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TEXT:

===== ATTACHMENT 1 =====

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TEXT:

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The following is a HEX DUMP:

The Continuing Importance of Trade Liberalization

Janet L. Yellen, Chair
Council of Economic Advisers
15 September 1997
National Association of Business Economists
New Orleans, Louisiana

The basic goals of the Clinton Administration's economic policies are simple and uncontroversial. First, to secure rising living standards now and in the future. And second, to ensure that the benefits of a rising standard of living are extended to all Americans. To attain these ends, the Administration's economic agenda has been based on three key policy initiatives: deficit reduction, investing in people through education and training, and opening markets worldwide to U.S. goods and services.

It is this third initiative--promoting free and fair trade--that I will focus on today. From his first days in office, President Clinton has advocated an outward-looking, "internationalist" trade policy. During the first four years of the Clinton Administration, over 200 trade agreements were ratified and implemented, some relatively large in scope--such as NAFTA and the Uruguay Round of GATT--others relatively small, but all vital to our nation's competitive future. President Clinton intends to extend and build upon this record during the Administration's next four years.

The single most important next step in the Administration's effort to open markets abroad and expand trade is for Congress to renew the President's authority to negotiate trade agreements on a "fast track" basis. This so-called "fast-track authority" allows the President to negotiate

trade agreements with other countries, and then requires Congress to take an up or down vote on the *entire* agreement. In other words, Congress cannot in effect reopen negotiations by adding or deleting individual provisions of a trade agreement by amendment during Congressional debate. Instead, Congress must vote on the agreement as a whole. Of course, the final decision as to whether the trade agreement--in its entirety--is approved or disapproved is still in the hands of Congress. Fast-track authority simply allows the President to seek approval or disapproval for the agreement as a whole.

Every President since 1974 has gotten fast-track authority from Congress. Why is it so important? The answer is that fast track lends credibility to trade negotiations. Under fast track, the parties to a trade agreement know that any provisions that are agreed upon cannot later be renegotiated individually, nor can such renegotiation be threatened.

History tells us that fast-track negotiating authority is critical: in the early 1970s, Congress failed to ratify the Kennedy Round GATT agreement in its entirety, and, as a result the Europeans refused to negotiate further trade agreements with the United States. For this reason, in 1974, Congress developed and passed legislation providing the President with fast track negotiating authority, and giving the President the credibility he needs to negotiate international trade agreements.

So, why do we need fast track authority today? And, what would the Administration use it for? The Clinton Administration would focus on three key areas for its use.

The first use for fast-track negotiating authority would be to complete the agenda that was

established in the Uruguay Round of GATT negotiations. At the end of the Uruguay Round negotiations, the United States, along with other countries, pushed for a timetable at which negotiations in different areas would resume. We did that, as did Europe and other countries, because we wanted more out of the Uruguay Round than we got. This year, we begin again the negotiations on government procurement; next year, we will begin intellectual property rights discussions; then we will begin talks on agriculture; then on services. Government procurement is a trillion-dollar market for the United States in Asia alone over the next decade; agriculture, a \$600-billion market globally; services, \$1.2 trillion market. The United States wants better access to those markets. And, we must have fast track authority before beginning discussions in these areas, otherwise countries will not put meaningful offers for market access on the table.

The second major use for fast-track authority is to extend the information technology agreement or ITA. The recently concluded ITA will reduce to zero tariffs on a range of information technology products: semiconductors, computers, telecommunications equipment, faxes, phones, integrated circuits -- a huge array of products in which U.S. firms tend to be highly competitive. The U.S. tariff barriers in those areas are either very low or zero. Asia's tariffs in these areas averaged 30 percent. With the ITA, the United States agreed -- with 43 other countries -- that tariffs on information technology products should be brought to zero across the board in all countries, by roughly the year 2000. We already have agreement among our trading partners for an ITA-2 -- which would expand the scope of the products encompassed by this extremely ambitious initiative. And, fast-track authority would be needed to expand that arrangement.

We are also considering seeking similar kinds of agreements in a number of other individual sectors where the United States is very competitive but global barriers tend to be high -- areas such as environmental equipment and services, medical equipment and technology, and transportation equipment. In all of these areas, it would be necessary to have fast track authority to negotiate a reduction of trade barriers.

Finally, the third area that fast-track will be used is for more comprehensive market access agreements with individual countries. Thus far, Chile has been identified as the first and most likely country for this kind of arrangement. Today, every major economy in this hemisphere--save the United States--has a preferential trade agreement with Chile. In practice, this means that U.S. firms face tariffs in Chile that make their goods 11 percent more expensive than those of competing firms from other countries. This is a serious competitive disadvantage.

The pace with which preferential trade agreements are being negotiated between and among countries around the world is fast. The United States could easily be left behind through inaction. Since 1992, other countries have negotiated 20 preferential trade agreements in Latin America and Asia that exclude the United States. The European Union has begun a process that will culminate in a free trade agreement with Brazil, Argentina, and other MERCOSUR nations; President Chirac of France has even gone so far as to declare that the economic interests of Latin America "lie not with the United States, but with Europe." And within South America itself, the four MERCOSUR countries are attempting to extend their preferential trade arrangements to encompass the entire continent. Moreover, other countries are aggressively pursuing expanded foreign trade. For example, China has targetted a number of Latin American countries--including

Chile, Mexico, and Brazil--for increased bilateral trade.

It is clear: now, more than ever, continued engagement with the global economy will require an active effort on the part of the United States. And, an extension of fast track authority must be an integral component of this effort. But, let's go back to a fundamental and important question: why is free trade so important? Why should we be concentrating so much effort in pushing for more open foreign markets, and how does freer trade contribute to the Administration's goal of securing higher living standards for all Americans? In short, what are the benefits of free trade for the U.S. economy? I will use the remainder of my time to address this question--which, in fact, speaks to my own comparative advantage as an economist.

I would begin by first saying that one of the benefits of free trade is not, as is sometimes supposed, an improved overall current account or trade balance. The Administration's policies do indeed affect the current account, but it is its budget, saving, and investment policies, not its trade liberalization policies, that do so. The current account is a macroeconomic phenomenon that reflects the gap between what we as a nation invest and what we save. The large budget deficits of the 1980s and early 1990s reduced the amount of saving that was available to cover the nation's investment in plant and equipment (investment was choked off too, but not by as much), and this shortfall had to be filled by importing goods from abroad. In an important sense, the nation was overconsuming in the 1980s, financing its consumption binge by borrowing output from foreigners. The result was a large and persistent trade deficit.

Today, we still face a trade deficit, but for a very different reason. Reducing the

government's budget deficit has left more room for investment in plant and equipment by the private sector. And invest it has: since 1993, real business fixed investment has grown nearly nine percent per year on average, a much faster rate than that of the preceding ten years. This rate of investment is above the rate at which Americans save--even with the federal government dissaving less by virtue of its smaller budget deficit. So, once again the shortfall is made up for by borrowing output from abroad, with the result being a current account deficit. But there is a big difference between borrowing in order to invest--as the economy is doing now--and borrowing in order to consume, as we did in the 1980s. In fact, running a trade deficit in order to expand the nation's productive capacity is not new to American history--in the 1800s, we did much the same thing in order to build up the nation's infrastructure, most notably during the railroad construction boom a century ago.

So, it is not the gap between imports and exports that is relevant as far as trade policy is concerned. But the level of trade--the "openness" of the U.S. economy--does matter. In recent years, the United States has seen rapid growth in its degree of exposure to the world economy: real U.S. imports of goods and services grew at an average rate of 11 percent over the past four years, while real exports grew at an average rate of 10 percent per year. In the current recovery, export growth has been responsible for roughly a third of overall GDP growth. The United States now exports an amount equal to 13 percent of its GDP every year and imports an amount equal to 15 percent of GDP; to put these figures in perspective, the corresponding figures for the 1960s were four and five percent, respectively. The American economy is now more open than at any time in its history.

What are the benefits of an open economy? Economists generally recognize two broad classes of benefits, the first being static, the second dynamic. I would like to discuss each in turn.

Ever since the work of Adam Smith and David Ricardo, economists have recognized that trade helps an economy by allowing it to specialize in what it does best. Adam Smith argued that specialization--the division of labor--enhances productivity, but noted that the degree to which an individual or a nation could specialize depended critically on the extent of its market. We all know the story of Robinson Crusoe, who, alone and isolated, had to do everything for himself: farm, weave cloth, build shelter, and so on. But if a group of Robinson Crusoes can trade amongst themselves, each can specialize in the production of what he or she is best at doing--thus producing more than would be possible were their attentions divided among goods which they are less skilled at making--and then can trade with his or her neighbors for the goods which they in turn are good at producing.

It might even be the case that one individual (or country, to drop the Robinson Crusoe analogy) is better than anyone else at producing *every* good. Such an argument is often invoked in order to “prove” that the U.S. cannot benefit from trade with a country such as Mexico. But it turns out that the argument in favor of free trade still carries the day. All that is required is for a country to be *relatively* less skilled than another in the production of some good in order for it to benefit from trade. This is, of course, the doctrine of comparative advantage--the fundamental (if perhaps counterintuitive) principle that underlies the theory of international trade.

This, in a nutshell, is the “classical” view of the benefits of free trade. It is important to note that the benefits from trade under the classical doctrine are primarily static in nature--that is, they affect the *level* of output. Moving from a situation in which there is less trade (or no trade) to one in which trade is freer raises output, but this is more along the lines of a one-time increase (even though it might take a number of years for the benefits from trade to be fully felt). This is not to dismiss the significance of these static benefits: for example, some economic historians have argued that most of the economic growth that occurred in the classical world was rooted in the expansion of markets that took place as a result of increased sea trade around the Mediterranean.

Recently, a new view of international trade has emerged which argues that increased trade actually raises an economy's *rate of growth*. If this is in fact the case, it makes the case for trade liberalization an even more compelling one. Raising the growth rate of the nation's economy, even by a few tenths of a percentage point per year, has vastly more significance for long-run living standards than even a relatively large one-off increase in the level of output; the reason, of course, is that a small increase in the economy's rate of growth cumulates over time to yield large gains.

What is the rationale behind the new trade theory--in other words, what is the source of the “dynamic” benefits from trade? Well, we know that economic growth has two sources: either we can increase the amount of inputs (capital, labor, and raw materials) that we feed into the productive process, or we can make those inputs more productive, through innovations in technology, better education and training, and so on. (In fact, this latter factor is necessary if the economy is to grow in per-capita terms in the long run, as sooner or later simply accumulating more inputs will run up against the law of diminishing returns.) The static benefits of trade

represent a one-off increase in this latter factor: specialization lets us allocate labor and capital to the production of goods that we are relatively good at producing, making a given amount of labor and capital more productive in a manner that is not unlike an improvement in managerial technique.

The new view of international trade also focusses on this second factor, but argues that international trade can actually increase the rate of innovation and technological change. One economist has summarized the argument with the following catena:

- International trade leads to greater competition;
- Competition induces greater innovation; and,
- Innovation (*i.e.*, technological change) drives economic growth.

(It's a simple notion once you think about it--though it will probably win the economists who thought it out a Nobel prize some day.)

In a sense, the emphasis of the new trade theory on the dynamic benefits of international trade comes full circle to Adam Smith. Although Smith's contribution to trade theory is generally seen as providing an argument in favor of free trade that highlighted the role of specialization in raising productivity, he also pointed out that specialization, by acquainting workers with a specific productive process, could give them insight into how such processes might be improved--thus fostering innovation. New trade theory also incorporates elements of Joseph Schumpeter's theory of "creative destruction," in which the competition that is a fundamental feature of a capitalist economy serves as a motive force for the economy's progress.

The new view of international trade represents a valuable contribution to academic economics. But theory alone cannot provide an airtight argument in favor of trade liberalization. There is, however, a large body of empirical literature which attempts to determine what drives economic growth across countries. Unsurprisingly, investment in physical capital--plant and equipment--and investment in human capital--education, for instance--are two factors which have a profound influence on economic growth. But these same studies have also found that an economy's degree of openness--as proxied, say, by the amount that it imports and exports relative to its overall output--has an effect on its rate of growth.

In an ideal world--the world in which economists live--free trade unambiguously benefits the economy *taken as a whole*. This is true in the real world as well, although the ideal case masks the fact that some will gain from freer trade, but others may lose--even though on net the winners could compensate the losers and still have something left over. In practice, increased globalization will induce reallocations of labor and capital across sectors as the focus of American industry moves to the production of those goods and services which we are relatively good at producing. Because our economy is not frictionless, these adjustments sometimes involve lengthy periods of dislocation until the reallocation of labor and capital across industries is complete.

Policy makers advocating freer trade must be aware of this fact, and the Clinton Administration has realized from the beginning that it is the government's duty to minimize the impact of this dislocation by speeding up the adjustment process however it can. For example,

one of the key provisions of NAFTA involved monitoring those industries that were in danger of being adversely affected by the free trade agreement, and the Administration committed itself early on to providing for dislocated workers through retraining programs. And, more generally, the Administration's commitment to investing in people through education and training serves as a strong complement to its policy of trade liberalization: since freer trade tends to benefit skilled workers most, the United States enjoys greater benefits from trade to the extent that more of its workers are highly skilled. In the end, though, those who would point to the short-term adverse effects of trade liberalization should not lose sight of an important point: Trade liberalization might adversely affect a small fraction of American workers in their role as producers, but it benefits all workers in their role as consumers.

Bottom line is: the benefits of increased openness and increased international trade are wide ranging -- more efficient utilization of resources, faster productivity growth, higher quality goods, and lower prices, all of which raise living standards.

Finally, in closing, I would note that I have said nothing of the benefits of trade that arise simply from the fact that it links the economic interests of nations more closely. John Maynard Keynes once argued that the greatest tragedy visited upon Europe by the First World War was the disruption of the system of international trade that was a hallmark of the European economy before 1914. The eventual breakdown in the world trading system and resulting deterioration of Europe's economy was a proximate cause of the Second World War, and kept living standards in Europe and the U.S. much lower for much longer than was necessary by prolonging the Great Depression. It is only in recent years that the scope of international trade has returned to the level

seen before the Great War.

The United States is now more closely tied to the rest of the world by trade than at any other time in its history. How the U.S. economy performs relative to the economies of other nations will depend critically on how we promote our commercial interests abroad. Aggressive pursuit of trade liberalization, for which fast track authority is a prerequisite, is the best way to ensure that the U.S. maintains its position as the strongest and most innovative economy in the world.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Jeffrey A. Frankel (CN=Jeffrey A. Frankel/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:17-SEP-1997 21:36:06.00

SUBJECT: draft of Targets and Timetables paper

TO: Adele C. Morris (CN=Adele C. Morris/OU=CEA/O=EOP @ EOP [CEA])

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CC: Randall W. Lutter (CN=Randall W. Lutter/OU=CEA/O=EOP @ EOP [CEA])

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TEXT:

I attach the current version of the paper.

Janet, perhaps you could read the Executive Summary at this time.

In the body of the paper, I know the description of model results still needs a lot of work to make it more readable (perhaps including a re-organization along the lines of the Executive Summary). The draft still to some extent reflects its origins as a means of keeping track of model results as they came in. Also I would like to add a description of the EMF results , and beef up the discussion of Table 4 (and the other results tabulated in our master table of model results), as well as the later Richels results. Also all the numbers should be fact-checked.

Adele and Joe: How would you like to take over the draft at this point, and revise those sections describing the model results? Or else I could keep working on it for another two days, if Thursday and Friday are full days for you.

Currently there is little discussion of "wishful thinking" and JI in the draft, nor of the magnitude of international transfers. All three topics could be easily added. I would be happy to do it, if it seems desirable.

You should all let me know how you would like to proceed, because I would like to get this wrapped up soon.

(Needless to say, this paper is very sensitive.)

Thanks

JF===== ATTACHMENT 1 =====

ATT CREATION TIME/DATE: 0 00:00:00.00

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Targets and Timetables : Executive Summary

A consideration of targets and timetables raises the question as to how ambitious to be in seeking to ameliorate global climate change. But it also raises the question as to whether it is advisable to reduce emissions of greenhouse gases (GHG) early and rapidly, or more gradually. This paper reviews the academic literature and other relevant information and analysis. It concludes that a given environmental goal, expressed in terms of the level at which atmospheric GHG concentrations are induced to level off, can be attained at far lower economic costs if emission reductions are phased in gradually rather than suddenly. More specifically, it concludes that a moderate path such as "eliminate emissions growth by 2010-2020, and return emissions to 1990 levels by 2040," is to be preferred to the more aggressive alternative "return emissions to 1990 levels by 2010."

1. The factors at work

It is easy to state the basic forces at work in the trade-off between front-loaded and back-loaded emissions reductions. Four factors work in favor of back-loading:

- the time-value of money (resources not spent on emission reductions early on can be invested at a positive return, so as to purchase more emission reductions later),
- allowing for uncertainty to be resolved,
- giving more lead time to develop and implement new technologies.
- allowing time for the capital stock to turn over. By way of stylized illustration, scrapping all coal-fired power plants by 2010 would mean writing off 88% of the capital stock in this sector; waiting until 2020 would necessitate scrapping only 49% of the plants before the end of their normal useful life.

The most important argument in favor of front-loading concerns political credibility:

- an announcement by the world's governments that they are committing to a serious agreement -- but that stringent policy measures will not be taken until 50 years or more into the future -- will not be credible. Only early concrete measures will send the signal necessary to move patterns of research, investment, and consumption onto the new path.

2. The costs of "1990 levels by 2010"

The costs of reducing emissions to 1990 levels by 2010, as the cost of any path, depend heavily on what is assumed about the international regime and domestic implementation. "We can do it smart or we can do it dumb." But any effective program will have to raise the cost of GHG emissions, particularly the cost of using fossil fuels that put carbon dioxide into the air. A broad range of models place the carbon permit price required to achieve this target in the range of \$70 - \$200 per ton. This surcharge translates into an increase in the price of gasoline between 18 and 50 cents per gallon and an increase in the price of coal between 250 and 500 per cent. Averaging over fuels, it is nine times greater than the BTU tax that was proposed in 1993, and as great as the oil shocks of the 1970s. (The necessary increase in price could be cut if we are able to pay Russia, developing countries, or others to reduce emissions in our place. But the remaining

price increase would nevertheless be substantial.)

These increases in the price of energy might or might not have substantial negative effects on output as did the 1970s oil shocks. The answer depends on many things, such as whether the policy is implemented efficiently (e.g., by auctioning emissions permits or a carbon tax) or inefficiently (e.g., by command-and-control style regulation), and whether any revenues that may be generated are redistributed by means of tax cuts that lower the cost of capital to firms. In any case, the policy will have substantial negative effects on consumption, in order to free up resources for investment in new low-carbon plant and equipment.

3. The effects of peaking in 2010-2020

A more moderate path would:

- (i) begin to reduce the rate of growth of emissions in the near-term (2000-2010)
- (ii) eliminate emissions growth in the medium term (so that emissions at the end of the decade 2010-2020 were the same as at the beginning), and
- (iii) return emissions to the 1990 level in the longer term (e.g., 2040).

The overall cost of this approach is much less than that of the more aggressive timetable. Estimates suggest that the price of carbon would be between \$5/ton and \$12/ton in 2010. (It would have to continue to rise thereafter, as is also true under the first approach.) Gas prices would rise by an estimated 2 to 3 cents, and coal prices by 25%-35%. Effects on the economy are scaled down accordingly. Estimates of the loss in consumption are roughly 1/10-1/3 the size of the more aggressive approach.

4. A comparison of paths assuming the same eventual emission levels

The natural question to ask is: what is the environmental loss that the planet must bear in exchange for this economic gain? The answer depends entirely on what is assumed about emissions during the remainder of the 21st century (and thereafter). Differences in emissions in the early years of the century are virtually negligible in their direct implications for the cumulative concentration levels. But "even the longest journey begins with a single step." Differences in that first step are important to the extent that they begin the journey down different pathways.

Let us first consider what happens if, after re-attaining 1990 emission levels -- whether in 2010 under the aggressive approach or 2040 under the moderate approach -- emissions remain at that same level for the remainder of the century. This assumption, on the one hand, implies a growing gap with the business-as-usual growth path while, on the other hand, entailing insufficient cuts to stabilize concentrations in the atmosphere. The "1990 by 2010" path only reduces the warming by an estimated 0.08 degrees centigrade in 2050 and 0.21 degrees in 2100. (Even a more aggressive path of 10 percent emission cuts by 2010 has virtually the same small effect, to one decimal place. This is relative to a warming of 1.06 and 2.36 degrees, respectively, under business as usual.) The date at which concentrations reach double pre-industrial levels is postponed by an estimated 9 years. How much of these environmental benefits are achieved by the moderate path? Warming is mitigated by 0.06 degrees in 2050 and 0.19 in 2100. No difference, to one decimal place.

5. A comparison of paths assuming the same eventual emission levels

Concentrations and temperatures continue to rise in subsequent centuries, under any of the paths just discussed. In order to put a bound on the magnitude of eventual climate disruption, one

has to put a bound on the magnitude of concentrations. Doing so requires reducing emissions below 1990 levels.

Perhaps the strongest case against an aggressive path like "1990 in 2010" is that *the same ultimate goal in terms of concentrations* can be achieved far more cheaply by imposing aggressive cuts in emissions later in the 21st century rather than earlier. It is possible to compute the path that minimizes the total economic costs of attaining a given ultimate concentration target. An estimate of the least-cost path, of those that eventually cause concentrations to level off at twice industrial levels (i.e., to 550 ppmv), is relatively gradual in the early years. The least cost mitigation path has emissions from Annex I countries peaking in the decade 2020-2030. The peak of emissions is 29 percent above 1990 levels. Annex I emissions do not return to their 1990 levels until after 2050. This experiment assumes that developing countries are successfully brought in to the agreement, with their participation phased in between 2030 and 2050. Emissions from developing countries peak in 2050. (Without the participation of the developing countries, attaining the target of 550 ppmv concentrations is virtually impossible, since they are such a rapidly growing share of world emissions.) This least cost mitigation path generates quite low values for carbon emissions rights in the early years. The permit price is only \$2/ton in 2010, and slowly rises thereafter. Only in the latter part of the century does it rise significantly, to \$156/ton in 2100. The least cost mitigation path costs the U.S. \$0.124 trillion in terms of lost consumption (present discounted value), as compared to \$0.303 trillion under the "1990 in 2010" path. Thus the least cost mitigation path generates savings of 60 percent from the 1990 in 2010 path. Assuming that environmental effects depend on concentrations, there is no little or no environmental cost to be weighed against the large economic benefits of going more slowly.

It is important to keep in mind that all these cost estimates are "best case" scenarios, in the sense that they assume efficient market implementation, international trading, and full international participation and enforcement. Actual costs could be much higher if less efficient command-and-control mechanisms of implementation are used, if there is not effective international trading, or if some countries do not accede to or abide by a treaty.

6. Political credibility

A path under which emissions peak in the decade 2020-2030 is far more conservative than the paths that have been discussed in international negotiations. The strong argument for moving the timetable forward is the one mentioned above: political credibility. The year 2020 is more than twenty years in the future. A path under which emissions peak in the decade 2010-2020 represents early commitment to a tangible target ("eliminate emissions growth"), while estimates suggest that it is almost as beneficial as the least-cost path. The political credibility of the path could be further boosted by commitments at earlier dates such as 2000-2010 ("reduce emissions growth"). Credibility would be particularly enhanced by a specific proposal to raise the price of energy, even if by only a small amount, if domestic political opposition was not overwhelming.

More aggressive paths are likely to arouse greater political opposition, in correspondence to their greater economic cost. Where domestic opposition is sufficiently great to kill a proposal politically, the set-back will be to international political credibility -- and to environmental progress. The last section of the paper, however, discusses one possible option for helping to limit the economic cost and corresponding domestic opposition, for any given target/timetable: an escape clause triggered by the price of carbon emissions.

Predecisional draft. Very preliminary. Close hold. Do not distribute

Targets and Timetables

A U.S. proposal for "targets and timetables" for reducing countries' emissions of greenhouse gases (GHG) must be made soon. The U.N. Framework Convention on Climate Change has called for economically cost-effective remedies to the problem [cite? From JY]. Tradeoffs have to be made -- both with respect to the ultimate target and with respect to the timetable under which it is achieved. The subject of this paper is how to do them. (The paper does not directly focus on two other key sets of policy decisions -- domestic implementation and proposals for developing country participation and other sorts of "when-and-where flexibility".)

It is futile to search for a single comprehensive econometric model within which these questions can be appropriately raised and definitively answered. Even within a given model, answers depend critically on the precise nature of the question asked (e.g., the extent of global participation and international trading, whether and how any revenue is recycled, what is assumed about technological progress, etc.) Furthermore, each model has strengths and weaknesses; each has questions to which it is better or worse suited to answer. Some, for example, model the energy sector in detail. Some allow for the fact that a coal-fired power plant cannot costlessly be converted to one that runs on natural gas. Some have enough tax policy detail to distinguish alternative ways of redistributing tax revenues. Some are capable of showing short-term macroeconomic disequilibria. Some include a long-term "carbon cycle" model that can keep track of the accumulation of GHG concentrations in the atmosphere and their climatological effects. Some break down the rest of the world into regions and so can model international trade. No one model does everything.

The existence of modeling difficulties does not mean that we can abandon rigorous economic analysis. Rather, we must employ a broad set of economic tools to analyze the policy options. The tools employed in this paper include results from models of the energy sector and economy over the next 25 years, including but not limited to the models that were used by the Interagency Analytical Team (IAT) earlier in this year. The survey also includes models that are designed to operate on the longer time frame that is relevant for thinking about climatological effects. Other tools include simple relevant statistics, "meta-analyses" of existing models, historical and sectoral examples, and basic economic reasoning. Drawing on this broad array of analytical tools allows an intelligent evaluation of the policy alternatives.

1. Why do economists estimate high costs to early reductions in emissions?

The large economic impact of aggressive action

The measures necessary to implement serious reductions in GHG emissions would inevitably have very major effects on the U.S. economy. One path that has been widely discussed in the U.S. is to return to 1990 levels in 2010. (Still more aggressive paths seek to cut emissions 10 percent or more below 1990 levels by 2010. Intermediate paths are to return to 1990 levels by 2020, or to 10 percent above 1990 levels by 2010.) Estimates suggest that to reduce 2010 emissions to the level of 1990, it would be necessary to increase the price of energy on the order of \$100 per ton of carbon.

This is a rough midpoint, around which there is a great range of uncertainty. The range of

estimates in the IAT exercise was \$80-\$140, for the case without international trading. Some agencies believe that the necessary increase in price would be less than this, others that it would be more. [These estimates are representative of the broad economic literature. References.¹] It is anticipated that prices would have to continue to increase after 2010, even if emissions were not brought down any further, because of the widening gap vis-a-vis the business-as-usual case. Energy modelers often make the assumption that, once the price of carbon goes high enough, some sort of unidentified "back-stop technology" will eventually be developed, thereby putting a limit on how high the price ultimately goes.

The estimate of \$100/ton in 2010 represents an increase in the price of oil of \$11/barrel (52%), an increase in the price of gasoline of 26 cents/gallon, and an increase in the price of coal of 273%. One standard of comparison is the BTU tax that the Administration proposed in 1993. The increase contemplated here is 9 times larger. (This is for a weighted average of fuels. The multiple for coal is greater than this, and for oil is less.)

These large price changes signal major changes in the allocation of resources across activities and sectors. Need they require a reduction in the rate of growth of aggregate income and output? This depends, in particular, on two things. First, adjustment costs can impose a negative effect on GDP and employment, especially in the short term. (Model estimates of GDP losses from "1990 by 2010" reached ___ in the IAT exercise under some pessimistic assumptions, and are higher in some other estimates. ____.) Second, if measures to raise the price of energy result in the generation of revenues for the government, and they are used to reduce the cost of capital to firms (e.g., by means of an investment tax credit), then negative effects on economic growth can in the long run be moderated, eliminated, or possibly even reversed. The meta-analysis of 162 simulations derived from 16 leading models by Repetto and Austin (1997, p.13) concludes that the negative effect on national income can be offset or reversed *if*:

- (i) tax revenues are recycled in the optimal way,
- (ii) developing countries participate in the agreement, *and*
- (iii) optimistic assumptions are made regarding the availability of non-carbon backstop technologies, efficient economic responses, and increased energy and product substitution.

