate Change Initiatives

Recognizing the profound implications that global warming and climate variation could have on the economy, environment and quality of life in the Southwest, New Mexico Governor Bill Richardson signed Executive Order 05-033 on June 5, 2005. This Executive Order had the following effects:

- It established the New Mexico Climate Change Advisory Group (CCAG) to provide specific, measurable proposals to the Action Council to reduce greenhouse gas emissions in New Mexico. Their work was completed in October, 2006 and the final report of that group can be reviewed at www.nmclimatechange.us.
- The Final Report of the Climate Change Advisory included an inventory of New Mexico greenhouse gas emissions. That appendix to the report, "New Mexico Greenhouse Gas Inventory and Reference Case Projections, 1990-2020", is available at this link.
- The New Mexico Environment Department's Final Inventory of New Mexico Greenhouse Gas Emissions: 2000-2007 is available at this link.
- It mandated the creation of a report on potential impacts of global warming on New Mexico. That report, "The Potential Effects of Climate Change on New Mexico" is available at this link.
- Another requirement of EO 05-033 is a report on water resource predictions that has been

Governor Bill Richardson

NEW MEXICO climate change

New Mexico Climate Master™ Program

Western Regional Climate Action Initiative

Executive Order 05-033

Executive Order 06-069

New Mexico Climate Change Advisory Group

The Potential Effects of Climate Change on New Mexico

The Impact of Climate Change on New Mexico's Water Supply

TITLE 20 ENVIRONMENTAL PROTECTION
CHAPTER 2 AIR QUALITY (STATEWIDE)
PART 350 GREENHOUSE GAS CAP AND TRADE PROVISIONS

[GENERAL PROVISIONS]

20.2.350.1 ISSUING AGENCY: Environmental Improvement Board.
[20.2.350.1 NMAC - N, 01/01/11]

20.2.350.2 SCOPE: All persons who:

A. own or operate a cap facility in the geographic area within the jurisdiction of the environmental improvement board;

B. are authorized account representatives pursuant to this part; or

C. voluntarily submit an application for registration for a general account pursuant to Subsection A of 20.2.350.101 NMAC.

[20.2.350.2 NMAC - N, 01/01/11]

20.2.350.3 STATUTORY AUTHORITY: Environmental Improvement Act, NMSA 1978, Section 74-1-8(A)(4), and Air Quality Control Act, NMSA 1978, Sections 74-2-1 et seq., including specifically Section 74-2-5(B)(1).
[20.2.350.3 NMAC - N, 01/01/11]

20.2.350.4 DURATION: Permanent.
[20.2.350.4 NMAC - N, 01/01/11]

20.2.350.5 EFFECTIVE DATE: January 1, 2011 except where a later date is cited at the end of a section.
[20.2.350.5 NMAC - N, 01/01/11]

20.2.350.6 OBJECTIVE: The objective of this part is to establish requirements for participation in a greenhouse gas emissions cap and trade market.
[20.2.350.6 NMAC - N, 01/01/11]

20.2.350.7 DEFINITIONS: The following definitions apply to this part. The definitions included in 20.2.2 NMAC and 20.2.300 NMAC shall apply to the terms used in this part, unless such term is defined in this part.

A. **Allocation year** of an allowance means the calendar year in which the allocation of that allowance is made.

B. An **allowance** under this part is a limited authorization by the department or a jurisdiction approved pursuant to ~~Section 20.2.350.206 NMAC~~this part to emit one metric ton of CO2e in accordance with this part.

C. **Authorized Account Representative** means a person designated and certified as such pursuant to Sections 20.2.350.400 NMAC or 20.3.350.401 NMAC.

D. **Cap emission** means any emission, in units of CO2e, that is defined as a cap emission in 20.2.300 NMAC. [Cap emissions include most but not all of the emissions required

NMED-ELY
EXHIBIT 4

to be reported by emitting facilities under the Federal greenhouse gas mandatory reporting rule, 40 CFR 98, as well as carbon dioxide removed from natural gas and emitted by natural gas treatment plants. Some of the emissions that are not cap emissions are those resulting from manure management and livestock, and fugitive methane emissions from landfills.]

E. A **cap facility** is any reported entity for which:

1. ~~for which~~ the reported cap emissions are equal to or greater than the cap threshold in any year; or

2. the designated account representative has voluntarily opted pursuant to section 20.2.350.300 NMAC to become a cap facility.

F. **Cap threshold** means 25,000 metric tons of cap emissions, in units of CO2e.

G. **CO2e** has the meaning established in 20.2.300 NMAC.

H. **Compliance instruments** include allowances, early reduction allowances and offset credits.

I. **Compliance instrument ~~transfer~~ surrender deadline** means midnight at the end of the June 30th occurring after the end of the relevant compliance period or, if that June 30th is not a business day, midnight of the first business day thereafter, and is the deadline by which compliance instruments shall be ~~submitted~~ surrendered for the compliance period immediately preceding the deadline.

J. **Compliance period** means a three-calendar-year time period. The first compliance period is from January 1, 2012 through December 31, 2014. Each subsequent sequential three-calendar-year period is a separate compliance period.

K. **Emissions year** means the calendar year in which the emissions occur.

L. An **external trading program** is a greenhouse gas cap and trade program consisting of multiple jurisdictions that:

1. do not include any jurisdiction in New Mexico; and

2. have entered into mutually binding agreements between those jurisdictions to establish consistent program and trading mechanisms for purposes of capping greenhouse gases and trading greenhouse gas compliance instruments.

M. **Initial Cap Year** means the first year for which cap emissions that occur during that year will be subject to an obligation to surrender compliance instruments under this part. The initial cap year refers to the cap and trade program rather than to any individual facility. The initial cap year shall be the later of:

1. 2012;

2. the year in which this part becomes effective; or

3. the year in which the provisions of Subsection D of Section 20.2.350.300 NMAC are met.

~~**New Emissions means emissions at a cap facility that are:**~~

~~1. the result of new equipment or changes in activities that first occur at the facility after July 1, 2011; and~~

~~2. directly related to an increase in annual production at the facility.~~

N. A **reported entity** is a facility, as defined in 20.2.300 NMAC, for which the owner or operator is required to report cap emissions, or has chosen to report and verify cap emissions pursuant to that Part.

O. **Vintage year** of an allowance means the first calendar year in which the allowance becomes valid for use in meeting a compliance obligation, and is established by the

issuing jurisdiction at the time of issuance. The vintage year of each allowance is reflected in the unique identification number given to the allowance.

20.2.350.8 SEVERABILITY: If any provision of this part, or the application of such provision to any person or circumstance, is held invalid, the remainder of this part, or the application of such provision to any person or circumstance other than those as to which it is held invalid, shall not be affected thereby.
[20.2.350.8 NMAC - N, 01/01/11]

20.2.350.9 CONSTRUCTION: This part shall be liberally construed to carry out its purpose.
[20.2.350.9 NMAC - N, 01/01/11]

20.2.350.10 COMPLIANCE WITH OTHER REGULATIONS: Compliance with this part does not relieve a person from the responsibility to comply with any other applicable federal, state, or local regulation.
[20.2.350.10 NMAC - N, 01/01/11]

20.2.350.11 NEW MEXICO GREENHOUSE GAS EMISSIONS CAP. The initial greenhouse gas emissions cap shall be the sum of the representative annual cap emissions for existing cap facilities, determined pursuant to Section 20.2.350.200 NMAC~~allowances issued to existing cap facilities and the new emissions set aside account in allocation year 2012~~. The cap shall decrease by ~~approximately~~ two percent per year thereafter. In the event that the representative annual cap emissions for an existing facility is reduced pursuant to Subsection F of 20.2.350.200 NMAC, the initial New Mexico greenhouse gas emissions cap shall be adjusted accordingly.
[20.2.350.11 NMAC - N, 01/01/11]

20.2.350.12 APPLICABILITY TO OWNERS AND OPERATORS. Any provision of this part that applies to a cap facility (including those requirements applicable to the authorized account representative of a compliance account) shall also apply to the owners and operators of such cap facility.
[20.2.350.12 NMAC - N, 01/01/11]

20.2.350.13 [RESERVED]
[20.2.350.13 NMAC - N, 01/01/11]

20.2.350.14 SUPERCESSION OF EXISTING EMISSION CAPS. This regulation supersedes any previously ~~existing~~ adopted Title 20 Chapter 2 regulation that establishes an emissions cap for greenhouse gases.
[20.2.350.14 NMAC - N, 01/01/11]

20.2.350.15 SUNSET CLAUSE. This part shall be superceded in the event that a greenhouse gas cap and trade program that is at least as effective as this part and established by the federal government becomes effective.
[20.2.350.15 NMAC - N, 01/01/11]

20.2.350.16 PROPERTY RIGHTS. An allowance issued under this part is a limited authority to emit, and shall not constitute a property right.
[20.2.350.16 NMAC - N, 01/01/11]

20.2.350.17 to 20.2.350.99 [RESERVED]

[TRACKING COMPLIANCE INSTRUMENTS]

20.2.350.100 TRACKING SYSTEM FOR COMPLIANCE INSTRUMENTS. The department shall maintain, or participate in, a system for tracking compliance instruments that is capable of:

A. maintaining records of compliance accounts and general ~~accounts for cap facilities, including~~accounts, including information regarding authorized account representatives;

B. serving as a permanent repository of information on all transactions involving ~~approved~~ compliance instruments from the time they are created or approved to the time they are retired, including transfers, prices, counter-parties, and other documentation;

C. maintaining and transferring between jurisdictions information ~~on~~as necessary regarding~~:~~

~~1. creation, approval, and retirement of~~ compliance instruments and~~; and~~

~~2. all~~ registrants; and

D. providing ~~a complete accounting of all approved compliance instruments to the agencies in other jurisdictions that may retire the instruments~~for public access and confidentiality of information, as appropriate.

20.2.350.101 GENERAL AND COMPLIANCE ACCOUNTS.

A. General Accounts

1. Nature and function of general accounts. Consistent with this section, the department shall establish, upon receipt and approval of a complete and accurate application, a general account for any person. Transfers of compliance instruments pursuant to Section 20.2.350.102 NMAC shall be recorded in the general account in accordance with this section.

2. Application for a general account. At any time after January 1, 2012, any person may apply to the department to open a general account for the purpose of holding and transferring compliance instruments. An application for a general account ~~may~~ shall designate one authorized account representative, and may designate one alternate authorized account representative, pursuant to ~~who may act on behalf of the authorized account representative. The authorized account representative and alternate authorized account representative and their designation shall meet~~ the requirements in Section 20.2.350.401 NMAC.

3. A complete application for a general account shall include the following elements in a format prescribed by the department:

a. Contact information requested by the department, such as name, address, e-mail address, telephone number, and facsimile transmission number of the authorized account representative and any alternate authorized account representative;

b. To the extent applicable, organization name and type of organization;

c. A list of all persons subject to a binding agreement for the authorized account representative or any alternate authorized account representative to represent their ownership interest with respect to the compliance instruments held in the general account;

d. The following certification statement by the authorized account representative and any alternate authorized account representative: "I certify that I was selected as the authorized account representative or the alternate authorized account representative, as applicable, by an agreement that is binding on all persons who have an ownership interest with respect to compliance instruments held in the general account. I certify that I have all the necessary authority to carry out my duties and responsibilities under 20.2.350 NMAC on behalf of such persons and that each such person shall be fully bound by my representations, actions, inactions, or submissions and by any order or decision issued to me by the department or a court regarding the general account."; ~~and~~

e. The signature of the authorized account representative and any alternate authorized account representative and the dates signed.

4. Documents of agreement referred to in the application for a general account shall not be submitted to the department. Neither the department nor its agent shall be under any obligation to review or evaluate the sufficiency of such documents.

5. A person cannot hold a compliance instrument until the department has approved the person's registration and created a general account for the person. ~~An entity~~ person shall maintain a current and valid registration in order to continue to hold compliance instruments.

6. Closing of general accounts

a. The department may revoke, suspend, or place restrictions on a general account of ~~an~~ a person ~~entity~~ for any violation of this part.

b. An authorized account representative of a general account may instruct the department to close the account by submitting a statement requesting such closure and by correctly submitting for recording under Section 20.2.350.102 NMAC a transfer of all compliance instruments in the account to one or more other accounts.

c. If a general account shows no activity for a period of six years or more and does not contain any compliance instruments, the department may notify the authorized account representative for the account that the account shall be closed 90 days after the notice is sent. The account shall be closed after the 90-day period unless before the end of the period the department receives a correctly submitted transfer of compliance instruments into the account pursuant to Section 20.2.350.102 NMAC or a statement submitted by the authorized account representative demonstrating to the satisfaction of the department good cause as to why the account should not be closed. The department shall have sole discretion to determine if the authorized account representative demonstrated that the account should not be closed.

B. Compliance Accounts

1. Nature and function of compliance accounts. Allocations of allowances, and deductions or transfers of compliance instruments pursuant to this part, shall be recorded in the compliance accounts in accordance with this part. The department shall establish:

~~a. one compliance account for each cap facility; or~~

~~b. at the request of the authorized account representative, one compliance account for multiple cap facilities if at least one of the cap facilities is subject to applicability under Paragraph 1 of Subsection A of 20.2.350.300 NMAC and all of the cap facilities:~~

~~i. have the same owners and authorized account representative;~~

~~ii. are the same type of facility [e.g. electric utility or compressor station]; and~~

~~iii. have the same units of production that will be used by the department when determining adjustments to the allocation of allowances under Subsection E of 20.2.350.200 NMAC and Subsection F of 20.2.350.200 NMAC~~.

2. A complete and accurate application for a compliance account shall be submitted to the department:

a. by October 1, 2012 for each cap facility for which reported cap emissions for emissions year 2011 meet or exceed the cap threshold; and

b. within 90 days after the first submittal for any facility of an emissions report under 20.2.300 NMAC for which cap emissions meet or exceed the cap threshold ~~in emissions year 2012 or later~~.

3. A complete application for a compliance account shall include:

a. An account certificate of representation for an authorized account representative, and if applicable an alternate authorized account representative, that meets the requirements under Subsection D of 20.2.350.400 NMAC; and

b. Identification of ~~each~~ the cap facility, including plant name and the identification number associated with the emissions reports submitted pursuant to 20.2.300 NMAC, to which the compliance account shall apply;

4. Upon receipt of a complete application for a compliance account under Paragraph 2 of Subsection B of ~~20.2.350.101 NMAC~~this section, the department shall establish a compliance account for the cap facility ~~or facilities~~ for which the application was submitted.

5. The department may place restrictions on a compliance account for any violation of this part.

6. Closing of compliance accounts. The department may close a compliance account if it determines that ~~there are~~:

a. no cap ~~facilities~~ facility is registered in the compliance account;

b. no outstanding compliance obligations are associated with the authorized account representative or ~~any facility registered in~~ the account; and

c. no remaining compliance instruments are in the account.

C. Accounts under the control of the department. The department shall create and maintain the following accounts:

1. an ~~general~~ account containing the ~~serial numbers of~~ allowances to be distributed by the department;

2. an ~~compliance~~ account into which compliance instruments shall be surrendered, or transferred for retirement or cancellation by the department;

3. a ~~new emissions~~new production set-aside account; and

4. a ~~new emissions~~new production reserve account.

D. The department shall not create a compliance or general account for any of the following:

1. a person verifying greenhouse gas emissions of a cap facility;

2. a person verifying greenhouse gas reductions, avoidances, or sequestration from an offset project; and

3. except as otherwise provided in this part, the department or its employees or contractors.

E. Account identification. The department shall assign a unique identifying number to each general and compliance account established under this part.

F. All submissions to the department pertaining to the account, including submissions concerning the deduction or transfer of compliance instruments in the account and modifications to the account, shall be made only by the authorized account representative for the account.

G. Banking. Each compliance instrument that is held in a compliance or general account shall remain in such account unless and until the compliance instrument is deducted or transferred under this part.

H. Account error. The department may, at its sole discretion, correct any error in any compliance account or general account under this Part. Within ten (10) business days of making such correction, the department shall notify the authorized account representative for the account.

20.2.350.102 COMPLIANCE INSTRUMENT TRANSFERS.

A. Submission of compliance instrument transfers. Each authorized account representative seeking to record a compliance instrument transfer to or from an account established under this part shall submit the transfer to the department by means of the tracking system established under Section 20.2.350.100 NMAC. To be considered correctly submitted, the compliance instrument transfer shall include the following elements in a format specified by the department:

1. The numbers identifying both the transferor and transferee accounts;

2. The ~~origin of the compliance instrument;~~

~~3. A specification by~~ serial number of each compliance instrument to be transferred, indicating;

a. the jurisdiction that originally issued the compliance instrument;

b. the vintage of the compliance instrument; and

c4. Whether the compliance instrument is an allowance or~~,~~ offset credit~~, or compliance instrument issued by an external trading program~~;

~~5~~3. ~~The printed name and signature of~~ Certification that the transfer is being conducted by the authorized account representative of the transferor account ~~and the date signed~~;

~~6~~4. The date of the ~~completion of the last sale or purchase~~ transaction ~~for the compliance instrument, if any~~; and

~~7~~5. The purchase or sale price of the compliance instrument that is the subject of a sale or purchase transaction.

B. In the event that a batch of compliance instruments issued by an external trading program is not in units of metric tons of CO2e, the department shall, prior to recording a transfer of such a batch into an account under this part:

1. determine the number of ~~convert the~~ compliance instruments that would represent in ~~into~~ metric tons CO2e the amount of greenhouse gases represented by the batch of external trading program compliance instruments.~~;~~

~~2.~~ and round the number of compliance instruments ~~to be transferred~~ in metric tons down to the nearest whole metric ton;

2. determine the difference between the number compliance instruments in the batch in the units used by the external trading program and the number of compliance instruments in the batch in units of metric tons, and notify the external trading program of the number and serial numbers of the external trading program compliance instruments to be retired in order to convert the remaining compliance instruments into units of metric tons CO2e; and

3. ~~assign each of the converted compliance instruments a unique identification number that shall include digits identifying it as an external trading program compliance instrument and indicating the vintage year for it~~identify the converted compliance instruments as being in units of metric tons CO2e.

C. Recording transfers of compliance instruments.

~~1. Within 5 business days of receiving~~ Each completed ~~a~~ compliance instrument transfer~~, except as provided in this section, the department shall record a compliance instrument transfer by moving each compliance instrument from~~shall be recorded by means of the tracking system established under Section 20.2.350.100 NMAC in the transferor account ~~to~~ and the transferee account. The transfer shall not be completed unless ~~as specified by the request, provided that~~:

~~1~~a. ~~T~~the transferor ~~is~~ has correctly submitted ~~under this section~~the transfer; and

2.~~b~~. t~~T~~he transferor account includes each compliance instrument identified by serial number in the transfer.

~~2. A compliance instrument transfer into or out of a compliance account that is submitted for recording following the compliance instrument transfer deadline and that includes any allowances that are of allocation years that fall within a compliance period prior to or the same as the compliance period to which the compliance instrument transfer deadline applies shall not be recorded until after completion of the process pursuant to Subsection A of 20.2.350.401 NMAC.~~

~~3. Where a compliance instrument transfer submitted for recording fails to meet the requirements of this section, the department shall not record such transfer.~~

D. Notification.

1. Notification of recording. ~~Within 5 business days of~~As soon as practicable after the recording of a compliance instrument transfer under Subsection B of ~~20.2.350.102 NMAC~~this part, the department shall electronically notify each party to the transfer. Notice shall be given to the authorized account representatives for both the transferor and transferee accounts.

2. Notification of non-recording. ~~Within 10 business days of~~As soon as practicable after receipt of a compliance instrument transfer that fails to meet the requirements of this part, the department shall electronically notify the authorized account representatives for both accounts subject to the transfer of:

a. A decision not to record the transfer, and

b. The reasons for such non-recording.

E. Nothing in this section shall preclude the submission of a compliance instrument transfer for recording following notification of non-recording.

20.2.350.103 RECORDKEEPING. Unless otherwise provided, the application for each general and compliance account, the account certificate of representation for the authorized account representative, and all documents that demonstrate the truth of the statements in the account certificate of representation, shall be maintained for 7 years after the document was

created, or until such documents are superseded because of the submission of a new account certificate of representation changing the authorized account representative, whichever is later. The authorized account representatives, owners of each account, and owners and operators of each cap facility shall keep copies of such documents and make them available to the department upon request.

20.2.350.~~104~~ to 20.2.350.199 [RESERVED]

[ACQUISITION OF COMPLIANCE INSTRUMENTS]

20.2.350.200 ~~INITIAL ALLOCATION OF ALLOWANCES~~BASELINE QUANTITIES FOR EXISTING CAP FACILITIES.

A. For the purposes of this part, an existing ~~electric utility is a~~ cap facility is one ~~or cap facilities~~ that:

1. began ~~operations~~ operating prior to ~~July~~ January 1, 2011; and

~~2. produced electricity for sale during the year 2011;~~

~~3. have as their primary purpose the production of electricity;~~

~~4. are all registered under the same compliance account pursuant to Subsection B of 20.2.350.101 NMAC; and~~

~~5. includes at least one cap facility that, for emissions that occurred in every year from 2012 to and including the year prior to allocation of allowances under this section (with the exception of 2011),~~ has been subject to the obligation to surrender compliance instruments pursuant to Paragraph 1 of Subsection A of 20.2.350.300 NMAC for emissions that occurred in every year from the initial cap year to and including the year prior to allocation of allowances under this part (with the exception of 2011).

B. By April 1, 2012, the owner, operator or authorized account representative of each existing cap facility shall provide to the department all relevant and necessary information to as accurately as possible determine baseline quantities for the cap facility for purposes of allocations under this Part. Additional information as requested by the department shall be provided by the deadlines established in the request.

C. Baseline quantities. For the purposes of this part, representative annual cap emissions and representative annual production mean the emissions and production, respectively, which occur during normal operation in a typical year contemporaneous with the effective date of this part.

1. Representative annual cap emissions for purposes of allocating allowances to existing cap facilities. Representative annual cap emissions of each existing cap facility shall be based on the best available estimate of emissions over the calendar years 2009 through 2011.

a. The best available estimate of emissions shall be based, where possible, on:

i. any greenhouse gas emissions reports submitted to the department for calendar years 2009, 2010, and 2011, with greater weight given to verified data; and

ii. any other emissions reports which have been verified by a third party;

b. Where emissions reports as specified in paragraph 1 of this subsection are not available for all years, emissions shall be estimated by best available methods, which may include the following methods. The department shall take into account the potential margin of error associated with the emissions estimates used.

i. Methods in 20.2.300 NMAC.

ii. Methods in 40 CFR 98.

iii. The department reporting procedures issued in any year for reporting under 20.2.73 NMAC or 20.2.87 NMAC.

iv. Reporting protocols of any voluntary GHG registry.

v Industry standard protocols for estimating GHG emissions.

vi. Simple correlations with production.

~~B. For the purposes of this part, an existing cap facility that is not an electric utility is a cap facility or cap facilities that:~~

~~1. began operations prior to July 1, 2011;~~

~~2. are not an existing electric utility pursuant to Subsection A of this Section;~~

~~3. have the same measure of production;~~

~~4. are all registered under the same compliance account pursuant to Subsection B of 20.2.350.101 NMAC; and~~

~~5. includes at least one cap facility that, for emissions that occurred in every year from 2012 to and including the year prior to allocation of allowances under this section (with the exception of 2011), been subject the obligation to surrender compliance instruments pursuant to Paragraph 1 of Subsection A of 20.2.350.300 NMAC.~~

~~C~~2. Representative annual ~~Baseline quantities~~ production for purposes of allocating allowances to existing ~~electric utilities~~cap facilities. Representative annual production of each existing cap facility shall be based on the best available estimate of production over the calendar years 2009 through 2011. The department shall take into account the potential margin of error associated with the production estimates used. The best available estimate of production shall be based, where possible, on:

a. any relevant reports submitted for the facility to the department or state or national databases for calendar years 2009, 2010, and 2011, with greater weight given to verified data; and

b. relevant reports provided by the authorized account representative which have been verified by a third party; and

c. additional information, if any, provided by the authorized account representative.

D. Comment and review.

1. ~~1.~~ By October 15, 2012, the department shall notify the authorized account representative of each existing ~~electric utility~~cap facility and release for public comment the department's preliminary determination of its representative annual cap emissions and representative annual ~~electricity~~ production.

~~For the purposes of this section, representative annual cap emissions and representative annual electricity production mean the sums, for those cap facilities in the compliance account, of emissions and production respectively, that occur during normal operation in a typical year contemporaneous with the effective date of this part. The department's preliminary determination for each existing electric utility shall be based on consideration of:~~

~~a. the greenhouse gas emissions reports submitted to the department for emissions years 2009, 2010 and 2011, with greater weight in resolving anomalies given to verified data;~~

~~b. additional information, if any, provided by the authorized account representative; and~~

~~c. as needed, additional data reported to state or national databases for the facility.~~

~~2. By December 15, 2012, the department shall, after consideration of comments received on its preliminary determination, notify the authorized account representative of each existing electric utility regarding the department's final determination of the representative annual cap emissions and representative annual electricity production for the existing electric utility for purposes of allocating allowances to the facility.~~

~~3. The department's final determination may be appealed to the environmental improvement board.~~

~~D. Baseline quantities for purposes of allocating allowances to existing cap facilities that are not electric utilities.~~

~~1. Representative annual cap emissions of each such existing cap facility shall be based on a consideration of the product of annual average activity level over the calendar years 2009 through 2011, multiplied by the ratio of emissions to activity level in 2011. Representative annual cap emissions for calendar years 2009, 2010, and 2011 shall be based on consideration of:~~

~~a. any greenhouse gas emissions reports submitted to the department for calendar years 2009, 2010, and 2011, with greater weight given to verified data;~~

~~b. any other emissions reports which have been verified by a third party;~~

~~c. measures of the activity level of the emitting units, such as fuel use or feedstock inputs.~~

~~2. By June 1, 2012, each existing such cap facility shall submit to the department, for each cap facility within the compliance account:~~

~~a. proposed measures of activity level and annual production, including a description of units of measurement and sources of data appropriate to quantifying the activity level and annual production at the facility; and~~

~~b. activity level and annual production values and supporting data and explanations for calendar years 2009, 2010, and 2011, for use by the department in determining the representative annual cap emissions and representative annual production for the cap facility.~~

~~3. In establishing the measure of activity level for a cap facility, the department shall consider that:~~

~~a. a common measure may be used for similar cap facilities, but measures may be facility-specific if justified by the unique profile of emitting activities at the cap facility;~~

~~b. the measure of activity level shall be related as directly as possible to the emitting activities, such as fuel use for a combustion source; and~~

~~c. measures based on fuel purchase records, product sales records, tax or other government payment records, and publicly reported data are preferred.~~

~~4. If the cap facility first began operations after January 1, 2009 and before July 1, 2011, annual average emissions and representative annual production shall be based on a consideration of the sum of the estimated total emissions and production, respectively, through 2011 divided by the number of whole and fractional years since initial startup.~~

~~5. By October 15, 2012 the department shall notify the authorized account representative of each cap facility of the measures of activity level and production, and the representative annual activity level, representative annual cap emissions, and representative annual production for the period 2009 through 2011, as determined by the department for the facility for purposes of allocating allowances to the facility.~~

~~6~~2. The Department's final determination may be appealed pursuant to the Air Quality Control Act, §74-2-7.H.~~The Department's final determination may be appealed to the Board~~.

E. ~~By December 31, 2012 the department shall allocate to the compliance account of each existing cap facility those allowances equal to the representative annual cap emissions, less a set-aside of three percent as provided by Section 20.2.350.203 NMAC. If the representative annual cap emissions less the set-aside is not a whole number, it shall be rounded to the nearest whole number for purposes of initial allocation.~~

~~F.~~ The department may revise the representative annual cap emissions or production for the existing cap facility if new information indicates that the values for representative annual cap emissions overestimated, or the values for representative annual production underestimated, that of normal operation in a typical year contemporaneous with the effective date of this part.

20.2.350.201 ALLOCATION OF ALLOWANCES ~~IN YEARS AFTER 2012~~.

A. By December 31 in ~~2013~~ the initial cap year, and on the same date in each subsequent consecutive year, the department shall allocate into the compliance account of each ~~existing~~ cap facility ~~those~~ allowances as calculated by Equation ~~200~~201-1. If the number of allowances as calculated by Equation ~~200~~201-1 is not a whole number, the allocation shall be that number rounded to the nearest whole number.

$$A_i = \left[((E_R \times I) - RPA_i) \times (1 - 0.03)\right] + A_{FB} + A_N$$

~~$$A_i = \left[(E_R - RPA) \times (1 - 0.03)\right] - (0.02 \times A_{i-1}) + A_{FB} + A_N$$~~ Equation ~~200~~201-1

Where:

A_i = allowances allocated in year i

~~A_{i-1} = allowances allocated in the year preceding year i~~

E_R = representative annual cap emissions. For cap facilities that are not existing cap facilities under Section 20.2.350.200 NMAC, the representative annual cap emissions shall be zero.

I = the cap adjustment factor determined in Equation 201-3 in Subsection E

0.03 = factor for deduction of allowances to be transferred to ~~new emissions~~new production set aside account pursuant to Subsection C of this section

~~0.02 = annual cap reduction factor~~

RPA_i = reduced production adjustment applied in allocation year i, calculated as specified in Subsection B

A_{FB} = flowback of previously set aside allowances, if any, calculated pursuant to Section 20.2.350.202 NMAC

A_N = ~~new emissions~~new production allowances, if any, ~~granted~~allotted ~~from the new emissions reserve as specified by~~pursuant to Section 20.2.350.202 NMAC.

B. Reduced Production Adjustment.

1. Each allocation year, the department shall determine the allocation production for each existing cap facility for purposes of allowance allocation. Allocation production shall be base on production that occurred during the year prior to the allocation year.

a. For an existing cap facility that is not grouped with any other cap facility pursuant to Subsection G of this Section, allocation production shall be the actual production at the existing cap facility, in the same units used for the facility's representative annual production.

b. For an existing cap facility that is grouped pursuant to Subsection G of this Section with one or more cap facilities that are not existing cap facilities, the allocation production shall be the sum of the actual production at all of the grouped cap facilities, in the same units used for the facility's representative annual production.

c. For an existing cap facility that is grouped pursuant to Subsection G of this Section with one or more cap facilities that include at least one other existing cap facility, the sum of the actual production at all of the grouped cap facilities, in the same units used for the facility's representative annual production, shall be divided between the existing cap facilities such that the ratio between the allocation production for each of the existing cap facilities shall be equal to the ratio of the representative annual production between the existing facilities.

2. If the allocation production ~~reported~~ for the existing cap facility ~~for the calendar year prior to the allocation year was~~is less than the representative annual production established for that facility in 20.2.350.200 NMAC, the reduced production adjustment ~~applied to that year's allocation~~ shall be calculated as specified by Equation ~~200~~201-2; otherwise the reduced production adjustment shall be zero:

$$RPA_i = E_R \times I \times \left(\frac{P_R - P_A}{P_R} \right)$$ Equation 201-2

~~$$RPA = E_R \times \left(\frac{P_R - P_{i-1}}{P_R} \right)$$ Equation 200-2~~

Where:

RPA_i = reduced production adjustment applied in allocation year i

E_R = representative annual cap emissions

P_R = representative annual production as specified in Subsection C or D of 20.2.350.200 NMAC

P_{Ai-1} = allocation ~~annual~~ production, as specified in paragraph 1 of this Subsection ~~for the year preceding year i~~

I = the cap adjustment factor determined in Equation 201-3.

C. The department shall transfer into the ~~new emissions~~new production set aside account the number of set-aside allowances deducted from the cap facility's allocation in Subsection A of this Section.

D. The department shall transfer into the ~~new emissions~~new production reserve account the number of allowances deducted from the cap facility's allocation as a result of the reduced production adjustment determined in Subsection ~~A~~ B of this Section.

E. The cap adjustment factor shall be calculated as specified by Equation 201-3:

$$I = 1 - [(Y_A - Y_{IN}) \times 0.02] \qquad \text{Equation 201-3}$$

Where:

I = the cap adjustment factor determined in Equation 201-3

Y_A = allocation year

Y_{IN} = initial cap year, as defined in Section 20.2.350.7 NMAC

0.02 = annual cap reduction

~~E~~F. Each year that the department determines that the delivery within the jurisdiction of this regulation, of electricity produced in jurisdictions outside the scope of this regulation has increased, and that there have been reduced production adjustments applied pursuant to Subsection A of ~~20.2.350.201 NMAC~~this section, the department shall transfer from the ~~new emissions~~new production reserve account into the ~~compliance~~ account established pursuant to Paragraph 2 of Subsection C of 20.2.350.101.C NMAC a number of allowances, as available, equal to the lesser of:

1. the estimated emissions, in metric tons of CO2e, that occurred in the production of the increase in the imported electricity; or
2. the number of allowances equal to the total of the reduced production adjustments for electric utilities.

G. Grouping of Cap Facilities. The authorized account representative of two or more cap facilities may request that the cap facilities be grouped for purposes of existing cap facility allowance allocation under this Section. Any cap facility in the group that is not an existing facility pursuant to Section 20.2.350.200 NMAC shall have representative annual production and representative annual cap emissions equal to zero. Such grouping shall:

1. along with any changes as to which cap facilities are included in the grouping, be subject to approval by the department;
2. be accomplished by means of registering the group with the department;
3. include at least one qualifying existing cap facility that meets the applicability requirements under Subsection A or Subsection B of 20.2.350.200 NMAC; and
4. include only cap facilities that:
   a.. have the same owners;
   b. have the same authorized account representative;
   c. are the same type of facility [e.g. electric utility or compressor station]; and
   d. have the same units of production that will be used by the department when determining allocation production under Subsection B of this Section.

20.2.350.202 ~~NEW EMISSIONS~~NEW PRODUCTION ALLOCATIONS.

A. The authorized account representative of any cap facility may choose to apply for allowance allocations for ~~new emissions~~new production that ~~are:~~

~~1. is~~ the result of new equipment or changes in activities that first occur at the facility after ~~July~~ January 1, 2011~~; and~~

~~2. directly related to an increase in annual production at the facility~~.

B. Authorization date for the ~~new emissions~~new production allocations. The authorized account representative of a cap facility may request allocations for ~~new emissions~~new production. The authorization date for the ~~new emissions~~new production allocations shall be the later of:

1. The date on which the department establishes the maximum allocations pursuant to Section 20.2.350.203 NMAC;

2. The date on which the department receives a request under this section that ~~new emissions~~new production allocations be established for the ~~new emissions~~new production; or

3. The date on which the department receives notification that the new production ~~that results from the new emissions~~ has commenced.

C. Distribution of ~~new emissions~~new production allocations. By December 31 of each year in which allocations are made under this part, the department shall:

1. evaluate the number of allowances in the ~~new emissions~~new production set-aside account and ~~new emissions~~new production reserve account;

2. determine the maximum ~~new emissions~~new production allocations that may be made under Section 20.2.350.203 NMAC for that allocation year to cap facilities that have requested such allocations; and

3. determine the amount of each ~~distribute such~~new production allocation~~s~~ pursuant to this Section such that:

a. no new production allocation to a cap facility shall exceed the maximum allocation amount ~~established~~ that may occur to that facility for ~~the new emissions~~ that allocation year~~associated with the authorization date~~;

b. no new production allocation ~~for new emissions~~ shall occur prior to the authorization date for ~~those new emissions~~new production allocations to that facility; and

c. allocations from the ~~new emissions~~new production set-aside account and ~~new emissions~~new production reserve account do not exceed the allowances in each account on the allocation date.

D. ~~Allocations~~ Distribution from the ~~new emissions~~new production reserve account. The department shall, until the account is exhausted or the sum of the maximum new ~~source~~ production allocations associated with authorized requests have been satisfied, ~~distribute~~ allot the allowances in the ~~new emissions~~new production reserve account in order of authorization date with the earlier dates first.

E. ~~Allocations for new emissions~~Distribution from the ~~new emissions~~new production set-aside account. If after ~~allocating~~ allotting allowances from the ~~new emissions~~new production reserve account under Subsection D of this Section, the sum of the remaining maximum new ~~source~~ production allocations associated with authorized requests have not been ~~allocated~~satisfied, the department shall take one of the following actions:

1. if the number of allowances represented by the sum of the maximum new ~~source~~ production allocations to remaining authorized requests is less than the number of

allowances in the ~~new emissions~~new production set-aside account, the department shall ~~allocate~~ allot the allowances; or

2. if the number of allowances represented by the sum of the maximum new ~~source~~ production allocations to remaining authorized requests is more than the number of allowances in the ~~new emissions~~new production set-aside account, the department shall ~~allocate~~ divide the allowances in the account between the remaining authorized requests ~~on a pro rata basis~~in amounts proportional to the maximum allocation for new production established for each for that allocation year.

F. Flow-back allocations from the ~~new emissions~~new production set-aside account. If after allocating allowances from the ~~new emissions~~new production set-aside account, allowances remain in the account, the department shall distribute the remaining allowances ~~on a pro rata basis~~ to ~~the~~ cap facilities in an amount proportional to ~~from which~~ the number of allowances that were set aside by each such facility.

20.2.350.203 MAXIMUM ALLOCATIONS FOR ~~NEW EMISSIONS~~NEW PRODUCTION.

A. No allocation of allowances under Section 20.2.350.202 NMAC may occur unless:

1. The authorized account representative has submitted a request that the department establish the maximum allocations for the ~~new emissions~~new production, which contains the following information:

a. the cap facility at which the ~~new emissions~~new production have or are to occur;

b. the equipment and activities associated with the ~~new emissions~~new production and date on which they commenced or are anticipated to commence production;

c. the increase in annual production associated with the ~~new emissions~~new production and the means of quantifying the increase in production;

d. a quantification of the new combustion emissions; and

e. a quantification of the new process emissions; and

2. The department has determined pursuant to this Section the maximum annual allocation and maximum allocation per unit of increased production that may occur for the ~~new emissions~~new production and the maximum production that may be associated with the authorization for such new production allocation.

B. Maximum allocations for ~~new emissions~~new production shall be determined by the department as follows.

1. The maximum annual allocation for combustion emissions per unit of increased production associated with the ~~new emissions~~new production shall not exceed the emissions that would occur using best available control technology for natural gas combustion.

2. The maximum annual allocation for process emissions per unit of increased production associated with the ~~new emissions~~new production shall not exceed those that would occur using best available control technology.

3. The maximum annual increase in production associated with the ~~new emissions~~new production allocation authorization shall be the lesser of:

a. that which may be reasonably expected from the new process or activity, considering the size of the equipment and nature of the activity; or

b. that which is provided pursuant to Paragraph ~~A.~~1 of Subsection A of this Section.

4. For purposes of determining the maximum allocation for the ~~new emissions~~new production for a specific allocation year, the term production (Pr) shall be the lesser of:

a. the ~~increased~~ actual production directly linked to the new equipment or activity associated with the request for ~~new emissions~~new production allocation;

b. for any cap facility that is grouped with other cap facilities pursuant to Subsection G of Section 20.2.350.201 NMAC, the difference between the sum of the allocation production for the group, and the sum of the representative annual cap emissions for the group ~~that occurred in the previous year and reported pursuant to 20.2.300 NMAC~~; or

~~b~~c. maximum annual increase in production associated with the new production allocation authorization under ~~pursuant to~~ paragraph ~~B.~~3 of Subsection B of this Section.

5. ~~The cap adjustment factor shall be calculated as specified by Equation 203-1:~~

~~$I = 1 - [(Y_A - Y_F) \times 0.02]$ Equation 203-1~~

~~Where:~~
~~I = the cap adjustment factor~~
~~Y_A = allocation year~~
~~Y_F = the first allocation year in which the cap facility received an allocation for the new emissions under Section 20.2.350.203 NMAC~~
~~0.02 = annual cap reduction~~

~~6.~~ The maximum allocation for the ~~new emissions~~new production in any allocation year shall be calculated as specified by Equation 203-~~2~~1:

$$A_{max} = \mathrm{Pr} \times (M_c + M_p) \times [1 - [(Y_A - Y_F) \times 0.02]]$$ Equation 203-~~2~~1

Where:
A_{max} = maximum new production allocation for the ~~new emissions in an~~ allocation year
Pr = Production, as specified in paragraph B.4 of this section.
M_c = maximum annual allocations per unit of ~~increased~~ production for combustion emissions, pursuant to paragraph B.1 of this section.
M_p = maximum annual allocations per unit of ~~increased~~ production for process emissions, pursuant to paragraph B.2 of this section.
Y_A = allocation year
Y_F = the first allocation year in which the cap facility received an allocation for the new production under Section 20.2.350.202 NMAC
0.02 = annual cap reduction~~I = the cap adjustment factor, determined by equation 203-1 pursuant to paragraph B.5 of this section~~.

6. The department may revise the maximum annual allocation for combustion or process emissions per unit of increased production associated with the new production, or the maximum annual increase in production associated with the new production

allocation authorization, if new information indicates that the values for emissions per unit of increased production or maximum annual increase in production were overestimated.

20.2.350.204 RECORDING OF ALLOWANCE ALLOCATIONS.

A. ~~By December 31, 2012 the department shall record in the following accounts the allowances for the allocation year 2012:~~

~~1. in each compliance account, the allowances allocated for the cap facility or facilities registered under that compliance account; and~~

~~2. in the new emissions set-aside account, the allowances allocated under Section 20.2.350.200 NMAC.~~

~~B.~~ By December 31 of the initial cap year and each following year the department shall record in the following accounts the allowances for that allocation year:

1. in each compliance account, ~~:~~

~~a.~~ the allowances allocated under Sections ~~20.2.350.200 or~~ 20.2.350.201 NMAC to the cap facility ~~or facilities~~ registered under that ~~compliance~~ account;

~~b. any new emissions allocations to the cap facility or facilities registered under that compliance account pursuant to Subsections D or E of 20.2.350.202 NMAC; and~~

~~c. any flow-back allowances allocated under Subsection F of Section 20.2.350.202 NMAC to the cap facility or facilities registered under that compliance account;~~

2. in the ~~new emissions~~new production set-aside account, the allowances transferred pursuant to Subsection C of 20.2.350.201 NMAC; and

3. in the ~~new emissions~~new production reserve account, the allowances transferred pursuant to Subsection D or 20.2.350.201 NMAC.

~~C~~B. Serial numbers for allocated allowances. ~~When~~ Prior to allocating allowances to and recording them in an account, the department shall assign each allowance a unique identification number that shall include digits identifying the vintage year for that allowance.

20.2.350.205 [Reserved for Early Reduction Allowances]

20.2.350.206 COMPLIANCE INSTRUMENTS THAT ORIGINATE IN OTHER JURISDICTIONS. A compliance instrument ~~that originates in~~issued by another jurisdiction may be used to meet a compliance obligation under Section 20.2.350.301 NMAC if the compliance instrument meets the requirements of this section.

A. The compliance instrument shall be:

1. recorded in the compliance account of the cap facility;

2. valid, ~~and have~~ not retired, and not ~~been~~ used to meet a compliance obligation in any other jurisdiction;

3. of a vintage year that occurs during or prior to the compliance period for which it is being used; and

4. issued by a jurisdiction approved under Subsection B of 20.2.350.206 NMAC.

B. The department may approve another jurisdiction for purposes of accepting a compliance instrument that originates from that jurisdiction if:

1. the department has evaluated the jurisdiction based on the qualifications described in Section 20.2.350.207 NMAC;
2. the department has provided public notice and an opportunity for public comment regarding the proposed approval of the jurisdiction; and
3. the department and the program authority have mutually acknowledged that their programs are compatible so as to:
   a. allow the mutual acceptance of compliance instruments issued by the department and other jurisdiction to meet compliance obligations; and
   b. provide that after any compliance instrument is retired or used to meet an obligation to surrender compliance instruments under a cap and trade program, it shall be disqualified for subsequent use under any system, whether such use is a sale, exchange, or submission to meet an obligation to surrender compliance instruments under a cap and trade program; and
4. the program authority for the other jurisdiction has provided assurances that it will continue to meet the qualifications in Section 20.2.350.207 NMAC.

20.2.350.207 QUALIFICATIONS FOR APPROVAL OF A JURISDICTION FOR PURPOSES OF ACCEPTING COMPLIANCE INSTRUMENTS THAT ORIGINATE FROM THAT JURISDICTION. In evaluating a jurisdiction, the department shall consider whether the jurisdiction:

A. has committed to a binding and annually declining aggregate total greenhouse gas emissions cap that covers one or more economic sectors in that jurisdiction; and

B. includes the following:
   1. a comprehensive registration requirement for all market participants;
   2. the capability to transfer relevant and necessary information on all registrants between the jurisdiction and the department using a non-commercial emissions tracking system that meets the criteria in Section 20.2.350.100 NMAC;
   3. provisions to ensure that offset credits accepted into the system provide ~~equal or greater~~ assurance ~~of~~ that the integrity of such offset credits is equal to or greater than that required by Section 20.2.350.208 NMAC;
   4. restrictions to the use of offset credits comparable to the quantitative usage limit established in Paragraph 3 of Subsection B of 20.2.350.301 NMAC;
   5. provisions for comparable monitoring, reporting, verification, compliance, and enforcement of its greenhouse gas emissions and emission reductions to that set forth in this part and 20.2.300 NMAC; and
   6. provisions that compliance instruments that are voluntarily retired or used to meet an obligation to surrender compliance instruments are disqualified from further use in any system;

C. includes enforcement mechanisms that:
   1. provide general market surveillance, identify suspect transactions, and provide for investigations and enforcement actions;
   2. ensure consequences for noncompliance are comparable between the other jurisdiction and this part;
   3. respond in a timely manner to requests by enforcement agencies in the jurisdiction and all jurisdictions approved by the department under this part for information on market participants under investigation by those agencies; and

4. transfer between systems in a timely manner relevant and necessary information of all relevant enforcement actions undertaken by the system's jurisdictional enforcement authority.

D. is capable of transferring between the jurisdiction and all jurisdictions approved by the department under this part information necessary to monitor market trends on a regional basis, including:

1. prices, aggregate emissions, positions of major market participants and expected issuance of offset credits; and

2. information that can be released to the public in a coordinated and consistent manner; and

E. provides an equal degree of protection for confidential business information.

20.2.350.208 OFFSET CREDITS

A. No offset credit shall be used to meet a compliance obligation unless the offset credit:

1. represents a greenhouse gas emission reduction, avoidance or sequestration that is real, additional, quantifiable, permanent, verifiable and enforceable;

2. has been authenticated through review and approval by ~~an offset providing program~~a jurisdiction or external trading program approved by the department under:

a.- Section 20.2.350.206 NMAC or Section 20.2.350.209 NMAC; and

b. Subsection B of this section;

3. has been developed using an offset protocol that has been reviewed and approved by the department to assure that the offset credit meets the requirements of this part.

4. has been issued for an offset project located in North America with a commencement date after December 31, 2006; and

5. is not the result of an offset project that reduced emissions that:

a. are covered by this Part; or

b. would be covered by this Part if they occurred within its jurisdiction.

B. The department shall not approve an offset ~~providing program~~from a jurisdiction or external trading program unless ~~such~~ the program authority can certify that the program will assure that the offset projects and offset credits that it authorizes are real, additional, quantifiable, permanent, verifiable and enforceable by:

1. performing audits of offset project sites;

2. requiring adequate reporting, recordkeeping and verification of the offset projects that produce offset credits; and

3. notifying the department in the event that an offset credit recorded in a general or compliance account under this part:

a. has been discovered to not meet the criteria of this section;

b. has been determined to be invalid; or

~~b~~c. has been used to meet a compliance obligation under a cap and trade program other than established by this part; and

4. retiring such offset credit from that jurisdiction or program at such time that the department notifies ~~it~~ the program authority that the offset credit has been used to meet a compliance obligation under this part.

C. If the department ~~or the offset providing program~~ determines that an offset credit recorded in a general or compliance account pursuant to this Part is or has become invalid:

1. the department shall:

a. notify the authorized account representative and program authority for the issuing jurisdiction or external trading program of such determination and the basis for it; and

b. if an invalid offset credit remains in the general or compliance account, remove it the from the account; and

2. if the offset credit has been used to meet a surrender obligation under this Part, the authorized account representative shall, within 30 days surrender a valid compliance instrument to replace each invalid offset credit.

20.2.350.209 COMPLIANCE INSTRUMENTS THAT ORIGINATE IN AN EXTERNAL TRADING PROGRAM.

A compliance instrument that originates in an external trading program may be used to meet a compliance obligation under Section 20.2.350.301 NMAC if:

A. The department has approved the external trading program after considering whether the program:

1. is run by a sub-national, national or regional government;

2. provides for emissions measurement, monitoring, reporting and verification that are comparable to the provisions of this part;

3. includes a binding ~~and declining~~ aggregate greenhouse gas emissions cap covering one or more economic sectors; and

4. contains offset credit provisions that

a. ensures a level of integrity commensurate with the offset requirements in Section 20.2.350.208 NMAC; and

b. limits the use of offsets so as to ensure that emissions reductions will also occur at the facilities covered by the external trading program;

B. The department and external trading program have established provisions to assure that after any compliance instrument issued by the external trading program is used to meet an obligation to surrender compliance instruments under this part, it shall be disqualified for subsequent use under any system, whether such use is a sale, exchange, or submission to meet an obligation to surrender compliance instruments under a cap and trade program; and

C. The compliance instrument is:

1. in units of metric tons CO2e~~, or has been converted to units of metric tons of CO2e and issued serial numbers pursuant to~~ [see Subsection B of 20.2.350.102 NMAC];

2. valid and has not been used to meet compliance obligations in any other jurisdiction; and

3. of a vintage year ~~in the external trading program~~ that ~~is~~ has occured during or prior to the compliance period for which it is being used.

