EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20502

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February 4, 1997

To: Assistant Secretaries Group

From: Rosina Bierbaum

RE: Revised paper on Emissions / Concentrations / Stabilization

Here is a slightly revised version of "The Longer-term View: The Relationship of Emissions to Atmospheric concentrations". All of the correct graphics are in this version and I tried to make the text a bit clearer.

Please e-mail any comments to me at RBIERBAU@OSTP.EOP.GOV or fax them to me at 202-456-6025.

Number of pages (including cover): 11

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THE LONGER-TERM VIEW: THE RELATIONSHIP OF EMISSIONS TO ATMOSPHERIC CONCENTRATIONS

Most discussions have focused on what steps might be taken in the medium term (2010-2020) to reduce emissions of greenhouse gases. Such actions represent only an initial step and, by themselves, would fall far short of significantly reducing the risks of climate change. Much more long-term planning will be necessary to achieve the goal of the Framework Convention on Climate Change:

> *"stabilization of greenhouse gas concentrations . . . at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should . . . allow ecosystems to adapt naturally to climate change; ensure that food production is not threatened; and enable economic development to proceed in a sustainable matter."*

This paper describes emissions paths that would be necessary to achieve various longer-term goals of stabilizing atmospheric concentrations of greenhouse gases. It also explores the implications that a longer term goal has for shaping near-term policy decisions.

Several aspects of the climate change issue underscore its long term nature, but also suggest a need for beginning action now:

- -- Once emitted, carbon dioxide will remain in the atmosphere for 150-200 years.
- -- Lags in the climate system result in temperatures increasing for several decades and sea level rising for centuries after greenhouse emissions have ceased to increase.
- -- Uncertainties in scientific understanding of climate change and its relationship to long-term costs and benefits make selecting any specific ultimate concentration goal somewhat speculative at this time.
- -- It has taken decades for the infrastructure of fossil-fuel based technologies to develop. A transition to alternative sources of energy will also require many decades, but will only begin in earnest if research and development is begun now and if proper incentives are provided.

I. GLOBAL EMISSIONS AND ATMOSPHERIC CONCENTRATIONS

In the absence of any actions specifically to limit carbon dioxide emissions, the Intergovernmental Panel on Climate Change (IPCC), as shown in Figure 1, estimated that current emissions (as shown by the 2 upper lines) of 6 billion tons of carbon per year could grow to between 15-25 billion tons of carbon by 2050 and continue to increase through the end of the

next century.

Global CO_2 Emissions & Concentrations

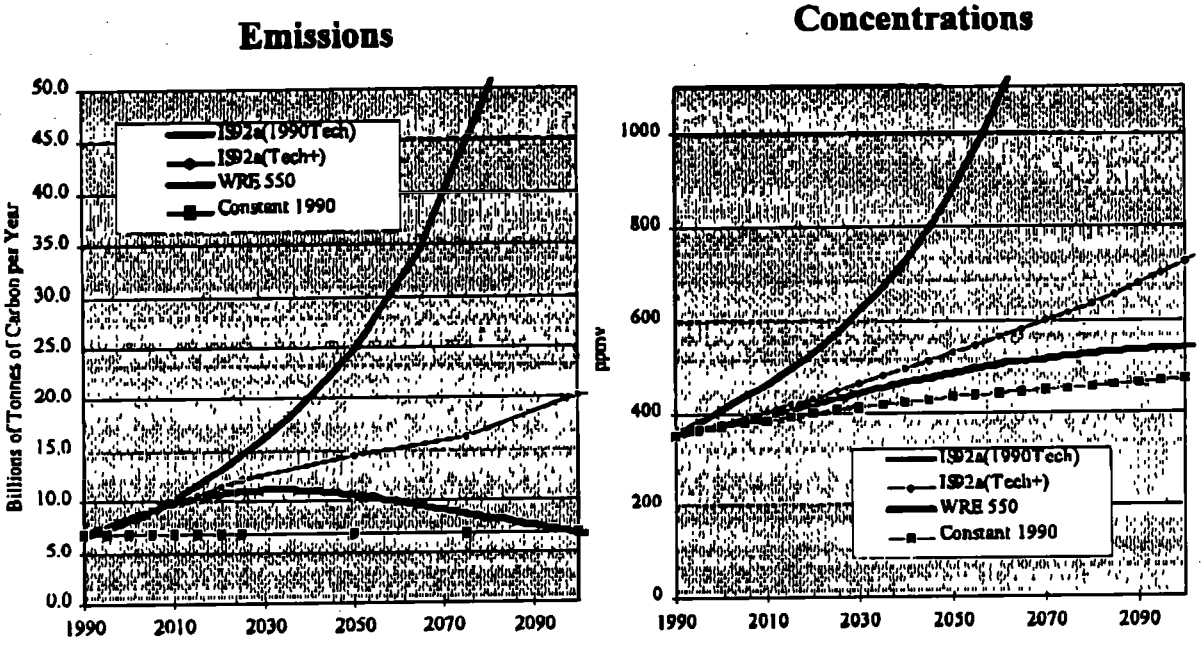


Figure 1

Figure 2

Figure 2 shows the impact of these emissions scenarios on atmospheric concentrations. For context, preindustrial levels of carbon dioxide were about 280 ppm, and have increased to today's levels of about 360 ppm. Two scenarios with unrestrained projected growth are shown in figures 1 and 2. The "1990 tech" scenario assumes technology remains constant at 1990 levels in the future. The "tech+" scenario assumes technology improves substantially and results in lower costs for alternative fuels and enhanced energy efficiency. (The latter scenario represents the "central case" developed by the IPCC and is sometimes referred to as "IS92a".) In both of these scenarios, emissions grow substantially over time and concentrations far exceed a doubling of preindustrial levels prior to the end of the next century.

If it were possible to cap global emissions in both developed and developing countries at 1990 levels, figure 2 (line labeled "constant 1990") shows that concentrations would nonetheless continue to rise throughout the next century and beyond, eventually exceeding a doubling of preindustrial levels.

Figure 3 shows the projected long-term atmospheric concentrations if emissions were stabilized at different levels. The figure shows that if emissions were stabilized at current levels (6 Pg C/yr), atmospheric concentrations would grow to almost 500 ppm by 2100, but continue increasing thereafter. It also shows that if emissions are stabilized at 10 PgC/yr, roughly 33 percent higher than today's level, then atmospheric concentrations would increase to more than a doubling from pre-industrial levels by 2100, while also continuing to increase thereafter.

CO2 Concentrations Associated with IS92a(Tech+) and Alternative Energy Related Emissions Stabilization Levels

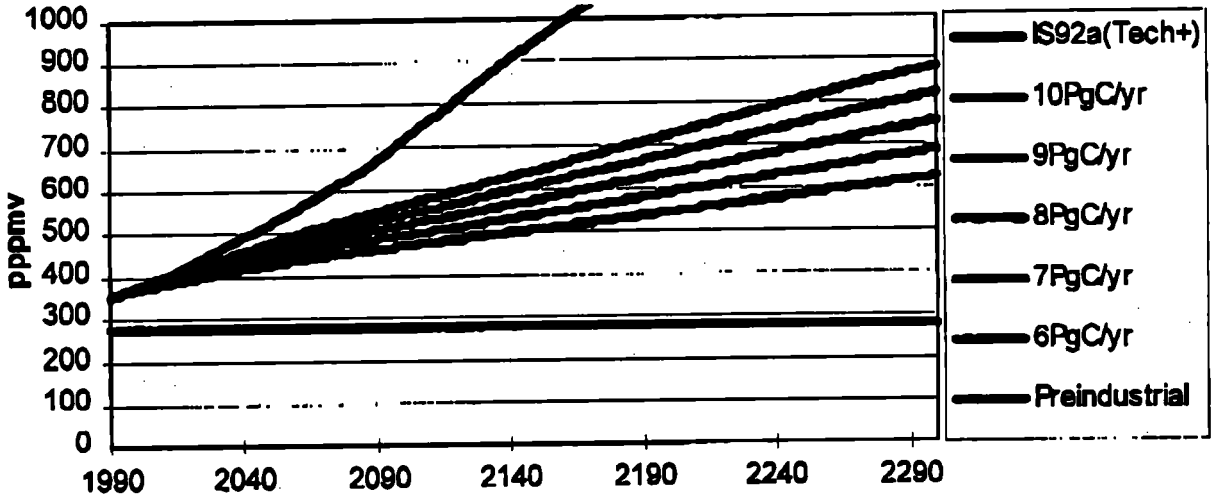


Figure 3

Table 1 shows how various concentration targets relate to emissions pathways. For example, to meet a 550 ppmv concentration goal, global emissions must begin to deflect from the business-as-usual curve by 2013. In this scenario, emissions would peak at 9.7 PgC/yr in 2033 and drop rapidly thereafter.

The Relationship Between CO_2 Concentration Ceilings, Maximum Emissions, and the Subsequent Rate of Emissions Decline: WRE Cases

Deflection Date IS92a (Tech+) [a]	2001	2007	2013	2018	2023
Growth Rate to Maximum Date [b]	0.3%	0.3%	0.5%	0.5%	0.4%
IS92a (Tech+) Growth Rate [c]	1.8%	1.4%	1%	0.9%	0.7%
Maximum Date	2005	2011	2033	2049	2062
Maximum Emission [d]	6.0	8.0	9.7	11.4	12.5
Rate of Decline [e]	n.a.	1.1%	0.8%	0.6%	0.5%

[a] The deflection date is the year in which emissions in the emissions stabilization trajectory first fall below IS92a emissions by more than 0.1 PgC/yr.

[b] Average annual rate of growth (%/yr) of WRE fossil fuel carbon emissions between the "Deflection Date" and the "Maximum Date."

[c] The rate of growth (%/yr) of fossil fuel carbon emissions between the "Deflection Date" and the "Maximum Date."

[d] PgC/yr fossil fuel carbon emissions on the date of maximum total anthropogenic carbon emissions.

[e] Rate of decline in fossil fuel carbon emissions, in percent per year, over the first 75 years following the date of maximum emissions. Note 350 ppmv not defined as it requires a negative net emission.

Table 1

II. DEVELOPED AND DEVELOPING COUNTRY EMISSION TRENDS

Figure 4 presents current and projected emissions of carbon dioxide for developed and developing countries. Of the current emissions of roughly 6 billion tons, approximately two-thirds are from developed and one-third from developing countries. The U.S. is currently the largest emitter of carbon dioxide, with China the second largest source. However, on a per capita basis, the U.S. emits about 5 tons of carbon per capita, compared to an average of approximately 4 tons per capita in Japan and Western Europe, and 0.4 tons per capita for developing countries. While per capita differences remain large over time, by the middle of the next century, developing countries would become a source for more than half of total global emissions.

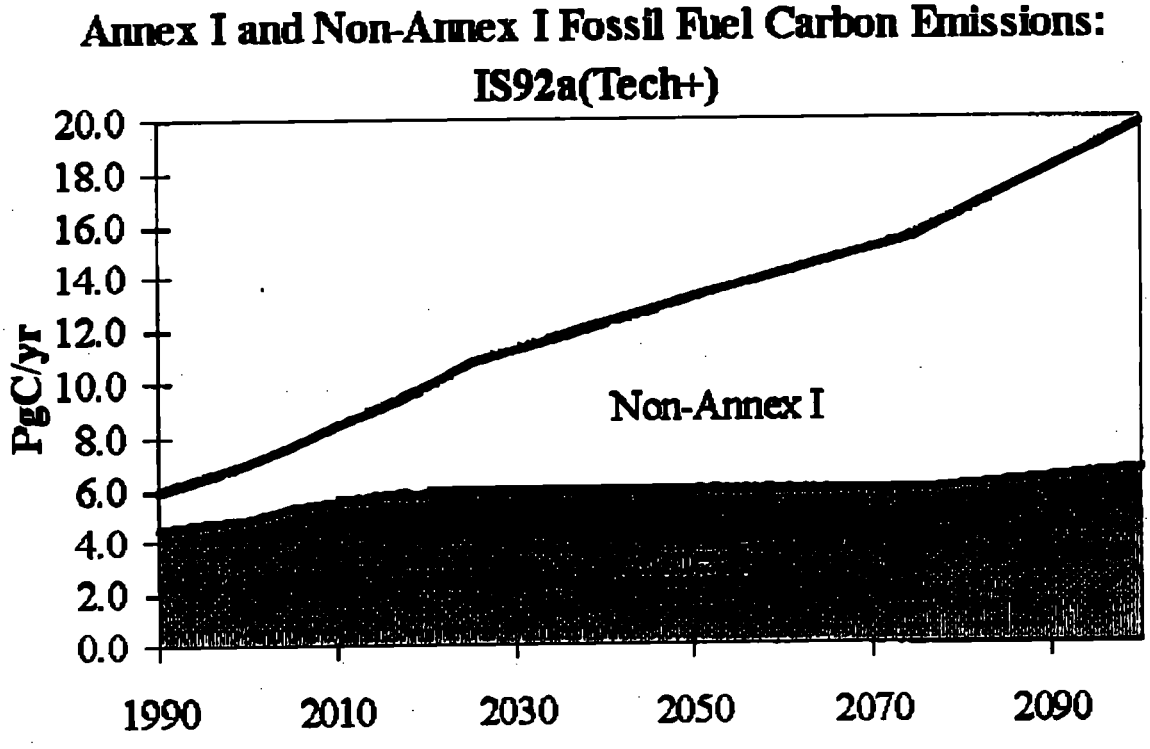


Figure 4

III. ILLUSTRATIVE EMISSION REDUCTION SCENARIOS

Limited mid-term actions to reduce emissions by developed countries alone have little impact on

shifting the atmospheric concentrations curve. Figure 5 shows the small change in concentrations if Annex I (developed countries) freeze emissions at 1990 levels in the year 2010.

Stabilizing US Emissions Reduces 2100 CO_2 Concentrations 12 ppmv & Stabilizing Annex I Emissions Reduces CO_2 45 ppmv

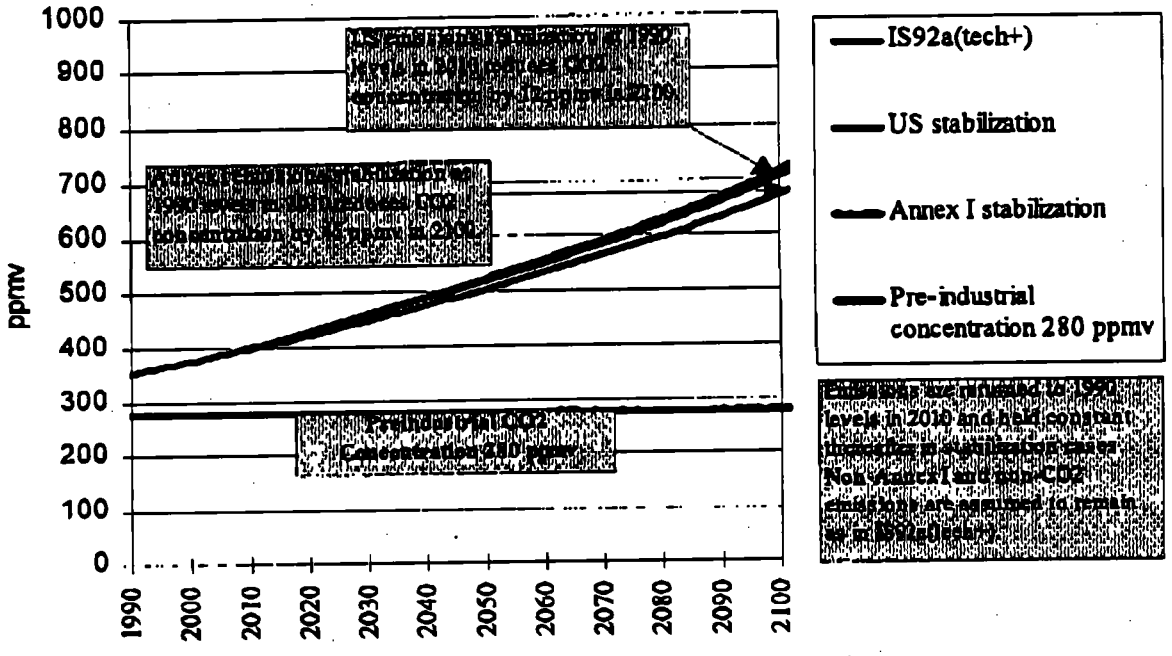
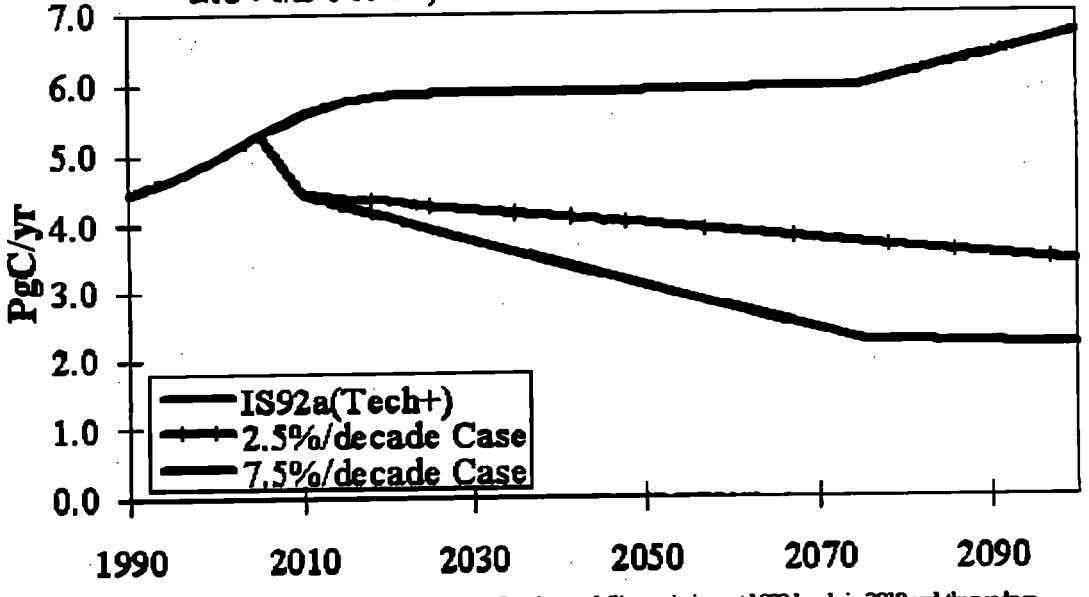


Figure 5

Annex I Fossil Fuel Carbon Emissions: IS92a(Tech+), and 2.5%/Decade, & 7.5%/Decade Reductions



2.5%/Decade Case assumes that Annex I nations stabilize emissions at 1990 levels in 2010 and then reduce emissions at 2.5%/decade through the year 2100.

7.5%/Decade Case assumes that Annex I nations stabilize emissions at 1990 levels in 2010 and then reduce emissions at 7.5%/decade until they are 50% of 1990 levels after which time they are held constant.

Figure 6

Figure 6 illustrates two possible emissions profiles for developed (Annex I) countries. Both scenarios assume a freeze in emissions at 1990 levels in 2010. On the hatched line, emissions are then reduced by 2.5% per decade and in the lower line they are reduced at 7.5% per decade. The highest line is the business-as-usual (TECH+) scenario from the IPCC. (To put these reductions in perspective, the U.S. has achieved annual efficiency improvements of 2.5 percent per year during the energy crises.)

Figures 7 and 8 are based on each of the Annex I pathways described in Figure 6. They show the pathway developing countries would need to follow to stabilize concentrations at 450 ppm, 550 ppm and 650 ppm. These figures show that to achieve stabilization at 550, developing countries would be able to emit on their currently projected path until about 2020 before significant reductions would be required. Figure 8 illustrates a similar case but assumes that developed countries freeze at 2010 at 1990 emissions but then reduce at 7.5% per decade.

Figures 9 and 10 show the per capita emissions for both developed and developing countries that result from the scenarios described in the previous two figures. They show that under these scenarios, developed country emissions stay substantially greater than those in developing countries (which rise to 1 TC/person only in the 650 ppm case).