However, the best single measure of aggregate economic costs is the appropriate summation over time -- the present discounted value -- of foregone consumption. Even in a case so optimistic that there might be no effect on output, early action to address climate change requires a diversion of resources from consumption to investment. Thus the present discounted value of consumption is likely to fall. By way of analogy, defense build-ups have appreciable economic costs, in terms of foregone consumption, even though there is often little or no negative effect on aggregate GDP.

Analogy with the oil shocks of the 1970s

¹ The range of variation across models reported by the Energy Modeling Forum, based in Stanford, is at least as large. Gaskins and Weyant (1993) and EMF (1994).

A standard of comparison for judging the magnitude of the price increases entailed in climate change policy is the oil shocks of the 1970s. The energy price increase now contemplated [an estimated 88 percent], for stabilization by 2010 is on the same order of magnitude as either the 1973-74 or 1979-80 oil price increases. Again, this is for a weighted average of primary fuels. Fossil fuel prices net of inflation doubled between 1972 and 1975, and doubled again by 1981. Gasoline prices rose by 30 percent between 1972 and 1974 and by nearly another 50 percent from 1974 to 1981. Coal, as a substitute for oil, also experienced a price increase in the earlier episode, but by much less.

One can check independently how the price increase necessary in the present context compares to those of the oil shock decade. Carbon emissions in the year 2000 will be about 15%__ (?) percent above 1990 levels. Between 1973 and 1984, U.S. energy use departed from its usual growth trend, and was essentially unchanged in absolute terms. U.S. emissions fell by only 6.2%. This comparison suggests that to return emissions to 1990 levels between 2000 and 2010, a decline of 15%, would require much greater increases in energy prices than took place over the decade of the oil shocks.

Those price increases, which are designated "supply shocks," are widely believed to have led to high levels of inflation that were eventually reversed only by means of high interest rates and very large losses in output over time. More specifically, they are believed to have led directly to the recessions of 1974 and 1980. (Indeed, the contraction in output, as much as the fall in the energy/output ratio, was a prime force reducing energy use below its long-run trend.) Some economists also believe that the oil shocks may have played a role in the abrupt slowdown in the long-term trend of productivity growth evidenced in the U.S. and other industrialized countries after 1973; but that is much less certain.

The large models that have been used to examine climate change policy tend to exclude supply-shock effects. [Only the DRI model is a macro model capable of addressing these effects; and it shows a loss of only 150,000 to 400,000 jobs in 2010.] The idea is that a path of gradual increases in energy prices will be fully built into the expectations of firms and workers, because of clear commitments to future policies. Thus they will be able to plan ahead and avoid serious microeconomic dislocation and macroeconomic disturbance. Furthermore, the 70s oil shocks entailed large transfers from the U.S. and other oil-importing countries to OPEC, thus depressing real income and spending in the former; a self-imposed energy price increase to address global climate change need not entail such a transfer of purchasing power. Still, if it is contemplated to introduce large increases in energy prices over a period as short as a single decade, it is worth remembering the experience of 1972-81. [Some further details are available in a separate memo.]

The role of turnover of the capital stock

Why do economic models consistently find that the cost of major reductions in emissions is much higher if they are implemented by 2010 than if they are stretched out for another decade or more? There are several arguments for waiting. They include

(1) the time-value of money (resources not spent on emission reductions early on can be invested at a positive return, so as to purchase more emission reductions later²),

² Meanwhile, a higher fraction of carbon emissions will have been naturally removed from the atmosphere by a fixed date, e.g., into the oceans, the earlier those emissions occur.

- (2) allowing for uncertainty to be resolved, and
- (3) giving more lead time to develop and implement new technologies. (There are also a number of reasons for wanting to go fast, listed in bullet form in the Section on cost-benefit analysis below.) But the most important reason for waiting is :
- (4) to allow time for the capital stock to turn over.

The basic point is that it would be very expensive to scrap the entire capital stock, to replace it with more carbon-free plant and equipment, while it is still in the prime of its useful life. But 20 to 40 years out into the future, much of our existing plant and equipment will be ready for replacement anyway, whether because the plant and equipment have depreciated gradually or because they have more suddenly come to the end of their useful life.

[FIGURE 1 GOES HERE]

The effect of the turnover of the capital stock is built into some of the models used to address climate change [e.g., Markal Macro; though not into most “bottom-up” engineering studies, like the Department of Energy’s Five-Labs study]. But it may be useful to look at a simple illustration of the point, for the case of the capital stock in power generation.

Figure 1 shows the effects of an accelerated replacement schedule for all of the 7,900 electric power plants built during the last 40 years. [One could skip directly to coal-fired plants, to save space.] Imagine, to take an extreme case, that all power plants had to be shut down within ten years (by 2007), and replaced with less-polluting technology. This would imply replacing 6,330 plants before the end of their normal lifespan, or 80 per cent of the total. Now imagine a policy that required replacement of all power plants in 20 years. This would constitute an accelerated replacement of 4,600 plants, or 58 per cent of the total. If one could wait 30 years, the complete replacement would mean an accelerated replacement of 2,000 plants, 26 per cent of the total. If one waited forty years, under the stylized assumption of a 40-year life there would be no additional cost to replacing them. [We have truncated the distribution at 40 years, the average lifespan of existing electric power plants. There are other plants that are still in use 50, 60, or even 90 years after they were built. But their numbers are small, and by the end of 40 years the cost of shutting them down would in any case be much-reduced, particularly as technology will have advanced in the meantime.]

Figure 2a does the same exercise for the set of power plants that are coal-fired. This is the class of generators that produce the most carbon and that would thus have to be replaced even under a moderate plan to address climate change. If a complete change-over of coal plants were to be accomplished in 10 years, 799 of the 1,122 coal-fired plants (71 per cent) would have to be replaced before the end of their expected lifespan. If replacement occurs over 20 years, 488 plants would be affected, or 43 percent of the total. If one could wait 30 years, 227 plants would be closed prematurely, or 20 per cent of the total.

Perhaps a comparison between 2010 and 2020 would be most relevant, as these two years figure prominently in the targets-and-timetables debate. In our stylized hypothetical experiment, imagine that all power plants had to be shut down by 2010 (i.e., within 13 years). This would imply replacing 88 percent of the plants before the end of their normal lifespan. Now imagine that all power plants had to be replaced by 2020 (23 years). This would constitute an accelerated replacement of only half the plants.

[FIGURES 2a AND 2b GO HERE]

Figure 2b repeats the exercise on the basis of coal plant capacity. Since newer plants tend to have larger capacity, the effects of a rapid replacement schedule are magnified. Closing all plants within 10 years implies that 289 million KW of capacity would be prematurely shut down, or 90 per cent of the total. If one could wait 20 years, 235 million KW of capacity would be affected, or 73 per cent. For 30 years, the capacity that would have to be replaced falls to 116 million KW, or 36 per cent of the total.

This exercise is not intended to be an estimate of the costs of different time-tables, even within this one sector. Rather, the point has been to illustrate concretely the importance of allowing time for the capital stock to turn over, and to illustrate it in a transparent framework that is independent of modeling assumptions over which analysts might differ.

One can pose the question regarding effects of alternative paths in three ways. (I) How do the economic and environmental effects of "1990 by 2010" compare to those of more moderate paths, e.g., in which that level is attained at some later date? (ii) What are the economic effects of alternative paths toward the same ultimate environmental objective, e.g., eventual stabilization of concentrations at twice pre-industrial levels? (iii) What is the optimal unconstrained path to balance estimates of economic costs and environmental benefits? We will consider each question in turn, though in reverse order.

[or would it be better to do it in order (I) (ii) (iii): 1990-LEVEL RESULTS, THEN 550PPM CONSTRAINT, THEN IA MODELS?]

2. Cost-benefit analysis in the Integrated Assessment models

It is difficult to put economic costs and climate benefits into the same unified analytical framework. This is in part because the effects are so uncertain, especially with regard to climate, and in part because the climate effects take place on a very long time scale. So-called Integrated Assessment models attempt to put everything into one framework. They attempt to quantify the benefits of averted climate change in the distant future, as well as the economic costs of programs to address emissions, and to compare the two.

Integrated Assessment models began with Nordhaus (1989, 1994). By now many of these models exist. An Appendix I to this paper elaborates. The literature is surveyed by Manne (1996). Those models that can be used for cost-benefit analysis tend to give a similar result: a plan that optimally balances costs and benefits calls for relatively small actions at the beginning, with the result that GHG emissions continue to rise, although at a reduced pace, for at least a century. Concentrations reach ____ ppmv by 21____. In the simplest case, damage from warming is assumed to rise linearly with temperature. But it is plausible that the costs in fact begin to rise more sharply, e.g., when concentrations and temperature go above a threshold level. Findings by Peck-Tiesberg (1992), using the CETA model and the case of a non-linear damage function (allowing the damage to rise increasingly sharply with the temperature), call for emissions peaking in 2080-2090.

Some of the authors have characterized in a striking way the gap between the optimal paths that their models produce and the frequently heard proposal to return emissions to 1990 levels by 2010: In their models, the economic costs of such a strong early response are so great that, if that were the only alternative, we would be better off doing nothing at all [Jorgenson testimony? Can't

find it in there. It's ____ of Stanford?]. In other words, the economic costs of "1990 levels by 2010" outweigh the benefits.

Arguments for earlier action

This conclusion, and the methodology that produced it, have been criticized on a number of grounds.

- Some claim that it gives insufficient weight to the (small, but nonetheless alarming) probability of a discontinuously-large and essentially irreversible catastrophe, such as the melting of the West Antarctic ice sheet [which might raise ocean levels by 5 to 6 meters], a runaway "positive-feedback" greenhouse effect (e.g., from methane release), or structural changes in ocean currents such as the Gulf Stream. [references: Cline (1992, p.34-35, Revelle, 1983, p.442, IPCC 1996a; Schelling AER 1995?]
- Some claim that it gives insufficient weight to the welfare of future generations that will bear the costs of climate change (that is, the discount rate is too high). [references: Cline (1992) and Howarth (199_).]
- Some claim that it neglects basic uncertainty about all parameters -- the economic effects, the climate effects, and the discount rate necessary to compare the two. [reference: Pizer (1996)]
- Some claim that it omits a basic point about political credibility: an announcement by the world's governments that they are committing to a serious agreement -- but that stringent policy measures will not be taken until 50 years or more into the future -- will not be credible, and understandably so. The arguments for postponing sharp cuts in emissions ten years only work if people use the intervening period to begin adjusting. If they are skeptical of the need to adjust, then ten years later nothing will have been accomplished, and the economy at that point will face the same high costs to early reductions as before. Only early concrete measures will send the signal necessary to move people's patterns of research, investment, and consumption onto the new path.³

3. Estimates of least-cost paths to stabilize concentration levels

Much of the debate about GHG stabilization takes as given that simply allowing emissions to continue to grow for a long period, albeit more slowly, puts the biosphere at too much risk and is not credible politically. An alternative strategy is to reason that the probability of catastrophe may rise to unacceptable levels unless GHG concentrations are capped at some particular level. Such an approach has the disadvantage that the choice of any specific concentration cap is arbitrary, and is inconsistent with the spirit of cost-benefit analysis. But it has the advantage of being analytically tractable, and offers a meaningful focal point for negotiation..

³ An opposing credibility point is also made: A proposed agreement that demonstrably imposes much higher costs than an alternative more measured approach, and thereby invites substantial domestic political opposition, will also suffer from credibility problems both here and abroad.

Stabilization of concentrations at 550 ppmv

We will consider the question of the optimal path subject to the constraint that concentrations be stabilized at 550 ppmv (approximately double the pre-industrial level of 275 ppmv⁴). One might ask why we need accept a level of concentrations, and corresponding probability of catastrophe, as high as this. Indeed, why accept any probability of catastrophe? It is important to recognize that it is already too late to keep this probability at zero (even if one were to accept that it would have been worth the cost to do so, had we known at the beginning of the Industrial Revolution what we know now). Concentrations are already at 365 ppmv, and it is impossible to prevent them rising further in the short run; one would have to reduce emissions almost to zero to do so.

[It would be useful to quantify the implicit gap between this strategy and the strategies resulting from the unconstrained optimization by the Integrated Assessment models. The difference represents the role being accorded to the four bullet points above. In addition, some sensitivity analysis with respect to the level of the concentration constraint would be desirable.]

Results for a less aggressive path

Wigley, Richels and Edmonds (1996) [WRE] examined alternative paths to reach 550 ppmv and other concentration levels. They considered a path where global emissions peaked in 2030 and did not return to 1990 levels until some date past 2100. Manne-Richels (1997) use the MERGE model to examine the implications of the WRE path in more detail.⁵ In their model, emissions from OECD countries as well as from other Annex I countries (most of the former Soviet Union and Eastern Europe) peak in the decade 2010-2020. (Annex I emissions do not return to their 1990 levels until sometime early in the decade 2030-2040. The price of crude oil peaks in 2040.) The reason that the peak in worldwide emissions lags two decades behind the peak in Annex I emissions is that the developing countries do not peak until 2050.

⁴ The concentration figure refers only to CO₂. Emission of other greenhouse gases will raise the warming potential, or carbon-equivalent, above this level.

⁵ MERGE's results regarding the comparison of the WRE and WG1 paths apparently fall in the middle of the results of 10 or so models that participate in the Energy Modeling Forum (EMF-14, Oslo, Aug. 1997).

WRE argue that this path has much lower economic costs than proposed paths that are more aggressive in terms of timing, while producing the same terminal effects on concentration. The more aggressive path they examine is the IPCC Working Group path 1 [WG1], which entails Annex I fossil fuel emissions peaking in 1990, and falling 24 percent worldwide below 1990 levels by 2010.⁶ (Of course, it is too late for this scenario to be realized. Seven years have passed during which emissions manifestly have not in fact begun to fall in the overwhelming majority of OECD countries. Below, we will also consider other alternative proposals that, while sufficiently ambitious as to be expensive to achieve, at least have the virtue of not having been ruled out by history.)

As noted earlier, the best single measure of aggregate economic costs is the present discounted value, i.e, the appropriate summation over time, of foregone consumption. The IPCC Working Group path shows a total worldwide consumption loss of \$8.6 trillion. (The loss would be lower if costless international trading were allowed -- \$3.3 trillion. On the other hand, the cost would be higher if the developing countries do not agree to the targets envisioned. Indeed, if the developing countries do not participate at all, then the goal would be impossible to attain at any cost.) The more moderate WRE path toward the same concentration goal entails far smaller costs: a total worldwide cost of \$1.57 trillion. (With costless global trading, it is \$0.77 trillion. The difference illustrates the great benefits of "where flexibility," assuming that international trading can be successfully implemented.) Thus the saving from letting emissions continue to rise as late as 2010 is more than three-quarters of the cost.

WRE did not attempt to compute the least-cost path for reaching the same goal.

The least-cost mitigation path, compared to 2010 constraints

Manne and Richels (1997) is believed to be virtually the first paper to compute the path that minimizes costs (again, using the MERGE model), subject to the constraint of stabilizing concentrations at a level such as 550 ppmv.⁷ They must necessarily make some assumption about international burden-sharing. The particular question is as follows: how much can we insist that developing countries (who are poor, but in many cases rapidly growing) reduce their emissions, relative to their (low, but often rapidly growing) paths? For the case of 550 ppmv concentrations, they assume that non-Annex I countries can plausibly be expected to begin to limit emissions in 2030, and to complete a transition to a regime under which their per-capita emission rights are equal to those of the industrialized countries by 2050.⁸

⁶ Worldwide emissions rise 8 percent by 2010 [from 5.885 to 6.351]. These numbers come from 8/28 personal communication with Richels. (Earlier communication had worldwide emissions rising 13.64% by 2010 under the IPCC path [to 7.798 PgC]. Evidently the former statistic refers only to fossil fuel emissions and the latter to all carbon emissions.)

⁷ Also Manne and Richels (1995). Kosobud, et al (1994) examine alternative paths to achieve a given temperature target in 2100. All three papers find that a return to 1990 emission levels early in the 21st century is a needlessly costly way to attain the 2100 goals for concentration and climate.

⁸ Based on 1990 populations. This formula could imply large transfers from OECD countries to developing countries. We consider an alternative scenario in the next section -- that the developing countries do not participate at all. It would also be desirable to look at the implications of a plan under

which a small number of middle-income countries (particularly Korea and Mexico) begin to limit emissions by 2010. Without China and India, however, the emissions of the middle-income countries are a small fraction of the world total, so that their involvement would be important only in order to point the way for other emerging economies, rather than to reduce emissions perceptibly in their own right.

The global numbers that Manne and Richels reported in their paper need to be broken down by region. In addition, they were asked to constrain the year 2000 emission levels to the BAU level, under the theory that a treaty that reduces emissions beginning in 1990 has already been ruled out by history, and that even a start in 1998 is extremely unlikely. Their model implies that the least cost mitigation path has emissions from OECD countries, as well as from other Annex I countries in general, peaking in the decade 2020-2030, a bit behind the WRE path. The peak of Annex I emissions is 29 percent above 1990 levels. [Source: personal communication from Richels, 8/21 and 8/28/97.] Emissions do not return to their 1990 levels until after 2050. Emissions from developing countries peak in 2050. The sum of the two, total worldwide emissions, also peaks in 2050. (By mid-century, developing countries are such an important source of emissions that they dominate the global peaking date and the date of return to 1990 levels.) Worldwide emissions return to their 1990 levels shortly before the end of the 21st century.

This least cost mitigation path generates quite low values for carbon emissions rights after implementation in 2000. The permit price is only \$2/ton in 2010, and slowly rises to \$3/ton in 2020. Only in the latter part of the century does it rise significantly, to \$156/ton in 2100.

In contrast to the least cost path, the following table demonstrates the effect of constraining Annex I emissions relative to 1990 levels in 2010. The constraint is imposed over the period 2010-2030. After 2030, further reductions in Annex I emissions occur in order to meet the constraint of concentrations at 550 ppmv. Developing countries again participate, consistent with the burden sharing formula described above. Thus the permit price estimates presuppose full global participation and trading ("where flexibility") but not intertemporal trading ("when flexibility").

Change in emissions relative to 1990 in 2010	Permit Price in 2010 (\$/ton)	Permit Price in 2020 (\$/ton)	Consumption Losses (trillions of dollars) ⁹		
			U.S. World	Annex I	
+10%	4	65	0.293	0.564	0.782
0%	67	88	0.303	0.619	0.939
-10%	120	112	0.429	1.054	1.276

According to Manne and Richels, their least cost mitigation path costs the U.S. \$0.124 trillion in terms of lost consumption (present discounted value), as compared to \$1.28 trillion under the IPCC Working Group path and as compared to \$0.303 trillion under the "1990 in 2010"

⁹ The present discounted value of consumption assumes a 5% discount rate and a time horizon of 1990-2100.

path. Thus the least cost mitigation path generates savings of 90 percent from WGI and 60 percent from the 1990 in 2010 path.¹⁰

It is important to keep in mind that all these cost estimates are “best case” (almost utopian) scenarios, in the sense that they assume efficient market implementation, international trading, and full international participation and enforcement. Actual costs could be much higher if less efficient command-and-control mechanisms of implementation are used, if there is not effective international trading, or if some countries do not accede to or abide by a treaty.

What if there is no international trading?

¹⁰ Most of this gain is also reflected in the WRE path, as described above.

It is important to keep in mind that the permit price estimates cited above assume perfect global trading. Under this assumption, emission reductions occur where it is cheapest to do so regardless of geographic location (including in developing countries). What if there is no opportunity to buy emission reductions from lower-cost countries? The following table shows permit prices in 2010 when Annex I emissions are constrained to 1990 levels under alternative assumptions about where flexibility. If the U.S. must attain its target by domestic emission cuts entirely, because developing countries do not participate and there is not trading even among Annex I countries, then the cost rises steeply. These conditions triple the price of the "1990 by 2010" target, in terms of the marginal cost of abatement, from \$67/ton to \$204.

U.S. Permit Prices in 2010, 1990 Level in 2010 Scenario

Where Flexibility	Global Trading	Annex I Only Trading	Domestic Only Trading
Permit Price in 2010 (\$/ton)	67	132	204

What if the developing countries do not agree to go along?

It is difficult to imagine that the industrialized countries will be able to extract commitments from developing countries much more serious than those assumed in the preceding section, the Manne-Richels burden-sharing schedule. (Or that U.S. taxpayers will agree to transfers to developing countries larger than those implicit in that schedule.) What if, as is more likely, the commitments extracted from developing countries are less strong than this, rather than more? On the one hand, as a matter of arithmetic, meeting the 550ppmv concentration constraint would require more aggressive targets and timetables on the part of the Annex I countries, if indeed it would be possible at all. On the other hand, as a matter of politics, the absence of the developing countries would probably lead the peoples of the Annex I countries to choose a less aggressive path, even though it would produce a higher terminal concentration level.¹¹ (An analytical balancing of costs and benefits would give the same answer -- a less aggressive path -- once the concentration constraint is relaxed.)

¹¹ Conversely, the developing countries are less likely to agree to participate if the Annex I countries have not already taken serious action.

To consider the possibility that developing countries might decline to participate, or decide to participate only to a lesser degree than the Manne-Richels burden-sharing formula, we ask what would be the effects, both economic and environmental, if the Annex I countries were constrained to the WRE path, but developing countries do not participate (i.e., developing countries remain on their BAU path). The welfare losses (in terms of present discounted value) will depend upon whether there is trading in emission rights among Annex I countries. If Annex I trading occurs, then Annex I countries' losses increase from \$0.62 trillion to \$0.91 trillion, or 47%. If emission trading among Annex I countries does not occur, then losses rise to \$1.00 trillion, or 61%. For the U.S., in the absence of developing country participation, welfare losses rise from \$0.28 to \$0.36 trillion, or 29%, assuming Annex I trading. Without Annex I trading, U.S. losses rise to \$0.41 trillion or 46%.¹² Meanwhile, the non-participation of the developing countries means a clear failure to meet the goal of capping global emissions at 550 ppmv.

Even if the Annex I countries choose an aggressive path of reducing emissions 10% below 1990 levels by 2010 (and stay at that level thereafter), the effect is to reduce global concentrations only 7 % below BAU levels in the year 2100. This is less than a third of the reductions achieved when the developing countries participate [22%; conversation 8/28] This result illustrates the problem of free riding. Moreover, the estimate does not include an allowance for "leakage" of carbon savings from participating to non-participating countries (e.g., reduced oil demand in the former, via a lower world price of oil, raises oil consumption in the latter). Once leakage effects are added to the free-riding problem, the difficulty of accomplishing meaningful reductions without the help of developing countries are even greater. The savings is only 5 percent in this case. In other words, of the 22 percent reductions achieved when the developing countries participate, 15 percentage points are lost to free-riding, and another 2 points to carbon leakage. [conversation 8/29.] This estimate captures only some of the possible leakage channels; it omits, for example, the relocation of production in polluting industries to non-participating countries. Indeed, no model measures this effect with much precision or accuracy.

**

4. What is the trade-off between the paths currently under discussion?

As we have seen, the Manne-Richels results suggest that the optimal path has Annex I emissions peaking in the decade 2020-2030 and returning to 1990 levels after 2050. The paths for emission reductions that have been discussed in the international negotiations are more aggressive.

¹² For purposes of this comparison, we assume that if developing countries do participate, there will be full global trading.

What are the additional economic costs, and climatological benefits, of moving from the optimal path to "1990 levels by 2010"? Table 4, "Climate and Economic Variables under Alternative Emissions Paths," which reports results from the SGM model, is designed to answer this question. The economic costs of the more aggressive path can be measured in several ways. The price of gasoline in 2010 would rise by 26 cents a gallon and coal prices by 273 percent, as compared to only 3 cents per gallon on the less ambitious path, and an increase in coal prices of only 53 per cent. The total economic loss, in the present discounted value of foregone consumption, \$206 billion, as compared to only \$95 billion on the less ambitious path. [These figures cumulate lost consumption out only to 2050, and thus are not comparable with the figures cited in the preceding section.] What is accomplished by the more aggressive strategy? The date at which concentrations are doubled is postponed by a mere 3 years (beyond the nine-year postponement achieved by the less aggressive path). The estimated warming in 2100 (2.45 degrees under the business as usual case) is reduced by a mere .03 degrees.. While different observers will weigh the economic costs and climate benefits in different ways, the percentage increase in costs from early action seems greater than the percentage reduction in concentrations and warming.

This conclusion omits that concentrations continue to rise in subsequent centuries. The way to address such concerns is by means of models (such as Integrated Assessment models) that keep track of economic and environmental effects on a longer time frame. The section of the paper on "Least-cost Paths to Stabilize Concentration Levels" explains how more moderate paths can attain the identical objective, in terms of terminal concentration levels, with lower economic costs than "1990 in 2010." But all these results leave out the major argument for early action mentioned elsewhere: the need for political credibility of an announced long-term plan. This argument suggests that a moderate path should be accompanied by early and specific announcement of serious domestic measures of implementation.

		<u>Concentration Level (ppmv)</u>		Year at Which Concentration Reaches 2x Pre-Industrial Level **	<u>Change in Temperature from 1990 Level (Celsius)</u>	
	Year	<u>2050</u>	<u>2100</u>		<u>2050</u>	<u>2100</u>
Business As Usual (BAU)		502	711	2064	1.06	2.36
<i>Deviation from BAU:</i>						
Annex I Participation Only	1990 -10% beginning in 2010	-21	-66	+10	-0.09	-0.25
	1990 beginning in 2010	-18	-55	+9	-0.08	-0.21
	peak in 2015, 1990 in 2040	-13	-52	+7	-0.06	-0.19
	1990 +10% beginning in 2010	-14	-47	+7	-0.07	-0.18
		<u>Carbon Permit Price (\$ per ton)</u>				Consumption *** (billions of \$)
		<u>Domestic Trading</u>		<u>Annex I Trading</u>		
		<u>2010</u>	<u>2050</u>	<u>2010</u>	<u>2050</u>	
Business As Usual (BAU)		0.00		0.00		121,650
<i>Deviation from BAU:</i>						
Annex I Participation Only	1990 -10% beginning in 2010	+175	+924	+91	+238	-980
	1990 beginning in 2010	+109	+582	+41	+149	-740
	peak in 2015, 1990 in 2040	+12	+563	+11	+153	-270
	1990 +10% beginning in 2010	+60	+310	+17	+113	-460

Table 4

Climate and Economic Variables under Alternative Emissions Paths *

Summary description

A plan to return carbon emissions to their 1990 levels by 2010 postpones by 9 years the date at which CO₂ concentrations reach twice pre-industrial levels. Global warming would be reduced by 0.21 degrees by the year 2100 versus an estimated 2.36 degrees under BAU. Under this emissions path the value of the estimated foregone consumption is \$740 billion.

A less ambitious path -- "eliminate emissions growth by 2010-2020" -- would postpone the doubling date by 2 years less, and would lead to another 0.02 degrees of warming. But, the economics would become much easier: The value of foregone consumption would be only \$270 billion.

* Preliminary CEA projections. The origin of these preliminary numbers is described on the accompanying page.

** Pre-industrial concentrations of CO₂ were approximately 275 ppmv.

*** Assumes domestic trading only. Annex I or worldwide trading may substantially reduce these costs.

Deviations are foregone consumption assuming a 5% discount rate for the time horizon 2000-2050.