20.2.350.210 to 20.2.350.299 [Reserved]

[SURRENDER OF COMPLIANCE INSTRUMENTS AND COMPLIANCE]

20.2.350.300 APPLICABILITY OF THE OBLIGATION TO SURRENDER COMPLIANCE INSTRUMENTS.

A. Except as provided in Subsections B and ~~C~~ D of this section, the obligation to surrender compliance instruments under Section 20.2.350.301 NMAC applies to the owner or operator of:

1. each cap facility for which emissions that meet or exceed the cap threshold are reported under 20.2.300 NMAC to have occurred in ~~2012~~ the initial cap year or any calendar year thereafter; and

2. each cap facility for which the designated account representative has voluntarily opted ~~to become subject to the obligation to surrender compliance instruments for cap emissions that occurred in 2012 or any calendar year thereafter~~in under the provisions of Subsection C of this Section.

B. Opting out of the obligation to surrender compliance instruments. If at any time after a facility becomes a cap facility the reported cap emissions at a cap facility are less than the cap threshold for 3 consecutive years, then the department may change the status of the facility to being no longer a cap facility. A facility that is no longer a cap facility is not subject to the obligation to surrender compliance instruments under this part for cap emissions that occur during subsequent years, until such future time that the facility becomes a cap facility under Subsection A of this section. The department may change the status of the facility to being not a cap facility if:

1. the designated account representative has requested~~:~~

~~a. the change of status for the cap facility, and~~

~~b. that the facility be removed from the compliance account~~; and

2. no outstanding compliance obligations are associated with the cap~~authorized account representative or the compliance account in which the~~ facility ~~is registered~~.

C. Opting into of the obligation to surrender compliance instruments. The designated account representative of a facility may voluntarily opt to have that facility become subject to the obligation to surrender compliance instruments pursuant to Section 20.2.350.301 NMAC for cap emissions that occurred in the initial cap year or any calendar year thereafter.

1. Opting in is subject to approval by the department.

2. The owner, operator or designated account representative shall apply for a compliance account for the facility in accordance with Subsection B of Section 20.1.350.101 NMAC.

3. Any facility that has opted in under this Section shall be subject to reporting requirements under 20.2.300 NMAC and verification requirements under 20.2.350.301 NMAC.

4. The effective date for opting in shall be January 1 of the calendar year following approval by the department.

5. A cap facility that has opted in may opt out under the provisions of Subsection B of this Section.

D. No facility shall be subject to an obligation to surrender a compliance instrument under this part for emissions that occur during a year prior to when the sum of initial cap year capped emissions of jurisdictions located in the United States and approved under Section 20.2.350.206 NMAC represent at least one hundred million metric tons CO2e.

20.2.350.301 ~~OBLIGATION TO~~ SURRENDER OF COMPLIANCE INSTRUMENTS.

A. The authorized account representative of each compliance account shall, as of the compliance instrument ~~transfer deadline~~surrender deadline, ~~hold in the compliance account~~surrender compliance instruments ~~available for compliance deductions, as defined under Subsection B of this section,~~ in an amount not less than the sum of the total cap emissions reported under 20.2.300 NMAC ~~for each cap facility within the compliance account~~ for each year ~~in the compliance period~~ for which the cap facility was subject to an obligation to surrender compliance instruments during the compliance period ~~under Section 20.2.350.300 NMAC~~. If the total cap emissions for the compliance period in units of metric tons is not a whole number, it shall be rounded up to the nearest whole number.

B. Qualifying c~~C~~ompliance instruments ~~available for compliance deduction~~. Compliance instruments that meet the following criteria ~~are available to be deducted~~may be used ~~in order for a cap facility~~ to comply with the obligation to surrender compliance instruments under this part.

1. The compliance instrument is valid.

2. The vintage year for each compliance instrument has occurred during or ~~is within a~~ prior to the compliance period ~~or the same compliance period~~ for which ~~the compliance instruments shall be deducted~~it is being used.

~~2~~3. ~~The compliance instruments are held in the compliance account as of the compliance instrument transfer deadline for that compliance period.~~

~~3.~~ The sum of offset credits and external trading program compliance instruments that are used to comply with ~~the~~ an obligation to surrender compliance instruments under this part for a compliance period may not exceed four percent of the total compliance obligation that applies for that compliance period to the cap ~~facilities in the compliance account~~facility.

~~**20.2.350.302 DEDUCTIONS FOR COMPLIANCE WITH AN OBLIGATION TO SURRENDER COMPLIANCE INSTRUMENTS.**~~

~~A. Deductions for compliance. Following the compliance instrument transfer deadline for a compliance period, the department shall deduct from each compliance account the compliance instruments to cover the sum of compliance obligations for all cap facilities in that account. Each cap facility's compliance obligation shall equal the facility's cap emissions for the compliance period.~~

~~B. Prior to deductions for compliance under Subsection A of this section, the department shall deduct any outstanding obligations from previous compliance periods, including any outstanding obligation under Subsection B of 20.2.350.303 NMAC.~~

~~C. A compliance instrument shall not be deducted, in order to comply with the requirements under Subsection A of this section, for a compliance instrument with a vintage year that occurs after the compliance period. The sum of offset credit and external trading program compliance instruments deducted under Subsections A or B of this section shall not exceed the limitation set out in Paragraph 3 of Subsection B of 20.2.350.301 NMAC.~~

~~D. The department shall make deductions from the compliance account until the amount of compliance instruments deducted equals the number of metric tons of total cap emissions for the compliance period from all cap facilities in the compliance account, or if there are insufficient compliance instruments available to meet compliance obligations, until no more compliance instruments available remain in the compliance account.~~

~~E. Identification of available compliance instruments by serial number; default compliance deductions.~~

~~1. The authorized account representative for a cap facility's compliance account may request that specific compliance instruments, identified by serial number, in the compliance account be deducted for emissions for a compliance period in accordance with Subsection A of this section.~~

~~2. The department shall deduct compliance instruments for a compliance period from the cap facility's compliance account, in the absence of an identification or in the case of a partial identification of available compliance instruments by serial number under Subsection A of 20.2.350.301 NMAC, in the following order:~~

~~a. First, subject to the relevant compliance deduction offset credit limitation under Paragraph 3 of Subsection B of 20.2.350.301 NMAC. Offset credits shall be deducted in chronological order (i.e., offset credits from earlier allocation years shall be deducted before offset credits from later allocation years). In the event that some, but not all, offset credits from a particular allocation year are to be deducted, offset credits shall be deducted by serial number, with lower serial number allowances deducted before higher serial number allowances.~~

~~b. Second, any allowances, other than offset credits, that are available for deduction under 20.2.350.301 NMAC. Allowances shall be deducted in chronological order (i.e., allowances from earlier allocation years shall be deducted before allowances from later allocation years). In the event that some, but not all, allowances from a particular allocation year are to be deducted, allowances shall be deducted by serial number, with lower serial number allowances deducted before higher serial number allowances.~~

~~F. The department shall record in the appropriate compliance account all deductions from such an account pursuant to Subsection A of this section.~~

~~G. The department may review and conduct independent audits concerning any submission under this part and make appropriate adjustments of the information in the submissions.~~

~~H. The department may deduct compliance instruments from, or transfer compliance instruments to, a source's compliance account based on information in the submissions.~~

C~~I~~. For each allowance that originated under this part and was surrendered to meet compliance obligations under this part or in any other jurisdiction, the department shall retire the compliance instrument and assure that it is disqualified for subsequent use in any program.

D~~J~~. For each compliance instrument that originated in another jurisdiction or program and surrendered to meet compliance obligations under this part, the department shall notify that jurisdiction or program that the compliance instrument shall be disqualified for subsequent use in any program.

20.2.350.~~303~~302 ENFORCEMENT AND PENALTIES FOR NON-COMPLIANCE.

A. Each of the following events shall constitute a separate violation of this part on each day of the applicable compliance period:

1. Each metric ton of cap emissions or portion thereof emitted in excess of the number of available compliance instruments in the compliance account on the compliance instrument ~~transfer deadline~~surrender deadline.

2. Each day or portion thereof that any report required by this part is not timely submitted or contains incomplete or inaccurate information.

B. In the event that a compliance account has insufficient compliance instruments to meet the obligation to surrender compliance instruments under Subsection A of 20.2.350.~~300~~ 301 NMAC, the following shall apply.

1. The compliance account shall be assessed an additional surrender obligation of compliance instruments equal to three times the number of insufficient compliance instruments. This assessment shall be in addition to any fine, penalty, assessment, corrective action, injunctive relief, or obligation otherwise applicable to the cap facility ~~or compliance account~~.

2. The authorized account representative shall ~~within 30 days transfer into the compliance account~~immediately surrender sufficient compliance instruments to cover the additional assessment. Offset credits and external trading program compliance instruments may be used to meet this obligation, provided that their sum shall adhere to the limit in Paragraph 3 of Subsection B of 20.2.350.301 NMAC.

~~3. The department shall deduct the additional assessment from the compliance account.~~

20.2.350.304 to 20.2.350.399 [Reserved]

[AUTHORIZED ACCOUNT REPRESENTATIVES]

20.2.350.400 AUTHORIZED ACCOUNT REPRESENTATIVES FOR CAP FACILITIES.

A. Authorization and responsibilities of authorized account representative.

1. Except as provided under Subsection B of this section, each cap facility shall have one authorized account representative, with regard to all matters under this part concerning the cap facility.

2. The authorized account representative of the cap facility shall be selected by an agreement binding on the owners and operators of the cap facility.

3. Upon receipt by the department of a complete account certificate of representation under Subsection D of this section, the authorized account representative of the capped facility shall represent and, by his or her representations, actions, inactions, or submissions, legally bind each owner and operator of the cap facility represented in all matters pertaining to this part, notwithstanding any agreement between the authorized account representative and such owners and operators. The owners and operators shall be bound by any decision or order issued to the authorized account representative by the department or a court regarding the source or unit.

4. No compliance account shall be established for a cap facility~~,~~ until the department has received a complete account certificate of representation under Subsection D of this section for an authorized account representative of the cap facility.

5. Each submission under this part shall be submitted, signed, and certified by the authorized account representative for each cap facility on behalf of which the submission is made. Each such submission shall include the following certification statement by the authorized account representative: "I am authorized to make this submission on behalf of the owners and operators of the cap facility for which the submission is made. I certify under penalty of law that I have personally examined, and am familiar with, the statements and information

submitted in this document and all its attachments. Based on my inquiry of those individuals with primary responsibility for obtaining the information, I certify that the statements and information are to the best of my knowledge and belief true, accurate, and complete. I am aware that there are significant penalties for submitting false statements and information or omitting required statements and information, including the possibility of fine or imprisonment."

6. The department shall accept or act on a submission made on behalf of owners or operators of a cap facility only if the submission has been made, signed, and certified in accordance with Paragraph 5 of this subsection.

B. Alternate authorized account representative.

1. An account certificate of representation may designate one and only one alternate authorized account representative who may act on behalf of the authorized account representative. The agreement by which the alternate authorized account representative is selected shall include a procedure for authorizing the alternate authorized account representative to act in lieu of the authorized account representative.

2. Upon receipt by the department of a complete account certificate of representation under Subsection D of this section, any representation, action, inaction, or submission by the alternate authorized account representative shall be deemed to be a representation, action, inaction, or submission by the authorized account representative.

3. Except in this section, whenever the term "authorized account representative" is used in this part, the term shall be construed to include the alternate authorized account representative.

C. Changing the authorized account representatives and the alternate authorized account representative; changes in the owner and operators.

1. Changing the authorized account representative. The authorized account representative may be changed at any time upon receipt by the department of a superseding complete account certificate of representation under Subsection D of this section. Notwithstanding any such change, all representations, actions, inactions, and submissions by the previous authorized account representative or alternate authorized account representative prior to the time and date when the department receives the superseding account certificate of representation shall be binding on the new authorized account representative and the owners and operators of the cap facility.

2. Changing the alternate authorized account representative. The alternate authorized account representative may be changed at any time upon receipt by the department of a superseding complete account certificate of representation under Subsection D of this section. Notwithstanding any such change, all representations, actions, inactions, and submissions by the previous or alternate authorized account representative or alternate authorized account representative prior to the time and date when the department receives the superseding account certificate of representation shall be binding on the new alternate authorized account representative and the owners and operators of the cap facility.

3. Changes in the owners and operators.

a. In the event a new owner or operator of a cap facility is not included in the list of owners and operators submitted in the account certificate of representation, such new owner or operator shall be deemed to be subject to and bound by the account certificate of representation, the representations, actions, inactions, and submissions of the authorized account representative and any alternate authorized account representative of the source or unit,

and the decisions, orders, actions, and inactions of the department, as if the new owner or operator were included in such list.

b. Within 30 days following any change in the owners and operators of a cap facility, including the addition of a new owner or operator, the authorized account representative or alternate authorized account representative shall submit a revision to the account certificate of representation amending the list of owners and operators to include the change.

D. Account certificate of representation.

1. A complete account certificate of representation for a authorized account representative or an alternate authorized account representative shall include the following elements in a format prescribed by the department:

a. identification of the cap facility or cap facilities for which the account certificate of representation is submitted;

b. the name, address, e-mail address, telephone number, and facsimile transmission number of the authorized account representative and any alternate authorized account representative;

c. a list of the owners and operators of the cap facility;

d. the following certification statement by the authorized account representative and any alternate authorized account representative: "I certify that I was selected as the authorized account representative or alternate authorized account representative, as applicable, by an agreement binding on the owners and operators of the cap facility. I certify that I have all the necessary authority to carry out my duties and responsibilities under 20.2.350 NMAC on behalf of the owners and operators of the cap facility and that each such owner and operator shall be fully bound by my representations, actions, inactions, or submissions and by any decision or order issued to me by the department or a court regarding the source or unit."; and

e. the signature of the authorized account representative and any alternate authorized account representative and the dates signed.

2. Unless otherwise required by the department, documents of agreement referred to in the account certificate of representation shall not be submitted to the department. Neither the department nor its agent shall be under any obligation to review or evaluate the sufficiency of such documents, if submitted.

E. Objections concerning the authorized account representative.

1. Once a complete account certificate of representation under Subsection D of this section has been submitted and received, the department shall rely on the account certificate of representation unless and until the department receives a superseding complete account certificate of representation under Subsection D of this section.

2. Except as provided in this part, no objection or other communication submitted to the department concerning the authorization, or any representation, action, inaction, or submission of the authorized account representative shall affect any representation, action, inaction, or submission of the authorized account representative or the finality of any decision or order by the department under this part.

3. The department shall not adjudicate any private legal dispute concerning the authorization or any representation, action, inaction, or submission of any authorized account representative, including private legal disputes concerning the proceeds of compliance instrument transfers.

F. Delegation by authorized account representative and alternate authorized account representative.

1. An authorized account representative may delegate, to one or more natural persons, his or her authority to make an electronic submission to the department under this part.

2. An alternate authorized account representative may delegate, to one or more natural persons, his or her authority to make an electronic submission to the department under this part.

3. In order to delegate authority to make an electronic submission to the department in accordance with this part, the authorized account representative or alternate authorized account representative, as appropriate, shall submit to the department a notice of delegation, in a format prescribed by the department that includes the following elements:

a. the name, address, e-mail address, telephone number, and facsimile transmission number of such authorized account representative or alternate authorized account representative;

b. the name, address, e-mail address, telephone number and facsimile transmission number of each such natural person, herein referred to as the "electronic submission agent";

c. for each such natural person, a list of the type of electronic submissions under this part for which authority is delegated to him or her; and

d. the following certification statements by such authorized account representative or alternate authorized account representative:

i. "I agree that any electronic submission to the department that is by a natural person identified in this notice of delegation and of a type listed for such electronic submission agent in this notice of delegation and that is made when I am a authorized account representative or alternate authorized account representative, as appropriate, and before this notice of delegation is superseded by another notice of delegation under 20.2.350 NMAC shall be deemed to be an electronic submission by me."; and

ii. "Until this notice of delegation is superseded by another notice of delegation under 20.2.350 NMAC, I agree to maintain an e-mail account and to notify the department immediately of any change in my e-mail address unless all delegation authority by me under 20.2.350 NMAC is terminated."

4. A notice of delegation submitted under this section shall be effective, with regard to the authorized account representative or alternate authorized account representative identified in such notice, upon receipt of such notice by the department and until receipt by the department of a superseding notice of delegation by such authorized account representative or alternate authorized account representative as appropriate. The superseding notice of delegation may replace any previously identified electronic submission agent, add a new electronic submission agent, or eliminate entirely any delegation of authority.

5. Any electronic submission covered by the certification in section and made in accordance with a notice of delegation effective under of this section shall be deemed to be an electronic submission by the authorized account representative or alternate authorized account representative submitting such notice of delegation.

20.2.350.401 AUTHORIZATION OF AUTHORIZED ACCOUNT REPRESENTATIVE FOR GENERAL ACCOUNT APPLICANTS.

A. Authorization of authorized account representative

1. Upon ~~receipt by the department of a complete application for~~establishment of a general account under this part, all of the following shall apply.

a. ~~The department shall establish a general account for the person or persons for whom the application is submitted.~~

~~b.~~ The authorized account representative and any alternate authorized account representative for the general account shall represent and, by his or her representations, actions, inactions, or submissions, legally bind each person who has an ownership interest with respect to compliance instruments held in the general account in all matters pertaining to this part, notwithstanding any agreement between the authorized account representative or any alternate authorized account representative and such person. Any such person shall be bound by any order or decision issued to the authorized account representative or any alternate authorized account representative by the department or a court regarding the general account.

~~c~~b. Any representation, action, inaction, or submission by any alternate authorized account representative shall be deemed to be a representation, action, inaction, or submission by the authorized account representative.

2. Each submission concerning the general account shall be submitted, signed, and certified by the authorized account representative or any alternate authorized account representative for the persons having an ownership interest with respect to compliance instruments held in the general account. Each such submission shall include the following certification statement by the authorized account representative or any alternate authorized account representative: "I am authorized to make this submission on behalf of the persons having an ownership interest with respect to the compliance instruments held in the general account. I certify under penalty of law that I have personally examined, and am familiar with, the statements and information submitted in this document and all its attachments. Based on my inquiry of those individuals with primary responsibility for obtaining the information, I certify that the statements and information are to the best of my knowledge and belief true, accurate, and complete. I am aware that there are significant penalties for submitting false statements and information or omitting required statements and information, including the possibility of fine or imprisonment."

3. The department shall accept or act on a submission concerning the general account only if the submission has been made, signed, and certified in accordance with this section.

B. Changing authorized account representative and alternate authorized account representative; changes in persons with ownership interest.

1. The authorized account representative for a general account may be changed at any time upon receipt by the department of a superseding complete application for a general account under this part. Notwithstanding any such change, all representations, actions, inactions, and submissions by the previous authorized account representative, or the previous alternate authorized account representative, prior to the time and date when the department receives the superseding application for a general account shall be binding on the new authorized account representative and the persons with an ownership interest with respect to the compliance instruments in the general account.

2. The alternate authorized account representative for a general account may be changed at any time upon receipt by the department of a superseding complete application for a general account under this part. Notwithstanding any such change, all representations, actions, inactions, and submissions by the previous authorized account representative, or the previous

alternate authorized account representative, prior to the time and date when the department receives the superseding application for a general account shall be binding on the new alternate authorized account representative and the persons with an ownership interest with respect to the compliance instruments in the general account.

3. In the event a new person having an ownership interest with respect to compliance instruments in the general account is not included in the list of such persons in the application for a general account, such new person shall be deemed to be subject to and bound by the application for a general account, the representations, actions, inactions, and submissions of the authorized account representative and any alternate authorized account representative, and the decisions, orders, actions, and inactions of the department, as if the new person were included in such list.

4. Within 30 days following any change in the persons having an ownership interest with respect to compliance instruments in the general account, including the addition or deletion of persons, the authorized account representative or any alternate authorized account representative shall submit a revision to the application for a general account amending the list of persons having an ownership interest with respect to the compliance instruments in the general account to include the change.

C. Objections concerning authorized account representative.

1. Once a complete application for a general account under this part has been submitted and received, the department shall rely on the application unless and until a superseding complete application for a general account under this part is received by the department.

2. Except as provided in this section, no objection or other communication submitted to the department concerning the authorization, or any representation, action, inaction, or submission of the authorized account representative or any alternate authorized account representative for a general account shall affect any representation, action, inaction, or submission of the authorized account representative or any alternate authorized account representative or the finality of any decision or order by the department under this part.

3. The department shall not adjudicate any private legal dispute concerning the authorization or any representation, action, inaction, or submission of the authorized account representative or any alternate authorized account representative for a general account, including private legal disputes concerning the proceeds of compliance instrument transfers.

D. Delegation by authorized account representative and alternate authorized account representative.

1. An authorized account representative may delegate, to one or more natural persons, his or her authority to make an electronic submission to the department provided for under this part.

2. An alternate authorized account representative may delegate, to one or more natural persons, his or her authority to make an electronic submission to the department provided for under this part.

3. In order to delegate authority to make an electronic submission to the department in accordance with this part, the authorized account representative or alternate authorized account representative, as appropriate, shall submit to the department a notice of delegation, in a format prescribed by the department that includes the following elements:

a. ~~The~~ contact information as required by the department, such as the name, address, e-mail address, telephone number, and facsimile transmission number of such authorized account representative, ~~or~~ alternate authorized account representative ;

~~b. The name, address, e-mail address, telephone number and facsimile transmission number of~~and each such natural person, herein referred to as "electronic submission agent";

~~c~~b. For each such natural person, a list of the type of electronic submissions under this part for which authority is delegated to him or her; and

~~d~~c. The following certification statements by such authorized account representative or alternate authorized account representative.

i. "I agree that any electronic submission to the department that is by a natural person identified in this notice of delegation and of a type listed for such electronic submission agent in this notice of delegation and that is made when I am an authorized account representative or alternate authorized account representative, as appropriate, and before this notice of delegation is superseded by another notice of delegation under 20.2.350 NMAC shall be deemed to be an electronic submission by me."

ii. "Until this notice of delegation is superseded by another notice of delegation under 20.2.350 NMAC, I agree to maintain an e-mail account and to notify the department immediately of any change in my e-mail address unless all delegation authority by me under 20.2.350 NMAC is terminated."

4. A notice of delegation submitted under this section shall be effective, with regard to the authorized account representative or alternate authorized account representative identified in such notice, upon receipt of such notice by the department and until receipt by the department of a superseding notice of delegation by such authorized account representative or alternate authorized account representative as appropriate. The superseding notice of delegation may replace any previously identified electronic submission agent, add a new electronic submission agent, or eliminate entirely any delegation of authority.

5. Any electronic submission covered by the certification in this section and made in accordance with a notice of delegation effective under this part shall be deemed to be an electronic submission by the authorized account representative or alternate authorized account representative submitting such notice of delegation.

A report of Working Group I of the Intergovernmental Panel on Climate Change

Summary for Policymakers

Drafting Authors:

Richard B. Alley, Terje Berntsen, Nathaniel L. Bindoff, Zhenlin Chen, Amnat Chidthaisong, Pierre Friedlingstein, Jonathan M. Gregory, Gabriele C. Hegerl, Martin Heimann, Bruce Hewitson, Brian J. Hoskins, Fortunat Joos, Jean Jouzel, Vladimir Kattsov, Ulrike Lohmann, Martin Manning, Taroh Matsuno, Mario Molina, Neville Nicholls, Jonathan Overpeck, Dahe Qin, Graciela Raga, Venkatachalam Ramaswamy, Jiawen Ren, Matilde Rusticucci, Susan Solomon, Richard Somerville, Thomas F. Stocker, Peter A. Stott, Ronald J. Stouffer, Penny Whetton, Richard A. Wood, David Wratt

Draft Contributing Authors:

J. Arblaster, G. Brasseur, J.H. Christensen, K.L. Denman, D.W. Fahey, P. Forster, E. Jansen, P.D. Jones, R. Knutti, H. Le Treut, P. Lemke, G. Meehl, P. Mote, D.A. Randall, D.A. Stone, K.E. Trenberth, J. Willebrand, F. Zwiers

This Summary for Policymakers should be cited as:

IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Introduction

The Working Group I contribution to the IPCC Fourth Assessment Report describes progress in understanding of the human and natural drivers of climate change,[1] observed climate change, climate processes and attribution, and estimates of projected future climate change. It builds upon past IPCC assessments and incorporates new findings from the past six years of research. Scientific progress since the Third Assessment Report (TAR) is based upon large amounts of new and more comprehensive data, more sophisticated analyses of data, improvements in understanding of processes and their simulation in models and more extensive exploration of uncertainty ranges.

The basis for substantive paragraphs in this Summary for Policymakers can be found in the chapter sections specified in curly brackets.

Human and Natural Drivers of Climate Change

Changes in the atmospheric abundance of greenhouse gases and aerosols, in solar radiation and in land surface properties alter the energy balance of the climate system. These changes are expressed in terms of radiative forcing,[2] which is used to compare how a range of human and natural factors drive warming or cooling influences on global climate. Since the TAR, new observations and related modelling of greenhouse gases, solar activity, land surface properties and some aspects of aerosols have led to improvements in the quantitative estimates of radiative forcing.

Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years (see Figure SPM.1). The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture. {2.3, 6.4, 7.3}

- Carbon dioxide is the most important anthropogenic greenhouse gas (see Figure SPM.2). The global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm to 379 ppm[3] in 2005. The atmospheric concentration of carbon dioxide in 2005 exceeds by far the natural range over the last 650,000 years (180 to 300 ppm) as determined from ice cores. The annual carbon dioxide concentration growth rate was larger during the last 10 years (1995–2005 average: 1.9 ppm per year), than it has been since the beginning of continuous direct atmospheric measurements (1960–2005 average: 1.4 ppm per year) although there is year-to-year variability in growth rates. {2.3, 7.3}

- The primary source of the increased atmospheric concentration of carbon dioxide since the pre-industrial period results from fossil fuel use, with land-use change providing another significant but smaller contribution. Annual fossil carbon dioxide emissions[4] increased from an average of 6.4 [6.0 to 6.8][5] GtC (23.5 [22.0 to 25.0] $GtCO_2$) per year in the 1990s to 7.2 [6.9 to 7.5] GtC (26.4 [25.3 to 27.5] $GtCO_2$) per year in 2000–2005 (2004 and 2005 data are interim estimates). Carbon dioxide emissions associated with land-use change

[1] *Climate change* in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

[2] *Radiative forcing* is a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. Positive forcing tends to warm the surface while negative forcing tends to cool it. In this report, radiative forcing values are for 2005 relative to pre-industrial conditions defined at 1750 and are expressed in watts per square metre ($W\ m^{-2}$). See Glossary and Section 2.2 for further details.

[3] ppm (parts per million) or ppb (parts per billion, 1 billion = 1,000 million) is the ratio of the number of greenhouse gas molecules to the total number of molecules of dry air. For example, 300 ppm means 300 molecules of a greenhouse gas per million molecules of dry air.

[4] Fossil carbon dioxide emissions include those from the production, distribution and consumption of fossil fuels and as a by-product from cement production. An emission of 1 GtC corresponds to 3.67 $GtCO_2$.

[5] In general, uncertainty ranges for results given in this Summary for Policymakers are 90% uncertainty intervals unless stated otherwise, that is, there is an estimated 5% likelihood that the value could be above the range given in square brackets and 5% likelihood that the value could be below that range. Best estimates are given where available. Assessed uncertainty intervals are not always symmetric about the corresponding best estimate. Note that a number of uncertainty ranges in the Working Group I TAR corresponded to 2 standard deviations (95%), often using expert judgement.

Changes in Greenhouse Gases from Ice Core and Modern Data

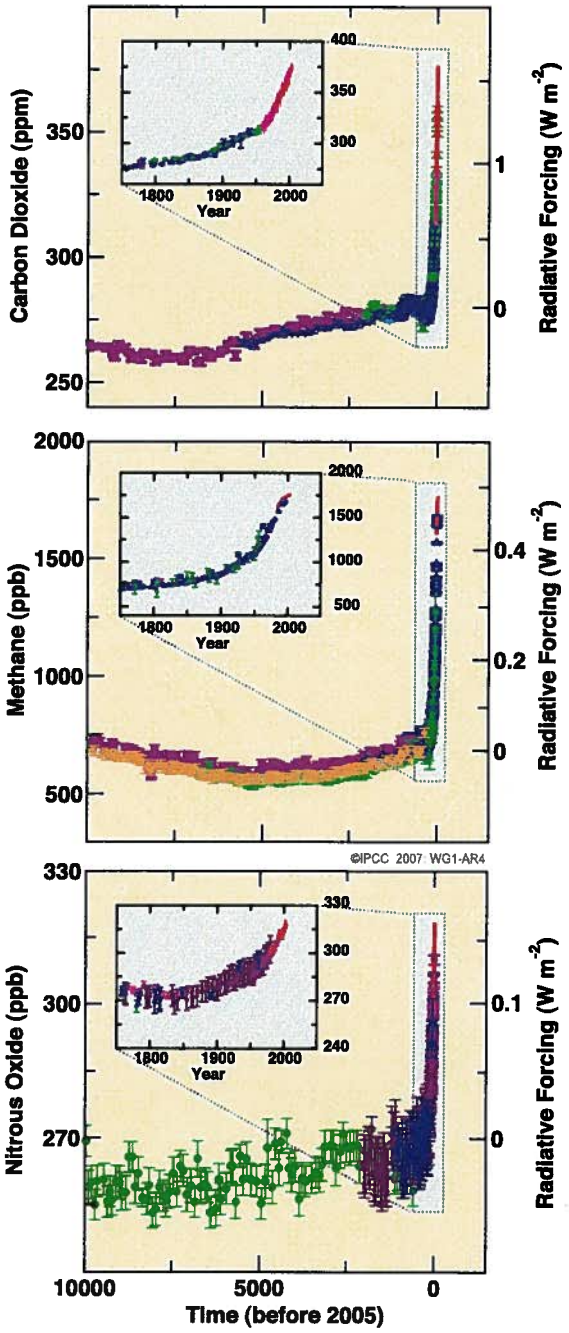


Figure SPM.1. *Atmospheric concentrations of carbon dioxide, methane and nitrous oxide over the last 10,000 years (large panels) and since 1750 (inset panels). Measurements are shown from ice cores (symbols with different colours for different studies) and atmospheric samples (red lines). The corresponding radiative forcings are shown on the right hand axes of the large panels. {Figure 6.4}*

are estimated to be 1.6 [0.5 to 2.7] GtC (5.9 [1.8 to 9.9] $GtCO_2$) per year over the 1990s, although these estimates have a large uncertainty. {7.3}

- The global atmospheric concentration of methane has increased from a pre-industrial value of about 715 ppb to 1732 ppb in the early 1990s, and was 1774 ppb in 2005. The atmospheric concentration of methane in 2005 exceeds by far the natural range of the last 650,000 years (320 to 790 ppb) as determined from ice cores. Growth rates have declined since the early 1990s, consistent with total emissions (sum of anthropogenic and natural sources) being nearly constant during this period. It is *very likely*[6] that the observed increase in methane concentration is due to anthropogenic activities, predominantly agriculture and fossil fuel use, but relative contributions from different source types are not well determined. {2.3, 7.4}

- The global atmospheric nitrous oxide concentration increased from a pre-industrial value of about 270 ppb to 319 ppb in 2005. The growth rate has been approximately constant since 1980. More than a third of all nitrous oxide emissions are anthropogenic and are primarily due to agriculture. {2.3, 7.4}

The understanding of anthropogenic warming and cooling influences on climate has improved since the TAR, leading to *very high confidence*[7] that the global average net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 [+0.6 to +2.4] W m^{-2} (see Figure SPM.2). {2.3., 6.5, 2.9}

- The combined radiative forcing due to increases in carbon dioxide, methane, and nitrous oxide is +2.30 [+2.07 to +2.53] W m^{-2}, and its rate of increase during the industrial era is *very likely* to have been unprecedented in more than 10,000 years (see Figures

[6] In this Summary for Policymakers, the following terms have been used to indicate the assessed likelihood, using expert judgement, of an outcome or a result: *Virtually certain* > 99% probability of occurrence, *Extremely likely* > 95%, *Very likely* > 90%, *Likely* > 66%, *More likely than not* > 50%, *Unlikely* < 33%, *Very unlikely* < 10%, *Extremely unlikely* < 5% (see Box TS.1 for more details).

[7] In this Summary for Policymakers the following levels of confidence have been used to express expert judgements on the correctness of the underlying science: *very high confidence* represents at least a 9 out of 10 chance of being correct; *high confidence* represents about an 8 out of 10 chance of being correct (see Box TS.1)

SPM.1 and SPM.2). The carbon dioxide radiative forcing increased by 20% from 1995 to 2005, the largest change for any decade in at least the last 200 years. {2.3, 6.4}

- Anthropogenic contributions to aerosols (primarily sulphate, organic carbon, black carbon, nitrate and dust) together produce a cooling effect, with a total direct radiative forcing of –0.5 [–0.9 to –0.1] W m^{-2} and an indirect cloud albedo forcing of –0.7 [–1.8 to –0.3] W m^{-2}. These forcings are now better understood than at the time of the TAR due to improved *in situ*, satellite and ground-based measurements and more comprehensive modelling, but remain the dominant uncertainty in radiative forcing. Aerosols also influence cloud lifetime and precipitation. {2.4, 2.9, 7.5}

- Significant anthropogenic contributions to radiative forcing come from several other sources. Tropospheric ozone changes due to emissions of ozone-forming chemicals (nitrogen oxides, carbon monoxide, and hydrocarbons) contribute +0.35 [+0.25 to +0.65] W m^{-2}. The direct radiative forcing due to changes in halocarbons[8] is +0.34 [+0.31 to +0.37] W m^{-2}. Changes in surface albedo, due to land cover changes and deposition of black carbon aerosols on snow, exert

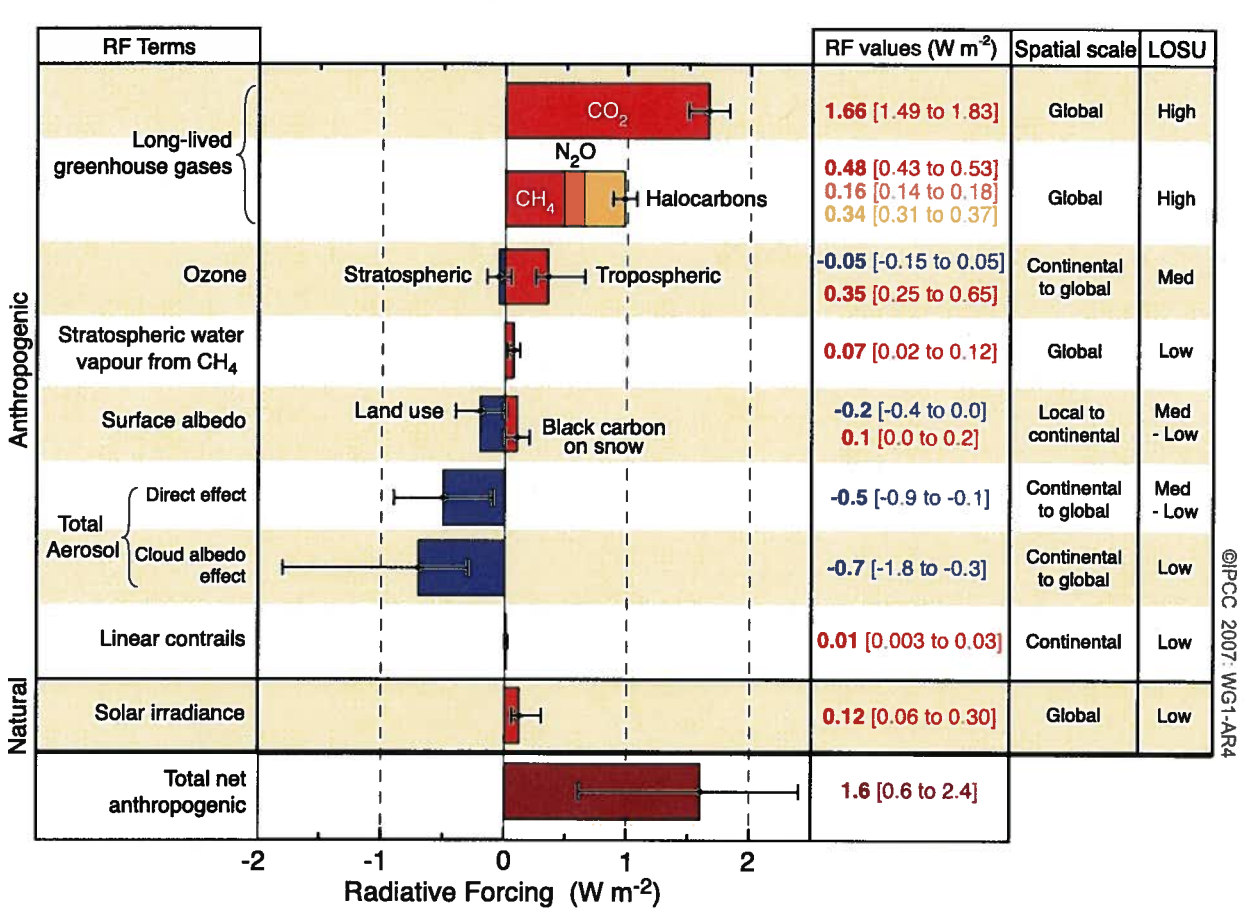


Figure SPM.2. *Global average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. These require summing asymmetric uncertainty estimates from the component terms, and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure due to their episodic nature. The range for linear contrails does not include other possible effects of aviation on cloudiness. {2.9, Figure 2.20}*

[8] Halocarbon radiative forcing has been recently assessed in detail in *IPCC's Special Report on Safeguarding the Ozone Layer and the Global Climate System* (2005).

respective forcings of –0.2 [–0.4 to 0.0] and +0.1 [0.0 to +0.2] W m^{-2}. Additional terms smaller than ±0.1 W m^{-2} are shown in Figure SPM.2. {2.3, 2.5, 7.2}

- Changes in solar irradiance since 1750 are estimated to cause a radiative forcing of +0.12 [+0.06 to +0.30] W m^{-2}, which is less than half the estimate given in the TAR. {2.7}

Direct Observations of Recent Climate Change

Since the TAR, progress in understanding how climate is changing in space and in time has been gained through improvements and extensions of numerous datasets and data analyses, broader geographical coverage, better understanding of uncertainties, and a wider variety of measurements. Increasingly comprehensive observations are available for glaciers and snow cover since the 1960s, and for sea level and ice sheets since about the past decade. However, data coverage remains limited in some regions.

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (see Figure SPM.3). {3.2, 4.2, 5.5}

- Eleven of the last twelve years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature[9] (since 1850). The updated 100-year linear trend (1906 to 2005) of 0.74°C [0.56°C to 0.92°C] is therefore larger than the corresponding trend for 1901 to 2000 given in the TAR of 0.6°C [0.4°C to 0.8°C]. The linear warming trend over the last 50 years (0.13°C [0.10°C to 0.16°C] per decade) is nearly twice that for the last 100 years. The total temperature increase from 1850–1899 to 2001–2005 is 0.76°C [0.57°C to 0.95°C]. Urban heat island effects are real but local, and have a negligible influence (less than 0.006°C per decade over land and zero over the oceans) on these values. {3.2}

- New analyses of balloon-borne and satellite measurements of lower- and mid-tropospheric temperature show warming rates that are similar to those of the surface temperature record and are consistent within their respective uncertainties, largely reconciling a discrepancy noted in the TAR. {3.2, 3.4}

- The average atmospheric water vapour content has increased since at least the 1980s over land and ocean as well as in the upper troposphere. The increase is broadly consistent with the extra water vapour that warmer air can hold. {3.4}

- Observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000 m and that the ocean has been absorbing more than 80% of the heat added to the climate system. Such warming causes seawater to expand, contributing to sea level rise (see Table SPM.1). {5.2, 5.5}

- Mountain glaciers and snow cover have declined on average in both hemispheres. Widespread decreases in glaciers and ice caps have contributed to sea level rise (ice caps do not include contributions from the Greenland and Antarctic Ice Sheets). (See Table SPM.1.) {4.6, 4.7, 4.8, 5.5}

- New data since the TAR now show that losses from the ice sheets of Greenland and Antarctica have *very likely* contributed to sea level rise over 1993 to 2003 (see Table SPM.1). Flow speed has increased for some Greenland and Antarctic outlet glaciers, which drain ice from the interior of the ice sheets. The corresponding increased ice sheet mass loss has often followed thinning, reduction or loss of ice shelves or loss of floating glacier tongues. Such dynamical ice loss is sufficient to explain most of the Antarctic net mass loss and approximately half of the Greenland net mass loss. The remainder of the ice loss from Greenland has occurred because losses due to melting have exceeded accumulation due to snowfall. {4.6, 4.8, 5.5}

- Global average sea level rose at an average rate of 1.8 [1.3 to 2.3] mm per year over 1961 to 2003. The rate was faster over 1993 to 2003: about 3.1 [2.4 to 3.8] mm per year. Whether the faster rate for 1993 to 2003 reflects decadal variability or an increase in the longer-term trend is unclear. There is *high confidence* that

[9] The average of near-surface air temperature over land and sea surface temperature.

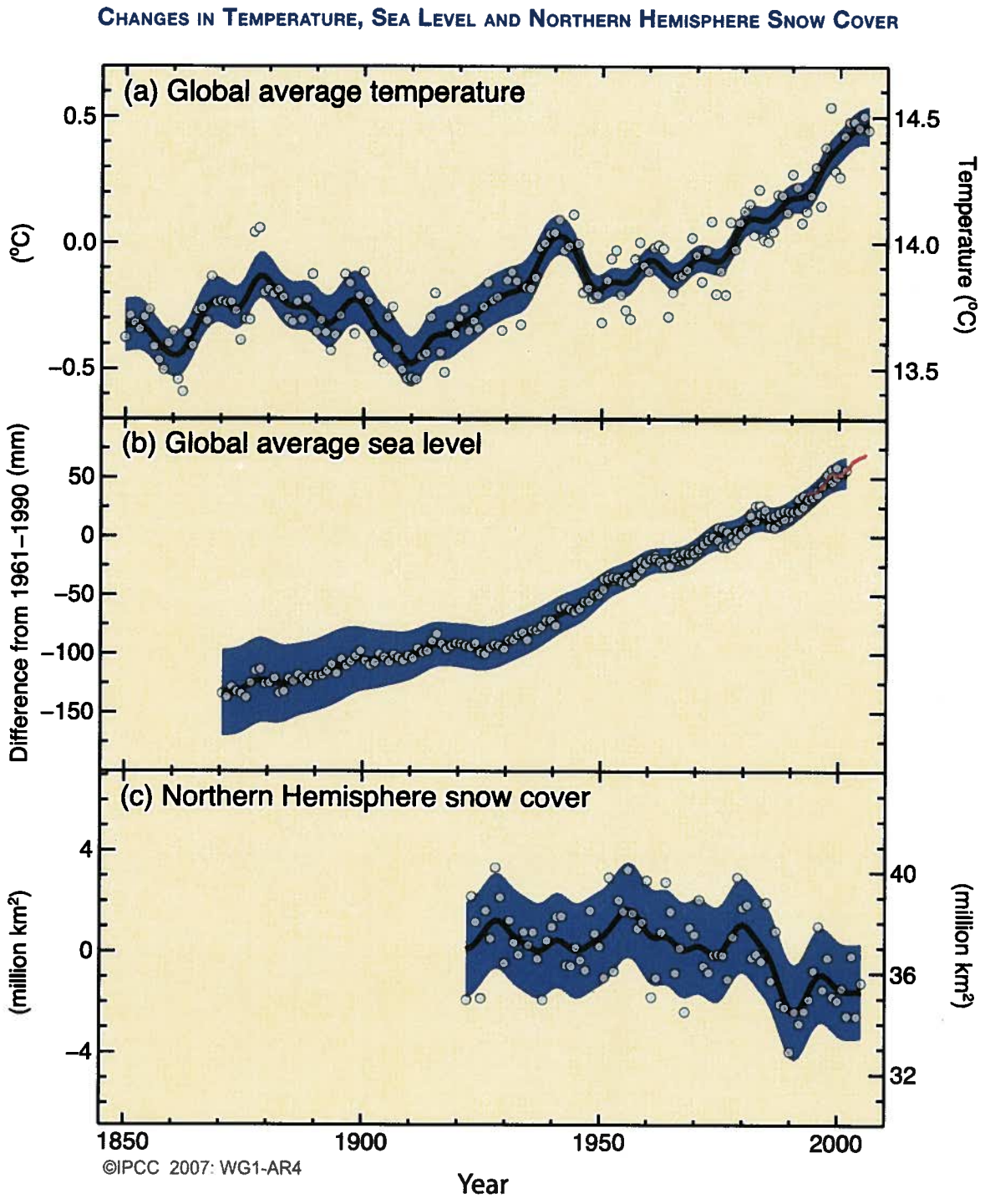


Figure SPM.3. *Observed changes in (a) global average surface temperature, (b) global average sea level from tide gauge (blue) and satellite (red) data and (c) Northern Hemisphere snow cover for March-April. All changes are relative to corresponding averages for the period 1961–1990. Smoothed curves represent decadal average values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c). {FAQ 3.1, Figure 1, Figure 4.2, Figure 5.13}*

the rate of observed sea level rise increased from the 19th to the 20th century. The total 20th-century rise is estimated to be 0.17 [0.12 to 0.22] m. {5.5}

- For 1993 to 2003, the sum of the climate contributions is consistent within uncertainties with the total sea level rise that is directly observed (see Table SPM.1). These estimates are based on improved satellite and *in situ* data now available. For the period 1961 to 2003, the sum of climate contributions is estimated to be smaller than the observed sea level rise. The TAR reported a similar discrepancy for 1910 to 1990. {5.5}

At continental, regional and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones.[10] {3.2, 3.3, 3.4, 3.5, 3.6, 5.2}

- Average arctic temperatures increased at almost twice the global average rate in the past 100 years. Arctic temperatures have high decadal variability, and a warm period was also observed from 1925 to 1945. {3.2}

- Satellite data since 1978 show that annual average arctic sea ice extent has shrunk by 2.7 [2.1 to 3.3]% per decade, with larger decreases in summer of 7.4 [5.0 to 9.8]% per decade. These values are consistent with those reported in the TAR. {4.4}

- Temperatures at the top of the permafrost layer have generally increased since the 1980s in the Arctic (by up to 3°C). The maximum area covered by seasonally frozen ground has decreased by about 7% in the Northern Hemisphere since 1900, with a decrease in spring of up to 15%. {4.7}

- Long-term trends from 1900 to 2005 have been observed in precipitation amount over many large regions.[11] Significantly increased precipitation has been observed in eastern parts of North and South America, northern Europe and northern and central Asia. Drying has been observed in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Precipitation is highly variable spatially and temporally, and data are limited in some regions. Long-term trends have not been observed for the other large regions assessed.[11] {3.3, 3.9}

- Changes in precipitation and evaporation over the oceans are suggested by freshening of mid- and high-latitude waters together with increased salinity in low-latitude waters. {5.2}

Table SPM.1. *Observed rate of sea level rise and estimated contributions from different sources. {5.5, Table 5.3}*

Source of sea level rise	Rate of sea level rise (mm per year) 1961–2003	1993–2003
Thermal expansion	0.42 ± 0.12	1.6 ± 0.5
Glaciers and ice caps	0.50 ± 0.18	0.77 ± 0.22
Greenland Ice Sheet	0.05 ± 0.12	0.21 ± 0.07
Antarctic Ice Sheet	0.14 ± 0.41	0.21 ± 0.35
Sum of individual climate contributions to sea level rise	1.1 ± 0.5	2.8 ± 0.7
Observed total sea level rise	1.8 ± 0.5[a]	3.1 ± 0.7[a]
Difference (Observed minus sum of estimated climate contributions)	0.7 ± 0.7	0.3 ± 1.0

Table note:
[a] Data prior to 1993 are from tide gauges and after 1993 are from satellite altimetry.

[10] Tropical cyclones include hurricanes and typhoons.

[11] The assessed regions are those considered in the regional projections chapter of the TAR and in Chapter 11 of this report.

- Mid-latitude westerly winds have strengthened in both hemispheres since the 1960s. {3.5}

- More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics. Increased drying linked with higher temperatures and decreased precipitation has contributed to changes in drought. Changes in sea surface temperatures, wind patterns and decreased snowpack and snow cover have also been linked to droughts. {3.3}

- The frequency of heavy precipitation events has increased over most land areas, consistent with warming and observed increases of atmospheric water vapour. {3.8, 3.9}

- Widespread changes in extreme temperatures have been observed over the last 50 years. Cold days, cold nights and frost have become less frequent, while hot days, hot nights and heat waves have become more frequent (see Table SPM.2). {3.8}

Table SPM.2. *Recent trends, assessment of human influence on the trend and projections for extreme weather events for which there is an observed late-20th century trend. {Tables 3.7, 3.8, 9.4; Sections 3.8, 5.5, 9.7, 11.2–11.9}*

Phenomenon[a] and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend[b]	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	*Very likely*[c]	*Likely*[d]	*Virtually certain*[d]
Warmer and more frequent hot days and nights over most land areas	*Very likely*[e]	*Likely (nights)*[d]	*Virtually certain*[d]
Warm spells/heat waves. Frequency increases over most land areas	*Likely*	*More likely than not*[f]	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Likely*	*More likely than not*[f]	*Very likely*
Area affected by droughts increases	*Likely* in many regions since 1970s	*More likely than not*	*Likely*
Intense tropical cyclone activity increases	*Likely* in some regions since 1970	*More likely than not*[f]	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis)[g]	*Likely*	*More likely than not*[f,h]	*Likely*[i]

Table notes:

[a] See Table 3.7 for further details regarding definitions.

[b] See Table TS.4, Box TS.5 and Table 9.4.

[c] Decreased frequency of cold days and nights (coldest 10%).

[d] Warming of the most extreme days and nights each year.

[e] Increased frequency of hot days and nights (hottest 10%).

[f] Magnitude of anthropogenic contributions not assessed. Attribution for these phenomena based on expert judgement rather than formal attribution studies.

[g] Extreme high sea level depends on average sea level and on regional weather systems. It is defined here as the highest 1% of hourly values of observed sea level at a station for a given reference period.