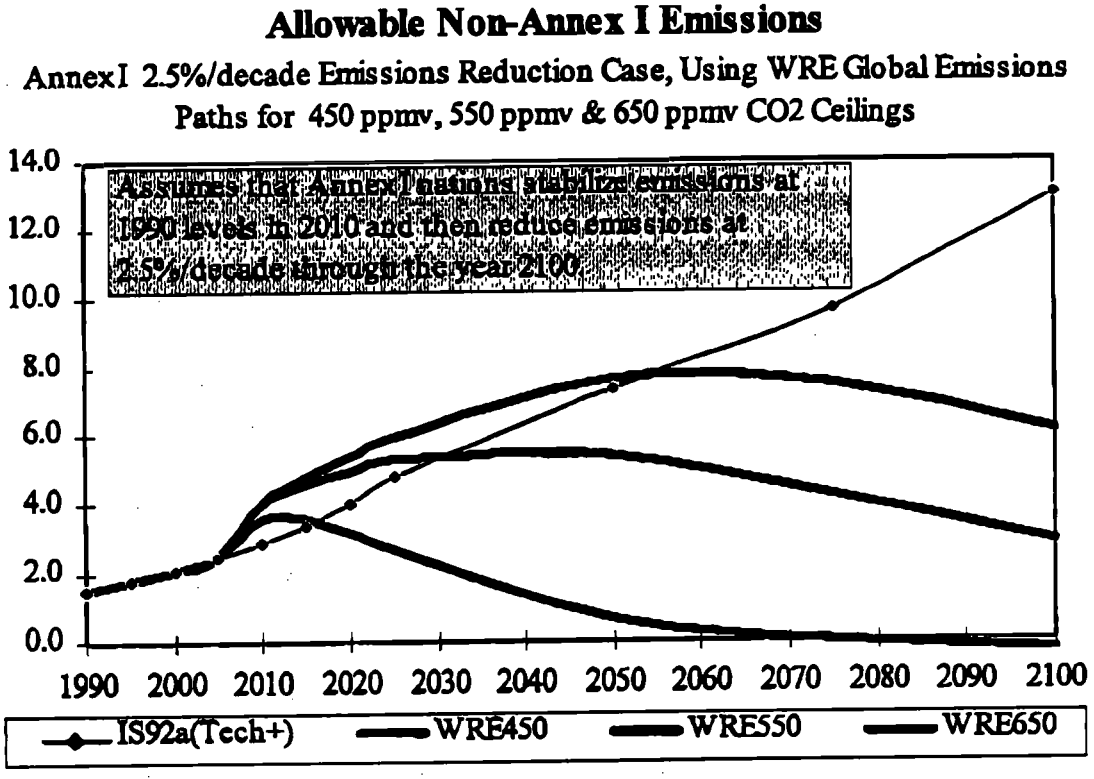


Figure 7

Allowable Non-Annex I Emissions

AnnexI 7.5%/decade Emissions Reduction Case, Using WRE Global Emissions Paths for 450 ppmv, 550 ppmv & 650 ppmv CO2 Ceilings

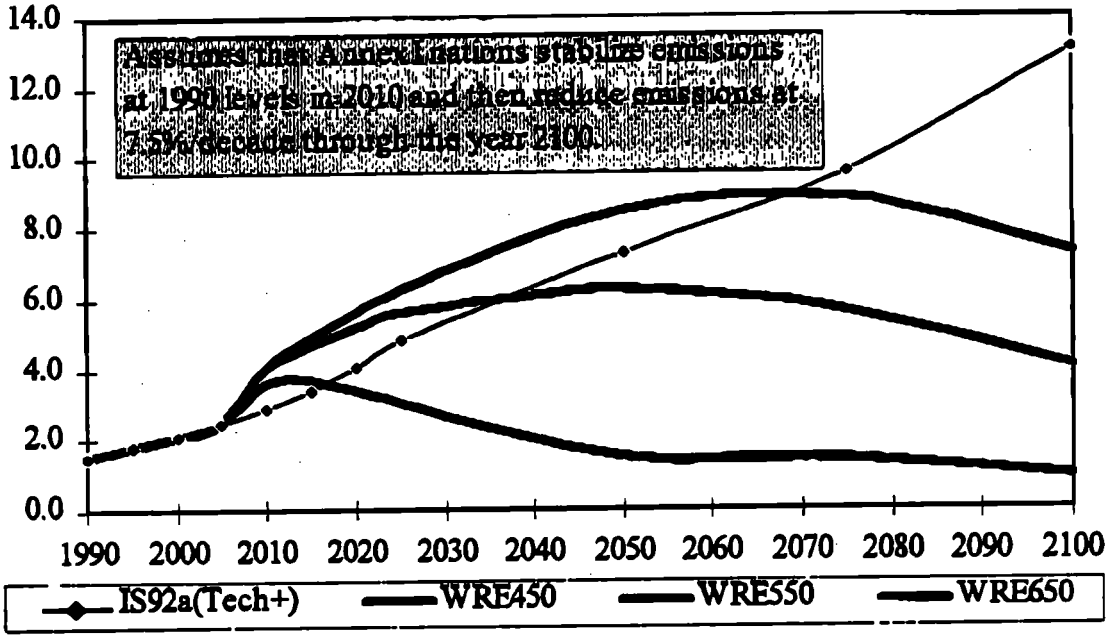


Figure 8

Per Capita Emissions
Various CO2 Concentration Ceilings--Annex I 2.5%/Decade Emissions Reductions

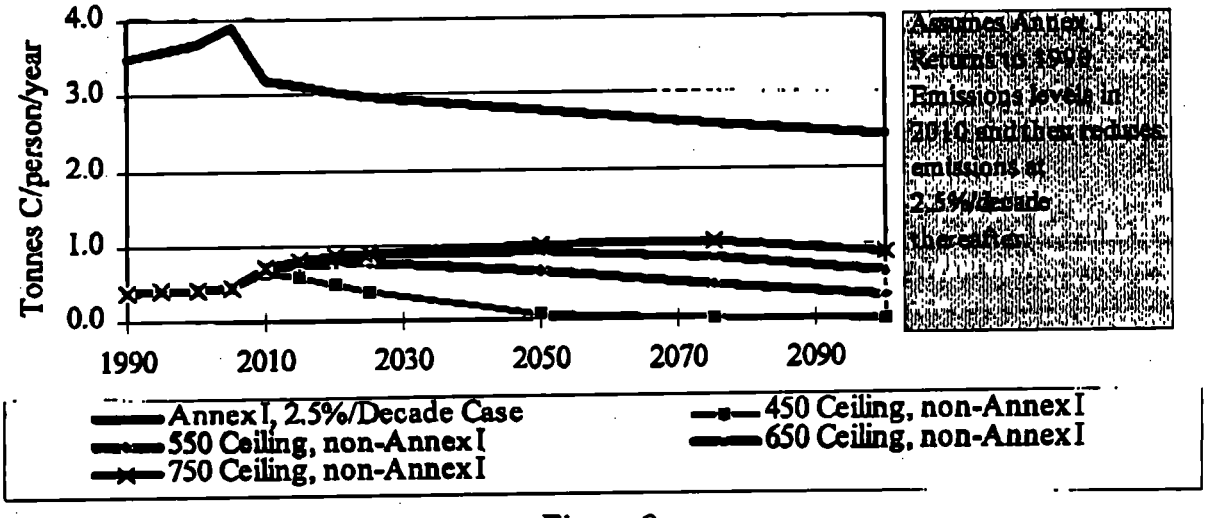


Figure 9

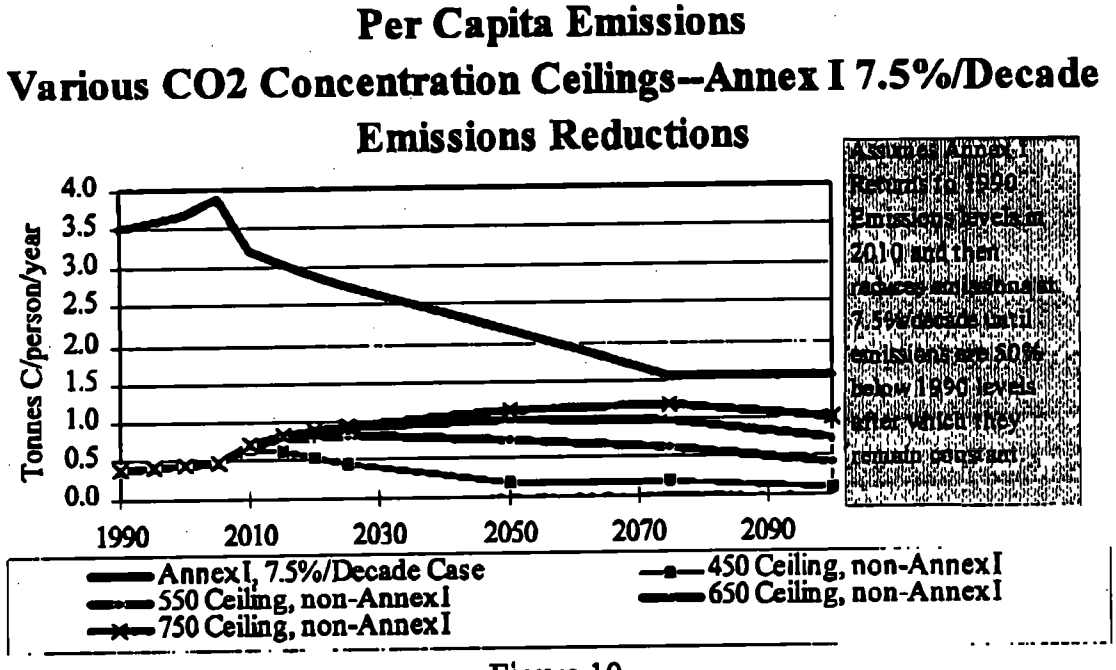


Figure 10

IV. THE ROLE OF TECHNOLOGY AND IMPACTS ON COSTS

As suggested in Figure 1, the rate of technological change can play a very important role in determining the level at which atmospheric concentrations can be stabilized. Figure 11 looks specifically at the costs associated with different technology cases. It looks at three specific cases:

-- 1990 tech: assumes no technological change from 1990

-- 1990 tech +: assumes significant improvements in reducing the costs of alternative fuels and in improving efficiency;

-- Advanced tech: assumes even further advances and cost savings.

A description of key assumptions for the latter two cases is included as Appendix 1.

Figure 11 shows for each of these technology cases, the total costs associated with achieving three different levels of atmospheric concentrations: 550, 650 and 750 ppm. The estimated costs under the assumption that no technological progress is possible were found to be about $12 trillion or 1.2% of total world GDP, compared to $1 trillion or 0.12% of GDP assuming substantial progress in reduction technologies. In the advanced technology case, which assumes very substantial non-fossil alternatives will be available by 2020, the cost virtually disappear. However, the assumed cost and performance of the alternative technologies would only become achievable with significant increases in research and development investments.

The Relationship Between Technology and Minimum Cost of Stabilizing the Atmosphere Below Various Ceilings

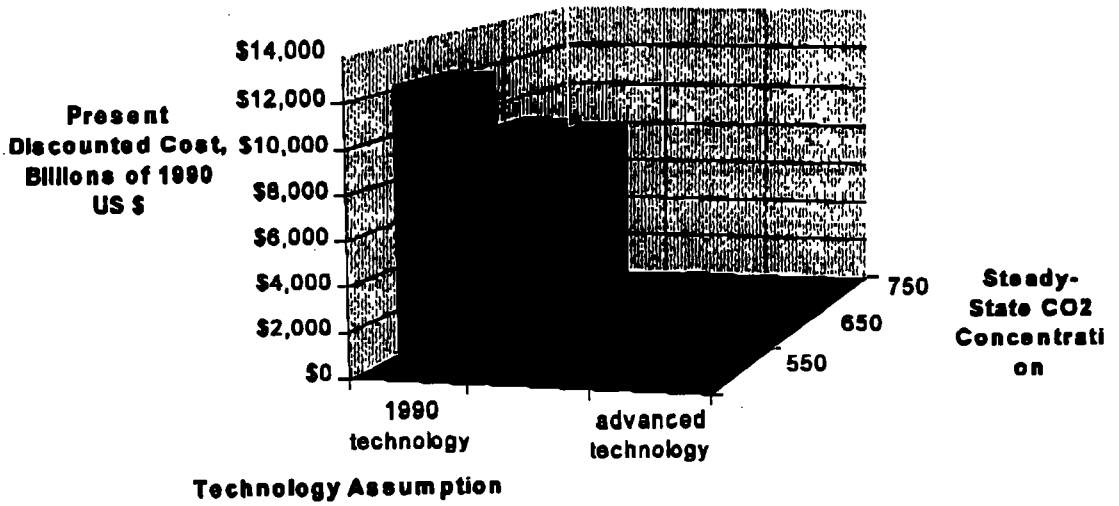


Figure 11

Substantial technological progress aimed at reducing the costs of emission reductions is critical for several reasons. It would result in lower costs to the U.S. economy, both in terms of reductions made domestically and in the costs of a reductions obtained abroad through any emissions trading regime. Reducing the costs of alternatives is also critical to limiting future emissions from developing countries, particularly those with large fossil fuel reserves. Finally, expanding the technological frontier offers U.S. industry significant potential opportunities for expanding our industrial base both at home and abroad.

APPENDIX

Key Assumptions about Technology Scenarios:

IS92a (Tech+)

- •End-use (AEEI) Improves at 1%/yr.
- •Conventional Fossil Fuel Power Generation Improves at 1%/yr.
- •Non-Fossil Power Sources Improves at 4.5%/yr, 1990 to 2025, 1.25%/yr thereafter.
- •Biomass Energy Improves at 1%/yr.

Advanced Energy Technology

- •Advanced solar/wind/fusion
  - - The cost of solar/wind power reaches a busbar cost of $0.04/kWh by 2020 and
  - - the cost decreases at 0.5 %/year thereafter.
- •Low cost biomass
  - - By the year 2020, 20% of the biomass resource is available at $1.40/GJ and
  - - 80% is available at $2.40
- • Advanced liquefied hydrogen fuel cells for transport

THE LONGER-TERM VIEW: THE RELATIONSHIP OF EMISSIONS TO ATMOSPHERIC CONCENTRATIONS

While most discussions have focused on what steps might be taken in the medium term to reduce emissions of greenhouse gases, it is generally recognized that any such actions represent only an initial step and, by themselves, would fall far short of significantly reducing the risks of climate change. This paper presents information related to emissions paths that would be necessary to achieve various longer-term goals of stabilizing atmospheric concentrations of greenhouse gases. It also explores the implications that a longer term goal has for shaping near term policy decisions.

Several aspects of the climate change issue underscore its long term nature, but also suggest a need for beginning action now:

-- Once emitted, carbon dioxide will remain in the atmosphere for a 150-200 years.
-- Lags in the climate system result in temperatures increasing for several decades and sea level rising for centuries after greenhouse emissions have ceased to increase.
-- Uncertainties in scientific understanding of climate change and its relationship to long-term costs and benefits make selecting any specific ultimate concentrations goal somewhat speculative at this time.
-- The infrastructure for fossil-fuel based technologies developed over many decades. A transition to alternative sources of energy will also require many decades, but will only begin in earnest if research and development is begun now and if proper incentives are provided.

I. GLOBAL EMISSIONS AND ATMOSPHERIC CONCENTRATIONS

In the absence of any actions specifically to limit carbon dioxide emissions, the Intergovernmental Panel on Climate Change (IPCC), as shown in Figure 1, estimated that current emissions of 6 billion tons of carbon per year will grow to between 15-25 billion tons of carbon by 2050 and continue to increase through the end of the next century.

Global CO_2 Emissions & Concentrations

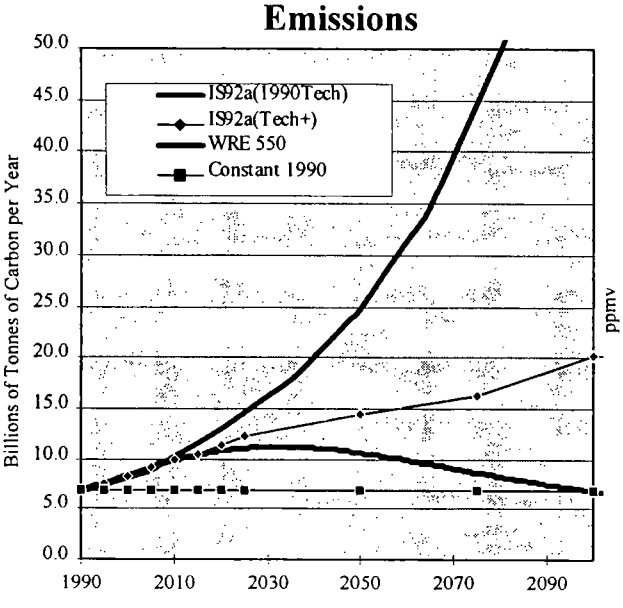


figure 1

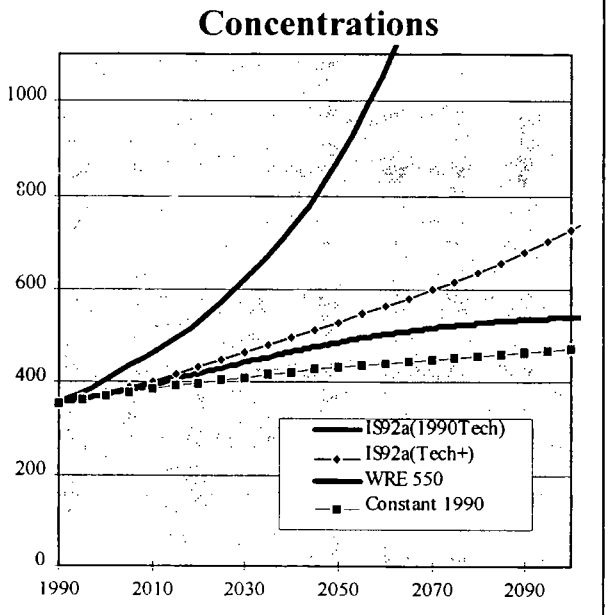


figure 2

(we will delete the WRE line)

Figure 2 shows the impact of these emissions scenarios on atmospheric concentrations. For context, preindustrial levels of carbon dioxide were about 280 ppm, and have increased to today's levels of about 360 ppm. Two scenarios with unrestrained projected growth are shown in figures 1 and 2. The "1990 tech" scenario assumes technology remains constant at 1990 levels in the future. The "tech+" scenario assumes technology improves substantially and results in lower costs for alternative fuels and enhanced energy efficiency. (The latter scenario represents the "central case" developed by the IPCC and is sometimes referred to as IS92a.) Under both of these scenarios, emissions grow substantially over time and concentrations far exceed a doubling of preindustrial levels prior to the end of the next century.

If it were possible to cap global emissions (both developed and developing countries) at 1990 levels, figure 2 shows that concentrations would nonetheless continue to rise throughout the next century and beyond, eventually exceeding a doubling of preindustrial levels.

Figure 3 shows the projected long-term atmospheric concentrations if emissions were stabilized at different levels. The figure shows that if emissions were stabilized at current levels, atmospheric concentrations would grow to almost 500 ppm by 2100, but continue increasing thereafter. It also shows that if emissions are stabilized at 10 PgC/yr, roughly 33 percent higher that today's level, then atmospheric concentrations would increase to more than a doubling from pre-industrial levels by 2100, while also continuing to increase thereafter.

ATMOSPHERIC STABILIZATION EMISSIONS PATHS

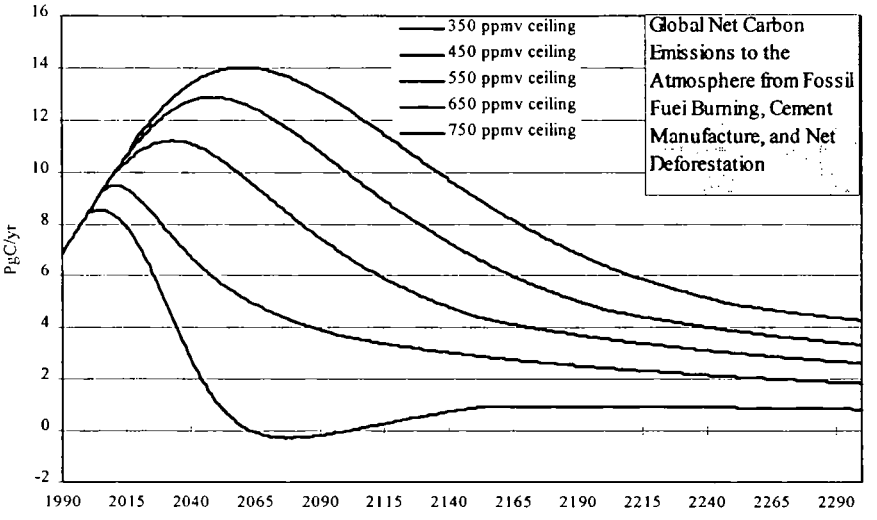


Figure 3

Key Dates & Rates

The Relationship Between CO_2 Concentration Ceilings, Maximum Emissions, and the Subsequent Rate of Emissions Decline: WRE Cases

Steady-State Concentration →	350 ppmv	450 ppmv	550 ppmv	650 ppmv
Deflection Date IS92a (Tech+) [a]	2001	2007	2013	2018
Deflection Date IS92a (1990Tech) [a]	2001	2006	2007	2007
Growth Rate to Maximum Date [b]	0.3%	0.3%	0.5%	0.5%
IS92a (Tech+) Growth Rate [c]	1.8%	1.4%	1.1%	0.9%
IS92a (1990Tech) Growth Rate [c]	1.6%	3.3%	2.8%	2.6%
Maximum Date	2005	2011	2033	2049
Maximum Emission [d]	6.0	8.0	9.7	11.4
Rate of Decline [e]	n.a.[e]	1.1%	0.8%	0.6%

[a] The deflection date is the year in which emissions in the emissions stabilization trajectory first fall below IS92a emissions by more PgC/yr.

[b] Average annual rate of growth (%/yr) of WRE fossil fuel carbon emissions between the "Deflection Date" and the "Maximum Dat

[c] The rate of growth (%/yr) of fossil fuel carbon emissions between the "Deflection Date" and the "Maximum Date."

[d] PgC/yr fossil fuel carbon emissions on the date of maximum totalanthropogenic carbon emissions.

[e] Rate of decline in fossil fuel carbon emissions, in percent per year, over the first 75 years following the date of maximum emissio 350 ppmv not defined as it requires a negative net emission.

Table 1

Table 1 also shows the relationship between various emission pathways and their impacts on various levels of atmospheric concentrations. For example, it illustrates that assuming the "Tech+" emission scenario, that global emissions must begin to deflect downward in the year 2013 to meet the 550 ppm concentration goal. It also shows the growth rates, rates of decline and maximum allowable emissions on a global basis for various emissions pathways and their corresponding concentration goals.

II. DEVELOPED AND DEVELOPING COUNTRY EMISSION TRENDS

Figure 4 presents current and projected emissions of carbon dioxide for developed and developing countries. Of the current emissions of roughly 6 billion tons, approximately two-thirds are from developed and one-third from developing countries. The U.S. is currently the largest emitter of carbon dioxide, with China the second largest source. However, on a per capita basis, the U.S. emits about 5 tons of carbon per capita, compared to an average of approximately 4 tons per capita in Japan and Western Europe, and 0.5 tons per capita for developing countries. While per capita differences remain large over time, by the middle of the next century, developing countries would become a source for more than half of total global emissions.

FIGURE 4

[INSERT FIG 4: shows developed and developing country emissions over time under a business as usual scenario.]

III. ILLUSTRATIVE EMISSION REDUCTION SCENARIOS

Limited mid-term actions to reduce emissions by developed countries alone have little impact on shifting the atmospheric concentrations curve. Figure 5 shows the small change in concentrations if Annex I (developed countries) freeze emissions at 1990 levels in the year 2010.