September 10, 1997

Sources and Explanations

Sources

Business As Usual (BAU) emissions projections are based on the assumptions employed in the IAT process. These projections incorporate the Annual Energy Outlook and International Energy Outlook projections, and closely mirror the IPCC IS92a emissions profiles with modifications made for the economic decline in the Former Soviet Union and Eastern Europe. BAU concentration and temperature projections are from the MAGICC model. Carbon permit price estimates and foregone consumption figures are from the SGM model. All these results were provided by Jae Edmonds, Marshall Wise, and Chris MacCracken at Battelle, Washington, DC.

Participation Cases

Annex I Participation Only: Assumes full compliance of stated targets and timetables by countries in Annex I; rest of the world behaves as in BAU.

Targets and Timetables

1990 (+/-10%) in 2010: Emissions follow BAU through 2000, reduce to 1990 (+/-10%) levels by 2010, and remain at 1990 (+/-10%) levels thereafter.

Peak in 2015, 1990 in 2040: Emissions follow BAU through 2005, peak at 2010 BAU levels in 2015, and stabilize at 1990 levels in 2040 and into the future. Because of linear interpolation in emissions profile between 2015 and 2040, this scenario may slightly overestimate the deviation of concentration from BAU.

Trading Scenarios

Domestic Trading: Trading only within each country.

Annex I Trading: Permits are grandfathered to Annex I nations based on 1990 emissions levels. All Annex I countries participate in the trading of permits.

Price Assumptions

Carbon: U.S. permit prices for the four policy options are from SGM, which assumes that all revenues are returned to the economy through a lump-sum redistribution.

Consumption: Deviations are present discounted value of foregone consumption differences for United States in billions of dollars between BAU and scenarios. The present discounted value assumes a discount rate of 5% and a time horizon of 2000-2050.

5. Escape clauses and other flexibility provisions

In addition to the question of the stringency of targets and timetables, there are a number of other important determinants of the economic costs of a program encompassed in the term “flexibility”. The U.S. has proposed both “when flexibility” and “where flexibility.”

Examples of “when flexibility” are our proposals for targets that are multi-year averages, for multiple target periods, and for banking and borrowing. An example of “where flexibility” is international trading, especially with the participation of developing countries. All of these proposals could substantially reduce the cost of a given level of emissions, and are crucial elements of our ability to attain moderate targets, let alone more ambitious targets. Costs would be far higher without them.

Another possibility that has recently received attention in the inter-agency process is to add one or more escape clauses. The main idea is to safeguard against unexpectedly large economic costs of emissions reductions. These are costs that could turn out to be unexpectedly large if the economic growth rate turned out higher than expected, or if unrealistic estimates regarding the ease of reducing emissions were built into treaty targets. One possible escape clause would focus on the price of energy per ton of carbon.

Nordhaus (1997) and McKibbin and Wilcoxon (1997) have proposed plans under which there is a cap on how much the price of carbon can rise. The proposal is that above a certain level, governments (or perhaps a supranational authority) could make available an indefinite quantity of emission permits at the predetermined price. While the academic proposals tend to call for common policies and measures to be negotiated worldwide, the idea could usefully be integrated into the U.S. proposal for targets and timetables regarding emission quantities, in the form of a conditional escape clause. The effect would be to convert the quantity limit into a price instrument under circumstances when the burden would otherwise be too burdensome.

Escape clauses could also serve other purposes as well. Possibilities include:

- An escape clause that would be triggered in the future if continued **scientific research** determined that the dangers from GHG concentrations and climate change were much less than previously feared. Presumably the treaty would be renegotiated in such a case anyway. But the arguments for putting this language in now are three: (1) to facilitate the change, should this come to pass, (2) so that we don’t look foolish in the eyes of history if this should come to pass, and most importantly, (3) to help allay the fears of today’s skeptics.
- An escape clause that would be triggered in the future if **developing country accession** turned out to be less than we expect after Kyoto.

- An escape clause that would be triggered by other Annex I countries' **failure to abide** by their commitments.

Each of these proposals, might be useful in avoiding economic costs that otherwise might be incurred needlessly.

6. Conclusions and Summary

[SEE EXECUTIVE SUMMARY AT THE BEGINNING]

Appendix I: Integrated Assessment Models (M. Toman)

Integrated Assessment (IA) analyses try to bring together assessments of the physical, ecological, economic, and social impacts of climate change with assessments of policies for responding to climate change and their socioeconomic consequences. Generally speaking, the models can be described schematically as linking economic decisions in the energy (and agriculture) sectors that give rise to GHG emissions (and changes in carbon sequestration), models of atmospheric composition, climatic change, and changes in oceans, and models that describe the potential impacts of climate change on health, natural resources, coastal areas, and other factors of socioeconomic interest. Different components of various IA frameworks are represented in differing degrees of detail and sophistication. A few models contain the capacity to be used for a benefit-cost analysis, in which it is possible to evaluate changes in the long-term path of GHG emissions that maximizes the net benefits of GHG control (these benefits are the avoided damages of climate change less the costs of control). A larger number of IA models can evaluate the benefits and costs of specified policies but are unable to indicate what emissions reductions maximize net benefits. IA frameworks are inherently more "top-down" in their characterization of economic decisionmaking, though some models contain a fair amount of energy sector detail.

A very striking feature of IA models is that they tend to indicate the desirability – from the perspective of maximizing net benefits over time -- of emissions continuing to rise well into the next century, if not beyond. (For a recent comparison of IA model results, see Manne 1996.) By 2100, the models indicate only small deviations downward from a business as usual (BAU) path (see also IPCC 1996b, Chapter 10). In some cases the emissions do stabilize toward the middle of the next century, but in other cases they continue rising (though more slowly than with business as usual) even beyond 2100. These emissions paths clearly imply increases in atmospheric concentrations of GHGs well beyond the kinds of targets that have been considered in current policy debates (e.g., 550

ppm). One important consequence is that the models indicate costs of near-term emissions stabilization well in excess of the avoided damage costs.

As noted in the text, a number of criticisms have been levelled at these IA results. These criticisms include:

Failure to consider the possibility of unlikely but catastrophic events that could result from climate change (e.g., catastrophic sea level rise from melting of the Antarctic ice sheet, runaway global warming from frozen methane releases, or relocation of the Gulf Stream – see IPCC 1996a, Chapter ____).

Failure to give adequate consideration to the scale of potential damages, even in the absence of catastrophe. Cline (1992), for example, argues that damages are much higher than is incorporated in most IA models (see also IPCC 1996a, Chapter 6 for various estimates). One specific concern that has been raised is that the IA models do not account adequately for the costs of a less stable climatic and ecological systems in the face of GHG accumulations.

Failure to consider the adverse consequences of less aggressive abatement policies for future generations – in the context of IA models themselves, the criticism is that discounting of future generations' well-being is excessive. Cline (1992) also raises this concern, as does Howarth (199__).

Failure to consider how uncertainty about all these effects affects the “optimal” decision (Pizer 1997).

Failure to consider how lack of early action will jeopardize the achievement of any longer-term mitigation by signalling a lack of political will ([NEED CITE]), or how lack of early action will retard induced technical progress that is needed to make mitigation affordable (Grubb 1995).

Sensitivity analyses carried out with IA models suggest that at least some of these criticisms are not major concerns; others may be serious concerns, but empirical judgments are not possible given the current state of knowledge. The Manne (1996) survey referred to above considered scenarios in which the climate's sensitivity to accumulating GHGs was greater than is typically assumed, or the damages are larger (by a factor of almost 8) for a given change in the atmosphere. In either case emissions should (from the perspective of maximizing net benefits) be lower, but the extra degree of emissions reductions required by 2010 is significant (on the order of 25 percent or more) only if climate damages are much higher than expected (the sensitivity of the atmosphere to GHG emissions seems much less important in these analyses). And even in this case, emissions still will be higher than 1990 levels unless the atmosphere and the ecological-economic systems both are quite sensitive. (Broadly similar conclusions follow if, instead of looking at higher damages, one looked at damages that grew proportionately faster as atmospheric GHG concentrations grew [CETA cite]). Thus, the IA models give little

support for a policy of near-term emissions stabilization unless damages turn out to be much higher than at least some experts expect.

As noted, one of the criticisms of many integrated assessments (IAs) is that they do not incorporate the possibility of catastrophe. Recent extensions of the IA literature include the possibility of a major, discontinuous jump in the damages caused by climate change. For example, a European paper by Gjerde et al (1997) incorporates the risk that climate change will suddenly cause damages equal to a significant share of global GDP. The risk is assumed to rise with an increase in temperature from global warming; following Nordhaus (1994b), the benchmark risk scenario assumes a 12% chance of a loss equal to 25% of GDP (the scale of the great depression) in 2090 if climate has warmed by 3 degrees C. Incorporating this risk into the IA framework causes the optimal path for global emissions to be reduced, but not by that much in the early years. By 2060, optimal emissions are only somewhat over half what they would have been without the risk of catastrophe, but the reduction by 2020 is on the order of 15% below the no-catastrophe case and still above emissions in 1990.¹³ Even sharper emissions reductions are implied if the catastrophe is truly shattering (on the order of the entire GDP), or if the discount rate is extremely low (high intergenerational egalitarianism.)

It is also true that the results of IA models are sensitive to the choice of discount rate used to compare consumption today and in the future. A very low discount rate will imply greater weight on damages accruing over time to future generations, and thus the need for a more aggressive abatement strategy. This tradeoff is influenced by the rate of economic growth, since growth will make future generations better off and thus better able to afford and respond to the damages of climate change (Schelling 1995). However, there are numerous economic and ethical controversies surrounding the appropriate way to discount future damages in IA models, and no clear consensus has emerged. One important point that is often ignored in this debate is how much *today's* generation is willing to sacrifice to provide for the increased protection of future generations through GHG abatement; this is a critical unknown since it is today's generation that must necessarily decide to pay the bill. All that can be said analytically, therefore, is that intergenerational equity *might* be an argument for more aggressive abatement.

¹³ The no-catastrophe optimal path is substantially below BAU in this analysis, an artifact of the assumptions of low abatement cost and high damage cost.

Uncertainty about future damages or other influences on the costs and benefits of abatement can make a difference. However, Pizer's (1997) analysis suggests that the most important source of uncertainty concerns the nature of our preferences for consumption and environmental protection. (Unlike the Manne (1996) analysis, Pizer considers the possibility that damages may be lower as well as larger.) A recent paper by Gjerde et al (1997) considers the risk of a sudden loss of economic output and well-being on the scale of the Great Depression from climate change. While their analysis indicates more aggressive abatement than other IA analyses without this risk, the introduction of the risk has little relative effect on the desirable level of emissions reduction by 2010, and little effect for a number of years thereafter (unless the loss is much larger even than the Depression).

This leaves the issues of political credibility and induced technical change. As for the latter, it is true that sending a less strong signal to energy markets will slow up technical progress. However, there is great uncertainty about how much of a loss this would be in practice, and the loss would have to be greater than most models seem to indicate before the substantial costs of near-term stabilization could be justified. This does *not* mean, however, that *no* actions are justified on cost-benefit grounds to reduce emissions or stimulate technical progress. Aside from initial steps to curb emissions growth, which signal the need for technical change, longer-term measures to promote the development of new technology are warranted. Political credibility is a more complicated issue.

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Jorgenson?

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Wigley, T.M.L., Richels, R, and Edmonds, J.A., Economic and Environmental Choices in the Stabilization of Atmospheric CO2 Concentrations, Nature, Vol 379, Jan 18, 1996.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Jeffrey A. Frankel (CN=Jeffrey A. Frankel/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:17-SEP-1997 10:24:19.00

SUBJECT: Talking points on EPI report

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

As you will see below, Peter has forwarded the talking points were agreed to Todd and others. The version I attach here adds an additional sentence at the end.

JF
-----I----- Forwarded by Jeffrey A. Frankel/CEA/EOP on
09/17/97 10:2
2
AM

Peter R. Orszag
09/17/97 10:13:58 AM
Record Type: Record

To: See the distribution list at the bottom of this message
cc:
Subject: Talking points on EPI report

Message Sent

To:
William J. Antholis/OPD/EOP
Todd Stern/WHO/EOP
Jonathan H. Adashek/WHO/EOP
Daniel K. Tarullo/OPD/EOP
Gene B. Sperling/OPD/EOP
Melissa Green/OPD/EOP
David B Sandalow/CEQ/EOP
Jeffrey A. Frankel/CEA/EOP
Michele Jolin/CEA/EOP
Kathleen A. McGinty/CEQ/EOP
Jake Siewert/OPD/EOP

===== ATTACHMENT 1 =====

ATT CREATION TIME/DATE: 0 00:00:00.00

TEXT:

Unable to convert ARMS_EXT:[ATTACH.D71]MAIL42358395J.216 to ASCII,
The following is a HEX DUMP:

Talking Points on EPI Climate Change Study September 17, 1997

Background: The Economic Policy Institute released a study today examining the economic ramifications of a policy designed to reduced U.S. greenhouse gas emissions to 1990 levels by the year 2010. The study concludes that such a policy would cause losses of millions of jobs, reduced consumer spending, and a substantial decline in GDP. The study is likely to be used by organized labor (particularly the coal sector) to argue against U.S. acceptance of binding emissions targets and timetables at the climate change negotiations in Kyoto this December.

- First, let's be clear: the Administration has not yet settled on a particular set of new policies to reduce greenhouse gas emissions. Instead, the President has been engaging in a discussion with all interested parties -- he has already met with senior corporate executives and with environmental groups, and he will hold a White House conference on climate change on October 6. This process is intended to inform the Administration's decision-making process, which will culminate in a U.S. policy position for the international negotiations in Kyoto in December of this year.
- Second, President Clinton's top priority, since his first days in office, has been revitalizing the U.S. economy, creating jobs and investing in people and technology to enhance long-term growth. And we have made tremendous progress. The President is not going to jeopardize that progress. Any policy he ultimately endorses on climate change will be informed by his commitment to sustaining a healthy and robust economy.
- Third, we can do this smart or we can do this dumb. By using flexible, market-based policies, we can slow climate change without harming the American economy. 2,500 economists, including 8 Nobel laureates, have signed a statement supporting measures to reduce the threat of climate change.
- Finally, we have learned that the results of climate change modeling exercises are extremely sensitive to the assumptions employed. For example, most studies suggest that international emissions trading has the potential to reduce significantly the costs of mitigating climate change. But the EPI study released today assumed no such international emissions trading -- suggesting that its results may be misleading.

Talking Points on EPI Climate Change Study
September 17, 1997

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- First, let's be clear: the Administration has not yet settled on a particular set of new policies to reduce greenhouse gas emissions. Instead, the President has been engaging in a discussion with all interested parties -- he has already met with senior corporate executives and with environmental groups, and he will hold a White House conference on climate change on October 6. This process is intended to inform the Administration's decision-making process, which will culminate in a U.S. policy position for the international negotiations in Kyoto in December of this year.
- Second, President Clinton's top priority, since his first days in office, has been revitalizing the U.S. economy, creating jobs and investing in people and technology to enhance long-term growth. And we have made tremendous progress. The President is not going to jeopardize that progress. Any policy he ultimately endorses on climate change will be informed by his commitment to sustaining a healthy and robust economy.
- Third, as I said in my congressional testimony, we could do this smart or we could do this dumb. By using flexible, market-based policies, we can slow climate change without harming the American economy. 2,500 economists, including 8 Nobel laureates, have signed a statement supporting measures to reduce the threat of climate change.
- Finally, we have learned that the results of climate change modeling exercises are extremely sensitive to the assumptions employed. For example, most studies suggest that international emissions trading has the potential to reduce significantly the costs of mitigating climate change. But the EPI study released today assumed no such international emissions trading -- suggesting that its results may be misleading. Of course the costs could indeed go up if were not able to implement international trading or other aspects of flexible, market-based policies.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:17-SEP-1997 10:14:53.00

SUBJECT: Typo in memo

TO: Jeffrey A. Frankel (CN=Jeffrey A. Frankel/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

----- Forwarded by Janet L. Yellen/CEA/EOP on 09/17/97
10:14 AM -----

Peter R. Orszag
09/15/97 07:14:43 PM
Record Type: Record

To: See the distribution list at the bottom of this message

cc:

Subject: Typo in memo

There is (at least) one typo in the memo on climate change: On page 11, the text under "Economic effects" reads that "the intermediate target of reaching 15 percent above 1990 levels by 2010 implies a permit price of about \$15 to \$30 in 2010..." It should read that "the intermediate target of 2000 by 2010 implies a permit price of about \$15 to \$30 in 2010..." (2000 levels are expected to be about 15 percent above 1990 levels, so the price effects are expected to be about the same also...)

Message Sent

To: _____
Gene B. Sperling/OPD/EOP
Daniel K. Tarullo/OPD/EOP
Kathleen A. McGinty/CEQ/EOP
David B Sandalow/CEQ/EOP
Melissa Green/OPD/EOP
Russell W. Horwitz/OPD/EOP
Janet L. Yellen/CEA/EOP
JONATHAN.GRUBER @ MS01.DO.treas.sprint.com @ INET @ LNGTWY

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Jeffrey A. Frankel (CN=Jeffrey A. Frankel/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:17-SEP-1997 08:43:43.00

SUBJECT: draft talking points on escape clause

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

CC: Randall W. Lutter (CN=Randall W. Lutter/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

CC: Joseph E. Aldy (CN=Joseph E. Aldy/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

CC: Adele C. Morris (CN=Adele C. Morris/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

Jon D. Haveman (CN=Jon D. Haveman/OU=CEA/O=EOP [CEA])

READ:UNKNOWN

TEXT:

for principles mtg. today

Jon: Please check that use of TRQ and safeguards, under trade policy, is right.

JF===== ATTACHMENT 1 =====

ATT CREATION TIME/DATE: 0 00:00:00.00

TEXT:

Unable to convert ARMS_EXT:[ATTACH.D47]MAIL427223951.216 to ASCII,
The following is a HEX DUMP:

ESCAPE CLAUSE

9/17/97

- ***“Price-trigger” escape clause*** would focus on the price of energy per ton of carbon: If the price rises to level P, then government(s) are prepared to sell at P however many emission permits are demanded (beyond the shares already allocated to countries, and to citizens by their governments). The effect would be to convert the quantity limit into a price instrument under circumstances when the burden would otherwise be too burdensome.
- ***Analogies from trade policy:***
 - Safeguards: GATT Article 19 (seems to work, despite its admitted vagueness)
 - Tariff-Rate Quotas: imports free up to a pre-assigned quota; additional imports allowed under a pre-set penalty rate.
- ***Insurance version:*** P would be set at “best-guess,” say \$100/ton. Or perhaps “best guess plus one standard deviation,” e.g., \$150. The intent is to safeguard against unexpectedly large economic costs of emissions reductions -- costs that could turn out to be unexpectedly large if the economic growth rate turned out higher than expected, or if unrealistic estimates regarding the ease of reducing emissions were built into treaty targets.
- ***Political version:*** The price could be set low, e.g., \$25. The effect would be to assure constituents that the program will not be too costly. Such a price could be justified:
 - (i) if one believes claims of the wishful-thinking free-lunch technology optimists
 - (ii) conditioned on the U.S. obtaining international agreement on all our demands, including not only international trading but also some serious participation by developing countries, or
 - (iii) even knowing that conditions (i) and (ii) are unlikely to be met. Then the escape clause could be explicitly acknowledged as probably converting a quantity target into a price target.
- ***Technical points:***
 - Who would sell permits? Could be:
 - (i) national governments (in countries with domestic emissions-trading schemes) or
 - (ii) a supra-national authority (in which case would have to decide how to split the proceeds).
 - What is time path? Would have to pre-set one price for 2010 and another for 2020. (Could also interpolate more points along the path; but banking and borrowing should have the same effect.)
- ***Scholarly references:*** Nordhaus (1997), McKibbin and Wilcoxon (1997) and Pizer (1996) have proposed plans under which there is a cap on how much the price of carbon can rise and argued that it has a number of desirable properties.

McKibbin, Warwick, and Peter Wilcoxon, 1997, “A Better Way to Slow Global Climate Change,” The Brookings Institution, Washington, DC, March.

Nordhaus, Bill, 1997, “Climate Allowances Protocol (CAP): Comparison of Alternative Global Tradable Emissions Regimes,” Yale University, June 17.

Pizer, William A, 1996, “Optimal Choice of Policy Instrument and Stringency Under Uncertainty: The Case of Climate Change,” Resources for the Future, Discussion Paper 97-17, Dec.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Joseph E. Aldy (CN=Joseph E. Aldy/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:17-SEP-1997 10:42:43.00

SUBJECT: talking points on EPI report

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

Janet,

I was in the process of drafting an email on this report for you when Jeff's email came through. Michele asked me last night to go through the report for you. If you want to talk in any detail about the assumptions (especially the difference in assumptions between this report and the DRI runs in the IAT report), let me know.

Joe

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Sanders D. Korenman (CN=Sanders D. Korenman/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:17-SEP-1997 13:24:21.00

SUBJECT: Cuts in funding for research on welfare reform:update.

TO: Michele Jolin (CN=Michele Jolin/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

I am trying to monitor the situation regarding cuts in ACF's appropriation for research and evaluation of welfare reform (and other social services research and evaluation). Attached is a reply from Barry White to my message regarding the above. (Michele: Janet has written to Bruce Reed on this matter.) I still cannot tell if DPS is making it a priority. Please advise as to possible next steps.
Sandy

----- Forwarded by Sanders D. Korenman/CEA/EOP on
09/17/97 01:19 PM -----

Barry White
09/17/97 01:12:35 PM
Record Type: Record

To: Sanders D. Korenman/CEA/EOP
cc: Keith J. Fontenot/OMB/EOP, Cynthia A. Rice/OPD/EOP
Subject: Re:

Welcome to the fray. This is an important issue to us, as well, one we are in contact with hill staff on, as is HHS. Keith Fontenot is my Branch Chief over this matter. He'll keep you posted on developments. If you have, or your members have, contacts on the appropriations committees, you should talk to Keith about perhaps making a call or two at the appropriate moment.

Thanks for the interest.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:18-SEP-1997 11:30:33.00

SUBJECT: Re: Cuts in funding for research on welfare reform:update.

TO: Sanders D. Korenman (CN=Sanders D. Korenman/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

Thanks for keeping me up to date. I have not gotten any response from Bruce Reed. You should not make calls to people on the Hill unless it has been cleared first by Michele and me and then the White House.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Jeffrey A. Frankel (CN=Jeffrey A. Frankel/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:19-SEP-1997 12:57:36.00

SUBJECT: international aspects of the Escape Clause proposal

TO: Joseph E. Aldy (CN=Joseph E. Aldy/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TO: Adele C. Morris (CN=Adele C. Morris/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TO: Randall W. Lutter (CN=Randall W. Lutter/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

CC: Jon D. Haveman (CN=Jon D. Haveman/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

At the principles meeting and in recent conversations with Rafe Pomerance at State, it has become clear that (1) some basic aspects of the price-triggered Escape Clause proposal have not been widely understood in other agencies (2) there are also parts of it that we ourselves need to think through more clearly. This is particularly true of the international dimension.

I attach a two-page write-up. It enumerates the features of each of the several versions of the proposal that seem to me to be workable. (I make no judgments about their relative merits in the memo, or indeed about the merit of the whole idea, tho I certainly think it has some.) The point here is just addressing workability. To take an extreme example, different countries cannot have escape clauses with different trigger prices in the presence of international trade in permits.

Please let me know what you think. Then let's meet to discuss it among ourselves.

JF===== ATTACHMENT 1 =====

ATT CREATION TIME/DATE: 0 00:00:00.00

TEXT:

Unable to convert ARMS_EXT:[ATTACH.D15]MAIL454284164.216 to ASCII,
The following is a HEX DUMP:

ESCAPE CLAUSE: INTERNATIONAL ASPECTS

Multilateral version:

- A supranational authority, presumably the same one that is to monitor countries' emission levels under any sort of agreement, stands ready to sell permits (beyond the basic agreed-to target levels) to whatever *national governments* wish to purchase them at a pre-determined price P.
- In the basic agreement, countries agree to emission targets, but reserve the right to whatever manner of domestic implementation they desire (as in current US position against "common policies and measures").
- Parties would have to agree in advance how to divide up the revenue.
- International trade in permits is superfluous in this case, but would do no harm.

Why couldn't individual firms also buy permits from the supra-national authority? In the multilateral version, it is suggested that only national governments be allowed to buy permits from the supra-national authority. Only they can be held internationally responsible for meeting their countries' aggregate emissions commitment. If permits could be purchased by individual firms, the government might be able to explain away any exceedence of its target by claiming that domestic firms might have paid for the extra permits in private transactions.. (This is also an argument why, aside from escape clauses, international trading probably needs to be done via national governments.) It might work for governments to act as the agents for individual firms in making international purchases.

National version:

- National governments stand ready to sell additional permits *to their own citizens* at a predetermined price P.
- In the basic agreement, countries agree to a common plan for domestic implementation: a scheme of tradable permits.
- It does not matter whether the initial allocation of permits in a particular country is done by auction or arbitrary allocation, insofar as the workability of the escape clause is concerned. All that matters is that the initial allocation is the quantity agreed to in the treaty.
- Each government would get to keep the revenue raised.
- International trade in permits is again superfluous in this case. Indeed, it might be necessary to rule it out. Otherwise an irresponsible government (think "transition economies") could flood the market with permits, which it prints at the cost of the paper while receiving real money for them. (Of course such a country would be grossly out of

compliance with the international treaty. But one does not wish to structure a treaty in such a way that a single irresponsible government can result in the breaching of intended emission limits, not just by its own economy, but worldwide.)

Why couldn't countries retain their own domestic implementation schemes? If some countries implemented their emission limits by means other than tradable permits, whether taxes or regulation, then it would be difficult to enforce the principle that the country's total emissions are to be limited by their initial allocation plus those demanded at the marginal cost P . The "marginality" becomes suspect. There would be nothing to stop a country from abolishing its existing energy taxes and regulations (or even adding energy subsidies!) and selling a lot of permits to its citizens because the true marginal cost of emission overruns would be far below P .

Wimp versions

The two versions described above pre-suppose a desire for an honest and workable system. It is possible that the multilateral version would be viewed as unacceptable because of aversion to supra-national authorities, and the national version as unacceptable because of aversion to insistence on a common domestic implementation measures. Is there some other way that the U.S. could tell its businesses they will be protected against a price higher than P ?

(1) The U.S. could insist that the U.S. government be the only one with the right to sell additional permits at price P . If this were accepted, it would have the desirable efficiency properties, while simultaneously transferring potentially huge amounts of money from other countries to the U.S. It is hard to see why any other country would be willing to consider this.

(2) The U.S. (and other countries if they wished) could assure its citizens that if the price were to rise above P , with scope for buying emission permits internationally already having been exploited, then *the country would borrow, as agreed to internationally, however many permits were necessary* to keep the domestic (and world) price from rising above P . This is perfectly workable institutionally. But it is hard to see why it would be any easier to attain quantity targets in 2015, and simultaneously pay back past borrowings, if the 2010 targets have turned out to be prohibitively expensive to meet.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Jeffrey A. Frankel (CN=Jeffrey A. Frankel/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:19-SEP-1997 13:06:54.00

SUBJECT: escape clause and McKibbin-Wilcoxon

TO: Joseph E. Aldy (CN=Joseph E. Aldy/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TO: Adele C. Morris (CN=Adele C. Morris/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TO: Randall W. Lutter (CN=Randall W. Lutter/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

You have heard me mention several scholarly references in connection with the Escape Clause proposal (tho I don't think any use that phrase or have in mind exactly what we want). Billy Pizer, who presented at the lunch seminar recently is quite relevant, regarding the uncertainty of prices vs. quantities. But I particularly recommend that people also look at a March paper by McKibbin-Wilcoxon. I am sending you all copies. I think it makes clear that what we would be contemplating in the Escape Clause is a potentially radical change in the proposed nature of the system -- but a change that has many desirable properties (given the mess otherwise).