[h] Changes in observed extreme high sea level closely follow the changes in average sea level. {5.5} It is *very likely* that anthropogenic activity contributed to a rise in average sea level. {9.5}

[i] In all scenarios, the projected global average sea level at 2100 is higher than in the reference period. {10.6} The effect of changes in regional weather systems on sea level extremes has not been assessed.

- There is observational evidence for an increase in intense tropical cyclone activity in the North Atlantic since about 1970, correlated with increases of tropical sea surface temperatures. There are also suggestions of increased intense tropical cyclone activity in some other regions where concerns over data quality are greater. Multi-decadal variability and the quality of the tropical cyclone records prior to routine satellite observations in about 1970 complicate the detection of long-term trends in tropical cyclone activity. There is no clear trend in the annual numbers of tropical cyclones. {3.8}

Some aspects of climate have not been observed to change. {3.2, 3.8, 4.4, 5.3}

- A decrease in diurnal temperature range (DTR) was reported in the TAR, but the data available then extended only from 1950 to 1993. Updated observations reveal that DTR has not changed from 1979 to 2004 as both day- and night-time temperature have risen at about the same rate. The trends are highly variable from one region to another. {3.2}

- Antarctic sea ice extent continues to show interannual variability and localised changes but no statistically significant average trends, consistent with the lack of warming reflected in atmospheric temperatures averaged across the region. {3.2, 4.4}

- There is insufficient evidence to determine whether trends exist in the meridional overturning circulation (MOC) of the global ocean or in small-scale phenomena such as tornadoes, hail, lightning and dust-storms. {3.8, 5.3}

A Palaeoclimatic Perspective

Palaeoclimatic studies use changes in climatically sensitive indicators to infer past changes in global climate on time scales ranging from decades to millions of years. Such proxy data (e.g., tree ring width) may be influenced by both local temperature and other factors such as precipitation, and are often representative of particular seasons rather than full years. Studies since the TAR draw increased confidence from additional data showing coherent behaviour across multiple indicators in different parts of the world. However, uncertainties generally increase with time into the past due to increasingly limited spatial coverage.

Palaeoclimatic information supports the interpretation that the warmth of the last half century is unusual in at least the previous 1,300 years. The last time the polar regions were significantly warmer than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to 4 to 6 m of sea level rise. {6.4, 6.6}

- Average Northern Hemisphere temperatures during the second half of the 20th century were *very likely* higher than during any other 50-year period in the last 500 years and *likely* the highest in at least the past 1,300 years. Some recent studies indicate greater variability in Northern Hemisphere temperatures than suggested in the TAR, particularly finding that cooler periods existed in the 12th to 14th, 17th and 19th centuries. Warmer periods prior to the 20th century are within the uncertainty range given in the TAR. {6.6}

- Global average sea level in the last interglacial period (about 125,000 years ago) was *likely* 4 to 6 m higher than during the 20th century, mainly due to the retreat of polar ice. Ice core data indicate that average polar temperatures at that time were 3°C to 5°C higher than present, because of differences in the Earth's orbit. The Greenland Ice Sheet and other arctic ice fields *likely* contributed no more than 4 m of the observed sea level rise. There may also have been a contribution from Antarctica. {6.4}

Understanding and Attributing Climate Change

This assessment considers longer and improved records, an expanded range of observations and improvements in the simulation of many aspects of climate and its variability based on studies since the TAR. It also considers the results of new attribution studies that have evaluated whether observed changes are quantitatively consistent with the expected response to external forcings and inconsistent with alternative physically plausible explanations.

Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.[12] This is an advance since the TAR's conclusion that "most of the observed warming over the last 50 years is *likely* to have been due to the increase in greenhouse gas concentrations". Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns (see Figure SPM.4 and Table SPM.2). {9.4, 9.5}

- It is *likely* that increases in greenhouse gas concentrations alone would have caused more warming than observed because volcanic and anthropogenic aerosols have offset some warming that would otherwise have taken place. {2.9, 7.5, 9.4}

- The observed widespread warming of the atmosphere and ocean, together with ice mass loss, support the conclusion that it is *extremely unlikely* that global climate change of the past 50 years can be explained without external forcing, and *very likely* that it is not due to known natural causes alone. {4.8, 5.2, 9.4, 9.5, 9.7}

- Warming of the climate system has been detected in changes of surface and atmospheric temperatures in the upper several hundred metres of the ocean, and in contributions to sea level rise. Attribution studies have established anthropogenic contributions to all of these changes. The observed pattern of tropospheric warming and stratospheric cooling is *very likely* due to the combined influences of greenhouse gas increases and stratospheric ozone depletion. {3.2, 3.4, 9.4, 9.5}

- It is *likely* that there has been significant anthropogenic warming over the past 50 years averaged over each continent except Antarctica (see Figure SPM.4). The observed patterns of warming, including greater warming over land than over the ocean, and their changes over time, are only simulated by models that include anthropogenic forcing. The ability of coupled climate models to simulate the observed temperature evolution on each of six continents provides stronger evidence of human influence on climate than was available in the TAR. {3.2, 9.4}

- Difficulties remain in reliably simulating and attributing observed temperature changes at smaller scales. On these scales, natural climate variability is relatively larger, making it harder to distinguish changes expected due to external forcings. Uncertainties in local forcings and feedbacks also make it difficult to estimate the contribution of greenhouse gas increases to observed small-scale temperature changes. {8.3, 9.4}

- Anthropogenic forcing is *likely* to have contributed to changes in wind patterns,[13] affecting extra-tropical storm tracks and temperature patterns in both hemispheres. However, the observed changes in the Northern Hemisphere circulation are larger than simulated in response to 20th-century forcing change. {3.5, 3.6, 9.5, 10.3}

- Temperatures of the most extreme hot nights, cold nights and cold days are *likely* to have increased due to anthropogenic forcing. It is *more likely than not* that anthropogenic forcing has increased the risk of heat waves (see Table SPM.2). {9.4}

[12] Consideration of remaining uncertainty is based on current methodologies.

[13] In particular, the Southern and Northern Annular Modes and related changes in the North Atlantic Oscillation. {3.6, 9.5, Box TS.2}

Global and Continental Temperature Change

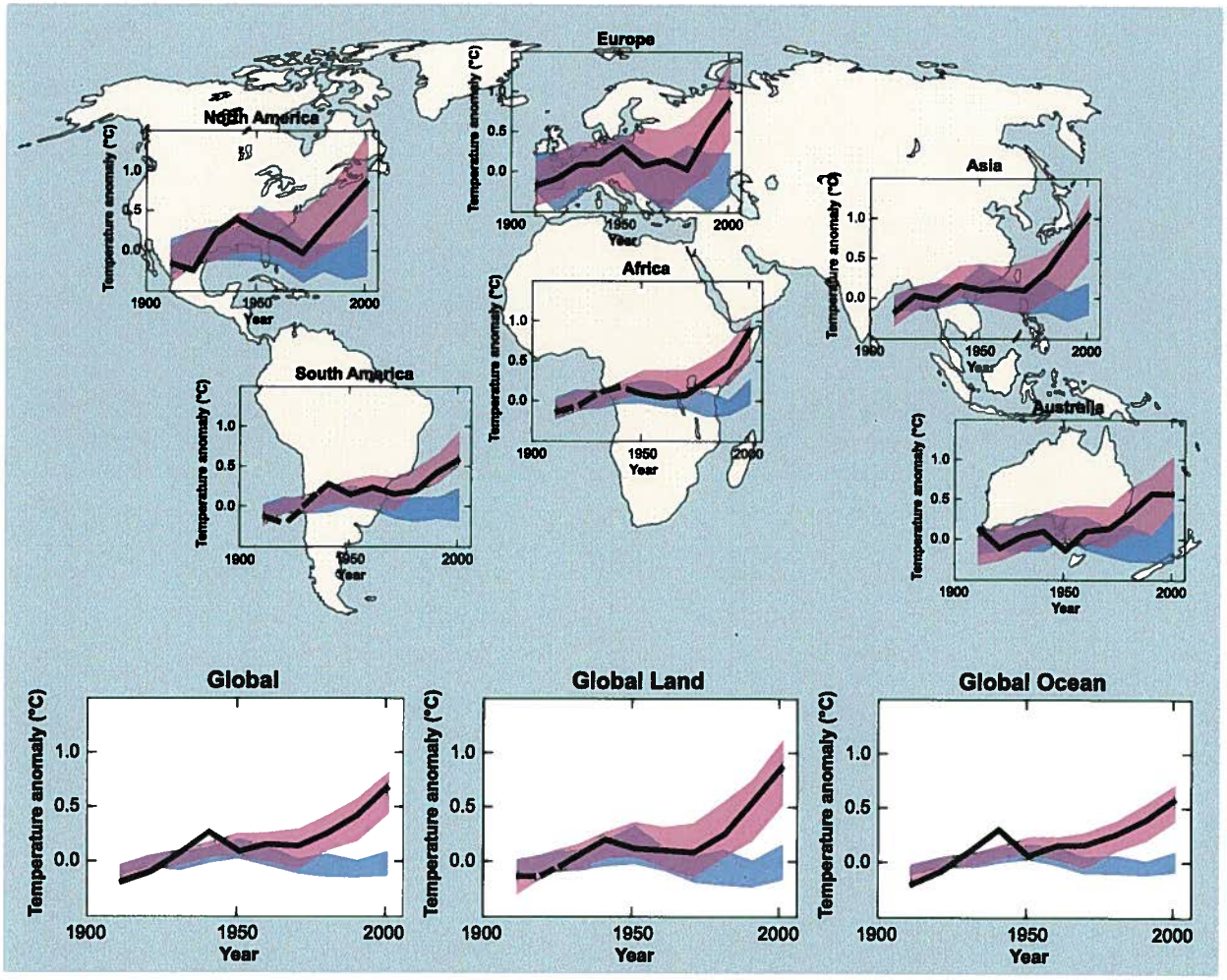


Figure SPM.4. *Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906 to 2005 (black line) plotted against the centre of the decade and relative to the corresponding average for 1901–1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5–95% range for 19 simulations from five climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5–95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings. {FAQ 9.2, Figure 1}*

Analysis of climate models together with constraints from observations enables an assessed *likely* range to be given for climate sensitivity for the first time and provides increased confidence in the understanding of the climate system response to radiative forcing. {6.6, 8.6, 9.6, Box 10.2}

- The equilibrium climate sensitivity is a measure of the climate system response to sustained radiative forcing. It is not a projection but is defined as the global average surface warming following a doubling of carbon dioxide concentrations. It is *likely* to be in the range 2°C to 4.5°C with a best estimate of about 3°C, and is *very unlikely* to be less than 1.5°C. Values substantially higher than 4.5°C cannot be excluded, but agreement of models with observations is not as good for those values. Water vapour changes represent the largest feedback affecting climate sensitivity and are now better understood than in the TAR. Cloud feedbacks remain the largest source of uncertainty. {8.6, 9.6, Box 10.2}

- It is *very unlikely* that climate changes of at least the seven centuries prior to 1950 were due to variability generated within the climate system alone. A significant fraction of the reconstructed Northern Hemisphere inter-decadal temperature variability over those centuries is *very likely* attributable to volcanic eruptions and changes in solar irradiance, and it is *likely* that anthropogenic forcing contributed to the early 20th-century warming evident in these records. {2.7, 2.8, 6.6, 9.3}

Projections of Future Changes in Climate

A major advance of this assessment of climate change projections compared with the TAR is the large number of simulations available from a broader range of models. Taken together with additional information from observations, these provide a quantitative basis for estimating likelihoods for many aspects of future climate change. Model simulations cover a range of possible futures including idealised emission or concentration assumptions. These include SRES[14] illustrative marker scenarios for the 2000 to 2100 period and model experiments with greenhouse gases and aerosol concentrations held constant after year 2000 or 2100.

For the next two decades, a warming of about 0.2°C per decade is projected for a range of SRES emission scenarios. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected. {10.3, 10.7}

- Since IPCC's first report in 1990, assessed projections have suggested global average temperature increases between about 0.15°C and 0.3°C per decade for 1990 to 2005. This can now be compared with observed values of about 0.2°C per decade, strengthening confidence in near-term projections. {1.2, 3.2}

- Model experiments show that even if all radiative forcing agents were held constant at year 2000 levels, a further warming trend would occur in the next two decades at a rate of about 0.1°C per decade, due mainly to the slow response of the oceans. About twice as much warming (0.2°C per decade) would be expected if emissions are within the range of the SRES scenarios. Best-estimate projections from models indicate that decadal average warming over each inhabited continent by 2030 is insensitive to the choice among SRES scenarios and is *very likely* to be at least twice as large as the corresponding model-estimated natural variability during the 20th century. {9.4, 10.3, 10.5, 11.2–11.7, Figure TS-29}

[14] SRES refers to the *IPCC Special Report on Emission Scenarios* (2000). The SRES scenario families and illustrative cases, which did not include additional climate initiatives, are summarised in a box at the end of this Summary for Policymakers. Approximate carbon dioxide equivalent concentrations corresponding to the computed radiative forcing due to anthropogenic greenhouse gases and aerosols in 2100 (see p. 823 of the TAR) for the SRES B1, A1T, B2, A1B, A2 and A1FI illustrative marker scenarios are about 600, 700, 800, 850, 1250 and 1,550 ppm respectively. Scenarios B1, A1B and A2 have been the focus of model intercomparison studies and many of those results are assessed in this report.

Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely* be larger than those observed during the 20th century. {10.3}

- Advances in climate change modelling now enable best estimates and *likely* assessed uncertainty ranges to be given for projected warming for different emission scenarios. Results for different emission scenarios are provided explicitly in this report to avoid loss of this policy-relevant information. Projected global average surface warmings for the end of the 21st century (2090–2099) relative to 1980–1999 are shown in Table SPM.3. These illustrate the differences between lower and higher SRES emission scenarios, and the projected warming uncertainty associated with these scenarios. {10.5}

- Best estimates and *likely* ranges for global average surface air warming for six SRES emissions marker scenarios are given in this assessment and are shown in Table SPM.3. For example, the best estimate for the low scenario (B1) is 1.8°C (*likely* range is 1.1°C to 2.9°C), and the best estimate for the high scenario (A1FI) is 4.0°C (*likely* range is 2.4°C to 6.4°C). Although these projections are broadly consistent with the span quoted in the TAR (1.4°C to 5.8°C), they are not directly comparable (see Figure SPM.5). The Fourth Assessment Report is more advanced as it provides best estimates and an assessed likelihood range for each of the marker scenarios. The new assessment of the *likely* ranges now relies on a larger number of climate models of increasing complexity and realism, as well as new information regarding the nature of feedbacks from the carbon cycle and constraints on climate response from observations. {10.5}

- Warming tends to reduce land and ocean uptake of atmospheric carbon dioxide, increasing the fraction of anthropogenic emissions that remains in the atmosphere. For the A2 scenario, for example, the climate-carbon cycle feedback increases the corresponding global average warming at 2100 by more than 1°C. Assessed upper ranges for temperature projections are larger than in the TAR (see Table SPM.3) mainly because the broader range of models now available suggests stronger climate-carbon cycle feedbacks. {7.3, 10.5}

- Model-based projections of global average sea level rise at the end of the 21st century (2090–2099) are shown in Table SPM.3. For each scenario, the midpoint of the range in Table SPM.3 is within 10% of the

Table SPM.3. *Projected global average surface warming and sea level rise at the end of the 21st century. {10.5, 10.6, Table 10.7}*

	Temperature Change (°C at 2090-2099 relative to 1980-1999)[a]		Sea Level Rise (m at 2090-2099 relative to 1980-1999)
Case	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations[b]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

Table notes:
[a] These estimates are assessed from a hierarchy of models that encompass a simple climate model, several Earth System Models of Intermediate Complexity and a large number of Atmosphere-Ocean General Circulation Models (AOGCMs).
[b] Year 2000 constant composition is derived from AOGCMs only.

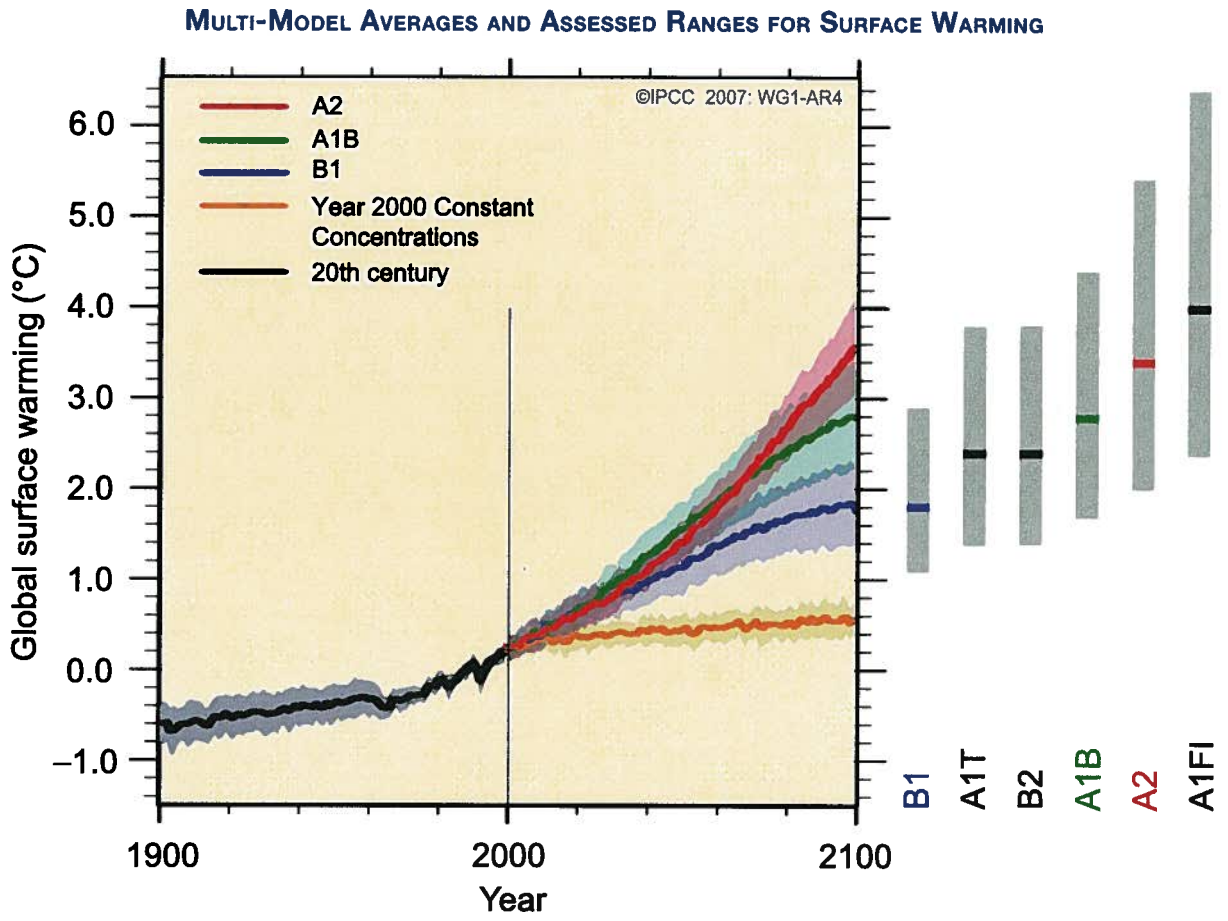


Figure SPM.5. *Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the ±1 standard deviation range of individual model annual averages. The orange line is for the experiment where concentrations were held constant at year 2000 values. The grey bars at right indicate the best estimate (solid line within each bar) and the **likely** range assessed for the six SRES marker scenarios. The assessment of the best estimate and **likely** ranges in the grey bars includes the AOGCMs in the left part of the figure, as well as results from a hierarchy of independent models and observational constraints. {Figures 10.4 and 10.29}*

TAR model average for 2090–2099. The ranges are narrower than in the TAR mainly because of improved information about some uncertainties in the projected contributions.[15] {10.6}

- Models used to date do not include uncertainties in climate-carbon cycle feedback nor do they include the full effects of changes in ice sheet flow, because a basis in published literature is lacking. The projections include a contribution due to increased ice flow from Greenland and Antarctica at the rates observed for 1993 to 2003, but these flow rates could increase or decrease in the future. For example, if this contribution were to grow linearly with global average temperature change, the upper ranges of sea level rise for SRES scenarios shown in Table SPM.3 would increase by 0.1 to 0.2 m. Larger values cannot be excluded, but understanding of these effects is too limited to assess their likelihood or provide a best estimate or an upper bound for sea level rise. {10.6}

- Increasing atmospheric carbon dioxide concentrations lead to increasing acidification of the ocean. Projections based on SRES scenarios give reductions in average global surface ocean pH[16] of between 0.14 and 0.35 units over the 21st century, adding to the present decrease of 0.1 units since pre-industrial times. {5.4, Box 7.3, 10.4}

[15] TAR projections were made for 2100, whereas projections in this report are for 2090–2099. The TAR would have had similar ranges to those in Table SPM.3 if it had treated the uncertainties in the same way.

[16] Decreases in pH correspond to increases in acidity of a solution. See Glossary for further details.

There is now higher confidence in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation and some aspects of extremes and of ice. {8.2, 8.3, 8.4, 8.5, 9.4, 9.5, 10.3, 11.1}

- Projected warming in the 21st century shows scenario-independent geographical patterns similar to those observed over the past several decades. Warming is expected to be greatest over land and at most high northern latitudes, and least over the Southern Ocean and parts of the North Atlantic Ocean (see Figure SPM.6). {10.3}

- Snow cover is projected to contract. Widespread increases in thaw depth are projected over most permafrost regions. {10.3, 10.6}

- Sea ice is projected to shrink in both the Arctic and Antarctic under all SRES scenarios. In some projections, arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century. {10.3}

- It is *very likely* that hot extremes, heat waves and heavy precipitation events will continue to become more frequent. {10.3}

- Based on a range of models, it is *likely* that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures. There is less confidence in projections of a global decrease in numbers of tropical cyclones. The apparent increase in the proportion of very intense storms since 1970 in some regions is much larger than simulated by current models for that period. {9.5, 10.3, 3.8}

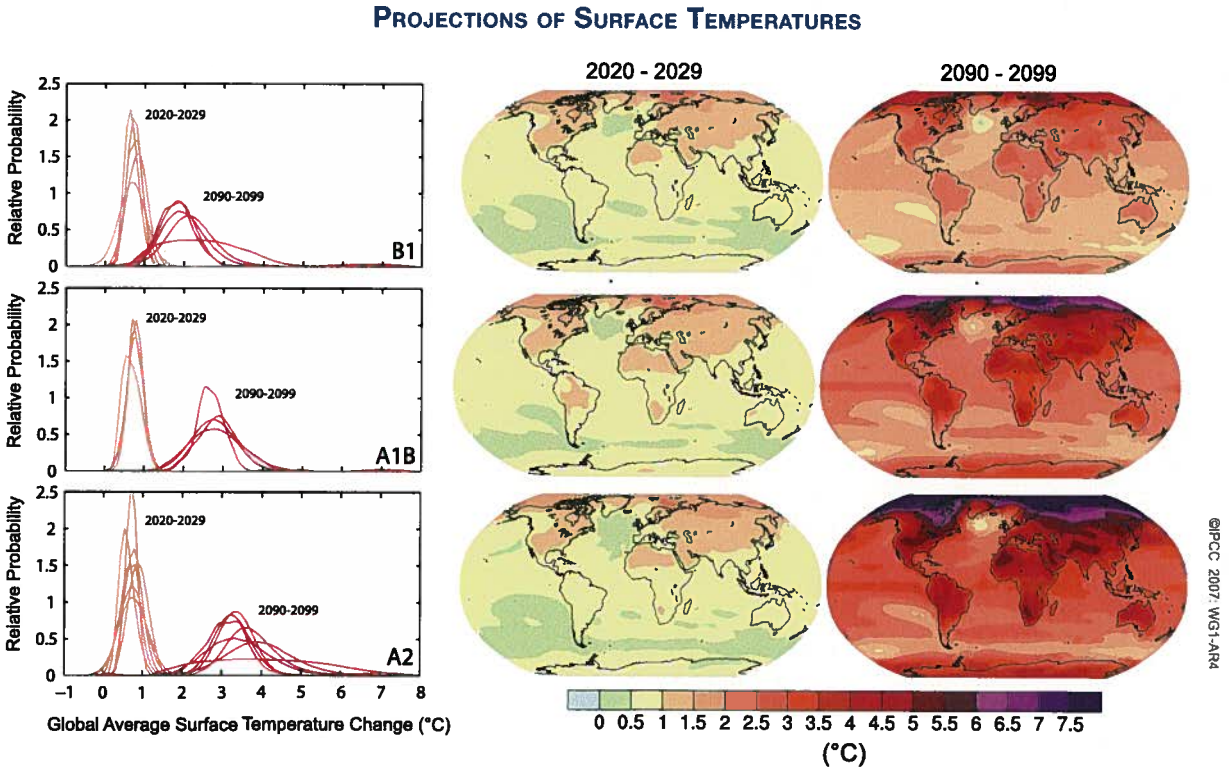


Figure SPM.6. *Projected surface temperature changes for the early and late 21st century relative to the period 1980–1999. The central and right panels show the AOGCM multi-model average projections for the B1 (top), A1B (middle) and A2 (bottom) SRES scenarios averaged over the decades 2020–2029 (centre) and 2090–2099 (right). The left panels show corresponding uncertainties as the relative probabilities of estimated global average warming from several different AOGCM and Earth System Model of Intermediate Complexity studies for the same periods. Some studies present results only for a subset of the SRES scenarios, or for various model versions. Therefore the difference in the number of curves shown in the left-hand panels is due only to differences in the availability of results. {Figures 10.8 and 10.28}*

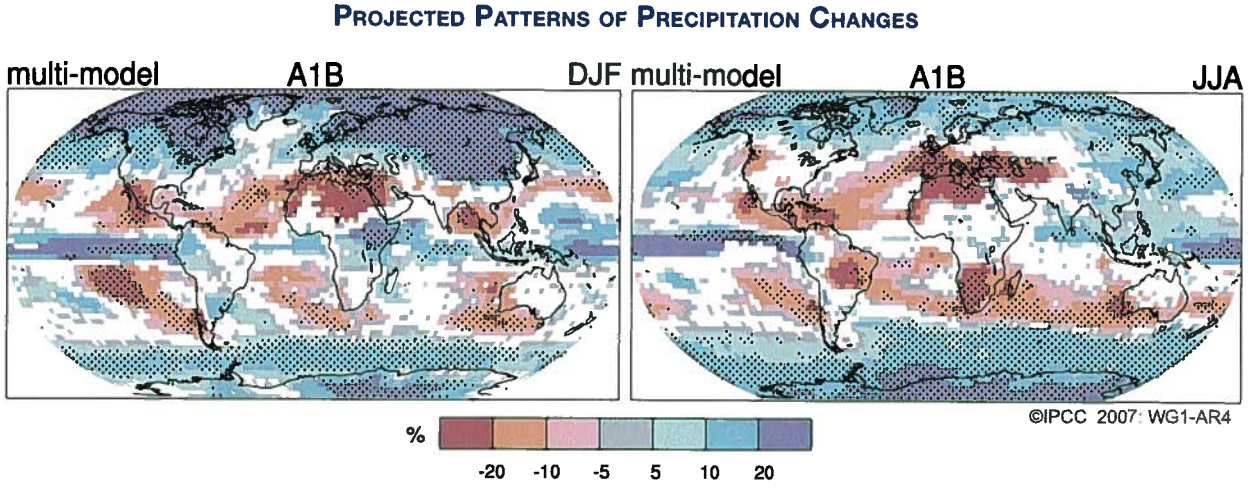


Figure SPM.7. *Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. {Figure 10.9}*

- Extratropical storm tracks are projected to move poleward, with consequent changes in wind, precipitation and temperature patterns, continuing the broad pattern of observed trends over the last half-century. {3.6, 10.3}

- Since the TAR, there is an improving understanding of projected patterns of precipitation. Increases in the amount of precipitation are *very likely* in high latitudes, while decreases are *likely* in most subtropical land regions (by as much as about 20% in the A1B scenario in 2100, see Figure SPM.7), continuing observed patterns in recent trends. {3.3, 8.3, 9.5, 10.3, 11.2 to 11.9}

- Based on current model simulations, it is *very likely* that the meridional overturning circulation (MOC) of the Atlantic Ocean will slow down during the 21st century. The multi-model average reduction by 2100 is 25% (range from zero to about 50%) for SRES emission scenario A1B. Temperatures in the Atlantic region are projected to increase despite such changes due to the much larger warming associated with projected increases in greenhouse gases. It is *very unlikely* that the MOC will undergo a large abrupt transition during the 21st century. Longer-term changes in the MOC cannot be assessed with confidence. {10.3, 10.7}

Anthropogenic warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilised. {10.4, 10.5, 10.7}

- Climate-carbon cycle coupling is expected to add carbon dioxide to the atmosphere as the climate system warms, but the magnitude of this feedback is uncertain. This increases the uncertainty in the trajectory of carbon dioxide emissions required to achieve a particular stabilisation level of atmospheric carbon dioxide concentration. Based on current understanding of climate-carbon cycle feedback, model studies suggest that to stabilise at 450 ppm carbon dioxide could require that cumulative emissions over the 21st century be reduced from an average of approximately 670 [630 to 710] GtC (2460 [2310 to 2600] $GtCO_2$) to approximately 490 [375 to 600] GtC (1800 [1370 to 2200] $GtCO_2$). Similarly, to stabilise at 1000 ppm, this feedback could require that cumulative emissions be reduced from a model average of approximately 1415 [1340 to 1490] GtC (5190 [4910 to 5460] $GtCO_2$) to approximately 1100 [980 to 1250] GtC (4030 [3590 to 4580] $GtCO_2$). {7.3, 10.4}

- If radiative forcing were to be stabilised in 2100 at B1 or A1B levels[14] a further increase in global average temperature of about 0.5°C would still be expected, mostly by 2200. {10.7}

- If radiative forcing were to be stabilised in 2100 at A1B levels[14], thermal expansion alone would lead to 0.3 to 0.8 m of sea level rise by 2300 (relative to 1980–1999). Thermal expansion would continue for many centuries, due to the time required to transport heat into the deep ocean. {10.7}

- Contraction of the Greenland Ice Sheet is projected to continue to contribute to sea level rise after 2100. Current models suggest that ice mass losses increase with temperature more rapidly than gains due to precipitation and that the surface mass balance becomes negative at a global average warming (relative to pre-industrial values) in excess of 1.9°C to 4.6°C. If a negative surface mass balance were sustained for millennia, that would lead to virtually complete elimination of the Greenland Ice Sheet and a resulting contribution to sea level rise of about 7 m. The corresponding future temperatures in Greenland are comparable to those inferred for the last interglacial period 125,000 years ago, when palaeoclimatic information suggests reductions of polar land ice extent and 4 to 6 m of sea level rise. {6.4, 10.7}

- Dynamical processes related to ice flow not included in current models but suggested by recent observations could increase the vulnerability of the ice sheets to warming, increasing future sea level rise. Understanding of these processes is limited and there is no consensus on their magnitude. {4.6, 10.7}

- Current global model studies project that the Antarctic Ice Sheet will remain too cold for widespread surface melting and is expected to gain in mass due to increased snowfall. However, net loss of ice mass could occur if dynamical ice discharge dominates the ice sheet mass balance. {10.7}

- Both past and future anthropogenic carbon dioxide emissions will continue to contribute to warming and sea level rise for more than a millennium, due to the time scales required for removal of this gas from the atmosphere. {7.3, 10.3}

The Emission Scenarios of the IPCC Special Report on Emission Scenarios (SRES)[17]

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil-intensive (A1FI), non-fossil energy sources (A1T) or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

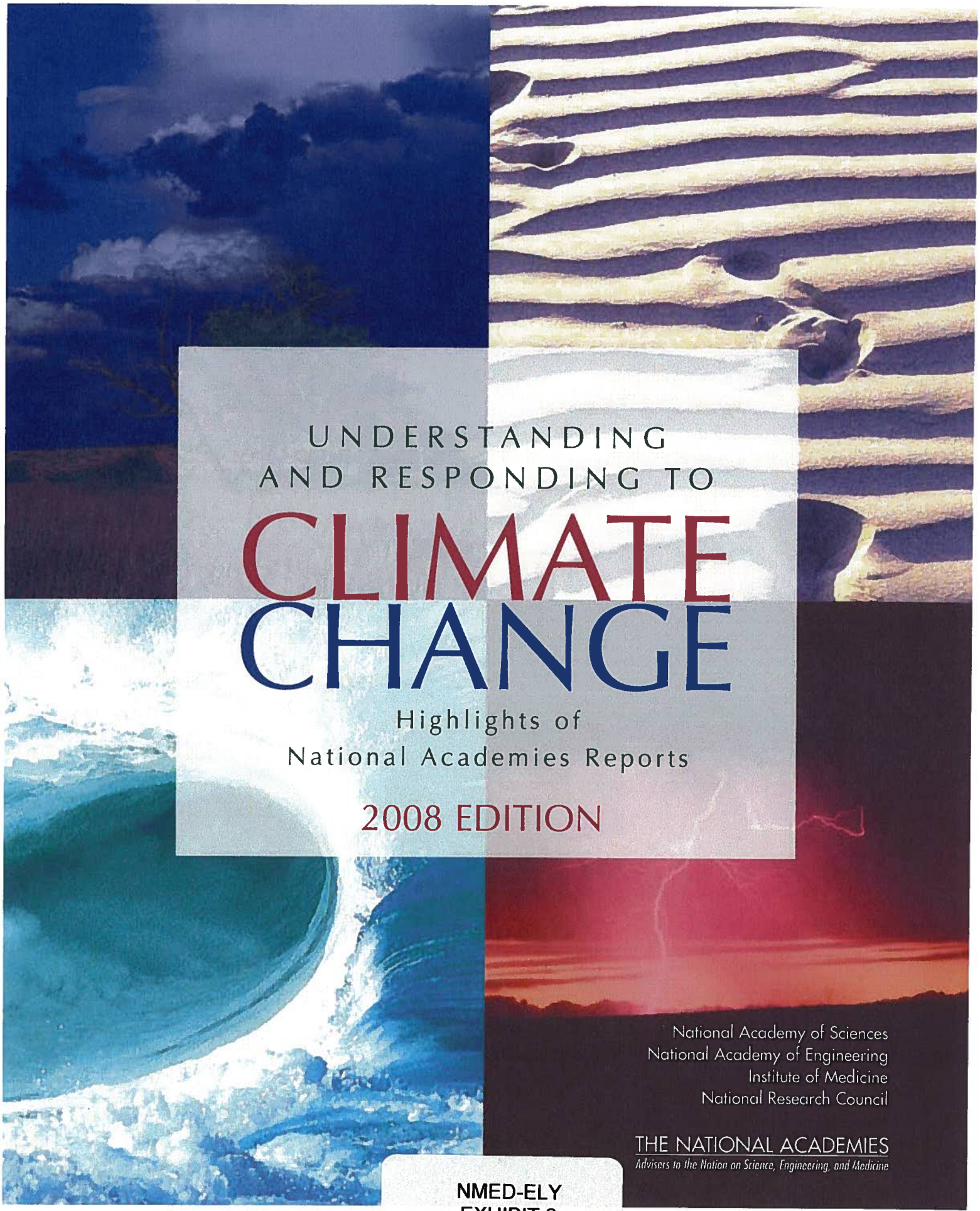
B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

An illustrative scenario was chosen for each of the six scenario groups A1B, A1FI, A1T, A2, B1 and B2. All should be considered equally sound.

The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.

[17] Emission scenarios are not assessed in this Working Group I Report of the IPCC. This box summarising the SRES scenarios is taken from the TAR and has been subject to prior line-by-line approval by the Panel.



UNDERSTANDING AND RESPONDING TO CLIMATE CHANGE

Highlights of National Academies Reports

2008 EDITION

National Academy of Sciences
National Academy of Engineering
Institute of Medicine
National Research Council

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

UNDERSTANDING AND RESPONDING TO CLIMATE CHANGE

2008 EDITION

UNDERSTANDING AND RESPONDING TO CLIMATE CHANGE

There is a growing concern about global warming and the impact it will have on people and the ecosystems on which they depend. Temperatures have already risen 1.4°F since the start of the 20th century—with much of this warming occurring in just the last 30 years—and temperatures will likely rise at least another 2°F, and possibly more than 11°F, over the next 100 years. This warming will cause significant changes in sea level, ecosystems, and ice cover, among other impacts. In the Arctic, where temperatures have increased almost twice as much as the global average, the landscape and ecosystems are already changing rapidly.

Most scientists agree that the warming in recent decades has been caused primarily by human activities that have increased the amount of greenhouse gases in the atmosphere (see Figure 1). Greenhouse gases, such as carbon dioxide, have increased significantly since the Industrial Revolution, mostly from the burning of fossil fuels for energy, industrial processes, and transportation. Carbon dioxide levels are at their highest in at least 650,000 years and continue to rise.

There is no doubt that climate will continue to change throughout the 21st century and beyond, but there are still important questions regarding how large and how fast these changes will be, and what effects they will have in different regions. In some parts of the world, global warming could bring positive effects such as longer growing seasons and milder winters. Unfortunately, it is likely to bring harmful effects to a much higher percentage of the world's people. For example, people in coastal communities will likely experience increased flooding due to rising sea levels.

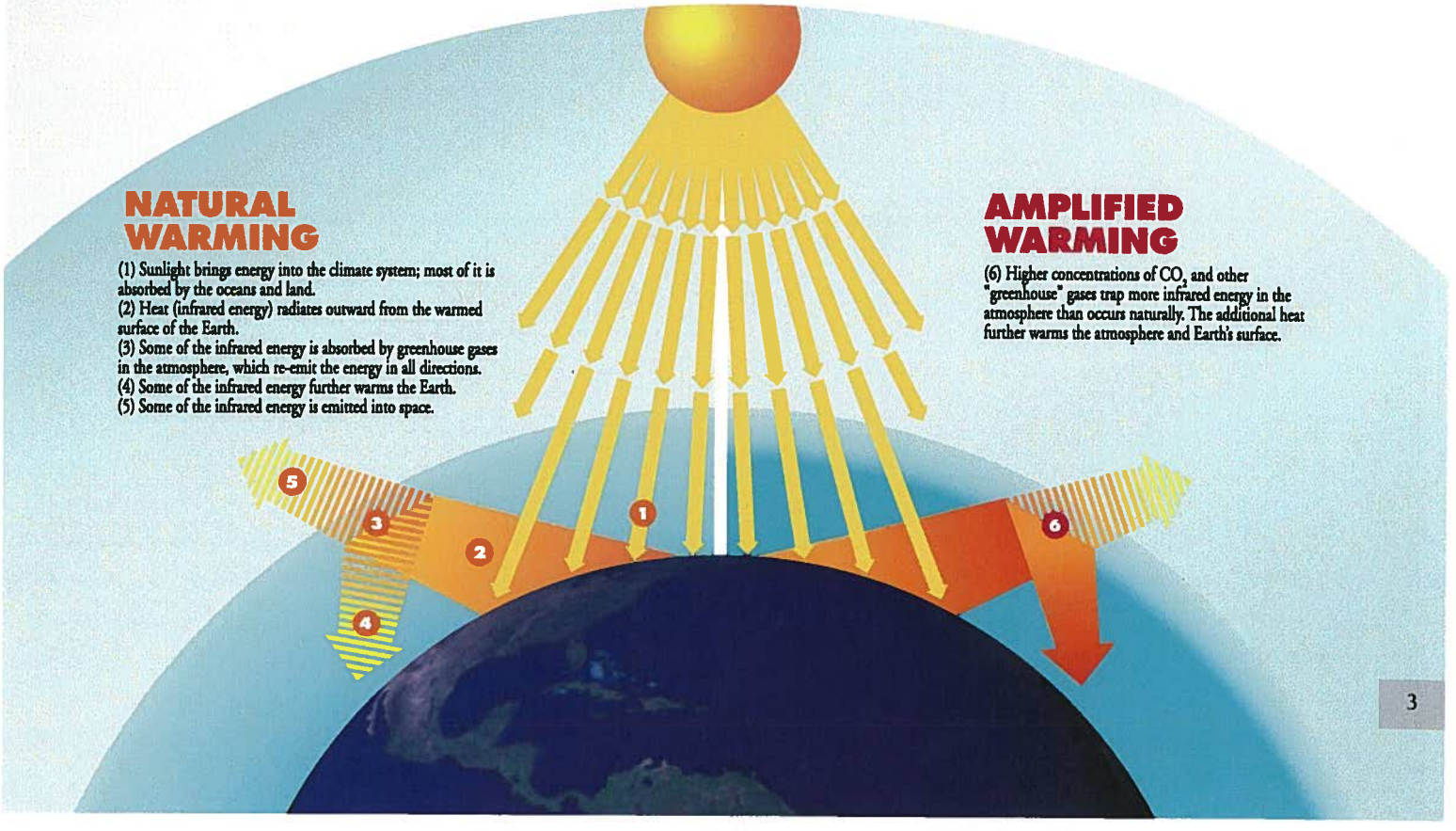
The scientific understanding of climate change is now sufficiently clear to begin taking steps to prepare for climate change and to slow it. Human actions over the next few decades will have a major influence on the magnitude and rate of future warming. Large, disruptive changes are much more likely if greenhouse gases are allowed to continue building up in the atmosphere at their present rate. However, reducing greenhouse gas emissions will require strong national and international commitments, technological innovation, and human willpower.

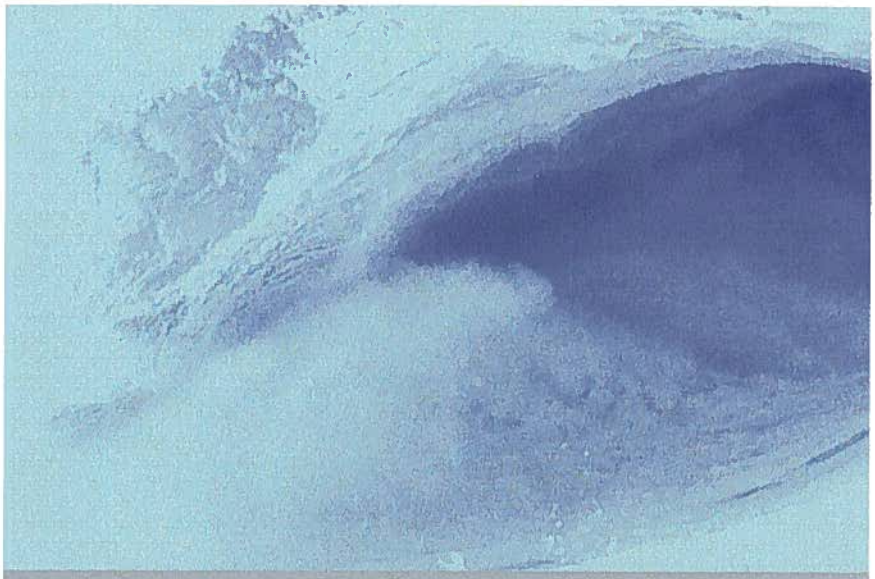
GLOBAL WARMING OR CLIMATE CHANGE?

The phrase "climate change" is growing in preferred use to "global warming" because it helps convey that there are changes in addition to rising temperatures.

This brochure highlights findings and recommendations from National Academies' reports on climate change. These reports are the products of the National Academies' consensus study process, which brings together leading scientists, engineers, public health officials, and other experts to address specific scientific and technical questions. Such reports have evaluated climate change science, identified new avenues of inquiry and critical needs in the research infrastructure, and explored opportunities to use scientific knowledge to more effectively respond to climate change.

Figure 1. The greenhouse effect is a natural phenomenon that is essential to keeping the Earth's surface warm. Like a greenhouse window, greenhouse gases allow sunlight to enter and then prevent heat from leaving the atmosphere. Water vapor (H_2O) is the most important greenhouse gas, followed by carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halocarbons, and ozone (O_3). Human activities—primarily burning fossil fuels—are increasing the concentrations of these gases, amplifying the natural greenhouse effect. Image courtesy of the Marion Koshland Science Museum of the National Academy of Sciences.





ABOUT THE SCIENCE

Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.

***—Climate Change 2007: The Physical Basis,* Intergovernmental Panel on Climate Change**

The Earth is warming.

Temperature readings from around the globe show a relatively rapid increase in surface temperature during the past century (see Figure 2). These data, which have been closely scrutinized and carefully calibrated to remove potential problems such as the "urban heat island" effect, show an especially pronounced warming trend during the past 30 years—in fact, 9 of the 10 warmest years on record have occurred during the past decade. Furthermore, the surface temperature data are consistent with other evidence of warming, such as increasing ocean temperatures, shrinking mountain glaciers, and decreasing polar ice cover.

One inevitable question people ask is whether the current warming trend is unusual compared to temperature shifts on Earth prior to the 20th century—that is, before the buildup of excess greenhouse gases in the atmosphere. To help answer this question, scientists analyze tree rings, ice cores, ocean sediments, and a number of other "proxy" indicators to estimate past climatic conditions. These studies are important for understanding many aspects of Earth's climate, including the natural variability of surface temperature over many centuries. *Surface Temperature Reconstructions for the Last 2,000 Years* (2006), produced in

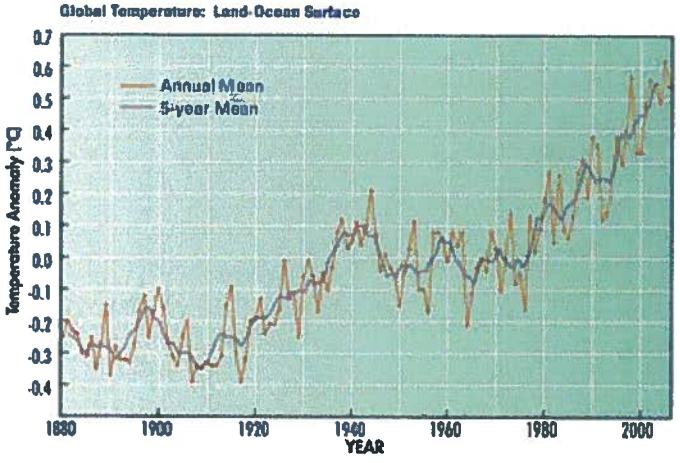


Figure 2. Global surface temperature, based on surface air temperature measurements at meteorological stations and on sea surface temperature measurements from ships and satellites, shows a temperature increase of 1.4°F (0.78°C) since the beginning of the 20th century, with about 1.1°F (0.61°C) of the increase occurring in the past 30 years. Data courtesy of NASA Goddard Institute for Space Studies.

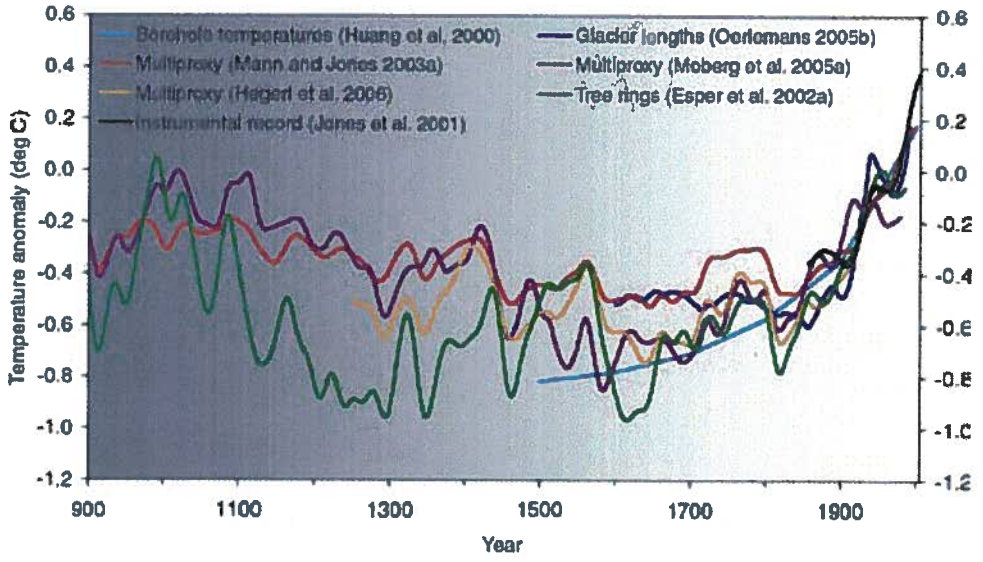


Figure 3. Surface temperature reconstructions made by six different research teams (colored lines) are shown along with the instrumental record of global surface temperature (black line). Each team used a different method and different set of "proxy" data to produce its temperature estimate. The uncertainty in each reconstruction generally increases going backward in time (as indicated by the gray shading). All the curves indicate that the last few decades of the 20th century were warmer than any comparable period during at least the past four centuries, and probably longer. Source: *Surface Temperature Reconstructions for the Last 2000 Years* (National Research Council, 2006)

response to a request from Congress, assesses the scientific evidence used to estimate global temperature variations during the past two millennia, as well as how these estimates contribute to our understanding of global climate change. The report concludes, with a high level of confidence, that global mean surface temperature was higher during the last few decades of the 20th century than during any comparable period since at least A.D. 1600 (see Figure 3). Estimating the Earth's global-average temperature becomes increasingly difficult going further back in time due to the decreasing availability of reliable proxy evidence, but the available evidence indicates that most regions are warmer now than at any other time since at least A.D. 900.

Human activities are changing climate.

In May 2001, the White House asked the National Academy of Sciences to assess our current understanding of climate change by answering some key questions related to the causes of climate change, projections of future change, and critical research directions to improve understanding of climate change. *Climate Change Science: An Analysis of Some Key Questions* (2001) concluded that "changes observed over the last several decades are likely mostly due to human activities." Additional evidence collected over the past several years has increased confidence in this conclusion.