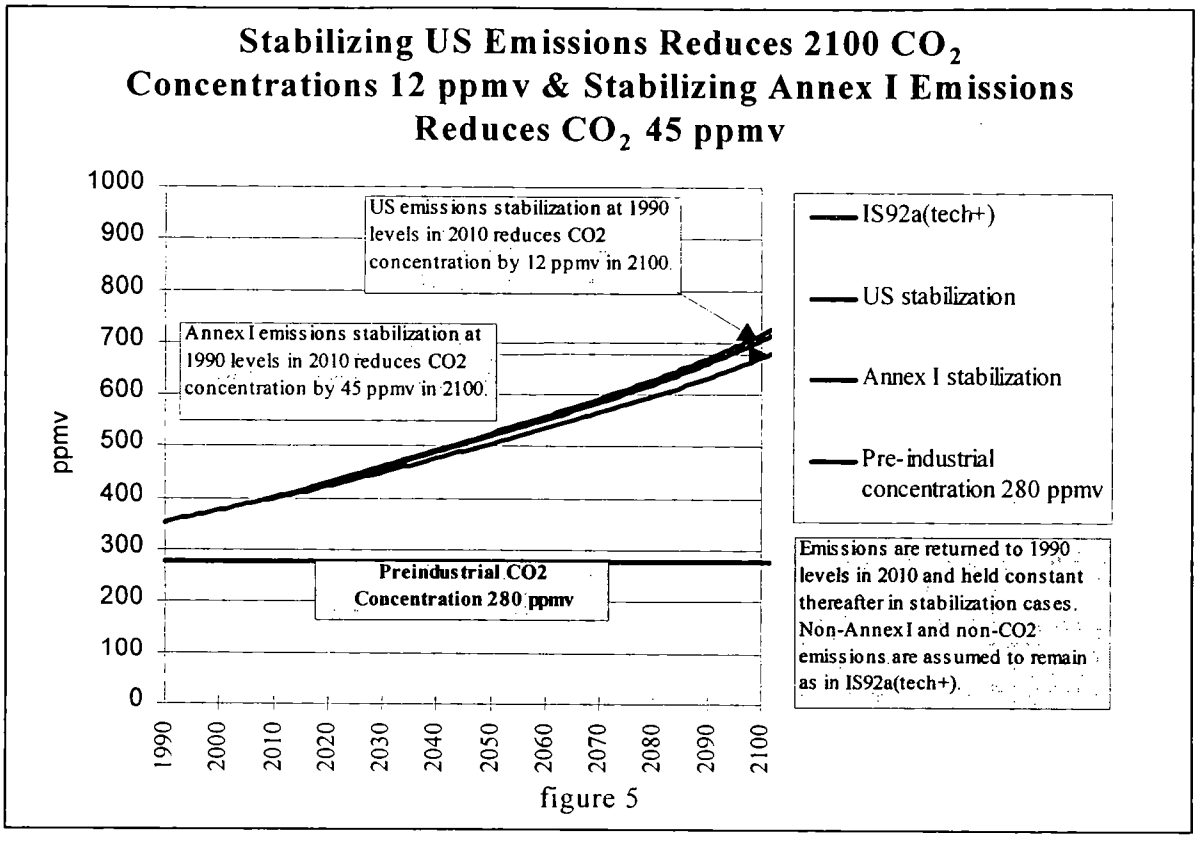


figure 5

Figure 6 illustrates two possible emissions profiles for developed countries. Both scenarios assume a freeze in emissions at 1990 levels in 2010. In one scenario emissions are then reduced by 2.5% per decade and in the second scenario they are reduced at 7.5% per decade. The figure compares these scenarios with the TECH+ scenario from the IPCC.

FIGURE 6

[see second to last page]

Figures 7 and 8 start with the developed country emission scenarios described in figure 6. These figures look at reductions that developing countries would have to take to limit global concentrations to 450 ppm, 550 ppm and 650 ppm. Figure 7 assumes that developed countries freeze emissions in 2010 at 1990 levels and then reduce emissions further at 2.5% per decade. It shows the level of allowable emissions for developing countries compared to their baseline (no action) case compared to the level of allowable emissions the goal were to stabilize atmospheric concentrations at 450, 550 and 650 ppm. This figure shows that to achieve stabilization at 550, developing countries would be able to emit on their currently projected path until about 2020 before significant reductions would be required. Figure 8 illustrates a similar case but assumes

that developed countries freeze at 2010 at 1990 emissions but then reduce at 7.5% per decade.

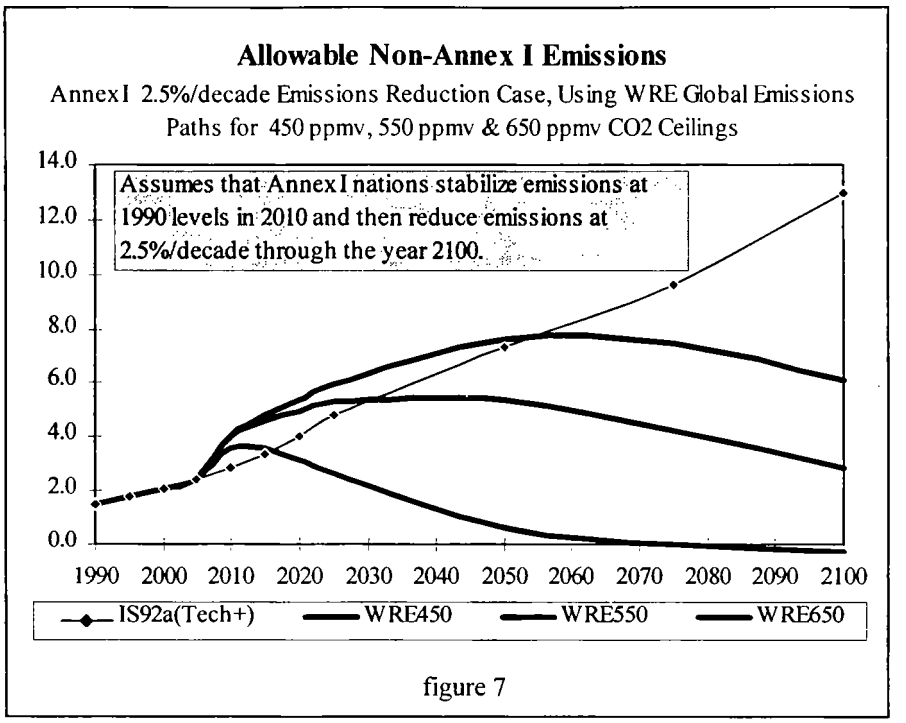


figure 7

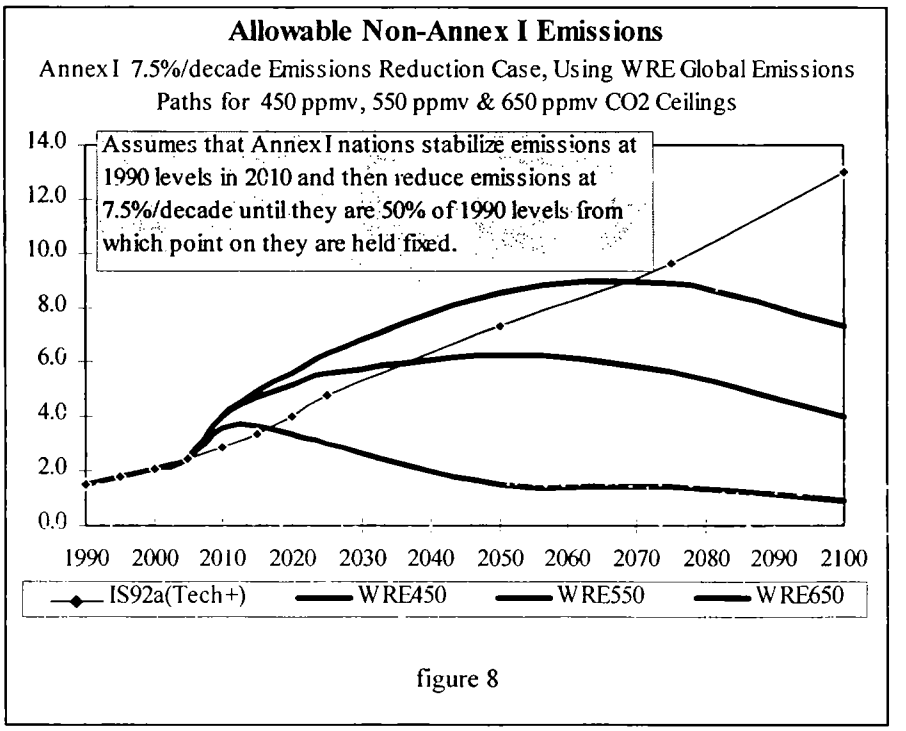


figure 8

Figure 9 shows the per capita emissions for both developed and developing countries that result from the scenarios described in the previous two figures. It shows that under these

scenarios, developed country emissions stay substantially greater than those in developing countries.

FIGURE 9

[see last page]

IV. THE ROLE OF TECHNOLOGY AND IMPACTS ON COSTS

As suggested in Figure 1, the rate of technological change can play a very important role in determining the level at which atmospheric concentrations can be stabilized. Figure 10 looks specifically at the costs associated with different technology cases. It looks at three specific cases:

-- 1990 tech: assumes no technological change from 1990

-- 1990 tech +: assumes significant improvements in reducing the costs of alternative fuels and in improving efficiency;

-- Advanced tech: assumes even further advances and cost savings.

A description of key assumptions for the latter two cases is included as Appendix 1.

Figure 10 shows for each of these technology cases, the total costs associated with achieving three different levels of atmospheric concentrations: 550, 650 and 750 ppm. The estimated costs under the assumption that no technological progress is possible were found to be about $12 trillion or 1.2% of total world GDP, compared to $1 trillion or 0.12% of GDP assuming substantial progress in reduction technologies. In the advanced technology case, which assumes very substantial non-fossil alternatives will be available by 2020, the cost virtually disappear. However, the assumed cost and performance of the alternative technologies would only become achievable with significant increases in research and development investments.

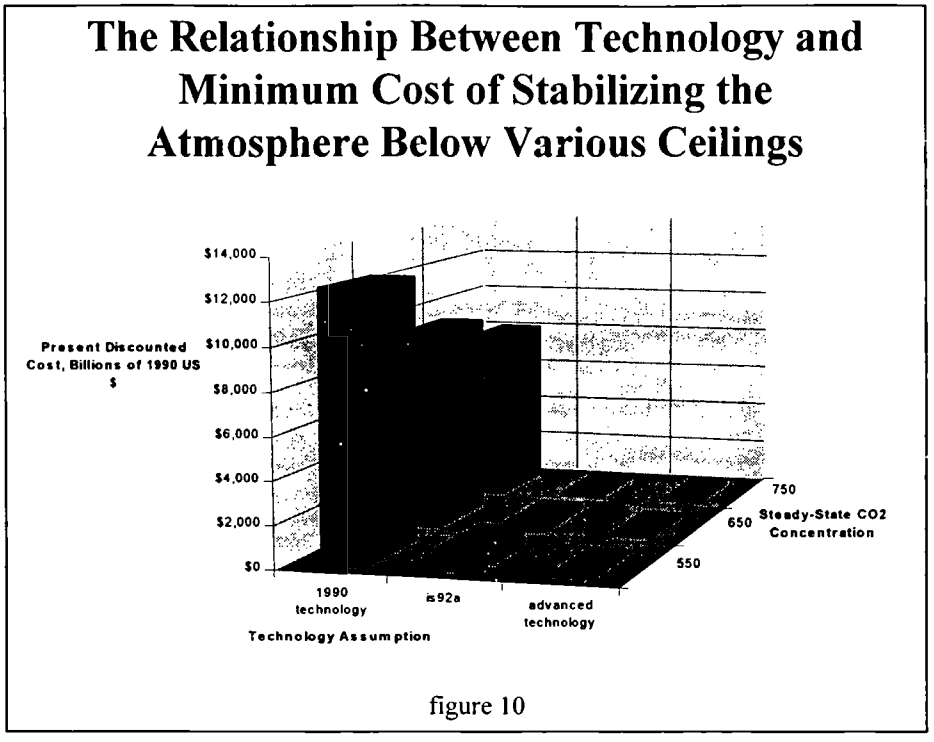


figure 10

Substantial technological progress aimed at reducing the costs of emission reductions is critical for several reasons. It would result in lower costs to the U.S. economy, both in terms of reductions made domestically and in the costs of a reductions obtained abroad through any emissions trading regime. Reducing the costs of alternatives is also critical to limiting future emissions from developing countries, particularly those with large fossil fuel reserves. Finally, expanding the technological frontier offers U.S. industry significant potential opportunities for expanding our industrial base both at home and abroad.

APPENDIX

KEY ASSUMPTIONS ABOUT TECHNOLOGY SCENARIOS:

IS92a (Tech+)

- **End-use (AEEI)** *Improves @ 1%/yr.*
- **Conventional Fossil Fuel Power Generation** *Improves @ 1%/yr.*
- **Non-Fossil Power Sources** *Improves @ 4.5%/yr, 1990 to 2025, 1.25%/yr thereafter.*
- **Biomass Energy** *Improves @ 1%/yr.*

ADVANCED ENERGY TECHNOLOGY

- **ADVANCED SOLAR/WIND/FUSION**
  - The cost of Solar/wind power reaches a busbar cost of $0.04/kWh by 2020 and
  - the cost decreases at 0.5 percent/year thereafter.
- **LOW COST BIOMASS**
  - By the year 2020, 20% of the biomass resource is available at $1.40/GJ, and
  - 80% is available at $2.40
- **ADVANCED LIQUEFIED HYDROGEN FUEL CELLS FOR TRANSPORT**

figure 6

ANNEX I ENERGY EMISSIONS

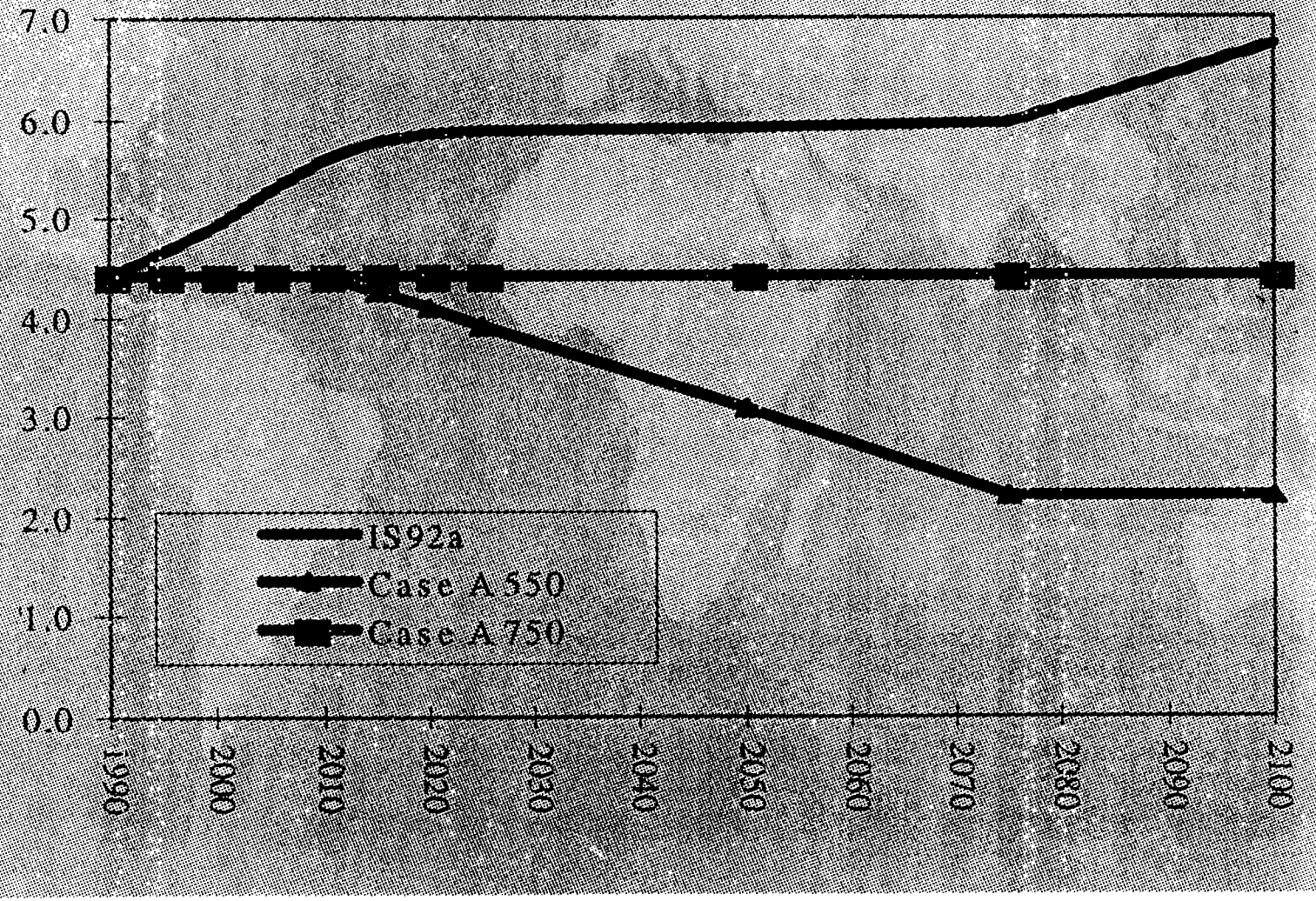
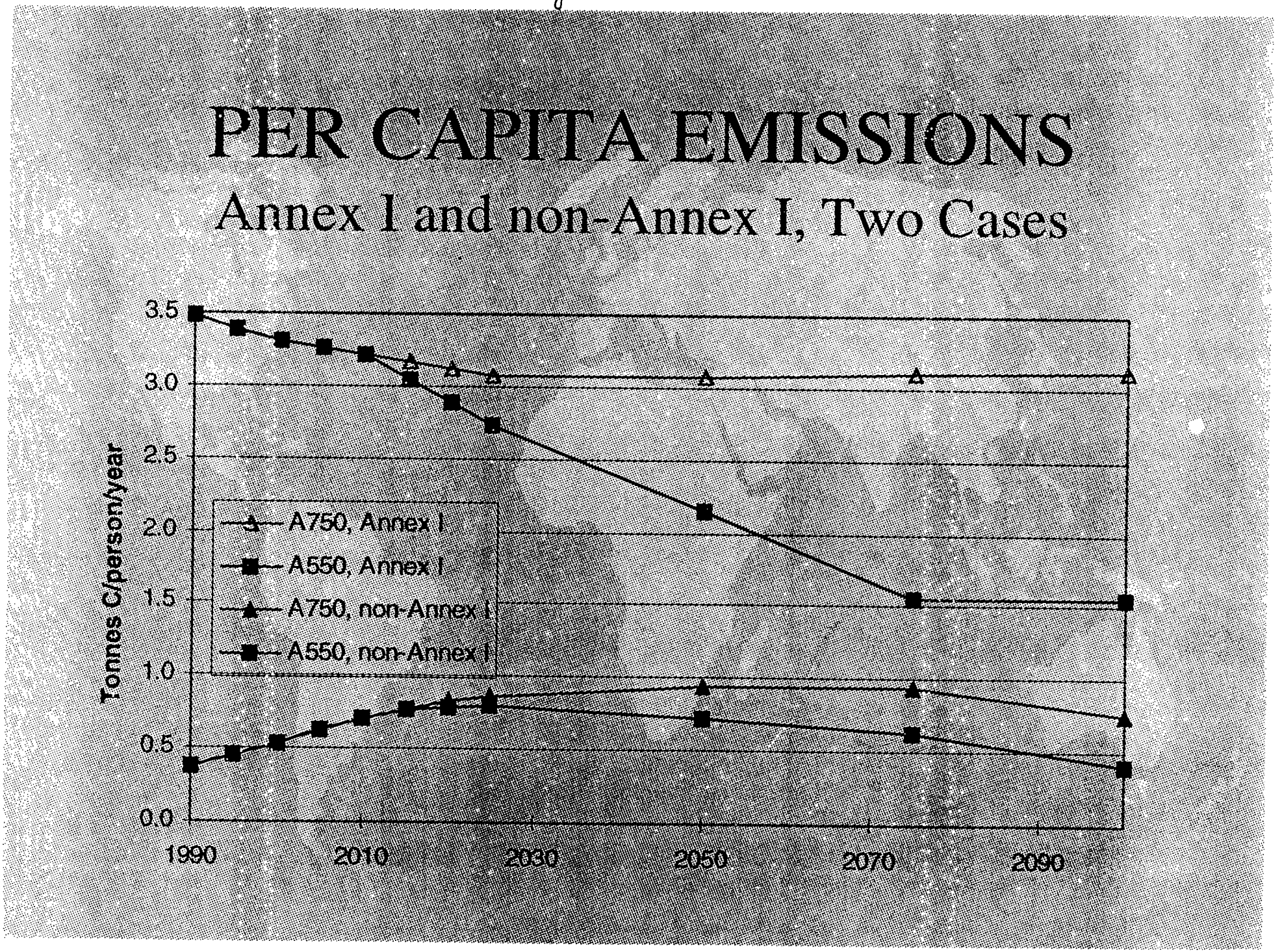


figure 9


PER CAPITA EMISSIONS
Annex I and non-Annex I, Two Cases
Tonnes C/person/year
3.5
3.0
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1990
2010
2030
2050
2070
2090
A750, Annex I
A550, Annex I
A750, non-Annex I
A550, non-Annex I

Mon, 2/3/97, 4pm

cc: JAF
SS
MM

Fax Cover Sheet

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Please Deliver to:

Alicia Munnell/Jeff Frankel

Fax #: 395-6958
Company: CEA

From:

JEREMY SYMONS

Phone:

Pages: 9

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Message:

Attached is the revised version of the Market Transformation Paper, for your review prior to the Assistant Secretaries' meeting on Monday.

Jeremy Symons
EPA, Office of Atmospheric Programs
202-233-9301

Role of Technology and Market Transformation in a National Policy to Limit Greenhouse Gas Emissions

Energy-efficient technologies provide a sizable opportunity to limit emissions of greenhouse gases while simultaneously enhancing economic productivity. However, to capitalize on this opportunity, the U.S. needs to overcome market barriers that have directed the country along a less-than-optimal energy efficiency path to date. This paper discusses the need to support current market transformation programs in order to capture the economic benefits of increased energy efficiency. This paper also discusses the potential for additional initiatives to provide further efficiency and economic improvement.

Market transformation policies would be a cornerstone of a national policy to limit greenhouse gas emissions, and would be complementary to other policies designed to implement whatever targets and timetables (emissions budgets) the U.S. adopts under the climate change negotiations. Some energy efficiency improvement would result from a clear policy signal on climate change and energy.[1] However, even highly efficient forms of regulation, such as cap and trade, do not address underlying market barriers that would restrain the energy-efficiency response to these policies. Failure to fix these barriers would result in a higher cost of the national policy than is necessary.