JF

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Steven N. Braun (CN=Steven N. Braun/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:19-SEP-1997 18:32:02.00

SUBJECT: Support BLS on Disabilities Language

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TO: Michele Jolin (CN=Michele Jolin/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TO: Jeffrey A. Frankel (CN=Jeffrey A. Frankel/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

I just read Katherine Abraham's fax to Janet on how soon BLS ought to be required to ask CPS questions to identify the disabled. I agree 100% with her request for a delay while sample survey questions are evaluated.

I am not sure how to lend support, however.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Michele Jolin (CN=Michele Jolin/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:22-SEP-1997 17:51:45.00

SUBJECT: Chafee questions

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

Attached.===== ATTACHMENT 1 =====

ATT CREATION TIME/DATE: 0 00:00:00.00

TEXT:

Unable to convert ARMS_EXT:[ATTACH.D39]MAIL437356465.216 to ASCII,
The following is a HEX DUMP:

Responses to Senator Chafee's Questions

1. The President, Members of the Cabinet and Senior White House officials have meeting with with a wide range of parties interested in the issue of global climate change. We have been consulting with representatives from business and labor, environmental groups, scientists, economists and others about the best, most cost-effective way to reduce greenhouse gas emissions. On October 6, the White House will hold a conference to discuss the scientific evidence, the economic impact and the international implications of global climate change. These discussions are intended to inform the Administration's decision-making process, which will culminate in a U.S. policy position for the international negotiations in Kyoto in December of this year.

With the lessons we have learned so far,, the Administration has established a broad framework within which this policy position will be developed. For example, we support the use of flexible approaches, such as joint implementation and international emissions trading. We support the requirement that non-Annex I countries, as they become wealthier, abide to binding emissions goals. And, for domestic implementation, we support the use of flexible, market based approaches.

2. No one model, or even a small set of models, can give a definite estimate of the effects of a policy on the economy 20 or 30 years into the future. There are a vast array of economic tools that provide us with a basis for informed judgment about the likely effects of different climate policies. For example, we know that a market based approach to reducing carbon emissions will be less costly than a command and control approach.

In developing a climate change policy, the Administration intends to bring to bear many analytic tools and perspectives found in the economics literature. Some of these may have strengths on issues where the models used in the IAT analysis were weak. I am confident that the analytic tools and perspectives available to the Administration can provide us with sufficient information to generate ranges of economic effects so that the Administration can make informed policy decisions.

3. At this time, the Administration has not settled on a particular set of policies. The Administration is considering an array of market based approaches to implement climate policy.

4. Tradeable emissions permits and energy taxes share several important characteristics. First, they both send a price signal to markets that would stimulate the development and adoption of energy efficient technologies. Second, they both provide flexibility to achieve emissions goals. In the case of tradeable permits, firms that find it very costly to reduce emissions may purchase permits from firms that find it less costly. In the case of taxes, firms would reduce their energy use until it became more costly than the tax. These both achieve emissions reductions at substantially lower costs than through command and control approaches.

Tradeable emissions permits would provide greater certainty than energy taxes of attaining a specified emissions cap. By specifying a number of permits and allowing firms to trade these

permits, the country can ensure that it is meeting an agreed upon carbon emissions goal. A tax, on the other hand, would provide greater certainty than a cap-and-trade approach of limiting costs, since the increase in unit costs would be determined by the tax.

5. For international emissions trading, all countries participating in the trading scheme will need to have their emissions capped.

International emissions trading can significantly decrease the costs of meeting an emissions goal. It would provide greater opportunities to reduce emissions at low costs. If some of the emissions reductions necessary to achieve the U.S. goal can be undertaken in other countries at lower costs, then U.S. emissions control costs will fall. Various modeling efforts have shown that the costs of achieving a variety of emissions goals could decrease by more than half.

For joint implementation, all countries may participate, regardless of when their emissions will be capped. Lower cost abatement opportunities abroad again suggest substantial savings to the United States could result if U.S. companies could receive credit for incremental abatement efforts in other countries.

6. Some innovation surely occurs in the absence of a price signal. Many studies suggest that energy use relative to GDP falls each year regardless of the price signal by 0.5 to 1.25 percent. To the extent that energy use is associated with climate change effects, and this causes damages not reflected in market prices, this innovation is unlikely to be sufficient. Additional incentives to innovation, such as price signals, or support for R&D may be needed.

7. Some observers of the climate change issue have suggested that capping only developed countries' emission will result in "leakage": the escape of jobs, capital, and polluting activity to developing countries. However, the economic evidence does not support the argument that climate policy will adversely affect U.S. economic competitiveness.

First, non-tradeable sectors account for a substantial share of carbon emissions. Transportation and residential and commercial buildings account for approximately two-thirds of U.S. carbon emissions. For these sectors, the "competitiveness" argument does not appear applicable. Second, energy costs comprise only a small percentage of total manufacturing costs. According to the 1995 Annual Census of Manufactures, energy costs for manufacturing industries averaged just 2.2% of total costs. Given the small share of energy in total costs, differential shifts in existing energy prices are unlikely to have substantial effects on location decisions and trade flows. Third, our experience in this country with environmental regulation has been that it does not cause significant leakage. Firms that decide to relocate to other countries do so because of international differences in labor costs, capital costs, material costs, and exchange rate changes that all swamp the costs of complying with environmental regulations.

To address the possibility of leakage occurring, we should do climate policy smart. If we do it dumb, it will cost our economy a lot. By doing it smart, through flexible, market-based approaches, we will make the costs of complying with an emissions goal much lower. In addition to using market-based approaches domestically, joint implementation and international emissions trading would also lower the costs of climate policy. These lower costs associated with a smart

climate policy would decrease the economic rationale for industries to move to developing countries.

Responses to Senator Boxer's Questions

1. Some observers of the climate change issue have suggested that capping only developed countries' emissions will result in "leakage": the escape of jobs, capital, and polluting activity to developing countries. However, the economic evidence does not support the argument that climate policy will adversely affect U.S. economic competitiveness.

First, non-tradeable sectors account for a substantial share of carbon emissions. Transportation and residential and commercial buildings account for approximately two-thirds of U.S. carbon emissions. For these sectors, the "competitiveness" argument does not appear applicable. Second, energy costs comprise only a small percentage of total manufacturing costs. According to the 1995 Annual Census of Manufacturers, energy costs for manufacturing industries averaged just 2.2% of total costs. Given the small share of energy in total costs, differential shifts in existing energy prices are unlikely to have substantial effects on location decisions and trade flows. Third, our experience in this country with environmental regulation has been that it does not cause significant leakage. Firms that decide to relocate to other countries do so because of international differences in labor costs, capital costs, material costs, and exchange rate changes that all swamp the costs of complying with environmental regulations.

To ensure that climate change policy does not damage U.S. competitiveness, we need a smart climate change policy. If we do it dumb, it could cost our economy a lot. By doing it smart, through flexible, market-based approaches, we will make the costs of complying with an emissions goal much lower. In addition to using market-based approaches domestically, joint implementation and international emissions trading would also lower the costs of climate policy. These lower costs associated with a smart climate policy would decrease the economic rationale for industries to move to developing countries.

2. The costs of reducing emissions in the U.S., and in Europe and Japan depend on how all of these countries implement their policies. If the U.S. employs a market based approach, the costs will not be that high relative to Europe and Japan. Regardless of the implementation approaches used in these countries, the costs of emissions reductions are not likely to affect U.S. competitiveness. As noted above, energy costs comprise a small share of total manufacturing costs (2.2%). Further, two-thirds of carbon emissions occur in non-tradeable sectors. The evidence on energy price differentials across countries suggests that they are not sufficient to spur firm relocation to other countries.

3. The IAT report did not focus on the benefits of reducing greenhouse gas emissions. Without a benefits assessment, the IAT could not provide estimates of the positive effects on human health and the environment. In addition, the IAT did not study the effects of the risks of climate change on economic activity. However, the report did assess the impacts of climate

policy on the economy. The IAT analysis confirms other economic research (for example, the recent report by the World Resources Institute) that smart climate policy can actually lead to net benefits in the long term. For example, the IAT analysis found that auctioning off tradeable permits and using the proceeds of the auction to lower income and corporate taxes would help the economy grow faster in the future than without climate policy.

4. The longer we wait to take any action can adversely affect the economic and environmental outcomes of climate policy. However, we do know that more gradual efforts to reduce our carbon emissions can lower the economic costs relative to very aggressive reductions efforts while still achieving the same carbon dioxide concentration goal. For example, some international proposals to reduce carbon emissions would have Annex I countries cutting emissions to 20% below 1990 levels by 2005. Such a target would have very substantial economic costs because it does not provide enough time for the capital stock to turn over. It is very expensive to scrap the existing capital stock, while much of it is in the prime of its life, and replace it with carbon-free technology. Further, such a target would require the economy to employ existing low-carbon and carbon-free technologies while longer-term targets would provide more lead time to develop and implement superior technologies. Given that it is the stock of carbon dioxide, not the annual emissions of carbon dioxide, that drive global warming, there is an opportunity to be flexible in the timing of emissions reductions. Less aggressive paths that 1990 -20% emissions level by 2005 could achieve the same carbon dioxide concentration stabilization goal in the year 2100 by increasing carbon reductions in the future when they are less costly to the economy.

5. It is very difficult to assess the nature of the economy, and especially specific industries, 20 or 30 years into the future. If the country embarked on a policy of reducing carbon emissions, obviously the firms and industries that can creatively and cost-effectively reduce their emissions will benefit relative to their competitors. To reduce carbon emissions, it is reasonable to envision that the products and services of industries that develop energy efficient technologies and industries that develop low-carbon based energy (such as renewable energy sources including wind, solar, and biomass) would be in greater demand.

Responses to Senator Lieberman's Questions

1. The Administration's analysis on the issue of climate policy has not occurred in a vacuum. In fact, climate change has been one of the more active areas of research in economics this decade. The economic literature on climate change, complemented by the IAT report, has already done quite a lot to inform the policy development process. Based on the economic research, we have identified some of the important characteristics of the climate policy we will develop: joint implementation, international emissions trading, developing country participation, emissions budgets, and market-based, flexible domestic implementation. My interpretation of the role of

economics differs -- I believe economics has informed the process, and I am confident that it will continue to play an important role in our country's deliberations over a climate policy position.

2. No one model, or even a small set of models, can give a definite estimate of the effects of a policy on the economy 20 or 30 years into the future. However, a vast array of economic tools exists to provide us with a basis for informed judgment about the likely effects of different climate policies. For example, we know that a market based approach to reducing carbon emissions will be less costly than a command and control approach. The Administration intends to bring to bear on the climate issue many analytic tools and perspectives. Some of these may have strengths on issues where the models used in the IAT analysis were weak. I am confident that the analytic tools and perspectives available to the Administration can provide us with sufficient information to generate ranges of economic effects so that the Administration can make informed policy decisions.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Adele C. Morris (CN=Adele C. Morris/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:22-SEP-1997 19:12:30.00

SUBJECT: T&T fixes

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

CC: Randall W. Lutter (CN=Randall W. Lutter/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

CC: Joseph E. Aldy (CN=Joseph E. Aldy/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

George,

Here are a few comments on T&T. Still working through it.

Plug for a hole:

p. 5 Electricity generation is responsible for 88.32% of coal use.

(computed from 1995 data from Annual Energy Outlook, p. 173. I computed the same statistic for 1994 with different data from a different book, and it was very comparable.)

Other comments:

p. 1, last sentence: I don't think you want to use the term "escape clause" here. It doesn't make sense in the context.

p. 2. Figure 1: You should have gotten the graph for Figure 1 from Dan Friday night. If not, or you can't locate the electronic version, talk to me and I'll get it for you to embed in the document.

p. 3, last sentence: You may want to say "several of your other advisers are more optimistic..." to clarify that your economic advisers aren't among them.

p. 4, last sentence of middle paragraph: I'd put national building codes in with the other command and control policies.

Adele

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:22-SEP-1997 22:25:45.00

SUBJECT: Targets and Timetables

TO: Peter R. Orszag (CN=Peter R. Orszag/OU=OPD/O=EOP @ EOP [OPD])

READ:UNKNOWN

CC: Jonathan.gruber (Jonathan.gruber @ treas.sprint.com [UNKNOWN])

READ:UNKNOWN

TEXT:

Attached is a rough draft of a targets and timetables paper. I am
finishing up the charts and figures and will send those separately. ===== ATTACHMENT 1
=====

ATT CREATION TIME/DATE: 0 00:00:00.00

TEXT:

Unable to convert ARMS_EXT:[ATTACH.D65]MAIL41690846T.216 to ASCII,
The following is a HEX DUMP:

September 20, 1997

CLOSE HOLD: PRELIMINARY

Targets and Timetables

Executive Summary

This memo provides a preliminary evaluation of the likely economic consequences for the United States of a program to attain 1990 CO₂ emissions levels by 2010. It concludes that, in the space of a decade, such a goal would be extremely difficult to achieve. *If attained through domestic emissions reductions alone* this target entails a reduction in CO₂ emissions of about 28% relative to projected 2010 emissions in the absence of policy intervention--a change in energy use in excess of that achieved during the decade of the oil shocks. An idealized system of international permit trading among Annex I countries would halve the change in carbon emissions prices needed to attain such a goal. Joint implementation with non-Annex I countries could further reduce the price impact in the United States. However, the proposed schemes for both international permit trading and joint implementation require enforcement and monitoring mechanisms that may be difficult to establish in the near term.

Economic analysis suggests that reaching 1990 emissions by 2010 would result in a stagflationary macroeconomic shock on the economy approximately equal in magnitude to the effects of the combined oil shocks of the 1970's. Both unemployment and inflation would undoubtedly rise for a time. Moreover, such a "front-loaded" emissions reduction path has been shown to increase the costs of achieving the long-term goal of stabilizing concentrations by a factor of 3 to 10. In this sense, such an aggressive path is inefficient. A plan to meet a 1990 by 2010 target would entail premature scrapping of capital and forego the considerable advantages of waiting for the development of carbon-lean technologies before replacing existing plant and equipment. Furthermore, the environmental benefits of an aggressive abatement target are extremely small since the differences in global temperatures between fast-abatement and slow-abatement paths are minimal. For example the expected difference in global average temperature in 2100 along a fast takeoff abatement path that attains 1990 emissions by 2010 and a slow takeoff abatement path that peaks in 2015 and attains 1990 emissions by 2040 is uniformly less than .05 degrees Celsius. Between now and 2100, global warming is expected to average about 2½ degrees Celsius irrespective of the path chosen for stabilization.

An economically and environmentally responsible approach for the United States would be to initiate meaningful actions now to create effective incentives to reduce carbon emissions over the next century. Such incentives must entail an immediate increase in the price of carbon emissions along with a credible commitment to further emissions price increases over time.

I. Introduction

The Framework Convention on Climate Change signed at the 1992 earth summit in Rio de Janeiro called for carbon dioxide emissions in 2000 at 1990 levels. Given that most countries, including the United States, are unlikely to achieve these emission reductions, most quantitative proposals that have been advanced in the run up to Kyoto focus on variants of the target and timetable agreed to at Rio. Such proposals thus represent the deferred fulfillment of a previously negotiated goal. Consequently, a proposal to “stabilize CO₂ emissions at 1990 levels by 2010” (and variants thereof, including a more stringent proposal by several EU countries to stabilize at 10% below 1990 levels by 2010) has received considerable attention.

This memo provides a preliminary evaluation of the likely economic consequences for the United States of a program to attain 1990 CO₂ emissions levels by 2010. It compares the costs and cost effectiveness of this baseline proposal with those of alternative targets and timetables that entail a less rapid initial reduction in CO₂ emission levels. The conclusions described here rely on the substantial body of economic analysis that has been conducted by researchers worldwide, including the Intergovernmental Panel on Climate Change (IPCC), and Administration economists.

II. 1990 by 2010: The Scope of the Task

To appreciate the ambitiousness of a program to curb U.S. emissions levels to 1990 by 2010 it is necessary to recognize that such a target involves a cutback of about 28 percent in energy use in 2010 relative to baseline. Carbon emissions are now 12 percent above 1990 levels. Growth in the economy over the next decade would further raise carbon emissions. Even under an optimistic assumption concerning the pace of improvement of energy efficiency (0.9 percent per year), under constant relative energy prices, there would be further increases in carbon emissions by 2010 of about 16 percent if we continue with business as usual. The net required reductions to achieve 1990 emissions in 2010 thus amount to about 28 percent.

Comparison with the Oil Shocks. Cutbacks in energy use (relative to GDP) of this magnitude are considerably greater than those achieved in the decade of the two oil shocks--a period in which relative energy prices more than doubled. Figure 1 shows aggregate energy use in the United States and the relative price of energy over the period 1960 to 1990. During the oil-shock decade--1972 to 1982--energy use was virtually constant in absolute terms, while GDP grew in real terms at about 2 percent per year. The relative price of energy rose by more than 150 percent over this period. In contrast, the “1990 by 2010” program entails larger emissions cutbacks. To meet the 1990 by 2010 goal it is not sufficient just to keep emissions constant between now and 2010: a further 12 percent roll back in emissions is needed to offset the expansion that has already occurred since 1990. Thus, we would need to accomplish a reduction in energy use considerably larger than what occurred over a decade in which the relative price of energy more than doubled. The experience of the oil shock period, and other empirical analysis, suggests that the responsiveness of energy use to changes in the price of energy (the price elasticity of demand for energy) over periods as short as a decade is no higher than 0.2. Assuming a price elasticity of demand of 0.2 over a decade, energy prices would have to rise by about 140 percent to

attain 1990 emissions by 2010.

Model results. Simple extrapolation from the historical experience of the oil shock suggests that a plan to reduce U.S. emissions to 1990 levels by 2010 would result in average energy price increases within the range of estimates that have been generated by large scale economic/energy models. Numerous models have been used to estimate the impact of a 1990 by 2010 program on energy prices. Such models differ somewhat in the assumptions they embody concerning the feasible range of technological options and likely technological trends. Nevertheless, a broad range of models, employing a common energy use baseline, place the carbon permit price required to achieve 1990 emissions by 2010 in the range of \$80 to \$200 per ton. If fully passed through to energy prices, a permit price of \$100 per ton would entail nearly a doubling of energy prices. The impact on the prices of different sources of energy are all large, but the effect on coal is particularly severe. The price of coal would more than triple, while the price of a barrel of petroleum would increase by about fifty percent. Gas at the pump would increase in price by about 26 cents. Relative to the BTU tax proposed by the Administration in 1993 this implicit tax is about 9 times as large. Thus, attaining a goal of 1990 by 2010 would entail very large economic consequences.

Evidence from International Comparisons. A final piece of evidence confirming the conclusion that a strong price signal over a long period of time is necessary to alter energy use comes from comparisons of energy usage between the United States and Europe. It should hardly be surprising that energy use per dollar of GDP is lower in Europe than the United States. Energy prices in Europe have long been substantially higher--roughly double U.S. energy prices at the present time. Moreover, major differences in living patterns between the United States and Europe result in higher European energy efficiency. In addition to the geographical "advantage", from an energy efficiency standpoint, of Europe's higher population density, resulting in lower transportation requirements, Europe has locked in place many long-run adaptations to high energy prices. Innovations in the design of housing and transportation systems and the configuration of residential areas have occurred in response to high energy prices. But in spite of its natural advantages and its long history of high energy prices, energy per dollar of GDP is only 44% lower in Europe than in the United States. This means that were the US to become Europe--energywise per dollar of GDP--its energy savings, even in the long run, would be no greater than 44 percent. This US-Europe comparison supports the conclusions drawn from the natural experiment of the oil shock: namely, a return to 1990 emissions will not occur in the absence of very major incentives over a long period of time.

The Role of Technology and the Scope for "No Regrets" Policies. According to the preceding assessment, a large price inducement is necessary to meet a 1990 by 2010 target. Your economic advisers agree on this conclusion. However several of your advisers are more optimistic about the chances of achieving a 1990 by 2010 target. They emphasize the current availability of "no regrets" (cost-saving) technologies that promise substantial opportunities for abatement. A recent report by the Department of Energy research laboratories, for example, catalogues emissions-savings technologies that, by their calculations, are currently "cost effective." If put in place now, the report concludes that such practices could reduce emissions by between 30 to 50 percent of the amount needed to reach a 1990 by 2010 target. Even so, the

report finds that “aggressive” and “invigorated” government policies—including potentially costly and intrusive regulations and standards--as well as a \$50 carbon tax would be necessary to reach the 1990 by 2010 target.

Your economic advisers agree that there now exist unused technological opportunities for emissions reduction, but question by what means, over what time frame, and at what expense government policies could change private behavior if such opportunities are currently underutilized. Economists believe that engineering studies miss the sometimes subtle disadvantages of available cost-savings technologies or overestimate their hypothetical returns. An example is illustrative: significant energy and cost savings could result if consumers replace incandescent bulbs with compact fluorescents. Over the long lifetime of such bulbs there would also be a substantial monetary gain. However, actual use of these light bulbs has been slow to date, possibly due to pure inertia, possibly because consumers dislike their color, or perhaps because they apply a high “discount rate” when valuing energy savings that accrue after the purchaser may have switched residence. Several recent studies have demonstrated that the actual returns to home improvement investments, such as attic insulation, often fall short of those predicted by engineering studies. Regardless of the reasons, if consumers have not adopted “no regrets” measures at a faster rate, it is likely that additional incentives will be necessary for them to change their minds. Rather than stressing the mere availability of alternative technologies, your economic advisers insist on realistic estimates of likely rates of adoption and diffusion and they stress the need for economic incentives--in this case a higher implicit price for emitting carbon--to induce the adoption of emissions-savings technology. They point out too that the baseline energy use estimates used to predict the price increase needed to attain a 1990 by 2010 target already assume substantial ongoing improvements in energy efficiency due to the diffusion of existing technologies and the development of new ones. Significant adoption of such technologies is necessary merely to meet this assumed baseline. Finally, it is important to note that the DOE labs study projects that extensive regulations, including stringent CAFE and appliance standards and national building codes--command and control policies that your economic advisers would oppose--along with a \$50 carbon tax would be needed to reach 1990 by 2010.

To summarize, in the absence of an aggressive set of regulations concerning energy use, your economic advisers do not consider it realistic to predict a substantial increase in the pace of adoption of new emissions-savings technologies--without a large price signal. They are optimistic, however, based in part on the evidence from the energy shocks of the 1970s, in part on international comparisons, and in part on model results, that energy use is responsive to changes in the price of CO₂ emissions--with larger responses to a given price change likelier the longer the time period for response. The evidence is strong that a very large price increase will be necessary to attain emissions reductions of 20 to 30 percent over a period as short as a decade.

In conclusion, your economic advisers believe that a clear price signal is essential to any effective strategy to reduce CO₂ emissions and to provide appropriate incentives for the development over time of lean carbon technologies. The emission of CO₂ involves a classic externality, since, absent a cost to emitting carbon, no individual has any economic incentive to use lean-carbon or carbon-free sources of energy. There is even less incentive for the private

development of carbon-saving technologies which no one has an incentive to buy. The solution to curbing carbon emissions relative to baseline, and also to induce private research and development, involves changing the incentive structure to encourage reductions in emissions and to spur the development of carbon-saving technologies.

III. Why are the costs of early emissions reductions so high?

The previous section argued that a "1990 by 2010" target would entail high carbon emission prices and significant economic costs. This section shows that the 1990 by 2010 timepath for emissions reductions is so aggressive as to be inefficient--in the sense of raising substantially the total projected economic cost of reaching a given environmental goal. Economists have tried to demonstrate this point by examining how the total costs of achieving a fixed environmental target for greenhouse gas concentrations varies with the aggressiveness of the initial reductions. There are three major reasons why an aggressive takeoff in curtailing emissions raises overall costs: (1) it induces premature obsolescence of the capital stock because it does not allow adequate time for the capital stock to turn over naturally; (2) it provides insufficient lead time to develop and implement new technologies; (3) it causes a significant stagflationary short-term macroeconomic shock. Additionally, a slower timetable for emissions reductions allows time for the resolution of uncertainty and takes advantage of the time-value of money (resources not spent on emission reductions early on can be invested at a positive return which could purchase more emission reductions later).

The Role of Turnover of the Capital Stock. The most clear-cut and easily quantifiable reason for the high price tag associated with rapid emissions reductions relates to the need for premature replacement of plant and equipment in response to large increases in the price of carbon emissions. A longer window in which to reduce carbon emissions allows more time for the capital stock to turn over. While it is very expensive to replace plants in the prime of their useful lives with less carbon-intensive plant and equipment, within 20 to 40 years, much of our existing plant and equipment will be ready for replacement anyway.

The advantage of a slower emissions reduction timetable in avoiding the large costs associated with premature obsolescence of the capital stock can be illustrated by considering electrical power generation. The case of electricity generation is important in its own right since this industry is responsible for @@% of coal use and more than one third of all carbon dioxide emissions in the United States. Nevertheless, the same principle concerning the costs of premature replacement applies broadly because reduced greenhouse gas emissions may entail the accelerated retrofitting of housing and commercial structures, the premature scrapping of vehicles, and the premature replacement of plant and equipment in energy intensive industries.

Figure 2 illustrates the effect of an accelerated retirement schedule for U.S. electric power generation capacity installed during the last 40 years. Imagine, to take an extreme case, that a timetable is adopted that necessitates replacing all power plants with less-polluting technology within ten years. This would require retiring 630 out of 670 gigawatts of generating capacity before the end of its normal life span, or 94 per cent of the total. If the timetable were extended so that all power plants instead had to be replaced within 20 years, the accelerated replacement of capacity would affect 450 gigawatts of capacity, or 67 per cent of the total. Allowing this

additional 10 years for turnover avoids the premature retirement of 27 per cent of existing electric power plant capacity. With a 30 years horizon, complete turnover would mean accelerated retirement of only 21 per cent of the total capacity and, with a 40 year timetable, there would be almost no additional costs due to premature obsolescence.^{1, 2}

The Advantage of Waiting for Superior Technologies. The example of electric power generation also illustrates a second important reason why a slow takeoff in curbing greenhouse gases emissions is ultimately less costly: it takes considerable time before emerging carbon-free or carbon-lean technologies are developed. Waiting until these new technologies are available before making expensive emissions-saving investments offers the potential of both lower economic costs and higher environmental payoffs. Under a tight target and timetable with its associated high carbon emissions price, electric utilities will be faced with the need to replace existing capacity in the very near future and to rely on currently available lean-carbon technologies, likely gas-turbine plants. Under the impetus of higher prices and a well-designed R&D program, however, there is undoubtedly the potential to improve the effectiveness and reduce the cost of these alternative technologies. A rapid timetable forces long-term investments to be made before superior technologies have been developed and refined.

¹The distribution has been truncated at 40 years, the average lifespan of existing electric power plants. A few plants of yet older vintage are still in use.

²The same exercise can be performed for coal-fired power plants. These generators produce the most carbon per kilowatt hour of electricity and thus will have a high incidence of replacement even under a moderate abatement plan. If a complete change-over of coal plants were to be accomplished in 10 years, 96 per cent of total capacity would be retired early. If retirement occurred over 20 years, only 64 per cent would be retired early. Allowing an additional 10 years for turnover would avoid premature retirement of one-third of existing coal-fired plant capacity.