How do we know that human activities are changing the Earth's climate? The concurrent increase in surface temperature with carbon dioxide and other greenhouse gases during the past century is one of the main indications. Prior to the Industrial Revolution, the amount of carbon dioxide released to the atmosphere by natural processes was almost exactly in balance with the amount absorbed by plants and other "sinks" on the Earth's surface. The burning of fossil fuels (oil, natural gas, and coal) releases additional carbon dioxide to the atmosphere. About half of this excess carbon dioxide is absorbed by the ocean, plants, and trees, but the rest accumulates in the atmosphere,

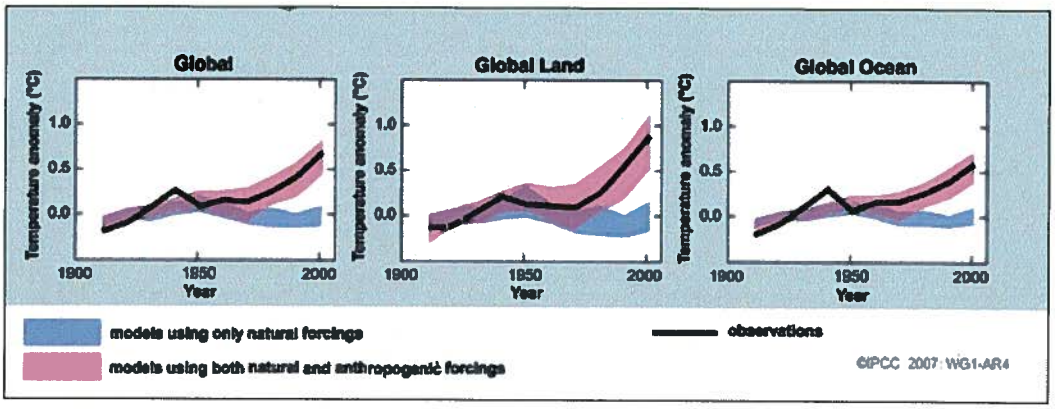


Figure 4. Model simulations of 20th century climate variations more closely match observed temperature when both natural and human influences are included. Black line shows observed temperatures. Blue-shaded regions show projections from models that only included natural forcings (solar activity and volcanos). Red-shaded regions show projections from models that include both natural and human forcings. Source: *Climate Change 2007: The Physical Science Basis*, Intergovernmental Panel on Climate Change 2007.

amplifying the natural greenhouse effect. There is also considerable evidence that human activities are causing the increases in other greenhouse gases such as methane and nitrous oxide.

Rising temperatures and greenhouse gas concentrations observed since 1978 are particularly noteworthy because the rates of increase are so high and because, during the same period, the energy reaching the Earth from the Sun has been measured precisely by satellites. These measurements indicate that the Sun's output has not increased since 1978, so the warming during the past 30 years cannot be attributed to an increase in solar energy reaching the Earth. The frequency of volcanic eruptions, which tend to cool the Earth by reflecting sunlight back to space, also has not increased or decreased significantly. Thus, there are no known natural factors that could explain the warming during this time period.

Additional evidence for a human influence on climate can be seen in the geographical pattern of observed warming, with greater temperature increases over land and in polar regions than over the oceans. This pattern is strongly indicative of warming caused by increasing greenhouse gas concentrations, as is the vertical profile of warming in the atmosphere and oceans. Further, model simulations of temperature change during the past century only match the observed temperature increase when greenhouse gas increases and other human causes are included (see Figure 4).

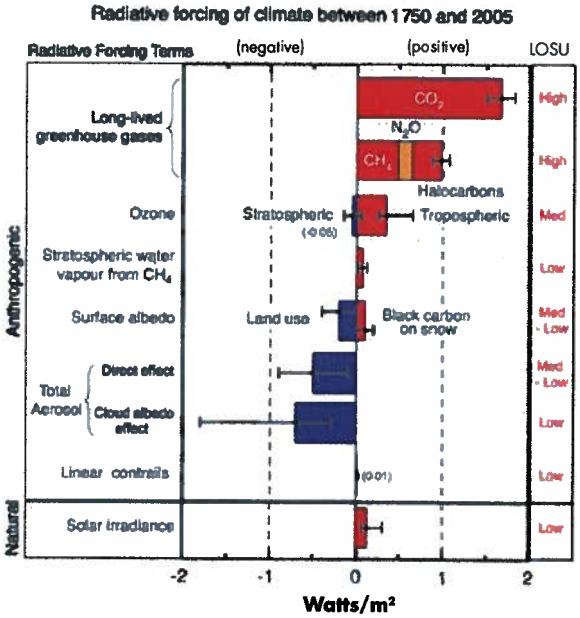


Figure 5. Various climate drivers, or radiative forcings, act to either warm or cool the Earth. Positive forcings, such as those due to greenhouse gases, warm the Earth, while negative forcings, such as aerosols, have a cooling effect. If positive and negative forcings remained in balance, there would be no warming or cooling. The column on the right indicates the level of scientific understanding (LOSU) for each forcing. Source: *Climate Change 2007: The Physical Science Basis*, Intergovernmental Panel on Climate Change 2007.

The Earth's temperature is influenced by many factors.

Many different factors play a role in controlling Earth's surface temperature. Scientists classify these factors as either *climate forcings* or *climate feedbacks* depending on how they operate. A forcing is something that is imposed externally on the climate system by either human activities or natural processes (e.g., burning fossil fuels or volcanic eruptions). Positive climate forcings, such as excess greenhouse gases, warm the Earth, while negative forcings, such as most aerosols produced by industrial processes and volcanic eruptions, cool the Earth (see Figure 5). In general, the cooling caused by aerosols is not as well understood as the warming caused by greenhouse gases.

Climate feedbacks, on the other hand, either amplify or dampen the response to a given forcing. A feedback is an energy change that is produced within the climate system itself in response to a climate forcing. During a feedback loop, a change in one factor, such as temperature, leads to a change in another factor, such as water vapor, which either reinforces or offsets the change in the first factor (see Figure 6a and 6b).

Radiative Forcing of Climate Change: Expanding the Concept and Addressing Uncertainties (2005) takes a close look at a range of different climate forcings. The report concludes that it is important to quantify how forcings cause changes in climate variables other than temperature. For example, regional changes in precipitation could have significant impacts on water availability for agricultural, residential, industrial, and recreational use.

WHAT WARMS AND COOLS THE EARTH?

"Forcings" are things imposed externally on the climate system that can warm or cool the Earth. If positive and negative forcings remained in balance, there would be no warming or cooling.

Greenhouse gases warm the planet:

Carbon dioxide (CO_2) has both natural and human sources, but CO_2 levels are increasing primarily because of the use of fossil fuels, with deforestation and other land use changes also making a contribution. Increases in carbon dioxide are the single largest climate forcing contributing to global warming (see Figure 5).

Methane (CH_4) has both human and natural sources, and levels have risen significantly since pre-industrial times due to human activities such as raising livestock, growing rice, filling landfills, and using natural gas (which releases methane when it is extracted and transported).

Nitrous oxide (N_2O) concentrations have risen primarily because of agricultural activities and land use changes.

Ozone (O_3) forms naturally in the upper atmosphere, where it creates a protective shield that intercepts damaging ultraviolet radiation from the Sun. However, ozone produced near the Earth's surface via reactions involving carbon monoxide, hydrocarbons, nitrogen oxide, and other pollutants is harmful to both animals and plants and has a warming effect. The concentration of O_3 in the lower atmosphere is increasing as a result of human activities.

Halocarbons, including chlorofluorocarbons (CFCs), are chemicals that have been used for a variety of applications, such as refrigerants and fire retardants. In addition to being potent greenhouse gases, CFCs also damage the ozone layer. The production of most CFCs is now banned, so their concentrations are starting to decline.

Other human activities can also force temperature changes:

Most aerosols (airborne particles and droplets), such as sulfate (SO_4), cool the planet by reflecting sunlight back to space. Some aerosols also cool the Earth indirectly by increasing the amount of sunlight reflected by clouds. Human activities, such as industrial processes, produce many different kinds of aerosols. The total cooling that these aerosols produce is one of the greatest remaining uncertainties in understanding present and future climate change.

Black carbon particles or "soot," produced when fossil fuels or vegetation are burned, generally have a warming effect because they absorb incoming solar radiation. Black carbon particles settling on snow or ice are a particularly potent warmer.

Deforestation and other changes in land use modify the amount of sunlight reflected back to space from the Earth's surface. Changes in land use can lead to positive and negative climate forcing locally, but the net global effect is a slight cooling.

Natural processes also affect the Earth's temperature:

The Sun is Earth's main energy source.The Sun's output is nearly constant, but small changes over an extended period of time can lead to climate changes. In addition, slow changes in the Earth's orbit affect how the Sun's energy is distributed across the planet, giving rise to ice ages and other long-term climate fluctuations over many thousands of years. The Sun's output has not increased over the past 30 years, so it cannot be responsible for recent warming.

Volcanic eruptions emit many gases. One of the most important of these is sulfur dioxide (SO_2), which, once in the atmosphere, forms sulfate aerosol (SO_4). Large volcanic eruptions can cool the Earth slightly for several years, until the sulfate particles settle out of the atmosphere.

FEEDBACKS CAN AMPLIFY WARMING AND COOLING

A feedback is an energy change within the climate system in response to a climate forcing. For example:

Water vapor (H_2O) is the most potent and abundant greenhouse gas in Earth's atmosphere. However, its concentration is controlled primarily by the rate of evaporation from the oceans and transpiration from plants, rather than by human activities, and water vapor molecules only remain in the atmosphere for a few days on average. Thus, changes in water vapor are considered a feedback that amplifies the warming induced by other climate forcings (see Figure 6a).

Sea ice reflects sunlight back to space. Changes in sea ice are a positive climate feedback because warming causes a reduction in sea ice extent, which allows more sunlight to be absorbed by the dark ocean, causing further warming.

Clouds reflect sunlight back to space, but also act like a greenhouse gas by absorbing heat leaving the Earth's surface. Low clouds tend to cool (reflect more energy than they trap) while high clouds tend to warm (trap more energy than they reflect). The net effect of cloudiness changes on surface temperature depends on how and where the cloud cover changes, and this is one of the largest uncertainties in projections of future climate change (see Figure 6b).

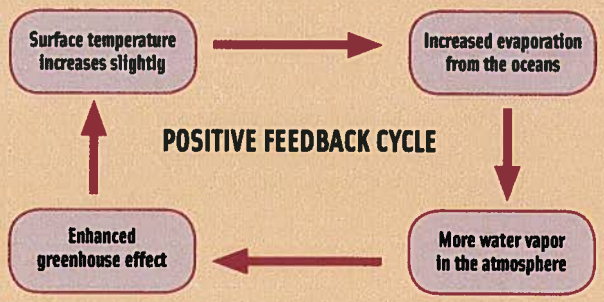


Figure 6a: This schematic illustrates just one of the dozens of climate feedbacks identified by scientists. The warming created by greenhouse gases leads to additional evaporation of water from the oceans into the atmosphere. But water vapor itself is a greenhouse gas and can cause even more warming. Scientists call this the "positive water-vapor feedback."

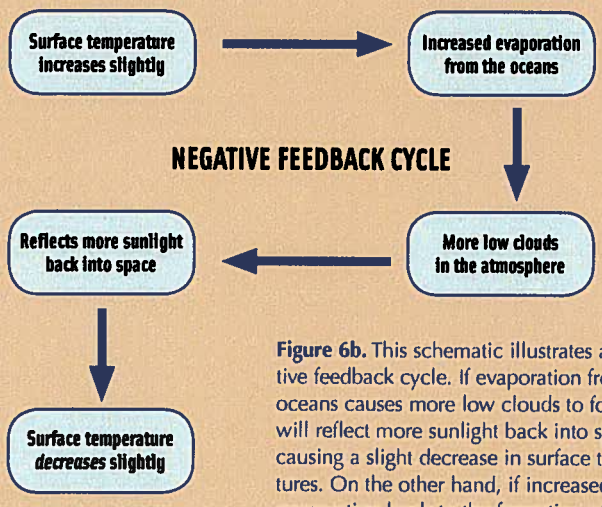


Figure 6b. This schematic illustrates a negative feedback cycle. If evaporation from the oceans causes more low clouds to form, they will reflect more sunlight back into space, causing a slight decrease in surface temperatures. On the other hand, if increased ocean evaporation leads to the formation of more high clouds, the result would be a positive feedback cycle similar to the water-vapor feedback shown in Figure 6a.

Another report, *Understanding Climate Change Feedbacks* (2003) examines what is known and not known about climate change feedbacks and identifies important research avenues for improving our understanding. A substantial part of the uncertainty in projections of future climate change can be attributed to an incomplete understanding of climate feedback processes. Enhanced research in the areas of climate monitoring and climate modeling are needed to improve understanding of how the Earth's climate will respond to future climate forcings.

The magnitude of future climate change is difficult to project.

The Intergovernmental Panel on Climate Change (IPCC), which involves hundreds of scientists from the United States and other nations in assessing the state of climate change, concluded in a 2007 report that average global surface temperatures will likely rise by an additional 2.0–11.5°F (1.1–6.4°C) by 2100. This temperature increase will be accompanied by a host of other environmental changes, such as an increase in global sea level of between 0.59 and 1.94 feet (0.18 and 0.59 meters).

Estimates of future climate change are typically called projections and are expressed as a range of possible outcomes. One reason for this uncertainty is because it is difficult to predict how human populations will grow, use energy, and manage resources, all of which will have a strong influence on future greenhouse gas emissions. There are also uncertainties about how the climate system will respond to rising greenhouse gas concentrations. For example, the IPCC's estimate

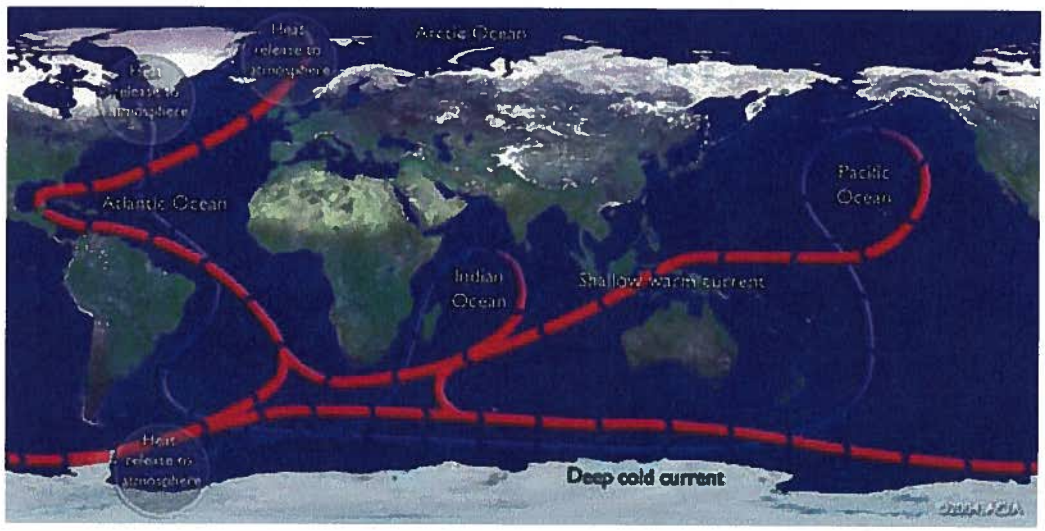


Figure 7. A key mechanism in the circulation of water through the world's oceans is the sinking of cold salty seawater. For example, in the Atlantic, oceanic currents transport warm, saline water to the North Atlantic where the water becomes denser as it is cooled by cold Arctic air. The chilled seawater sinks to the bottom, forming a southward-moving water mass. It has been hypothesized that large inputs of less dense fresh water from melting ice caps could disrupt ocean circulation by preventing the formation of chilled salty water. Such a disruption could trigger a host of climate changes such as cooling across much of northern Europe. Source: *Impacts of a Warming Arctic: Arctic Climate Impact Assessment*, p. 32

of future sea level rise does not take into account the possibility that ice sheets or glaciers could start melting more rapidly as the temperature rises.

It is very likely that increasing global temperatures will lead to higher maximum temperatures, more heat waves, and fewer cold days over most land areas. Some scientists believe that hurricanes may also become more intense as ocean temperatures rise, but others have argued that this intensification could be moderated or offset by other changes, such as changes in tropical winds or El Niño events.

One of the most important areas of uncertainty being investigated is regional climate change. Although scientists are beginning to project how the climate will change in specific regions and what some of the impacts of these changes might be, their level of confidence in these projections is not as high as for global climate change projections. In general, global temperature is easier to project than regional changes such as rainfall, storm patterns, and ecosystem impacts.

Complicating things further is the fact that the climate has changed abruptly in the past—within a decade—and could do so again. Abrupt changes, such as the Dust Bowl drought of the 1930s which displaced hundreds of thousands of people in the American Great Plains, take place so rapidly that humans and ecosystems have difficulty adapting to them. *Abrupt Climate Change: Inevitable Surprises* (2002) outlines some of the evidence for and theories about abrupt change. One theory is that melting ice caps could "freshen" the water in the North Atlantic, slowing down the natural ocean circulation that brings warmer Gulf Stream waters to the north and cooler waters south again (see Figure 7). Such a slowdown would make it much cooler in northern Europe.

CARBON DIOXIDE: FORCING OR FEEDBACK?

The role of carbon dioxide in warming the Earth's surface via the natural greenhouse effect was first proposed by Swedish scientist Svante Arrhenius more than 100 years ago. Arrhenius suggested that changes in carbon dioxide might explain the large temperature variations over the past several hundred thousand years known as the ice ages (see Figure 8a). Carbon dioxide appears to have acted like a feedback during these cycles, reinforcing temperature changes initiated by natural variations in Earth's orbit. In contrast, carbon dioxide levels were nearly constant during the past several thousand years until human activities began emitting large amounts of carbon dioxide into the atmosphere, amplifying the natural greenhouse effect (see Figure 8b). Thus, while carbon dioxide may have acted as a feedback in the past, it is acting as a forcing in the current climate.

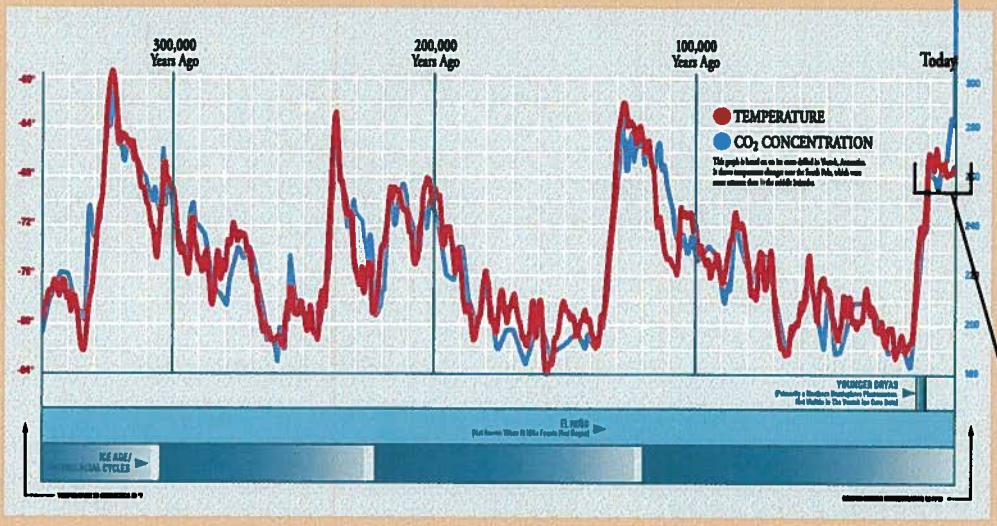
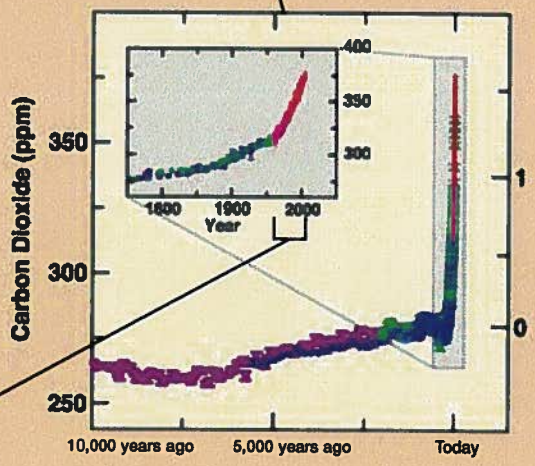


Figure 8a. (left) As ice core records from Vostok, Antarctica show, the temperature near the South Pole has varied by more than 20° F during the past 350,000 years in a regular pattern that constitutes the ice age/interglacial cycles. Changes in carbon dioxide concentrations (in blue) track closely with changes in temperature (in red) during these cycles, but carbon dioxide levels are now higher than at any time during the past 650,000 years. Image courtesy of the Marian Koshland Science Museum of the National Academy of Sciences.

Figure 8b. (right) Atmospheric concentrations of carbon dioxide during the past 10,000 years (large panel) and since 1750 (inset panel) show a rapid increase in carbon dioxide. Measurements are shown from ice cores (symbols with different colors for different studies) and atmospheric samples (the red line, which is data from the Keeling curve shown below). Source: *Climate Change 2007: The Physical Science Basis*, Intergovernmental Panel on Climate Change.



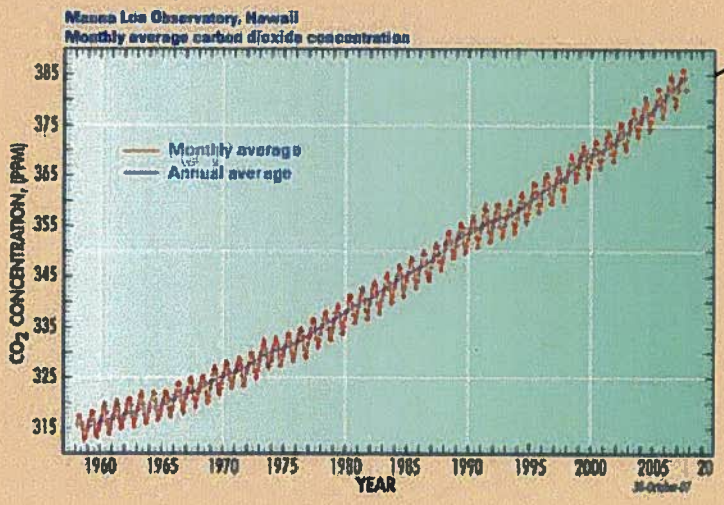


Figure 9. Charles Keeling's curve provides a precise record of atmospheric carbon dioxide (CO_2) concentrations, which he began measuring in 1958. The steady upward trend shows increases in annual average CO_2 concentrations. The sawtooth pattern seen in the Keeling curve is like the breathing of the planet. In the wintertime, carbon dioxide is released into the atmosphere by the decaying of vegetation from the previous growing season and by soil respiration. Then in the spring and summer of the following year, carbon dioxide is taken up by plants as they grow. Data source: Carbon Dioxide Information Analysis Center.

HOW THE SCIENCE IS DONE

Our understanding of climate and how it has varied over time is advancing rapidly as new data are acquired and new investigative instruments and methods are employed.

—Ralph Cicerone, *foreword of Surface Temperature Reconstructions for the Last 2000 Years,* National Research Council, 2006

Observations and data are the foundation of climate science.

In the 1950s, long before the idea of human-induced climate change was prevalent, oceanographer Roger Revelle suggested that the sea could not absorb all the carbon dioxide being released from fossil fuel usage. Revelle made the first continual measurements of atmospheric carbon dioxide with the goal of better understanding the carbon cycle—how carbon is exchanged between plants, animals, the ocean, and the atmosphere. In 1958, Revelle's colleague Charles Keeling began collecting canisters of air once or twice each week at the Mauna Loa Observatory, 11,000 feet above sea level in Hawaii, far away from major industrial and population centers. This remarkable 50-year dataset, known as the Keeling curve (see Figure 9, left), is a cornerstone of climate change science. Similar observations are now routinely made at stations across the globe.

Most of the observing systems used to monitor climate today were established to provide data for other purposes, such as predicting daily weather; advising farmers; warning of hurricanes, tornadoes, and floods; managing water resources; aiding ocean and air transportation; and understanding the ocean. Data used for climate research, however, have unique requirements. Higher accuracy and precision are often needed to detect gradual climate trends, observing programs must be sustained over long periods of time, and observations are needed at both global scales and at local scales to serve a range of climate information users.

A key requirement for climate change science is the ability to generate, analyze, and archive long-term climate data records in order to make ongoing assessments of

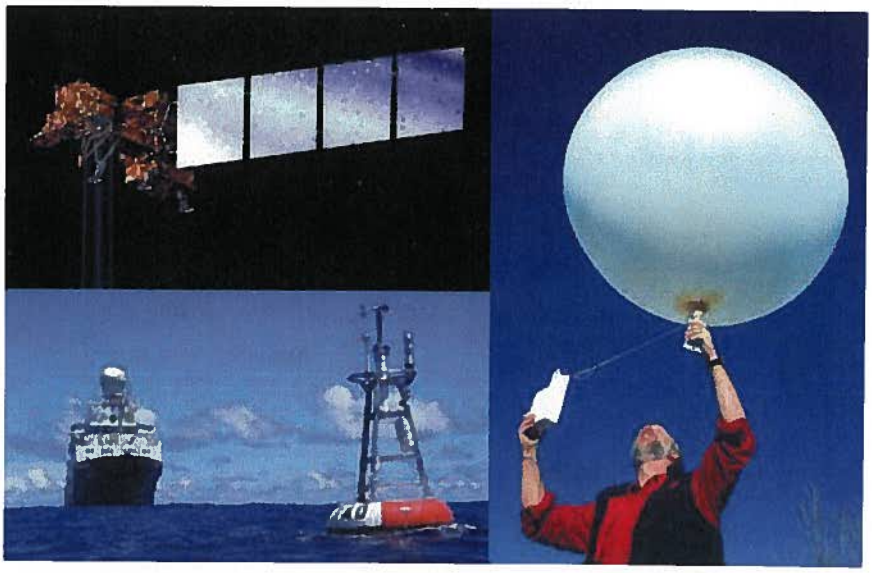


Figure 10. (**top left**) The Landsat satellite series has provided continuous record of the Earth's continental surfaces since 1972, providing critical information for global change research. Image courtesy of the NASA Goddard Space Flight Center. (**bottom left**) Weather stations, both on land and floating on buoys moored at sea, provide regular measurements of temperature, humidity, winds, and other atmospheric properties. Image courtesy of TAO Project Office, NOAA Pacific Marine Environmental Laboratory. (**right**) Weather balloons, which carry instruments known as radiosondes, provide vertical profiles of some of these same properties throughout the lower atmosphere. Image © University Corporation for Atmospheric Research.

the state of the environment. *Climate Data Records from Environmental Satellites* (2004) defines a climate data record as a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change. The report identifies several elements of successful climate data record generation programs that range from effective, expert leadership to a long-term commitment to sustaining observations and archives.

Climate science relies on a wide range of data sources.

Climate scientists rely on data collected using a wide array of observing systems, operated by various government agencies, universities, and other domestic and international groups (see Figure 10). For example, surface temperature measurements are taken by both humans and automated instruments at fixed stations on land and on buoys in the ocean, and also on ocean-going ships. Measurements of temperatures at different heights in the atmosphere are obtained primarily from weather balloons and satellites. All measurements go through rigorous quality control procedures and must be carefully calibrated to account for changes in measuring technology. Having multiple independent data sources is impor-

WHAT'S THE DIFFERENCE BETWEEN WEATHER AND CLIMATE?

Weather refers to hour-to-hour and day-to-day changes in temperature, cloudiness, precipitation, and other meteorological conditions. *Climate* is commonly thought of as the average weather conditions at a given location over time, but it also includes more complicated statistics such as the average daytime maximum temperature each month and the frequency of storms or droughts. *Climate change* refers to changes in these statistics over years, decades, and even centuries. The term *global change* is sometimes used to include these and other environmental changes, such as deforestation, ozone depletion, and the acidification of the world's oceans because of rising carbon dioxide levels.

The accuracy of weather forecasts can be confirmed by observing the actual weather. Climate models, on the other hand, produce projections many years into the future, making them difficult to verify. Further, climate models must take into account a much larger number of variables, such as changes in ocean circulation, vegetation, and greenhouse gas concentrations. Climate models have been shown to accurately simulate a number of past climate changes, including the cooling observed after major volcanic eruptions, global temperature change during the 20th century, and even the ice ages, so our confidence in these models is increasing.

tant for detecting and removing biases and other errors.

Space-based observations are especially important for monitoring present and future climate change because they offer a unique vantage point and can take measurements over the entire surface of the Earth. *Earth Science and Applications from Space: Urgent Needs and Opportunities to Serve the Nation* (2005) examines the current and planned system of U.S. environmental satellites, including the satellites needed to observe climate change, and concludes that the system is "at risk of collapse." A subsequent report, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond* (2007), presents a prioritized list of space programs, missions, and supporting activities that would restore the satellite observations needed to address the most important environmental issues of the next decade and beyond, including climate change.

Scientists have also developed a variety of methods for estimating how the Earth's climate varied prior to the mid-19th century, when thermometer measurements first became widely available (see Figure 11). For example, ice cores are drilled in polar and mountain ice caps and analyzed to reconstruct past climate changes; in addition to analyzing the isotopes of hydrogen and oxygen atoms that make up the ice to infer past temperatures in the region, the bubbles trapped in the ice can be sampled to determine past concentrations of greenhouse gases. Tree rings, corals, ocean and lake sediments, cave deposits, and even animal nests have also been analyzed to estimate past variations in climate.

Various human records can also be used to reconstruct past climate conditions. Shipping records have been analyzed to estimate changes in the frequency of hurricanes in the Atlantic Ocean during the past 150 years. In Burgundy, France, monastery

Figure 11. Scientists infer past temperatures using several different methods: ice cores from polar ice caps and mountain glaciers (left) provide samples of past atmospheres frozen in the ice—the deeper you go, the further back in time. Temperature is inferred by examining characteristics of the hydrogen and oxygen atoms that make up the ice, among other data. Tree rings (right) can reveal past climate conditions based on the width of each annual ring and many other characteristics, such as density of the wood in each ring. Other types of samples used to infer past climate include marine sediments and soil samples. Ice core photo courtesy of the National Geophysical Data Center. Tree ring photo courtesy of Connie Woodhouse.

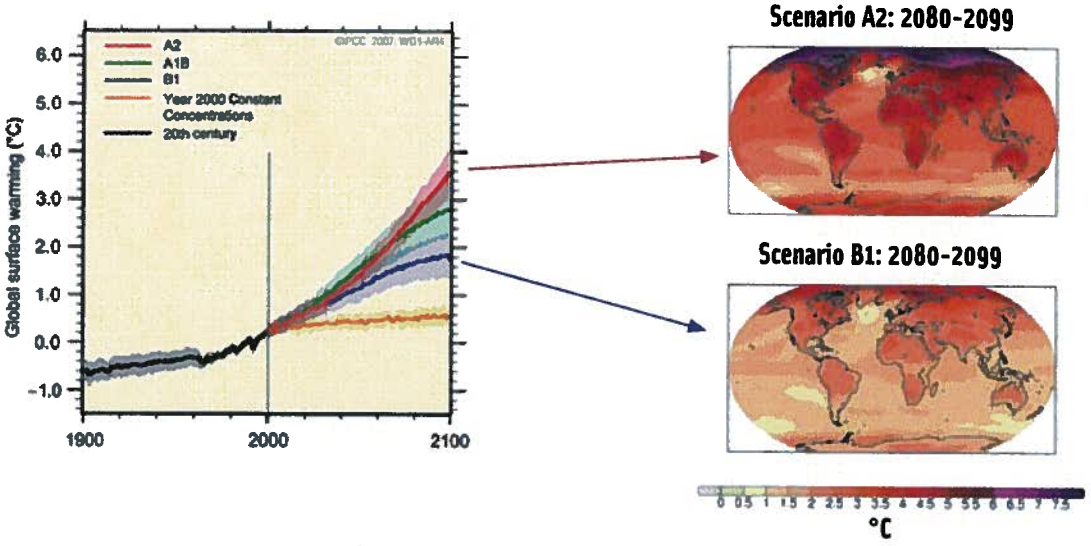


Figure 12. Climate models often are used to help inform policy decisions. The graph on the left shows the projected global mean temperature change for several different scenarios of future emissions based on assumptions of future population growth, economic development, life style choices, technological change, and availability of energy alternatives. Each line represents the average of many different models run using the same scenario. The images on the right show the projected geographical pattern of annual mean surface air temperature changes at the end of the century (relative to the average temperatures for the period 1980–1990) for the scenarios A2 and B1 (red and blue lines). The projected warming by the end of the 21st century is less extreme in the B1 scenario, which assumes significant reductions in greenhouse gas emissions, than in the A2 scenario, which assumes "business as usual." In both scenarios, land areas are expected to warm more than oceans, and the greatest warming is projected at high latitudes. Source: *Climate Change 2007: The Physical Science Basis,* Intergovernmental Panel on Climate Change 2007.

archives record the timing of the pinot noir harvest back to 1370, which provides information about climate, and similar records exist for the blossoming dates of cherry trees and other flowering plants in Japan and China. Records of Alpine glacier length, some derived from paintings and other documentary sources, have even been used to reconstruct surface temperature variations in south-central Europe for the past several centuries.

Models help illuminate the many dimensions of climate change.

Climate models are important tools for understanding how different components of the climate system operate today, how they may have functioned differently in the past, and how the climate might evolve in the future in response to forcings from both natural processes and human activities. Climate models use mathematical equations to represent the climate system, first modeling each system component separately and then linking them together to simulate the full Earth system. These models are run on advanced supercomputers.

Since the late 1960s, when climate models were pioneered, their accuracy has increased as computing power and our understanding of the climate system have improved. *Improving Effectiveness of U.S. Climate Modeling* (2001) offered several recommendations for strengthening climate modeling capabilities in the United States. The report identified a shortfall in computing facilities and highly skilled technical workers devoted to climate modeling as two important problems. Several of the report's recommen-

dations have been adopted since it was published, but concerns remain about whether the United States is training enough people to work on climate change issues.

Social science helps us understand how human choices affect climate.

Research on the social and behavioral sciences is essential for understanding and responding to climate change. Research on the human dimensions of global change focuses on four general areas: (1) human activities that alter the Earth's environment, (2) the forces that drive these activities, (3) the consequences of environmental changes for societies and economies, and (4) how humans respond to these changes. *Global Environmental Change: Understanding the Human Dimensions* (1992) develops a conceptual framework for combining the efforts of natural and social scientists to better understand how human actions influence global change.

Although fossil fuel burning is the most significant human activity contributing to climate change, other activities also have significant influences. For example, land-use changes, such as the conversion of forests and wetlands to agricultural or urban uses, have a strong influence on both local and global climate. *Population, Land Use, and Environment* (2005) looks at the many demographic factors—including population growth, density, fertility, mortality, and the age and sex composition of households—that are known to affect land use and land cover change. The report identifies the research needed to better understand these connections.

FEDERALLY COORDINATED RESEARCH ON CLIMATE CHANGE

More than a dozen federal agencies are involved in producing and using climate change data and research. The first efforts at a coordinated government research strategy culminated in the creation of the U.S. Global Change Research Program (USGCRP) in 1989. USGCRP made substantial investments in understanding the underlying processes of climate change, documenting past and ongoing global change, improving modeling, and enhancing knowledge of El Niño and the ability to forecast it.

The U.S. Climate Change Science Program (CCSP) was formed in February 2002 as a new management structure to coordinate government activities on climate. The CCSP has asked the National Academies to provide independent advice on numerous aspects of the program, including a two-stage review of its strategic plan, metrics for evaluating the progress of the program, scientific reviews of assessment reports, and ongoing strategic advice on the program as a whole.

Evaluating Progress of the U.S. Climate Change Science Program (2007) concluded that the program has made good progress in documenting and understanding temperature trends and related environmental changes, and the influence of human activities on these observed changes. The ability to predict future climate changes has improved, but efforts to understand the impacts of climate changes on society and analyze mitigation and adaptation strategies are still relatively immature. The program also had not yet met expectations in supporting decision making, studying regional impacts, and communicating with a wider group of stakeholders.

Much of the uncertainty about how the climate will change during the next 100 years is due to an inability to predict how population growth, economic development, energy and land use, and other human activities will evolve. To illustrate how various human choices affect future climate change, climate models are typically run using a number of different "scenarios," each of which is designed to represent a plausible and internally consistent prediction of future human activities (see Figure 12). Improving these scenarios depends on progress in understanding changes in human behavior and how these changes affect climate forcing.

IMPACTS OF CLIMATE CHANGE

Many of the world's poorest people, who lack the resources to respond to the impacts of climate change,are likely to suffer the most.

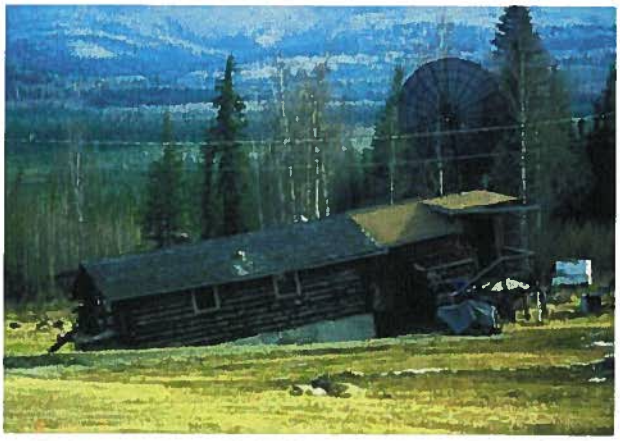
—Joint science academies' statement on sustainability, energy efficiency, and climate protection (May 2007)

Climate change will have many kinds of impacts.

Climate change will affect ecosystems and human systems—such as agricultural, transportation, and health infrastructure—in ways we are only beginning to understand (see Figure 13). There will be positive and negative impacts of climate change, even within a single region. For example, warmer temperatures may bring longer growing seasons in some regions, benefiting those farmers who can adapt to the new conditions but potentially harming native plant and animal species. In general, the larger and faster the changes in climate are, the more difficult it will be for human and natural systems to adapt.

Unfortunately, the regions that will be most severely affected are often the regions that are the least able to adapt. Bangladesh, one of the poorest nations in the world, is projected to lose 17.5 percent of its land if sea level rises about 1 meter (39 inches), displacing millions of people. Several

The Chinstrap penguin: a regional winner. Even within a single regional ecosystem, there will be winners and losers. For example, the population of Adélie penguins has decreased 22 percent during the past 25 years, while the Chinstrap penguin population increased by 400 percent. The two species depend on different habitats for survival: Adélies inhabit the winter ice pack, whereas Chinstraps remain in close association with open water. A 7-9° F rise in midwinter temperatures on the western Antarctic Peninsula during the past 50 years and associated receding sea-ice pack is reflected in their changing populations.



Global changes most keenly felt in polar regions
Recent years have brought a flurry of dramatic changes in the polar environment—changes that are happening faster than at other latitudes and faster than scientists had expected. Glaciers and sea ice are melting more and more quickly. Thawing permafrost can cause houses to sink, create forests of "drunken trees" that tilt at odd angles, and weaken roads, runways, and pipelines. Photo courtesy Larry Hinzman.

islands in the South Pacific and Indian oceans may disappear. Many other coastal regions will be at increased risk of flooding, especially during storm surges, threatening animals, plants, and human infrastructure such as roads, bridges, and water supplies.

Developed nations, including the United States, also will be affected. For example, most models indicate that snowpack is likely to decline on many mountain ranges in the West, which would bring adverse impacts on fish populations, hydropower, water recreation, and water availability for agricultural, industrial, and residential use. However, wealthy nations have a better chance of using science and technology to anticipate and adapt to sea level rise, threats to agriculture, and other climate impacts. Adaptations measures could include revising construction codes in coastal zones or the development of new agricultural technologies. Developing nations will need assistance in building their capacity to meet the challenges of adapting to climate change.

Polar regions are already experiencing major changes in climate.

Like the proverbial canary in the coal mine, changes in the polar regions can be an early warning of things to come for the rest of the planet, and the environmental changes now being witnessed at higher latitudes are alarming. For example, Arctic sea ice cover is decreasing rapidly and glaciers are retreating and thinning (see Figure 14, next page), NASA data show that Arctic sea ice shrunk to a new record low in 2007; 24 percent lower than the previous record (2005), and 40 percent lower than the long-term average.

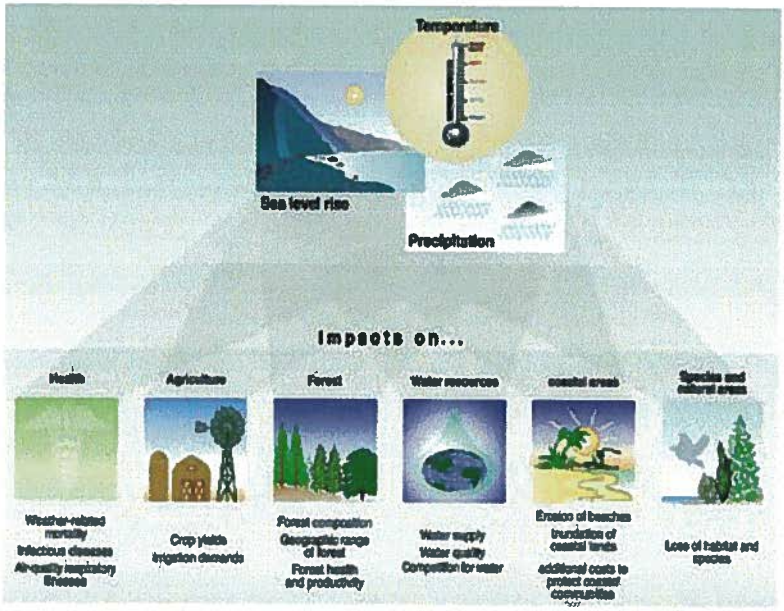


Figure 13. Climate changes could have potentially wide-ranging effects on both the natural environment and human activities and economies. Source: U.S. Environmental Protection Agency.

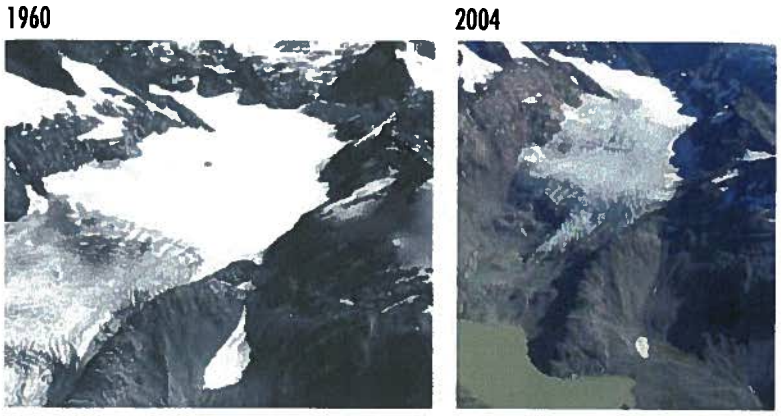


Figure 14. Warmer temperatures are causing glaciers to recede, as illustrated by theses photos of South Cascade Glacier in the state of Washington. Photo courtesy of Andrew Fountain.

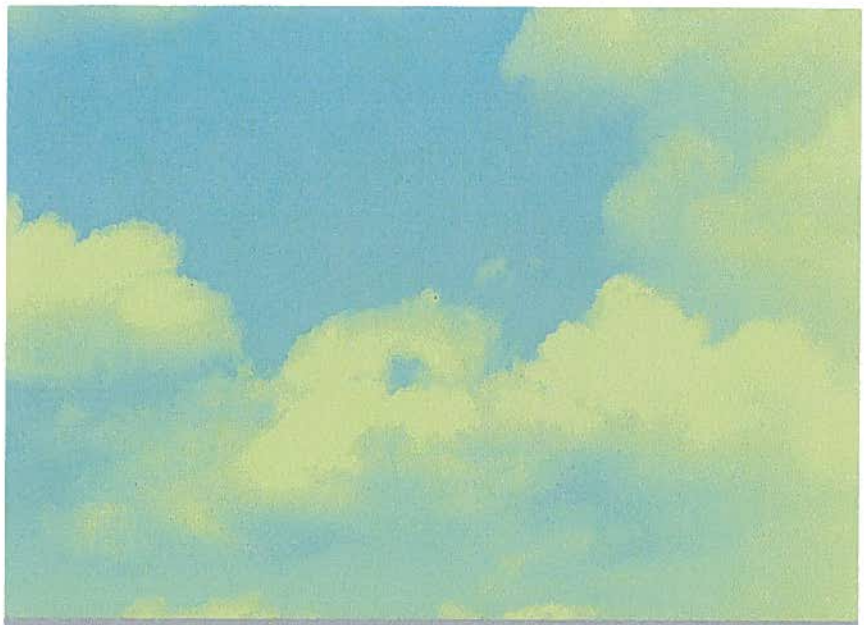
A number of ecosystem changes, such as plants flowering earlier in the year and declines in animal species that depend on sea ice for habitat, have been attributed to the strong warming observed at northern latitudes. Changing climate is also having human impacts: some Alaskan villages have been moved to higher ground in response to increasing storm damage, and the thawing of permafrost is undermining infrastructure, affecting houses, roads, and pipelines in northern communities around the world.

Given the global significance of changes in the polar regions, it is vital to have observational records that are sufficiently complete to both understand what is happening and guide decision makers in responding to change. *A Vision for the International Polar Year 2007-2008* (2004) recommends that the IPY 2007-2008—an unprecedented multinational effort to better understand the polar regions—be used as an opportunity to design and implement multidisciplinary polar observing networks. The Arctic has an especially limited record of observations that are often few and far between, short-term, and not coordinated with related observations. *Toward an Integrated Arctic Observing Network* (2006) recommends building a network that delivers complete pan-arctic observations.

CLIMATE AND HUMAN HEALTH

There are many ways in which climate change might affect human health, including heat stress, increased air pollution, and food scarcities due to drought or other agricultural stresses. Because many disease pathogens and carriers are strongly influenced by temperature, humidity, and other climate variables, climate change may also influence the spread of infectious diseases or the intensity of disease outbreaks. For example, some studies have predicted that global climate change could lead to an increase in malaria transmission by expanding mosquito habitat.

Current strategies for controlling infectious disease epidemics rely primarily on surveillance and response. *Under the Weather: Climate, Ecosystems, and Infectious Disease* (2001) recommends a shift toward prediction and prevention, such as developing early warning systems. Overall vulnerability to infectious disease could be reduced through water treatment systems, vaccination programs, and enhanced efforts to control disease carriers. The report also recommends increasing interdisciplinary collaboration among climate modelers, meteorologists, ecologists, social scientists, and medical and health professionals to better understand the linkages between climate change and disease.



HOW SCIENCE INFORMS DECISION-MAKING

Policymakers look to climate change science to answer two big questions: what could we do to prepare for the impacts of climate change, and what steps might be taken to slow it?

—Richard Alley, Professor, Pennsylvania State University

Steps can be taken to prepare for climate change.

Climate information is becoming increasingly important to public and private decision-making in various sectors, such as emergency management, water management, insurance, irrigation, power production, and construction. The emerging ability to forecast climate at seasonal-to-interannual time scales can be of tremendous value if the information is used well. *Making Climate Forecasts Matter* (1999) identifies research directions toward more useful seasonal-to-interannual climate forecasts and how to use forecasting to better manage the human consequences of climate change.

There is a wealth of climate data and information already collected that could be made useful to decision-makers in the form of "climate services." Such efforts are analogous to the efforts of the National Weather Service to provide useful weather information. *A Climate Services Vision: First Steps Towards the Future* (2001) outlines principles for improving climate services: for example, climate data should be made as user-friendly as weather information is today, and the government agencies, businesses, and universities involved in climate change data collection and research should establish active and well-defined connections to users and potential users.

Weather forecasts have benefited from a long and interactive history between providers and users, but this kind of communication is only beginning to develop in climate science. For example, western states have traditionally relied on January snowpack surveys to project annual streamflows. During the past several years, climate scientists have worked with water management agencies to develop streamflow projections

based on increasingly reliable El Niño predictions, which are available several months ahead of the January surveys and thus allow greater management flexibility. *Research and Networks for Decision Support in the NOAA Sectoral Applications Research Program* (2007) identifies additional ways to build communications between producers and users of climate information.

Another way to prepare for climate change is to develop practical strategies for reducing the overall vulnerability of economic and ecological systems to weather and climate variations. Some of these are "no-regrets" strategies that will provide benefits regardless of whether a significant climate change ultimately occurs in a region. No-regrets measures could include improving climate forecasting based on decision-maker needs; slowing biodiversity loss; improving water, land, and air quality; and making our health care enterprise, financial markets, and energy and transportation systems more resilient to major disruptions.

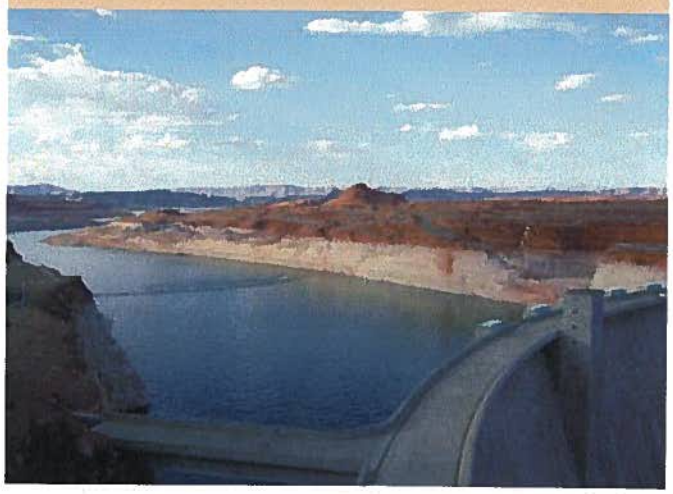
Steps can be taken to mitigate climate change.