Policies that can unleash more of the potential of energy-efficient technologies are important because they allow a smoother and less costly transition to meeting a carbon constraint. In addition, greater energy efficiency will enhance the economy by generating productivity investments. Paying energy bills is a relatively less productive use of consumer and business resources than the many other investments and spending choices that consumers and businesses have available to them.[2] Shifting capital from wasted energy expenditures to new investments will therefore help drive economic growth, employment and consumer income. Further improvements in productivity and competitiveness can occur due to the substantial ancillary benefits of advanced technologies and processes in the industrial sector.[3] Several major studies support the economic value of improved energy efficiency:

- Most recently, the Energy Information Administration released an energy efficiency report based on the *Annual Energy Outlook 1996*. The study suggests that a reduction in U.S. energy consumption of 12 percent (by the year 2015) would increase GDP by 0.5 percent.

- Additional studies by the National Academy of Sciences, the Office of Technology Assessment, and the American Council for an Energy-Efficient Economy (jointly with the Union of Concerned Scientists and others) have all demonstrated that the technological potential exists to cut energy consumption by 20% or more at a net economic benefit.[4]

However, there is clear evidence that this potential is not being realized in the current market system because of a number of institutional, organizational, and other barriers that work against the diffusion of existing, energy-efficient technologies and the development of advanced technologies. Many cost-effective, energy-efficient technologies have relatively small market shares and low rates of technology diffusion. There is a sizable remaining potential, or "efficiency gap."

Market Barriers Constrain the Markets for Energy-Efficient Technologies

The existence or availability of a financially attractive technology does not by itself mean the technology will be purchased and used in sizable quantities. For high rates of market penetration, a number of other key factors have to be in place:

- Potential buyers of products need to know of the technology;
- Potential buyers of products need clear, reliable information on the performance and economic benefits of the technology;
- Potential buyers must be the ones to see the benefits of lower energy bills; and
- Service providers and users of the technologies must have expertise to appropriately design for, install, and operate the technology.

In many cases, these factors are not in place due to a wide variety of market barriers. For example, the attached table provides a list of market barriers in the buildings sector.

These barriers result in consumers and businesses ignoring otherwise cost-effective investments in energy-efficient technologies. Consequently, many cost-effective, energy-efficient technologies have relatively small market shares and low rates of technology diffusion. There is a sizable remaining potential, or "efficiency gap." For example, fluorescent lighting ballasts were found in almost every commercial building in 1989. Energy-efficient ballasts had been on the market for many years, were based on well-known, proven technology, delivered equivalent performance to its inefficient counterpart, and had a longer lifetime. Although purchases of efficient magnetic ballasts in 1989 represented investments with IRRs of 60% or greater, only about 12 percent of the market had found the technology and about 24 percent of the market was purchasing the technology due to state standards. The remaining 64 percent of the market was purchasing less efficient technologies and committing themselves to much higher operating expenses over the life of the ballast. This remaining 64% represented a large efficiency gap for building lighting.

The benefits of removing the barriers to the penetration of products such as efficient ballasts extend beyond their direct energy and cost savings. There is a substantial ripple effect that further increases the potential for energy-efficient technologies. First, overcoming barriers to diffusion of today's technologies improves the manufacturers' incentives to invest in R&D needed for the next generation of technologies. This leads to new technologies that expand the potential for future energy savings. Second, as sales and production experience increases for efficient technologies, both the fixed and variable costs of production generally fall, reducing the cost of the technology to the end-user. This "learning by doing" increases the cost-effectiveness of energy-efficient technologies and expands the potential for greenhouse gas reductions.

Current Programs Are Overcoming Many Barriers to Energy Efficiency

A number of market transformation programs are currently underway. The Administration's Climate Change Action Plan (CCAP) launched over 40 initiatives in 1993. Building on other DOE and EPA programs, the CCAP's goal was to return U.S. greenhouse gas emissions to 1990 levels by the year 2000. Despite large funding cuts, the CCAP programs are successfully overcoming market barriers and are currently expected to deliver approximately 3/4 of the emissions reductions originally projected in the CCAP. With continued support beyond the year 2000, these programs will significantly restrain growth in U.S. greenhouse gases through 2010 and beyond. Current Administration projections indicate that around 1/3 of total emissions growth through 2010 will be avoided by the CCAP programs.

For example, DOE's Rebuild America program and EPA's Green Lights and ENERGY STAR® Buildings programs are demonstrating that many of the barriers in the commercial buildings sector can be overcome. These programs have formed over 2500 partnerships to improve energy efficiency in buildings by up to 40% through technology investments with annual rates of return of 20-50%. Program partners saved over $250 million on their energy bills in 1996. Because the rates of return are so high, they offer increased yields to businesses over typical investment opportunities, spurring new investment, economic growth, increased federal tax revenues, and new jobs.

Additional programs are working successfully in other energy markets. For example, through EPA and DOE's ENERGY STAR® Consumer Labeling program, barriers that consumers have faced are being removed. These efforts ask manufacturers to label their more efficient products as consumers are provided with information on these products' environmental and economic benefits. Through 1996, this program has seen thousands of products labeled and billions of dollars invested in ENERGY STAR® products. Consumers saved approximately $500 million on their energy bills in 1996.

From a federal government budget perspective, market transformation programs are a cost-effective means of achieving change through government intervention. For every dollar spent on the programs by the government, approximately $40 of private investment in better technologies is leveraged, leading to energy cost savings of approximately $100.[5] Total expenditures on CCAP programs in 1997 is $183 million.

Areas of Opportunity to Boost Economic Growth While Reducing Greenhouse Gas Emissions

A successful strategy to reduce greenhouse gas emissions while improving the economy would include:

(1) Restored full funding of CCAP programs, with a sustained commitment to these programs beyond the year 2000.

(2) New initiatives to overcome additional market barriers throughout the economy.

Because the CCAP's focus on the year 2000 limited the options that were implemented, a longer term goal would provide significant new opportunities to overcome remaining market barriers. Some of these areas of opportunity are discussed below. An interagency effort is underway to assess potential initiatives to address these opportunities and to develop a national market transformation plan that effectively narrows the efficiency gap by 2010 and beyond. Example approaches mentioned below are illustrative of the types of initiatives that may be included in a final plan.

Opportunities in the Commercial and Residential Sectors

The commercial and residential sectors are the focus of several successful CCAP programs, such as the ENERGY STAR consumer labeling programs, the Rebuild America program, and the Green Lights and ENERGY STAR Buildings programs. These programs overcome important informational and other barriers. There remain opportunities to overcome additional market barriers and achieve greater efficiency. For example:

Builder/Buyer Split Incentives -- Key decisions on building specifications and equipment replacement are often left to builders and architects who do not pay the energy bills and have little or no incentive to choose and apply proven, state-of-the-art technologies and designs. Builders and architects as well as building owners have expressed a desire for a means of providing reliable and impartial energy performance information for commercial buildings. This would allow building purchasers to make informed decisions and demand good energy performance. CCAP programs in this sector have built the reputations and developed the technical expertise that would be needed to address this barrier.

Landlord/Tenant Split Incentives -- In landlord-tenant arrangements, the building owner often makes long-range investment decisions but does not pay the energy bills for the property. In these situations, the owner will not invest in energy efficiency opportunities in spite of excellent, low-risk financial returns. An initiative that could improve leasing practices could help to eliminate this important barrier. For example, an initiative that provided reliable information on energy performance to potential tenants would correctly align the market incentives.

Energy Information -- Empowering consumers and businesses to save money and preserve the environment requires that they be properly informed about energy choices. One available vehicle for better information is their monthly energy bills. Better information could include benchmarking comparisons showing how their bill measures up to model, cost-effective efficiency and to other customers. It could also include information on the overall efficiency and renewable components of the customer's power provider.

Opportunities in the Industrial Sector

Current government efforts in the industrial sector include a strategic set of programs focusing on both short-term and long-term efficiency and productivity improvements. For example, the Climate Wise program encourages greater efficiency, and DOE's Industries for the Future is working with key industrial sectors to bring new technologies to market through 2020. The announcement of a new climate policy would create a large opportunity to work more aggressively with industries on early reductions in greenhouse gas emissions through available technologies.

In addition, there is an important new opportunity to facilitate the use of efficient *distributed generation* technologies. Small-scale cogeneration of heat and power, as well as renewable technologies, are attractive options for many industrial sites (as well as large commercial sites) around the country, and ongoing efforts by DOE continue to improve their competitiveness. These technologies can provide electricity on-site with relatively low carbon emissions (compared to fossil fuel utility plants). But distributed generation has not been embraced largely due to a range of economic disincentives arising from the structure of the regulated utility industry. The deregulation of the electric utilities is therefore opening important new opportunities for these technologies. However, the dampening effect of the historic difficulties in implementing distributed generation projects as well as the confusion of the new market place (due, for instance, to the unproven reputations of a host of new players) will likely continue to restrain growth in efficient distributed

generation. Programs that could provide reliable information and technical guidance could bridge the transition from a regulated to a more effective market. The structure of a new climate change policy could present additional opportunities to further encourage efficient distributed generation technologies.

Cross-cutting Opportunities

A number of additional opportunities exist across all sectors of the economy. For example:

Financing for Energy Efficiency Investments -- Large companies often rely on their own capital for new investments and yet are reluctant, due to organizational barriers, to use that same capital for investments in efficiency (even though they offer impressive rates of return). Small to mid-size businesses and consumers have little access to capital to begin with, and they have a difficult time obtaining reasonable financing. Consequently, in all sectors of the economy, there are significant opportunities for efficiency improvements that could be made if financing designed specifically for energy efficiency investments were widely available. Previous opportunities to achieve a public good through organizing financial markets have been addressed by creating a secondary financing market through "Government sponsored enterprises" (GSEs), like Fannie Mae, Freddie Mac or Sallie Mae. These GSEs purchase particular types of loans (e.g. home mortgages, student loans) from primary lenders, such as commercial banks and mortgage companies, and bundle these loans for sale in the secondary security market to investors.

Incentives Through a Domestic Greenhouse Gas Policy -- A new U.S. climate change policy would provide unique opportunities to provide further incentives to improve the penetration and innovation of energy efficiency and renewable technologies. In addition to constraining the diffusion of existing technologies, the market barriers discussed in this paper also lead to under investment in private R&D for the next generation of technologies. Because consumers and businesses undervalue the energy cost savings of new technologies, manufacturers see little reward from efficiency innovation and do not invest sufficiently in R&D. As barriers to the diffusion of existing technologies are removed, private R&D will increase, but not sufficiently to maintain a sustainable emissions pathway. For this reason, federal R&D efforts are important to long-range environmental and economic success (see the paper on "Research and Development"). A new climate change policy provides additional opportunities to stimulate increased private R&D by providing more direct incentives. This could work in a number of ways. For example, under a domestic trading system with a cap on greenhouse gas emissions, a reserve of allowances or a portion of auction revenues could be set aside to reward new R&D investment and production of efficient and renewable technologies.

Business Accounting Practices -- Currently, companies ignore future energy liability and undervalue the benefits of investments in energy efficiency. When a firm invests in energy efficiency, the accounting shows only a liability, and there is no recognition of the reduction in future energy expenditures. With the longer term focus beyond 2000 and a clear policy signal on energy, it may be possible to work with businesses to develop new practices that more accurately reflect energy liabilities. Strategic improvements to tracking demand and use of energy resources would allow firms to identify and capitalize on profitable improvements that are currently hidden in the noise of corporate financial data.

Government Procurement -- In addition to providing a strong energy signal to businesses, a new climate policy will create additional opportunities for coordinated government action in promoting efficient technologies. Programs like ENERGY STAR Computers have benefited

significantly from federal procurement policy in the past, but innovative initiatives are often difficult because of decentralized and sometimes restrictive procurement policies. The federal, state, and local governments together purchase a sizable portion of energy-consuming technologies. Harnessing the combined purchasing power of all levels of government could be an important opportunity to provide large markets for efficient and renewable technologies. This would provide a strong incentive for increased R&D; reduce the cost of production of these technologies (due to the effects of "learning by doing"); demonstrate the successful performance of new technologies; and make all participating governments more energy efficient.

END NOTES

1. Under the 1987 Montreal Protocol to limit stratospheric ozone depletion, the U.S. required the phase out of the production of CFCs by 1996. Early analyses suggested that the cost to reduce CFC use by 50% would be $3.50 per kilogram. By 1990, it became clear that CFC use could be entirely eliminated by 1996 at a cost of $2.45 per kilogram. The technological innovations that have reduced the cost were made possible by a tradeable permit regime, but were spurred by the clear policy signal of the Montreal Protocol and by government efforts working with manufacturers.

2. In 1992, the American Council for an Energy-Efficient Economy (ACEEE) applied input-output economic modeling to measure the impact of the Market Case in their study, *America's Energy Choices*. They found that the projected 20% decrease in energy use (from baseline growth) would lead to the creation of one million new jobs (net, an increase of 0.7%), a 0.5% increase in personal income, and a 0.1% increase in GDP. [See Laitner, Skip, "Energy Efficiency as Both a Climate Change Action Strategy and an Economic Development Initiative for the United States," *Proceedings from the June 1996 White House Climate Change Analysis Workshop.*] Also, new energy efficiency investments should be seen as a down payment toward economic well-being. Michael Porter, a professor at the Harvard Business School, notes that "the underlying cause of sustained national advantage is improvement and innovation" [Porter, Michael E., *The Competitive Advantage of Nations* (New York, NY: The Free Press, 1990), page 652].

3. Many industrial efficiency improvements also offer important productivity benefits. As an example, in 1990 a North Carolina textile firm installed a radio frequency dryer to replace a gas dryer which was used to dry cashmere wool. The project reduced the energy required for drying by almost half, and reduced fibre loss from over drying by more than 5 percent. The energy savings was about $0.05 per pound of cashmere was more than $1.50 per pound. While the so-called "cashmere effect" at first may seem to be an extreme example of larger productivity benefits, it is not a case in isolation. Indeed, many other examples can be cited. For instance, the average total annual savings from efficiency projects from the Louisiana Division of Dow Chemicals were 3 to 13 times as large as the energy savings alone. Based on this example and other industrial experiences looking at groups of projects, the average total savings can be assumed to be as high as 4 to 6 times as large as the energy savings for projects that are implemented.

4. The Office of Technology Assessment (1991) study indicates a potential of over 400 MMTCE of reductions possible through 2010 or 2015 with a net savings to the economy. The National Academy of Sciences (1991) study shows as much as 450 MMTCE potential for emissions reductions at a cost savings. *America's Energy Choices* (1990), a study by the ACEEE, the Union of Concerned Scientists and others, concluded that energy use could be cut by over 500 MMTCE in its least aggressive "Market Case," in which only cost-effective investments are made.

5. Derived from current information on the Green Lights program. The original CCAP estimated even higher returns for all of the CCAP programs combined: $75 in private investment and $300 in energy savings for every $1 spent by the government on CCAP programs. Energy savings are cumulative through 2010. All numbers are undiscounted.

Historical Forces Leading to Market Barriers to Energy Efficiency in the Buildings Market

Type of Barrier	Nature of Barrier	Examples of Barrier
Imperfect Competition		
Natural Monopoly	Economies of scale	Electric utilities
Market Power (Monopoly and Oligopoly)	Bargaining power; Interdependent conduct	Uniqueness of building location; few development firms in one area
Anti-Competitive Conduct	Collusion; predation	Manipulation of permit process to the detriment of competitors
Information Availability		
Information Costs	Transaction costs	High cost of customized audit (cheaper if done en masse); collecting product info; finding credible information sources
Asymmetric Information	Unequal bargaining	Developer's superior knowledge of building
Misinformation	Misinformed exchange	Belief: "no efficiency increase is possible"
Lack of Information	Uninformed exchange	No knowledge of efficient technologies
Economic Non-Rationality		
Bounded Rationality, Satisficing	Using rules of thumb to reduce transaction costs; not maximizing profits	Ignore costs that are < 5% of rent; use a two year payback; seek acceptable profits
Other Non-Rationality	Cultural reasons for taking actions that affect business practice	Preferring energy production to cost-cutting because it is more congruent with management culture
Risk Aversion	Resistance to change	Avoid changes in suppliers and technologies; avoid new technologies
Side Effects	Negative externalities from power production	Pollution from power generation; dependence on imported oil; risks of nuclear energy
Split Incentives	Utility costs not paid by purchaser and user of equipment	Landlord-tenant problem; builder-buyer problem
Public Goods		
R&D	Non-excludability, zero marginal costs	Too little R&D performed
Expertise and Training	Non-excludability, zero marginal costs	Too little training on efficient design, installation and maintenance; too little information dissemination
Cash Flow Constraints	Lack of access to capital	Small business tenants on the edge; developer's reluctance to take on more debt
Regulatory Distortions		
Regulatory Bias	More profits for energy production than for efficient use	Utility reluctance to install conservation even when cheaper than new supply
Average Cost Pricing	Price signals do not reflect cost, leading to inefficient usage	Utility regulation in the US
Building Codes	Obsolete codes and poor code enforcement inhibit innovation and efficiency; # of inconsistent codes inhibits achieving economies of scale	Local US building codes contain requirements that interfere with efficient construction; thousands of building codes in the US

Mon, 2/3/97, 4pm
cc: SAP
JS
MW

FAX TRANSMISSION

U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF POLICY, PLANNING AND EVALUATION
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202-260-4332
FAX: 202-260-0275

To: Assistant Secretaries' Climate Change group (See attached list)

Date: January 31, 1997

Fax #: See attached list

Pages: 13, including this cover sheet.

From: William N. White
Special Assistant to David Gardiner

Subject: Regulation and standards paper

COMMENTS:

Please find attached the draft paper on Regulation and Standards for discussion at the Assistant Secretaries meetings next week. Please contact me directly at 260-1345 if you do not receive the complete transmission.

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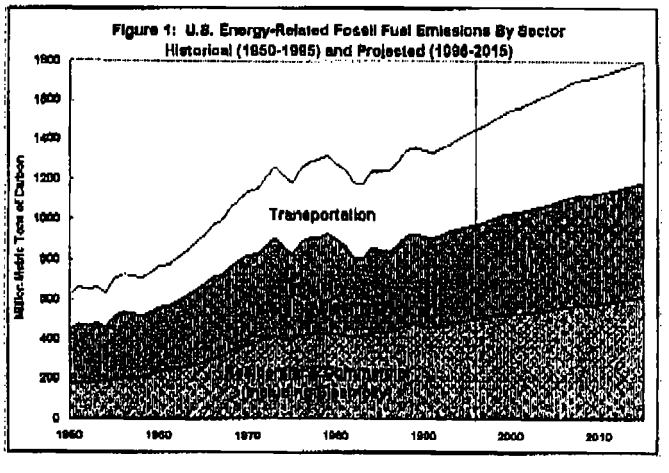
Using Standards and Regulations to Reduce Greenhouse Gas Emissions

Introduction

Limitations on greenhouse gas emissions could take the form of standards and regulations. This paper lays out the broad policy options available for limiting emissions using standards and other measures, but does not analyze the costs and benefits of particular options. Standards to limit greenhouse gas emissions could take the form of:

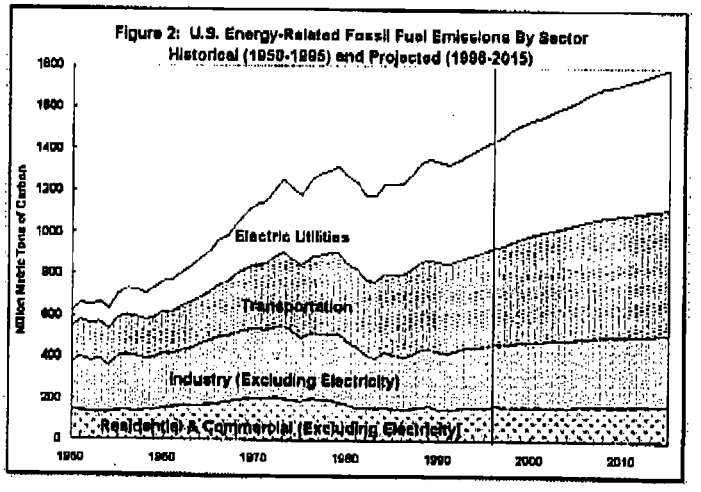
- *Minimum energy efficiency standards for energy consuming equipment:* Historically, these have targeted appliances and other residential and commercial equipment, as well as personal transportation (i.e., the Corporate Average Fuel Economy (CAFE) program).
- *Other measures:* These can take many forms and could include minimum purchase requirements for renewable sources of electricity, demand side management programs (which mandate electric utilities to undertake information and energy efficiency subsidy programs), federal spending rules for transportation infrastructure, and federal procurement policies.
- *Direct limits on greenhouse gases:* Standards could specify allowable greenhouse gas emission levels per unit of output (or some other factor). For example, a powerplant could face a limit on the amount of carbon dioxide emitted per kilowatt of electricity generated. Another example is methane from some landfills, which is already controlled due to limits on emissions of volatile organic compounds.

Within any program of standards, flexibility could be introduced by allowing those who perform better than the levels prescribed by the standards to trade their resulting "credits" with others, thereby reducing costs. Such a program could share many of the characteristics of an emissions trading program.



Figures 1 and 2 summarize sectoral CO_2 emissions (with and without emissions associated with electricity). As indicated, with respect to direct emissions, electric utilities account for about one-third of total CO_2 emissions, transportation for about one third, roughly one fifth for industry, seven percent for the residential sector, and about 4% for the

commercial sector. If electric utility emissions are attributed to final energy consumers, then industry's share rises to about one third and the residential and commercial sectors each account for 15-20% of the total.



Energy Efficiency Standards

1. Appliance Standards

Standards for energy consuming equipment can expand markets for such technologies, help to reduce information barriers and can lower consumer's decision costs. Standards can also provide incentives to private research and development by reducing uncertainty in the market. U.S. homeowners spend $110 billion each year to power home appliances. These uses account for about 70% of all the primary energy consumed in homes.

During its typical 10-15 year lifetime, an appliance's operating costs may exceed its initial purchase price several times over. Nevertheless, many consumers do not consider energy efficiency when making purchases. Manufacturers are often reluctant to invest in more efficient technology that may not be accepted in the highly competitive marketplace.