Implication: The Need for a Credible, Long-Term Price Increase. The example of electricity generation illustrates two general principles. First, the responsiveness of both demand and supply are greater in the long run than in the short run. This means that, with a longer horizon, any given amount of abatement can be accomplished with a smaller increase in carbon emissions prices. Second, and perhaps yet more important for policy, this example shows that any credible emissions reduction strategy requires both a price signal at the outset and also a clear commitment to maintain and likely increase that signal over time. Without such a commitment, the changes in behavior required to meet even a long-run target of emissions reduction will likely not occur. Consider a utility that today is beginning its plans for a new power plant, either as replacement for an old plant or as totally new construction. That utility will choose among today's technologies, which vary in their costs and CO₂ emissions. In order to induce the utility to choose a more costly, lean-emissions technology today, it must be clear that over the future (40 year or more) life of that plant, CO₂ emissions will be costly--costly enough over the lifetime of the investment to justify a more costly investment option today. In terms of Figure 2 we might imagine that today a small number of plants, those of older vintages, are being replaced. Even though the fraction of plants being replaced over the course one, two, five or even ten years is fairly small, over yet longer periods of time the impact of those decisions cumulates. A large cumulative reduction in emissions is possible, starting with a modest carbon emissions price increase now, but only if the managers of the utilities have sufficient incentives to choose lean-carbon technologies when plants are replaced. This requires not just an emissions price increases now but also a credible commitment to a long term policy of increasing emission penalties over time.

Stagflationary Macroeconomic Impact. From a macroeconomic perspective, increases in energy prices constitute a "supply shock." Such shocks are stagflationary because they raise both inflation and unemployment simultaneously, creating a painful macroeconomic dilemma. As noted above, a plan to attain 1990 emissions levels by 2010 would require a change in energy prices over the first decade of the 21st century at least comparable in magnitude to the two oil shocks of the 1970s. Those shocks are widely acknowledged to have had a substantial adverse impact on both unemployment and inflation. Similarly, the energy price increases required by a 1990 by 2010 program would raise inflation, lower real wages (@@ by how much?) and raise unemployment. Unemployment in the four years after the first oil shock averaged 7.2 percent in comparison to 5.0 percent in the four years prior and unemployment rose further to an average of 8.7 percent in the four-year aftermath of the second. There remains debate about how much of this was due directly to the oil shock, because there was a simultaneous decline in productivity growth and transfers of real income to OPEC producers. In contrast to the two oil shocks, the increases in energy prices associated with a treaty to reduce greenhouse gases would be anticipated, rather than a surprise. Nevertheless, we should expect that the efforts of the Federal Reserve to contain inflation, coupled with likely efforts on the part of workers to recoup real wage losses--even if those losses are anticipated--will lead to a period of higher unemployment.

Furthermore, it is important to note that most model-based estimates of the costs of a program to attain 1990 emissions levels by 2010 assume that resources are fully employed, thereby ignoring these potential short-term effects. Such models therefore provide no assessment of the consequent increases in unemployment.

IV. Quantifying the Economic Costs of Slow versus Fast Take-off

The relative costs of slow versus fast takeoff timetables in curbing CO₂ emissions has recently been analyzed by the Stanford Energy Modeling Forum (EMF). To enable meaningful comparisons of results across models, the EMF has coordinated a series of projects in which a number of large scale energy models are used to estimate the impact of given, specified emission reduction scenarios under common standardized, benchmark assumptions concerning population and economic activity, discount rates, energy resource availability and prices and technology availability. In its most recent comparison exercise (EMF-14), the Stanford group used six models to compare the total projected cost of two alternative emissions reduction time paths--one "frontloaded", the second more "backloaded". Both paths were designed eventually to stabilize atmospheric concentrations of CO₂ at double the pre-industrial level--550 ppmv.³ Although a high degree of uncertainty attaches to particular numerical estimates from individual models, the simulations nevertheless point to some robust qualitative conclusions. The major conclusion to be drawn from the EMF-14 comparison project is that an emission reductions path characterized by an aggressive initial phase is substantially more costly--3 to 10 times more costly--than a path with a slower takeoff but larger eventual reductions.

To enable a comparison of the costs of slow and rapid takeoff strategies, the EMF investigators asked each of six modeling groups to simulate the economic impacts of two alternative strategies to attain stabilization of CO₂ concentrations at 550 ppmv. The first strategy (the WG-1 path) corresponds to an emissions pathway published in 1994 by Working Group 1 (WG-1) of the Intergovernmental Panel on Climate Change (IPCC). Using the Wigley model of the carbon cycle, the working group computed a set of global CO₂ emissions pathways consistent with stabilization of concentrations at 550 ppmv and several alternative concentration levels. The WG-1 path entails an immediate departure from the baseline or "business as usual" emission path. Subsequently, Wigley, Richels and Edmonds (WRE) published an alternative set of emission profiles to achieve the same concentration targets. In contrast to the WG-1 paths, the WRE emission path was constructed to follow the baseline or "business as usual" scenario in the early years with sharper reductions after this initial phase. Wigley, Richels and Edmonds hypothesized that their slower-takeoff emissions pathways would yield identical environmental objectives with substantially lower economic costs, for the reasons discussed above. The EMF-14 exercise validates this hypothesis.

³ All energy models make numerous simplifications and approximations in order to describe the energy sector globally and over the span of a century or more. In particular, all of the models assume full employment, thereby abstracting from the likely short-run macroeconomic costs of an emissions reduction program.

The EMF-14 comparison project assessed the total costs to the OECD, the EEFSU (Eastern Europe and the former Soviet Union) and the non-Annex I countries of the WG-1 and WRE pathways to stabilization of CO₂ concentrations at 550 ppmv. The appropriate economic measure of total cost is the present discounted value of losses in future consumption relative to a "Business as Usual" scenario. Estimates of regional costs depend on the extent of burden sharing--namely, the assumed "division of labor"--between Annex-I and non-Annex I countries in controlling emissions as well as the extent of international emissions trading. Recall that, by the end of the next century--by 2100-- assuming "business as usual"--non Annex I countries will have more than 90 percent of CO₂ emissions. Thus, developing country participation is absolutely essential to achieving stabilization of concentrations. Consistent with the Berlin Mandate, the simulations assumed that the burden of emissions reduction would fall on Annex I countries exclusively during the early decades; that by 2030, non-Annex I countries would begin to participate; and by 2050, a full transition to targets based on equal per capita emission rights is assumed.

Figure 3 plots the OECD emissions paths in the WG-1 and WRE scenarios. Under the WG-1 scenario, OECD emissions begin to decline immediately and continue to decline for roughly four decades. For example, OECD emissions fall 10 percent below initial levels ten years after implementation--corresponding closely to 1990 by 2010, which requires a reduction of 12 percent reduction from current emissions. In contrast, OECD emissions along the WRE path continue to rise for roughly two decades--corresponding to a plan calling for emissions to peak around 2020--return to 1990 levels around 2040 and decline substantially further in subsequent decades.

Table 1 illustrates a robust conclusion that emerges from the EMF-14 comparison of the fast take-off WG 1 path and its slow take-off WRE counterpart: fast takeoff in emission reduction greatly increases the costs. Table 1 shows the discounted value of OECD consumption loss for the WG-1 and WRE paths--both with and without idealized international trading of permits. In 10 out of 12 simulations--for six different models with and without permit trading--the costs on the slow-takeoff WRE path is less than a third of the cost on the corresponding fast take-off path. The average ratio of relative costs for the 12 comparisons is less than 0.3. Taking account of the likely adverse short-run macroeconomic consequences of the aggressive WG-1 path would further strengthen this conclusion.

Table 2 illustrates a second, robust conclusion from the EMF-14 exercise: a viable system of international permit trading would very much reduce OECD costs. With global permit trading, the sharp, early emission reductions required on the WG-1 by OECD countries would be avoided through the purchase of emission permits from countries with lower abatement costs. With one exception, all of the cost ratios reported--the cost with idealized permit trading relative to the cost without--are considerably less than one; the average ratio for the twelve simulation outcomes is 0.44.⁴

⁴ The computations in Table 2 verify that the WRE path, which permits emissions to depart relatively little from business as usual for several decades, is a substantially less costly than the alternative WG-1 path with its sharper immediate reductions. Since both paths are arbitrarily

chosen to conform with the 550 ppmv concentration target, a natural question concerns the characteristics of an optimal or least-cost path for achieving this concentration target. An important recent study by Alan Manne and Richard Richels uses their MERGE model (included in the EMF-14 project) to compute the least cost path with 550-stabilization in 2100 and international permit trading. The optimal path, while not identical to the WRE path, is similar in character. This least-cost path peaks approximately three decades after the initiation of the program and declines thereafter.

Finally, it is important to note that in most of the EMF models, policy actions to raise carbon emissions prices must be taken at the inception of the WRE program and a commitment to increasing emissions prices over time is required to achieve additional emission reductions. Naturally, the required initial carbon emissions price is substantially lower, at the outset, under the WRE than under the WG-1 path. Thus, although the WRE emissions path initially approximates the business as usual baseline, credible incentives must be put into place immediately, and strengthened over time, to achieve the needed investments in carbon-efficient technologies.

V. The Environmental Consequences of Slow versus Fast Takeoff.

While the excess cost of a fast compared to a gradual takeoff emissions reduction path has been shown to be large, the difference in projected global temperatures over the next century between the fast and the slow paths are quite small, both in absolute amount and relative to temperature changes expected from global warming. Under “business as usual” assumptions, increasing concentrations of greenhouse gases are expected to raise average global temperatures by about 1 degree Celsius by 2050 and about 2½ degrees Celsius by 2100. The emission reductions achieved by a path that would stabilize emissions at 1990 levels by 2010 and hold them at this level thereafter serves to mitigate this temperature increase by roughly 0.1 degrees by 2050 and 0.2 degrees by 2100. In contrast, an emissions path that peaks around 2015 and stabilizes at 1990 levels by 2040, again holding emissions constant at 1990 levels thereafter provides virtually the identical environmental benefits: the temperature differences between these two paths diverge by no more than .05 degrees over the next century. Similarly, the temperature differences along the aggressive WG-1 and less aggressive WRE paths designed ultimately to stabilize concentrations at 550 ppmv differ by a maximum of 0.2 degrees over the next several centuries.⁵

⁵ If a model assumes that sulfur dioxide emissions decline with the decline in carbon dioxide emissions under climate policy (as predicted, given the extent of sulfur emissions associated with fossil fuel combustion, and incorporated in the IPCC’s IS92 emissions projections), the WG-1 path will be *warmer* than the WRE path between 2000 and 2040. This result reflects the negative impact of sulfate aerosols on the greenhouse effect. Early and substantial cuts in fossil fuel combustion, while decreasing the carbon emissions that warm the atmosphere, also decrease the sulfate aerosols that cool the atmosphere.

The limited climatological impact of even an extremely aggressive emission reduction program measured in terms of temperature impacts during the next century results from extremely long lags involved in the underlying physical processes and the dependence of temperature on the total stock of carbon dioxide in the atmosphere, rather than the flow of emissions at a given time. Emissions reductions do matter to temperature, but over an extremely long horizon. The cumulative nature of the process points to a payoff from early action, but also suggests that there is little effect on global temperature from a slow rather than from a fast abatement takeoff. The addition to the total stock of carbon from a slow rather than a fast start to abatement adds relatively little to the total atmospheric stock of CO₂ between now and 2100 for four separate reasons: the difference in carbon emissions between a slow and a fast start over the initial decades of abatement is only a small fraction of total emissions in that period; the stock of CO₂ in the atmosphere is itself the result of many decades of emissions; some of the CO₂ emissions of the early decades will have been re-absorbed; and the most serious build-up in CO₂ under business as usual occurs late in the next century, as a consequence of burgeoning emissions from non-Annex I countries, so that Annex I emissions will not dominate that build-up.

The preceding analysis abstracts from the possibility of catastrophic environmental effects, such as the melting of the West Antarctic ice sheet, a runaway greenhouse effect (e.g., from release of trapped methane with the melting of the permafrost), or structural changes in ocean currents such as the Gulf Stream. However, even the potential for these disruptions does not fundamentally affect the basic trade-offs between the high costs of fast vs. slow takeoff paths. These factors do, however, add, perhaps greatly, to the urgency of adopting moderate long-term greenhouse gas concentration targets and a program involving an immediate, albeit moderate, increase in the price of CO₂ emissions.

VI. International Trading of Permits

As has already been noted, an effective system of international carbon emission permit trading among Annex I countries has the potential to substantially diminish the cost of a CO₂ abatement program, although such trading would likely result in substantial transfers to Eastern Europe and the former Soviet Union. An Annex I trading system could, potentially, reduce the cost to the United States of any emissions goal by about 50%. Moreover, joint implementation projects with non-Annex I countries hypothetically produces further gains of similar magnitude.

Although international trading and joint implementation--so-called "where flexibility"--has enormous advantages in theory, your economic advisers are concerned that substantial barriers would arise in implementing any workable analogue of such an idealized system--at least in the near term. Consequently, they would stress that Annex I international permit trading and joint implementation between the U.S. and nonAnnex I countries can realistically serve only a limited role in reducing the costs associated with meeting a "1990 by 2010" target.

A hypothetical example shows how an international trading system would work, and why it would reduce each participant country's abatement costs. Suppose, ideally, that every country adopts a domestic permit system to implement its Kyoto target. Absent international trading, the

price of emissions permits could differ across countries, reflecting differing marginal costs of abatement internationally. With different permit prices in different national markets, profit seeking traders would be motivated to buy permits in countries where they are cheap and resell them in countries where they are more expensive. Such arbitrage activities would create an international permit market, bringing permit prices into equality worldwide. This idealized system promotes global efficiency in achieving any worldwide abatement goal. Agents in countries with permit prices below world levels have the incentive to reduce emissions further in order to profit from international permit sales. As a consequence of such actions, low permit price countries would export permits and cut back their emissions beyond their Kyoto requirements. Similarly, agents in high abatement cost (high permit price) countries would reduce costs by importing permits, thereby relaxing their Kyoto emissions constraints. The U.S. government could avoid any direct participation in such a system as long as it deems foreign-issued permits presented to the U.S. government by U.S. carbon-emitting entities as valid as those issued by the U.S. government itself.

The preceding description of how an international permit trading system would work provides an idealized picture of its possibilities. But the actual benefits of such a system are apt to fall short of this utopian portrayal. One reason is that countries are not obliged to implement domestic permit trading schemes to fulfill their Kyoto commitments and few Annex I countries have indicated an intention to do so. Consider, for example, the potential for U.S. emissions trades with countries that decide to limit domestic emissions through energy taxes or command and control regulations. In either case, international trading would involve government to government negotiations, and difficult political decisions. In contrast, in the idealized system, trades result from profit oriented transactions among individuals, mediated through the market. For example, consider a government that has decided to limit domestic emissions through regulatory controls. International permit sales that result in tighter domestic constraints could well be politically unpopular so that a government would hesitate before selling its emission rights to the United States. Similarly, international permit sales by a country that is meeting its Kyoto obligations through domestic carbon or energy taxes requires a further hike in those taxes.

Monitoring and enforcement issues are also likely to be paramount in insuring the workability of international trading. If domestic enforcement is effective in all countries, so that mechanisms operate to ensure that consumers and firms in each country actually limit emissions to the national permit levels, international permit sales by private agents in the country actually translate into lower domestic emissions. But consider the difficulties that can occur with imperfect enforcement. If the government of a country--country X--finds it difficult either to measure domestic emissions or to enforce the purchase of permits by domestic emitters, then reductions in X's emissions may be insufficient to reach the Kyoto target. Those agents in X that are lucky enough to have been assigned the rights to X's permits will be able to sell them, at a quick profit, on the international market. With imperfect enforcement, international sales, without corresponding domestic emissions reductions, could emanate from countries with the weakest systems of enforcement. To prevent such "paper trades", which profit some participants and increase emissions, many countries will want controls to ensure the integrity of international permits. Buyers, too, will want clear concrete guarantees of the validity of permits so as to be sure they will not be asked to reduce emissions on-site as well. These controls and guarantees

may raise the costs of participating in this market and make the estimated savings illusory. In fact, most of the benefits projected from the international sale of permits come from inducing emissions reductions from countries in Eastern Europe and the former Soviet Union--countries with particularly weak tax collection and enforcement mechanisms. Without such countries in the scheme the gains from international trading of permits will be very small.

Model results suggest that joint implementation with non-Annex I countries also has the potential to reduce the U.S. burden of attaining any given timetable. Prior to the adoption of quantitative targets by the developing countries, however, emissions trading is apt to occur on a project-by-project basis in situations where it is demonstrable that a given project has reduced emissions relative to business as usual. For example, US businesses could receive credit for the construction of nuclear, oil or natural gas electricity generation plants in China if it were confidently expected that China would instead have constructed coal-fired plants with much higher CO₂ emissions. Permits for such trades might be overseen by an international agency to ensure that the projects were emissions-replacing. Such a project by project system is likely the most that is feasible without quantitative targets, but the efficiency benefits are not likely to be as great as with an enforceable system of international permit trading. In contrast, model results concerning the benefits of joint implementation treat it as equivalent to full international trading.

VII. Recycling of Revenues

The ultimate economic cost of an emission abatement program depends upon how the revenues realized from carbon taxes or auctioned permits are used. It has been estimated that the efficiency loss from collecting an extra dollar of tax revenue amounts to around 30 cents. If the resulting revenues from a carbon tax or auctioned permits are used to reduce inefficient taxes inhibiting work or investment, there would be welfare gains that offset the micro efficiency losses from energy curtailment. According to some estimates, GNP would actually increase if the revenues were used to reduce taxes on capital. Simulations by Nordhaus show that the optimal size of an abatement program would depend on how the revenues are recycled. Abstracting from the potential incentive gains from recycling, Nordhaus has shown that an initial carbon taxes of about \$5 is optimal for the U.S., given his projections of abatement costs and environmental benefits. However when revenues are used to replace other taxes with an efficiency loss of 30 cents, the initial optimal carbon tax rises to almost \$60. The simple lesson is that the costs of emission abatement are greatly reduced if the revenues from the taxes levied can be put to good use.

So far we have approached the recycling of revenues from the standpoint of microeconomic efficiency. There is also the potential for using the revenues to abate the macroeconomic consequences of the emissions program. The oil shock is believed by many economists to have resulted in increased unemployment because workers resisted the fall in real wages that was associated with the inflationary impact of higher energy prices. Increased wage demands added inflationary pressures to the economy that could only be suppressed by tighter monetary policy. Thus it might be argued that the effects of the real wage shock on inflation and unemployment could be diminished by lowering payroll or other worker taxes to offset the real

wage losses from higher energy prices.

But England's experience points to the need for caution in assessing the potential for revenue recycling to allay the macroeconomic consequences of the rising energy costs. In 1979, immediately after her election, Margaret Thatcher increased the VAT tax and simultaneously decreased the income tax. These two policy changes had offsetting effects on real after tax incomes, and therefore might have been expected to have had no effect on wage bargaining. However, the increase in the VAT tax resulted in an immediately noticeable increase in the CPI. A wage-price spiral ensued as workers attempted to maintain their pre-tax real wages.

VIII. Policy Implications

The foregoing arguments point to the attractiveness, from both an economic and environmental standpoint, of a U.S. policy to raise the price of carbon emissions--either through a carbon tax or a system of auctioned permits--by a moderate amount--for example, between \$10 and \$25 per ton of carbon-- in the near term, with further increases scheduled over the longer term. Under this program, U.S. emissions would continue to rise for at least a decade before declining to current, then 1990 levels and below. Such a program could be defended as a significant policy action consistent with a strong U.S. commitment to attaining the ultimate objective of the Framework Convention--namely to stabilizing atmospheric concentrations of CO₂ and hence mean global temperatures.

A program involving gradual increases in the relative price of carbon emissions over time would avoid the possibly substantial macroeconomic consequences of a 1990 by 2010 program. The energy price increases associated with this program would have a modest impact on family income that could be offset by compensating cuts in other taxes.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Joseph E. Aldy (CN=Joseph E. Aldy/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:22-SEP-1997 19:42:21.00

SUBJECT: inserts and comments on T&T paper

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])
READ:UNKNOWN

TEXT:
Janet,

Exec. Summary: the last sentence appears to be awkward -- is escape clause the appropriate subject?

p. 2, paragraph 1: is the EU proposal 1990 -10% in 2010? The only reference I have on this proposal is 1990 by 2000. Several EU countries have proposed 1990 -10% in 2010 (and even tighter constraints).

p. 2, para. 2: if you would like to expand the list of sources for our economic analysis, you could insert the Energy Modeling Forum.

p. 3, para. 2: The range of permit prices can be modified to "\$80 and \$200 per ton". MERGE estimates \$204/ton in 2010 with no trading to achieve 1990 levels.

p. 3, para. 2: You may want to add a footnote that all of the energy prices reflect a \$100/ton permit, and that higher permit prices would result in even higher energy prices. Also, note that the BTU tax value on one calculation we have had done at \$100/ton permit price is 9 times the 1993 proposed BTU tax, not 10 times. Randy is going to replicate this calculation.

p. 3, para. 3: Delete sentence that starts "This exceeds the 28% reduction from BAU necessary to attain '1990 by 2010,' but not by so very much." I think this is the incorrect comparison and weakens your argument. The 44% in energy savings reflects the long-run for Europe -- 1990 in 2010 for the U.S. is short run. In fact, Randy and I think that the previous sentence should be rewritten to reflect that 44% would be a long-run upper bound given several of the advantages in Europe for energy conservation (e.g., the effect of population density on transportation patterns).

p. 4, para. 2: National building codes are also command and control policies, so the last sentence could be rewritten to move "national building codes" right after appliance standards. Note that the report does not explicitly state CAFE, appliance standards, or building codes, but does state that "the broad nature of the actions could include... energy efficiency codes and standards", and only through conversations with DOE staff (Howard Gruenspecht) have we heard explicitly from DOE that they imply these 3 controls.

p. 6, para. 3: Gas-turbine plants is appropriate in discussion of currently available carbon-lean tech.

p. 10, para. 1: I have the chart with WRE, WG-1, and least-cost emissions paths. All three represent full international trading starting in the year 2000. These are the actual emissions by OECD countries, not their original allocations. Attached is the freelance file -- I will also drop off a hard copy.

p. 10, para. 2 and exec. summary: Our discussion of climatic effects is incorrect. The values for temperature change we have are not for stabilization cases -- they are for 1990 in 2010 (and variants) and Peak in 2015 where we straight line out to 2100 emissions at 1990 levels after the target date (e.g., in 1990 from 2010, emissions are at 1990 levels through 2100), and we invoked several different burden sharing rules (Non-Annex I BAU through 2100, Non-Annex I BAU through 2030 and stabilize at 2030 levels in 2030 and stay at these levels through 2100, Non-Annex I and Annex I stabilize at 1990 levels in 2030; note that the per capita permit case yielded anomalous results). For comparison of WRE and WG-1, we can rely on the WRE paper in Nature. There, the largest differential at any one point in time is 0.2 degrees C, not 0.05. Also note that temperature results are sensitive to SO2 emissions modeling (in fact, WRE has LOWER temperatures than WG-1 in the early part of the next century if one assumes that SO2 emissions decrease with a decline in carbon emissions). Let's talk about this.

Joe

===== ATTACHMENT 1 =====
ATT CREATION TIME/DATE: 0 00:00:00.00

TEXT:

Unable to convert ARMS_EXT:[ATTACH.D0]MAIL41151746E.216 to ASCII,
The following is a HEX DUMP:

Clinton Presidential Records Automated Records Management System [EMAIL]

This is not a presidential record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

Hex Dump file is not in a recognizable format, has been incorrectly decoded or is damaged.

File Name: p_d6471509_cea_html_1.pre

Attachment Number: [ATTACH.D0]MAIL41151746E.216

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Peter R. Orszag (CN=Peter R. Orszag/OU=OPD/O=EOP [OPD])

CREATION DATE/TIME:22-SEP-1997 13:46:42.00

SUBJECT: Memo

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

===== ATTACHMENT 1 =====

ATT CREATION TIME/DATE: 0 00:00:00.00

TEXT:

Unable to convert ARMS_EXT:[ATTACH.D72]MAIL45801546K.216 to ASCII,
The following is a HEX DUMP:

DRAFT #1: CLOSE HOLD

September 22, 1997

MEMORANDUM FOR THE PRESIDENT

FROM:

SUBJECT: Climate change

This memorandum provides more detail on some of the issues raised during our climate change meeting with you on September 18. A working group at the Assistant Secretary level has drafted longer memoranda on most of these topics; if you would like even more detail on any specific issue, we could forward the appropriate memorandum to you. [We have also attached an updated workplan that maps out the decision-making process over the next month.]

This paper:

- Outlines the sources of current emissions in the United States;
- Discusses several aspects of a tradeable permits system, including:
 - The potential benefits of a permits system relative to mandated standards;
 - The lessons offered by the SO₂ trading program;
 - Grandfathering versus auctioning with revenue recycling; and
 - Where in the production stream the permit requirements would best be imposed.
- Illustrates why economists believe that a more gradual approach to emissions reductions dramatically reduces the costs involved in addressing climate change;
- Examines why environmentalists believe that a gradual approach is dangerous for international efforts;

- Discusses the potential for technology to reduce the costs of emissions reductions, and highlights a possible technology program to address climate change;
- Presents more detail on the escape clause concept; and
- Discusses several ideas that are popular with corporations, including international trading, joint implementation, and an early credit program.

I. Sources of emissions in the United States

The major greenhouse gases include water vapor, carbon dioxide (C₂O), methane (CH₄), nitrous oxide (N₂O), ozone (O₃), and a variety of engineered chemicals, including chlorofluorocarbons (CFCs), and hydrochlorofluorocarbons (HCFCs). In 1995, gross U.S. emissions of greenhouse gases amounted to 1.676 billion metric tons of carbon equivalent. But forests and other natural “sinks” absorb carbon; on a net basis, therefore, U.S. emissions amounted to 1.559 billion metric tons of carbon equivalent.

Carbon dioxide represented 85 percent of U.S. greenhouse gas emissions during 1995, and accounts for a majority of recent increases in the heat-trapping capacity of the atmosphere. Efforts to address climate change therefore usually focus on carbon dioxide emissions.

[FULL SECTION FROM ROSINA DUE TUESDAY MORNING]

II. Tradeable Permits

During our meeting with you, we discussed a tradeable permits system for reducing carbon emissions. This section examines several questions related to tradeable permits. The first is why a tradeable permits system facilitates less costly reductions than mandated standards (e.g., that every car must have a fuel efficiency higher than some level).

Tradeable Permits Versus Mandated Standards

A natural question about tradeable permits is why they reduce the costs associated with meeting a given emissions reduction objective. Wouldn't it be easier and more straightforward to mandate standards on items such as automobile fuel efficiency?

Mandated standards are generally a more costly approach than market-based systems to reducing pollution. The reason is that standards require all participants to reduce their polluting activities, regardless of the cost, and then offer no

incentive to improve environmental efficiency beyond the given standard. A tradeable permits system, on the other hand, allows reductions to take place wherever they are cheapest and imposes no arbitrary constraint on incentives for further improvement. And in most cases, a tradeable permits system is less administratively costly.

An example may be helpful. Assume that there are two coal-fired plants, both of which emit 100,000 tons of carbon per year. The first plant can easily switch to less carbon-intensive fuels (such as natural gas), and thereby reduce carbon emissions even for a given level of energy output (since natural gas has less carbon per BTU than coal). To be more specific, this first plant can achieve carbon emissions reductions at a cost of \$25 for every carbon ton reduction. The second plant, however, was designed in a manner that makes it extremely difficult to switch away from coal and reduce emissions: It can achieve emissions reductions only at a cost of \$150 per ton.

The cost of mandating that carbon emissions at each plant fall by 30 percent is therefore \$5.25 million (\$0.75 million at the first plant, and \$4.5 million at the second). Under a permit system, however, the total cost would be dramatically reduced by allowing the second plant to buy permits from the first plant. This way, a 30 percent reduction in total emissions would cost only \$1.5 million (all of the 60,000 ton reduction would occur at the first plant, at a cost of \$25 per ton). In this example, the permit system produces a cost saving of over 70 percent *to achieve the same environmental goal*. This level of cost saving is not unrealistic: studies by environmental economists often find that market-based systems reduce the cost of environmental regulations by between 40 and 90 percent.