Despite remaining unanswered questions, the scientific understanding of climate change is now sufficiently clear to justify taking steps to reduce the amount of greenhouse gases in the atmosphere. Because carbon dioxide and other greenhouse gases can remain in the atmosphere for many decades, centuries, or longer, the climate change impacts from greenhouse gases emitted today will likely continue well beyond the 21st century. Failure to implement significant greenhouse gas emission reductions now will make it much more difficult to stabilize atmospheric concentrations at levels that avoid the most severe impacts.

Governments have proven they can work together to reduce or reverse negative human impacts on nature. A classic example is the successful international effort to phase out use of chlorofluorocarbons (CFCs) in aerosol sprays and refrigerants, which were destroying the Earth's protective ozone layer. Although the success of controls on CFCs cannot be denied, the problem of control-

CLIMATE DATA INFORM WATER MANAGEMENT DECISIONS IN COLORADO

Studies of past climate and streamflow conditions of the Colorado River Basin have shed new light on long-term water availability in the region. Water management decisions have been based on the past 100 years of recorded streamflows. However, studies reveal many periods in the past when streamflow was much lower than at any time in the past 100 years of recorded flows. *Colorado River Basin Water Management* (2007) concludes that managers are therefore basing decisions on an overly optimistic forecast of future water availability, particularly given regional warming trends. The report recommends that Colorado prepare for possible water shortages that can not be overcome through current technology and management practices. Photo of Lake Powell, courtesy of Brad Udall, University of Colorado.



ling greenhouse gas emissions is much more difficult: alternative technologies are not readily available to offset many human activities that contribute to climate change, and, instead of the handful of companies responsible for producing CFCs, there are literally billions of individuals, as well as many businesses and governments, making decisions that affect carbon dioxide and other greenhouse gas emissions.

At the present time there is no single solution that can eliminate future warming. However, as early as 1992, *Policy Implications of Greenhouse Warming* (1992) concluded that there are many potentially cost-effective technological options that could help stabilize greenhouse gas concentrations. Personal, national, and international choices have an impact; for example driving less, regulating emissions, and sharing energy technologies would all help reduce emissions. The climate change problem is one of the most difficult problems of managing the "commons"—environmental goods that benefit everyone but that can be degraded by the individual actions of anyone. Social scientists are working to identify social institutions that are suitable for managing commons problems, such as greenhouse gas emissions.

The increasing need for energy is the single greatest challenge to slowing climate change.

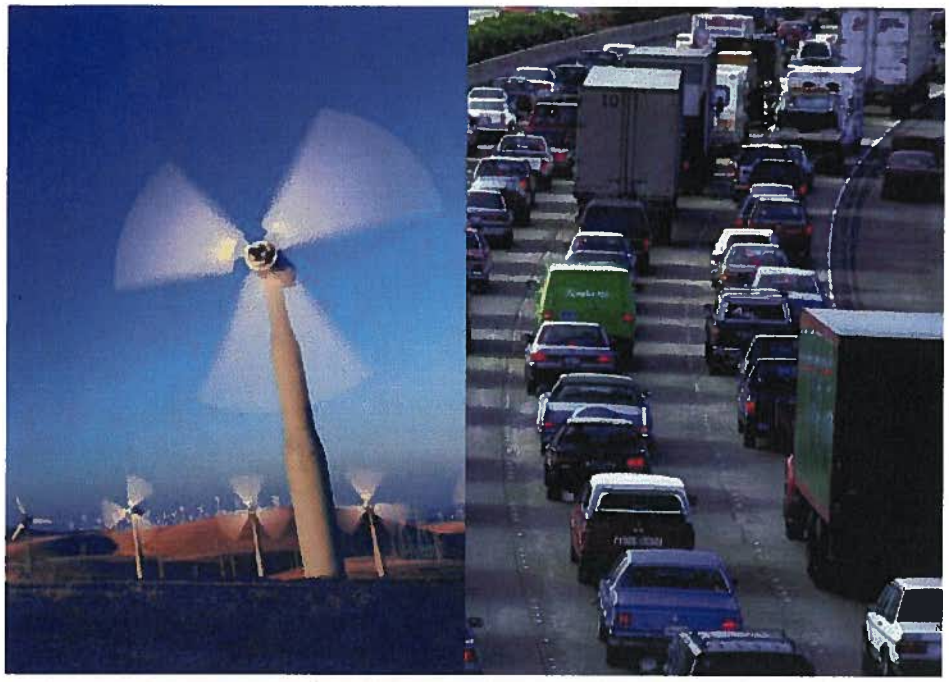
Energy is essential for all sectors of the economy, including industry, commerce, transportation, and residential use. Worldwide energy use continues to grow with economic and population expansion. Fossil fuels supply most of today's energy needs. According to the Department of Energy, about 82 percent of all greenhouse gases produced in the United States by human activity comes from burning fossil fuels. Developing countries, China and India in particular, are rapidly increasing their use of energy, primarily from fossil fuels, and consequently their carbon dioxide emissions are rising sharply (see Figure 15, next page).

Carbon dioxide emissions can be reduced either by switching to alternative fuels that produce less or no carbon dioxide or by using energy more efficiently. Energy efficiency could be improved in all sectors of the U.S. economy. Many of these improvements are cost-effective, but constraints such as a lack of consumer awareness and higher initial costs hold them back. *Energy Research at DOE: Was It Worth It?* (2001) addresses the benefits of increasing the energy efficiency of lighting, refrigerators, and other appliances.

Oil is the main fuel in the transportation sector. *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards* (2002) evaluates car and light truck fuel use and analyzes how fuel economy could be

INFORMING POLICY THROUGH ASSESSMENTS

Climate change assessments are collective, deliberative processes by which experts review, analyze, and synthesize scientific knowledge to provide information for decision-making or about remaining scientific uncertainties. One of the most influential set of assessments on climate change is produced by the Intergovernmental Panel on Climate Change (IPCC), which was established by the World Meteorological Organization and the United Nations Environment Programme to assess scientific, technical, and socioeconomic information relevant for the understanding of climate change. IPPC's fourth assessment report was issued in 2007. *Analysis of Global Change Assessments: Lessons Learned* (2007) identifies the key elements of effective assessments, such as the development of tools that make use of scientific analyses at the regional and local level where decisions are made.



Personal, national, and international choices have an impact. For example, driving less, regulating emissions, and sharing energy technologies would all help reduce emissions.

improved. Steps range from improved engine lubrication to hybrid vehicles.

There are many alternatives to producing energy from fossil fuels. Electricity can be produced without significant carbon emissions using nuclear power and renewable energy technologies, such as solar, wind, hydropower, and biomass (fuels made from plant matter). Biofuels can also be used to power vehicles. Interest in these technologies is growing, and research and development could make all of them more viable, but each renewable energy technology carries its own set of issues and challenges. For example, *Water Implications of Biofuels Production in the United States* (2008) concludes that although ethanol and other biofuels can help reduce our nation's dependence on fossil fuels, the increase in agriculture to grow biofuel crops, such as corn, could have serious impacts on water quality due to more intense use of fertilizers and increased soil erosion.

Another way to reduce emissions is to collect carbon dioxide from fossil-fuel-fired power plants and sequester it in the ground or the ocean. *Novel Approaches to Carbon Management: Separation, Capture, Sequestration, and Conversion to Useful Products* (2003) discusses the development of this technology. If successful, carbon sequestration could weaken the link between fossil fuel use and greenhouse gas emissions, but considerable work remains before this approach can be widely adopted.

Capturing carbon dioxide emissions from the tailpipes of vehicles is essentially impossible, which is one factor that has led to considerable interest in hydrogen as a fuel. However, as with electricity, hydrogen must be manufactured from primary energy sources. If hydrogen is produced from fossil fuels (currently the least expensive method), carbon capture and sequestration would be required to reduce net carbon dioxide emissions. Substantial technological and economic barriers in all phases of the hydrogen fuel cycle must also be surmounted. *The Hydrogen Economy: Opportunities, Costs, Barriers and R&D Needs* (2004) presents a strategy that could lead eventually to production of hydrogen from a variety of domestic sources—such as coal with carbon sequestration, nuclear power, wind, or photo-biological processes—and its efficient use in fuel-cell vehicles.

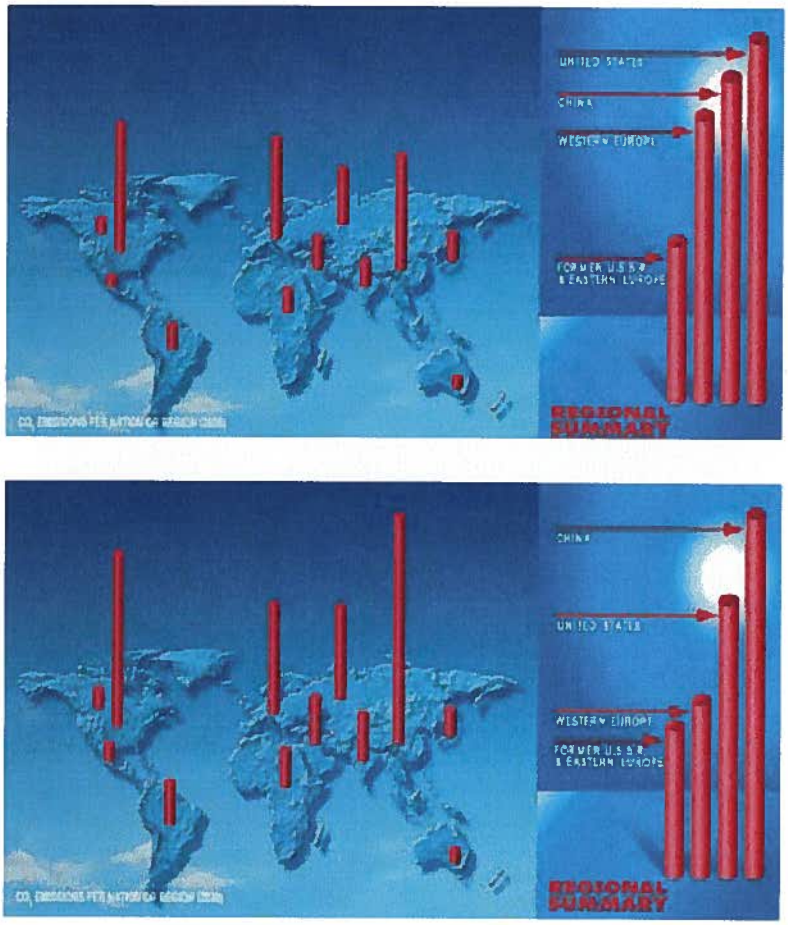


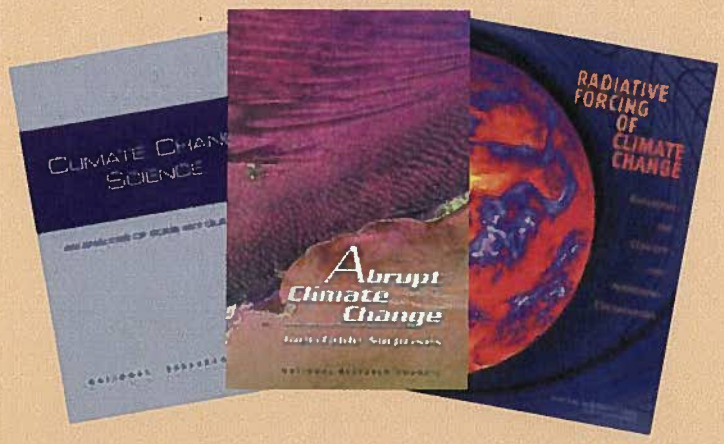
Figure 15. The two panels compare CO_2 emissions per nation in 2005 and projections for 2030. In 2005, the largest emitter of CO_2 was the United States, which is responsible for 25 percent of global emissions. By 2030, China and the developing world are expected to have significantly increased their CO_2 emissions relative to the United States. Image courtesy of the Marian Koshland Science Museum of the National Academy of Sciences, updated 2007.

Continued scientific efforts to address a changing climate

Although the understanding of climate change has advanced significantly during the past few decades, many questions remain unanswered. The task of mitigating and adapting to the impacts of climate change will require worldwide collaborative input from a wide range of experts, including physical scientists, engineers, social scientists, medical scientists, business leaders, economists, and decision-makers at all levels of government. It is important to continue to improve our understanding of climate change science, and to make sure that available climate information more fully addresses the needs of decision makers. Through its expert consensus reports, the National Academies will continue to provide analysis and direction to the policymakers and stakeholders involved in understanding and responding to climate change.

CLIMATE CHANGE AND RELATED REPORTS FROM THE NATIONAL ACADEMIES

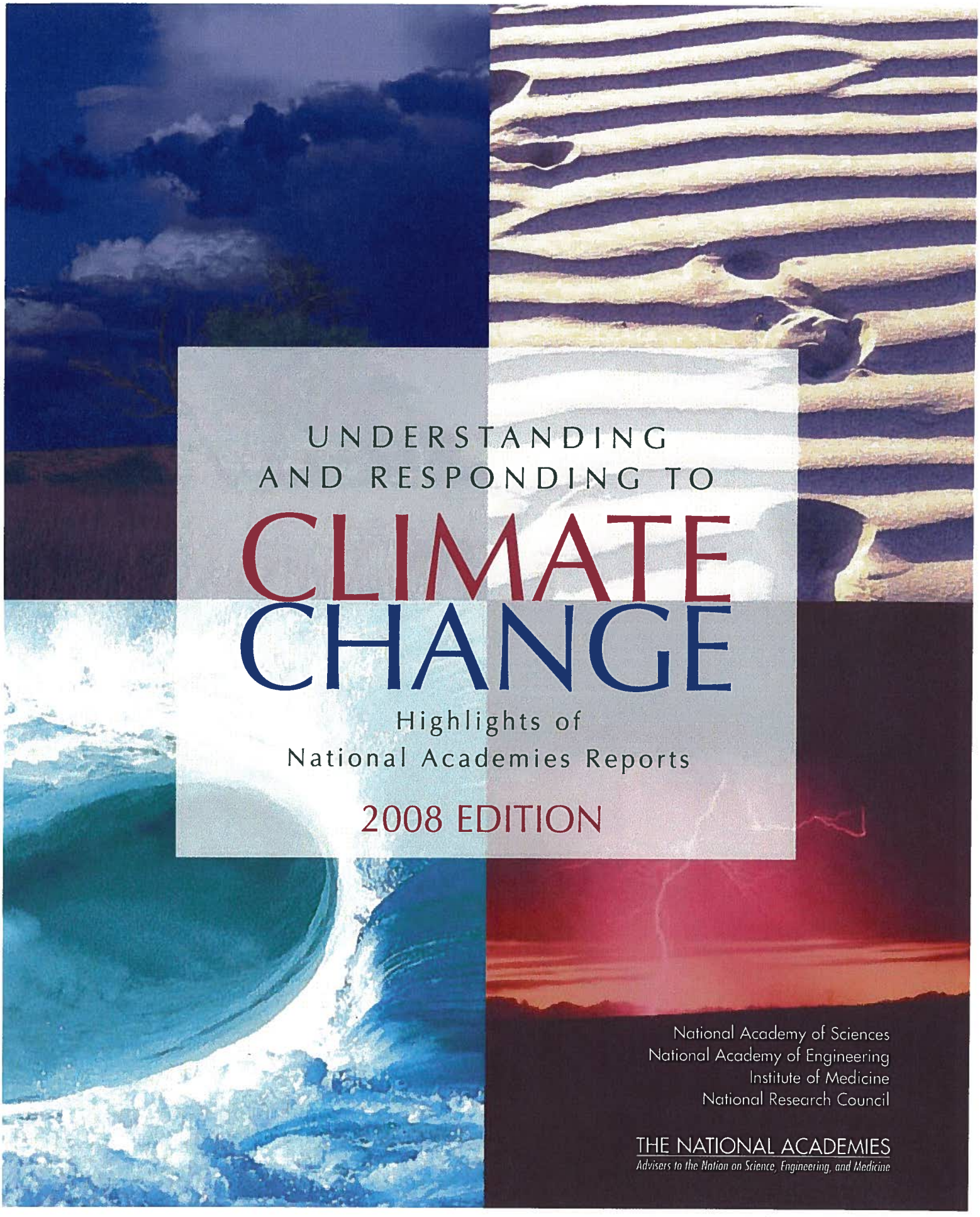
Highlighted in this booklet



Water Implications of Biofuels Production in the United States (2008)
Analysis of Global Change Assessments: Lessons Learned (2007)
Colorado River Basin Water Management: Evaluating and Adjusting to Hydroclimatic Variability (2007)
Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond (2007)
Evaluating Progress of the U.S. Climate Change Science Program (2007)
Research and Networks for Decision Support in the NOAA Sectoral Applications Research Program (2007)
Surface Temperature Reconstructions for the Last 2000 Years (2006)
Toward an Integrated Arctic Observing Network (2006)
Earth Science and Applications from Space: Urgent Needs and Opportunities to Serve the Nation (2005)
Population, Land Use, and the Environment (2005)
Radiative Forcing of Climate Change: Expanding the Concept and Addressing Uncertainties (2005)
Thinking Strategically: The Appropriate Use of Metrics for the Climate Change Science Program (2005)
A Vision for the International Polar Year 2007-2008 (2004)
Climate Data Records from Environmental Satellites (2004)
The Hydrogen Economy: Opportunities, Costs, Barriers and R&D Needs (2004)
Implementing Climate and Global Change Research: A Review of the Final U.S. Climate Change Science Program Strategic Plan (2004)
Novel Approaches to Carbon Management: Separation, Capture, Sequestration, and Conversion to Useful Products (2003)
Planning Climate and Global Change Research: A Review of the Draft U.S. Climate Change Science Program Strategic Plan (2003)
Understanding Climate Change Feedbacks (2003)
Abrupt Climate Change: Inevitable Surprises (2002)
Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards (2002)
A Climate Services Vision: First Steps Towards the Future (2001)
Climate Change Science: An Analysis of Some Key Questions (2001)
Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research from 1978 to 2000 (2001)
Improving the Effectiveness of U.S. Climate Modeling (2001)
Under the Weather: Climate, Ecosystems, and Infectious Disease (2001)
Making Climate Forecasts Matter (1999)
Global Environmental Change: Understanding the Human Dimension (1992)
Policy Implications of Greenhouse Warming: Mitigation, Adaptation, and the Science Base (1992)

EXPERT CONSENSUS REPORTS

For more studies and related information see http://dels.nas.edu/globalchange and http://dels.nas.edu/basc. National Academies reports are available from the National Academies Press, 500 Fifth Street, NW, Washington, DC 20001; 800-624-6242; http://www.nap.edu. Reports are available online in a fully searchable format.



UNDERSTANDING AND RESPONDING TO CLIMATE CHANGE

Highlights of National Academies Reports

2008 EDITION

National Academy of Sciences
National Academy of Engineering
Institute of Medicine
National Research Council

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

About the National Academies

The National Academies are nongovernment, nonprofit organizations that were set up to provide independent scientific and technological advice to the U.S. government and nation. The National Academies include three honorary societies that elect new members to their ranks each year—the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine—and the National Research Council, the operating arm that conducts the bulk of the institution's science policy and technical work. The Academies enlist committees of the nation's top scientists, engineers, and other experts, all of whom volunteer their time to study specific issues and concerns.

The National Academies offer the following e-mail newsletters and notifications related to climate change:

Earth & Life Studies at the National Academies, http://dels.nas.edu
(immediate notification of new projects, committee postings, reports, and events)

Climate and Global Change at the National Academies e-update,
http://dels.nas.edu/globalchange (monthly)

The Board on Atmospheric Sciences and Climate Newsletter,
http://dels.nas.edu/basc (quarterly)

For more information, contact the Board on Atmospheric Sciences and Climate at 202-334-3512 or visit http://dels.nas.edu/basc. This brochure was prepared by the National Research Council based on National Academies' reports. It was written by Amanda Staudt, Nancy Huddleston, and Ian Kraucunas and was designed by Michele de la Menardiere. Support for this publication was provided by the Presidents' Circle Communications Initiative of the National Academies. Thanks to Antonio Busalacchi, Richard Alley, Sherry Rowland, Dennis Hartmann, Tom Vonder Haar, Tom Wilbanks, Taro Takahashi, Alan Crane, Art Charo, Chris Elfring, Paul Stern, and Gregory Symmes for their helpful contributions.

At a time when responding to our changing climate is one of the nation's most complex endeavors, reports from the National Academies provide thoughtful analysis and helpful direction to policymakers and stakeholders. These reports are produced by committees organized by the Board on Atmospheric Sciences and Climate, its Climate Research Committee, and numerous other entities within the National Academies. With support from sponsors, the National Academies will continue in its science advisory role to the agencies working on understanding changing climate, documenting its impacts, and developing effective response strategies.

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

The nation turns to the National Academies—National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council—for independent, objective advice on issues that affect people's lives worldwide.
www.national-academies.org

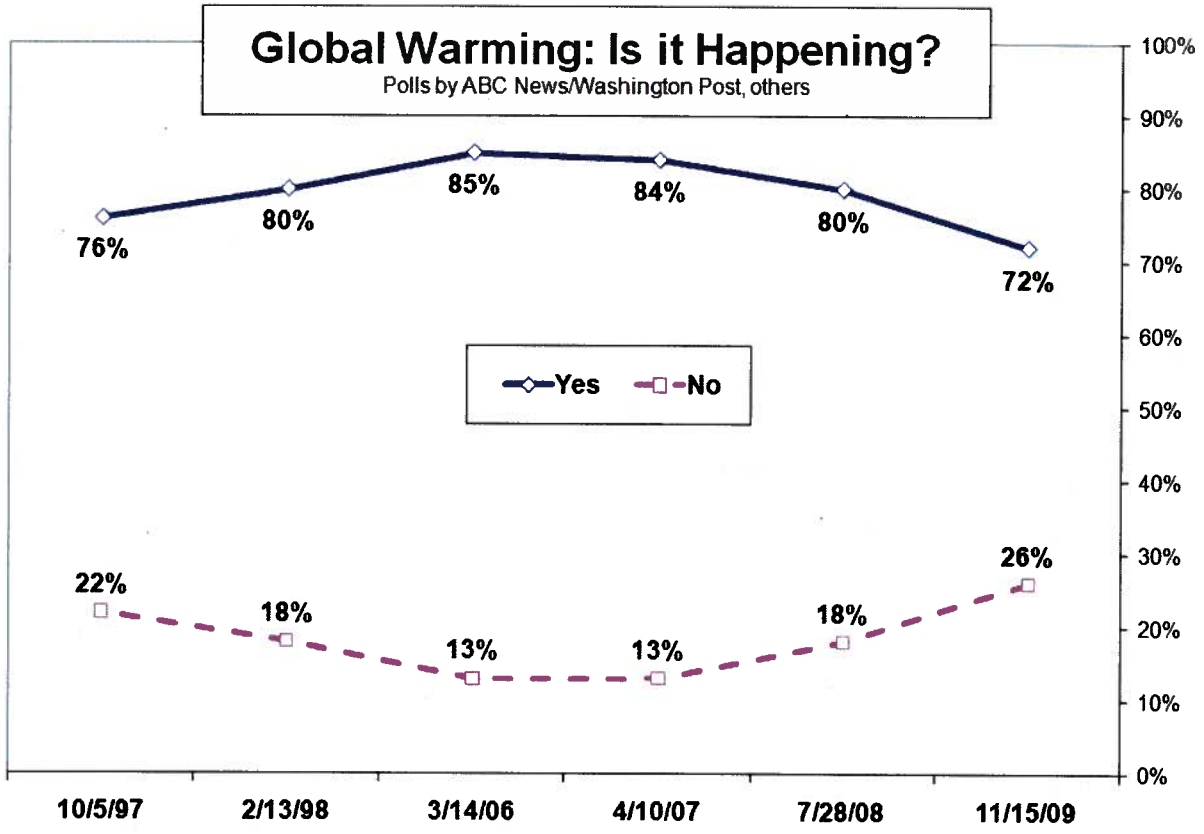
ABC NEWS/WASHINGTON POST POLL: GLOBAL WARMING
EMBARGOED FOR RELEASE AFTER 5 p.m. Tuesday, Nov. 24, 2009

Conservatives, Republicans Move Away From Belief that the Earth is Warming

The number of Americans who believe global warming is occurring has declined to its lowest since 1997, though at 72 percent it's still a broad majority. The drop has steepened in the last year and a half – almost exclusively among conservatives and Republicans.

This ABC News/Washington Post poll also finds that support for government action to address the issue, while still a majority, likewise is down from its levels in summer 2008.

Belief that the Earth is warming peaked at 85 percent in 2006, then flattened before turning back. Even with the decline, Americans who think global warming probably is occurring outnumber those who think not by nearly 3-1, 72 percent to 26 percent.

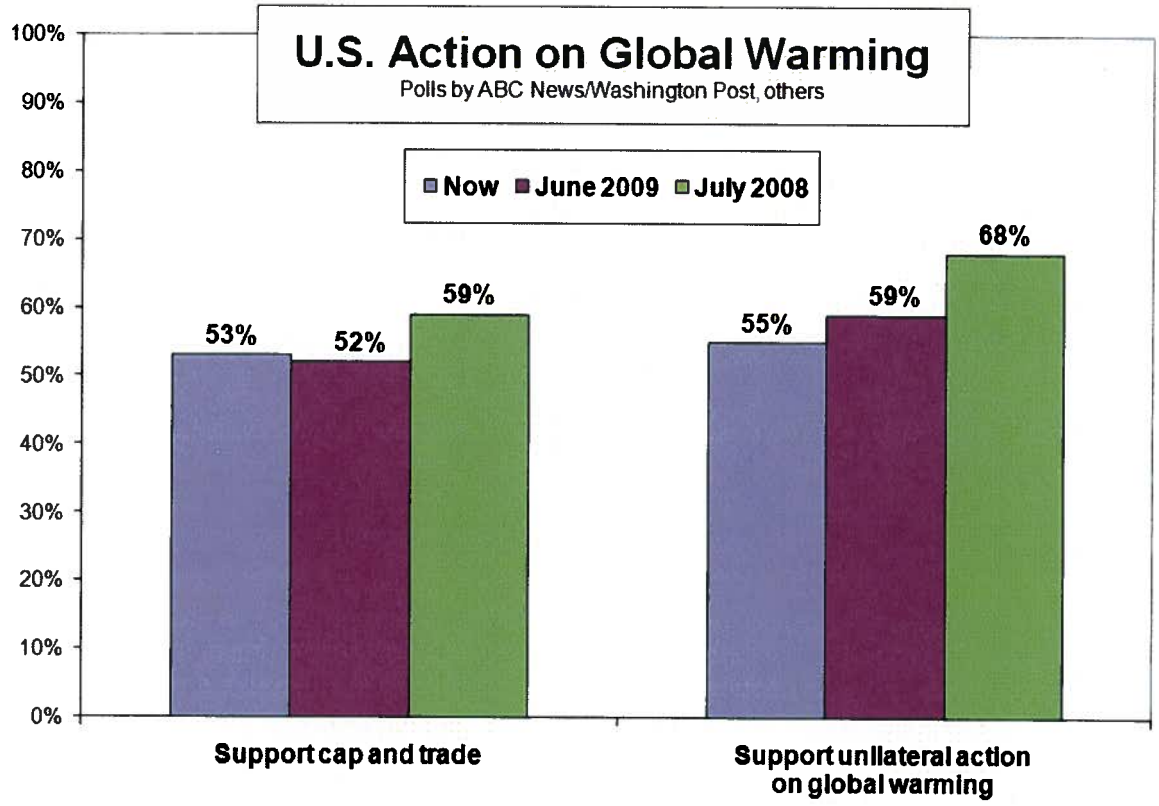


Levels of concern are undiminished among those who think it is happening, and intensity of sentiment has risen: Eighty-two percent call it a serious problem right now (it was a similar 84 percent last year); 44 percent call it "very serious," up 6 points.

NMED-ELY
EXHIBIT 7

On policy, 76 percent now favor unspecified government action on global warming, down from 86 percent in summer 2008. This now includes 55 percent who favor the United States taking steps even if countries such as China and India do less; that's down from 68 percent.

On one specific proposal, 53 percent support a cap-and-trade system to limit greenhouse gases. That's slipped from 59 percent in summer 2008.

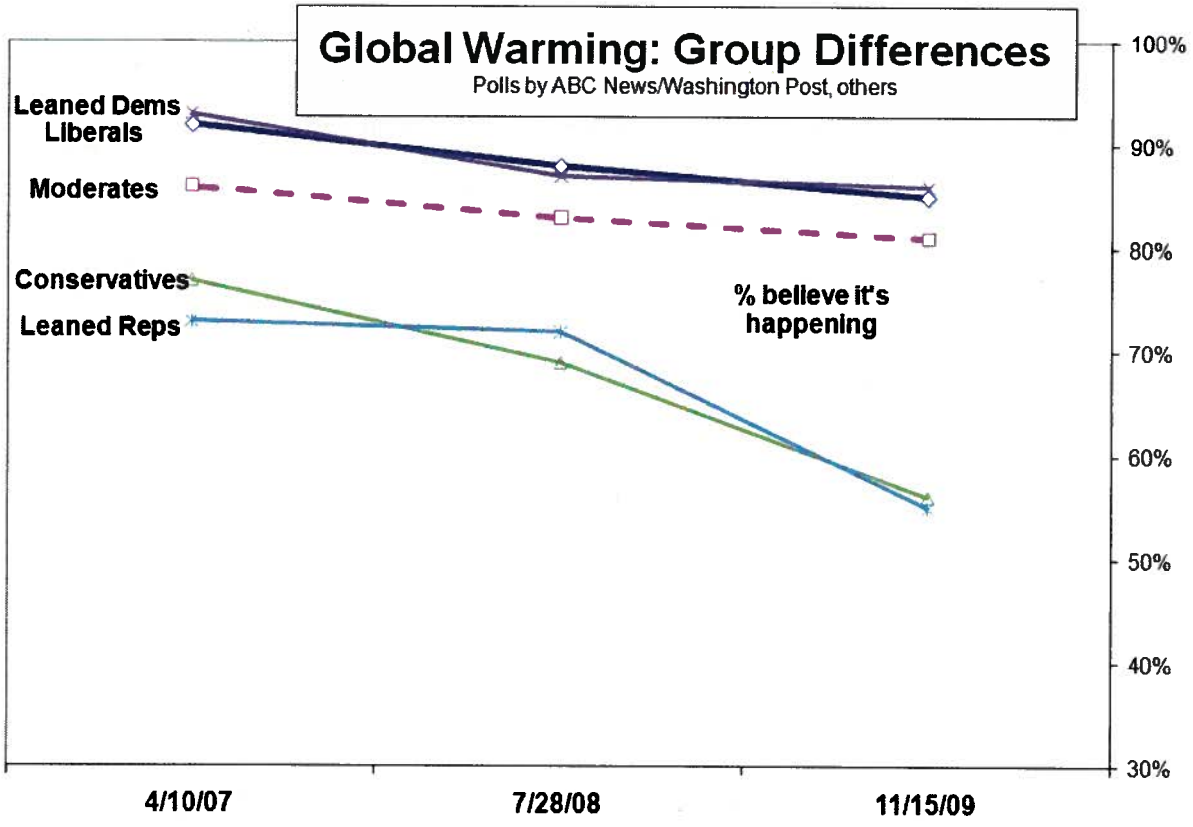


Discussion of government action to address global warming has intensified in advance of a United Nations-sponsored conference in Copenhagen Dec. 7-18. Representatives of 191 countries have been invited; the White House is expected to say shortly whether President Obama will go.

GETTING WARMER? – Belief that global warming is occurring – specifically, that the world's temperature has been going up slowly in the past hundred years – was 76 percent in an Ohio State University poll in 1997 and 85 percent in an ABC/Time/Stanford University poll in spring 2006. It subsided to 80 percent last year, vs. 72 percent now.

The ideological and partisan nature of the change, especially in the last year, supports previous research finding that views on global warming are heavily informed by political and ideological predispositions. (So, for example, are views of the economy, particularly when its condition or direction aren't clear.)

Since summer 2008 belief that warming is occurring fell by 13 points among conservatives while holding essentially steady among liberals and moderates. It fell by 20 points among Republicans and 8 points among independents while steady among Democrats. Grouping Republicans with independents who lean toward the Republican Party finds a 17-point drop in this group, compared with no real change (-1) among Democrats and Democratic-leaning independents.



The changes in the two groups in which it's chiefly occurred are striking ones. Last year leaned Republicans by 72-25 percent believed the Earth was warming; today it's 55-43 percent. Conservatives last year divided by 69-28 percent on the question; today, by contrast, it's 56-41 percent. Combining these groups – that is, among conservative Republicans – a bare majority now says global warming is not occurring, the only group in which more than half says so.

	Think global warming is occurring				
	Now		July 2008		Change, yes
	Yes	No	Yes	No	
All	72%	26	80%	18	-8
Lib	85	12	88	11	-3
Mod	81	18	83	16	-2
Cons	56	41	69	28	-13
Dem	86	12	87	13	-1
Ind	71	27	79	20	-8

Rep	54	43	74	24	-20
Leaned Dem	86	13	87	12	-1
Leaned Rep	55	43	72	25	-17
Cons Rep	45	52	65	32	-20

Looking back another year, to spring 2007, shows changes that also are disproportionately among conservatives and Republicans. In this comparison, belief that global warming is occurring has dropped by 21 points among conservatives vs. 7 points and 5 points, respectively, among liberals and moderates; and by 18 points among leaned Republicans vs. 7 points among leaned Democrats.

WHY? – Policy preferences could hold a clue as to why these changes have occurred. Conservatives and Republicans broadly oppose proposed government measures to deal with climate change. A heightened sense that such changes may be coming, particularly since the Obama administration took office, may encourage more people in these groups to express disbelief that global warming is occurring in the first place.

Data in this survey show, as expected, that belief that global warming is occurring predicts support for measures to deal with it. But the reverse also is true: Views on government measures to address climate change predict belief in whether it's occurring. Directionality is difficult to establish, and may well run both ways. In any case, including one of these variables when predicting the other in a statistical model increases the model's explanatory power.

In further evidence, belief that global warming is occurring has fallen since summer 2008 entirely among people who oppose cap and trade and who oppose unilateral action by the United States. Among their policy opposites, belief has held steady.

	Think global warming is occurring		
	Now	June 2008	Change
Cap and trade:			
Support	83%	84%	-1
Oppose	59	72	-13
Unilateral action:			
Support	88%	87	+1
Oppose	52	65	-13

The change in views among conservatives and Republicans has occurred even as scientific consensus and the urgency of warnings about the impact of a warmer Earth have increased. Previous research, however, has shown that conservatives and Republicans simply are less disposed to accept those warnings as reliable.

SERIOUSLY? – Among people who believe climate change is occurring, there again are ideological and partisan differences on its seriousness. Three-quarters of conservatives in this group say it's a serious problem now, 9 and 13 points fewer than the number of moderates and

liberals who say so. The partisan gap is wider: Among Republicans who think it's happening, 63 percent call it serious; that jumps to 82 percent of independents and 90 percent of Democrats.

ACTION/BELIEF – As noted, belief that global warming is occurring, and that it's a serious problem, are the strongest independent predictors of support for government action in general, and a cap-and-trade law in particular.

Among people who say it's happening and is a serious problem now, 73 percent favor unilateral action by the United States to address global warming; that drops to 40 percent among those who think it's happening but isn't serious, and just 24 percent of those who don't think it's occurring. Similarly, support for cap and trade peaks at 65 percent of those who see a serious problem now, drops to 42 percent among those who think the Earth is warming but don't see a serious problem at this point and bottoms out at 33 percent of those who don't think it's occurring.

Support for action, like belief in the phenomenon and its seriousness, also are influenced by ideology and partisanship. Seventy-two percent of liberals and 67 percent of moderates favor action by the United States even if other countries do less; that dives to 34 percent among conservatives. And conservatives are more than 20 points less apt to back cap and trade.

Politically, Democrats and Republicans are at odds on both of these, with independents closer to Republicans, particularly on cap and trade.

	Cap and trade?		Should the United States take action?		
	Yes	No	Even if others do less	Only if others do same	No
All	53%	42	55%	21	22
Dem	66	28	66	18	14
Ind	49	46	52	25	21
Rep	39	56	43	17	37
Lib	65	28	72	15	8
Mod	61	35	67	19	14
Cons	40	55	34	25	38

In terms of change the past year and a half, support for cap and trade has declined by 12 points among Republicans and Republican-leaning independents, vs. 4 points among leaned Democrats; it's also declined more among conservatives than among liberals and moderates. Support for unilateral action, though, has fallen more generally across these groups; it's down by 15 points among leaned Democrats as well as by 13 points among leaned Republicans.

There are other factors in views on policy. People who think the economy is recovering are 20 points more apt to support cap and trade, a significantly predictive factor even when controlled for other variables, including partisanship and ideology. (Economic views don't significantly predict opinions on unilateral U.S. action in general.) Additionally, younger adults are 16 points more apt than their elders (and 25 points more likely than seniors) to support unilateral U.S. action. This holds as an independent predictor when controlled for other factors.

OTHER DATA – Other recent polls have shown similar declines in belief that global warming is occurring, with results differing in degree given the different questions posed. They also show less credence among conservatives and Republicans, but with changes involving other groups as well as these, unlike the ABC/Post results.

A Gallup poll in March found an 8-point decline from 2008, to 53 percent, in belief that the effects of global warming "have already begun" to happen; a 6-point decline, to 60 percent, in personal worry about it; and a 6-point rise, to 41 percent, in the belief its seriousness is "generally exaggerated," a view Gallup called "somewhat volatile" in polls since 2001. (Views that the effects have begun fell by 16 points among conservatives from March 2008 to March 2009, compared with 6 points among moderates and an insignificant 1-point gain among liberals in Gallup's data.)

In a Fox News poll last May, 69 percent (of registered voters) said they "believe global warming exists," down from 82 percent in January 2007. And a Pew Research poll last month found a 14-point drop, from 71 percent in spring 2008 to 57 percent, in people saying there's "solid evidence" temperatures have been rising the past few decades. The ABC/Post question asks if people think temperatures probably have or probably have not been rising, a lower bar than "solid evidence."

METHODOLOGY – This ABC News/Washington Post poll was conducted by telephone Nov. 12-15, 2009, among a random national sample of 1,001 adults, including landline and cell-phone-only respondents. Results for the full sample have a 3.5-point error margin. Click here for a detailed description of sampling error. Sampling, data collection and tabulation by TNS of Horsham, PA.

Analysis by Gary Langer.

ABC News polls can be found at ABCNEWS.com at http://abcnews.com/pollingunit

Media contact: Cathie Levine, (212) 456-4934.

Full results follow (*= less than 0.5 percent).

1-39 previously released or held for release.

40. On another subject, you may have heard about the idea that the world's temperature may have been going up slowly over the past 100 years. What is your personal opinion on this - do you think this has probably been happening, or do you think it probably has not been happening?

	Has been happening	Has not been happening	No opinion
11/15/09	72	26	2
7/28/08*	80	18	2
4/10/07	84	13	3
3/14/06	85	13	2
2/13/98	80	18	2
10/5/97	76	22	2

*2008, ABC/Planet Green/Stanford University; 2007, ABC/Post/Stanford; 2006, ABC/Time/Stanford; 1998 and 1997, Ohio State University

41. (IF GLOBAL WARMING HAPPENING) How serious of a problem do you think global warming is right now: very serious, somewhat serious, not so serious or not serious at all?

	------ Serious ------			----- Not serious -------			
	NET	Very	Somewhat	NET	Not so	Not at all	No opinion
11/15/09	82	44	38	17	11	6	*
7/28/08	84	38	46	15	10	5	1

42. There's a proposed system called "cap and trade." The government would issue permits limiting the amount of greenhouse gases companies can put out. Companies that did not use all their permits could sell them to other companies. The idea is that many companies would find ways to put out less greenhouse gases, because that would be cheaper than buying permits. Would you support or oppose this system?

	Support	Oppose	No opinion
11/15/09	53	42	5
8/17/09	52	43	6
6/21/09	52	42	6
7/28/08	59	34	7

43. Do you think the United States should take action on global warming only if other major industrial countries such as China and India agree to do equally effective things, that the United States should take action even if these other countries do less, or that the United States should not take action on this at all?

	Take action only if other countries do	Take action even if other countries do less	Should not take action at all	No opinion
11/15/09	21	55	22	3
6/21/09	20	59	18	3
7/28/08	18	68	13	2

44-55 previously released.

END

Research & Polling, Inc.

New Mexico Global Warming Survey
Summary of Results

Methodology

This study was conducted by Research & Polling, Inc., to assess the attitudes and opinions of New Mexico voters as they relate to environmental issues. A random sample of 400 voters statewide was interviewed by telephone between January 26th and February 1st, 2007. A sample size of 400 provides a maximum margin of error of plus or minus 4.9%.

Key Findings

Over the past two years, few other issues have received as much media attention and public discussion as global warming. The results of this survey show that the large majority of registered voters in New Mexico are concerned about global warming and this concern appears to be growing. In fact, the percentage of those who say global warming is a *very serious problem* has nearly doubled over the past two years. The large majority of voters in New Mexico are looking to both State and Federal governments to address the issue and take action. However, most voters see the Federal Government as having the primary responsibility in reducing the emissions that cause global warming. The issue of global warming is intricately linked to our energy policies and development of alternative forms of energy. Thus, it is not surprising that most voters support policies and programs that encourage the development of alternative energy sources.

Perceived Seriousness of Various Issues
(Summary Table)

Ranked by Highest Percentage "Very Serious Problem"

Total Sample (N=400)

	Very Serious Problem 5	*4*	*3*	*2*	*No Problem At All 1*	*Don't Know/ Won't Say*	*Mean †*
Global warming	38%	21%	20%	9%	10%	2%	*3.7*
Availability of future gas and oil supplies	34%	29%	23%	9%	4%	1%	*3.8*
Air pollution	26%	28%	23%	17%	6%	-	*3.5*
Strength of the economy	21%	28%	30%	12%	9%	*	*3.4*
Drought	21%	22%	29%	17%	9%	2%	*3.3*

† The mean score is derived by taking the average score based on the 5-point scale. The Very serious problem response is assigned a value of 5; the No problem at all response is assigned a value of 1. The Don't know/won't say responses are excluded from the calculation of the mean.

**Less than 1% reported.*

Voters were asked to rate how serious a problem they feel various issues are using a 5-point scale where 5 is a *very serious problem* and 1 is *no problem at all*. As shown above, three-fifths (59%) of voters feel global warming is a serious problem as indicated by a score of 4 or 5 on a 5-point scale. In fact, 38% say it is a *very serious*

problem. Similarly, 63% of voters feel the availability of future gas and oil supplies is a serious problem (34% say it is a *very serious problem*).

The majority of voters (54%) also feel air pollution is a serious problem, while nearly half (49%) feel this way about the strength of the economy. Finally, 43% of registered voters statewide say the drought is a serious problem.

Perceived Seriousness of Global Warming
(Trending Analysis)

	Very Serious Problem 5	*4*	*3*	*2*	*No Problem At All 1*	*Don't Know/ Won't Say*	*Mean †*
2007 Total Sample (N=400)	**38%**	**21%**	**20%**	**9%**	**10%**	**2%**	***3.7***
2005 Total Sample (N=500)	22%	20%	25%	15%	16%	2%	*3.3*

† The mean score is derived by taking the average score based on the 5-point scale. The Very serious problem response is assigned a value of 5; the No problem at all response is assigned a value of 1. The Don't know/won't say responses are excluded from the calculation of the mean.
**Less than 1% reported.*

Concern about global warming has grown significantly over the past two years. In a similar study conducted among 500 registered voters statewide in 2005, 42% rated global warming as a serious problem compared to 59% observed currently.

Global Warming

Opinion About Global Warming

(Aided Categories)

	2005 Total Sample (N=500)	***2007 Total Sample (N=400)***
Global warming has been established as a very serious problem, and strong, immediate measures are necessary	23%	**32%**
There is enough evidence that global warming is taking place and some action should be taken	31%	**37%**
We don't know enough about global warming, and more research is necessary before we take strong actions	29%	**21%**
Concern about global warming has been greatly exaggerated	14%	**9%**
Don't know/won't say	3%	**1%**

Voters were read four statements about global warming and asked which is closest to their personal opinion. As shown above, 32% of voters believe global warming has been established as a very serious problem and *strong*, immediate measures are necessary. In addition, 37% of voters believe there is enough evidence that global warming is taking place and *some* action should be taken. Thus, over two-thirds of voters (69%) believe the problem of global warming warrants action.

Less than one-third of the voters either believe we don't know enough about global warming and that more research is necessary before we take strong actions (21%) or feel the concerns about global warming have been greatly exaggerated (9%)

The increased concern that voters have about global warming is further illustrated by the fact that in the 2005 study 54% of voters believed there was evidence of global warming and that at least some action should be taken compared to 69% currently.

Global Warming

Agreement or Disagreement With Global Warming Statements (Summary Table)

Ranked by Highest Percentage "Strongly Agree"

Total Sample (N=400)

	Strongly Agree 5	*4*	*3*	*2*	*Strongly Disagree 1*	*Don't Know/ Won't Say*	*Mean †*
The United States government is not doing enough to address the issue of global warming	39%	14%	24%	10%	11%	3%	*3.6*
The state of New Mexico needs to do more to reduce the emissions that cause global warming	38%	23%	16%	10%	12%	2%	*3.7*
The main cause of global warming is the emission of gasses such as carbon dioxide from the burning of fossil fuels	33%	20%	10%	10%	10%	8%	*3.6*

† The mean score is derived by taking the average score based on the 5-point scale. The Strongly agree response is assigned a value of 5; the Strongly disagree response is assigned a value of 1. The Don't know/won't say responses are excluded from the calculation of the mean.

Voters were read several statements about global warming and for each one asked to rate how strongly they either agree or disagree using a 5-point scale where 5 is *strongly agree* and 1 is *strongly disagree.* As shown above, the majority of voters (53%) feel the United States is not doing enough to address the issue of global warming as indicated by a score of 4 or 5 on a 5-point scale. Voters are even more likely to agree (61%) that New Mexico needs to do more to reduce emissions that cause global warming. The majority of voters (53%) also agree the main cause of global warming is the emission of gasses such as carbon dioxide from the burning of fossil fuels.

Agreement or Disagreement With Global Warming Statements (2007 Summary Table)

Ranked by Highest Percentage "Strongly Agree"

Total Sample (N=400)

	Strongly Agree 5	4	3	2	Strongly Disagree 1	Don't Know/ Won't Say	Mean †
Even if global warming is happening it won't really affect me in my lifetime	18%	8%	18%	16%	38%	2%	2.5
Even if global warming won't affect me in my lifetime, we need to take action now in order to protect our children and grandchildren	61%	17%	10%	4%	6%	1%	4.2

† *The mean score is derived by taking the average score based on the 5-point scale. The Strongly Agree response is assigned a value of 5; the Strongly Disagree response is assigned a value of 1. The Don't know/won't say responses are excluded from the calculation of the mean. *Less than 1% reported.*

The majority of voters (54%) do not agree with the statement, "Even if global warming is happening it won't really affect me in my lifetime." Approximately one-in-four voters do appear to believe that global warming will not affect them. Furthermore, the vast majority (78%) of voters believe that even if global warming will not affect them in their lifetime, we need to take action now in order to protect our children and grandchildren (61% *strongly agree* with this sentiment).

Renewable Energy

Agreement or Disagreement With Statements About Renewable Sources of Energy

Total Sample (N=400)

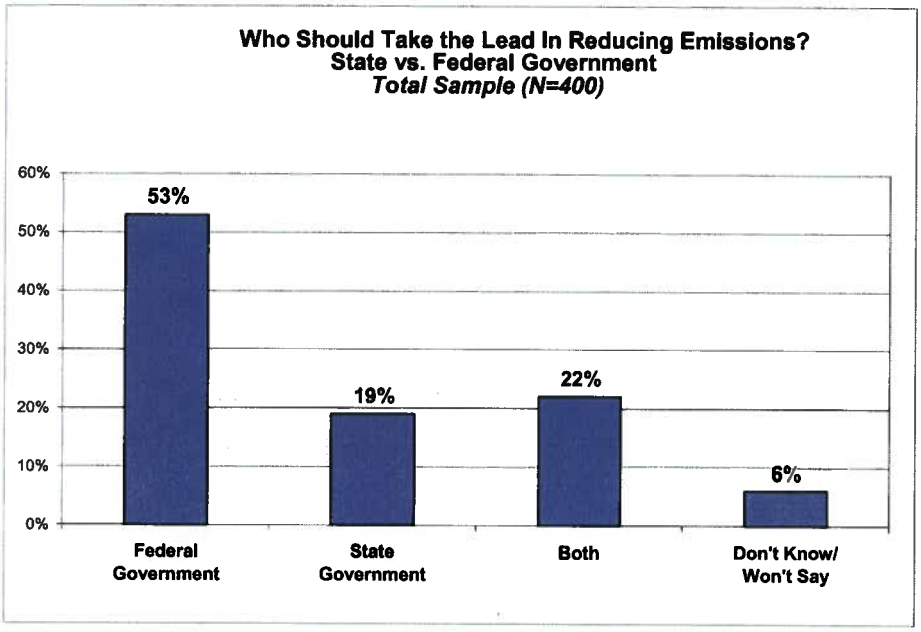
	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	Don't Know/ Won't Say
The Federal Government should offer incentives, such as tax credits or other financial assistance, to encourage the use of solar energy systems at homes and businesses that generate solar hot water and air or solar electricity	63%	27%	5%	4%	2%
We should develop policies that help homeowners and businesses generate their own electricity from renewable sources such as wind and solar power even if that cuts into utility profits or means that utility customers have to pay a little more	45%	35%	11%	6%	3%

Given the perceived seriousness of the availability of future energy resources, it is not surprising to find that the large majority of voters are supportive of programs that encourage the development of alternative forms of energy.

As shown in the table above, 63% of voters *strongly agree* and another 27% *somewhat agree* the Federal Government should offer incentives such as tax credits or other financial assistance to encourage the use of solar energy systems at homes and businesses that generate solar hot water and air, or solar electricity.