Recognizing the great potential for energy savings, many states began prescribing minimum energy efficiencies for appliances. Anticipating the burden of complying with differing state standards, manufacturers supported the development of federal standards that would preempt state standards. Federal standards provide a high degree of certainty for energy savings and achieve higher penetration rates for efficiency gains than voluntary, educational or incentive programs.

In 1975, the U.S. Congress established a program of test procedures, energy conservation standards, and labeling for certain major household appliances including refrigerators, freezers, air conditioners, water heaters, furnaces, dishwashers, clothes washers, clothes dryers and kitchen ranges and ovens. A 1987 amendment, the National Appliance Energy Conservation Act, set the first national efficiency standards for these appliances and established a schedule for regular updates by DOE to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified.

The Energy Policy Act (EPACT) of 1992 expanded coverage to certain commercial and industrial equipment, including commercial heating and air-conditioning equipment, water heaters, certain incandescent and fluorescent lamps, distribution transformers, and electric motors. EPACT also established maximum water flow-rate requirements for certain plumbing products and provided for voluntary testing and consumer information programs for office equipment, luminaires, and windows.

Under DOE's first rulemaking in November 1989, updated standards were set for refrigerators and freezers that went into effect January 1993. The Final Rule for energy conservation standards for clothes washers, clothes dryers, and dishwashers issued in May 1991 became effective May 14, 1994.

The initial standards included in EPCA, and those already amended by DOE, are expected to save about 23 quadrillion Btus (24.3 exajoules) of source energy from 1993 to 2015. Current appliance standards have already saved consumers $1.9 billion and will ultimately save $58 billion in energy costs over the lifetimes of units installed between 1990 and 2015.

In addition, more efficient products are more competitive internationally and have environmental benefits from reduced atmospheric emissions. The total emission reductions of federal appliance standards implemented to date are estimated to be 14.2 MMTCE in the year 2000. Further development of standards could result in additional reductions.

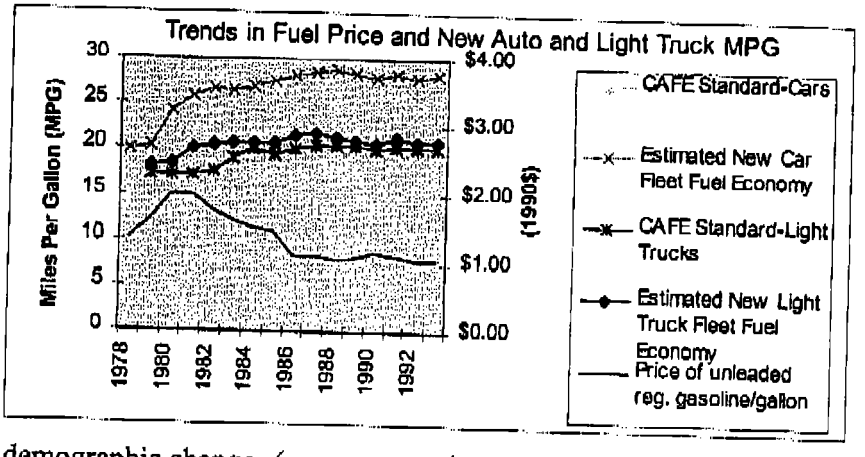
2. Personal Transportation

Consumers make choices about which type of vehicle to purchase and how much they drive their vehicles. There are many attributes that consumers may consider when purchasing a vehicle, such as: price, fuel economy, quality, safety, styling, performance, reliability, handling, comfort, options, size, etc. Fuel economy can conflict with a number of these attributes, and recent surveys confirm that fuel economy is very low on the list of attributes that consumers seek today. If the cost to society of greenhouse emissions is not reflected in the cost of owning and operating a vehicle, consumers will make inefficient choices, a classic case of market failure. One way to incorporate the external costs into the prices that consumers face is through regulation.

Such regulations already exist in the United States. The Energy Policy and Conservation Act of 1975 established mandatory average fuel economy standards for new cars and light trucks starting with the 1978 model year. The standard (currently, 27.5 mpg for cars and 20.7 mpg for light trucks) is calculated by each manufacturer's fleet (domestic or import) and model year. Each manufacturer's fleet average is equal to the sales-weighted fuel economy of all its new cars or light trucks of that vintage that are sold in the United States. Manufacturers that exceed the standard can carry forward credits for up to three years; manufacturers that fall short can carry backward projected future credits for up to three years. Failure to comply with CAFE requirements can result in a civil penalty. No major U.S manufacturer has ever paid a fine; only European manufacturers of luxury cars have opted to pay a fine rather than comply with the standards in a given year or take advantage of the credit system.

Emissions of greenhouse gases from the transportation sector account for about one-third of total U.S. GHG emissions. Transportation greenhouse gas emissions are expected to grow from about 430 million metric tons of carbon "equivalent" (MMTCe) in 1990 to 550 or more MMTCe in 2010. Passenger cars and light duty trucks (light vehicles) contribute the majority of transportation emissions. Emissions from light vehicles alone accounted for 20% of total U.S. greenhouse gas emissions in 1990, and in the absence of new policy measures are expected to rise from about 250 million metric tons of carbon equivalent (MMTCe) in 1990 to 350-400 MMTCe in 2010. All of this growth will likely be from light trucks, which are projected to account for a greater share of emissions than cars by the year 2000.

The major factors underlying the rapid growth in emissions from light vehicles are: growth in vehicle miles traveled; stagnant new fleet fuel economy levels; and growth in the relative proportion of light trucks sold, which have lower CAFE standards than cars.



Actual growth in vehicle miles traveled (VMT) since 1990 has averaged 2.4% per year. Growth in VMT is a function of a number of factors, including demographic changes (more women in the workforce; immigration), land use patterns (where people live in relation to where they work, shop, etc); the cost of driving each mile (now at an all-time low on an inflation-adjusted basis); and others.

Corporate average fuel economy of new car fleets increased steadily along with increasing CAFE standards throughout the late 1970s until the mid 1980s. Since then, new car and light truck fuel economy has been stagnant as new more efficient technologies have been applied to performance (which has increased by 60% for all light vehicles in the last 15 years) and utility rather than to fuel economy. Absent a driving force such as policy changes or fuel price increases, no significant increase in new fleet fuel economy is expected to occur. Further, because new vehicle fuel economy has been stagnant for several years, the in-use fleet of cars and light-trucks has also nearly reached a fuel economy equilibrium.

In fact, the overall in-use fuel economy of the combined new light vehicle fleet (i.e., cars and light trucks such as minivans, sport utility vehicles, and pickup trucks) has already begun to *decline*. Each year, about 15 million light vehicles are sold in the United States. In the past 15 years, sales of light trucks have skyrocketed. They have gone from under 25% of the market in 1982 to almost 45% today. A key reason that this shift is important in terms of GHG emissions is that light trucks face lower CAFE standards than cars (almost 7 mpg lower). Moreover, since light trucks tend to last longer than cars, they are likely to be driven more miles over their lifetime than cars.

In 1994, President Clinton convened a Federal Advisory Committee Policy Dialogue to assist in the development of measures to significantly reduce greenhouse gas emissions from personal motor vehicles ("CarTalk"). Although CarTalk ended without consensus among all members of the Committee, the process did result in a number of analyses and proposed policy options. These are summarized in the attachment.

Other Mandates

Standards could also be used to limit greenhouse gas emissions in other sectors of the economy. Most prominent among these are:

Electricity Restructuring: There is currently a trend among states to adopt retail competition for the electricity industry. This trend could be accelerated with federal legislation. Retail competition is expected to lower the price of electricity by as much as 20-25% in certain regions and change the fuel mix of generation. Preliminary EPA and DOE analysis indicates that utility greenhouse gas emissions could rise by as much as 2-6% as a result. To mitigate the environmental impacts of competition and maintain the environmental benefits of current state level renewable and demand side management programs, a number of options have been adopted at the state level (for states that have already adopted competition) or are under consideration for the rest of the nation. These include:

- A "portfolio standard" for renewable energy or greenhouse gas emissions: This involves requiring that all generators meet a specified level of renewable generation

or greenhouse gas emission reduction either by undertaking such projects themselves or purchasing "credits" from others who have.

- A social benefit fund: Revenue is collected by placing a charge on transmission service. The funds are then used to subsidize energy efficiency projects or low income consumers. California has already adopted this approach.

- Information disclosure requirements: Generators could be required to disclose the emission profiles of their generation, facilitating the marketing of "green" electricity.

- Additional air pollutant requirements: Many states are hesitant to adopt retail competition because they perceive that differing regional environmental requirements both put their electric industry at a competitive disadvantage and will result in more pollution being transported into their states. Thus, additional environmental requirements to "level the playing field" – which could include greenhouse gas emission reductions – are currently being debated.

The Intermodal Surface Transportation Efficiency Act (ISTEA): This Act establishes the rules for federal transportation funding to the states. In 1991, ISTEA authorized $140 billion in transportation projects over a six year period. The Act expires in 1997 and Congress is now considering options for its reauthorization. These could include provisions that would indirectly reduce greenhouse gas emissions. Examples include the following:

- *Congestion Mitigation and Air Quality Improvement Program:* Additional funds could be targeted to transportation projects that reduce air emissions and energy consumption on a long-term sustainable basis.

- *Brownfields Restoration:* Successful redevelopment of browfields can help revive inner city areas and reduce sprawl, thereby reducing vehicle miles traveled. By focusing job growth in inner city areas it encourages greater reliance on more energy efficient and environmentally sound transporation modes, including transit, walking, and bicycling. More funds could be made available for these projects.

- *Incentive Funds:* Climate actions through ISTEA can produce economic efficiency and reduce emissions, while increasing mobility choice and community livability. One option would be to create a $500 million Fuel Efficiency Incentive Fund that rewards the ten states that are able to reduce fuel consumption, on a per capita basis, the greatest over the next five years.

A Program of Standards on Direct Emissions

This system would establish a set of greenhouse gas performance standards for sources of emissions. Flexibility could be introduced by allowing the trading of emission

reduction "credits" when sources perform superior to specified levels. A source could thus comply with the performance standard either through its own control efforts, or by purchasing credits from other sources.

For such a system to work, a performance standard would be established for each sector covered under the program. For example, for coal fired electric boilers, a limit could be placed on the amount of carbon per Btu of energy combusted. Sources surpassing that limit would earn "credits" that would be tradable. The amount of tradable credit would be based on the source's past production rate.

The performance standards themselves would be "rate based." That is, they would establish allowable emissions per unit of production, but not set total output limits. The total amount of tradable credit available to a source would be the product of the amount by which the source is surpassing the rate-based standard and its historical production levels.

Likely candidates to include in such a program include:

- Manufacturers of energy-using equipment for which an efficiency standard can be set. For example, residential, commercial, and industrial equipment (refrigerators, furnaces, ranges, HVAC equipment, motors, and lighting) could be included.
- Transportation equipment manufacturers, including passenger vehicles, light and heavy duty trucks, commercial transport equipment (planes, trains), and off-road equipment (e.g., tractors, farm equipment) and small engines (e.g., mowers).
- The many sources of non-CO_2 emissions (such as coal mine methane, agricultural sources of emissions, and halogenated substances). A credit program is also well suited to "opt-in" smaller sources which are not included under the regulator requirements due to administrative and monitoring considerations, but have the potential to reduce emissions at low costs.
- Electric utilities and heavy industry
- Petroleum refiners

Under a program of this type, the set of performance standards for all sectors must be consistent with the national target. Since total CO_2 emissions are not directly limited, such compliance would have to be projected based on an analysis of the performance standards.

Trading Credits and Determining Compliance

Credits could be traded bilaterally between the source who creates the credit and the source whose performance (i.e., emissions) exceed the regulatory standard. Alternatively, brokers and central exchanges could also be a mechanism for trades.

The authenticity of the credit generating reductions must be approved by the regulating authority at some point. For some sectors, credits could be certified for one year only. For example, a utility emitting under its limit in a year would generate credits equal to the reductions in that year only. These may be sold in that year or banked for the utilities or use or future sale.

For other sectors, annual certification would not be feasible. For equipment manufacturers, credits would be granted for each piece of equipment sold with performance better than the standard. Credits would equal the emissions associated with this improvement for the life of the equipment. It would not be feasible to track each piece of equipment that is produced to ensure its continued operation and performance. Therefore, lifetimes, usage, and degradation assumptions would need to be stipulated.

Conclusion

There is a long history of government using standards and regulations to address market failures relating to environmental externalities, the provision of information, and energy security. In addition, the role of government in the provision of transportation infrastructure and the regulation of natural monopolies is large. Consequently, the number of actions could be taken to mitigate emissions of greenhouse gases is large. These range from direct limits on emissions, to changes in government policies that indirectly affect the demand for energy. Given this wide array, choices must be made that consider both the costs that such interventions may impose and the resulting reductions in greenhouse gas emissions.

Attachment: Summary of the "Car Talk" Process

In 1994, President Clinton convened a Federal Advisory Committee Policy Dialogue to assist in the development of measures to significantly reduce greenhouse gas emissions from personal motor vehicles ("CarTalk"). Although CarTalk ended without consensus among all members of the Committee, the process did result in a number of analyses and proposed policy options. In 1995, several members of the CarTalk Committee published a "Majority Report" that contains a package of recommendations to return greenhouse gas emissions from light vehicles to their 1990 levels in each of three target years: 2005, 2015, and 2025. Their recommendations include a mix of regulatory and other options in three key areas (fuel economy, alternative fuels, and VMT) that are designed to work together to achieve the objective. Separately, other members of the Committee issued a "Report Acceptable to Auto Industry Members" that includes a different set of options to achieve the same objective.

There are essentially three ways to reduce carbon emissions from light vehicles: improve fuel economy; use fuels with lower life-cycle carbon emissions; or reduce miles driven. The regulatory options considered by the Committee and recommended in the *Majority Report* or the *Report Acceptable to Auto Industry Members* are described below. As both reports point out, it is important to keep in mind that there is no "silver bullet" for reducing greenhouse gas emissions from light vehicles. Instead, a package of options designed to complement each other is likely to be the most effective in reducing emissions.

Fuel Economy Measures

The regulatory approach recommended in the CarTalk *Majority Report* calls for increased CAFE standards, combined with feebates. Taken together, these measures were estimated to reduce emissions by 39 MMTCe in 2005, 121 MMTCe in 2015, and 179 MMTCe in 2025.

Increase CAFE: The Committee estimated that a 1.5 mpg per year increase in the CAFE standards (average for combined car and light truck fleet), beginning in 1998, would reduce emissions by 36 MMTCe in 2005. This corresponds to 45 mpg for new cars and 34 mpg for new light trucks in 2007; a 1.0 mpg per year increase would reduce emissions by 117 MMTCe in 2015.

Introduce feebates for fuel economy: A feebate structure for fuel economy would require rebates proportional to the extent to which a vehicle's fuel consumption is lower than average and would assess fees to the extent to which fuel consumption is higher than average. Since carbon emissions are inversely proportional to fuel economy, feebates could also be based on relative carbon emissions per mile. The *Majority Report* also discusses introduction of feebates for after-market low rolling resistance tires. Tire

feebates would provide a rebate for purchase of tires that have rolling resistance below a set point, and fees for rolling resistance levels above the set point.

Alternative Fuels Measures

Provide subsidies and tax incentives for low GHG alternative fuels: The Committee recommended subsidies and tax incentives for natural gas vehicles and infrastructure, electric vehicles, and other potentially low GHG emitting fuels. The lowest GHG fuels are those which are produced from biomass feedstocks, with very few fossil fuel inputs. One example is production incentives to producers of alternative fuels in proportion to life-cycle greenhouse gas emissions. The CarTalk *Majority Report* estimates that subsidies and tax incentives, plus a research and development investment to encourage commercialization of electric vehicles, natural gas vehicles, and other alternatively-fueled vehicles could reduce emissions by 6.6 MMTCe in 2005, 48 MMTCe in 2015, and 117.6 MMTCe in 2025.

VMT Measures

The *Majority Report* recommends a package of measures to reduce the number of vehicle miles driven each year. Taken together, these measures are estimated to reduce emissions by 41 MMTCe in 2005, 56 MMTCe in 2015, and 75 MMTCe in 2025.

Encouraging equitable shift of state and local road subsidies to cost-of-driving (VMT fees): Money spent by federal, state, and local governments to build and maintain roads far outweighs money collected through gas taxes and tolls. The *Majority Report* states that a VMT fee could shift the costs of road building and maintenance which road users do not now directly cover. Such a fee could be designed to be revenue neutral.

Encouraging land use changes away from auto dependency: The *Majority Report* recommended a package of options for increasing density in urban areas, thereby reducing VMT. Examples include financing programs and policies to require government facilities to be located in areas accessible to public transit. Also recommended is funding through ISTEA for programs to guide development planning and for development of bicycle and pedestrian infrastructure.

Reforming workplace parking subsidy programs: Currently, employees do not have to pay taxes on parking benefits of up to $160 per month. Employer-provided transit benefits are tax-exempt only up to $60 per month, and no tax-exempt benefit is available for those who walk or bike to work, or rideshare. The *Majority Report* called for substantial reform of the workplace parking subsidy by equalizing the federal tax benefit for any commuting mode and making the benefit contingent on an employers' offering a taxable cash allowance instead of the benefit.

The *Report Acceptable to Auto Industry Members* called for many of the same measures outlined above, with very important exceptions. This report does not include increased CAFE or feebates, but does recommend either a gasoline tax or VMT fee, and additional research and development funding.

Gasoline Tax: The *Report Acceptable to Auto Industry Members* states that increasing the variable cost of driving will provide an appropriate and effective incentive for Americans to drive less, use less fuel, and produce less CO2, and for improvements in fuel economy. The revenues could be returned to the public or costs could be shifted so that total driving costs do not increase but rather the proportion of driving costs that motorists perceive to vary with number of miles driven. The *Report Acceptable to Auto Industry Members* estimates reductions from a gasoline tax increase of 4 cents per mile per year (above inflation) at 54 MMTCe in 2005, 119 MMTCe in 2015, and 202 MMTCe in 2025.

The Role of R&D in Limiting Greenhouse Gas Emissions

Achieving greenhouse gas levels that are not harmful to humans or the environment will require major advances in technology in every sector of the economy. Fortunately the necessary advances are within plausible pathways of current research and development efforts. Federal R&D is already pursuing most of the important CO2-mitigating technologies because they provide other benefits to the Nation that have long been the basis of national policy, such as achieving dramatic reductions in the criteria air pollutants and other environmental harms; decreased dependence on foreign oil; increased competitiveness of domestic industries and reduced inflation; and leadership in industries likely to achieve an international market of several hundred billion dollars per year in the next century.

Achieving these goals will nonetheless be difficult at a time of constrained federal spending and sharp reductions in long-term private sector R&D. Since 1978, federal investment in energy R&D has declined 75%. Energy R&D investment by industry fell 33% from 1983 to 1993; the electric utility and the gas industry have cut their R&D investments sharply. Industry as a whole has reduced its basic and applied research from 27% of its total R&D in 1988 to 17% in 1994.

The need for major technology advances can be seen from the following equation:

Emissions = *Population* x *Affluence* (GDP/capita) x *Technology* (Emissions/GDP)

From 1990 to 2060, we may well see global population double and affluence increase by a factor of four. At the same time, the world may ultimately need to *lower* emissions from 1990 levels, requring the average emissions-related technology to improve by more than a factor of ten during the next few decades and then be rapidly deployed throughout the world.

Any R&D effort is intrinsically valuable but inherently risky. We can confidently expect significant benefits (based on empirically high returns on federal, private or blended investment) and some

unexpected benefits: much of the gas turbine technology that is today generating cleaner, low-cost electricity had its roots in government-funded work on jet engines. We cannot predict ahead of time the technology "winners" from R&D. The operational risks are making premature decisions that are actually technical or economic dead ends (the breeder reactor or synfuels). At the other extreme, underfunding the most promising areas, as we did during the 1980s in energy efficiency and renewable energy R&D, misuses scarce resources while foregoing substantial progress. Lessons learned form the the past two decades have shaped our current R&D strategy, which chart a middle course between the two extremes.

This paper will examine the most promising R&D for mitigating CO2, focusing on four strategic thrusts: (1) Clean power generation, (2) Energy efficiency, (3) Carbon sequestration accompanying a transition to a hydrogen-based economy, and (4) Very advanced research, such as superconductivity, nanotechnology, and photosynthetic mechanisms. Responding to the climate problem may require breakthroughs in all of these areas. The high-risk nature of R&D requires the pursuit of multiple pathways. Successful (i.e. low-cost) climate stabilization will require accelerated diffusion of existing low-CO2 technologies by 2010 (see "Market Transformation" paper); significant penetration of new very-low-CO2 technologies from 2010 to 2020 (which is the period of greatest economic risk in the current negotiations); followed by deployment of near-zero-CO2 technologies in the succeeding decades (where the possibility exists of fundamental alterations in the energy system).

If these R&D efforts are to succeed, the government's current R&D spending in these areas, roughly $1.3 billion, will need a large boost. Also, partnerships with industry, market pull, improved regulations, and other policies will be required to ensure technological success and accelerated market penetration. The benefits could be enormous, including the avoidance of the costs associated with the other approaches to CO2 mitigation—higher taxes and regulation. A 1997 study by Pacific Northwest Laboratory found that developing and deploying advanced technologies over the next 15 to 30 years could lower the present value cost to the global economy of stabilizing the atmosphere at 550 ppm CO2 from one trillion dollars

down to nearly zero.

Clean Power Generation

Natural gas technologies now set the benchmark for low cost, cleaner power generation. But a spectrum of renewable technologies are becoming competitive: photovoltaics (PV), which convert sunlight into electricity, have dropped from 90 cents per kilowatt-hour in 1980 to under 20 cents today while wind power has dropped from 25 cents per kWh to 5.

Advances in natural gas turbines will yield overall energy conversion efficiencies of 60% or more in the next decade, doubling the efficiency of traditional coal-fired plants. Fuel cells, which generate electricity directly from hydrogen derived from fuels such as natural gas, are promising because of their high efficiency and low emissions. High temperature fuel-cells, such as molten carbonate and solid oxide, may have significant application in power generation with further R&D. Molten carbonate fuel cells are expected to reach 50–60% efficiency by 2000, and perhaps 70% by 2005.