It may also be worthwhile examining the specific case of fuel efficiency standards. Federal regulation began in 1976 through Corporate Average Fuel Efficiency (CAFE) standards. When the CAFE standards first went into effect, new vehicle average fuel efficiency was 17.2 miles per gallon (mpg). That figure rose 10 mpg over the next ten years. Fuel efficiency levels have since stabilized at around 28 mpg. Proponents of fuel efficiency standards argue that currently available technologies could markedly improve motor vehicle efficiency, and that higher CAFE standards would help to effect such improvements. Indeed, the Congressional OTA has reported that regulatory pressure could raise average new car fuel efficiency by about 13 percent in 2000 and 22 percent by 2005.

A debate is ongoing over the cost effectiveness of the CAFE standards. While improvement in new car fuel efficiency between 1975 and 1986 is not disputed, opponents to the standards point out that real gasoline prices tripled during that period. They argue that manufacturers responded to consumer demand for high mileage vehicles in the face of rising fuel prices (and expectations of continued price increases). On the other hand, since gasoline only represents about 10 percent of total automobile operating costs, fuel efficiency may not significantly influence consumers' purchasing decisions—especially if consumers question characteristics such as comfort and safety of a more efficient car.

Tighter CAFE standards should not be viewed as a costless approach to reducing carbon emissions in the United States. For example, tighter standards would have to cover sport utility vehicles to ensure effectiveness. Such vehicles now comprise almost 50 percent of new vehicle sales in the U.S., and tighter standards would therefore force consumers to pay

higher prices or forgo their obvious attraction to these fuel-inefficient vehicles.

Krupnick et. al. estimated the cost effectiveness of increasing the CAFE standard to 37.5 miles per gallon at \$106 per ton of carbon dioxide reduced. [Krupnick, A., Walls, M. and Collins, C., Global Warming and Urban Smog: The Cost Effectiveness of CAFE Standards and Alternative Fuels, Resources for the Future, ENR92-13, 1992.]

The SO₂ Example: How Much Can We Learn From It?

Another natural question regarding a carbon emissions permit trading system is what we can learn from the *sulfur dioxide (SO₂) allowance trading* program. The SO₂ permit program evolved out of the Clean Air Act Amendments of 1990, which required a 50 percent reduction in SO₂ emissions from electric-utility boilers. To accomplish this goal, a fixed number of emission allowances were allocated to electric utilities based on historical fuel use. (In addition, a small number of allowances are now auctioned every year.) Allowances may be traded to any party anywhere, and may be "banked" for use in future years. Participants must regularly monitor emissions and make an annual accounting of their emissions. Penalties are imposed if emissions exceed the number of allowances held by a source.

Around the time that the 1990 Amendments were enacted, a commonly held view was that attaining a 50 percent reduction (10 million tons) in SO₂ would require permit prices between \$400 and \$800 per ton. Those predictions have proven too pessimistic. Currently, the price of SO₂ allowances ranges between \$90 and \$120.

Clearly, the SO₂ allowance program has been very successful -- and therefore offers hope that a similar program for carbon emissions would prove similarly successful. But there are nonetheless several grounds for concern over whether the SO₂ experience will be repeated:

- The success of the SO₂ program results from factors related to the program itself -- for example, the development of cheaper scrubbers -- and from factors that had little to do with the program -- for example, the deregulation of the freight-carrying railroads, which allowed low-sulfur coal to be shipped less expensively. It is imprudent to *assume* that other policy changes will prove so salubrious for greenhouse gas program.
- The greenhouse program will be substantially larger: The annual stock of permits under the SO₂ program is worth less than \$1 billion; the annual stock of permits under a carbon trading program might be worth between \$30 billion and \$150 billion. The difference in aggregate permit values reflects the fundamental changes in the economy required to reduce carbon emissions -- it will likely prove more difficult to move away from combustion of petroleum-based fuels in the transportation, utility, and manufacturing sectors in a greenhouse program than it was to switch from high-sulfur coal to low-sulfur coal in the utility sector in the SO₂ program.

- A meaningful greenhouse gas control program will be a great deal more complicated to administer than the current SO₂ program. The SO₂ trading program currently covers approximately 2,000 utility sources; a greenhouse gas trading program will have to cover substantially more sources. Even if the number of sources were minimized by placing the permit requirement as far upstream as possible -- that is, at the primary fossil fuel producer level -- the number of sources could range from 3,000 to just under one million.

Grandfathering Versus Auctioning-With-Revenue Recycling

Another issue related to a permit system, and one we touched upon in our meeting, is whether the permits should be auctioned or grandfathered. To summarize the cases for and against grandfathering:

- Auctioning would raise revenue -- potentially more than \$100 billion a year -- that could be used to reduce other taxes, fund the adjustment programs favored by the labor unions, offset the regressivity of the emissions reduction scheme, or raise national saving. As some rough examples of what could be done under a revenue-neutral auction approach, \$100 billion raised from auctioning permits could be used for one of the following:
 - Exclude over \$6,000 of payroll excluded from both the employer and employee part of the OASDI tax;
 - Cut the employees' OASDI payroll tax (currently 6.2 percent) in half;
 - Reduce the 15 percent income tax rate in the lowest bracket to 10.2 percent; or
 - More than double the standard deduction (currently \$6,700 for married couple)
- By contrast, grandfathering in effect confers an enormous amount of wealth on corporations -- possibly upwards of \$100 billion per year, or about 20 percent of total after-tax corporate profits. Grandfathering thus precludes a "tax waste, not work" strategy.
 - One way to think about the difference between grandfathering and auctioning is to recognize that grandfathering is functionally equivalent to auctioning the permits, and then giving the proceeds of the auctions back to existing emitters.
- Although firms are likely to pass most of the cost through to consumers, auctions ostensibly force businesses to pay large costs simply for the right to maintain their business-as-usual operations. *Regardless of whether the permits are auctioned or grandfathered, consumers are likely to bear most of the costs involved in reducing emissions (through higher energy prices).* Ironically, grandfathering seems

- The prospects for support from key businesses -- such as those you met with last month -- are much higher with grandfathering than an auction. The theoretical benefits of auctions as a means of distributing the permits will be much less salient to the CEO of a large corporation than the necessity of having to purchase permits to continue operations.
- While grandfathering may reduce corporate opposition, it would also attract many claimants. Deciding which claimants deserve the permits could prove very difficult, and the lobbying behavior inherent in attempts to capture the permit wealth could make the entire system inefficient. Furthermore, pressure for grandfathered permits is likely to be strongest among mid-stream firms -- such as electric utilities and perhaps large energy-intensive manufacturers. As discussed below, however, this may not be the optimal point in the production cycle to impose the permit requirement.

Where To Impose the Permit Requirement

A key policy decision in a tradeable permits system is where in the production process to impose the permit requirement. This question is related to the grandfathering question discussed above: for example, if we grandfather permits by giving them to manufacturers, it would seem incongruous to impose the permit requirement further upstream (e.g., at the well-head).

The two principal possibilities for imposing the requirement include the primary fuel and the sectoral level:

- ***Imposing the Requirement on Primary Fuel Producers.*** Under a program in which primary fuel producers are required to hold allowances, permits would be required for the carbon dioxide (CO₂) emission potential contained in fuel extracted and sold. Oil, gas and coal producers would have to hold allowances at either the point of extraction, point of first inter- or intra-company transaction, or at the distributor level. Primary fuel and refined product imports and exports would also need to be accounted for in such a system. Alternative methods of implementing a primary fuel permit program include:

Requiring permits upon extraction. Approximately 600,000 oil wells, 260,000 gas wells and 3,600 coal mines would require permits at this level. The total number of companies involved would be 2,000 oil and natural gas producers and 3,600 coal companies. The administrative complexity of the system would be magnified considerably if the decision were made to monitor and verify at the source level rather than at the company level.

Requiring transporters or distributors to hold permits. A distribution-level system would target natural gas distributors, and gasoline and other petroleum product distributors (e.g., commercial, industrial and home heating oil

distributors). Advantages of this approach include reliable data quality and monitoring feasibility. However, the number of potential sources is extremely large.

Requiring permits at the processing level. Permits could also be issued to processors – – natural gas processors, coal blending/cleaning facilities, and refiners. At the processing level, there are 200 oil refineries, 3,600 coal blending/cleaning facilities and 623 natural gas processing facilities (responsible for processing approximately 89 percent of total gas processed in the US). Coal processors are typically affiliated with mines. Therefore there is little practical difference between requiring permits at the point of extraction or processing for coal.

Requiring permits at the point of first sale (a permit is surrendered with the first inter-or intra-company transaction). Such a system would include transactions between a coal company and an electric utility, between a natural gas producer and its marketing arm, between a natural gas producer and a broker, or between an oil extraction company and its refinery operations. It would thus target under 5,000 points in the energy chain. Fuel importers would also require permits to import fuel. This procedure would capture all fossil fuel inputs, including fuel consumed in refining.

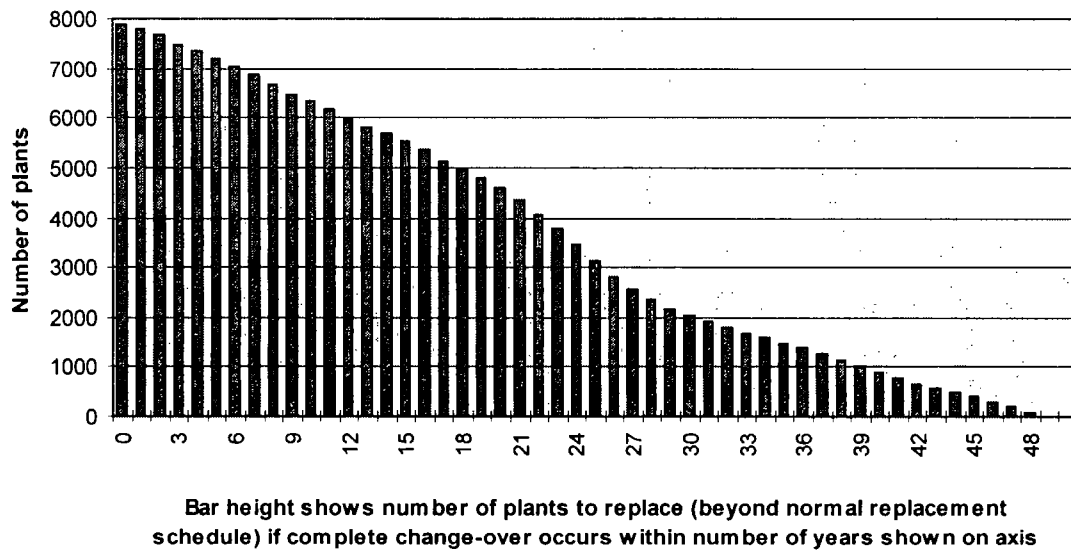
- ***Imposing Permit-Holding Requirements by Sector.*** An alternative approach, which is consistent with permits being grandfathered by sector, would be to require participants in each sector to hold and use permits. Although this system would be most comparable to the current SO₂ emissions allowance trading system, it would be fundamentally more difficult to implement because of the number of emitters. Utilities account for about one-third of total CO₂ emissions. Transportation-related emissions account for one-third and the residential, commercial and industrial (less electricity generation) sectors combined account for one-third.

A sectoral emission allocation could work only for large emitters. Including the six largest *industrial*/CO₂ emitting sectors (including electric utilities, but excluding the transportation sector) in a sectoral trading program would encompass about 20,000 market participants and but only 51 percent of total U.S. CO₂ emissions. For the literally millions of small emitters, permit requirements would probably have to be shifted upstream in a manner that would mimic the permit requirements for primary fuel producers discussed in the previous section. Requiring the permits at an earlier stage of this chain offers administrative advantages and the ability to comprehensively cover all emissions. Appendix B provides additional background on sectoral issues.

III. The Economists' Case on the Importance of a Gradual Approach

Your economic advisers are extremely concerned that a target anywhere close to 1990 emissions levels by 2010 would be excessively costly. A more gradual approach, one that allows the economy to adjust slowly over time to the new constraints being imposed, would be substantially less costly. The reason is that it is very expensive to scrap the nation's entire capital

Figure 1: Accelerated Replacement of Electric Power Plants



stock while it is still in the prime of its useful life, and replace it with new plant and equipment that is more energy-efficient. But over the course of twenty to forty years, much of our existing plant and equipment will be ready for replacement anyway -- allowing for relatively lower-cost environmental upgrading at that point. *Making efficiency improvements when the plants would have been replaced in any case significantly reduces the costs of such improvements -- because there are no additional costs to scrapping otherwise productive plant.*

An illustrative example of the importance of capital turn-over

It may be useful to look at a simple illustration of the point. Figure 1 shows the effects of an accelerated replacement schedule for all of the 7,900 electric power plants built during the last 50 years. To take an extreme case, imagine that all power plants had to be shut down within ten years (by 2007), and replaced with less-polluting technology. Such a policy would imply replacing 6,330 plants (80 percent of the total) before the end of their normal lifespan. If instead all power plants had to be replaced with less-polluting technology in 20 years, only 4,600 plants (58 per cent of the total) would have to be replaced before the end of their normal lifespan. And if the policy were implemented over 30 years, the complete replacement would mean an accelerated replacement of only 2,000 plants, 26 per cent of the total.¹

¹ Under the stylized assumption of a 50-year plant life, there would be no additional cost to upgrading over a 50-year period. We have truncated the distribution at 50 years, the average lifespan of existing electric power plants. There are other plants that are still in use 60, 70, or even 90 years after they were built. But their numbers are small, and by the end of 50 years the cost of shutting them down would in any case be much-reduced.

A similar exercise can be done for the set of power plants that are coal-fired -- the class of generators that produce the most carbon and that would thus have to be replaced even under a moderate plan to address climate change. If a complete change-over of coal plants were to be accomplished in 10 years, 799 of the 1,122 coal-fired plants (71 per cent) would have to be replaced before the end of their expected lifespan. If replacement occurs over 20 years, 488 plants would be affected, or 43 percent of the total. If one could wait 30 years, 227 plants would be closed prematurely, or 20 per cent of the total. And since newer plants tend to have larger capacity, the effects of a rapid replacement schedule are magnified. Closing all plants within 10 years implies that 289 million KW of capacity would be prematurely shut down, or 90 per cent of the total. If one could wait 20 years, 235 million KW of capacity would be affected, or 73 per cent. For 30 years, the capacity that would have to be replaced falls to 116 million KW, or 36 per cent of the total.

Oil shock comparison

[Gruber]

IV. The Case Against a Gradual Approach

[Sandalow]

V. The Role of Technology

Over the long-run, all your advisers concur that advances in technology are crucial to reducing greenhouse gas emissions. Since the world economy is likely to grow by several multiples during the next century, the ratio of greenhouse gas production to economic activity must be cut dramatically to reconcile continued economic growth with reduced greenhouse gas emissions. According to your science advisers, three kinds of technologies seem promising:

- Technologies that use energy and materials more efficiently -- like the PNGV car;
- Technologies that produce energy using solar cells, plants and wood waste, and other methods that do not result in net production of greenhouse gases; and
- Technologies that can sequester or permanently store greenhouse gases in deep aquifers or in other ways.

There is agreement that a package of technology options should be a component of any U.S. climate strategy. Options could include direct government expenditures, tax breaks for R&D, or regulatory standards. *But your advisers have sharp disagreements about how much we can reasonably expect of technological advances without the spur of a price increase.*

- Some of your advisers believe that the cost estimates presented above are too high because even without an increase in the price of energy, there are numerous opportunities for energy-saving technologies to be developed and applied. For example, one controversial study conducted by five of the Department of Energy's national laboratories concluded that even without an increase in the price of carbon, "cost-effective energy efficiency alone can take the nation 30 to 50% of the way to 1990 levels" by 2010.
- Your economic advisers raise a series of significant methodological objections to the study mentioned above. They also stress the importance of market incentives for technological advances, and the substantial body of evidence that markets respond to such incentives. They argue that technology will clearly be one of the conduits for meeting an emissions reduction target, but that both theoretically and historically, the most rapid technological advances come in response to significant increases in the relative price of energy.

For instance, over the entire postwar period, the fossil-fuel efficiency of the U. S. economy has improved at slightly more than one percent per year. Between 1970 and 1986, during which time the economy suffered two oil-price shocks, fossil-fuel efficiency grew by more than 2½ percent per year. The pace of efficiency improvement has slowed down, but not stopped, since the late 1980s, as the relative price of energy has fallen.

The degree of disagreement on this crucial topic, however, can easily be exaggerated. Despite ongoing debates over the precise role of technology, therefore, *there is broad technical agreement that a significant price signal is crucial to achieving emissions reductions of the sort being considered in international fora.* In other words, it is impossible to achieve 1990 emissions levels by 2010 without a substantial increase in carbon prices.

VI. An Escape Clause

Given the wide range of cost estimates associated with emission reduction schemes -- partially reflecting different views about the potential for technology to reduce costs -- it seems essential to provide an "escape clause" that would limit the economic costs associated with our target and timetable. Such an escape clause would provide insurance that the costs of meeting our target and timetable do not become excessive.

Under the escape clause, the U.S. Government would stand ready to sell permits at a given price, say \$X per ton. Then private firms would have the option of buying a permit from other firms, through the tradeable permits scheme, or buying a permit from the government at \$X per ton. If the price in the secondary market were below \$X, no firm would purchase from the government. If the price threatened to exceed \$X, however, firms would begin purchasing from the government -- thus expanding the supply of permits and driving down the price. In effect, the government's promise to sell at \$X ensures that the cost per ton of reduction never exceeds \$X. *Thus the economic cost of the overall policy is capped at \$X per ton. It*

is crucial to recognize, however, that if the escape clause is triggered we will not meet our target and timetable path because the government will be selling additional permits.

The value of \$X is crucial to the escape clause. If \$X is set high relative to the range of estimates for the costs involved in a given target and timetable, the probability of triggering the escape clause would be low and the escape clause would be purely an insurance scheme against very bad outcomes. If \$X is set on the more optimistic side, however, the escape clause is more likely to be triggered and the target and timetable is therefore less likely to be met -- implying that the fee of \$X per ton is the binding policy instrument to slow carbon emissions, rather than the target and timetable.

More complicated versions of the escape clause could include increases in the real value of \$X over calendar years (e.g., \$X for 2010-2020, \$X+\$15 for 2020-2030, etc.). The mechanism could also provisions to raise \$X as more permits are sold (e.g., \$X for the first 100,000 tons through the escape clause, \$X+\$5 for the next 100,000 tons, etc.). If the price per ton rises as more permits are sold, the price increase will exert more pressure on emissions to return to the original target and timetable glidepath.

In sum, the escape clause recognizes that a relatively tight target and timetable is crucial for international purposes and for the environmental constituency, but also recognizes that corporate opposition will be somewhat reduced if the costs are contained. It allows technology optimists to believe that we will meet the target and timetable without triggering the escape clause, but provides an upper bound on the economic costs imposed (even if that means the target and timetable is not met).

International ramifications

An escape clause provision would likely have to be included as part of our international obligations under a climate change treaty, and other nations are likely to insist on similar escape clauses. We would likely need to identify the substantive condition under the escape clause could be triggered, and we could exceed our target, without violating the treaty. The conditions could be vague and subjective (e.g., where economic growth would render fulfillment of the obligation seriously harmful to the national economy) or more quantitative and objective (e.g., where the price of permits reaches a certain predetermined level of \$X per ton). Vague conditions are likely to criticized particularly sharply internationally. We would need to identify whether the condition for discharge was "self-judging" (i.e., by the party in question), or subject to a decision by other Parties to the agreement or a third party.

Another question would be whether the Party invoking the escape clause would be entirely "off the hook" for additional permits sold, or would be allowed to exceed the target only by a particular amount or for a limited period of time. A related question is whether the extra permits have to be "paid back" at a later period. Finally, securing an escape clause provision could be difficult. And seeking it would likely result in such clauses being demanded by other countries -- raising a series of difficult issues for countries that do not rely on a tradeable permits system for

implementing their obligations.

VII. Other Issues

FUEL SUBSIDIES (?) AND OTHER TAX ISSUES

International trading

Joint implementation

Another source of disagreement among your advisers is the role of joint implementation (JI). JI is a mechanism by which a private entity in the United States could invest in greenhouse gas mitigation projects in developing countries without emissions budgets. In exchange, the investor (and the U.S.) would receive credit towards its emission budget. Your administration has consistently supported joint implementation, from early in your first term. The Vice President has signed framework agreements on this subject with several Latin American countries. In addition, the business community strongly supports joint implementation and some companies -- especially in the utility sector -- have been making joint implementation a reality over the past few years. But some of your advisers are concerned that it will be difficult to change the program from its current pilot scale to a full-blown international system.

In principle, JI provides a very low cost mechanism for reducing emissions, by “trading” emissions here for emissions abroad, where the cost of reduction is much lower. In practice, however, JI requires a mechanism for guaranteeing that emission reductions that qualify for credits are “additional” to -- above and beyond -- reductions that would have happened anyway in the baseline case. How can we tell whether the low emissions power generation plant built in a developing country would have been built in the absence of JI incentives? If credit is given for investments that would have happened anyway, then the use of these credits to meet developed country obligations will result in higher global emissions. On the other hand, if the standard of “additionality” is set too high, or if projects are choked off by transaction costs associated with resolving baseline and additionality questions, then the large potential savings associated with JI will be lost.

Appendix A

U.S. Experience with Emissions Trading

The United States has had experience with a number of emissions trading schemes other than the SO₂ trading.

Water Effluent Trading: The US generally has regulated surface water quality through a system of discharge limits for large sources of water pollution. In addition, states have standards for ambient water quality that are often not attained even after large dischargers apply "best technology" because small sources (such as runoff from farms) contribute significantly to water pollution. A number of state and local governments are employing trading systems for watersheds that either allow trading among large dischargers, or allow large dischargers to fulfill their requirements by controlling small sources. Examples include the Fox River in Wisconsin, the Dillon Reservoir in Colorado, and the Tar-Pamlico River in North Carolina. The latter two programs are designed to reflect expected economic growth in the future, so the quantity of effluent allowances allocated exceeds current discharge levels. Once growth consumes this excess, trading is expected to reduce compliance costs.

Inter-refinery Lead Trading: EPA operated a lead trading program from 1983 to 1987 as it phased out lead from gasoline. Lead trading allowed refiners and importers to trade lead reduction credits to meet limits for the lead content of gasoline. The quantity of allowances to which a firm was entitled was determined by the amount of leaded fuel produced by the firm and the contemporaneous EPA standard. Those who bettered the standard could sell their credits to others. Some 10 billion grams of lead were traded during the course of the program, at prices ranging from 0.75 to 5 cents per gram. Allowing the trading of lead credits reduced the costs of the program by approximately 20 percent.

Criteria Air Pollutant Trading: EPA first began incorporating aspects of emissions trading in its air program in 1974, when it allowed a modified source to use "credits" earned by another source within the same plant to avoid additional regulatory requirements. Since then, emission trading has substantially expanded. Trades have numbered in the thousands and have been estimated by Hahn and Hester (1986) to have saved between \$525 million and \$12 billion.

Market Mechanisms for Chlorofluorocarbon (CFC) Phaseout: Under the 1987 Montreal Protocol to limit stratospheric ozone depletion, the U.S. required the phase out of the production of CFCs by 1996. As part of its program, the U.S. adopted a tradable permit regime covering CFC manufacturers and importers. These allowances were allocated based on each firm's 1986 market share. As the market for CFCs declined, the system allowed firms to allocate production among different facilities according to the least-cost pattern of supply. It also gave CFC users the flexibility to switch between different CFC compounds, within the overall limit on allowances. This program helped reduce the costs of the phaseout. In 1988, EPA estimated that the cost to *halve* CFC use would be \$3.55 per kilogram. By 1993, it became clear that all uses could be *eliminated* by 1996 at a cost of \$2.45 per kilogram.

Appendix B

Sectoral Emissions Trading Issues

Requiring manufacturers to hold permits to emit would greatly increase the complexity of a trading system, compared with the system of requiring primary fuel producers to hold permits.

1. Electric Utilities

The electric utility sector emits about one-third of the CO₂ in the United States, with emissions of 495 MMTC in 1994. The number of utility point sources is limited and well defined, totaling about 2,115 generating units in 1995. As a result of the SO₂ program, the electric utility sector is one of the few in the U.S. that is familiar with permit trading programs.

The definition of what constitutes a "source" under an electric utility program has an influence on coverage, the degree of leakage, and the administrative and monitoring costs. A source could be defined as a combustion unit, a plant, or a corporate entity (which may own multiple units and plants). Units covered by the acid rain program are already required to report carbon emissions data to the EPA. It is also possible to target a trading program at the company level based on total fuel inputs. This type of company level allocation could also be applied to independent power producers (IPPs), many of whom own several facilities. Smaller entities (e.g., municipals, IPPs owning one or a few small generators) could be excluded based on annual emissions levels.

Covered sources could be limited to those fired by coal, natural gas, and fuel oil. Alternative-fuel fired units, such as those burning municipal solid waste, refuse derived fuels, or waste fuels (such as wood chips) may or may not be included as well.

2. Heavy Manufacturing Industries

The industrial sector emitted approximately 293 million metric tons of carbon in 1994 from the combustion of fossil fuels and industrial processes. There is no single industry sector (excluding the electric utility sector) that generates the majority of CO₂ emissions. Paper and allied products is the largest sector (including direct emissions from by-products), followed by chemical and allied products, primary metals, and petroleum refining. [[Cement manufacturers are the fourth largest source category among the manufacturing sector. In 1994, calcining cement manufacture (a non-combustion process by which limestone materials are converted to lime) accounted for 9.5 million metric tons of carbon emissions, while fuel combustion accounted for another 6 million MMTC.]]]

The industry sectors listed above represent about 58 percent of industrial emissions, and about 12 percent of total U.S. CO₂ emissions. Individually, each represents less than five percent of total US emissions. A CO₂ regulatory program including electric utilities and the 17,000 industrial sources in the sectors listed above would thus capture about 90 percent of total industrial emissions (including utilities) and about 51 percent of total US CO₂ emissions.

The scope and effectiveness of a manufacturing sector program would depend on what level emission caps were

placed, and the types of sources and fuels included. These issues parallel those in the utility sector and are discussed below.

Allocation Basis. An emissions trading program could be implemented at the corporate or facility level, or for specific sources (e.g., boilers). Corporate level fuel consumption data may be more comprehensive than industrial source data, which may not currently be tracked.

Coverage. A manufacturing trading program could be limited to specific sources, including industrial boilers, on-site electricity generation and cogeneration, and carbon (or other greenhouse gas emissions) from industrial processes (such as cement manufacture).

Source Size. Within a source category (e.g., boilers), exemptions may be granted based on size (e.g., industrial boilers smaller than 25 MMBtu/hour). Exempting small units may involve a certain amount of leakage, as utilization may be shifted from affected boilers to unaffected ones. Regulations could be designed to address this issue.

Data quality could determine the scope of a manufacturing program. Most large industrial companies probably maintain data on purchases of natural gas, coal and fuel oil at the facility or corporate level. It would be difficult to verify the accuracy of these reports and emissions monitoring may be impractical for all but the largest sources. Boiler level data would be easier to verify. However, boiler-level fuel input data is typically currently maintained by only the largest industrial sources.

3. Transportation

Motor vehicle manufacturers consumed only 0.5 percent of US manufacturing energy consumption (netting-out emissions associated with the sector's electricity use). This sector's direct combustion may be captured in a trading regime, depending on the program's scope. Much more important are the carbon emissions associated with the fleet of private, commercial, and other transportation sector equipment (such as off-road vehicles, buses, trains and planes) manufactured. The transportation sector is responsible for approximately 32 percent of US CO₂ emissions.