Four-in-five voters also either *strongly agree* (45%) or *somewhat agree* (35%) that we should develop policies that help homeowners and businesses generate their own electricity from renewable sources such as wind and solar power even if that cuts into utility profits or means that utility customers have to pay a little more.

Government Involvement In Global Warming



When asked directly, the majority of voters (53%) feel it is primarily the responsibility of the Federal Government to take the lead in reducing emissions that cause global warming, whereas 19% feel it is primarily the responsibility of state government. Twenty-two percent of voters volunteered that it is equally the responsibility of *both* states and the Federal Government.

Perceived Leadership on Global Warming
(Summary Table)

Ranked by Highest Percentage "Very Strong"

Total Sample (N=400)

	Very Strong 5	4	3	2	Not Strong At All 1	Don't Know/ Won't Say	Mean †
Governor Bill Richardson	22%	35%	20%	7%	8%	8%	*3.6*
Representative Tom Udall	16%	19%	23%	6%	6%	30%	*3.5*
Senator Jeff Bingaman	12%	23%	25%	8%	6%	26%	*3.4*
Senator Pete Domenici	10%	19%	27%	11%	12%	21%	*3.1*
Governor Arnold Schwarzenegger	9%	21%	22%	7%	9%	31%	*3.2*
President George W. Bush	8%	8%	21%	13%	43%	6%	*2.2*
Senator John McCain	5%	14%	28%	11%	9%	33%	*2.9*
Senator Harry Reid	2%	6%	17%	5%	9%	60%	*2.7*

† *The mean score is derived by taking the average score based on the 5-point scale. The Very Strong response is assigned a value of 5; the Not Strong at All response is assigned a value of 1. The Don't know/won't say responses are excluded from the calculation of the mean.*
**Less than 1% reported.*

Voters were asked to rate the leadership of various state and national politicians on the issue of global warming using a 5-point scale where 5 is *very strong* and 1 is *not strong at all.* As shown above, Bill Richardson is perceived as playing the most prominent position on global warming (among those listed) as 57% say the New Mexico Governor has been a strong leader on the issue, as indicated by a score of 4 or 5. Governor Bill Richardson was the only person the majority of voters rated as a strong leader on global warming.

Both Representative Tom Udall and Senator Jeff Bingaman are rated as strong leaders on global warming by 35% of New Mexico voters, with relatively few viewing them as being weak on the issue (as indicated by a score of 1 or 2). Senator Pete Domenici is viewed as a strong leader on global warming by 29% of voters, though 23% give Senator Domenici a weak rating.

When it comes to politicians outside of New Mexico, voters are most apt to view Governor Arnold Schwarzenegger as being a strong leader on global warming (30%), when compared to Arizona Senator John McCain (19%), Nevada Senator Harry Reid (8%), or President George Bush (16%). It should be noted that the majority of voters (56%) view President Bush as being a weak leader on global warming, as indicated buy a score of 1 or 2, on a 5-point scale.

It should also be noted that many voters either have no opinion or a neutral opinion (a score of 3) about the leadership of these various political figures, both on the local and national level. In fact, approximately half of the voters are unsure or have a neutral opinion about the leadership of Representative Udall and Senators Bingaman and Domenici.

Issues for the New US Congress
(Summary Table)

Ranked by Highest Percentage "Very Important"

Total Sample (N=400)

	Very Important 5	4	3	2	Not Important At All 1	Don't Know/ Won't Say	Mean †
Working to reduce America's dependence on foreign oil	67%	21%	9%	1%	1%	1%	*4.5*
Working to develop clean alternative energy sources such as solar and wind	57%	24%	13%	4%	1%	1%	*4.3*
Working for stronger protection of our natural environment	51%	25%	16%	5%	3%	-	*4.2*
Working to replace petroleum based fuels, with biofuels such as ethanol and biodiesel	43%	29%	18%	4%	4%	3%	*4.1*
Working on cutting greenhouse gas emissions to stop global warming	42%	21%	20%	8%	7%	2%	*3.9*

† The mean score is derived by taking the average score based on the 5-point scale. The Very Important response is assigned a value of 5; the Not Important at All response is assigned a value of 1. The Don't know/won't say responses are excluded from the calculation of the mean.
**Less than 1% reported.*

The large majority of voters believe the new Democrat controlled US Congress should take a lead in addressing global warming, renewable energies, and protecting the environment. Nearly nine-in-ten voters feel it is important for the US Congress to work in reducing America's dependence on foreign oil (67% *strongly agree*). One way of reducing the need for foreign oil is to develop other energy sources. To this end, we observe that 81% of voters believe it is important for Congress to work on developing clean alternative energy sources such as solar and wind. Seventy-two percent also believe it is important that Congress work to replace petroleum based fuels with biofuels such as ethanol and biodiesel.

On a more general level, 76% of voters believe Congress should be working to protect our natural environment. Finally, approximately two-thirds (63%) of voters believe that Congress should be working on cutting greenhouse emissions to stop global warming.

White Paper

Insights Not Numbers:
The Appropriate Use of Economic Models

By

Janet Peace and John Weyant

April 2008

Insights Not Numbers:
The Appropriate Use of Economic Models[1]
by

Janet Peace and John Weyant

April 2008

Executive Summary

Economic modeling has played a prominent role in the climate-change policy debate as stakeholders have sought to understand the impacts and assess the costs of different strategies for reducing greenhouse gas (GHG) emissions. Models are an invaluable tool for exploring alternative policy choices and for generating insights about how the economy might respond to different types and forms of regulation. They cannot, however, predict future events, nor can they produce precise projections of the consequences of specific policy.

Every model uses its own set of assumptions, definitions, structure and data – its results ultimately depend on these attributes and choices. A proper understanding of economic models, their uses and limitations, is therefore critical in furthering a constructive debate about options for climate policy. As a starting point we highlight three general observations about the use of economic models:

- While economic models have become increasingly sophisticated, forecasting the future remains inherently uncertain. The longer the time horizon of the analysis, the larger the uncertainties involved.
- Model results are strongly dependent on input assumptions and on the structure of the model itself. Critical assumptions and structural biases are not always readily apparent to the outside observer.
- What is left out of a model can be as important as what goes in. Whether a model accounts for the benefits (or avoided costs) of climate mitigation, technological change

[1] The maxim "insights, not numbers" has a long and illustrious history starting with Hamming (1962) who argued that "insights not numbers" constitute the purpose of computing. The same maxim was subsequently applied by Geffrion (1976) in the context of mathematical programming and by Huntington, et al. (1982) in the context of mathematical modeling. We are also indebted to William Hogan who made the link to the Geoffrion piece and Richard Richels for occasionally reminding us what our objectives in modeling ought to be. These ideas probably all build on the work of W. Edwards Demming in the 1950s who, without ever explicitly using the phrase, surely implied that insights, not numbers are the purpose of statistical quality control.

spurred (or "induced") by climate policy, or the "recycling" of revenues generated through certain policies can have large effects on the results.

Many of the cost analyses published over the last decade rely on general equilibrium models that use complex systems of mathematical equations and large amounts of data to simulate the workings of the economy. Comparisons across multiple studies suggest that several categories of assumptions are especially important in driving model results:

(1) specific features of the policy or policies being analyzed (including the degree of flexibility allowed in meeting the emissions constraints);
(2) reference case (or baseline assumptions) about how the economy and environment will perform in the absence of the policy;
(3) flexibility in the economy—that is, the ease with which consumers/producers can adapt to emissions limits;
(4) pace and magnitude of technological change/innovation; and
(5) treatment of benefits (or avoided costs) from climate-change mitigation—what benefits are included and how.

A detailed comparison of results from two modeling initiatives sponsored by the Pew Center reveals that cost estimates can differ widely as a result of structural characteristics and assumptions embedded in the model, even where other key parameters (such as the policy being analyzed and base-case projections of future emissions) are the same. For example, the responsiveness (or elasticity) of various components of the economy—including assumptions not only about how readily low-carbon alternatives will be substituted for carbon-intensive goods and services, but also about how readily individuals make trade-offs between consumption and leisure are critical assumptions. A model which assumes a highly responsive relationship between consumption and leisure will find larger economy-wide impacts than one that assumes a less responsive relationship. This type of variable is a key component of most economic models and often there is no single, accepted value that all models or modelers use, so the choice of a particular number remains inescapably subjective.

The fact that modeling requires subjective judgment does not diminish the value of economic modeling but rather reinforces the idea that models are not perfect predictors of the future. In addition the individual characteristics and assumptions used in each model make comparisons of results between models difficult. Notably where modeling analyses differ in critical input assumptions, it is impossible to make an "apples to apples" comparison of their results. Nevertheless, such analyses are valuable for at least three reasons: (a) internal consistency in any one model or model projection provides a good basis for assessing the relative implications of policy alternatives; (b) despite all the complexities and uncertainties involved, some rough bounds on mitigation costs are apparent, and (c) modeling can help to illuminate what types of policy architectures are likely to lead to lower rather than higher costs.

In terms of crucial insights for policy architectures, numerous studies find a strong link between program flexibility and cost. Maximizing the options available to firms and citizens as they respond to GHG constraint, for example, leads to lower mitigation costs across all models. Notably, policy flexibility can be enhanced in a number of dimensions—by allowing emission permits, including both allowances and offsets, to be traded across sectors and between countries and by including greenhouse gases other than carbon dioxide. Modeling studies have also pointed to additional options for reducing cost, such as complementing emissions limits with well-designed technology policies (such as public support for research and development) and announcing policies well in advance of implementation so that firms have time to adjust and invest accordingly. Finally, modeling can be used to explore the distributional impacts of policies and to craft strategies for addressing disparate burdens on different regions, sectors, and segments of the population.

In summary, estimates of the cost of combating climate change are highly contingent on the underlying assumptions and modeling approach used to generate them, as well as on the specific policies and measures being analyzed. As the climate policy debate evolves, it is increasingly important that stakeholders understand the strengths and limitations of economic models and look to them for broad insights, not absolute answers.

Introduction

Many participants in the climate change debate—in government, industry, academia, and non-governmental organizations—have used economic modeling to assess the costs of various policies to address climate change, often with widely diverging results. Some analyses suggest that reducing greenhouse gas (GHG) emissions will produce net economic benefits, while others point to enormous costs. The fundamental reason for this divergence of results is that the underlying economic models are not like crystal balls—they cannot predict the future. Instead, models are complex mathematical representations of the economy, designed to give insight into economic relationships, assess the importance of key variables, and explore the sensitivity of various outcome measures to different policy options. While economic modeling has progressed significantly in the last several years and while the variety of applications for which it can be used has significantly expanded, modeling results still depend— and always will—on the unique set of inputs, embedded assumptions, and model structure itself used to generate them.

Few modelers would claim that their results represent precise predictions of the future; indeed most are quick to point to the assumptions and uncertainties inherent in their analyses. Unfortunately such caveats are often lost when findings are portrayed to the general public and to policy makers. For example, in testimony before the Senate Committee on Commerce, Science and Transportation in 2006, an economist stated unequivocally that the McCain-Lieberman climate bill would cost an average U.S. household $725 dollars per year in 2010 and result in the loss of 1.3 million U.S. jobs by 2020 (Thorning, 2006).[2] While these numbers may sound definite, they are not. In that case, the model used specific assumptions about the lack of flexibility of the U.S. economy, the high cost of low-carbon energy alternatives, and very high future "business-as-usual" emission levels—all of which yielded results that suggest curbing GHG emissions will be very expensive. Cost estimates are also highly sensitive to the specific policy being modeled (e.g., a command-and-control type of regulatory approach will tend to produce significantly higher cost estimates than a market-based approach). In short, model results are only as good as the underlying data, assumptions, and model structure allow. And

[2] The bill referenced here, S. 280, is a prominent GHG cap-and-trade proposal introduced in the 110th Congress by Senators John McCain and Joe Lieberman.

while such results are very useful for analyzing climate policy options, they must be viewed as highly uncertain and ultimately contingent on the design of the analysis that produced them. As Warwick McKibbin, an economist internationally known for his contribution to global economic modeling, has said: "economic models can play a very useful role but they need to be used carefully and form the core of a structured debate not the source of definitive answers" (McKibben, 1998).

This paper builds on earlier Pew Center reports that have sought to improve and demystify economic models in a climate policy context. It begins by providing background and context, including a review of key modeling assumptions;[3] next it compares assumptions and model variability in the two reports, Ross et al. 2008 and Jorgenson et al. 2008, released in conjunction with this paper (available at http://www.pewclimate.org). Finally, the conclusion identifies key climate policy insights that have emerged from economic modeling efforts to date (including those from the Pew Center's two most recent reports).

Background and Context

In the past decade a large number of analyses about the economic implications of climate policy—for states, for nations and even globally—have been published. These analyses frequently rely on economic models, which are useful because they integrate economic theory (and sometimes scientific theory) with reams of data using computer programs. The result is a single framework that can be used to tease out insights about the relative merits of alternative policy designs.

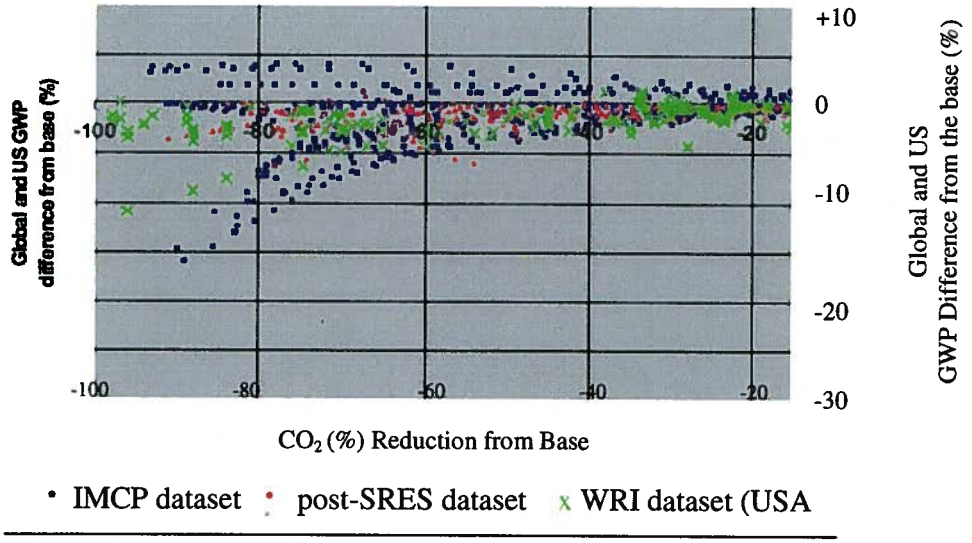
One of the most common tools used to analyze the long-run economic implications of climate policy is called a computable general equilibrium (CGE) model. Constructed of systems of mathematical equations, CGE models can analyze very large amounts of data about the economy as a whole; about production and consumption by industry sector; about investment and taxes, etc.; and about inputs and prices of capital, labor, and energy. In a general sense, CGE models attempt to represent a market economy by simulating the interaction of households and firms as they optimize their economic choices. State-of-the-art CGE models solve multiple equations

[3] Readers interested in a more detailed discussion of these issues should consult Weyant, 2000 & 2002; Fischer and Morgenstern, 2005; Barker, 2006; or IPCC, 2007.

simultaneously to capture the interrelated behaviors of different economic agents and thereby illuminate the direct and indirect effects of policy on the broader economy over the long run. Their application to climate policy requires that data about the energy sector (which is responsible for most GHG emissions) and the rest of the economy are incorporated at a significant level of detail so that interactions between the two can be assessed. CGE models can highlight policy sensitivities, identify unintended consequences, provide some rough bounds on potential costs, and generally provide a benchmark for "good" policy.

Looking at the huge range of CGE-generated cost estimates in the literature on climate change mitigation, however, it is hard not to conclude that there is a lot of uncertainty surrounding model projections. A range of cost estimates for the same level of mitigation can vary by nearly two orders of magnitude. A relatively recent meta-analysis of economic modeling results by Barker (2006) illustrates the large disparity between model estimates of mitigation cost (see Figure 1).[4] This analysis also illustrates that the larger the magnitude of emissions reductions modeled (moving from right to left on the graph), the wider the spread of results and consequently the greater the uncertainty about mitigation costs.

Figure 1. Estimates of Cost in 2030—as Percent Reduction in Gross World Product (GWP)—Compared to Different Levels of CO_2 Reduction



Source: Barker et al.. 2006

[4] A meta-analysis is a statistical research technique designed for cross-model comparisons of methodological or other factors that explain the wide range of cost estimates.

Note: Figure 1 shows estimated 2030 costs of stabilizing CO_2e at 500–550 ppm for three sets of modeling data. IMCP refers to the Innovation Modeling Comparison Project (Grubb et al. 2006); this dataset originates from a nine-model analysis that looked at three stabilization scenarios for CO_2 concentrations by 2100. The post-SRES data (Nakicenovic, et al., 2000) come from results associated with the IPCC Special Report on Emissions Scenarios. The WRI (World Resources Institute) data are for the United States only and reflect modeling results spanning 14 years (1983–1997) from 16 different energy-economy models (Repetto and Austin, 1997).

Table 1 presents mitigation cost estimates generated as part of the recently completed Fourth Assessment Report of the Intergovernmental Panel for Climate Change (IPCC). Costs were estimated for a range of GHG stabilization targets ranging from 445 to 710 parts per million (ppm).[5] Here again, the wide variability in results indicates a high level of uncertainty. Notably these cost estimates are likely to be optimistic because the IPCC scenarios assume perfect global GHG emissions trading starts immediately (in some cases they assume global trading began in 2000) and continues for the rest of the century. Put another way, the IPCC results assume that mitigation policies are introduced in a globally coordinated fashion such that the marginal cost of GHG abatement measures is equalized across all regions and countries. Any reduction or restriction in the number of participating countries or regions would increase both the carbon permit price and the economic cost (GDP or GWP reduction) associated with achieving a given stabilization target (Weyant and Hill, 1999). Obviously globally coordinated policies were not in place in 2000, nor is this scenario likely to emerge in the short term.

[5] Stabilization targets represent a goal for limiting GHG concentrations in the atmosphere at a specific level in order to prevent significant alterations to the climate. Common targets that have been proposed in national and international policy debates include 450 ppm and 550 ppm. To put these numbers in context, the atmospheric concentration of CO_2, measured at Mauna Loa in Hawaii in December 2006 was about 382 ppm; in recent years this number has been increasing by about 2.5 ppm per year.

Table 1. IPCC Estimates of Mitigation Cost in 2050 (GDP impacts are expressed as a percentage relative to BAU baseline)

Stabilization levels (ppm CO_2 eq)	Median GDP impact (%)	Range of GDP impact (%)	Impact on average annual GDP growth rates (percentage points)
590-710	(-0.5)	+1 to (-2)	< (-0.05)
535-590	(-1.3)	Slightly positive to (-4)	<(-0.1)
445-535	Not available	< (-5.5)	<(-0.12)

Source: Adapted from IPCC, 2007, p. 15.

Note: These results suggest that for GHG stabilization targets ranging from 445 to 710 ppm CO_2-equivalent in 2050, estimated costs based on the existing models reviewed by IPCC range from a positive GDP gain of 1 percent for the least ambitious target to a negative GDP loss of 5.5 percent for the most ambitious goal (stabilizing global GHG concentrations below 535 ppm).

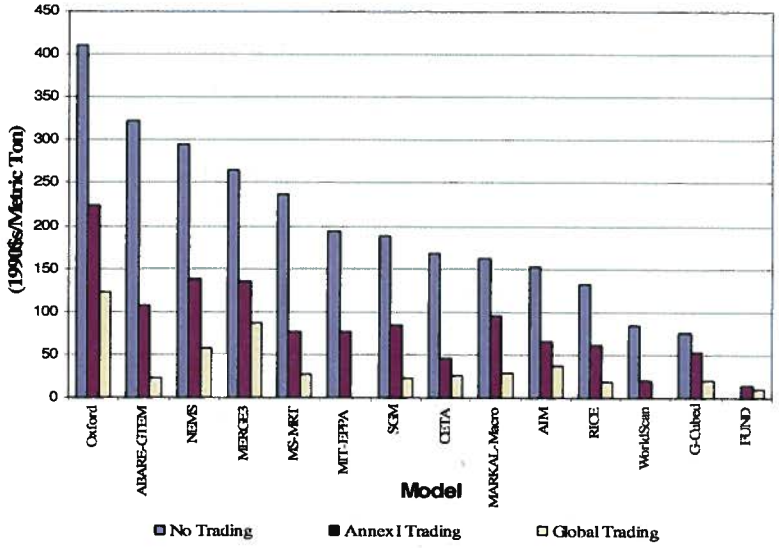
Given the wide variety of options that exist for reducing GHG emissions and the magnitude of the policy challenge in terms of the shift that will need to occur in global emissions trends, it is not surprising that a large amount of uncertainty exists with regard to future mitigation costs. To estimate these costs, changes in the world economy and future energy systems need to be projected over many decades using numerous assumptions about productivity growth, fuel prices, and technology development and deployment. Resulting cost estimates are also highly sensitive to the interest rate/discount rate used, with higher discount rates leading to lower values for future costs and benefits.[6] Finally, modelers must also make critical assumptions concerning future government policies. What type of post-2012 global climate policy will be developed? What countries will adopt binding emissions targets? Will a global trading program be established? What incentives will exist for developing alternative forms of energy and will these incentives tend to increase or reduce GHG emissions? For example, policies to reduce

[6] A discount rate attempts to account for the time value of money, recognizing that—for example—a $1000 cost experienced 50 years in the future is not equivalent to a $1000 cost experienced today. Rather, a cost of $1000 incurred 50 years in the future would be worth $608 today at a 1 percent per year discount rate or $228 at a 6 percent per year discount rate. The issue of which discount rate to use when evaluating the social benefits of long-lived environmental goods is fairly contentious—as was demonstrated in the critical debate over the Stern Review. Willam Nordhaus, for example, has pointed out that if the discount rate used by the Review were changed (along with the consumption elasticity) from 0.1 percent to 1.5 percent, the social cost of carbon would change from the $350-per-ton figure estimated in the Review to $35 per ton—an order of magnitude difference (Nordhaus, 2007).

dependence on conventional oil could increase emissions (if, for example, they promote oil shale development) or reduce emissions (if they promote sustainable biofuels development).[7]

An earlier Pew Center report (Weyant, 2000) further illustrates the large uncertainties associated with projecting mitigation costs while also highlighting the importance of policy flexibility as a driver of likely cost. The findings of this report, which was largely based on an assessment by Stanford's Energy Modeling Forum (EMF) of the costs of compliance with the Kyoto Protocol (Weyant and Hill, 1999),[8] are shown in Figure 2. The figure shows projections of the carbon price that would be required for the United States to achieve its Kyoto target in 2010.[9]

Figure 2. Estimated Year 2010 Carbon Price Needed to Achieve U.S. Target under Kyoto Protocol



Source: Weyant, 2000 (based on EMF-16 results)

The first thing to note about the results is that they range widely: from about $10 per ton of carbon to about $400 per ton. This huge range again underscores the uncertainty surrounding these projections. Furthermore, this uncertainty about future costs may be even larger than the figure implies, simply because model inputs and parameters are often held within unrealistically narrow ranges—that is, they reflect mean projections with little or no uncertainty analyses.

[7] Of course, even policies to promote biofuels could produce mixed results from a climate perspective, particularly if they result in land-use changes that transform carbon sinks to carbon sources (e.g., induced deforestation).
[8] Stanford's EMF has produced a series of assessments or studies; the one referenced in Weyant, 2000 and Figure 2 is EMF Study #16.
[9] The United States ultimately chose not to commit to achieving this target.

Predicting future trends and developments is never easy and it becomes more difficult the further out in time one attempts to project. The current debate on climate policy involves time spans of at least 50 years and often 100 years into the future. To put the modeling challenge in perspective, one need only think of the likelihood that anyone in 1957 could have foreseen the technological developments that have shaped our current economy (e.g., cell phones, computers, the internet, etc), let alone the likelihood that someone in 1907, when horses and buggies still dominated the roadway and the patent for a flying machine had only recently been approved,[10] could have made accurate predictions about the state of the world a century later.

The Importance of Model Assumptions

That climate change is a long-term issue and that there is significant uncertainty inherent in economic models does not make the models irrelevant for examining climate policy—just the reverse. Economic models, and CGE models in particular, provide a framework for assessing the many complicated issues and interactions important in our economy and allow us to test how the economy may respond to various policy scenarios under differing assumptions. The importance of input assumptions and model structure, however, cannot be overstated, both in terms of understanding and interpreting model results and in terms of the insights that these results provide for policy design.

Weyant's earlier report for the Pew Center (2000) identified five key categories of assumptions that explain the majority of differences in modeled cost estimates:

(1) type of specific policy or policies included (including the degree of flexibility allowed in meeting the emissions constraints);

(2) reference case (or baseline assumptions) about how the economy/environment will perform in the absence of climate policy;

(3) flexibility in the economy (ease with which consumers/producers can adapt);

(4) pace and magnitude of technological change/innovation; and

(5) characterization of the GHG-reduction benefits, particularly how and what benefits are included.

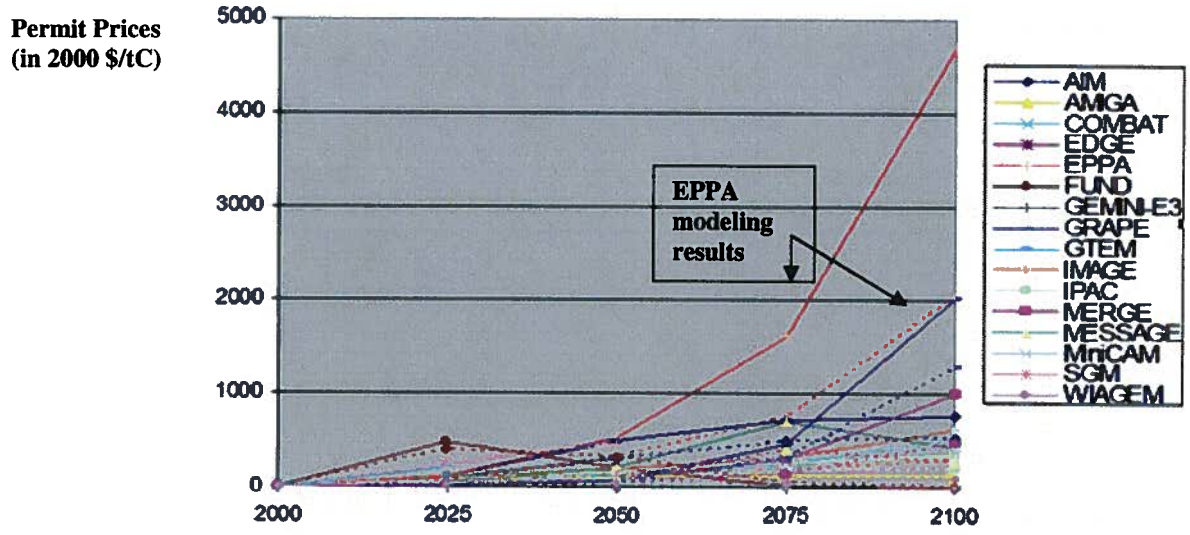
[10] In 1906, the U.S. Patent Office granted the Wright brothers patent No. 821,393, for a flying machine. http://www.uspto.gov/web/offices/ac/ido/oeip/cc/2003/cc20.pdf

The Stanford EMF analysis that generated the cost estimates shown in Figure 2 (EMF Study #16) examined the importance of key policy assumptions—including, specifically, the importance of policy flexibility. It found that the additional flexibility afforded by international emissions trading could produce significant cost reductions. Specifically, if trading among developed (Annex 1) countries was assumed, the modeled price of carbon was reduced by about a factor of two or more compared to a no-trading scenario. Estimated costs were further reduced—by another factor of two or more—if full international emissions trading (including developing as well as developed countries) was assumed. A broader scope for emissions trading allows the model to take full advantage of the potential for low-cost reduction opportunities in different regions around the world. Fewer such opportunities exist, and costs are higher as a result, when trading is restricted to a smaller area (as would be the case in a U.S.-only program). Early experience with the European Union's Emissions Trading Scheme (EU ETS) suggests that implementing a large-scale international trading system will not be cheap or easy, but the economic benefits of such a system seem well worth pursuing despite the difficulties.

The importance—from a cost perspective— of assumptions about the types of GHGs covered by the policy was also identified by Reilly et al. (2003) and EMF Study #21 (Weyant et al., 2006). Specifically, both of these studies analyzed the relative impact of including or not including GHGs other than carbon dioxide (CO_2). Reilly found that both carbon prices and welfare losses were 33 percent lower when all GHGs were covered.[11] The EMF study (as illustrated by Figure 3) demonstrated that the impact of including non-CO_2 gases might be even larger.. Cost estimates obtained using the Emissions Prediction and Policy Analysis (EPPA) model developed by the Massachusetts Institute of Technology (MIT), for example, suggest that including all gases could reduce the costs of a trading program more than 150 percent by 2100 (the MIT EPPA results are represented by the red dashed line in Figure 3).

[11] Welfare is a measure of well-being often used to refer to changes in national income or household income.

Figure 3. Comparison of Modeled Permit Prices for CO_2-Only vs. Multi-Gas Policies



Source: Weyant, et al., 2006

Note: The dotted lines represent multi-gas scenarios whereas the solid lines represent the CO_2-only scenarios. Notice that the dotted lines are consistently much lower than the solid lines.

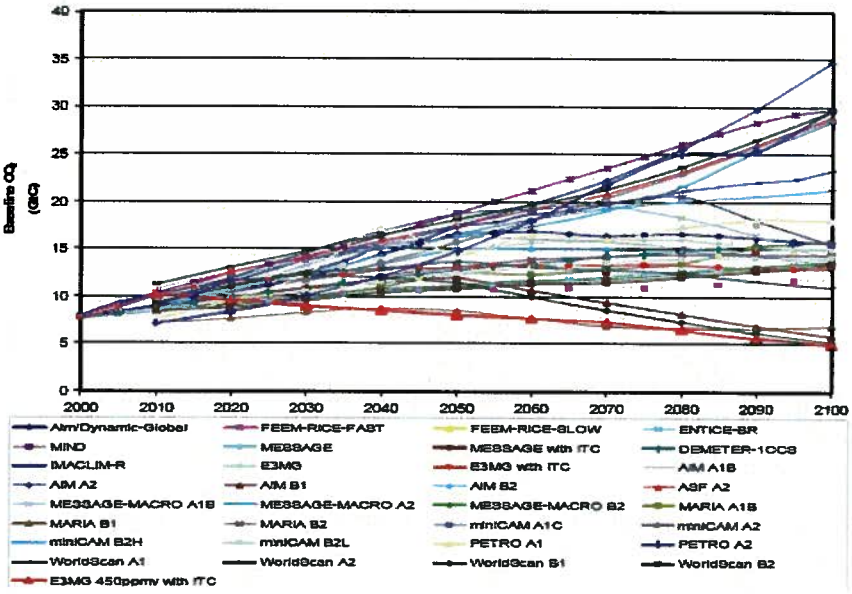
The logical consequence of these findings is that analysts cannot make very accurate cost projections without knowing what basic policy regime will be used to limit future GHG emissions and how stringent that regime will be (in terms of the emissions mitigation target it is designed to achieve). As a result, cost estimates are meaningless if they are presented without reference to the specific set of policies and measures assumed in the modeling analysis. For example, an analysis that assumes only CO_2 emissions will be covered under a future policy regime will project higher economy-wide costs for achieving a given GHG-mitigation target than an analysis that assumes both CO_2 and non-CO_2 gases are included. Assumptions about program scope and coverage, as well as other important aspects of policy design, must therefore be clearly communicated when presenting the results of any cost analysis.

Another key set of assumptions in any modeling analysis concerns the choice of a "base case." The base case, also known as the baseline, reference, or "business-as-usual" (BAU) case, reflects modelers' best guess about what will happen in the future without policy intervention to limit GHG emissions. Embedded in the base-case projection are assumptions about population,

economic growth, emissions growth, resource availability/resource prices, and technology availabilities/costs—all variables that can strongly affect model results. The higher expected BAU growth in economic activity and emissions, the more emissions must be reduced and the higher the cost to achieve a particular environmental target. Base-case projections for key economic parameters, such as GDP or employment, are also important because they constitute the baseline against which the costs of a climate policy are typically measured.

Fischer and Morgenstern (2005) and more recently Barker et al. (2006) have also noted the importance of base-case assumptions. Figure 4 from Barker's 2006 meta-analysis compares base-case emissions projections from different modeling analyses. Not surprisingly, the divergence between forecast emissions (and hence the uncertainty associated with any given projection) increases over time. In Figure 4, the highest base-case emissions projection for 2100 is six times greater than the lowest base-case projection.

Figure 4. Model Variation between EMF-Forecasted Baseline CO_2 Emissions



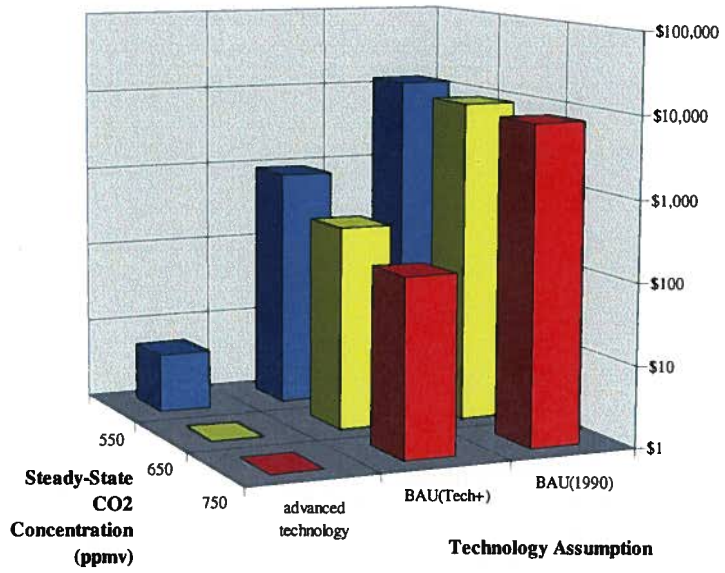
Note the greater than six-fold difference between assumed baseline emission levels in 2100

Source: Barker, 2006

The technology assumptions embedded in models are also critically important to the base-case projections and mitigation cost estimates generated by a given analysis. Optimistic assumptions about technological change—how quickly it will occur, how broad its scope will be, and how quickly costs for new technology are likely to decline—will produce lower cost estimates for

achieving a given GHG stabilization target. Figure 5 presents results from Edmonds et al. (2000) that underscore the important relationship between technology assumptions and cost projections.

Figure 5. The Importance of Technology Assumptions



Source: Edmonds et al. (2000)

While assumptions about basic policy structure, baseline, and technological change are critical in driving final model results, other modeling assumptions and parameters are also important. For example, Stern (2007) has identified several additional factors that account for the wide divergence of cost estimates found in the Barker (2006) meta-analysis:

- different assumptions about how revenues generated by a GHG mitigation policy would be used or "recycled"[12]
- ability of different models to account for induced technological change[13]
- inclusion (or not) of climate and other benefits of GHG mitigation measures
- type of economic model used to generate cost estimates

[12] A carbon tax would generate revenues for the government, as would a GHG trading program in which some or all emissions permits (or allowances) are sold by the government rather than distributed for free. The net economic impacts of any policy that generates revenue will depend in part on how those revenues are used—and in particular, whether the revenues collected by government are returned to the economy in a way that maximizes economy-wide benefits. For example, most economic models find that economy-wide benefits are higher from a carbon tax or trading program if the collected revenues are used to reduce taxes on income or capital investment.

[13] Induced technological change refers to the additional change that would occur—above and beyond whatever rate of technology advancement is assumed in the base case—in response to price signals or other incentives generated by the policy being modeled.

Table 2 shows the impact of different model assumptions on estimates of future gross world product (GWP) in the cost studies reviewed as part of Barker's meta-analysis. With assumptions that would tend to reduce mitigation costs (e.g., active revenue recycling, induced technological change, accounting for non-climate benefits, etc.), modeled estimates of future GWP were, on average, 3.9 percent higher than the base case. In analyses that did not include or "turned off" these assumptions, projected GWP was, on average, 3.4 percent lower than the base case.[14]

Table 2. Average Impact of Model Assumptions on World GWP [15]

	Percentage point GWP (% difference from the base case)
Worst case assumptions	**-3.4**
Best case assumptions	**+3.9**
Key assumptions	
Active revenue recycling	1.9
Induced technology	1.3
Non-climate benefit	1.0
Climate benefit	0.2
International mechanism	0.7
Backstop technology	0.6
CGE model	1.5

Source: Sterns 2007 (based on Barker et al, 2006)

Economic models only estimate how the economy will perform given very specific assumptions and only as allowed by the structure of the model. Different assumptions and different model structures yield very different results. This general point is reinforced by results from two recent modeling studies commissioned by the Pew Center to explore different design options for a market-based climate policy.

[14] Best and worst case impacts are not the sum of impacts from all assumptions because not all assumptions were included in any one model.

[15] Meta-analyses survey multiple studies, using statistics to compare model assumptions to model results, as a way to assess the relative importance of different model inputs. Their findings thus depend on the underlying models and the degree to which these models agree. By their very nature, meta-analyses are no more or less accurate than the individual analyses they examine.

A Comparison of Results from Two Pew Center Modeling Analyses

The Pew Center has always maintained that well-designed climate policies are critical to ensure that GHG emissions are reduced as cost effectively as possible. To facilitate policy discussions and explore the implications of alternative policy designs and instruments, the Center has been engaged for a number of years with two major modeling efforts. The first, led by Professors Dale Jorgenson and Richard Goettle of Harvard University and Northeastern University, respectively, uses IGEM (the Intertemporal General Equilibrium Model). The second effort is led by Dr. Martin Ross and colleagues at an independent research institute, RTI International, and uses the ADAGE (Applied Dynamic Analysis of the Global Economy) model.

IGEM and ADAGE are general equilibrium models that can simulate the effects of a policy on all sectors of the economy. For both of the modeling studies discussed here, analysts (1) assumed a modest climate policy that stabilizes emissions at 2000 levels by 2010; (2) allowed for inter-temporal optimization (that is, the models assume that economic agents have perfect knowledge about what will happen in the future and incorporate this knowledge into "current" decisions); (3) utilized the same emissions projections from the Energy Information Administration's 2004 Annual Energy Outlook (AEO 2004); (4) included non-CO_2 GHGs in the cap-and-trade program being modeled; and (5) allowed for the use of emissions offsets (essentially, credits for GHG reductions from sources not covered under the cap).[16] Superficially, the IGEM and ADAGE models are quite similar—yet their results vary significantly because of differences in the structural characteristics and assumptions embedded in each model.

Table 3 summarizes policy assumptions and modeling results from the two analyses. In terms of the projected price of emissions permits in 2020, the IGEM estimate is about 20 percent lower than the ADAGE estimate: $10.50 per metric ton of CO_2-equivalent emissions compared to $13.60 per metric ton. Despite lower expected permit prices, however, projected GDP losses under IGEM are nearly two times higher than indicated by the ADAGE results.

[16] For further information on the details of the modeling analysis, see companion reports by Jorgenson (2007) and Ross (2007).

Table 3. Comparison of IGEM and ADAGE Model Results

Policy Assumptions	IGEM	ADAGE
Constraint GHG basis (2000 levels by 2010)	Yes	Yes
Non-CO2 abatement possibility at economic cost	Yes	Yes
Offsets (15% limit at economic cost)	Yes	Yes
Domestic sequestration	Yes	No
International Permit trading	Yes	Yes
Banking	Yes	Yes
Policy Outcomes 2020		
Permit Price $(2000) MT CO_2e	$10.50	$13.60
Real GDP % change[17]	-.69%	-.24%
Real Consumption % change	-.26%	-.12%
Real Investment % change	-1.34%	-.95%
Coal Price % change	39.5%	100%
Coal Quantity % change	-23.2%	-49.6%
Electricity Price % change	3.9%	11.3%
Electricity Quantity % change	-3.8%	-6.6%

Source: Jorgenson (2008) and Ross (2008)

Note: Results shown in Table 3 are relative to the base-case projection for 2020. For example, if GDP growth to 2020 is projected to average 4 percent per year in the base case, a reduction of 0.24 percent implies that GDP growth will instead average 3.76 percent per year.

These differences arise because the models have differing assumptions embedded within their structures. One assumption about the relationship between leisure and consumption, in particular, is quite different. [18] In the IGEM model, Jorgenson and Goettle assume a fairly

[17] Percentage change reflects a change from the base case assumption. For example, if GDP is assumed to grow 4 percent annually, a reduction of 0.24 percent implies that growth would be 3.76 percent.

[18] Economic theory holds that as the prices of goods and services rise, people will substitute leisure for consumption—in other words, people will work less and buy less. Under a mandatory climate policy, prices would be expected to rise for all goods and services with embedded GHG content, including all goods and services whose production or delivery involves the use of fossil fuels. Because the IGEM model assumes a highly responsive relationship between consumption and leisure, a relatively small increase in prices will produce a relatively large loss of consumption and a commensurate increase in the demand for leisure. The result is a larger impact on most measures of economic impact—whether couched in terms of lost GDP or consumption or labor demand, costs look higher. Conversely, the ADAGE model assumes a less responsive relationship between consumption and leisure, higher prices for goods and services will have a smaller effect on consumption. In this case, the model assumes that consumers will, in effect, simply absorb higher prices without changing their work or consumption habits very much. As a result, costs will appear—by most measures of economic impact—to be lower.

responsive relationship between leisure and consumption and apply an elasticity of 0.8 to represent this relationship. In contrast, Ross et al. assume a less responsive relationship and apply an elasticity of 0.4 in the ADAGE model.

Jorgenson and Goettle demonstrate the importance of this assumption for estimating the costs of climate policy in an internally consistent way by running their model with two different elasticities, one implying a more responsive relationship between consumption and leisure and one implying a less responsive relationship. Results in Table 4 show that impacts on the economy are, by all the measures listed in the table, smaller if the model assumes a less responsive relationship. The magnitude of this difference also expands the farther out into the future the model attempts to forecast (once again underscoring the earlier point that model results become even less certain the farther they are projected into the future).

Table 4. The Impact of Alternative Assumptions about the Elasticity of Substitution between Consumption and Leisure within the IGEM model

Domestic Only with 15% Limit on Offsets		
	More Responsive	**Less Responsive**
Real consumption impacts		
2010-2025	-.19%	-.02%
2025-2040	-.40%	-.12%
Capital Stock impacts		
2010-2025	-.67%	-.47%
2025-2040	-1.15%	-.90%
Labor Demand impacts		
2010-2025	-.46%	-.30%
2025-2040	-.67%	-.35%
Leisure Demand impacts		
2010-2025	.15%	-.09%
2025-2040	.22%	.11%

Source: Jorgenson and Goettle, 2007

While economic theory can provide a foundation for the equations in a model, this example underscores the point that modelers must make many subjective determinations. The relationship between consumption and leisure represents only one of these determinations—critical judgments must also be made about the functional form of the model, what to assume about time delay, how to treat expectations, and how to include technological change, among many others.

The sensitivity of modeling results to a single assumption—in this case, the elasticity of substitution between consumption and leisure—also serves to illustrate that important differences between models are not always obvious. Most casual users would never dive deep enough into model documentation to ascertain that IGEM and ADAGE utilize a different assumption about the tradeoff between consumption and leisure. For this reason, it is very important that model developers (a) make transparent their assumptions and inputs (as Jorgenson, Goettle, and Ross do) and (b) to the extent possible, characterize principal sources of uncertainty in the model design and identify limitations that influence model results.

All models have such limitations, and IGEM and ADAGE are no exception. Neither of these models includes the benefits of avoided climate damage or the co-benefits associated with some GHG-mitigation measures (such as measures that simultaneously reduce emissions of other pollutants).[19] Neither model incorporates a detailed representation of the process of technology innovation, nor does either model explicitly account for promising technologies that are currently on the drawing board, like carbon capture and storage or plug-in hybrid vehicles.[20] Furthermore, neither model includes the administrative costs of implementing a policy (including costs for monitoring, enforcement, and verifying offset credits in an emissions trading program). These limitations are important and must be acknowledged, but they do not mean the modeling results are not useful. On the contrary, the models can provide valuable insights concerning the implications of different policy choices. To apply these insights, policymakers must understand that modeling results do not represent exact predictions about what will happen in the future under a given policy regime. Rather, these results, like all modeling results, are closely tied to

[19] Criteria pollutants like SO_2, NO_x and mercury will be reduced as fossil fuel consumption is reduced.
[20] At the relatively low carbon prices estimated in the Pew Center scenario, neither carbon capture and storage nor plug-in hybrids would enter the market (as such this is not truly a binding limitation for the scenario considered).

assumptions—they represent what *might* happen in response to a plausible range of input conditions.

Model Insights

While models (including IGEM and ADAGE) cannot predict the future, they can shed light on important economic relationships and test the robustness of alternative policy architectures, and in this way help inform the design of a market-based climate change policy. Likely one of the most significant and robust insights to have emerged from modeling efforts to date is that increased program flexibility reduces cost. Maximizing the options available to individual firms and citizens as they respond to GHG constraints helps to reduce both private and societal costs and leads to lower mitigation costs across all models (see Figure 2).

Notably, policy flexibility can be enhanced in a number of dimensions. For example, maximum flexibility to take advantage of the lowest cost mitigation opportunities wherever they exist can be achieved by allowing GHG emission rights and emission offsets to be traded between individuals, sectors, and countries. Results from the IGEM model, for example, suggest that increasing program limits on the use of offsets from 15 percent to 50 percent reduced overall program costs by 30 percent over the 2010–2025 timeframe and by 50 percent over the 2025–2040 time period. Similarly, modeled GHG permit prices were 50 percent lower in 2040 when international emission reductions were allowed into a U.S.-based emissions trading program (see Table 2, of Jorgenson and Goettle). In other words, allowing offsetting emission reductions from sources and countries outside the capped sectors to count toward program compliance dramatically reduces the costs of the policy.[21]

These insights regarding the benefits of trading and of creating a broader market for emission reductions (including offset credits for reductions achieved at sources that are not directly regulated under a cap-and-trade program) were confirmed in the EMF study of Kyoto compliance costs (Figure 1). More recent analysis of S. 280, a prominent GHG cap-and-trade proposal introduced in the 110th Congress by Senators McCain and Lieberman, reaches similar

[21] Administration costs may somewhat reduce these benefits but models today do not capture this result.

conclusions (EPA, 2007).[22] In modeling the costs of the McCain-Lieberman legislation, the U.S. Environmental Protection Agency found that including offset credits without restriction reduced allowance prices by 35 percent each year relative to a scenario in which—as proposed in S. 280—the use of such credits was limited to 30 percent of the overall compliance obligation in a given year. Similarly, modeled effects on GDP and consumption in the years 2030 and 2050 were about 33 percent lower with no limit on the use of offsets. Notably, when offsets were completely excluded (as opposed to being included subject to a 30 percent limit), modeled allowance prices increased by over 150 percent.

Flexibility was also increased (and costs reduced) under a program design that included all major GHGs and not just CO_2 (Figure 2). Intuitively, including non-CO_2 gases (such as methane, nitrous oxide, sulfur hexafluoride, and certain hydrofluorocarbons and perfluorocarbons) expands the universe of available low-cost options for reducing GHG emissions, especially because many of these gases have high warming potential and because, absent a price signal, firms have historically lacked incentives to pursue related mitigation opportunities (Reilly, 2003).

As complements to a market-based mechanism for reducing emissions, additional measures to promote advanced technology have also been shown by models to reduce costs. For example, modeling by Larry Goulder of Stanford University suggests that meeting any specific GHG reduction target will be significantly cheaper if R&D subsidies are implemented along with a carbon price, rather than applying either of these policies (subsidies or carbon price) alone (Goulder, 2004). Goulder also finds that announcing a policy ahead of time, so that firms have time to adjust, significantly reduces program costs. While most current proposals for a mandatory U.S. program to reduce GHG emissions include these elements—in the sense that they build in lead-time for firms to adjust and provide for complementary technology incentives—related modeling efforts do not always capture the benefits of these provisions. When they do, estimated costs are reduced accordingly. As policy makers try to craft a sound, least-cost strategy for reducing GHG emissions, economic models clearly have a critical role to

[22] The EPA analysis of S. 280 also used the IGEM and ADAGE models.

play in exploring the implications of alternative program designs and assessing the impact of complementary policies.

Models can also provide important insights concerning the distribution of cost impacts across different industry sectors, households, regions, and even nations. Knowing which sectors or regions are likely to be hardest hit by a cap-and-trade program gives policy makers the knowledge necessary to adjust the policy or structure compensation so as to address equity concerns. Allocating free allowances under a cap-and-trade program is one potential avenue for directing compensation to certain sectors or even states. Because the ADAGE model has significant state-level detail it has been used to demonstrate that alternative allowance allocation options can have important implications for households in different states. An important insight from this is that allocation design can be used to reduce or equalize policy-related cost burdens—on states or across different segments of the U.S. population.

Last but not least, economic models (including the ADAGE and IGEM models) can be used to gauge the magnitude of overall costs that could be expected from the implementation of a cap-and-trade type climate policy. Under a plausible range of assumptions about the U.S. economy and assuming a policy architecture that imposes a modest cap on GHG emissions but allows trading and is implemented gradually, with advance announcement, the likely impact on the U.S. economy in a near- to medium-term timeframe is quite small: a less than 1 percent reduction in the expected growth of U.S. GDP by 2020. Looking at a broader range of modeling results (e.g., EMF, 1999, 2004, 2006; Edenhofer et al., 2006; IPCC, 2007), it is reasonable to conclude that stabilizing GHG concentrations in the atmosphere at 500–550 ppm CO_2-equivalent will cost—depending on how the policies used to reduce emissions are structured—somewhere between 0.1 percent and 10 percent of the world's total economic output (GWP) per year (Figure 1). That this range is quite large (spanning at least two orders of magnitude) is not surprising, given the large uncertainties involved. It might be possible to narrow the range of cost estimates by half, if the basic elements of the policy regime likely to be adopted in various countries could be identified. Cost uncertainties could be further reduced if it was clear that governments would choose the least-cost policy options in most cases. Generally speaking, this would mean

broadening the scope and maximizing the flexibility of GHG-reduction policies to the extent feasible and consistent with maintaining program integrity.