High efficiency coal-fueled power plants, such as integrated gasification combined cycle (IGCC) are now being demonstrated at efficiencies (40 to 43 percent) that are competitive with more traditional coal fired power plants but with much lower emissions, including 35–45% lower CO2 emissions. The efficiency of the next generation IGCC plant could exceed 55%, and, in combination with a fuel cell, achieve 60% by 2015.

While electricity from fossil fuels continue to become cleaner and cheaper, expanded R&D and deployment could make a number of renewable technologies competitive on purely economic grounds in the next two decades: wind power, PV, biomass power, PV, biomass power, solar thermal, and geothermal. In a greenhouse-gas constrained world, these zero-CO2 emitting sources of power would be even more competitive. One plausible set of prices over the next two decades is shown in Figure 1 (from Royal Dutch/Shell).

These cost-reductions will occur not just because of R&D, such as advances in thin film PV, but also

through economies of scale and improvements in manufacturing that come with increased production. Both wind and PV are experiencing a 20% cost reduction for every doubling of cumulative production.

Therefore, a key element of a low-CO2 power generation strategy is to increase the market penetration of technologies such as PV and fuel cells. That strategy needs an international component, since many renewables are cost-effective today in countries without an electricity grid. Domestically, the Climate Change Action Plan contains a number of measures to reduce costs through accelerated deployment for wind, PVs, geothermal, and fuel cells. Besides lowering costs, many of these efforts give utilities experience using these new technologies in niche markets, helping to remove barriers to more expanded use in the future as the technology improves. The old linear model of R&D, where research could be divorced from application, must be thrown out if we are to achieve the desired end: rapid market penetration of clean technologies.

A new government partnership with utilities may be necessary, as the industry is reducing R&D and deployment of renewables and fuel cells in the face of increased competitive pressure and the prospect of a more competitive, restructured industry, which in turn drives short-term cost-cutting efforts. Congressional legislation to restructure the utility industry may well be enacted in the next two years and that will be a crucial opportunity to find alternative means to support R&D and deployment of low-CO2 power.

Nuclear power plants emit no CO_2. Today, the United States operates 109 nuclear power plants, which provide about 22% of our electricity (second only to coal). Between 1973 and 1994, our nuclear power plants enabled the U.S. to avoid about 1,700 million metric tons of carbon emissions. Nuclear's contribution to reducing global climate change gases is increasing. As U.S. plants become more efficient over the next decade, they will reduce carbon emissions more than any other single source. Just since 1994, increases in nuclear power plant availability have reduced annual carbon emissions by 25 million

metric tons. Today, U.S. nuclear plants operate about 80% of the time and may reach 85% by the end of the decade. Every one percent increase in utility-wide nuclear power plant availability results in an annual reduction of carbon emissions of nearly two million metric tons.

To keep nuclear power a viable option for future electricity production, the Department has developed a program to address critical technology issues that could impact the continued operation of U.S. nuclear power plants. Nearly completed is a program to complete and gain Nuclear Regulatory Commission certification of advanced nuclear reactor designs. Nuclear plants similar to these advanced designs have been built or are under construction in countries such as Japan, South Korea, Taiwan. A plant was recently completed in Japan in just over four years, at a cost of about $3 billion, under half the time and about half the cost to complete the most recently finished U.S. nuclear plants. The successful, timely, and low-cost construction of advanced U.S.-designed nuclear plants overseas, coupled with recent reports that nuclear plant operating and maintenance costs have dropped to the same level as for coal plants, have improved the prospects for economical nuclear power generation in the future.

A major R &D effort aimed at improving low-CO2 power generation could have a significan impact on greenhouse gas emissions. The "sustained growth" scenario developed by Royal/Dutch Shell shows one "plausible archetype" (see Figure 2). New energy technologies achieve annual sales of a few hundred *billion* dollars per year in a few decades. Figure 3 shows global CO2 emissions through 2100. Emissions of the criteria air pollutants would show an even sharper decline. Carbon dioxide content in the atmosphere would stabilize at about 550 to 600 ppm.

Given the uncertain nature of R&D, the level of funding necessary to achieve such a world cannot be known, but is likely to be considerably higher than today's investment levels, especially if the Nation seeks to maintain world leadership in these technologies. In PVs, deep R&D cuts in the 1980s have left us with only 40% of the world market. The Japanese outspend our $60 million R&D effort in PVs by more than two to one. The relatively high price for electricity in other developed nations, and the far greater

financial incentives they offer industry, means alternative energy will be cost-effective in foreign countries before it is here. Our primary competitive advantage can come only from technological leadership.

Energy Efficiency

Another key response to climate change is R&D to improve the efficiency of energy use. Three sectors are particularly important: transportation, industry, and buildings.

Transportation

Transportation R&D is essential because the sector uses very little electricity, so advances in clean power offer little hope of lowering its CO2 emissions. Also, two other major national problems—urban air pollution and dependence on foreign oil—stem largely from the transportation sector. The current federal strategy is to develop cars and trucks that are highly fuel-efficient as well as ones that run on fuels other than petroleum, including natural gas, electricity, and biofuels (ethanol).

The partnership for a New Generation of Vehicles (PNGV) is a collaboration among federal agencies, national laboratories, and the auto industry to design and build a prototype clean car by 2004 with three times the fuel efficiency of existing cars and very low emissions, but comparable or improved performance, safety, and cost. Multiple technology paths are being pursued to build a hybrid vehicle that has both an advanced engine (such as a clean diesel, Stirling or gas turbine) and an energy storage device (such as a battery, fly-wheel or ultracapacitor). Supporting R&D includes lightweight, super-strong materials such as composites; high-temperature ceramics; regenerative breaking; and advanced power electronics.

Biofuels are one of the most attractive options for lowering transporation's CO2 emissions. Federal R&D has brought the cost of ethanol from $3.60 per gallon in 1980 to $1.20 per gallon. With continued R&D in bio-engineered organisms and fast-growing crops, the biofuels program is expected to produce ethanol from waste paper, crop waste, and dedicated crops for under 70 cents a gallon by 2005, competitive with oil at $25 a barrel, its current price. Significant penetration of biofuels is possible in the next two decades.

Proton-exchange membrane (PEM) fuel cells have perhaps the greatest long-term potential for reducing transportation CO2. Recently PNGV developed an on-board reformer for converting gasoline into hydrogen to run a PEM fuel cell, which would have a 50% increase in fuel efficiency over an internal combustion engine, half the CO2, and a 99% reduction below ultra-low emission vehicle standards. A PEM fuel cell running on ethanol would have virtually no net CO2 emission. A decade of R&D may be needed to bring costs down and integrate the fuel cell into a commercial vehicle. Maximum efficiency and emissions reductions would come from running the car on hydrogen directly, which will require even more research.

The ultimate low-CO2 vehicles and the fuels they would use cannot be known today. To ensure that the R&D leads to commercially viable vehicles, a number of programs are needed to ensure that the infrastructure is available to support vehicles that run on non-traditional fuels.

INDUSTRY

The industrial sector consumes about one-third of the nation's energy. The seven most energy-intensive industries—steel, aluminum, petroleum refining, chemicals, pulp and paper products, glass, and metal casting—account for about 80% of the energy consumed in U.S. manufacturing and more than 90% of the hazardous waste. They represent the largest opportunity for reducing industrial CO2 emissions.

The Department of Energy has formed partnerships with each of these industries to develop visions of energy-efficient, low-polluting, highly competitive "Industries of the Future" and then technology roadmaps to identify the best R&D opportunities. These include advanced materials development, such as ceramic composites; separation technology, such as advanced membranes; catalysis; bioprocessing, biocatalysis, and renewable feedstocks; sensors and controls; and industrial cogeneration of electricity and heat, which can achieve overall efficiencies of more than 80% and ultimately utilize biomass.

These industries (except chemicals) significantly underinvest in R&D compared to the industry average.

What R&D they have devoted to the environment has traditionally been focused on compliance—end-of-pipe treatment and control, as opposed to prevention—since that is how our regulatory system is designed. While increased R&D is needed, if federal pollution prevention technology development is to achieve maximum industry cost-share, market penetration, and significant greenhouse gas reduction, the Administration must complete its regulatory reinvention revolution, exploring innovative approaches through Project XL, the Common Sense Initiative, and the Environmental Leadership Program.

Tradtional point-source controls that address a single waste at a time and only afte the waste has been generated must be replaced by prevention-based, innovation friendly strategies. These include basing standards on desired performance, not "best available technology"; focusing on facilities, communities, and ecosystems, not the waste, the media nor the pipe; emphasizing multi-media solutions that address all wastes; emphasizing continuous improvement, not bright-line fixed compliance; expanding the use of information, measurement, and feedback, such as the Toxic Release Inventory; and wherever possibly, using fiscal tools and market mechanisms such as trading schemes and bankable emissions credits.

Prevention R&D, as opposed to end-of-pipe R&D, is the key to CO2 mitigation, and prevention-oriented regulations can help unleash billions of private-sector dollars in the industrial sector to low-CO2 industrial technologies.

BUILDINGS

The buildings sector consumes one-third of the nation's energy and two-thirds of its electricity. Federal R&D into buildings technologies has been remarkably successful. Consider just five technologies developed or advanced by the national laboratories in the past two decades at a cost of roughly $40 million—building design software and advanced lighting, windows, oil burners, and refrigerator compressors. These have provided cumulative net savings of more than $15 *billion* to consumers and businesses, which exceeds the $14 billion spent on all energy efficiency R&D since 1978. They are today

providing more than 10 million metric tons of annual CO2 savings.

Continued R&D in the buildings sector is likely to prove just as cost-effective. Key near-term technologies include improvements in lighting, superwindows, advanced design software, high-efficiency clothes washing, heat-pump water heaters, gas heat pumps, improved insulation and duct systems, more efficient cooling including gas cooling, solar heating and cooling, and daylighting. Urban heat island mitigation R&D could enable deep and highly cost-effective energy savings in air conditioning, while dramatically reducing smog formation. Relevant R&D includes developing highly reflective roofing and road materials, and modeling the impact of those materials and shade trees on buildings and cities.

Longer term R&D needs include electrochromic glazings for windows, building-integrated PV systems, and PEM fuel cells. In 2010, a building using efficient technologies with electricity and hot water provided by an 80% efficient fuel cell could have no first-cost penalty with well under half the energy of a typical 1990 building and one-tenth the CO2 emissions.

Dematerialisation

A major R&D effort aimed at improving energy efficieny could have a significant impact on greenhouse gas emissions. Shell's "Dematerialisation" scenario imagines such a world with improvements in energy intensity reaching a sustained 2% per annum, which has been seen for only limited periods in the past, from a "New Generation Vehicle" and other relentless advances in efficient technology (see Figure 4).

The market for clean technologies could be a few hundred billion dollars per year. Figure 5 shows global CO2 emissions through 2100. Again, emissions of the criteria air pollutants would show an even sharper decline. National and world dependence on Persian Gulf oil would be severely reduced. Carbon dioxide content in the atmosphere would stabilize at about 550 to 600 ppm.

Capture and Sequestration

A relatively simple series of chemical reactions can take coal, oil, natural gas or biomass and convert them into relatively pure streams of carbon dioxide and hydrogen. If R&D makes it possible to find bulk means of sequestering CO2 safely and cost-effectively, and if advances continue in hydrogen utilization, particularly in PEM fuel cells, then the possibility would exist for a long-term transition to a nearly

pollution-free economy with sharply reduced levels of greenhouse gas emissions.

A number of sequestering options are worth exploring further, including the deep ocean, depleted gas and oil reserves, and underground aquifers. In September 1996, Statoil of Norway began storing CO2 from a gas field into a sandstone aquifer a kilometer beneath the North Sea at a rate equal to the CO2 produced from a 140 megawatt coal-fired power plant. Pilot studies had shown that most of the CO2 will react to form solid calcite, with some dissolving in the groundwater and some remaining as gas. While cost information has not been shared, Statoil has stated it is less than the Norwegian carbon tax of $50 per ton of CO2.

A long-term R&D strategy would include demonstration of a number of sequestration options and research into their possible environmental impacts; converting CO2 into an industrial chemical feedstocks; other novel sequestration options, such as C02 fixation by microalgae; selectively permeable membranes for CO2 capture; processes for converting fossil fuels and biomass into CO2 and hydrogen; development of hydrogen infrastructure technology, including transportation and storage; and PEM fuel cells.

As noted earlier, R&D into clean power generation and energy efficiency support many long-standing national goals and have been pursued for years. Carbon dioxide capture and sequestration, however, makes sense on a massive scale only in a greenhouse-gas constrained world. So, at least in this country, this area has been relatively underfunded. Since 1990, Japan has spent more than 30 times what we have on CO2 capture and sequestration.

Other Advanced Research

A number of areas of basic research could prove crucial to responding to climate change, including photosynthetic mechanisms, biotechnology, fermentation microbiology, combustion research, polymer and ceramic science, process engineering, supercritical CO2, new materials synthesis, and nanotechnology.

One essential area for expanded R&D is superconductivity. Superconductors offer the possibility of nearly lossless energy storage and transmission, with potential savings of 5% to 10% of all electricity presently generated by utilities. Highly efficient superconducting motors could have an even larger impact since motors currently consume 60% of all electricity. While U.S. and German funding is roughly $40 million annually, Japan spends nearly $70 million, not including their superconducting MagLev train program, where some $3.5 billion is being spent over five years. Significant increases in both basic and applied research in superconductivity should be an essential part of a low-CO2 R&D strategy.

Summary

New technologies offer the prospect of dramatically lowering the cost of CO2 mitigation while achieving many other national benefits. The roughly $1.3 billion the federal government is currently spending on relevant R&D will likely have to be increased substantially. At the same time, a number of regulatory and other policy tools will be needed both to maximize private sector investment in this R&D and to help create conditions needed for these technologies to achieve rapid marketplace penetration.

Options (These are not mutually exclusive, but demonstrate the range of possibilities)

1) Augment Federal energy R&D budgets, emphasizing most promising low- or zero- CO2 technologies

- within a zero-sum constraint toward Federal R&D resources that would necessitate reducing investments in other R&D areas, or
- expand the overall Federal R&D effort

2) Expand current partnerships with industry to focus on key CO2 objectives through initiatives e.g.electric utilities, natural gas industry, industrial processes (Industries of the Future), transportation (PNGV), and buildings.

3) Lay the R&D foundation for longer-term radical energy system shifts, e.g. hydrogen economy or building in CO2 sequestration technologies into the energy system.

4) Market adjustments (not contemplated in this paper), e.g. accelerated depreciation for low-carbon technologies, tax credits for low-carbon technology development and deployment

5) Design legislation to support CO2 goals, including regulatory reinvention. Ensure that expect legislation, such as utility restructing, supports C02 goals.

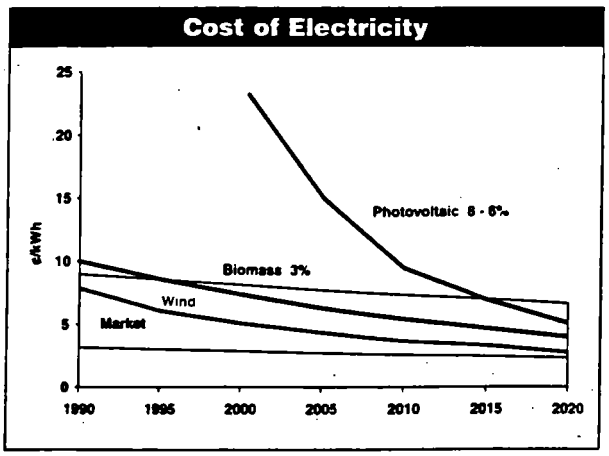


FIG 1

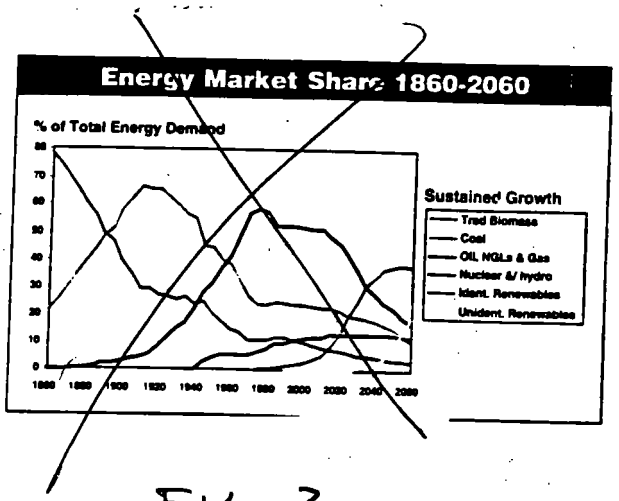


FIG 2

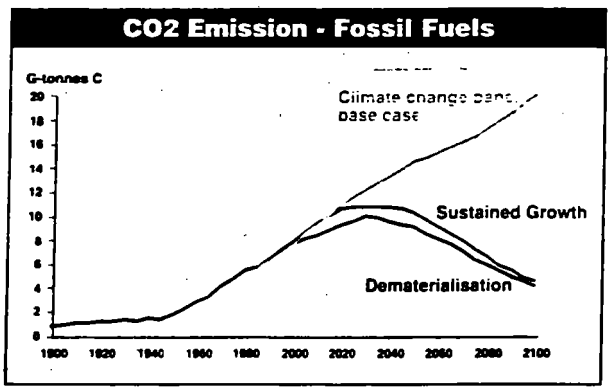


FIG 3

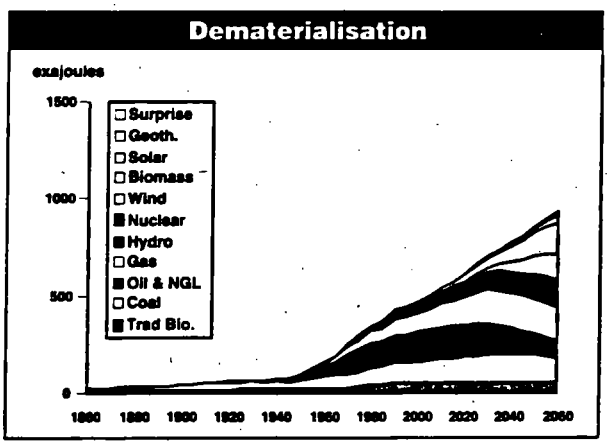


FIG 4

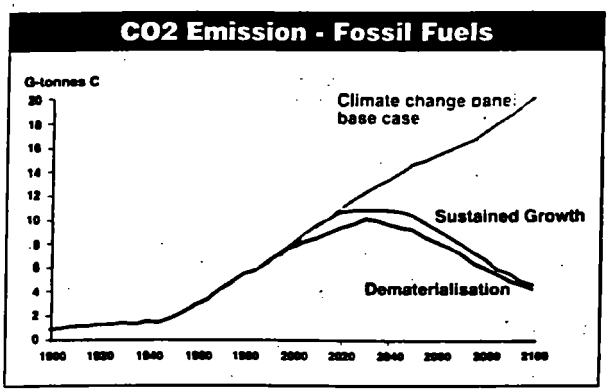


FIG. 5

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DOL	Andrew Samet	219-5980

January 31, 1997 Pre-decisional draft: Do Not Cite or Quote

THE ROLE OF R&D IN LIMITING GREENHOUSE GAS EMISSIONS

One of the key issues in developing a domestic climate change policy will be the emphasis placed on potentially expanding the Federal R&D effort into technologies that promise to reduce future greenhouse gas emissions and/or lower the cost of achieving a given greenhouse gas reduction target. While advances in technology clearly will play a pivotal role in long-term emission reductions, the key decisions will involve:

- the emphasis placed on medium term vs. long term emission reductions;
- the near-term budget implications of enhanced investments in technology development;
- the extent and character of private-sector participation in an expanded R&D effort;
- the relationship between R&D and near-term technology deployment efforts; and
- the role, if any, of international coordination on R&D efforts.

Achieving greenhouse gas emission reductions that would stabilize atmospheric concentrations at "safe" levels will require major advances in technology in every sector of the economy. Fortunately, many of the necessary advances are within plausible pathways of current research and development efforts. Federal R&D is already pursuing most of the important CO_2-mitigating technologies because they provide other benefits that have long been the basis of national policy, such as reducing criteria air pollutants and other environmental harms; decreasing dependence on foreign oil; increasing the competitiveness of domestic industries; and providing leadership in industries likely to achieve an international market of several hundred billion dollars per year in the next century.

Achieving these goals will nonetheless be difficult at a time of constrained federal spending and sharp reductions in long-term private sector R&D. Since 1978, federal investment in energy R&D has declined 75%. Energy R&D investment by industry fell 33% from 1983 to 1993; the electric utility and the gas industry have cut their R&D investments sharply. Industry as a whole has reduced its basic and applied research from 27% of its total R&D in 1988 to 17% in 1994. A viable R&D component of a climate strategy would entail both expanding federal resources and stimulating additional private sector R&D activity.

The need for major technology advances can be seen from the following equation:
Emissions = *Population* x *Affluence* (GDP/capita) x *Technology* (Emissions/GDP)

From 1990 to 2060, we may well see global population double and affluence increase by a factor of four. At the same time, the world may ultimately need to *lower* emissions from 1990 levels, requiring the average emissions-related technology to improve by more than a factor of ten during the next few decades and then be rapidly deployed throughout the world.

Any R&D effort is intrinsically valuable but inherently risky. We can confidently expect significant benefits (based on empirically high returns on federal, private or blended investment) as well as some unexpected benefits (e.g. much of the gas turbine technology that is today generating cleaner, low-cost electricity had its roots in government-funded work on military jet engines). However, we cannot predict ahead of time the technology "winners" from R&D. The operational risks are making premature commitments to development programs that prove to be technical or economic dead ends, such as the breeder reactor or synfuels debacles of the 1970s. At the other extreme, underfunding the most promising areas by spreading an R&D effort too thinly across a spectrum of technologies, as we did during the 1980's in energy efficiency and renewable energy R&D, misuses scarce resources while foregoing substantial progress. Lessons learned form the past two decades have shaped our current R&D strategy, which chart a sensible middle course between the two extremes.