Unlike utility or heavy industrial sources however, the transportation sector is comprised of millions of individual sources. Effective control of transportation emissions could involve alternative approaches directed at the equipment manufacturers, fuel producers or end-user. Manufacturers could be required to hold permits covering the CO₂ emissions associated with the automobile fleet (and other equipment). The level of allowances required could be determined based on several factors, including:

Average fuel consumption (miles per gallon) for the vehicle fleet, weighted by sales of each vehicle or equipment type

Estimated annual average vehicle miles traveled (VMT) per car in the fleet, for each fuel type

Estimated average lifetime of a car in the fleet

[Automated Records Management System Hex-Dump Conversion]

CO₂ emission rates for gasoline, diesel, and other fuels.

The problem with this approach is that it does not focus on emissions, but rather fuel efficiency. An automobile that gets 10 miles to the gallon but is driven only 1,000 miles a year would bear greater cost than a 40 mile per gallon automobile that is driven 40,000 miles, despite the fact that the latter emits 10 times as much CO₂.

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CREATOR: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:22-SEP-1997 22:29:33.00

SUBJECT: Targets and timetables

TO: Jeffrey A. Frankel (CN=Jeffrey A. Frankel/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

I enclose a revised copy of the targets and timetables paper. ===== ATTACHMENT 1
=====

ATT CREATION TIME/DATE: 0 00:00:00.00

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September 20, 1997

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Targets and Timetables

Executive Summary

This memo provides a preliminary evaluation of the likely economic consequences for the United States of a program to attain 1990 CO₂ emissions levels by 2010. It concludes that, in the space of a decade, such a goal would be extremely difficult to achieve. *If attained through domestic emissions reductions alone* this target entails a reduction in CO₂ emissions of about 28% relative to projected 2010 emissions in the absence of policy intervention--a change in energy use in excess of that achieved during the decade of the oil shocks. An idealized system of international permit trading among Annex I countries would halve the change in carbon emissions prices needed to attain such a goal. Joint implementation with non-Annex I countries could further reduce the price impact in the United States. However, the proposed schemes for both international permit trading and joint implementation require enforcement and monitoring mechanisms that may be difficult to establish in the near term.

Economic analysis suggests that reaching 1990 emissions by 2010 would result in a stagflationary macroeconomic shock on the economy approximately equal in magnitude to the effects of the combined oil shocks of the 1970's. Both unemployment and inflation would undoubtedly rise for a time. Moreover, such a "front-loaded" emissions reduction path has been shown to increase the costs of achieving the long-term goal of stabilizing concentrations by a factor of 3 to 10. In this sense, such an aggressive path is inefficient. A plan to meet a 1990 by 2010 target would entail premature scrapping of capital and forego the considerable advantages of waiting for the development of carbon-lean technologies before replacing existing plant and equipment. Furthermore, the environmental benefits of an aggressive abatement target are extremely small since the differences in global temperatures between fast-abatement and slow-abatement paths are minimal. For example the expected difference in global average temperature in 2100 along a fast takeoff abatement path that attains 1990 emissions by 2010 and a slow takeoff abatement path that peaks in 2015 and attains 1990 emissions by 2040 is uniformly less than .05 degrees Celsius. Between now and 2100, global warming is expected to average about 2½ degrees Celsius irrespective of the path chosen for stabilization.

An economically and environmentally responsible approach for the United States would be to initiate meaningful actions now to create effective incentives to reduce carbon emissions over the next century. Such incentives must entail an immediate increase in the price of carbon emissions along with a credible commitment to further emissions price increases over time.

I. Introduction

The Framework Convention on Climate Change signed at the 1992 earth summit in Rio de Janeiro called for carbon dioxide emissions in 2000 at 1990 levels. Given that most countries, including the United States, are unlikely to achieve these emission reductions, most quantitative proposals that have been advanced in the run up to Kyoto focus on variants of the target and timetable agreed to at Rio. Such proposals thus represent the deferred fulfillment of a previously negotiated goal. Consequently, a proposal to "stabilize CO₂ emissions at 1990 levels by 2010" (and variants thereof, including a more stringent proposal by several EU countries to stabilize at 10% below 1990 levels by 2010) has received considerable attention.

This memo provides a preliminary evaluation of the likely economic consequences for the United States of a program to attain 1990 CO₂ emissions levels by 2010. It compares the costs and cost effectiveness of this baseline proposal with those of alternative targets and timetables that entail a less rapid initial reduction in CO₂ emission levels. The conclusions described here rely on the substantial body of economic analysis that has been conducted by researchers worldwide, including the Intergovernmental Panel on Climate Change (IPCC), and Administration economists.

II. 1990 by 2010: The Scope of the Task

To appreciate the ambitiousness of a program to curb U.S. emissions levels to 1990 by 2010 it is necessary to recognize that such a target involves a cutback of about 28 percent in energy use in 2010 relative to baseline. Carbon emissions are now 12 percent above 1990 levels. Growth in the economy over the next decade would further raise carbon emissions. Even under an optimistic assumption concerning the pace of improvement of energy efficiency (0.9 percent per year), under constant relative energy prices, there would be further increases in carbon emissions by 2010 of about 16 percent if we continue with business as usual. The net required reductions to achieve 1990 emissions in 2010 thus amount to about 28 percent.

Comparison with the Oil Shocks. Cutbacks in energy use (relative to GDP) of this magnitude are considerably greater than those achieved in the decade of the two oil shocks--a period in which relative energy prices more than doubled. Figure 1 shows aggregate energy use in the United States and the relative price of energy over the period 1960 to 1990. During the oil-shock decade--1972 to 1982--energy use was virtually constant in absolute terms, while GDP grew in real terms at about 2 percent per year. The relative price of energy rose by more than 150 percent over this period. In contrast, the "1990 by 2010" program entails larger emissions cutbacks. To meet the 1990 by 2010 goal it is not sufficient just to keep emissions constant between now and 2010: a further 12 percent roll back in emissions is needed to offset the expansion that has already occurred since 1990. Thus, we would need to accomplish a reduction in energy use considerably larger than what occurred over a decade in which the relative price of energy more than doubled. The experience of the oil shock period, and other empirical analysis, suggests that the responsiveness of energy use to changes in the price of energy (the price elasticity of demand for energy) over periods as short as a decade is no higher than 0.2. Assuming a price elasticity of demand of 0.2 over a decade, energy prices would have to rise by about 140 percent to

attain 1990 emissions by 2010.

Model results. Simple extrapolation from the historical experience of the oil shock suggests that a plan to reduce U.S. emissions to 1990 levels by 2010 would result in average energy price increases within the range of estimates that have been generated by large scale economic/energy models. Numerous models have been used to estimate the impact of a 1990 by 2010 program on energy prices. Such models differ somewhat in the assumptions they embody concerning the feasible range of technological options and likely technological trends. Nevertheless, a broad range of models, employing a common energy use baseline, place the carbon permit price required to achieve 1990 emissions by 2010 in the range of \$80 to \$200 per ton. If fully passed through to energy prices, a permit price of \$100 per ton would entail nearly a doubling of energy prices. The impact on the prices of different sources of energy are all large, but the effect on coal is particularly severe. The price of coal would more than triple, while the price of a barrel of petroleum would increase by about fifty percent. Gas at the pump would increase in price by about 26 cents. Relative to the BTU tax proposed by the Administration in 1993 this implicit tax is about 9 times as large. Thus, attaining a goal of 1990 by 2010 would entail very large economic consequences.

Evidence from International Comparisons. A final piece of evidence confirming the conclusion that a strong price signal over a long period of time is necessary to alter energy use comes from comparisons of energy usage between the United States and Europe. It should hardly be surprising that energy use per dollar of GDP is lower in Europe than the United States. Energy prices in Europe have long been substantially higher--roughly double U.S. energy prices at the present time. Moreover, major differences in living patterns between the United States and Europe result in higher European energy efficiency. In addition to the geographical "advantage", from an energy efficiency standpoint, of Europe's higher population density, resulting in lower transportation requirements, Europe has locked in place many long-run adaptations to high energy prices. Innovations in the design of housing and transportation systems and the configuration of residential areas have occurred in response to high energy prices. But in spite of its natural advantages and its long history of high energy prices, energy per dollar of GDP is only 44% lower in Europe than in the United States. This means that were the US to become Europe--energywise per dollar of GDP--its energy savings, even in the long run, would be no greater than 44 percent. This US-Europe comparison supports the conclusions drawn from the natural experiment of the oil shock: namely, a return to 1990 emissions will not occur in the absence of very major incentives over a long period of time.

The Role of Technology and the Scope for "No Regrets" Policies. According to the preceding assessment, a large price inducement is necessary to meet a 1990 by 2010 target. Your economic advisers agree on this conclusion. However several of your advisers are more optimistic about the chances of achieving a 1990 by 2010 target. They emphasize the current availability of "no regrets" (cost-saving) technologies that promise substantial opportunities for abatement. A recent report by the Department of Energy research laboratories, for example, catalogues emissions-savings technologies that, by their calculations, are currently "cost effective." If put in place now, the report concludes that such practices could reduce emissions by between 30 to 50 percent of the amount needed to reach a 1990 by 2010 target. Even so, the

report finds that “aggressive” and “invigorated” government policies—including potentially costly and intrusive regulations and standards—as well as a \$50 carbon tax would be necessary to reach the 1990 by 2010 target.

Your economic advisers agree that there now exist unused technological opportunities for emissions reduction, but question by what means, over what time frame, and at what expense government policies could change private behavior if such opportunities are currently underutilized. Economists believe that engineering studies miss the sometimes subtle disadvantages of available cost-savings technologies or overestimate their hypothetical returns. An example is illustrative: significant energy and cost savings could result if consumers replace incandescent bulbs with compact fluorescents. Over the long lifetime of such bulbs there would also be a substantial monetary gain. However, actual use of these light bulbs has been slow to date, possibly due to pure inertia, possibly because consumers dislike their color, or perhaps because they apply a high “discount rate” when valuing energy savings that accrue after the purchaser may have switched residence. Several recent studies have demonstrated that the actual returns to home improvement investments, such as attic insulation, often fall short of those predicted by engineering studies. Regardless of the reasons, if consumers have not adopted “no regrets” measures at a faster rate, it is likely that additional incentives will be necessary for them to change their minds. Rather than stressing the mere availability of alternative technologies, your economic advisers insist on realistic estimates of likely rates of adoption and diffusion and they stress the need for economic incentives—in this case a higher implicit price for emitting carbon—to induce the adoption of emissions-savings technology. They point out too that the baseline energy use estimates used to predict the price increase needed to attain a 1990 by 2010 target already assume substantial ongoing improvements in energy efficiency due to the diffusion of existing technologies and the development of new ones. Significant adoption of such technologies is necessary merely to meet this assumed baseline. Finally, it is important to note that the DOE labs study projects that extensive regulations, including stringent CAFE and appliance standards and national building codes—command and control policies that your economic advisers would oppose—along with a \$50 carbon tax would be needed to reach 1990 by 2010.

To summarize, in the absence of an aggressive set of regulations concerning energy use, your economic advisers do not consider it realistic to predict a substantial increase in the pace of adoption of new emissions-savings technologies—without a large price signal. They are optimistic, however, based in part on the evidence from the energy shocks of the 1970s, in part on international comparisons, and in part on model results, that energy use is responsive to changes in the price of CO₂ emissions—with larger responses to a given price change likelier the longer the time period for response. The evidence is strong that a very large price increase will be necessary to attain emissions reductions of 20 to 30 percent over a period as short as a decade.

In conclusion, your economic advisers believe that a clear price signal is essential to any effective strategy to reduce CO₂ emissions and to provide appropriate incentives for the development over time of lean carbon technologies. The emission of CO₂ involves a classic externality, since, absent a cost to emitting carbon, no individual has any economic incentive to use lean-carbon or carbon-free sources of energy. There is even less incentive for the private

development of carbon-saving technologies which no one has an incentive to buy. The solution to curbing carbon emissions relative to baseline, and also to induce private research and development, involves changing the incentive structure to encourage reductions in emissions and to spur the development of carbon-saving technologies.

III. Why are the costs of early emissions reductions so high?

The previous section argued that a "1990 by 2010" target would entail high carbon emission prices and significant economic costs. This section shows that the 1990 by 2010 timepath for emissions reductions is so aggressive as to be inefficient--in the sense of raising substantially the total projected economic cost of reaching a given environmental goal. Economists have tried to demonstrate this point by examining how the total costs of achieving a fixed environmental target for greenhouse gas concentrations varies with the aggressiveness of the initial reductions. There are three major reasons why an aggressive takeoff in curtailing emissions raises overall costs: (1) it induces premature obsolescence of the capital stock because it does not allow adequate time for the capital stock to turn over naturally; (2) it provides insufficient lead time to develop and implement new technologies; (3) it causes a significant stagflationary short-term macroeconomic shock. Additionally, a slower timetable for emissions reductions allows time for the resolution of uncertainty and takes advantage of the time-value of money (resources not spent on emission reductions early on can be invested at a positive return which could purchase more emission reductions later).

The Role of Turnover of the Capital Stock. The most clear-cut and easily quantifiable reason for the high price tag associated with rapid emissions reductions relates to the need for premature replacement of plant and equipment in response to large increases in the price of carbon emissions. A longer window in which to reduce carbon emissions allows more time for the capital stock to turn over. While it is very expensive to replace plants in the prime of their useful lives with less carbon-intensive plant and equipment, within 20 to 40 years, much of our existing plant and equipment will be ready for replacement anyway.

The advantage of a slower emissions reduction timetable in avoiding the large costs associated with premature obsolescence of the capital stock can be illustrated by considering electrical power generation. The case of electricity generation is important in its own right since this industry is responsible for @@% of coal use and more than one third of all carbon dioxide emissions in the United States. Nevertheless, the same principle concerning the costs of premature replacement applies broadly because reduced greenhouse gas emissions may entail the accelerated retrofitting of housing and commercial structures, the premature scrapping of vehicles, and the premature replacement of plant and equipment in energy intensive industries.

Figure 2 illustrates the effect of an accelerated retirement schedule for U.S. electric power generation capacity installed during the last 40 years. Imagine, to take an extreme case, that a timetable is adopted that necessitates replacing all power plants with less-polluting technology within ten years. This would require retiring 630 out of 670 gigawatts of generating capacity before the end of its normal life span, or 94 per cent of the total. If the timetable were extended so that all power plants instead had to be replaced within 20 years, the accelerated replacement of capacity would affect 450 gigawatts of capacity, or 67 per cent of the total. Allowing this

additional 10 years for turnover avoids the premature retirement of 27 per cent of existing electric power plant capacity. With a 30 years horizon, complete turnover would mean accelerated retirement of only 21 per cent of the total capacity and, with a 40 year timetable, there would be almost no additional costs due to premature obsolescence.^{1, 2}

The Advantage of Waiting for Superior Technologies. The example of electric power generation also illustrates a second important reason why a slow takeoff in curbing greenhouse gases emissions is ultimately less costly: it takes considerable time before emerging carbon-free or carbon-lean technologies are developed. Waiting until these new technologies are available before making expensive emissions-saving investments offers the potential of both lower economic costs and higher environmental payoffs. Under a tight target and timetable with its associated high carbon emissions price, electric utilities will be faced with the need to replace existing capacity in the very near future and to rely on currently available lean-carbon technologies, likely gas-turbine plants. Under the impetus of higher prices and a well-designed R&D program, however, there is undoubtedly the potential to improve the effectiveness and reduce the cost of these alternative technologies. A rapid timetable forces long-term investments to be made before superior technologies have been developed and refined.

¹The distribution has been truncated at 40 years, the average lifespan of existing electric power plants. A few plants of yet older vintage are still in use.

²The same exercise can be performed for coal-fired power plants. These generators produce the most carbon per kilowatt hour of electricity and thus will have a high incidence of replacement even under a moderate abatement plan. If a complete change-over of coal plants were to be accomplished in 10 years, 96 per cent of total capacity would be retired early. If retirement occurred over 20 years, only 64 per cent would be retired early. Allowing an additional 10 years for turnover would avoid premature retirement of one-third of existing coal-fired plant capacity.

Implication: The Need for a Credible, Long-Term Price Increase. The example of electricity generation illustrates two general principles. First, the responsiveness of both demand and supply are greater in the long run than in the short run. This means that, with a longer horizon, any given amount of abatement can be accomplished with a smaller increase in carbon emissions prices. Second, and perhaps yet more important for policy, this example shows that any credible emissions reduction strategy requires both a price signal at the outset and also a clear commitment to maintain and likely increase that signal over time. Without such a commitment, the changes in behavior required to meet even a long-run target of emissions reduction will likely not occur. Consider a utility that today is beginning its plans for a new power plant, either as replacement for an old plant or as totally new construction. That utility will choose among today's technologies, which vary in their costs and CO₂ emissions. In order to induce the utility to choose a more costly, lean-emissions technology today, it must be clear that over the future (40 year or more) life of that plant, CO₂ emissions will be costly--costly enough over the lifetime of the investment to justify a more costly investment option today. In terms of Figure 2 we might imagine that today a small number of plants, those of older vintages, are being replaced. Even though the fraction of plants being replaced over the course one, two, five or even ten years is fairly small, over yet longer periods of time the impact of those decisions cumulates. A large cumulative reduction in emissions is possible, starting with a modest carbon emissions price increase now, but only if the managers of the utilities have sufficient incentives to choose lean-carbon technologies when plants are replaced. This requires not just an emissions price increases now but also a credible commitment to a long term policy of increasing emission penalties over time.

Stagflationary Macroeconomic Impact. From a macroeconomic perspective, increases in energy prices constitute a "supply shock." Such shocks are stagflationary because they raise both inflation and unemployment simultaneously, creating a painful macroeconomic dilemma. As noted above, a plan to attain 1990 emissions levels by 2010 would require a change in energy prices over the first decade of the 21st century at least comparable in magnitude to the two oil shocks of the 1970s. Those shocks are widely acknowledged to have had a substantial adverse impact on both unemployment and inflation. Similarly, the energy price increases required by a 1990 by 2010 program would raise inflation, lower real wages (@@ by how much?) and raise unemployment. Unemployment in the four years after the first oil shock averaged 7.2 percent in comparison to 5.0 percent in the four years prior and unemployment rose further to an average of 8.7 percent in the four-year aftermath of the second. There remains debate about how much of this was due directly to the oil shock, because there was a simultaneous decline in productivity growth and transfers of real income to OPEC producers. In contrast to the two oil shocks, the increases in energy prices associated with a treaty to reduce greenhouse gases would be anticipated, rather than a surprise. Nevertheless, we should expect that the efforts of the Federal Reserve to contain inflation, coupled with likely efforts on the part of workers to recoup real wage losses--even if those losses are anticipated--will lead to a period of higher unemployment.

Furthermore, it is important to note that most model-based estimates of the costs of a program to attain 1990 emissions levels by 2010 assume that resources are fully employed, thereby ignoring these potential short-term effects. Such models therefore provide no assessment of the consequent increases in unemployment.

IV. Quantifying the Economic Costs of Slow versus Fast Take-off

The relative costs of slow versus fast takeoff timetables in curbing CO₂ emissions has recently been analyzed by the Stanford Energy Modeling Forum (EMF). To enable meaningful comparisons of results across models, the EMF has coordinated a series of projects in which a number of large scale energy models are used to estimate the impact of given, specified emission reduction scenarios under common standardized, benchmark assumptions concerning population and economic activity, discount rates, energy resource availability and prices and technology availability. In its most recent comparison exercise (EMF-14), the Stanford group used six models to compare the total projected cost of two alternative emissions reduction time paths--one "frontloaded", the second more "backloaded". Both paths were designed eventually to stabilize atmospheric concentrations of CO₂ at double the pre-industrial level--550 ppmv.³ Although a high degree of uncertainty attaches to particular numerical estimates from individual models, the simulations nevertheless point to some robust qualitative conclusions. The major conclusion to be drawn from the EMF-14 comparison project is that an emission reductions path characterized by an aggressive initial phase is substantially more costly--3 to 10 times more costly--than a path with a slower takeoff but larger eventual reductions.

To enable a comparison of the costs of slow and rapid takeoff strategies, the EMF investigators asked each of six modeling groups to simulate the economic impacts of two alternative strategies to attain stabilization of CO₂ concentrations at 550 ppmv. The first strategy (the WG-1 path) corresponds to an emissions pathway published in 1994 by Working Group 1 (WG-1) of the Intergovernmental Panel on Climate Change (IPCC). Using the Wigley model of the carbon cycle, the working group computed a set of global CO₂ emissions pathways consistent with stabilization of concentrations at 550 ppmv and several alternative concentration levels. The WG-1 path entails an immediate departure from the baseline or "business as usual" emission path. Subsequently, Wigley, Richels and Edmonds (WRE) published an alternative set of emission profiles to achieve the same concentration targets. In contrast to the WG-1 paths, the WRE emission path was constructed to follow the baseline or "business as usual" scenario in the early years with sharper reductions after this initial phase. Wigley, Richels and Edmonds hypothesized that their slower-takeoff emissions pathways would yield identical environmental objectives with substantially lower economic costs, for the reasons discussed above. The EMF-14 exercise validates this hypothesis.

³ All energy models make numerous simplifications and approximations in order to describe the energy sector globally and over the span of a century or more. In particular, all of the models assume full employment, thereby abstracting from the likely short-run macroeconomic costs of an emissions reduction program.

The EMF-14 comparison project assessed the total costs to the OECD, the EEFSU (Eastern Europe and the former Soviet Union) and the non-Annex I countries of the WG-1 and WRE pathways to stabilization of CO₂ concentrations at 550 ppmv. The appropriate economic measure of total cost is the present discounted value of losses in future consumption relative to a "Business as Usual" scenario. Estimates of regional costs depend on the extent of burden sharing--namely, the assumed "division of labor"--between Annex-I and non-Annex I countries in controlling emissions as well as the extent of international emissions trading. Recall that, by the end of the next century--by 2100-- assuming "business as usual"--non Annex I countries will have more than 90 percent of CO₂ emissions. Thus, developing country participation is absolutely essential to achieving stabilization of concentrations. Consistent with the Berlin Mandate, the simulations assumed that the burden of emissions reduction would fall on Annex I countries exclusively during the early decades; that by 2030, non-Annex I countries would begin to participate; and by 2050, a full transition to targets based on equal per capita emission rights is assumed.

Figure 3 plots the OECD emissions paths in the WG-1 and WRE scenarios. Under the WG-1 scenario, OECD emissions begin to decline immediately and continue to decline for roughly four decades. For example, OECD emissions fall 10 percent below initial levels ten years after implementation--corresponding closely to 1990 by 2010, which requires a reduction of 12 percent reduction from current emissions. In contrast, OECD emissions along the WRE path continue to rise for roughly two decades--corresponding to a plan calling for emissions to peak around 2020--return to 1990 levels around 2040 and decline substantially further in subsequent decades.

Table 1 illustrates a robust conclusion that emerges from the EMF-14 comparison of the fast take-off WG 1 path and its slow take-off WRE counterpart: fast takeoff in emission reduction greatly increases the costs. Table 1 shows the discounted value of OECD consumption loss for the WG-1 and WRE paths--both with and without idealized international trading of permits. In 10 out of 12 simulations--for six different models with and without permit trading--the costs on the slow-takeoff WRE path is less than a third of the cost on the corresponding fast take-off path. The average ratio of relative costs for the 12 comparisons is less than 0.3. Taking account of the likely adverse short-run macroeconomic consequences of the aggressive WG-1 path would further strengthen this conclusion.

Table 2 illustrates a second, robust conclusion from the EMF-14 exercise: a viable system of international permit trading would very much reduce OECD costs. With global permit trading, the sharp, early emission reductions required on the WG-1 by OECD countries would be avoided through the purchase of emission permits from countries with lower abatement costs. With one exception, all of the cost ratios reported--the cost with idealized permit trading relative to the cost without--are considerably less than one; the average ratio for the twelve simulation outcomes is 0.44.⁴

⁴ The computations in Table 2 verify that the WRE path, which permits emissions to depart relatively little from business as usual for several decades, is a substantially less costly than the alternative WG-1 path with its sharper immediate reductions. Since both paths are arbitrarily

chosen to conform with the 550 ppmv concentration target, a natural question concerns the characteristics of an optimal or least-cost path for achieving this concentration target. An important recent study by Alan Manne and Richard Richels uses their MERGE model (included in the EMF-14 project) to compute the least cost path with 550-stabilization in 2100 and international permit trading. The optimal path, while not identical to the WRE path, is similar in character. This least-cost path peaks approximately three decades after the initiation of the program and declines thereafter.

Finally, it is important to note that in most of the EMF models, policy actions to raise carbon emissions prices must be taken at the inception of the WRE program and a commitment to increasing emissions prices over time is required to achieve additional emission reductions. Naturally, the required initial carbon emissions price is substantially lower, at the outset, under the WRE than under the WG-1 path. Thus, although the WRE emissions path initially approximates the business as usual baseline, credible incentives must be put into place immediately, and strengthened over time, to achieve the needed investments in carbon-efficient technologies.

V. The Environmental Consequences of Slow versus Fast Takeoff.

While the excess cost of a fast compared to a gradual takeoff emissions reduction path has been shown to be large, the difference in projected global temperatures over the next century between the fast and the slow paths are quite small, both in absolute amount and relative to temperature changes expected from global warming. Under “business as usual” assumptions, increasing concentrations of greenhouse gases are expected to raise average global temperatures by about 1 degree Celsius by 2050 and about 2½ degrees Celsius by 2100. The emission reductions achieved by a path that would stabilize emissions at 1990 levels by 2010 and hold them at this level thereafter serves to mitigate this temperature increase by roughly 0.1 degrees by 2050 and 0.2 degrees by 2100. In contrast, an emissions path that peaks around 2015 and stabilizes at 1990 levels by 2040, again holding emissions constant at 1990 levels thereafter provides virtually the identical environmental benefits: the temperature differences between these two paths diverge by no more than .05 degrees over the next century. Similarly, the temperature differences along the aggressive WG-1 and less aggressive WRE paths designed ultimately to stabilize concentrations at 550 ppmv differ by a maximum of 0.2 degrees over the next several centuries.⁵

⁵ If a model assumes that sulfur dioxide emissions decline with the decline in carbon dioxide emissions under climate policy (as predicted, given the extent of sulfur emissions associated with fossil fuel combustion, and incorporated in the IPCC’s IS92 emissions projections), the WG-1 path will be *warmer* than the WRE path between 2000 and 2040. This result reflects the negative impact of sulfate aerosols on the greenhouse effect. Early and substantial cuts in fossil fuel combustion, while decreasing the carbon emissions that warm the atmosphere, also decrease the sulfate aerosols that cool the atmosphere.

The limited climatological impact of even an extremely aggressive emission reduction program measured in terms of temperature impacts during the next century results from extremely long lags involved in the underlying physical processes and the dependence of temperature on the total stock of carbon dioxide in the atmosphere, rather than the flow of emissions at a given time. Emissions reductions do matter to temperature, but over an extremely long horizon. The cumulative nature of the process points to a payoff from early action, but also suggests that there is little effect on global temperature from a slow rather than from a fast abatement takeoff. The addition to the total stock of carbon from a slow rather than a fast start to abatement adds relatively little to the total atmospheric stock of CO₂ between now and 2100 for four separate reasons: the difference in carbon emissions between a slow and a fast start over the initial decades of abatement is only a small fraction of total emissions in that period; the stock of CO₂ in the atmosphere is itself the result of many decades of emissions; some of the CO₂ emissions of the early decades will have been re-absorbed; and the most serious build-up in CO₂ under business as usual occurs late in the next century, as a consequence of burgeoning emissions from non-Annex I countries, so that Annex I emissions will not dominate that build-up.

The preceding analysis abstracts from the possibility of catastrophic environmental effects, such as the melting of the West Antarctic ice sheet, a runaway greenhouse effect (e.g., from release of trapped methane with the melting of the permafrost), or structural changes in ocean currents such as the Gulf Stream. However, even the potential for these disruptions does not fundamentally affect the basic trade-offs between the high costs of fast vs. slow takeoff paths. These factors do, however, add, perhaps greatly, to the urgency of adopting moderate long-term greenhouse gas concentration targets and a program involving an immediate, albeit moderate, increase in the price of CO₂ emissions.