By bounding the range of likely costs associated with stabilizing atmospheric GHG concentrations, economic models provide some sense of the magnitude of the policy challenge and provide context for weighing climate concerns relative to other broad societal objectives (for example, in the realms of national security, health, education, and welfare). Finally, modeling results can help to highlight the costs and trade-offs associated with accommodating certain political, environmental, or other considerations—whether those argue for postponing near-term mitigation efforts, limiting program flexibility, or imposing more drastic emissions reduction requirements.

Conclusions

More sophisticated economic models and vastly increased computing power have made it possible to simulate the complex workings of the economy and process enormous amounts of data to estimate the likely consequences of different GHG-mitigation policies. Nevertheless, the results obtained using such models represent—at best—approximations. Moreover these approximations are highly dependent on the underlying assumptions and model structure used to derive them. In many cases these drivers are readily apparent; in other cases they are difficult to tease out because they are embedded in detailed aspects of the model's structure.

Given the wide variation that exists between models and the significant uncertainties inherent in projecting future economic and technological conditions, as well as likely policy outcomes, the question arises: is there any value to projecting mitigation costs? The answer, we believe, remains 'yes.' In spite of the substantial variability that characterizes different model results, cost estimates are valuable for at least three reasons: (1) internal consistency[23] in any one model or model projection provides a good basis for assessing the relative implications of policy alternatives; (2) despite all the complexities and uncertainties involved, some rough bounds on

[23] Internal consistency in any one model is important because this allows for an "apples to apples" rather than "apples to oranges" comparison. Comparing results across models with often widely divergent assumptions is without question an "apples to oranges" exercise.

mitigation costs are apparent, and (3) modeling can help to illuminate what types of policy architectures are likely to lead to lower rather than higher costs.

Notably a policy architecture that provides more flexibility in terms of the GHG mitigation options available to producers and consumers—such as a trading program—will yield lower program costs than one that is less flexible. Flexibility can be enhanced by including multiple GHGs (not just CO_2), by allowing offset credits for mitigation measures that address sources or types of emissions not covered by the cap (both domestic and international), and by including well-designed technology policies—such as subsidies for R&D—as a complement. In addition, two further conclusions can be drawn from modeling results to date. The first is that announcing a policy well in advance of implementation will reduce overall costs; the second is that allowance allocation provides the opportunity and the means to reduce net cost impacts on specific states, industrial sectors, and individuals or households.

When model inputs and methodologies are clearly presented and reflect plausible and generally accepted and/or peer reviewed assumptions, the resulting estimates of future mitigation cost can provide valuable insights for policy makers and stakeholders in the climate policy debate. Even a rough bounding of potential costs can be quite useful for policy makers who often hear extremely pessimistic or, alternatively, highly optimistic estimates from analyses designed to support a particular policy agenda.

In sum, cost estimates are highly contingent on the underlying assumptions and modeling approach used to generate them, as well as on the specific policies and measures being analyzed. To put modeling results in perspective and draw appropriate conclusions, it is critical that all parties have a clear understanding of the assumptions and limitations that underlie the analysis. Such assumptions and limitations must be clearly identified and prominently stated in any report or presentation on the costs of climate change policy. Few if any of the experts who work closely with models believe that whatever estimate they generate for future energy costs or GDP impact will actually materialize under a given policy. Rather, these results are interesting for the broader insights they reveal. In the effort to craft and implement cost-effective, well-designed strategies for addressing the problem of climate change, it is critical that all who seek to

understand and use modeling results share a realistic view of their proper role in the climate policy debate.

References

Barker, Terry, Mahvash Saeed Qureshi and Jonathoan Kohler. 2006. The Costs of Greenhouse Gas Mitigation with Induced Technological Change: A Meta-Analysis of Estimates in the Literature. Cambridge Center for Climate Change Mitigation Research Department of Land Economy, University of Cambridge. July.

Edenhofer , O., K. Lessman, C. Kemfert, M. Grubb. And J. Kohler. 2006. "Induced Technological Change: Exploring its Implications for the Economics of Atmospheric Stabilization. Synthesis Report from the Innovation Modeling Comparison Project". *Energy Journal,* 27, 1-51.

Edmonds, J.A., T. Wilson, and R. Rosenzweig. 2000. A Global Energy Technology Strategy Project Addressing Climate Change: An Initial Report an International Public-Private Collaboration. Joint Global Change Research Institute, College Park, MD.

Edmonds, J.A., T. Wilson, and R. Rosenzweig. 2000. *A Global Energy Technology Strategy Project Addressing Climate Change: An Initial Report an International Public-Private Collaboration.* Joint Global Change Research Institute, College Park, MD.

EPA. 2007. EPA Analysis of the Climate Stewardship and Innovation Act of 2007. July 16. Available on line at http://www.epa.gov/climatechange/downloads/s280fullbrief.pdf .

Fischer, Carolyn and Richard Morgenstern. 2005. Carbon Abatement Costs: Why the Wide Range of Estimates? Resources for the Future. Discussion Paper. Nov. Available at http://www.rff.org/Documents/RFF-DP-03-42-REV.pdf (Accessed Aug. 6, 2007).

Geoffrion, A.M., "The Purpose of Mathematical Programming is Insight, Not Numbers," *Interfaces*, 7:1, 81-92 (November 1976).

Goulder, L. 2004. *Induced Technological Change and Climate Policy*
Prepared for the Pew Center on Global Climate Change. October. Available at http://www.pewclimate.org/global-warming-in-depth/all_reports/itc Downloaded Aug. 20, 2007.

Grubb, M., C. Carraro, and J. Schellnhuber. 2006. Technological Change for Atmospheric Stabilization: Introductory Overview to the Innovation Modeling Comparison Project. Energy Journal 27, 1-16.

Hamming, R.W., 1962. "The purpose of computing is insight, not numbers." Numerical Methods for Scientists and Engineers. McGraw-Hill.

Huntington, Hillard G., John P. Weyant, and James L. Sweeney. " Modeling for Insights, Not Numbers: The Experiences of the Energy Modeling Forum." OMEGA: The International Journal of the Management Sciences, Vol. 10, No 5, August 1982, pp 449-62.

IPCC 2007. Summary for Policymakers. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate

Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)] Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jorgenson, Dale W., Richard J. Goettle, Peter J. Wilcoxen and Mun S. Ho 2000. *The role of substitution in understanding the costs of climate change policy*, Pew Center on Global Climate Change, September. Available at http://www.pewclimate.org/global-warming-in-depth/all_reports/role_of_substitution

Jorgenson, Dale W., Richard J. Goettle, Peter J. Wilcoxen, Mun S. Ho. 2008. *The Economic Costs of a Market-based Climate Policy.* Pew Center on Global Climate Change, Forthcoming. Available at Pewclimate.org

McKibbin, Warwick. 1998. *Greenhouse gas abatement policy insights from the G-cubed multi-country model.* Journal of Agricultural and Resource Economics. 42 (1) 99-113.

Nakicenovic, N. and A. Gritsevskyi. 2000. "Modeling uncertainty of induced technological change", Laxenburg: International Institute for Applied Systems Analysis.

Nordhaus, William. 2007. The Stern Review on the Economics of Climate Change. May Available at http://www.econ.yale.edu/~nordhaus/homepage/stern_050307.pdf. Accessed June, 2007.

Repetto, Robert, and Duncan Austin. 1997. The Costs of Climate Protection: A Guide for the Perplexed. Washington, D.C.: World Resources Institute. Available at http://www.wri.org/climate/pubs_description.cfm?pid=2475. Accessed Aug. 3, 2007.

Reilly, John, Henry Jacoby, Ronald Prinn. 2003. Multi-gas contributors to global climate change; Climate Impacts and mitigation Costs of Non-CO2 Gases. Prepared for the Pew Center on Global Climate Change. Feb. Available at http://www.pewclimate.org/global-warming-in-depth/all_reports/multi_gas_contributors.

Ross, M.T., B.C. Murray, R.H. Beach and B.M. Depro (2008), "State-level Economic Impacts of Global Climate Change Polices: Analysis of the Climate Stewardship Act (S.A.2028)," Prepared by the Research Triangle Institute International (RTI) for the Pew Center on Global Climate Change, Forthcoming.

Stern, Nicholas. 2007 The Economics of Climate Change, the Stern Review. Cambridge University Press.

Thorning, Margo. 2006. Written Testimony April 5th for the U.S. Senate Committee on Commerce, Science and Transportation Subcommittee on Global Climate Change and Impacts. Available at http://www.iccfglobal.org/pdf/test-impactVM.pdf Accessed August 10, 2007.

Weyant, J.P., and J.N. Hill, 1999. "Introduction and Overview." The Energy Journal Special Issue: The Costs of the Kyoto Protocol: A Multi-Model Evaluation, pp. vii-xliv.

Weyant, John. 2000. An Introduction to the Economics of Climate Change. Prepared for the Pew Center on Global Climate Change. Available at http://www.pewclimate.org/global-warming-in-depth/all_reports/economics_of_climate_change . Accessed Aug 5, 2007.

Weyant, John P.,2002 "Review Of Mitigation Cost Studies And Trajectories, And Assumptions That Drive Them," in U.S. Policy on Climate Change: What Next?, Frank Loy and Bruce Smart, editors, Aspen Institute, 2002.

Weyant, John, Francisco C. de la Chesnaye, and Geoff J. Blanford, 2006 "Overview of EMF-21: Multigas Mitigation and Climate Policy," in Special Issue of The Energy Journal, Francisco C. de la Chesnaye and John P. Weyant, editors, December, pp. 1-32.

Geoffrion, A.M., 1976 "The Purpose of Mathematical Programming is Insight, Not Numbers," *Interfaces*, **7**:1, 81-92 (November).

Weyant, John. 2007. Presentation at the Haagan-Smit Symposium: Climate Change: Envisioning a Low Carbon Society in 2050 Aptos CA. May 14-17, 2007

Western Climate Initiative

Market Oversight Draft Recommendations

April 1, 2010

Executive Summary

The Western Climate Initiative is a collaboration of seven US states and four Canadian provinces to reduce greenhouse gas emissions, including the design and implementation of a cap-and-trade program. The WCI is working through five committees, including the Markets Committee, to complete tasks and deliverables for implementation. Recommendations on oversight of markets for greenhouse gas allowances and offset certificates ("compliance instruments") is among the Markets Committee's tasks. This document provides draft recommendations on market oversight. Following public comment and continued work by the Markets Committee, the Committee will issue Final Recommendations.

The Markets Committee has used a variety of sources of information in developing its recommendations, including published reports, presentations, stakeholder comment, contact with market participants and regulators, and contracting with outside advisers. It adopted principles to guide its work and recommendations.

The Markets Committee has identified twelve items as the tools or decisions WCI Partner jurisdictions can use or make to establish effective oversight of compliance instruments. The Draft Recommendations are:

1. Treat Compliance Instruments as Commodities for Market Oversight Purposes
2. Information on Derivatives Positions
3. Treat Allowances and Offset Certificates Identically for Market Oversight Purposes
4. Establish Legal Relationship with Market Participants Through Compliance Instrument Ownership Interest and Tracking System
5. Do Not Limit Market Participation to Compliance Entities
6. Require Registration of Intermediaries as Market Professionals
7. Holdings Limits

8. Require Use of a Central Limit Order Book for Secondary Market Transactions
9. Require Reporting of Beneficial Ownership
10. Information Required for Compliance Instrument Transfer
11. Secondary Market Holdings and Transfer Information Disclosed to Public
12. Market Monitoring

In many cases, the Draft Recommendations are interrelated, and changing one could change another. Importantly, the first Draft Recommendation implies the adoption of an existing framework for regulating compliance instrument derivatives. Consequently, Draft Recommendations 3 – 12 are primarily focused on secondary markets.

In considering Draft Recommendations, the Markets Committee recognized and attempted to weigh a number of factors that were often difficult to predict and sometimes were in competition. These included transparency, market liquidity, allowing markets to evolve, adopting best practices and lessons from more mature markets, leadership, resource demands on jurisdictions and participants, unique characteristics of markets for compliance instruments, and enforceability. The Committee believes that the resulting Draft Recommendations describe policies that will enhance the ability of the cap-and-trade program to contribute to greenhouse gas emissions reductions at relatively low cost, provide regulatory oversight, and promote market participant confidence. The Committee welcomes comment on the Draft Recommendations individually and collectively, and in particular on:

A. Whether the tools available to WCI Partner jurisdictions for market oversight have been completely and correctly identified;
B. Whether the Draft Recommendations would correctly maximize the environmental and economic benefit to the public and support WCI's Principles of Market Oversight;
C. Whether the Committee should recommend collection of derivatives position information from market participants, including on over-the-counter derivatives; and if so, what of that information to disclose to the public; and
D. The Draft Recommendation to require secondary market trades to use a central limit order book.

Table of Contents

1 Purpose and Background

The Western Climate Initiative (WCI) is a cooperative effort of seven U.S. states and four Canadian provinces that are collaborating to identify, evaluate, and implement policies to reduce greenhouse gas (GHG) emissions, including the design and implementation of a regional cap-and-trade program. The WCI began in February 2007 with the governors of Arizona, California, New Mexico, Oregon, and Washington, who have since been joined by the premiers of British Columbia, Manitoba, Ontario, and Quebec, and the governors of Montana and Utah. Participation in the WCI reflects each Partner jurisdiction's strong commitment to identifying, evaluating, and implementing collective and cooperative actions to address climate change.

In September 2008, the Partner jurisdictions released the final "Design Recommendations for the WCI Regional Cap-and-Trade Program."[1] The first compliance period for the cap-and-trade program will begin January 1, 2012, covering GHG emissions from electricity generation (including emissions associated with imported electricity), combustion at large industrial and commercial facilities, and industrial process emissions for which adequate measurement methods exist. Starting in 2015, the program's coverage expands to include transportation fuels in addition to residential, commercial, and small industrial combustion. Thus, by 2015 the cap-and-trade program will cover almost 90% of GHG emissions in the Partner jurisdictions.

In February 2009, the Partner jurisdictions released the WCI 2009 – 2010 Work Plan, describing the approach to implementing the Design Recommendations.[2] The WCI is working through five committees: Offsets, Reporting, Complementary Policies, Cap Setting and Allowance Distribution, and Markets. The Work Plan describes the tasks and deliverables for each committee. The purpose of one of the Markets Committee's tasks, "market oversight," is to recommend measures to ensure that the allowance and offset certificate trading market is organized properly to operate reliably and prevent or minimize manipulation. This task was included in the work plan based on the consensus among WCI Partner jurisdictions on the need to provide effective oversight to assure an efficient and transparent carbon market.

These Draft Recommendations are based on the information collected and reviewed by the Markets Committee on market oversight approaches and issues. The information was obtained through several means, including the following:

---

[1] The Design Recommendations and accompanying Background Report can be found at http://westernclimateinitiative.org/the-wci-cap-and-trade-program/design-recommendations.

[2] The 2009 – 2010 Work Plan can be found at http://westernclimateinitiative.org/component/remository/general/workplans/2009-2010-WCI-Work-Plan/.

- The Markets Committee held a stakeholder workshop on market oversight in Seattle, Washington in April 2009. The Committee presented a draft set of principles of market oversight, and a list of questions for discussion with those who attended in person or online.[3] Stakeholders were invited to submit written comments.[4] Stakeholders' responses guided the Committee's consideration of issues and the Committee revised the principles of market oversight as set forth below. The principles guided the Committee's research, analysis, and deliberation, and will continue to do so as the Committee progresses towards final recommendations.

- The Markets Committee made a presentation to the WCI Partners on September 16, 2009, at a public meeting in Toronto, Canada, and invited stakeholder comment at the meeting.

- The Markets Committee made a presentation to the WCI Partners on November 18, 2009, at a public meeting in Santa Fe, New Mexico, and invited stakeholder comment at the meeting.

- The Markets Committee issued a white paper on market oversight[5] on November 19, 2009, and invited written public comment by December 18, 2009. Eleven parties submitted comments.[6]

- The Markets Committee held a stakeholder call December 2, 2009, to present and discuss the market oversight white paper.[7]

- The Markets Committee made a presentation to the WCI Partners on March 3, 2010, at a public meeting in Vancouver, British Columbia, and invited stakeholder comment at the meeting.

- The Markets Committee held a webinar with the market monitor used by the Regional Greenhouse Gas Initiative (RGGI).[8]

---

[3] The principles and questions can be found at http://westernclimateinitiative.org/component/remository/func-startdown/25/. Market oversight was one of three tasks for which the Committee developed draft principles for comment; the others were auction design and compliance verification and enforcement.

[4] Stakeholder comments were submitted to the WCI website, and can be found at http://westernclimateinitiative.org/documents/public-comments/document/2.

[5] The white paper can be found at the WCI website, at http://westernclimateinitiative.org/component/remository/func-startdown/174/.

[6] Comments can be found at the WCI website, at http://westernclimateinitiative.org/public-comments/document/13.

[7] The presentation from the stakeholder call is available on the WCI website, at http://westernclimateinitiative.org/component/remository/Markets-Committee-Documents/Market-Oversight-White-Paper-Presentation/.

- The Markets Committee consulted with U.S., Canadian, state, and provincial regulatory authorities, and received input from European market regulators, potential market participants, trade associations, market infrastructure providers, and other stakeholders.

- The Markets Committee conducted a literature review with the assistance of our task advisor at the Nicholas Institute for Environmental Policy Solutions at Duke University.

Through this process, the Committee acquired substantial knowledge about the types of regulation in place in existing financial markets, the roles of regulators and exchanges, and the scope of existing carbon-related financial products.

In this document, "compliance instrument" refers to either an allowance or an offset certificate, unless otherwise noted. This document builds on the definitions and discussion in the market oversight White Paper without restating them, in most cases.

2 Principles

These principles were adopted with the publication of the white paper on November 18, 2009, and have been modified only to change "allowance" to "compliance instrument" and "offset credit" to "offset certificate" to standardize nomenclature. They serve as guidelines for developing oversight of the compliance instrument and associated derivatives trading markets to assure maximum environmental and economic benefit to the public.

- **Fairness:** All market participants, especially covered entities, have fair and equal access to the market.

- **Efficiency:** The market is designed to operate efficiently so that greenhouse gas (GHG) emission reductions can be achieved at the least cost. An efficient market means that allowance and offset certificate prices reflect supply and demand, and accurately reveal the value of allowances and offset certificates.

- **Effective Oversight:** The design and oversight of the market is effective in preventing or minimizing fraud, manipulation, and speculative excess.

---

[8] The presentation from the webinar is available at http://westernclimateinitiative.org/component/remository/Markets-Committee-Documents/Monitoring-Emissions-Allowance-Markets/.

- **Transparency and the Reporting and Disclosure of Relevant Information:** Transparency in the design and the operation of the allowance and offset credit market builds and retains public confidence.
    - Reporting of relevant information to regulatory authorities and public disclosure of information has important benefits. It enables regulatory authorities to conduct effective oversight and ensure compliance. It also helps to ensure market efficiency, effective oversight, and compliance and enforcement. The release of information can change the decisions of market participants, which impacts the prices of allowances and offset credits. Timely, accurate, coordinated and consistent release of market-relevant information allows all market participants to have equal access to public information.
    - The reporting and disclosure requirements for compliance, verification and enforcement balance these benefits against the need for entities to protect certain sensitive information. The potential to disclose certain information that could be used to manipulate the market is also considered. This balancing is consistent with applicable law relating to the disclosure of information.

- **Administrative Simplicity and Cost:** Proposed rules are designed to be understood and enable entities to have a clear compliance path. Administrative costs and transaction costs are minimized for all parties, consistent with the need to provide effective oversight.

- **Accountability:** All entities involved in the allowance and offset credit market, as either regulators or market participants, are accountable for their actions. The responsibility, authority, and capacity to conduct the necessary oversight and take appropriate action are fully defined for all agencies charged with compliance, verification and enforcement.

- **Conflicts of Interest:** Conflicts of interest between market participants, monitors, and regulators are prevented.

3 Stakeholder Comments on White Paper

The Markets Committee received 11 written comments to the white paper. The Committee identified and asked for comment on three key issues, as well as general comment on the content of the white paper.

The first key issue was, "Whether current U.S. and Canadian regulation of commodity markets is appropriate." Five commenters responded to this issue. In general, the comments favored treating allowances as commodities, rather than construct a new definition or new framework for their regulation. One commenter, however, said that though allowances would fit the

framework for regulation as commodities, oversight of over-the-counter (OTC) derivatives beyond current commodity oversight was needed.

The second key issue was, "Whether to place restrictions on OTC instruments." Seven commenters responded to this issue. Six commenters recommended not restricting the use of OTC instruments, citing their flexibility and the costs of clearing in exchange transactions. Of those six, three recommended requiring more information on such transactions than is currently reported to regulators. One commenter recommended restricting transactions to exchanges, to reduce complexity and the risk of market manipulation.

The third key issue was, "The appropriate transparency and disclosure requirements." Five commenters responded to this issue. They said that an appropriate balance of transparency and confidentiality, as well as the costs and benefits of collecting particular data, exists. Three commenters recommended that more information be revealed to regulators than would be made public, and specifically recommended aggregation of data prior to public disclosure. On the December 2, 2009 stakeholder call, some stakeholders requested a specific proposal to respond to. One commenter made specific recommendations on information requirements to restrict the use of inside information.

Commenters made further recommendations to the WCI Partner jurisdictions. Two described recommended roles for a central market monitor. Two requested clarification of the legal authority jurisdictions had over allowance markets, as prerequisites for determining the specific recommendations for oversight. A short discussion of the roles of provincial, state, and federal regulatory authorities is in section 5 of this paper. The Final Recommendations paper will include a more detailed discussion.

Some comments addressed issues outside the scope of the market oversight task, and some commenters took issue with phrasing in the white paper. Two commenters requested a fuller acknowledgement than in the white paper of the possibility and consequences of market manipulation. One commenter requested more information on the risks of low market liquidity, including the risk that liquidity would be harmfully low.

4 Draft Recommendations

The Draft Recommendations presented here incorporate the information the Markets Committee has received and developed on market oversight. Among the general conclusions the Committee reached is that many aspects of oversight are interrelated. In many cases, a Draft Recommendation below depends on the implementation of another Draft Recommendation. For each Draft Recommendation, the Committee has noted these

relationships; if one were to change, others likely would as well. For this reason, the Committee has considered the Draft Recommendations as a package.

Of particular note is Draft Recommendation 1 (Treat Compliance Instruments as Commodities for Market Oversight Purposes). It does not recommend that the Partner jurisdictions implement new restrictions on the trading of derivatives. This influences the discussion of the further Draft Recommendations, especially by narrowing the focus of several to secondary markets.

Second, some of the Draft Recommendations imply or require particular technical capabilities in a cap-and-trade compliance instrument tracking system. Where this is the case, the requirements are discussed with the Draft Recommendation. An electronic tracking system provides complete accounting of compliance units, recording the real-time status of issuance, holdings and transfer of compliance units between accounts, and providing the function to reconcile reported emissions for each compliance period with the compliance entity's holdings.

4.1 Allowances, Offset Certificates, and Derivatives

4.1.1 Draft Recommendation 1: Treat Compliance Instruments as Commodities for Market Oversight Purposes

4.1.1.1 Background

Commodity cash and derivatives markets are closely linked, and activity in one will affect behavior in the other. Nevertheless, they are different in definition and in legal framework and warrant separate treatment. The market oversight white paper described commodity derivatives and the regulatory framework for them, and the discussion here builds on that.

4.1.1.2 Options

The first of the "key issues" the Markets Committee asked for comment on in the white paper was:

A) Whether cap-and-trade compliance instruments should be treated as commodities, which would place them in the context of a body of existing law and regulation, or
B) Whether to attempt to define compliance instruments in such a way that they would not be commodities, and develop a new body of law and regulation.

4.1.1.3 Evaluation of Options

As described in the market oversight white paper, "Commodities are goods that are interchangeable with other goods of the same type." Cap-and-trade compliance instruments in the US Acid Rain Program, RGGI, and the European Union Emissions Trading Scheme (EU ETS)

have been treated in many ways as commodities by market participants and regulators. Though they are instruments that will ultimately be used to satisfy legal requirements, as finite resources they have market prices.

Whether to treat compliance instruments as commodities for market oversight purposes is a fundamental question in the US especially, because federal law preempts the states from certain regulation of commodity derivatives. By "derivatives" we mean both exchange-traded instruments, such as futures and options contracts, as well as instruments traded over-the-counter. Therefore, determining that compliance instruments are commodities places the responsibility for regulation of their derivatives in the US primarily with the US Commodity Futures Trading Commission (CFTC). The advantages to this include the long history of futures and options regulation, and staff and infrastructure resources at the CFTC. The disadvantages include potentially less control of the non-cash markets by the Partner jurisdictions.

Like energy commodities, compliance instruments could be considered an input to many kinds of economic activity, including production of electricity and use of transportation fuels. In addition to concern that financial manipulation might benefit a few persons at the expense of many, high volatility and higher-than-expected prices in compliance instrument markets have the potential to undermine public support for a cap-and-trade program, which could make achievement of environmental goals more difficult. Partners, therefore, might weigh tradeoffs between transparency, market efficiency, prices, and volatility differently from the legislators and regulators who have established the framework for commodity derivatives regulation.

Participants trading compliance instruments in existing carbon markets have generally treated them as commodities. Many firms that are covered in existing cap-and-trade programs require energy commodities as inputs. As with commodities, compliance instrument prices should reflect market fundamentals, such as economic conditions and industrial production more than the decision of a single firm. (In contrast, the price of a firm's securities can be linked closely to the business decisions of that firm.)

In its consideration of alternatives to treating compliance instruments as commodities, the Markets Committee found three additional strong arguments not to create an alternative framework. First, the definition of "commodity" in the Commodity Exchange Act[9] is sufficiently broad that it would be difficult to devise a definition of compliance instruments that would not place their derivatives under CFTC regulation in the US. Second, no alternative framework rose up as superior. Third, though the Canadian provinces each have a securities commission that regulate derivatives, in general, because of federal preemption, the US state governments

[9] 7 U.S.C. 1a (4)

retain less authority to regulate national financial markets and, as a result, creating the regulatory capacity for oversight of compliance instrument derivatives traded on national markets could require a significant investment of time and funds.

4.1.1.4 Experience in Existing Environmental Cap-and-Trade Programs

In the US, Acid Rain Program and RGGI compliance instrument derivatives are regulated by the CFTC as commodity derivatives. In the EU ETS, regulation of derivatives is performed by individual countries. That said, most of the exchange-based derivatives activity takes place on the European Climate Exchange, based in London, which is regulated as a commodity derivatives exchange by the UK Financial Services Authority.

4.1.1.5 Draft Recommendation

The Markets Committee recommends that compliance instruments be treated in the same framework and by the same regulators as commodities for the purpose of derivatives regulation. This implies the primacy of the provincial securities commissions and the CFTC in oversight of that aspect of the market. The Committee recommends a close coordination of oversight efforts between agencies of the Partner jurisdictions and US federal regulators.

4.1.1.6 Relationship to Other Draft Recommendations

A discussion on the collection and dissemination of data on derivative positions is included in Draft Recommendation 2 (Information on Derivatives Positions). Some of the data that could be collected is not currently collected by the CFTC or provincial securities commissions, and would then be an exception to the general recommendation that compliance instruments be treated like other commodities.

The remainder of the Draft Recommendations would then apply only to secondary markets in compliance instruments.

4.1.1.7 Requirements of Tracking System

This Draft Recommendation does not imply technical requirements of the tracking system.

4.1.2 Draft Recommendation 2: Information on Derivatives Positions

4.1.2.1 Background

The WCI cap-and-trade program will likely lead to the development of a market for compliance instrument derivatives, as covered entities seek to hedge the cost and availability of compliance instruments in order to meet their compliance obligations. In the United States, regulation of commodity derivative markets occurs at the federal level. In Canada, these markets are regulated at the provincial level. Currently, derivative trading in energy commodity markets

occurs in a variety of venues including regulated exchanges and through private "over-the-counter" (OTC) contracts. Market regulators in Canada and the United States do not track OTC trading of energy-related derivatives as closely as exchange-traded contracts. As a result, it is difficult to track trading activity across the energy derivative markets. Efforts are underway in both countries to reform market regulation, in part because of concerns that OTC opacity allows for undetectable manipulative behavior or drives speculative bubbles. These efforts may increase surveillance of OTC trading but the likely outcome is unclear.

4.1.2.2 Options

The Markets Committee identified the following options regarding collection of information on derivative positions:

A. Collect on an ongoing basis information on derivative positions from those with accounts in the cap-and-trade tracking system or ownership interest in a compliance instrument that is additional to the information currently collected by commodities regulators;
B. Collect on an ongoing basis information on derivative positions from some entities, e.g., registered intermediaries;
C. Do not collect derivative position information on an ongoing basis, but ensure that regulatory authorities are authorized to collect and fully disclose derivative position-related information in a timely fashion on an as-needed basis, including information that would be material to an investor's decision to acquire or dispose of a derivative;
D. Do not collect additional information on derivative positions.

Depending upon which of the options above the Markets Committee recommends, the WCI cap-and-trade program may or may not have information on derivative positions to retain internally or disclose publicly. If information on derivative positions is collected on an ongoing basis, the Markets Committee has identified the following options for disclosure of derivatives market information:

A. Disclose all derivative positions reported (i.e., those of participants with tracking system accounts or ownership interest in a compliance instrument);
B. Disclose the largest derivative positions (e.g., exceeding a certain percentage of the total market);
C. Disclose derivative positions aggregated to a level similar to the Commodity Futures Trading Commission Commitments of Traders reports; or
D. Do not disclose information on derivative positions.

The Markets Committee has considered the following options in terms of how derivatives market information could be disclosed:

A. Directly through a central derivatives information repository, and through search functions;
B. Through exchanges where transactions occur;

C. Through periodic WCI market reports published on a website; and/or,
D. Situationally by commodities derivatives regulators, as they deem appropriate.

Frequency of data collection will also have important consequences for each of the above options. The Markets Committee has considered daily, weekly, monthly, and quarterly disclosures.

4.1.2.3 Evaluation of Options: Data Collection

Rationale for Data Collection

Three main benefits may accrue from collecting data on account holders' derivative positions. First, though data on exchange transactions is relatively transparent to regulators, the Partner jurisdictions appear to be in a position to collect information on OTC transactions that is not currently routinely accessible to market monitors. Data collection as part of the cap-and-trade program could supplement the regular efforts to monitor compliance instrument derivatives markets; the data could be transmitted to provincial and US federal monitors. A consolidated repository of information on the compliance instrument derivatives markets across jurisdictions and trading venues could enhance transparency of the cap-and-trade market.

Second, in the event of unexpected or suspicious activity, the derivatives position data collected could serve a forensic purpose as regulators examined market activity and traced causes.

Third, as stated in the Design Recommendations for the WCI Regional Cap-and-Trade Program, "the WCI Partner jurisdictions are committed to providing appropriate technical and other compliance assistance to the program participants."[10] If it is using derivatives contracts as part of its strategy, an entity may be better able to demonstrate that it is on track and managing its risk in the accumulation of compliance instruments during a compliance period if derivative positions are reported. (In the EU ETS, the majority of the market is in derivatives, not the spot market. Derivatives would not be reflected in the tracking system until settlement.)

Timing

To identify trading irregularities as they occur and initiate immediate enforcement actions, regulators need to receive and evaluate market data on an ongoing basis. Product innovation and market structure changes challenge regulators, in their policymaking role, to constantly consider whether the current regulatory framework continues to provide investor protection and market integrity given new products and structures. Collecting, aggregating, maintaining,

---

[10] "Design Recommendations for the WCI Regional Cap-and-Trade Program," Western Climate Initiative, September 23, 2008, http://www.westernclimateinitiative.org/component/remository/general/design-recommendations/Design-Recommendations-for-the-WCI-Regional-Cap-and-Trade-Program/ (Accessed February 12, 2010), p. 13.

and analyzing large amounts of data requires informational technology and staff resources. The cost of collecting data more frequently should also be weighed against its benefits.

If the goal is more limited, e.g. to identify trends and maintain data for use during longer-term enforcement actions, daily reporting by market participants becomes less important. In that instance, weekly or monthly reports may be sufficient to monitor general trends in trading behavior and have on record in the event enforcement actions become necessary.

Proposed Derivative Reforms

Systematic ongoing collection of OTC derivatives data would go beyond the approach currently used by commodities regulators in North America, which may be seen to be an advantage or disadvantage. The Partner jurisdictions may feel that a nascent market created by government action has intrinsic differences from other commodities, including necessary public support, to say that the standards and tools of effective oversight are also different. The Partners jurisdictions may wish to anticipate or influence the financial reform efforts in favor of reporting OTC derivatives. Requiring such reporting in advance of the uncertain outcome of such reform efforts would make a strong statement about its importance in effective market oversight, and could influence the reforms.

US federal legislative proposals on financial market reform generally would require increased reporting and disclosure of OTC derivatives. In May 2009, the US Treasury Department released a proposal to reform OTC derivative markets.[11] A key component of the proposal is mandatory clearing of standardized contracts and giving the regulators authority to determine whether a contract is standardized or not.

The US House of Representatives passed a financial reform bill in December 2009 that addresses mandatory clearing and transparency.[12] Title III of the bill applies to derivative markets and creates a presumption that standardized swap transactions will be cleared. The clearing requirement does not apply if one of the counterparties (a) is not a swap dealer or major swap participant, (b) is using swaps to hedge a commercial risk, or (c) notifies the CFTC how it meets financial obligations when entering into non-cleared swaps. If one of these exemptions applies and a swap transaction is not cleared through a registered clearing facility, the transaction must be reported to a registered swap repository. If no repository will accept the transaction, the transaction must be reported directly to the CFTC.

---

[11] "Regulatory Reform Over-the-Counter Derivatives," US Department of the Treasury press release, May 13, 2009, http://www.ustreas.gov/press/releases/tg129.htm (Accessed March 14, 2010).

[12] "House Approves Historic New Rules to Govern America's Financial System," House Committee on Financial Services press release, December 11, 2009, http://house.gov/frank/pressreleases/2009/12-11-09-fsc-press-release-final-bill.html (Accessed March 14, 2010).

Senate Banking Committee Chairman Christopher Dodd released a financial reform bill on March 16, 2010. As in the bill that passed the House of Representatives, Senator Dodd's bill would require central clearing of standardized OTC contracts. The bill includes exemptions for certain swap transactions, but would require the CFTC to consult a Financial Stability Oversight Council before issuing an exemption. The Dodd bill would expand the CFTC's jurisdiction over OTC instruments and grant federal regulators and clearing houses a role in determining whether clearing is required; regulators would have to pre-approve contracts before clearing houses could clear them. The bill would require federal regulators to determine margin requirements for un-cleared transactions and also require data collection through clearing houses or swap repositories. The Senate has not acted on the Dodd bill, and the Senate Banking Committee may amend the OTC provisions during the committee process.

Collecting information about derivatives contracts from registered intermediaries (e.g., brokers, merchants, traders, advisors, and pool operators) could provide regulators with a more complete picture of market activity, thereby helping regulators identify and prevent fraudulent activity. The WCI Partner jurisdictions could collect information from these entities about the products offered and sold during the reporting period, including volume, prices, contracting parties, types of contracts, and locations of the trades.

Arguments

There may be a number of drawbacks to collecting data on account holders' derivative positions. First, assuming the implementation of Draft Recommendation 4 (Establish Legal Relationship with Market Participants Through Compliance Instrument Ownership Interest and Tracking System), the WCI Partner jurisdictions may not be able to collect derivatives information from some entities who have neither tracking system accounts nor ownership interest in compliance instruments. Such participants represent a potentially large portion of the derivatives market. For example, entities who only participated in cash-settled derivatives markets would not need to hold accounts. Entities trading physically-delivered derivatives could still avoid holding accounts if they closed their positions before the delivery date. In addition, violations of the reporting requirement might not be visible to regulators; whether or not a report was complete in its listing of OTC derivatives would be difficult to determine.

Second, the potential benefit of collecting information on derivatives positions must be weighed against the potential increase administrative burden and cost for regulators and for the compliance entities that use derivatives to manage their risk. It may be challenging to anticipate new financial innovations that lead to market manipulation by analyzing the information on derivatives positions, so regulators may be limited to primarily using the information for forensic purposes.

Third, due to the nature of OTC derivatives, it may be difficult to collect derivatives positions information in a sufficiently consistent manner through the tracking system to allow broad analysis.

It is important to note that mandatory reporting of OTC derivative positions would require development of a new information technology platform. There exist companies that provide repository services and associated automated processing services for OTC derivatives. WCI Partner jurisdictions may therefore consider that there are models for collection of derivatives information that would not require an investment of funds from the jurisdictions. However, the process to select a provider would demand time and resources.

The International Swaps and Derivatives Association (ISDA) has recently concluded the selection of independent systems as global repositories for interest rate and equity derivatives, and is rumored to be considering a selection process for a commodity derivatives repository. If ISDA designates a repository, it could be a strong candidate for selection by the WCI jurisdictions as well, depending in part on the access regulators would have to collected data.

4.1.2.4 Evaluation of Options: Public Disclosure

In the view of at least one trade association of professional derivatives market participants (ISDA), policy makers tend to view transaction transparency—meaning in this circumstance "public disclosure"—as a desirable end in itself.[13] In contrast, ISDA asserts, the academic literature tends to view transparency as a means to an end, for example, improved market efficiency, which implies the existence of tradeoffs. On the one hand, ISDA states, transparent markets might be more efficient from the standpoint of the information content of prices; but on the other hand, transparent markets might be less efficient when considering spreads and other transaction costs. For example, ISDA asserts that one would expect mandated transparency to lead to increased explicit costs (e.g., for accounting) because of the necessity to maintain both systems and staff to comply with the requirements; in addition, central reporting structures, if used, might charge fees to reporting firms.

ISDA argues that this trade-off suggests that market transparency should be evaluated in the context of specific market circumstances and public policy should push for higher transparency only in those cases where it can demonstrably make markets more efficient and more beneficial to users. To the extent that market participants demand more transparency as markets mature, ISDA believes that financial markets are likely to evolve ways to address market participants' desire for more information relevant to their trading and risk transfer

[13] "Transparency and over-the-counter derivatives: The role of transaction transparency," International Swaps and Derivatives Association, Research Note, No. 1, 2009, http://www.isda.org/researchnotes/pdf/ISDA-Research-Notes1.pdf (Accessed March 10, 2010).

decisions. Mandated transparency, in contrast, specifies a particular solution across the board. ISDA cautions that such a "one-size-fits-all policy" runs the danger of disregarding the inherent nature of specific markets and could short-circuit the evolution of market-based transparency provision that would otherwise arise in response to real market demands.

The current Chairman of the CFTC, Gary Gensler, has a different view. In his words, "[t]he financial regulatory system failed the American public."[14] He has testified that "as a critical component of reform... we have to bring comprehensive regulation to the over-the-counter (OTC) derivatives markets. We must lower risk, promote greater market integrity and improve market transparency." He proposes to "eliminate exclusions and exemptions from regulation for OTC derivatives," such that the law "covers the entire marketplace, without exception." The reforms he proposes have many components, only one of which is public disclosure. On that subject, he calls for "mandatory public disclosure of aggregate data on swap trading volumes and positions." Rather than arguing for transparency as a desirable end in itself, Chairman Gensler argues for transparency and other steps "to protect the American Public."

Canada's financial regulatory system has fared well through the economic recession, illuminating an alternate perspective. Prime Minister Stephen Harper delivered a message at the World Economic Forum in Davos, Switzerland that "Canada believes that financial sector regulation... must not be excessive." Canada's model is based on a simpler regulatory approach that focuses more on the outcomes the regulated community must achieve than how they are achieved, to ensure innovation is not stifled.

In comments to the WCI Markets Committee on the market oversight white paper issued November 19, 2009, several commenters recommended greater transparency in and oversight of the OTC derivatives markets.

In this issue as in many that the Markets Committee is considering, there may be a tradeoff between a desire to allow a secondary market to evolve and a desire to adopt lessons and best practices from experience in other markets.

4.1.2.5 Comparison to Other Markets

In the United States, the Commodity Exchange Act (CEA) and its implementing regulations require that regulated exchanges provide information regarding derivative trades to the CFTC.

---

[14] "Testimony of Chairman Gary Gensler, Commodities Futures Trading Commission Before the House Committee on Agriculture," September 22, 2009, http://www.cftc.gov/ucm/groups/public/@newsroom/documents/speechandtestimony/opagensler-10.pdf (Accessed March 10, 2010).

This information is collected on a daily basis and includes aggregated position limits and trading activity for all of their members. The aggregated data for each member includes:

> open long and short positions, purchases and sales, exchanges of futures for cash, and futures delivery notices for the previous trading day. This data is reported separately by proprietary and customer accounts by futures month, and for options by puts and calls, expiration date and strike price.[15]

The CEA also requires regulated exchanges to make data available to the public regarding trading volume, open contracts, futures delivery notices, exchanges for cash, and prices.[16]

Futures commission merchants, members of regulated exchanges, and foreign brokers must provide a daily report to the CFTC regarding "special accounts," those with futures and options positions above the reporting level specified by the CFTC. The requirement to provide this specific data is referred to as the CFTC's Large Trader Reporting Program.[17] The reports must include data regarding "each futures position, separately for each reporting market and for each future, and each put and call options position separately for each reporting market...."[18] Reporting entities must aggregate their interest in or control of multiple accounts for the purpose of determining whether their positions trigger reporting requirements.[19]

In Canadian provinces, the obligation to report positions or trades is determined by exchange rules. For example, in Quebec all members of the Montréal Exchange,[20] a derivatives exchange, must disclose to the exchange their net positions when they exceed a certain threshold that triggers the reporting requirement. There are no obligations to disclose, on a daily basis, information to the regulator, the Autorité des marchés financiers (AMF).

The US Acid Rain Program, RGGI, and the EU ETS do not require special reporting of OTC derivatives in compliance instrument markets.

---

[15] http://www.cftc.gov/industryoversight/marketsurveillance/ltrp.html
[16] 17 CFR Part 16.
[17] "Large Trader Reporting Program," http://www.cftc.gov/industryoversight/marketsurveillance/ltrp.html (Accessed March 15, 2010).
[18] 17 CFR 17.00(a)(1).
[19] 17 CFR 17.00(a)(2).
[20] "Home page – Montreal Exchange: the Canadian Financial Options and Futures Exchange," http://www.m-x.ca/accueil_en.php?changeLang=yes& (Accessed March 15, 2010).

4.1.2.6 No Draft Recommendation

The Markets Committee has not yet decided upon a Draft Recommendation on the collection and public disclosure of derivative positions. The Committee requests public comment on this issue.

4.1.2.7 Requirements of Tracking System

Collecting information on derivative positions would require the establishment of a repository for that information. Such a repository could, but is not required to be, a part of the compliance instrument tracking system. If the repository and tracking system are different, protocols for information exchange between them may be necessary.

4.1.3 Draft Recommendation 3: Treat Allowances and Offset Certificates Identically for Market Oversight Purposes

4.1.3.1 Background

The WCI cap-and-trade design involves two types of compliance instruments: allowances and offset certificates. There are differences between the creation and use of these two types of compliance instruments. First, Partner jurisdictions will issue offset certificates for projects that can demonstrate that removed or avoided emissions are real, additional, verifiable, and permanent. That process will have requirements for information transparency and disclosure, project approval, monitoring, and treatment of the risk of reversal that are separately being considered by the Offsets Committee. The process by which allowances are created and issued, in a predetermined quantity, will be different. Second, the WCI Partners have approved final recommendations for limiting the use of offset certificates to meet compliance.[21] Third, offset projects and allowances have differing risks; offset certificates may carry some risk of reversal, depending on jurisdictions' policy choices. Partly for these reasons, the market prices for allowances and offset certificates are different in the EU ETS, and likely to be different in a WCI market. Further, the number of offset certificates will be much smaller than the number of allowances.

4.1.3.2 Options

The Markets Committee has identified the following options for treatment of different types of compliance units:

A. Treat allowances and offset certificates identically for market oversight purposes; or,
B. Establish distinct requirements for offset certificates.

---

[21] "WCI Recommendations for Implementing the Offset Limit," Western Climate Initiative, March 11, 2010. http://westernclimateinitiative.org/component/remository/func-startdown/224/ (Accessed March 18, 2010).

4.1.3.3 Evaluation of Options

For the purposes of this section, the Markets Committee considered the Market Oversight Draft Recommendations to define the scope of the policy decisions. In the case of each of the eleven other Draft Recommendations, the Committee evaluated the different nature of allowances and offset certificates and the additional complexity that would likely follow if the types of compliance instruments were treated differently.

In two cases, Draft Recommendation 7 (Holdings Limits) and Draft Recommendation 12 (Market Monitoring), the much smaller number of offset certificates could lead to differences in the implementation of a recommendation. In each, for example, the definition of market power would be different. However, these are likely to be quantitative differences rather than qualitative differences.

4.1.3.4 Experience in Existing Environmental Cap-and-Trade Programs

No offset certificates are issued in the Acid Rain Program, and none have yet been issued in RGGI. To the best of our knowledge, offset certificates usable for compliance in the EU ETS are treated, like allowances, as commodities.

4.1.3.5 Draft Recommendation

The Markets Committee recommends that the WCI cap-and-trade system treat allowances and offset certificates identically for market oversight purposes.

4.1.3.6 Relationship to Other Draft Recommendations

All other Draft Recommendations assume the adoption of this one, and are written for compliance instruments without distinction.

4.1.3.7 Requirements of Tracking System

This Draft Recommendation implies no additional requirements of a tracking system.

4.2 Market Participants

4.2.1 Draft Recommendation 4: Establish Legal Relationship with Market Participants Through Compliance Instrument Ownership Interest and Tracking System

4.2.1.1 Background

The WCI Partner jurisdictions intend to create a system to track compliance instruments. The instruments would exist as electronic records rather than physical certificates. The Partner

jurisdictions are designing the requirements for this tracking system, and considering options for implementation.

This paper describes Draft Recommendations on market oversight. For each, the Markets Committee evaluated enforceability of the Draft Recommendation. A consideration for enforceability is the existence and nature of the relationship between the regulator and the market participant. The nature of the relationship will differ, for example, depending on whether or not a person has a legal obligation to surrender compliance instruments (is a "compliance entity").

The nature of the relationship will also hold some combination of a "regulatory" relationship, and a "contractual" relationship. Here, a regulatory relationship is considered to be mandatory for designated persons, with the authority of a regulator established by statute and written into the regulations of a jurisdiction. A "contractual" relationship would be one voluntarily entered into by a person, with a counterparty of one or more jurisdictions or the tracking system, that provides the person the ability to take certain actions, under certain conditions. These types of relationships also imply differences in enforcement actions.

The Partner jurisdictions will have established relationships with the entities that will have compliance obligations under the cap-and-trade program. These relationships include reporting requirements and surrender obligations, though they are not the subject of these Draft Recommendations, which are focused on the activities around the holding and trading of compliance instruments.

The Markets Committee is particularly interested in defining the relationship between regulators and entities that do not have a compliance obligation under the cap-and-trade program.

4.2.1.2 Draft Recommendation

The Markets Committee recommends that either or both of having ownership interest in a compliance instrument and having an account in the tracking system would establish a legal relationship between one or more regulators and the account holder. These relationships would entail certain obligations of the entity.

4.2.1.3 Relationship to Other Draft Recommendations

Among the obligations entailed by holding an account in the tracking system would be Draft Recommendations 6 (Require Registration of Intermediaries as Market Professionals) and 9 (Require Disclosure of Beneficial Ownership). In addition, this Draft Recommendation assumes the implementation of Draft Recommendation 5 (Do Not Limit Market Participation to Compliance Entities), that compliance entities not be the only market participants. If

participation is limited to compliance entities, the need to create a regulatory relationship to implement trading rules would probably be largely satisfied.

4.2.1.4 Requirements of Tracking System

This Draft Recommendation suggests a conceptual role for the tracking system. Technical requirements may include the ability to perform enforcement actions, such as revocation or suspension of trading for an entity or for all accounts.

4.2.2 Draft Recommendation 5: Do Not Limit Market Participation to Compliance Entities

4.2.2.1 Background

A WCI carbon market could involve diverse participants who may trade to satisfy a compliance obligation, purchase for resale to emitters, speculate on the price of compliance instruments, or diversify an investment portfolio. Entities that could participate in the carbon market may include compliance entities, investors, brokers and other intermediaries. Each entity would play a different role in the market.

Even if compliance entities receive allowances without charge from a government, the number may not be equal to their obligation, perhaps due to growth or contraction in their emissions or policy decisions on the quantity or formula for distribution. These entities may then choose to purchase additional compliance instruments from the primary or secondary market, or sell compliance instruments they will not require for compliance or for other reasons. In early 2009, industrial facilities in the EU ETS sold allowances, many freely allocated, to raise cash when other avenues of raising funds became more difficult.[22]

Though they would not be required to hold compliance instruments for compliance, other categories of participants could play market roles. Brokers and other intermediaries may, for a fee, arrange trades of compliance instruments between parties, or provide advice or other services. Investors may desire to be market participants to profit from trading.

4.2.2.2 Options

With regard to the secondary market, the WCI cap-and-trade program could either:

A) Limit market participation to compliance entities; or,
B) Open market participation to non-compliance entities.

---

[22] E.g., "Carbon Markets 2009," IFSL Research, July 2009, http://www.ifsl.org.uk/upload/Carbon_Markets_2009.pdf (accessed October 1, 2009).

The Market Committee is separately developing Draft Recommendations on participants in the auctioning of allowances (primary market).