This paper will examine the most promising R&D for mitigating CO_2, focusing on four strategic thrusts: (1) clean power generation, (2) energy efficiency, (3) carbon sequestration accompanying a transition to a hydrogen-based economy, and (4) very advanced research, such as superconductivity, nanotechnology, and photosynthetic mechanisms. Responding to the climate problem may require breakthroughs in all of these areas, and in any case the high-risk nature of R&D requires the pursuit of multiple pathways. From a technology development standpoint, successful (i.e. low-cost) climate stabilization will require:

- Accelerated diffusion of existing low-CO_2 technologies by 2010 (see "Market Transformation" paper);

- Significant penetration of new very-low-CO_2 technologies from 2010 to 2020 (the period of greatest economic concern in the current negotiations); and

- Substantial or nearly universal deployment of near-zero-CO_2 technologies in the succeeding decades (where the opportunity exists for fundamental alterations in the energy system).

Increasing the probability of achieving these desirable outcomes will require expanding the government's current R&D spending in these areas, which is roughly $1.3 billion per year. Also, partnerships with industry, "market pull" deployment initiatives, improved regulations, and other policies will be required to ensure technological success and accelerated market penetration. The benefits could be enormous, including the avoidance of the costs associated with the other approaches to CO_2 mitigation such as higher taxes and regulation. A 1997 study by Pacific Northwest Laboratory found that developing and deploying advanced technologies over the next 15 to 30 years could lower the present value cost to the global economy of stabilizing the atmosphere at 550 ppm CO_2 from one trillion dollars down to nearly zero.

CLEAN POWER GENERATION

Natural gas technologies now set the benchmark for low cost, cleaner power generation. Moreover, advances in natural gas turbines will yield overall energy conversion efficiencies of 60% or more in the next decade, doubling the efficiency of traditional coal-fired plants. Fuel cells, which generate electricity directly from hydrogen derived from fuels such as natural gas, are promising because of their high efficiency and low emissions. High temperature fuel-cells, such as molten carbonate and solid oxide, may have significant application in power generation with further R&D. Molten carbonate fuel cells are expected to reach 50-60% efficiency by 2000, and perhaps 70% by 2005.

High efficiency coal-fueled power plants, such as integrated gasification combined cycle (IGCC) are now being demonstrated at efficiencies (40 to 43%) that are competitive with more traditional coal-fired power plants but with much lower emissions, including 35-45% lower CO_2 emissions. The efficiency of the next generation IGCC plant could exceed 55%, and, in combination with a fuel cell, achieve 60% by

Given the uncertain nature of R&D, the level of funding necessary to achieve such a world cannot be known, but is likely to be considerably higher than today's investment levels, especially if the Nation seeks to maintain world leadership in these technologies. In PVs, deep R&D cuts in the 1980's have left us with only 40% of the world market. The Japanese outspend our $60 million R&D effort in PVs by more than two to one. The relatively high price for electricity in other developed nations, and the far greater financial incentives they offer industry, means alternative energy will be cost-effective in foreign countries before it is here. Our primary competitive advantage can come only from technological leadership.

ENERGY EFFICIENCY

Another key response to climate change is R&D to improve the efficiency of energy use. A major R&D effort aimed at improving energy efficiency could have a significant impact on greenhouse gas emissions. Shell's "DEMATERIALISATION" scenario imagines such a world with improvements in energy intensity reaching a sustained 2% per annum, which has been seen for only limited periods in the past, from a "New Generation Vehicle" and other relentless advances in efficient technology (see Figure 4).

The market for clean technologies could be a few hundred billion dollars per year. Figure 5 shows global CO_2 emissions through 2100 in this scenario. Again, emissions of the criteria air pollutants would show an even sharper decline. National and world dependence on Persian Gulf oil would be severely reduced. Carbon dioxide content in the atmosphere would stabilize at about 550 to 600 ppm. Three sectors are particularly important for energy efficiency gains: transportation, industry, and buildings.

TRANSPORTATION

Transportation R&D is essential because the sector uses very little electricity, so advances in clean power generation offer little hope of lowering its CO_2 emissions in the near term. Also, two other major national problems– urban air pollution and dependence on foreign oil –stem largely from the transportation sector. The current federal strategy is to develop cars and trucks that are highly fuel-efficient as well as ones that run on fuels other than petroleum, including natural gas, electricity, and biofuels (ethanol).

The partnership for a New Generation of Vehicles (PNGV) is a collaboration among federal agencies, national laboratories, and the auto industry to design and build a prototype clean car by 2004 with three times the fuel efficiency of existing cars and very low emissions, but comparable or improved performance, safety, and cost. Multiple technology paths are being pursued to build a hybrid vehicle that has both an advanced engine (such as a clean diesel, Stirling or gas turbine) and an energy storage device (such as a battery, fly-wheel or ultra capacitor). Supporting R&D includes lightweight, super-strong materials such as composites; high-temperature ceramics; regenerative breaking; and advanced power electronics.

Biofuels are one of the most attractive options for lowering transportation's CO_2 emissions. Federal R&D has brought the cost of ethanol from $3.60 per gallon in 1980 to $1.20 per gallon. With continued R&D in bio-engineered organisms and fast-growing crops, the biofuels program is expected to produce ethanol from waste paper, crop waste, and dedicated crops for under 70 cents a gallon by 2005, competitive with oil at $25 a barrel, its current price. Significant penetration of biofuels is possible in the next two decades.

Proton-exchange membrane (PEM) fuel cells have perhaps the greatest long-term potential for reducing transportation CO_2. Recently PNGV developed an on-board reformer for converting gasoline into hydrogen to run a PEM fuel cell, which would have a 50% increase in fuel efficiency over an internal combustion engine, half the CO_2, and a 99% reduction in conventional pollutants below ultra-low emission vehicle standards. A PEM fuel cell running on ethanol would have virtually no net CO_2

emission. A decade of R&D may be needed to bring costs down and integrate the fuel cell into a commercial vehicle. Maximum efficiency and emissions reductions would come from running the car on hydrogen directly, which will require even more research.

The ultimate low-CO_2 vehicles and the fuels they would use cannot be known today. To ensure that the R&D leads to commercially viable vehicles, a number of programs are needed to ensure that the infrastructure is available to support vehicles that run on non-traditional fuels.

INDUSTRY

The industrial sector consumes about one-third of the nation's energy. The seven most energy-intensive industries—steel, aluminum, petroleum refining, chemicals, pulp and paper products, glass, and metal casting—account for about 80% of the energy consumed in U.S. manufacturing and more than 90% of the hazardous waste. They represent the largest opportunity for reducing industrial CO_2 emissions.

The Department of Energy has formed partnerships with each of these industries to develop visions of energy-efficient, low-polluting, highly competitive "Industries of the Future" and then technology roadmaps to identify the best R&D opportunities. These include advanced materials development, such as ceramic composites; separation technology, such as advanced membranes; catalysis; bioprocessing, biocatalysis, and renewable feedstocks; sensors and controls; and industrial cogeneration of electricity and heat, which can achieve overall efficiencies of more than 80% and could ultimately utilize biomass.

These industries (except chemicals) significantly under invest in R&D compared to the industry averages. What R&D they have devoted to the environment has traditionally been focused on compliance- end-of-pipe treatment and control, as opposed to prevention—since that is how our regulatory system is designed. While increased R&D is needed, if Federal pollution prevention technology development is to achieve maximum industry cost-share, market penetration, and significant greenhouse gas reduction, the Administration must complete its regulatory reinvention revolution, exploring innovative approaches through Project XL, the Common Sense Initiative, and the Environmental Leadership Program.

Traditional point-source controls that address a single waste at a time and only after the waste has been

generated must be replaced by prevention-based, innovation friendly strategies. These include basing standards on desired performance, not "best available technology"; focusing on facilities, communities, and ecosystems, not the waste, the media nor the pipe; emphasizing multi-media solutions that address all wastes; emphasizing continuous improvement, not bright-line fixed compliance; expanding the use of information, measurement, and feedback, such as the Toxic Release Inventory; and wherever possibly, using fiscal tools and market mechanisms such as trading schemes and bankable emissions credits. Prevention R&D, as opposed to end-of-pipe R&D, is the key to CO_2 mitigation, and prevention-oriented regulations can help shift private-sector R&D dollars in the industrial sector to the development of low-CO_2 industrial technologies.

BUILDINGS

The buildings sector consumes one-third of the nation's energy and two-thirds of its electricity. Federal R&D into buildings technologies has been remarkably successful. Consider just five technologies developed or advanced by the national laboratories in the past two decades at a cost of roughly $40 million— building design software and advanced lighting, windows, oil burners, and refrigerator compressors. These have provided cumulative net savings of more than $15 *billion* to consumers and businesses, exceeding the $14 billion spent on *all* energy efficiency R&D since 1978. They are today providing more than 10 million metric tons of annual CO_2 savings.

Continued R&D in the buildings sector is likely to prove just as cost-effective. Key near-term technologies include improvements in lighting, superwindows, advanced design software, high-efficiency clothes washing, heat-pump water heaters, gas heat pumps, improved insulation and duct systems, more efficient cooling including gas cooling, solar heating and cooling, and day lighting. Urban heat island mitigation R&D could enable deep and highly cost-effective energy savings in air conditioning, while dramatically reducing smog formation. Relevant R&D includes developing highly reflective roofing and road materials, and modeling the impact of those materials and shade trees on buildings and cities.

Longer term R&D needs include electrochromic glazes for windows, building-integrated PV systems, and PEM fuel cells. In 2010, a building using efficient technologies with electricity and hot water provided by an 80% efficient fuel cell could have no first-cost penalty with well under half the energy of a typical

1990 building and one-tenth the CO_2 emissions.

CAPTURE AND SEQUESTRATION

In addition to the portfolio of R&D options related to less CO2 intensive technologies for energy supply and use, capture and disposal of CO2 offers an additional alternative for reducing atmospheric concentrations of CO2. If major reductions in CO2 emissions are necessary, and global reliance on fossil fuels continues beyond the middle of the next century, then some form of CO2 sequestration will almost certainly be needed as part of the CO2 solution mix. The Climate Technology Initiative, launched under the auspices of the Framework Convention on Climate Change and supported by the US, stresses the need to "assess the feasibility of developing longer term technologies to capture, remove or dispose of greenhouse gases...."

Moreover, a successful program to develop save, low cost greenhouse gas sequestration options should garner bipartisan support for progress on climate change issues by allowing for continued use of fossil fuels while minimizing the direct costs of mitigation programs. If these disposal techniques are sufficiently low in cost, they could also be a means to induce developing country participation in a climate change mitigation program, thereby overcoming another institutional barrier to implementing an effective mitigation program.

A long-term R&D strategy would include demonstration of a number of sequestration options and research into their possible environmental impacts; converting CO_2 into an industrial chemical feedstocks; other novel sequestration options, such as CO_2 fixation by micro-algae; selectively permeable membranes for CO_2 capture; processes for converting fossil fuels and biomass into CO_2 and hydrogen; development of hydrogen infrastructure technology, including transportation and storage; and PEM fuel cells.

As noted earlier, R&D into clean power generation and energy efficiency support many long-standing national goals and have been pursued for years. Carbon dioxide capture and sequestration, however, makes sense on a massive scale only in a greenhouse-gas constrained world. So, at least in this country, this area has been relatively under funded; since 1990 Japan has spent more than 30 times what we have on CO_2 capture and sequestration.

- within a zero-sum constraint toward Federal R&D resources that would necessitate reducing investments in other R&D areas, or

- expand the overall Federal R&D effort

2) Expand current partnerships with industry to focus on key CO_2 objectives through sectoral R&D initiatives in electric utilities, natural gas industry, industrial processes (e.g. Industries of the Future), transportation (e.g. PNGV), and buildings.

3) Lay the R&D foundation for longer-term radical energy system shifts, e.g. a hydrogen-based energy economy or building CO_2 sequestration technologies into the energy system.

4) Fiscal policy adjustments (not contemplated in this paper), e.g., accelerated depreciation for low-carbon technologies, tax credits for low-carbon technology development and deployment.

5) Design legislation to support CO_2 reduction goals, including reinventing environmental regulation to encourage energy efficiency investments as a key compliance strategy. Ensure that expected legislation, such as utility restructing, supports CO_2 goals.

6) Engage in internationally-coordinated R&D efforts, either under the aegis of a negotiated protocol to the Framework Convention on Climate Change or through other mechanisms.

FIGURE 4

DEMATERIALISATION

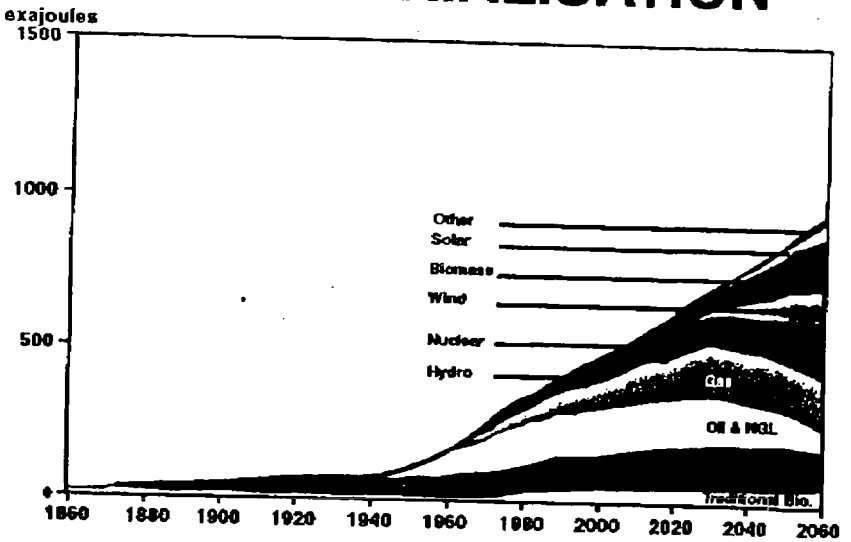
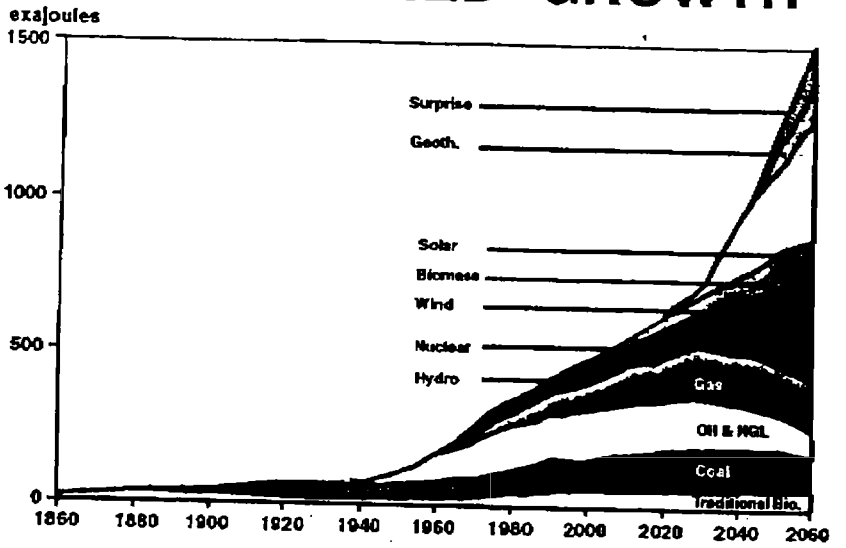


FIGURE 2

SUSTAINED GROWTH



FIGURES 3 and 5

CO2 EMISSION - FOSSIL FUELS

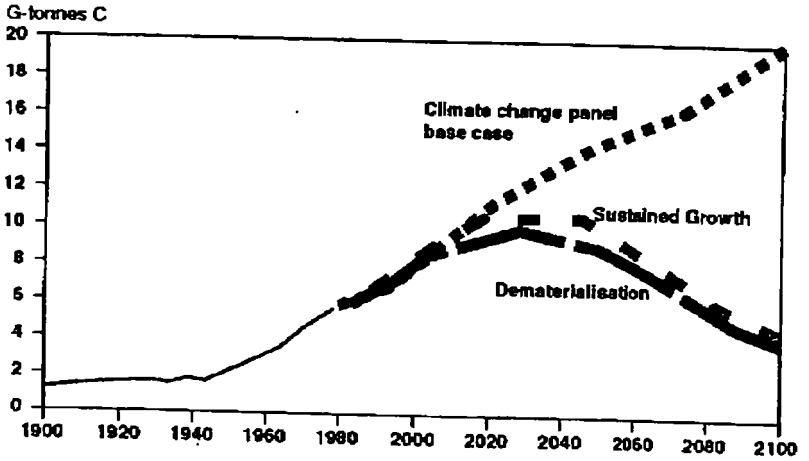
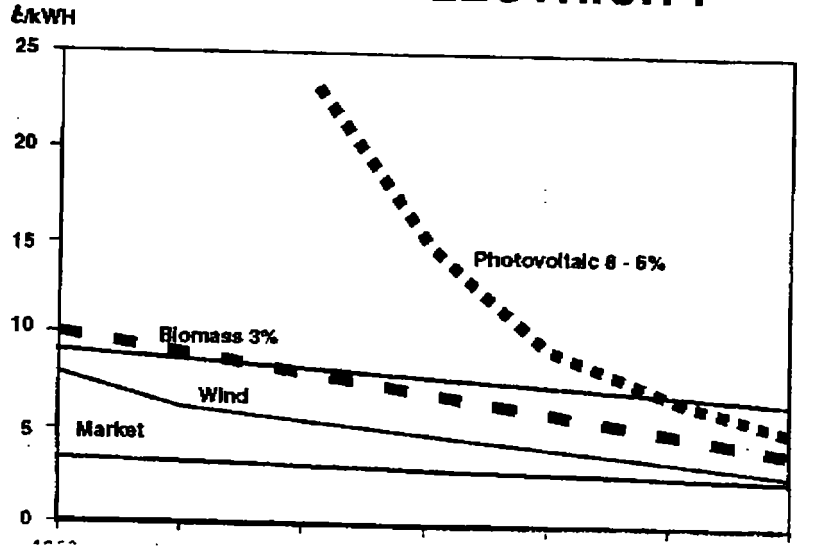


FIGURE 1

COST OF ELECTRICITY



LAST LAUGHS:

Jay Leno: "Our old buddy Boris 'Buy Me A Drink' Yeltsin is back on the job in Russia. He's looking good. He's got a new slogan, 'Four more beers! Four more beers!'"

Sen. John McCain: "We usually start with the oldest and most senile." (As 69-year old Sen. John Warner waited to testify at a Senate Commerce, Science and Transportation Committee hearing.) Sen. Warner, responding to McCain: "When I was Secretary of the Navy, I was your boss."

CEA Member Alicia Munnell: "Who am I? The Vice President's running mate?" (Responding to a question from an ignorant reporter this morning during a press conference. Munnell and Gore were touting the new economic news.)

WH Bulletin
1/31/97

ALICIA MUNNELL

Friday, January 31, 1997

10:10	Pre-brief on GDP #s, VP West Wing Ofc
10:30-10:55	Press Briefing on GDP #s, WH Press Rm
10:30	Conf Call (Housing Sales), x66755/66, Code 8692
11:30	HOLD-Radio Interviews on GDP, poc: Rica, x65664
12:30	CEA Lunch Seminar w/Pat Ruggles re Measuring Poverty
2:00	WEB (p)
3:00	NEC Mtg on Aging, Small/ Medium Enterprizes & G7 w/Tarullo, Rm. 231
4:00-6:00	Farewell Party for Eric Toder @ Treas, Diplomatic Reception Rm. (3rd flr)
7:45	British Emb Dinner for Mr/Mrs Joe Grice, 76 Kalorama Circle, NW w/HH (462-6212)

RELs: NAPM (AM) & Personal Inc (phone call) (JAF), Market Memo (JAF)

REVISED

The Initiative for a Caring World

1 The "Initiative for a Caring World" proposed by Prime Minister Hashimoto at the Lyon Summit is based on the idea that we can help each other to improve our societies by sharing experiences and knowledge on the broad issues concerning social security systems. As one step in putting this idea into practice, the OECD sponsored a High Level Conference entitled "Beyond 2000: the New Social Policy Agenda" in November 1996, in which developed countries exchanged views. On that occasion, it was agreed that each country would compile a national report based on a commonly defined basic format. These reports are expected to set the foundation for discussion in the OECD, particularly at the OECD Meeting of Social Policy Ministers to be held in 1998.

As regards co-operation with developing countries, Japan hosted an East Asian Ministerial Meeting on Caring Societies in Okinawa, in December 1996. The G-7 countries also participated in this meeting, which underlined the importance of building a social security infrastructure in developing countries

2. Our approach to this problem could, therefore, take two tracks. One track could focus on discussion of those problems particular to developed countries A consensus already seems to exist that the issue of the population ageing would be an appropriate topic of discussion at the Denver Summit. Concerning the second track, namely, co-operation with developing countries, the issue of emerging and re-emerging infectious diseases could be highlighted in our discussion among G-7 countries. Furthermore, the role of G-7 countries in supporting developing countries' efforts in the institutionalisation of social security infrastructure, including medical/health care and welfare services, could also figure as part of our discussion before and during the Denver Summit.

Japan has prepared two short papers which set out a possible basis for discussion: one on ageing populations (Annex 1), the other on emerging and re-emerging infectious diseases (Annex 2).

Annex 1: Ageing Populations

1. The G-7 leaders should give their political blessing and guidance to the analytical works currently being carried out in international fora, particularly in the OECD.

The OECD is already carrying out a study on population ageing. In the first phase of the study, problems caused by rapid ageing in the social policy areas such as public pension, health and long-term care have been analysed. The study has also examined the phenomenon of active ageing (including positive social participation by the elderly), as well as macroeconomic policy areas such as finance, labour and capital markets. The OECD is expected to expand its analysis in the second phase and to propose policy measures to deal with such selected problems as the effect of a growing burden of medical, health and long-term care for the elderly on public finance, employment of the elderly, and the effect of ageing on patterns of consumption and enterprise production. The OECD work should be encouraged by providing political support, and if possible, guidance on the follow-up of these works.

2. Apart from giving political support and guidance to the works to be carried out in the OECD, G-7 leaders could discuss the following policy issues:

What efforts have been made or are being considered to promote public understanding and consensus on the questions of reform in social security system?

What will be the effect of population ageing, along with the decline in infant birth rate, on the overall lifestyle, social mentality and political outlook of the general public?