4.2.2.3 Evaluation of Options

The WCI Partner jurisdictions have received oral and written comments from stakeholders suggesting that market participation be limited to compliance entities. Many of these comments referred specifically to auctions, which are the subject of a separate WCI white paper, but may also be addressed in the context of secondary markets. The concerns expressed can be summarized as:

1) That participation by non-compliance entities will increase the price of allowances.
2) That participation by non-compliance entities increases the chances of market manipulation.
3) That participation by non-compliance entities will limit access to allowances.

The first concern may be related to questions regarding the role of speculation in markets. Investors can play important roles in competitive markets by increasing liquidity. A healthy market is "liquid," meaning there is a sufficient number of buyers and sellers in the marketplace to allow trading to take place. Larger numbers of market participants make it more likely that there will be counterparty (i.e., another party willing to participate in a trade). A market with less liquidity may be subject to more price volatility and it may be more difficult for entities needing to buy compliance instruments to locate willing sellers. Unlike a traditional commodity market, a compliance instrument market will not have natural sellers outside of the primary market. Consequently, concerns about potential "excess" speculation by investors must be weighed against these benefits of allowing investors access to the carbon market.

The second concern implies either that more market participants increases the ease or risk of manipulation, or that non-compliance entities might attempt market manipulation while compliance entities would not. However, a larger number of market participants would most likely make manipulation more difficult, not less, by increasing liquidity and making control of a significant proportion of compliance instruments by one or a few persons harder.

The Markets Committee assumes for this discussion that the fraction of potential market participants who would attempt a manipulation is small. However, the potential for damage from a successful manipulation is large, and has precedent in recent experience in energy markets in WCI Partner jurisdictions, notably the energy crisis of 2000 – 2001. The Committee believes that participants who would consider an attempt to manipulate the market exist both among compliance and non-compliance entities. Limiting market participation to compliance entities would exclude some number of beneficial participants without measurable benefit in changing the fraction of participants who would consider market manipulation.

The third concern is that non-compliance entities may hold compliance instruments for some period of time, making them unavailable to compliance entities that may need them for compliance. There are many possible non-compliance reasons to hold compliance instruments; the auction design recommendation report commissioned by RGGI identifies five:[23] speculation; allowance market manipulation; electricity market interference; competitive advantage; and external compliance. In none of these cases would market risks be reduced by restricting the market to compliance entities, save potentially external compliance.[24] When restricting a market reduces liquidity, in fact, the risks are increased. Though this risk might be enhanced by allowing non-compliance entities to participate, it is nevertheless very small, as it has not been proposed by the existing GHG cap-and-trade programs, RGGI and the EU ETS.

In addition to considering whether participation limits are desirable, the Committee has considered whether they are practical. Fairly and reliably determining who has a compliance obligation in advance of the reporting deadline for a given year's emissions is not possible. The identities of compliance entities will also change as some enter or leave the program due to changes in their emissions or change in program scope, such as the inclusion of transportation fuels and residential and commercial fuel combustion in the second compliance period.

Limiting participation to compliance entities would also be difficult to enforce. For example, a person who would like to attempt a market manipulation but was otherwise excluded by participation rules might purchase some fractional interest in a facility that was a compliance entity, with an agreement that the person could trade as a representative of the entity. Under Draft Recommendation 1 (Treat Compliance Instruments as Commodities for Market Oversight Purposes), US states in the WCI would not have primary jurisdiction over derivatives markets and would therefore have constrained ability to enforce a participation limit in markets considered broadly.

4.2.2.4 Experience in Existing Environmental Cap-and-Trade Programs

The Acid Rain Program, RGGI, and EU ETS do not limit participation to compliance entities.

---

[23] "Auction Design for Selling CO2 Emission Allowances Under the Regional Greenhouse Gas Initiative," Charles Holt, William Shobe, Dallas Burtraw, Karen Palmer, Jacob Goeree, October, 2007, section 9, "Hoarding of Allowances," http://www.rggi.org/docs/rggi_auction_final.pdf (Accessed October 6, 2009).

[24] "External compliance" is the possibility of another cap-and-trade program accepting WCI compliance instruments in lieu of its own, without any reciprocal acceptance of the program's compliance instruments by WCI jurisdictions.

4.2.2.5 Draft Recommendation

The Markets Committee recommends that both compliance and non-compliance entities be allowed to participate in the secondary compliance instrument market. Broad participation would be beneficial, and narrow participation harmful, to an compliance instrument market, especially in its early stages. Limiting participation to compliance entities would not be an effective policy to reduce the potential for market manipulation.

4.2.2.6 Relationship to Other Draft Recommendations

Draft Recommendation 6 (Require Registration of Intermediaries as Market Professionals) describes a requirement for a type of participant, assuming that intermediaries who are not compliance entities could be participants.

4.2.2.7 Requirements of Tracking System

The adoption of this Draft Recommendation would require that the tracking system be able to accommodate more accounts, and potentially more trades, than one for a program with limited participation.

4.2.3 Draft Recommendation 6: Require Registration of Intermediaries as Market Professionals

4.2.3.1 Background

There will likely be numerous types of market participants in the WCI cap-and-trade program. Each account holder would be required to provide some information (e.g., identifying information) to regulators in order to establish an account, a process that could be called "registration."

One category of market participants could be "intermediaries," which would include traders, dealers, advisers and investment managers in the market. There exist precedents of registration requirements for intermediaries operating in the majority of commodities derivatives markets and in limited commodities markets. In both the US and Canada, some commodities derivatives traders are required to register with regulators and/or self-regulatory organizations. This process is also widely referred to as "registration." According to the National Futures Association (NFA), "The primary purposes of registration are to screen an applicant's fitness to engage in business as a futures professional and to identify those individuals and organizations whose activities are subject to federal regulation." [25] The screening can improve consumer and market protection. In this discussion, the question is whether to require that persons be subject

[25] "Registration," National Futures Association, http://www.nfa.futures.org/NFA-registration/index.HTML (Accessed February 11, 2010).

to the requirements of knowledge of trading law, capital requirements, etc. that are needed to trade or offer professional advice on derivatives in the US and Canada, as described below. This type of registration is referred to in this paper as "market professional registration."

In the US, the CFTC oversees market professional registration of entities engaged in trading of commodities and derivatives. The CFTC authorizes the NFA, a private organization, to perform registration processing functions on behalf of the Commission. Regulation of similar activities in Canada is performed by a combination of provincial regulatory authorities, a national database, and the Investment Industry Regulatory Organization of Canada (IIROC). Like the NFA, the IIROC is a private organization.

Under both countries' regulatory systems, entities must determine whether the business being conducted qualifies as trading or advising under the applicable law. If the activity does fall within the applicable law, the next step is to determine whether there is an exemption from the requirement to be registered set out in the law. If there is no exemption, the person or firm will be required to obtain market professional registration in order to conduct trading activities.

US Registration Requirements[26]

The US Commodity Exchange Act sets forth registration requirements for entities engaged in trading commodities and regulated derivative transactions. The CFTC identifies the following categories of market participants that must register with the NFA unless they qualify for an exemption:

- **Merchants**
  - Futures Commission Merchant (FCM) – A FCM is an individual or organization which does both of the following:
    - Solicits or accepts orders to buy or sell futures contracts or options on futures and
    - Accepts money or other assets from customers to support such orders.
  - Agricultural Trade Option Merchant (ATOM) – Any person that is in the business of soliciting or entering option transactions involving an agricultural commodity listed in the CEA that are not conducted or executed on or subject to the rules of an exchange.
- **Brokers**
  - Introducing Broker (IB) – A person who is engaged in soliciting or in accepting orders for the purchase or sale of any commodity for future delivery on an

[26] "Intermediaries," Commodity Futures Trading Commission, http://www.cftc.gov/industryoversight/intermediaries/index.htm (Accessed February 11, 2010)

exchange who does not accept any money, securities, or property to margin, guarantee, or secure any trades or contracts that result therefrom.
    - Floor Broker (FB) – A person with exchange trading privileges who executes trades for others by being personally present in the pit or ring for futures trading.
- **Floor Trader** (FT) – A person with exchange trading privileges who executes his or her own trades by being personally present in the pit or ring for futures trading.
- **Commodity Trading Advisor** (CTA) – A person who, for pay, regularly engages in the business of advising others as to the value of commodity futures or options or the advisability of trading in commodity futures or options, or issues analyses or reports concerning commodity futures or options.
- **Commodity Pool Operators** (CPOs) – A person engaged in a business similar to an investment trust or a syndicate and who solicits or accepts funds, securities, or property for the purpose of trading commodity futures contracts or commodity options. The commodity pool operator either itself makes trading decisions on behalf of the pool or engages a commodity trading advisor to do so.
- **Associated Person** (AP) – An individual who solicits or accepts (other than in a clerical capacity) orders, discretionary accounts, or participation in a commodity pool, or supervises any individual so engaged, on behalf of a FCM, IB, CTA, CPO, or an ATOM.

The NFA develops registration requirements for each category of intermediary listed above. In general, the registration requirements include a completed registration form with information about the activities of the intermediary, an application fee, NFA membership dues, and fingerprint cards for principals and associated persons, as well as proficiency requirements.

FCMs and IBs must also include a financial statement (if the firm does not meet minimum capital requirements, it may face additional reporting requirements), and a description of procedures regarding the following:

- money laundering;
- business continuity and disaster recovery;
- electronic order routing;
- promotional materials;
- supervision of associated persons;
- customer complaints; and
- margins/segregation (if applicable).

Canadian Registration Requirements

i. Provincial legislation

Depending on their type of market activity, intermediaries may be required to register with provinces and with the Investment Industry Regulatory Organization of Canada. The statute that establishes jurisdiction in a province and territory varies. In most provinces and territories

The Securities Act establishes the requirement to register to trade or advise in the trading of securities or derivatives.

In Ontario and Manitoba, The Commodity Futures Act requires that entities register with the provincial regulator before trading or providing advice regarding the trading of exchange-traded derivatives. The Act also provides jurisdiction to define what will be included under the term "commodity."

In Quebec, registration to trade or provide advice in exchange traded or over the counter derivatives is mandated in The Derivatives Act.

The legislation in each province permits enactment of regulations or rules that provide the detailed requirements to obtain or maintain registration. In many cases these requirements are consistent among the provinces and territories and are referred to as National Instruments (when all jurisdictions have adopted the requirements) or Multilateral Instruments (when one or more jurisdictions have not adopted the requirements).

Canadian Securities Administrators interpret and apply the "National Instrument 31-103," enacted in September 2009, and Companion Policy 31-103CP "Registration Requirements and Exemption," which contain categories and requirements for registration of individuals and firms for trading or advising in exchange contracts.

ii. National Registration Database

In Canada, the National Registration Database[27] (NRD) is an internet-based system which provides firms and individuals with the ability to file most registration information electronically with any number of the provinces and territories. The use of NRD is mandated by all provinces and territories for securities and derivatives registrations.

The forms that are required to be used and submitted on NRD are standardized.

iii. Investment Industry Regulatory Organization of Canada (IIROC)

In all provinces and territories in Canada, in most cases a business or individual in the business of trading or advising in the trading of derivatives contracts is required to be a member of the IIROC. IIROC has been recognized as a self regulatory organization responsible for setting standards and regulating the conduct of its members.

---

[27] "National Registration Database Information | Site d'information de la BDNI," National Registration Database, http://www.nrd-info.ca/ (Accessed February 11, 2010)

The inclusion of the IIROC membership requirement by the provincial and territorial regulators means the same standards apply to all Investment Dealers in the business of carrying out derivatives transactions in Canada.

Applicability of the provincial and territorial laws, as well as the requirements of IIROC establishes a comprehensive set of proficiency, capital, solvency, and client relationship requirements. In addition there is authority to conduct compliance audits of members, investigate and take action to suspend or cancel registration, and take action to stop activities that pose a risk to markets and market participants.

4.2.3.2 Options

The Markets Committee has identified the following options:

A. Requiring every account holder to register as a commodities market professional .
B. Requiring every account holder in the business of advising or trading on behalf of other entities to register as a commodities market professional.
C. Not requiring any market participants to register as a commodities market professionals.

In addition, the Committee considered with whom an entity would register: with the state and provincial governments, or with a third party.

4.2.3.3 Evaluation of Options

As stated by the NFA, the two primary advantages of requiring registration are to screen the fitness of potential traders, and an identification of those traders to regulators. The disadvantages are that market professional registration requirements impose burdens on the entities that are required to register, as well as on the governments enforcing the requirements and the entity (government or third-party) that establishes criteria and evaluates applicants against them. In addition, assuming the implementation of Draft Recommendation 4 (Establish Legal Relationship with Market Participants Through Compliance Instrument Ownership Interest and Tracking System), WCI Partner jurisdictions would be able to require registration of account and compliance instrument holders, but may not have the ability to require registration of entities without tracking system accounts or ownership interest in compliance instruments.

Requiring market professional registration would also create an enforcement obligation for government regulators to maintain and monitor registration data.

The specialized expertise to register as a market professional is not typically found in the firms that will be compliance entities, and so would have to be acquired if all participants were required to register. The NFA's two arguments for registration are also weaker when

considering compliance entities: First, they have been identified to regulators through their compliance obligation. Second, it could be argued that they have been "pre-screened" by their very inclusion in the cap-and-trade program—that is, regulators have already determined them to be fit to trade.

Intermediaries with tracking system accounts could similarly be said to be identified to Partner jurisdiction regulators. However, they would not necessarily be identified to US federal regulators in the way that derivatives traders are. In addition, it may aid confidence in the market to have intermediaries "screened" as described above. Especially in a new market, participant confidence in intermediaries is important. Many prospective intermediaries are already registered to trade commodity derivatives, and standards for, e.g., record keeping and accounting for customer funds are reasonable protections for clients.

Intermediaries without tracking system accounts or ownership interest in compliance instruments, who are active only in the secondary market, may fall outside this requirement, which could weaken its effect.

The Partner jurisdictions could require market professional registration with an agency of the jurisdiction. This would allow for determination of the specific market professional registration requirements appropriate for the regional cap-and-trade system, and could expand upon existing registration requirements in Canada. It could also mean that requirements would not necessarily be subject to changes in US law. It could further provide for consistency across jurisdictions. Partner jurisdictions would also have full access to registration documents and any required reports.

Alternatively, Partners jurisdictions could require market professional registration with a third party. Doing so could reduce administrative costs for governments by shifting the burden to define requirements, evaluating applications, and receiving reports. The WCI Partners could contract with an independent market monitor to facilitate market professional registration, or attempt to establish relationships with the NFA and/or the IIROC. As noted above, many potential intermediaries are already registered with those organizations.

4.2.3.4 Experience in Existing Environmental Cap-and-Trade Programs

Neither RGGI nor the US Acid Rain Program requires market professional registration to participate in the secondary market. Derivatives trading in both markets, including registration requirements, is overseen by the CFTC.

4.2.3.5 Draft Recommendation

The Markets Committee recommends that brokers, merchants, and advisors who hold accounts in the tracking system and are in the business of trading or offering financial advice regarding

WCI compliance instruments be required to register as market professionals with an SRO to do so. Compliance entities and entities trading on their own behalf should not be required to register. The Committee recommends that Partner jurisdictions use or establish relationships with the NFA and IIROC to authorize them to register intermediaries on the jurisdictions' behalf.

4.2.3.6 Relationship to Other Draft Recommendations

This recommendation assumes the implementation of Draft Recommendation 4 (Establish Legal Relationship with Market Participants Through Compliance Instrument Ownership Interest and Tracking System), Draft Recommendation 1 (Treat Compliance Instruments as Commodities for Market Oversight Purposes), and Draft Recommendation 5 (Do Not Limit Market Participation to Compliance Entities).

4.2.3.7 Requirements of Tracking System

Adoption of this Draft Recommendation would necessitate a way to associate a registration number with a tracking system account.

4.3 Holdings and Transfers

4.3.1 Draft Recommendation 7: Holdings Limits

"Market power" is the ability of an entity to move prices through its behavior. Market power can be derived from the control of a large fraction of the instruments in question. Though not all exercises of market power are malign, some are intended to manipulate the market. The Markets Committee is interested in the possibility of reducing the risk of market manipulation by limiting the accumulation of market power. One mechanism it has identified is the use of "holdings limits," or limits on the number of compliance instruments any one entity could control in the tracking system. The Committee has commissioned a consultant's report on holdings limits, and will consider that report among other information as it works towards final recommendations.

4.3.2 Draft Recommendation 8: Require Use of a Central Limit Order Book for Secondary Market Transactions

4.3.2.1 Background

In secondary market trading, counterparties exchange cash or its equivalent for prompt delivery of compliance instruments. Any other type of transaction or contract—one, for example, in which counterparties agree to exchange cash for compliance instruments at some future date—is not a secondary-market trade but a derivative contract, and is subject to derivatives market regulations. For the purpose of discussion in this section, adoption of Draft Recommendation 1 (Treat Compliance Instruments as Commodities for Market Oversight Purposes), is assumed,

implying no new restrictions on derivatives trades. The discussion here will then be of secondary markets.

Secondary market trades may be executed in a variety of venues, with different characteristics, including how market participants determine prices, transparency, and clearing. The Markets Committee has focused on three types of venues: exchanges, central limit order books (CLOBs), and "over the counter" (OTC) transactions.

Exchange Transactions:
Exchanges are trading venues that have agreed rules for membership, trade reporting, order matching, and many other facets of transactions. One set of rules determines how buyers and sellers agree on prices. In general, exchanges maintain "order books." An order is the instruction to buy (a "bid") or sell (an "offer" or "ask") under certain conditions. A "limit order" is the instruction to buy or sell a certain quantity at a certain price (the bid or ask price). A "market order" is the instruction to buy or sell a certain quantity at the best price available. The order book lists the bids and offers, arranged by price and then by the time the order was placed. If there are a bid and offer at the same price, an order matching system will pair them and the transaction will be completed, for the volume of the smaller order. The remainder of the larger order remains on the order book for a subsequent match. In very liquid markets, the time between the posting of an order and its fulfillment is very short.

Members of an exchange can see the entire order book, and the available orders—both price and volume—contain information that will influence orders they place. For example, the "bid-ask spread" is the difference between bid prices and offer prices. A trader would typically place an order within the spread. Visibility of the order book may tend to keep the spread smaller, as a central price is clear to market participants. However, exchange order books and transactions are typically anonymous.

Exchanges typically make the price and volume of transactions publicly available after they have been executed.

Exchange transactions also imply other services to participants, including settlement (the exchange of money and goods or instruments) and clearing (in which a central organization is the counterparty for both the buyer and the seller). Clearing is discussed in more detail in the next section.

Central Limit Order Book Transactions:
A central limit order book (CLOB) is separable from the other services of an exchange. A CLOB would be an order book visible to market participants. A "hard" CLOB would, like the order-matching system on an exchange, execute matching orders automatically. A hard CLOB would

allow orders either anonymously or with an identification of the participant. A "soft" CLOB would be a central location to post and find bids and offers, but would not automatically match them; traders would have to separately contact each other to complete the transaction. A soft CLOB could not be anonymous. Bids and offers would be as transparent as on an exchange. Post-transaction data could also be reported by a CLOB; this could be largely automatic on a hard CLOB, where orders were automatically and bindingly matched, but on a soft CLOB participants would have to report final prices and volume for public disclosure. Final prices and volume might well be different than the posted order as a result of the counterparties' negotiation.

Clearing, if it were used, and settlement would be through venues other than the CLOB, selected by the counterparties.

Over-the-Counter Transactions:
For purposes of this discussion, "OTC" refers to cash market trades of compliance instruments that bypass centralized quotation and execution systems, and which may trade outside the bid-ask spread listed on those systems. There is no central order book; prices are determined by bilateral negotiation between parties, who may refer to data on transactions in other venues, if they are available, to determine a fair price. In most OTC markets, there is no prompt and automatic reporting and disclosure of price and volume, making activity relatively opaque. Whether this opacity is damaging is subject to debate, and depends among other things on the liquidity of trades in more transparent venues. Clearing, if it is used, and settlement are through venues chosen by the counterparties.

4.3.2.2 Options

The Markets Committee has identified two categories of options in trading venues.
The first category is whether or not to require transparency in orders:

A. Require all secondary market transactions to occur on one or more exchanges.
B. Require orders for all secondary market transactions to be posted on a hard CLOB.
C. Require orders for all secondary market transactions to be posted on a soft CLOB.
D. Allow OTC transactions without use of a central order book.

The second category is whether or not to require clearing of all transactions, independent of order book transparency.

4.3.2.3 Evaluation of Options

Choice of Venue
The Markets Committee seeks a recommendation that would maximize both market transparency and market liquidity. It believes that both are needed for price discovery for compliance instruments, which is necessary for entities to make efficient decisions on

investments and compliance strategies. However, there may be tradeoffs between transparency and liquidity.

Transparency is important for several reasons. First, transparency is crucial to market participants' evaluation of the trades they are considering. Participants without knowledge of the current buying and selling interest in the form of firm bid and ask quotations and transaction reports are at a distinct disadvantage in assessing the value of traded assets. Thus, transparency is crucial to pricing efficiency, the market's ability to accurately reveal the value of traded assets. In addition, transparency permits investors to evaluate whether the market is treating them fairly by identifying the best available price. Without access to the prices other market participants are paying for the same asset, they cannot effectively determine whether they have paid a fair price.

Second, access to accurate market information enhances the ability of regulatory examiners and independent auditors to carry out their respective responsibilities to ensure that transactions and positions are priced appropriately.

Pre-trade market transparency is supported by exchange-based and central limit order book trading. Pre-trade transparency makes the price and quantity of actionable buying and selling interest accessible to all market participants.

Post-trade transparency makes the price and size of the most recently executed trades accessible to all market participants. An exchange or a hard CLOB could make immediate post-trade transparency automatic. If a transaction price is required to transfer allowances from one account to another, post-trade transparency from all venues, including OTC, could also be supported by publication of data submitted to the tracking system (see section 4.3.4). However, timing is crucial. If the market is changing rapidly, delays in reporting by participants could obscure important information. The Markets Committee is concerned about the enforceability of requirements to report transactions promptly.

In a wholly OTC secondary market, buyers or sellers would solicit prices by telephone or email from whatever subset of intermediaries or potential counterparties they have the time and resources to contact, and hope that they have gotten a fair price. If traded prices are not promptly reported, traders cannot confirm whether or not they have obtained a fair price. In the absence of centralized collection and reporting of quotations and traded prices, intermediaries such as brokers and broker-dealers may emerge as market makers, offering pockets of liquidity to counterparties who might not otherwise find each other. The less transparent the market is, the more reliant compliance entities and others would be on intermediaries that would charge fees for transactions and could have significant information advantages.

At the same time, intermediaries can increase liquidity. First, a broker may have a broader understanding of a market than compliance entities or other participants, and may be able to facilitate negotiation of trades. Second, dealers may act as "market makers," willing to either buy or sell compliance instruments at any time. Market makers make money on the spread, always attempting to sell allowances for a price higher than they paid. The narrower the spread is, the less incentive there is for an intermediary to be a market maker. Narrower spreads could then decrease liquidity.

Selecting one or a small number of trading venues may "drive liquidity" to that venue and ensure that buyers and sellers can find each other. However, exchanges and CLOBs fund themselves in part through fees which, though small, may discourage some transactions. Liquidity is not only affected by policy decisions, but can affect them as well. The importance of driving transactions to one or more regulated platforms depends in part on the liquidity of other pieces of the market. If a sufficient number of transactions occur that the current fair market price for a compliance instrument is discernable from widely available data, e.g., from exchanges, then bid and ask spreads should be small and transactions should seldom deviate far from that price. However, if secondary market transactions are rare, the reported price could be quite volatile, and current orders opaque.

The derivatives markets also play roles in price discovery and liquidity that may affect the tradeoffs in a policy decision to select one or more venues. The various inputs to consider appear to be impossible to predict.

In principle, multiple venues could be linked to a single quotation system. As an example of such a system, in the secondary market for US equity securities, all exchanges and Alternative Trading Systems (ATSs) are required to contribute their quotations in real time to a central quotation system called a securities information processor. The collection, processing, and distribution of quotations is a central function of a collection of rules, practices, and infrastructure known as the national market system (NMS). The purpose of the NMS is to ensure transparency, effective oversight, fairness and pricing efficiency. Nearly all secondary-market transactions of U.S. securities listed on exchanges and ATSs are executed at prices within the NMS's published bid-ask spread for listed shares, and last-trade price and quantity are available in real time to all market participants.

Customization in OTC transactions and duration of OTC contracts compared to illiquid long-term markets are often cited as reasons to allow OTC derivative contracts. However, in secondary markets, neither of these is a strong argument: there is very little to customize, and the timescale is short by definition. An exception is repurchase or "repo" agreements, in which compliance instruments are sold by one entity to another, with an agreement that the first

entity will buy them back in the future. This is effectively creating a loan with the compliance instruments as collateral. Technically derivatives, repos still require an OTC transfer of ownership.

Partner jurisdictions could enforce use of a particular venue by requiring an identifying number for an order or executed transaction to accompany transfers of allowances from one account to another. The venue could be required to provide information on transactions to the jurisdictions, as well as quotations and last-trade prices. Compliance entities might be offered low- or no-cost access to order-matching services at the designated venue (though see section 4.2.2 for a discussion of identifying compliance entities).

However, there is a blurry line between the secondary and derivatives markets. The European Climate Exchange offers a standard contract for European Union Emission Allowance Daily Futures, which are settled by physical delivery in at most two business days. If the Draft Recommendation 1 (Treat Compliance Instruments as Commodities for Market Oversight Purposes) is adopted and the Partner jurisdictions make no collective recommendations to restrict derivatives trades, then restrictions on secondary market transactions might be easily dodged by firms creating forward contracts with very short expirations. Treatment of allowance transfers that are the fulfillment of derivatives contracts and not secondary market transactions would be another implementation consideration. Also, compliance entities might desire to transfer compliance instruments between facilities owned by a single company, or between entities owned by the same holding company. From 1994 – 2003, only about half of the allowance transfers in the U.S. Acid Rain Program were between "economically distinct organizations."[28] The implications for creating and enforcing exceptions to a venue requirement should be considered.

Clearing

In a recent case of a systemic problem due to counterparty risk, the September 15, 2008 bankruptcy filing of Lehman Brothers was part of, and greatly accelerated, a financial panic, in part because Lehman Brothers was counterparty to many other large financial institutions in a variety of transactions. Its collapse left counterparties uncertain about their losses, and uncertain about the exposure of others. This uncertainty helped to freeze financial activity.

The clearing organizations associated with exchanges require from all members security deposits that can be used if a member defaults on its contracts. In this way, the risk of default

[28] WCI staff analysis of data at "Trading Activity Breakdown | Market Analyses | Assessments and Tools | Clean Air Markets | Air &", Environmental Protection Agency, http://www.epa.gov/airmarkt/progress/transtable.html (Accessed January 4, 2010).

from one company is shared by clearing members. The members then have a strong incentive to set the rules for membership and for transactions to balance default risk and the cost of doing businesses.

Clearing through a central counterparty can reduce the risk of systemic problems by setting requirements for collateral, limiting the exposure of any single member, and collecting information for regulators and the public. On the other hand, clearing organizations may not be willing to guarantee all trades that would be economically efficient, and will charge for their services. The clearing function is typically integrated with trade confirmation, netting, registry (or "depository") and settlement services. Without clearing organizations, traders would need to individually evaluate the credit risk of every trade and counterparty, and establish separate payment and delivery arrangements with each counterparty. Central counterparty clearing reduces transaction processing costs for participating traders, and enables higher trading volumes by streamlining post-trade processing. However, clearing is effectively the extension of credit by the central counterparty, which comes at some cost. Many end users of commodities can obtain similar credit for at smaller expense, and so prefer not to clear transactions.

Though there are differing opinions about the advantages of clearing, in general it is believed to reduce the risk of systemic problems by reducing or redistributing counterparty risk. This risk is larger in derivatives markets, where positions may be built up over some period of time, and during which time the price may change, than in secondary market transactions, which are settled in the matter of a day or two at an agreed-upon price.

In a typical secondary-market exchange, only firms that sustain a high volume of trades are clearing members. Lower-volume or occasional traders trade through intermediaries (brokers or asset managers, e.g.) that are also clearing member firms. It is not necessary to operate as a clearing member firm in order to benefit from the transaction-processing efficiencies of a cleared market. However, requiring an intermediary that is a clearing member is potentially a cost to compliance entities and others.

4.3.2.4 Experience in Existing Environmental Cap-and-Trade Programs

Neither the Acid Rain Program nor RGGI requires secondary market transactions to go through a single venue, quotations to be reported to a central service, or clearing for secondary market transactions.

4.3.2.5 Draft Recommendation

The Markets Committee recommends that orders for secondary market transactions be required to be reported to a "hard" central limit order book to centralize liquidity and enhance transparency. The CLOB could be the order-matching system of a designated exchange or another system designated by the WCI Partner jurisdictions. Considering all the tradeoffs

identified above, the Committee believes that the public is best served by clear and immediate price signals. However, we recognize that this is a particularly complex issue and we invite stakeholder comment on this Draft Recommendation.

In the event that the CLOB is not part of an exchange, the Committee does not recommend requiring clearing of non-exchange transactions. The risks identified are small in secondary markets.

4.3.2.6 Relationship to Other Draft Recommendations

This Draft Recommendation relies on the adoption of Draft Recommendation 4 (Establish Legal Relationship with Market Participants Through Compliance Instrument Ownership Interest and Tracking System). It assumes the adoption of Draft Recommendations 1 (Treat Compliance Instruments as Commodities for Market Oversight Purposes); 5 (Do Not Limit Market Participation to Compliance Entities), and 10 (Information Required for Compliance Instrument Transfer).

4.3.2.7 Requirements of Tracking System

The tracking system would be required at least to accept and verify a transaction number from the central limit order book before compliance instruments were transferred between accounts. The tracking system could potentially provide the function of the central limit order book.

4.3.3 Draft Recommendation 9: Require Reporting of Beneficial Ownership

4.3.3.1 Background

When one person holds property (or some other interest) for the benefit of another person, the person holding the property is referred to as the "record" or "legal" owner and the person for whom the property is being held is referred to as the "beneficial," "equitable," or "indirect" owner. For example, where title to land is registered in the name of a trustee who holds the property for the benefit of the owners of the trust, the trustee is the record owner and the beneficiaries of the trust are the beneficial owners. Similarly, when a brokerage firm holds securities (e.g., stock certificates) in their own firm's name (their "street name") for their customers' accounts with the firm, the firm is the legal owner and the customers are the beneficial owners.

4.3.3.2 Options

WCI Partner jurisdictions have several options regarding reporting of beneficial ownership, including, but not limited to the following:

A. Requiring that account holders publicly disclose beneficial ownership;

B. Requiring that account holders report beneficial ownership to regulators on a confidential basis;
C. Require that account holders maintain records of beneficial ownership and produce such records upon written request of regulators; or
D. Not require that account holders maintain records of or disclose information regarding beneficial ownership.

Should the WCI jurisdictions elect to require reporting of beneficial ownership to regulators and/or disclosure to the public, decisions must also be made regarding the timing of such disclosures. For example, disclosure of the beneficial ownership could be required

A. When an account is opened on the registry;
B. Contemporaneously with any transaction transferring ownership
C. On a periodic basis, or
D. With some other fixed or variable requirement regarding the timing of the disclosure.

4.3.3.3 Evaluation of Options

The different options outlined above in 4.3.3.2 have significant implications for the regulators charged with the administration, monitoring and enforcement of the compliance instrument markets and the overall cap and trade program. In addition, the different options have impacts on the level of transparency in the market. Below we discuss the major implications identified to date.

The regulators responsible for prevention of manipulation and speculative activity that leads to price distortion in the compliance instrument markets will benefit from access to information regarding the beneficial ownership of compliance instruments. Absent this information, regulators may not be able to perform their duties, which may include: (a) monitoring the market for manipulative trading schemes such as "wash" sales, which are trades that appear to be between two parties but are really between different accounts controlled by the same person; (b) detecting the accumulation of substantial positions in compliance instruments that could allow the beneficial owner to exercise of market power; (c) enforcing a holdings limit or other rule designed to avoid speculative activity that leads to price distortion; or (d) providing accurate and timely information on the compliance instrument and derivatives market to other regulators (e.g., US federal regulators of derivatives markets).

In addition, the regulators responsible for environmental compliance could also benefit from access to information regarding beneficial ownership. Those regulators may want the ability to track the actual compliance instrument holdings of reporting sources (at least at a business entity level) over time, rather than simply at the end of a three-year compliance period. Such information would allow early detection of sources that have (a) taken insufficient steps to procure the compliance instruments they will need at the end of the compliance period, or (b)

appear to be taking on excessive risk through the accumulation of a large excess of compliance instruments. Such assessments would be difficult, if not impossible, without accurate information as to the beneficial ownership of compliance instruments.

The public disclosure of beneficial ownership has several potential implications we have identified to date. Public disclosure of beneficial ownership would enhance the transparency of the cap and trade program. This may help maintain pubic confidence in the program. Transparency in ownership also would allow local interests to track the market position of local sources. Transparency in ownership would enhance the flow of information in the market, which could lead to improved efficiency. Transparency in ownership also puts more "eyes" on the market, increasing the likelihood that market violations will be detected and reported. Transparency in ownership could also reveal corporate trading strategies; however, such information may already be public for a large number of sources (e.g., because the account holder and owner are one and the same, or because disclosure is required by another regulator such as the SEC or a Utilities Commission).

4.3.3.4 Experience in Existing Environmental Cap-and-Trade Programs

In existing emissions markets in the United States, the EPA and RGGI have set up at least two classifications of accounts on their registries: compliance accounts and general accounts. Each facility with a compliance obligation must have a compliance account registered in its own name. In creating the compliance account, EPA and RGGI regulations require that the facility disclose the names of the legal and equitable owners and operators of all emitting units at the facility, identify those units in detail and assign an individual as the authorized account representative. Since the compliance account is tied to a single facility, it is relatively easy to track beneficial ownership.

Under the EPA's and RGGI's regulations, general accounts may be opened by a facility, a person owning one or more facilities, or a person with no compliance obligation (e.g., brokers, dealers, banks, individuals, non-governmental organizations, etc.). General accounts are opened in the name of the representative and her company or organization, as opposed to the name of a single facility. Registration of a general account requires identification of "all parties with an ownership interest in the allowances held in this account."[29] If the parties to an account change, the form must be amended and resubmitted within 30 days.[30] In this way, the EPA and RGGI appear to capture some beneficial ownership information both up front and on an ongoing basis through the registration process.

---

[29] "Instructions for General Account Form," Environmental Protection Agency Form 7610-5 (Revised 12-2009), http://www.epa.gov/airmarkets/business/docs/forms/gen_acct2010.pdf (Accessed February 22, 2010).
[30] US Code of Federal Regulations, Title 40, section 73.31 (c)(iv).

In addition, all persons or groups participating in a RGGI auction must disclose their beneficial relationships to other persons and groups participating in the auction. Information on beneficial ownership is gathered via a thorough an online application system for participants in the regional auctions and is used, in part, to ensure that participants comply with the 25% purchase limit.

Not currently gathered by RGGI and the EU ETS, however, is each beneficial owner's fractional interest in compliance instruments in an account. This information would be necessary if the WCI Partner jurisdictions were to decide to fully evaluate an entity's holdings (see section 4.3.1).

4.3.3.5 Draft Recommendation

The Markets Committee recommends that account holders be required to report beneficial ownership of all compliance instrument holdings to regulators on a confidential basis, including each owner's share in an account. This means each participant in compliance instrument markets where WCI compliance instruments are sold will be obligated to report any party who sponsors or benefits from an agent's activities.

The Committee further recommends that account holders be required to report changes in the fractional ownership of compliance instruments in an account immediately upon the transaction, even if the transaction does not involve a transfer of allowances between accounts.

When some portion of the ownership information is proprietary, it should be kept confidential.

4.3.3.6 Relationship to Other Draft Recommendations

This Draft Recommendation assumes the adoption of Draft Recommendations 4 (Establish Legal Relationship with Market Participants Through Compliance Instrument Ownership Interest and Tracking System), 5 (Do Not Limit Market Participation to Compliance Entities), 6 (Require Registration of Intermediaries as Market Professionals), and interacts with Draft Recommendations 10 (Information Required for Compliance Instrument Transfer), and 11 (Secondary Market Holdings and Transfer Information Disclosed to Public). Implementing a holdings limit, discussed in Draft Recommendation 7 (Holdings Limits), would require disclosure of beneficial ownership to regulators.

4.3.3.7 Requirements of Tracking System

If disclosure of beneficial ownership is required, the tracking system would need to accommodate multiple owners for accounts, their fractional ownership, and mechanisms to update this information quickly as it changes.

4.3.4 Draft Recommendation 10: Information Required for Compliance Instrument Transfer

4.3.4.1 Background

Assuming the adoption of Draft Recommendation 4 (Establish Legal Relationship with Market Participants Through Compliance Instrument Ownership Interest and Tracking System), the tracking system would hold the record of ownership of compliance instruments. Collection of basic information would be required upon transfer of ownership to make the tracking system a reliable repository and to collect market information that is important for transparency. (Draft Recommendation 11 considers which of this collected information would be disclosed to the public).

4.3.4.2 Options

At a minimum, the tracking system, to be a complete record of ownership, would need to record for each transfer:

A. The account of origin, and name of the authorized person for that account;
B. The receiving account;
C. The serial numbers of the compliance instruments being transferred (and by implication the quantity being transferred); and,
D. The date and time of the transfer.

Any number of additional data could be collected; the Markets Committee has identified the following to be of particular interest:

E. Changes to beneficial ownership;
F. The name of an authorized person for the account that will receive compliance instruments;
G. The compliance instrument price and currency (US or Canadian dollars);
H. Date of the contract, if different from date of transfer (e.g., for derivatives contracts);
I. Other information related to derivatives transactions.

4.3.4.3 Evaluation of Options

A minimum amount of information must be kept by the tracking system in order for it to be a reliable record of ownership. Additional information may assist regulators in oversight of the market, and disclosure to the public would increase market transparency. These benefits can be weighed against the additional burden to participants of reporting more information, and to regulators in collecting and analyzing it.

Draft Recommendation 9 (Require Disclosure of Beneficial Ownership) includes a discussion of beneficial ownership. Draft Recommendation 8 (Require Use of a Centralized Order-Matching

System for Transactions) includes a discussion of a centralized quotation service. Draft Recommendation 11 (Secondary Market Holdings and Transfer Information Disclosed to Public) includes a discussion of public disclosure of both account holder information and secondary market information.

In general, it is only a small amount of additional reporting burden to request the name of the authorized person for the receiving account. In the case of exchange trading where transactions are netted and anonymous, the jurisdictions may choose to require a net report of accounts from which or to which allowances were transferred. The compliance instrument price for the transaction could be challenging if, for example, compliance instruments were bundled with another product (electricity or natural gas) with a single price. However, the Partner jurisdictions could insist on a price report.

The price and date of contract could also be challenging for some derivatives. For example, an exchange-traded futures contract is settled at an agreed-on date, with the product transferred for a settlement price that is likely to be different than the price at which the contract was purchased. The gain or loss is computed at some interval, say, daily, and added to or subtracted from the margin accounts of market participants. The "date of contract" and price would then have to be carefully defined in order to avoid confusion.

4.3.4.4 Experience in Existing Environmental Cap-and-Trade Programs

The Acid Rain Program does not require price information or any information about the date of a contract to deliver compliance instruments. RGGI requires price information for any transfer between non-affiliated entities, as well as date of contract; the date of contract is defined to be the settlement date.

4.3.4.5 Draft Recommendation

The Markets Committee recommends requiring identification of: the name of the authorized person for the account of origin; the number of the account of origin; the name of the authorized person for the account that receives compliance instruments; the account receiving compliance instruments; the serial numbers of the compliance instruments being transferred, and the compliance instrument price. It further recommends requiring a net report from an exchange or any organization that nets transactions. It recommends that the tracking system supply the time and date stamp. If the Partner jurisdictions require collection of derivative positions (Section 4.1.2) it would be duplicative to require information on date of contract.

4.3.4.6 Relationship to Other Draft Recommendations

This Draft Recommendation assumes the adoption of Draft Recommendations 4 (Establish Legal Relationship with Market Participants Through Compliance Instrument Ownership Interest and Tracking System), 5 (Do Not Limit Market Participation to Compliance Entities), 8 (Require Use

of a Centralized Order-Matching System for Transactions), 9 (Require Disclosure of Beneficial Ownership), and 11 (Secondary Market Holdings and Transfer Information Disclosed to Public).

4.3.4.7 Requirements of Tracking System

This Draft Recommendation would require the tracking system to allow and require that the fields for all the above named data, as well as net reports, and supply a time and date stamp with the submission of information.

4.3.5 Draft Recommendation 11: Secondary Market Holdings and Transfer Information Disclosed to Public

4.3.5.1 Background

As stated in the Market Oversight white paper released in November 2009, the central purpose of a market mechanism is to aggregate and transmit price information. With full, true and plain disclosure, both regular and timely, market participants can use the information to determine a fair market price. In the secondary market, it is important for participants to have reliable, good quality and timely information about outstanding bids and offers, and recent trades, so they can discover the right price and act accordingly.

The WCI Markets Committee has proposed the principle of "Transparency and the Reporting and Disclosure of Relevant Information," to acknowledge that the release of information on the operation of the compliance instrument market builds and retains public confidence, and can change the decisions of market participants.

> "A transparent marketplace could provide carbon market participants, regulators, and potentially the general public with information to determine where carbon instruments are trading, the entities involved in the transactions, the trading volume, and the prices at which they are trading. This, in turn, could allow government officials and market watchdogs to quickly determine the cause(s) of unusual price volatility. In addition, information about prices, volume, and bid/ask spreads could also help market participants make informed investment decisions, thereby reducing some of the causes of price volatility in the first place."[31]

---

[31] Source: "U.S. Carbon Market Design: Regulating Emission Allowances as Financial Instruments", Jonas Monast, Jon Anda, Tim Profeta, Duke University, February 2009, CCPP 09-01, working paper, Climate Change Policy Partnership http://www.nicholas.duke.edu/ccpp/ccpp_pdfs/carbon_market_primer.pdf (Accessed March 30, 2010).

As noted in section 4.3.3.4, RGGI and the Acid Rain Program have created two types of accounts: general accounts, which any person may have and can be used for trading; and compliance accounts, which are established for entities that must surrender compliance instruments matching their emissions to satisfy a regulatory obligation. The Partners are developing requirements for a tracking system; the Markets Committee considered the possibility of two types of accounts in developing this Draft Recommendation.

4.3.5.2 Options

Account Information Disclosure

The Markets Committee has considered the following options for public disclosure of account holder information:

A. Account representative for compliance and trading accounts;
B. Owner/operator associated with compliance accounts;
C. Beneficial owners of compliance units held within account;
D. State/province in which account representative is located.

Secondary Market Information Disclosure

The Markets Committee has considered the following options in for public disclosure of compliance instrument transfers:

A. Trade volume, quantity and settlement prices of compliance units traded;
B. Names of counterparties to each transaction;
C. Names of beneficial owners;
D. Compliance account holdings;
E. Trading account holdings.

The Markets Committee has considered the following options for means of disclosure of secondary market information:

A. Directly through the online tracking system, and through search functions;
B. Through exchanges where transactions occur; and/or,
C. Through periodic WCI market reports published on the WCI website.

The Markets Committee has considered the following options for the frequency and timing of the secondary market information disclosure:

A. In real time for volumes and prices;
B. Daily for volumes and prices; and/or,
C. Quarterly or post-regional auctions for summaries.

4.3.5.3 Evaluation of Options

The WCI Markets Committee recognizes that a balance must be struck between the benefits of transparency and the need for entities to protect certain sensitive information, consistent with applicable law relating to the disclosure of information. Some information may reveal

competitive positions that would do more to assist market manipulation than prevent it. Thus, certain information collected through the tracking system or other aspects of the WCI cap and trade system should not be disclosed publicly in its original reported form. In some cases information can be aggregated in order to maintain the anonymity of the actors while still relaying important market information.

The WCI Partner jurisdictions will have access to the raw information reported to the tracking system, as it is required for regulatory authorities to conduct effective oversight and monitor compliance. In its Final Recommendations, the Markets Committee may recommend restrictions on staff of those regulatory authorities who have access to confidential market information collected through the tracking system from operating in the market, to prohibit insider trading based on undisclosed material information and tipping.

The key characteristics that the WCI Markets Committee seeks in terms of disclosed information are that it is:

- Full;
- Straightforward;
- Good quality;
- Reliable;
- Regular; and,
- Timely.

The holdings in a compliance account are useful to reveal to support compliance, as an indication of whether a regulated entity is on track to retiring as many compliance instruments as are required to cover its covered emissions for a compliance period. However, holdings in trading account are not required for the same purpose, and may reveal sensitive information. The total number of compliance instruments within the cap and trade will be publicly established by the Partner jurisdictions as they create their allowance budgets.

The increased transparency resulting from a high frequency of market information disclosure must be balanced against the administrative cost to market participants and regulatory authorities to report, collect and process that information within the given timeframe.

4.3.5.4 Experience in Existing Environmental Cap-and-Trade Programs

Existing environmental cap and trade programs handle public disclosure in the following ways:

DISCLOSURE	EU ETS: Community Independent Transaction Log	RGGI: RGGI COATS[32]
Delivery	Information on all transactions (transfer, issuance, etc. of allowances) recorded by the Community Independent Transaction Log, including originating and destination account number, holder and type. This information will be made available online and at EU level but not until five years after the year in which the transaction took place. Price is not recorded in ETS registries or in the CITL.	RGGI CO_2 Allowance Tracking System (COATS) allows public to view, customize and download reports of allowance market activity
Account information	Varies by country. In the UK, reports listing operator holding accounts and person holding accounts are published on UK registry website. Reports are updated regularly.	Account number, account name, facility owner/operator (for compliance accounts), parties with an ownership interest in the allowances in the account (for general accounts), account type, authorized account representative, and state are all public.
Transaction information	Counterparties not disclosed.	Transaction type, financial transaction date, RGGI COATS allowance transfer recordation date, price and number of allowances for each transaction, and weighted average price of all transactions during the range of dates specified by the query are public. Counterparties not disclosed.
Trading/active account holdings	Number of instruments in each account is not disclosed.	Number of instruments in each account is not disclosed.
Compliance/ retirement account holdings	Not applicable.	Number of instruments in each account is not disclosed.
Derivatives positions	Not disclosed.	Not disclosed.
Market reports	Exchanges and news services produce daily and real-time market reports.	Exchanges and news services produce market reports; the third-party market monitor prepares a public report on each auction.

4.3.5.5 Draft Recommendation

The WCI Markets Committee recommends the following:

Tracking system account information publicly disclosed on an ongoing basis:

---

[32] RGGI > CO2 Allowance Tracking System > Data in RGGI COATS > Public Reports (http://www.rggi.org/tracking/data/public_reporting)

A. Account representative for compliance and trading accounts;
B. Owner/operator associated with compliance accounts;
C. Names of beneficial owners of compliance units held within account;
D. State or province in which account representative is located.

Market information publicly disclosed daily through the tracking system:

E. Compliance account holdings.

Market information not publicly disclosed:

F. Names of counterparties and beneficial owners to each transaction;
G. Fraction of each beneficial owner's interest in an account;
H. Trading account holdings.

4.3.5.6 Relationship to Other Draft Recommendations

Assuming the adoption of Draft Recommendation 8 (Require Use of a Central Limit Order Book for Secondary Market Transactions), price information will be publicly disclosed through that mechanism, and need not be duplicated through the tracking system. This Draft Recommendation also relies on the implementation of Draft Recommendations 9 (Require Disclosure of Beneficial Ownership) and 10 (Information Required for Compliance Instrument Transfer). Draft Recommendation 2 (Information on Derivatives Positions) includes a related discussion on disclosure of derivatives position information.

4.3.5.7 Requirements of Tracking System

This Draft Recommendation implies that the tracking system must:

- Be online;
- Have some services of the tracking system accessible to the public;
- Have some services of the tracking system restricted to account holders, to authorized staff of regulatory authorities, or to system maintenance service providers;
- Have filters such that, for example: compliance account holdings are shown but general trading account holders are not;
- Have the ability to generate customized reports for regulatory authorities.

4.4 Market Monitoring

4.4.1 Draft Recommendation 12: Market Monitoring

The Markets Committee believes that a third-party contractor may improve oversight by complementing and supplementing the monitoring of the Partner jurisdictions. For its Final Recommendations, the Committee will evaluate options more fully and may describe the recommended role of a contractor.

5 Roles of Provincial, State, and Federal Regulatory Agencies

The Markets Committee is analyzing market oversight jurisdiction at the US federal and state and Canadian federal and provincial levels, for both secondary and derivatives markets. Specifically, the committee is examining whether WCI jurisdictions currently have the authority to implement the recommendations made for oversight of the secondary market, and what agencies have this authority. In its Final Recommendations, the Committee intends to include a discussion of jurisdiction for the oversight authorities recommended, as well as coordination between the relevant regulatory bodies.

6 Conclusion

The Markets Committee believes that these Draft Recommendations, collectively, are in accord with the principles adopted for market oversight, and that they provide good risk management in balancing the potential for market manipulation against the potential to stifle legitimate market activity. It has also identified some areas where additional work is required to make a recommendation. The Committee welcomes comment on the Draft Recommendations individually and collectively, and in particular on:

A. Whether the tools available to WCI Partner jurisdictions for market oversight have been completely and correctly identified;
B. Whether the Draft Recommendations would correctly maximize the environmental and economic benefit to the public and support WCI's Principles of Market Oversight;
C. Whether the Committee should recommend collection of derivatives position information from market participants, including on over-the-counter derivatives; and if so, what of that information to disclose to the public;
D. The Draft Recommendation to require secondary market trades to use a central limit order book.

Incorporating stakeholder comment on the Draft Recommendations among other sources of information, the Committee plans to release Final Recommendations before June 30, 2010.