How can G-7 countries promote co-operation in research and development in geriatrics and gerontology? This would entail co-operation not only in the medical field but also in other areas such as the development of supportive devices, housing, city planning, etc., with the view of dealing with the declining physical mobility which comes with age.

Annex 2: Emerging and Re-emerging Infectious Diseases

1. Improvement of information-sharing networks on scientific knowledge

Although there have been exchanges of information among various research institutions on infectious diseases, there is still room for improvement of information sharing networks among them.

In the process leading up to the Denver Summit, G-7 should discuss and elaborate how we should improve such networks of information on infectious diseases so that we can share information on the scientific knowledge of channels of infection, methods of prevention and treatment and other research-related expertise.

2. Improvement of the global surveillance system and emergency-response network

In order to effectively respond to emerging and re-emerging infectious diseases, it is important: i) to grasp correctly and share the information on the entire situation behind the outbreak of the diseases and emergence of bacteria resistant to antimicrobial agents; and ii) to ensure co-ordination among those responsible for surveillance and investigation and those responsible for medical treatment.

On the first point, several international monitoring systems have been developed to track the occurrence of infectious diseases. These include WHO's Weekly Epidemiological Record (WER), and Mortality and Mobility Weekly Report (MMWR) of the CDC(Center for Disease Control and Prevention). However, these systems are not linked to the national surveillance systems of individual countries, and the WER does not necessarily list information on all emerging infectious diseases such as viral haemorrhagic fevers.

On the second point, although several countries have dispatched surveillance and medical teams to prevent further spread of infection, it appears that there is room for improvement for more effective co-ordination among them.

It is, therefore, desirable that G-7 discuss how to promote close international co-ordination in strengthening the global surveillance system and improving international emergency prevention and medical system.

3. Prevention of infectious diseases in developing countries

To prevent and control the prevalence of infectious diseases in developing countries, it is important to improve basic health and medical care and the public health environment in those countries.

Developing countries which suffer infectious diseases are not in possession of medical infrastructure which can identify in an organised way outbreaks of diseases and arrange proper information networks and treatment facilities. To improve this situation is a gigantic task. As a first step, therefore, developed countries could jointly pick up some pilot projects in some selected countries or areas, which improve socio-medical infrastructure that can contain certain infectious diseases (e.g. through such projects, we could identify more clearly modalities of cooperation for developing countries in their fight against diseases).

In this connection, it may be worthwhile to consider holding an international conference (e.g. experts' meeting) on basic health and medical care and public health environment in Africa, a region most seriously affected by diseases.

Note: In a broad sense, "emerging and re-emerging infectious diseases" include HIV/AIDS. In this paper, however, we categorized AIDS separately because of difference in social factors and for other practical reasons.

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A. Quantitative analysis of private-sector job creation in SMEs

--SMEs account for more than half of all existing jobs in OECD countries
--SMEs are creating new jobs in proportion to their role in economy
--a small number of high-growth SMEs account for most of the SME job creation
--globalizing SMEs account for a disproportionate amount of the SME job creation

B. "Best practice" policies for SMEs

--financing
--business environment
--management capability
--access to markets
--regulatory reform

[C. Globalizing SMEs]

PHASE 2 OF AGEING PROJECT

PROPOSED WORK PLAN

The Ministerial Mandate

1. The Phase I report which was reviewed by Ministers in May (and is now published *as Ageing in OECD Countries: a Critical Policy Challenge*, Social Policy Studies No 20) called for a second phase of the work that would extend the analysis in the following areas:

- the economy-wide and international effects of pensions, especially with respect to private pensions, roles of financial market institutions and the regulatory environment, implications with respect to national savings and investment, inter-generational implications such as those related to wealth and equity, effects on international capital flows within and beyond the OECD area.
- effects of ageing on the labour market and learning. This would include a discussion of possible changes in labour market, education and training policies, wage-setting practices and the human resource practices of corporations.
- effects on a range of topics that were not discussed in Phase I -- including social protection for older workers, migration, housing and transport, and an assessment of equity and security from a life-course/generational perspective.
- non-market effects, including voluntary activity, learning, family care-giving and broader health and social effects.
- synthesis of existing data that shed light on ageing, life-course and generational trends and comparisons, together with proposals for future directions in data collection and analysis.
- advice on incorporating ageing and life-course considerations into the decision-making and consultative processes in Member countries, including considerations related to social marketing, transparency and accountability, and techniques that allow identification of the life-course and inter-generational effects of programs.
- best practices and lessons learned -- a practical review of the experience of countries in responding to the ageing challenges. This would be selective and limited to policy areas of highest priority.

Subsequent Events

2. Subsequent to the acceptance of the Phase I report by Ministers:

- With respect to the nexus of issues around pensions, savings and financial markets, ECO has identified 3 possible projects -- macro effects on saving, investment and productivity; the economics of pension reform; and the role of ageing on corporate governance. More recently, DAFFE has prepared a detailed proposal covering the role of financial institutions in private pensions schemes, funded pensions and financial systems, the regulation and supervision of pension schemes, statistics on funded pension schemes, and financial policy recommendations.
- the Secretary-General has underlined the potential importance of the Phase II work on ageing as a medium-term strategic priority of the Organisation.

- the Beyond 2000 conference underscored the importance of broad system-wide and life-course perspectives in the evolution of the welfare state.

- the Japanese initiative on a Caring World has created several possible linkages with our work on ageing. One involves a report on ageing in the context of the Denver Summit. The other is the Japanese proposal for country reports to prepare the basis for discussion at the 1998 meeting of Social Policy ministers -- this would provide a vehicle for reporting on lessons learned and best practices.

5. Peter Hicks has also been informally consulting people, both internally and also with the European Commission, various departments in Ottawa and Washington, and with several international bodies and researchers. His conclusion are that:

- the work-retirement transition is a central theme. It is of high priority in its own right and one which touches most other ageing issues -- working life flexibility, life-long learning, wage policies, work disincentives in social protection, as well as pension policies. *(It is the key interest of the Social Security Administration in Washington which has contributed $67.000 to our work.)*

- a broad focus on life-course perspectives is needed, as opposed to a narrow focus on demography. Successful policies are those that influence people as they age, not when they are old. *(Human Resource Development Canada has indicated they may contribute up to $200,000 given a work program with a life-path perspective.)*

- there should be a significant focus on the data and research needed to support ageing and life-course perspectives *(Statistics Canada may contribute $50,000 and do some work on this. The US National Institute on Ageing is interested in creating linkages between the considerable research it funds in this area and those who provide international policy advice. They may contribute funding towards this end.)*

- there is much interest in the broader effects on the labour market and productivity as people age, including effects on unemployment and the links to learning, wages and skills. *(People at the European Commission suggested that this is an area where the OECD is uniquely placed to add value.)*

- there would be much value if Phase II could clarify an often confused debate around the mix of public and private elements in the retirement income system -- particularly in light of the undoubted international consequences that are likely to flow from the coming US pension debate, a debate which is likely to be highly focused on private savings.

- the pension discussion needs to take better account of the wealth as well as the income position of older people, and the generational implications. *(The Netherlands has indicated an interest in contributing $100, 000 to support work in this area. The Americans express considerable concern about the future consequences for retirement income of a possible sharp decline in the value of housing assets.)*

- there is a need for a more integrated approach to the discussion of health and long-term care, and for including an analysis of invalidity among older workers. A particular concern has been expressed that raising the statutory age of entitlement to retirement benefits may increase the numbers of people in receipt of invalidity benefits.
- while it is not an area of OECD expertise, Phase II should have a better analysis of the family dimension to ageing. The evolution of family structures may well be as important as, and closely tied to, the market dimensions that were discussed in Phase I. For example, a discussion of the inter-generational implications of ageing -- or of care for the frail elderly or the adequacy of retirement income -- could be quite misleading if it is not tied to a family analysis.
- last, but perhaps most important, is the proposed focus on identifying and overcoming institutional obstacles to reform. It is the area which has attracted the most positive interest during informal discussions.

4. However, the Phase I report was well received not only because it was a broad, synthetic document, but also because it added value by producing new findings in a couple of key areas -- the new data on health by age, and the scenarios showing the fiscal effects of ageing, particularly the effects of the different pension reform scenarios. The challenge is to find the handful of central areas where new work by OECD in Phase II could have a similarly high payoff.

Proposed New Work

5. New work will be needed to compile and co-ordinate material on best practices and practical lessons. This will concentrate on areas of highest priority for most countries, including the work-retirement transition, the nexus of issues around pensions/savings and around health/invalidity/care, and overcoming institutional obstacles to reform.

6. In addition, it is proposed that new analytic work be undertaken in the following areas.

A. ***retirement income, savings, financial markets***: Two complementary packages of new work would be involved:

1. ***macro perspective***: household savings behaviour and government influences on that behaviour, government dissaving, regulation of private pensions, investment and financial markets, capital flows within and beyond the OECD Member countries. This would include the work along the lines outlined in the recent DAFFE proposal. ECO and DAFFE would take the lead on this work. The Development Centre has also expressed an interest in the international dimensions of this work.

2. ***individual perspective***: security, equity and sustainability in old-age provision, including assets etc., as well as the balance of pension income from a range of sources -- public, compulsory but private, tax-advantaged private, purely private. Unlike Phase I, which focused mainly on public pensions, this work would stress the potential role of capitalised pensions, the role of assets, etc. This would provide a framework for a substantive discussion of retirement income policy that focused on the ultimate goals of pension policy, as well as its fiscal and international financial dimensions. ECO, DEELSA and DAFFE would collaborate on this work.

B. ***labour market and lifelong learning:***

3. ***acquisition of skills***: making lifelong learning a real strategy for investing in human capital. The starting point would be the work-retirement transition, with emphasis on providing workers as they age with the skills needed to maintain their productivity and flexibility. DEELSA would take the lead on this.

4. ***utilisation of skills***: the other side of coin -- a review of the labour market and human resource development policies and practices that would allow workers, as they age, to productively use the skills they possess. Again, the starting point would be older workers, but the analysis would need to cover all workers; there cannot be separate practices for the old only. This would involve a discussion of an ageing work-force, wages, productivity, flexible enterprises, human resource practices, ageist discrimination, etc. DEELSA and DSTI would take the lead on this.

B. ***improving health, reducing dependency/invalidity and better care-giving***: This would build on Phase I, but would integrate the discussion of health and long-term care and would add an analysis of invalidity among older workers. DEELSA would take the lead on this.

C. ***building consensus and overcoming institutional barriers to reform***: This would assess ways of overcoming obstacles to the emergence of a social contract that reflects contemporary ageing, generational and life-course realities. To the extent that there is an ageing "crisis", it is not one of the demography per se, since this has been long understood. Rather it is crisis of governance -- the difficulties that governments face in incorporating long-term factors such as ageing into the policy process and in dealing with generational and life-course issues. DEELSA and PUMA would take the lead on this.

7. In summary, the work in Phase II would consist of:

- completion of the broad synthetic work of Phase I – filling a number of gaps and supporting the argument with consistent data;
- a focused, policy-oriented review based on the practical lessons that have been learned from country experiences in a handful of areas of highest priority;
- new analytic work in the six areas listed above.

Products

8. Phase II could have the following products:

- *final report* -- to Ministers for their Spring 1998 meeting. This would be short and action-oriented. It would identify the key areas for priority action, together with a review of practical lessons to be learned from the experience of Member countries in these areas.
- *interim report* -- a report intended mainly for the 1997 G7 summit, to be reviewed by OECD Ministers at their Spring 1997 meeting. It would have the same substance as the Phase I report, but would be short and written from the perspective of policy action. It would also report on the preliminary results of new work to the extent that they are available.
- *general publication* -- a longer document containing the policy analysis. It would be aimed at a wide policy-oriented audience and would be intended to build consensus around a practical ageing, generational and life-course approach to policy.
- *background documents* supporting the argument of the general publication -- especially ones related to detailed lessons learned and to data.

TIMETABLE

9. The key dates are the spring Ministerial meetings in 1997 and 1998.

end-November 1997	Modus operandi for management of project determined
mid -December 1997	Countries asked to identify experts. Internally, data requirements and processes for carrying out new work would be identified.
January-March 1997	Brainstorming by experts on the proposed areas of new work, based on issues papers. (In some areas, this could extend into the spring)
March 1997	Finalise input to interim report for the G7 and the OECD Ministers, if required
November 1997	Complete new research, data manipulations
December 1997-March 1998	Complete draft of final report for review by ELSAC and the other interested committees
March-June 1998	Submit report to Ministerial meeting.

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INSURANCE COMMITTEE

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Restricted

THE OECD AGEING PROJECT: PROPOSAL FOR WORK ON AGEING POPULATIONS, PENSION REFORM AND FINANCIAL MARKETS

This note by the Secretariat, is circulated for consideration under item 8b) of the Committee on Financial Markets agenda, and item 7a) of the Insurance Committee agenda

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Introduction

1. During the May 1995 meeting of the OECD Council at Ministerial Level, Ministers requested that the OECD "consolidate and analyse the policy implications of ageing populations with an initial report ... by 1996." The work on the requested report was executed as part of a horizontal project, with DEELSA, DSTI, ECO and DAFFE as contributing directorates. The resulting report, "Policy Implications of Ageing Populations" , was submitted for discussion and consideration at this year's Ministerial meeting (21-22 May 1996). Ministers requested the OECD "to disseminate the first report on the policy implications of ageing populations and further the analysis of the challenges in key policy areas ... and report back in 1998". **This note contains an outline of the proposed DAFFE contributions to this second phase of the study, with DEELSA, PUMA and ECO as the other contributing directorates. The focus of the analysis by DAFFE is on the relationships between ageing, pension system reform and OECD financial systems.** The proposed contributions to the ageing project are part of the 1997-1998 work programme approved by both the Committee on Financial Markets [DAFFE/CMF(96)10/REV1] and the Insurance Committee [DAFFE/AS(96)6].

2. Delegates of the Committees on Financial Markets and Insurance are invited to comment on the proposed outline of the contributions as well as the suggested plan of action.

Background

3. Most OECD countries face an outlook in which the elderly are becoming a significantly larger proportion of the population, while the working-age population is projected to shrink in most OECD countries and grow only slowly in others. These two trends are likely to exert considerable pressure on existing public pension systems in many OECD countries and this, in turn, could have a major negative impact on government finances (1).

4. These concerns have prompted OECD policy makers to initiate pension system reform programmes as part of a comprehensive reform of old-age security systems. An important reform trend in many countries is the shift to a greater reliance on funded pension schemes (as opposed to pay-as-you-go systems). The growing importance of funded pension systems, in turn, is putting the spotlight on the regulatory, supervisory and tax regimes of pension systems (notably asset allocation rules) and the role of financial markets in providing retirement income.

5. Taking into account the demographic and financial environment as described in paragraphs 3 and 4 the following sections outline contributions that the CMF and the Insurance Committee (IC) would provide to the ageing population project.

Role of financial institutions in private pensions schemes

6. This part of the study would provide a comparative analysis of the various types of private pensions schemes at the occupational and personal level and likely future developments in this field. Against this backdrop, the potential role of the financial institutions involved in private pensions schemes (pensions funds, insurance companies, securities firms and banks) in the context of the challenges arising from ageing populations would be analysed. Attention will be paid in this context to policy issues such as the complementary role of private schemes in relation to public schemes (interrelation between the three

pillars, features of the different private systems, etc.). This section would need to be drafted in close co-ordination with the other Directorates involved in the project.

Funded pension systems and financial systems

7. This section would analyse the impact of funded pension systems on the functioning of financial markets and the extent to which pension plan sponsors need well-functioning capital markets to run plans in an efficient manner.

8. Defined-contribution and defined-benefit funded plans have led to a significant accumulation of savings in the hands of retirement systems in many OECD countries, a trend that is likely to continue in the years ahead. In a number of other countries however, such pre-funded systems only play a relatively small role; if these countries reform their pension systems in the direction of funded schemes in response to the (projected) budgetary pressures due to ageing, there will be an increased concentration of vast amounts of savings under the control of funded pension systems.

9. Funded systems are likely to have an important impact on the functioning of financial markets via different financial intermediation functions (2). The growth in funded pension schemes (corporate, government and personal plans) implies that an increasing amount of savings need to be invested in the capital market in order to generate "adequate" returns on financial assets. Plan sponsors (employers, employees, government) need well-developed securities markets for the efficient execution of their investment strategies. The more efficiently a plan is run (measured by net investment returns), less contributions will be needed for defined benefit plans and, indirectly, for defined contribution plans. (It may be noted that analysts have calculated that an individual whose pension assets underperform his peer group by 1 per cent over a 35-year working life, will have a pension which is 42 per cent lower in value).

10. Conversely, a funded pension sector that can invest freely in financial assets (subject only to prudential rules) encourages the development of capital markets. In particular, pension funds can be significant forces in the development of stock markets insofar equities are used to enhance long-term returns. It is often claimed that a dynamic funded pension sector contributes to the development of capital markets in various ways (3): by raising the supply of longer-term funds; by improving the efficiency of fund allocation; by stimulating the modernisation of the capital market infrastructure; and by encouraging the demand for new capital market instruments.

Financial issues related to regulation and supervision of pension schemes

11. This part of the study would focus on the regulatory, supervisory and tax aspects of funded pension systems. These aspects determine to an important extent the freedom to manage and operate funded systems, including the execution of investment strategies (4). Regulation and taxation are also key determinants for understanding the growth (or lack thereof) of funded pension plans. For these reasons, additional information on the regulatory, supervisory and tax aspects of funded pension systems needs to be collected.

12. The expected increase of the role of funded schemes in pensions raises major issues for policymakers related to both the protection of the retirees and the conditions for the development of the private pensions markets. The importance of financial markets for the management of funded pension schemes implies that regulatory and supervisory aspects need to be carefully assessed. In several OECD countries, the present regulatory regime (e.g. minimum funding rules, portfolio restrictions, requirements

to employ domestic fund managers) may prevent pension funds from reaching an optimal risk/return profile. For example, a number of OECD countries require pension assets to be invested to a greater or lesser degree in their own government bonds; the free competition among fund managers may be limited by requirements to employ local managers or to manage funds internally; there are also limits on investing in foreign assets (5). Also, prudential rules (concerning, for instance, licensing, technical reserves and related solvency rules, disclosure rules, supervisory techniques, monitoring of financial and actuarial management) may have to be adequately considered or revisited in order to respond to technical, managerial and financial risks associated with the expansion of such schemes. Over-regulatory effects have, however, to be carefully avoided.

13. Considerations may also have to be given to the structure of tax provisions affecting funded pension schemes. Regulators and tax authorities should be encouraged to allow greater efficiency in investment management and pension plan administration. For example, in some countries tax laws discriminate against funded pension schemes; other countries impose taxes on contributions.

Non-level playing field between financial institutions

14. The different types of funded pension schemes operate under different regulatory and supervisory regimes. This raises the general issue of a non-level playing field for the different institutional players involved in the management of pension schemes on the financial market (6). This part of the project will focus in particular on the extent to which the playing field for life insurance companies, pension funds and other financial institutions offering "pension-type" products is non-level and the resulting degree of "unfair" competition (7).

Statistics on funded pension schemes

15. The Group of Financial Statisticians (GFS) has undertaken, and will continue, to collect data on the portfolio composition of pension funds within the framework of the "Institutional Investor" exercise carried out by the CMF. This part of the ageing project would aim to provide comprehensive and complete statistics to facilitate policy analysis. The database will be expanded by i) including investment performance statistics on the various funded pension schemes and ii) collecting information, on the basis of an internationally comparable methodology to be developed by the GFS, on the structure of contributions and benefits in relation to pension plans (8).

Financial policy recommendations

16. The study would conclude with policy recommendations regarding the contribution that financial markets can (and should) make to the efficient operation and management of funded pension systems and the impact of the various dimensions of funded pension systems on the functioning of financial markets. The following categories of policy recommendations are currently envisaged:

-- pension funds and the development of securities markets (equity and corporate bonds);

-- pension funds and the supply of risk capital;

-- pension funds and financial market infrastructure;

-- financial issues related to regulation and supervision of pension schemes;

-- non-level playing field in the supply of pension-type products.

Suggested plan of action

From an operational viewpoint, it is proposed to proceed as follows:

-- To incorporate in the study those parts of the work of the CMF on Institutional Investors that cover funded pension systems and the relevant part of the work of the Insurance Committee (IC) on private pensions.

-- CMF delegates have provided the Secretariat with a substantial amount of information concerning financial issues related to funded pensions systems as well as on several regulatory, supervisory and tax aspects of these systems, as part of the institutional investor project. Some additional material will need to be provided and incorporated. The regulatory sections of the project would benefit from the current work of the Insurance Committee related to the comparative analysis of regulatory and supervisory systems of pension funds and insurance companies, including solvency issues, and of their role in the future development of retirement systems (9). The study can also refer to the work of the Joint CMIT/IC Group on portfolio investment abroad by insurance companies and pension funds. CMF and IC delegates will also need to assess whether there are problems with a non-level playing field due to differences in regulatory and supervisory regimes of life insurance companies and pension schemes.

-- Several parts of the study are fairly technical (e.g. the structure of the various funded schemes, specific aspects of the different regulatory and supervisory regimes, special issues related to investment policies). It is proposed to discuss these more technical issues and their policy implications in a separate Experts' Meeting to which both CMF and IC Delegates will be invited.

NOTES

1. D. Roseveare, W. Leibfritz, D. Fore and E. Wurzel, Ageing Populations, Pension Systems and Government Budgets: Simulations for 20 OECD Countries, OECD Working Papers No. 168. OECD/GD(96)134.

2. See Institutional Investors and Financial Markets in OECD Countries, DAFFE/CMF(96)18/REV1, section 5.

3. Philip Davis, Pension Funds, Oxford, Clarendon Press, 1995; D. Vittas, Pension Funds and Capital Markets, mimeo, World Bank, 1995.

4. Institutional Investors and Financial Markets in OECD Countries, DAFFE/CMF(96)18/REV1, sections 2 and 6.2.

5. Portfolio investment abroad by insurance companies and pensions funds, DAFFE/INS(96)1

6. Institutional Investors and Financial Markets in OECD Countries, DAFFE/CMF(96)18/REV1, section 6.2.

7. Outline of prudential standards for pension business, DAFFE/AS(96)3

8. With the technical and methodological assistance of the Working Group on insurance statistics.

9. The Insurance Committee's specific work on solvency issues will be covered by the Group of Governmental Experts on Insurance Solvency.