VI. International Trading of Permits

As has already been noted, an effective system of international carbon emission permit trading among Annex I countries has the potential to substantially diminish the cost of a CO₂ abatement program, although such trading would likely result in substantial transfers to Eastern Europe and the former Soviet Union. An Annex I trading system could, potentially, reduce the cost to the United States of any emissions goal by about 50%. Moreover, joint implementation projects with non-Annex I countries hypothetically produces further gains of similar magnitude.

Although international trading and joint implementation--so-called "where flexibility"--has enormous advantages in theory, your economic advisers are concerned that substantial barriers would arise in implementing any workable analogue of such an idealized system--at least in the near term. Consequently, they would stress that Annex I international permit trading and joint implementation between the U.S. and nonAnnex I countries can realistically serve only a limited role in reducing the costs associated with meeting a "1990 by 2010" target.

A hypothetical example shows how an international trading system would work, and why it would reduce each participant country's abatement costs. Suppose, ideally, that every country adopts a domestic permit system to implement its Kyoto target. Absent international trading, the

price of emissions permits could differ across countries, reflecting differing marginal costs of abatement internationally. With different permit prices in different national markets, profit seeking traders would be motivated to buy permits in countries where they are cheap and resell them in countries where they are more expensive. Such arbitrage activities would create an international permit market, bringing permit prices into equality worldwide. This idealized system promotes global efficiency in achieving any worldwide abatement goal. Agents in countries with permit prices below world levels have the incentive to reduce emissions further in order to profit from international permit sales. As a consequence of such actions, low permit price countries would export permits and cut back their emissions beyond their Kyoto requirements. Similarly, agents in high abatement cost (high permit price) countries would reduce costs by importing permits, thereby relaxing their Kyoto emissions constraints. The U.S. government could avoid any direct participation in such a system as long as it deems foreign-issued permits presented to the U.S. government by U.S. carbon-emitting entities as valid as those issued by the U.S. government itself.

The preceding description of how an international permit trading system would work provides an idealized picture of its possibilities. But the actual benefits of such a system are apt to fall short of this utopian portrayal. One reason is that countries are not obliged to implement domestic permit trading schemes to fulfill their Kyoto commitments and few Annex I countries have indicated an intention to do so. Consider, for example, the potential for U.S. emissions trades with countries that decide to limit domestic emissions through energy taxes or command and control regulations. In either case, international trading would involve government to government negotiations, and difficult political decisions. In contrast, in the idealized system, trades result from profit oriented transactions among individuals, mediated through the market. For example, consider a government that has decided to limit domestic emissions through regulatory controls. International permit sales that result in tighter domestic constraints could well be politically unpopular so that a government would hesitate before selling its emission rights to the United States. Similarly, international permit sales by a country that is meeting its Kyoto obligations through domestic carbon or energy taxes requires a further hike in those taxes.

Monitoring and enforcement issues are also likely to be paramount in insuring the workability of international trading. If domestic enforcement is effective in all countries, so that mechanisms operate to ensure that consumers and firms in each country actually limit emissions to the national permit levels, international permit sales by private agents in the country actually translate into lower domestic emissions. But consider the difficulties that can occur with imperfect enforcement. If the government of a country--country X--finds it difficult either to measure domestic emissions or to enforce the purchase of permits by domestic emitters, then reductions in X's emissions may be insufficient to reach the Kyoto target. Those agents in X that are lucky enough to have been assigned the rights to X's permits will be able to sell them, at a quick profit, on the international market. With imperfect enforcement, international sales, without corresponding domestic emissions reductions, could emanate from countries with the weakest systems of enforcement. To prevent such "paper trades", which profit some participants and increase emissions, many countries will want controls to ensure the integrity of international permits. Buyers, too, will want clear concrete guarantees of the validity of permits so as to be sure they will not be asked to reduce emissions on-site as well. These controls and guarantees

may raise the costs of participating in this market and make the estimated savings illusory. In fact, most of the benefits projected from the international sale of permits come from inducing emissions reductions from countries in Eastern Europe and the former Soviet Union--countries with particularly weak tax collection and enforcement mechanisms. Without such countries in the scheme the gains from international trading of permits will be very small.

Model results suggest that joint implementation with non-Annex I countries also has the potential to reduce the U.S. burden of attaining any given timetable. Prior to the adoption of quantitative targets by the developing countries, however, emissions trading is apt to occur on a project-by-project basis in situations where it is demonstrable that a given project has reduced emissions relative to business as usual. For example, US businesses could receive credit for the construction of nuclear, oil or natural gas electricity generation plants in China if it were confidently expected that China would instead have constructed coal-fired plants with much higher CO₂ emissions. Permits for such trades might be overseen by an international agency to ensure that the projects were emissions-replacing. Such a project by project system is likely the most that is feasible without quantitative targets, but the efficiency benefits are not likely to be as great as with an enforceable system of international permit trading. In contrast, model results concerning the benefits of joint implementation treat it as equivalent to full international trading.

VII. Recycling of Revenues

The ultimate economic cost of an emission abatement program depends upon how the revenues realized from carbon taxes or auctioned permits are used. It has been estimated that the efficiency loss from collecting an extra dollar of tax revenue amounts to around 30 cents. If the resulting revenues from a carbon tax or auctioned permits are used to reduce inefficient taxes inhibiting work or investment, there would be welfare gains that offset the micro efficiency losses from energy curtailment. According to some estimates, GNP would actually increase if the revenues were used to reduce taxes on capital. Simulations by Nordhaus show that the optimal size of an abatement program would depend on how the revenues are recycled. Abstracting from the potential incentive gains from recycling, Nordhaus has shown that an initial carbon taxes of about \$5 is optimal for the U.S., given his projections of abatement costs and environmental benefits. However when revenues are used to replace other taxes with an efficiency loss of 30 cents, the initial optimal carbon tax rises to almost \$60. The simple lesson is that the costs of emission abatement are greatly reduced if the revenues from the taxes levied can be put to good use.

So far we have approached the recycling of revenues from the standpoint of microeconomic efficiency. There is also the potential for using the revenues to abate the macroeconomic consequences of the emissions program. The oil shock is believed by many economists to have resulted in increased unemployment because workers resisted the fall in real wages that was associated with the inflationary impact of higher energy prices. Increased wage demands added inflationary pressures to the economy that could only be suppressed by tighter monetary policy. Thus it might be argued that the effects of the real wage shock on inflation and unemployment could be diminished by lowering payroll or other worker taxes to offset the real

wage losses from higher energy prices.

But England's experience points to the need for caution in assessing the potential for revenue recycling to allay the macroeconomic consequences of the rising energy costs. In 1979, immediately after her election, Margaret Thatcher increased the VAT tax and simultaneously decreased the income tax. These two policy changes had offsetting effects on real after tax incomes, and therefore might have been expected to have had no effect on wage bargaining. However, the increase in the VAT tax resulted in an immediately noticeable increase in the CPI. A wage-price spiral ensued as workers attempted to maintain their pre-tax real wages.

VIII. Policy Implications

The foregoing arguments point to the attractiveness, from both an economic and environmental standpoint, of a U.S. policy to raise the price of carbon emissions--either through a carbon tax or a system of auctioned permits--by a moderate amount--for example, between \$10 and \$25 per ton of carbon-- in the near term, with further increases scheduled over the longer term. Under this program, U.S. emissions would continue to rise for at least a decade before declining to current, then 1990 levels and below. Such a program could be defended as a significant policy action consistent with a strong U.S. commitment to attaining the ultimate objective of the Framework Convention--namely to stabilizing atmospheric concentrations of CO₂ and hence mean global temperatures.

A program involving gradual increases in the relative price of carbon emissions over time would avoid the possibly substantial macroeconomic consequences of a 1990 by 2010 program. The energy price increases associated with this program would have a modest impact on family income that could be offset by compensating cuts in other taxes.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:23-SEP-1997 08:37:19.00

SUBJECT: Charts and Tables for Targets and Timetables Paper

TO: Randall W. Lutter (CN=Randall W. Lutter/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TO: Adele C. Morris (CN=Adele C. Morris/OU=CEA/O=EOP @ EOP [CEA])

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TO: Joseph E. Aldy (CN=Joseph E. Aldy/OU=CEA/O=EOP @ EOP [CEA])

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CC: Michele Jolin (CN=Michele Jolin/OU=CEA/O=EOP @ EOP [CEA])

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TEXT:

As far as I can determine, I have none of the charts and tables for the targets and timetables in electric form. Could you try to send them to me today so that I can incorporate them in the paper? They are as follow:
Figure 1: Energy Prices and Changes in Energy Use (Randy and I discussed revisions to this last night); Figure 2: Accelerated Retirement of Electric Power Plan Capacity; Figure 3: WRE and WG1 Emissions Pathways for OECD to Stabilize Concentrations at 550 ppmv. Table 1: The Effects of Emissions Pathway on Consumption Losses by OECD Countries--Not Intl. Permit Trading and With International Permit Trading; Table 2: The Effects of International Permit Trading on Consumption Losses by OECD Countries--WRE Emissions Pathway to 550 ppmv and WG1 Emissions Pathway to 550 ppmv.

Attached is the most recent version of the paper. I am extremely grateful to all of you for your help in putting this together. I have tried to incorporate the comments you have given me thus far and can still make further changes that you suggest.

I have sent copies of this paper to Jon Gruber at Treasury and to Peter Orszag. I expect to collaborate with Treasury on revisions to the paper so that it reflects a common CEA/Treasury view. Beyond working with Jon and Peter, you should not circulate this paper outside of CEA,

===== ATTACHMENT 1 =====
ATT CREATION TIME/DATE: 0 00:00:00.00

TEXT:

Unable to convert ARMS_EXT:[ATTACH.D65]MAIL404323565.216 to ASCII,
The following is a HEX DUMP:

September 20, 1997

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Targets and Timetables

Executive Summary

This memo provides a preliminary evaluation of the likely economic consequences for the United States of a program to attain 1990 CO₂ emissions levels by 2010. It concludes that, in the space of a decade, such a goal would be extremely difficult to achieve. *If attained through domestic emissions reductions alone* this target entails a reduction in CO₂ emissions of about 28% relative to projected 2010 emissions in the absence of policy intervention--a change in energy use in excess of that achieved during the decade of the oil shocks. An idealized system of international permit trading among Annex I countries would halve the change in carbon emissions prices needed to attain such a goal. Joint implementation with non-Annex I countries could further reduce the price impact in the United States. However, the proposed schemes for both international permit trading and joint implementation require enforcement and monitoring mechanisms that may be difficult to establish in the near term.

Economic analysis suggests that reaching 1990 emissions by 2010 would result in a stagflationary macroeconomic shock to the economy approximately equal in magnitude to the effects of the combined oil shocks of the 1970's. Both unemployment and inflation would undoubtedly rise for a time. Moreover, such a "front-loaded" emissions reduction path has been shown to increase the costs of achieving the long-term goal of stabilizing concentrations by a factor of 3 to 10. In this sense, such an aggressive path is inefficient. A plan to meet a 1990 by 2010 target would entail premature scrappage of capital and forego the considerable advantages of waiting for the development of carbon-lean technologies before replacing existing plant and equipment. Furthermore, the environmental benefits of an aggressive abatement target are extremely small since the differences in global temperatures between fast-abatement and slow-abatement paths are minimal. For example the expected difference in global average temperature in 2100 along a fast takeoff abatement path that attains 1990 emissions by 2010 and a slow takeoff abatement path that peaks in 2015 and attains 1990 emissions by 2040 is uniformly less than .05 degrees Celsius. Between now and 2100, global warming is expected to average about 2½ degrees Celsius irrespective of the path chosen for stabilization.

An economically and environmentally responsible approach for the United States would be to initiate meaningful actions now to create effective incentives to reduce carbon emissions over the next century. Such incentives must entail an immediate increase in the price of carbon emissions along with a credible commitment to further emissions price increases over time.

I. Introduction

The Framework Convention on Climate Change signed at the 1992 earth summit in Rio de Janeiro called for carbon dioxide emissions in 2000 at 1990 levels. Given that most countries, including the United States, are unlikely to achieve these emission reductions, most quantitative proposals that have been advanced in the run up to Kyoto focus on variants of the target and timetable agreed to at Rio. Such proposals thus represent the deferred fulfillment of a previously negotiated goal. Consequently, a proposal to "stabilize CO₂ emissions at 1990 levels by 2010" (and variants thereof, including a more stringent proposal by several EU countries to stabilize at 10% below 1990 levels by 2010) has received considerable attention.

This memo provides a preliminary evaluation of the likely economic consequences for the United States of a program to attain 1990 CO₂ emissions levels by 2010. It compares the costs and cost effectiveness of this baseline proposal with those of alternative targets and timetables that entail a less rapid initial reduction in CO₂ emission levels. The conclusions described here rely on the substantial body of economic analysis that has been conducted by researchers worldwide, including the Intergovernmental Panel on Climate Change (IPCC), and Administration economists.

II. 1990 by 2010: The Scope of the Task

To appreciate the ambitiousness of a program to curb U.S. emissions levels to 1990 by 2010 it is necessary to recognize that such a target involves a cutback of about 28 percent in energy use in 2010 relative to baseline. Carbon emissions are now 12 percent above 1990 levels. Growth in the economy over the next decade would further raise carbon emissions. Even under an optimistic assumption concerning the pace of improvement of energy efficiency (0.9 percent per year), under constant relative energy prices, there would be further increases in carbon emissions by 2010 of about 16 percent if we continue with business as usual. The net required reductions to achieve 1990 emissions in 2010 thus amount to about 28 percent.

Comparison with the Oil Shocks. Cutbacks in energy use (relative to GDP) of this magnitude are considerably greater than those achieved in the decade of the two oil shocks--a period in which relative energy prices more than doubled. Figure 1 shows aggregate energy use in the United States and the relative price of energy over the period 1960 to 1990. During the oil-shock decade--1972 to 1982--energy use was virtually constant in absolute terms, while GDP grew in real terms at about 2 percent per year. The relative price of energy rose by more than 150 percent over this period. In contrast, the "1990 by 2010" program entails larger emissions cutbacks. To meet the 1990 by 2010 goal it is not sufficient just to keep emissions constant between now and 2010: a further 12 percent roll back in emissions is needed to offset the expansion that has already occurred since 1990. Thus, we would need to accomplish a reduction in energy use considerably larger than what occurred over a decade in which the relative price of energy more than doubled. The experience of the oil shock period, and other empirical analysis, suggests that the responsiveness of energy use to changes in the price of energy (the price elasticity of demand for energy) over periods as short as a decade is no higher than 0.2. Assuming a price elasticity of demand of 0.2 over a decade, energy prices would have to rise by about 140 percent to

attain 1990 emissions by 2010.

Model results. Simple extrapolation from the historical experience of the oil shock suggests that a plan to reduce U.S. emissions to 1990 levels by 2010 would result in average energy price increases within the range of estimates that have been generated by large scale economic/energy models. Numerous models have been used to estimate the impact of a 1990 by 2010 program on energy prices. Such models differ somewhat in the assumptions they embody concerning the feasible range of technological options and likely technological trends. Nevertheless, a broad range of models, employing a common energy use baseline, place the carbon permit price required to achieve 1990 emissions by 2010 in the range of \$80 to \$200 per ton. If fully passed through to energy prices, a permit price of \$100 per ton would entail nearly a doubling of energy prices. The impact on the prices of different sources of energy are all large, but the effect on coal is particularly severe. The price of coal would more than triple, while the price of a barrel of petroleum would increase by about fifty percent. Gas at the pump would increase in price by about 26 cents. Relative to the BTU tax proposed by the Administration in 1993 this implicit tax is about 9 times as large. Thus, attaining a goal of 1990 by 2010 would entail very large economic consequences.

Evidence from International Comparisons. A final piece of evidence confirming the conclusion that a strong price signal over a long period of time is necessary to alter energy use comes from comparisons of energy usage between the United States and Europe. It should hardly be surprising that energy use per dollar of GDP is lower in Europe than the United States. Energy prices in Europe have long been substantially higher--roughly double U.S. energy prices at the present time. Moreover, major differences in living patterns between the United States and Europe result in higher European energy efficiency. In addition to the geographical "advantage", from an energy efficiency standpoint, of Europe's higher population density, resulting in lower transportation requirements, Europe has locked in place many long-run adaptations to high energy prices. Innovations in the design of housing and transportation systems and the configuration of residential areas have occurred in response to high energy prices. But in spite of its natural advantages and its long history of high energy prices, energy per dollar of GDP is only 44% lower in Europe than in the United States. This means that were the US to become Europe--energywise per dollar of GDP--its energy savings, even in the long run, would be no greater than 44 percent. This US-Europe comparison supports the conclusions drawn from the natural experiment of the oil shock: namely, a return to 1990 emissions will not occur in the absence of very major incentives over a long period of time.

The Role of Technology and the Scope for "No Regrets" Policies. According to the preceding assessment, a large price inducement is necessary to meet a 1990 by 2010 target. Your economic advisers agree on this conclusion. However several of your advisers are more optimistic about the chances of achieving a 1990 by 2010 target. They emphasize the current availability of "no regrets" (cost-saving) technologies that promise substantial opportunities for abatement. A recent report by the Department of Energy research laboratories, for example, catalogues emissions-savings technologies that, by their calculations, are currently "cost effective." If put in place now, the report concludes that such practices could reduce emissions by between 30 to 50 percent of the amount needed to reach a 1990 by 2010 target. Even so, the

report finds that “aggressive” and “invigorated” government policies—including potentially costly and intrusive regulations and standards—as well as a \$50 carbon tax would be necessary to reach the 1990 by 2010 target.

Your economic advisers agree that there now exist unused technological opportunities for emissions reduction, but question by what means, over what time frame, and at what expense government policies could change private behavior if such opportunities are currently underutilized. Economists believe that engineering studies miss the sometimes subtle disadvantages of available cost-savings technologies or overestimate their hypothetical returns. An example is illustrative: significant energy and cost savings could result if consumers replace incandescent bulbs with compact fluorescents. Over the long lifetime of such bulbs there would also be a substantial monetary gain. However, actual use of these light bulbs has been slow to date, possibly due to pure inertia, possibly because consumers dislike their color, or perhaps because they apply a high “discount rate” when valuing energy savings that accrue after the purchaser may have switched residence. Several recent studies have demonstrated that the actual returns to home improvement investments, such as attic insulation, often fall short of those predicted by engineering studies. Regardless of the reasons, if consumers have not adopted “no regrets” measures at a faster rate, it is likely that additional incentives will be necessary for them to change their minds. Rather than stressing the mere availability of alternative technologies, your economic advisers insist on realistic estimates of likely rates of adoption and diffusion and they stress the need for economic incentives—in this case a higher implicit price for emitting carbon—to induce the adoption of emissions-savings technology. They point out too that the baseline energy use estimates used to predict the price increase needed to attain a 1990 by 2010 target already assume substantial ongoing improvements in energy efficiency due to the diffusion of existing technologies and the development of new ones. Significant adoption of such technologies is necessary merely to meet this assumed baseline. Finally, it is important to note that the DOE labs study projects that extensive regulations, including stringent CAFE and appliance standards and national building codes—command and control policies that your economic advisers would oppose—along with a \$50 carbon tax would be needed to reach 1990 by 2010.

To summarize, in the absence of an aggressive set of regulations concerning energy use, your economic advisers do not consider it realistic to predict a substantial increase in the pace of adoption of new emissions-savings technologies—without a large price signal. They are optimistic, however, based in part on the evidence from the energy shocks of the 1970s, in part on international comparisons, and in part on model results, that energy use is responsive to changes in the price of CO₂ emissions—with larger responses to a given price change likelier the longer the time period for response. The evidence is strong that a very large price increase will be necessary to attain emissions reductions of 20 to 30 percent over a period as short as a decade.

In conclusion, your economic advisers believe that a clear price signal is essential to any effective strategy to reduce CO₂ emissions and to provide appropriate incentives for the development over time of lean carbon technologies. The emission of CO₂ involves a classic externality, since, absent a cost to emitting carbon, no individual has any economic incentive to use lean-carbon or carbon-free sources of energy. There is even less incentive for the private

development of carbon-saving technologies which no one has an incentive to buy. The solution to curbing carbon emissions relative to baseline, and also to induce private research and development, involves changing the incentive structure to encourage reductions in emissions and to spur the development of carbon-saving technologies.

III. Why are the costs of early emissions reductions so high?

The previous section argued that a "1990 by 2010" target would entail high carbon emission prices and significant economic costs. This section shows that the 1990 by 2010 timepath for emissions reductions is so aggressive as to be inefficient--in the sense of raising substantially the total projected economic cost of reaching a given environmental goal. Economists have tried to demonstrate this point by examining how the total costs of achieving a fixed environmental target for greenhouse gas concentrations varies with the aggressiveness of the initial reductions. There are three major reasons why an aggressive takeoff in curtailing emissions raises overall costs: (1) it induces premature obsolescence of the capital stock because it does not allow adequate time for the capital stock to turn over naturally; (2) it provides insufficient lead time to develop and implement new technologies; (3) it causes a significant stagflationary short-term macroeconomic shock. Additionally, a slower timetable for emissions reductions allows time for the resolution of uncertainty and takes advantage of the time-value of money (resources not spent on emission reductions early on can be invested at a positive return which could purchase more emission reductions later).

The Role of Turnover of the Capital Stock. The most clear-cut and easily quantifiable reason for the high price tag associated with rapid emissions reductions relates to the need for premature replacement of plant and equipment in response to large increases in the price of carbon emissions. A longer window in which to reduce carbon emissions allows more time for the capital stock to turn over. While it is very expensive to replace plants in the prime of their useful lives with less carbon-intensive plant and equipment, within 20 to 40 years, much of our existing plant and equipment will be ready for replacement anyway.

The advantage of a slower emissions reduction timetable in avoiding the large costs associated with premature obsolescence of the capital stock can be illustrated by considering electrical power generation. The case of electricity generation is important in its own right since this industry is responsible for 88% of coal use and more than one third of all carbon dioxide emissions in the United States. Nevertheless, the same principle concerning the costs of premature replacement applies broadly because reduced greenhouse gas emissions may entail the accelerated retrofitting of housing and commercial structures, the premature scrapping of vehicles, and the premature replacement of plant and equipment in energy intensive industries.

Figure 2 illustrates the effect of an accelerated retirement schedule for U.S. electric power generation capacity installed during the last 40 years. Imagine, to take an extreme case, that a timetable is adopted that necessitates replacing all power plants with less-polluting technology within ten years. This would require retiring 630 out of 670 gigawatts of generating capacity before the end of its normal life span, or 94 per cent of the total. If the timetable were extended so that all power plants instead had to be replaced within 20 years, the accelerated replacement of capacity would affect 450 gigawatts of capacity, or 67 per cent of the total. Allowing this

additional 10 years for turnover avoids the premature retirement of 27 per cent of existing electric power plant capacity. With a 30 years horizon, complete turnover would mean accelerated retirement of only 21 per cent of the total capacity and, with a 40 year timetable, there would be almost no additional costs due to premature obsolescence.^{1, 2}

The Advantage of Waiting for Superior Technologies. The example of electric power generation also illustrates a second important reason why a slow takeoff in curbing greenhouse gases emissions is ultimately less costly: it takes considerable time before emerging carbon-free or carbon-lean technologies are developed. Waiting until these new technologies are available before making expensive emissions-saving investments offers the potential of both lower economic costs and higher environmental payoffs. Under a tight target and timetable with its associated high carbon emissions price, electric utilities will be faced with the need to replace existing capacity in the very near future and to rely on currently available lean-carbon technologies, likely gas-turbine plants. Under the impetus of higher prices and a well-designed R&D program, however, there is undoubtedly the potential to improve the effectiveness and reduce the cost of these alternative technologies. A rapid timetable forces long-term investments to be made before superior technologies have been developed and refined.

¹The distribution has been truncated at 40 years, the average lifespan of existing electric power plants. A few plants of yet older vintage are still in use.

²The same exercise can be performed for coal-fired power plants. These generators produce the most carbon per kilowatt hour of electricity and thus will have a high incidence of replacement even under a moderate abatement plan. If a complete change-over of coal plants were to be accomplished in 10 years, 96 per cent of total capacity would be retired early. If retirement occurred over 20 years, only 64 per cent would be retired early. Allowing an additional 10 years for turnover would avoid premature retirement of one-third of existing coal-fired plant capacity.

Implication: The Need for a Credible, Long-Term Price Increase. The example of electricity generation illustrates two general principles. First, the responsiveness of both demand and supply are greater in the long run than in the short run. This means that, with a longer horizon, any given amount of abatement can be accomplished with a smaller increase in carbon emissions prices. Second, and perhaps yet more important for policy, this example shows that any credible emissions reduction strategy requires both a price signal at the outset and also a clear commitment to maintain and likely increase that signal over time. Without such a commitment, the changes in behavior required to meet even a long-run target of emissions reduction will likely not occur. Consider a utility that today is beginning its plans for a new power plant, either as replacement for an old plant or as totally new construction. That utility will choose among today's technologies, which vary in their costs and CO₂ emissions. In order to induce the utility to choose a more costly, lean-emissions technology today, it must be clear that over the future (40 year or more) life of that plant, CO₂ emissions will be costly--costly enough over the lifetime of the investment to justify a more costly investment option today. In terms of Figure 2 we might imagine that today a small number of plants, those of older vintages, are being replaced. Even though the fraction of plants being replaced over the course one, two, five or even ten years is fairly small, over yet longer periods of time the impact of those decisions cumulates. A large cumulative reduction in emissions is possible, starting with a modest carbon emissions price increase now, but only if the managers of the utilities have sufficient incentives to choose lean-carbon technologies when plants are replaced. This requires not just an emissions price increase now but also a credible commitment to a long term policy of increasing emission penalties over time.

Stagflationary Macroeconomic Impact. From a macroeconomic perspective, increases in energy prices constitute a "supply shock." Such shocks are stagflationary because they raise both inflation and unemployment simultaneously, creating a painful macroeconomic dilemma. As noted above, a plan to attain 1990 emissions levels by 2010 would require a change in energy prices over the first decade of the 21st century at least comparable in magnitude to the two oil shocks of the 1970s. Those shocks are widely acknowledged to have had a substantial adverse impact on both unemployment and inflation. Similarly, the energy price increases required by a 1990 by 2010 program would raise inflation, lower real wages (@@ by how much?) and raise unemployment. Unemployment in the four years after the first oil shock averaged 7.2 percent in comparison to 5.0 percent in the four years prior and unemployment rose further to an average of 8.7 percent in the four-year aftermath of the second. There remains debate about how much of this was due directly to the oil shock, because there was a simultaneous decline in productivity growth and transfers of real income to OPEC producers. In contrast to the two oil shocks, the increases in energy prices associated with a treaty to reduce greenhouse gases would be anticipated, rather than a surprise. Nevertheless, we should expect that the efforts of the Federal Reserve to contain inflation, coupled with likely efforts on the part of workers to recoup real wage losses--even if those losses are anticipated--will lead to a period of higher unemployment.

Furthermore, it is important to note that most model-based estimates of the costs of a program to attain 1990 emissions levels by 2010 assume that resources are fully employed, thereby ignoring these potential short-term effects. Such models therefore provide no assessment of the consequent increases in unemployment.

IV. Quantifying the Economic Costs of Slow versus Fast Take-off

The relative costs of slow versus fast takeoff timetables in curbing CO₂ emissions has recently been analyzed by the Stanford Energy Modeling Forum (EMF). To enable meaningful comparisons of results across models, the EMF has coordinated a series of projects in which a number of large scale energy models are used to estimate the impact of given, specified emission reduction scenarios under common standardized, benchmark assumptions concerning population and economic activity, discount rates, energy resource availability and prices and technology availability. In its most recent comparison exercise (EMF-14), the Stanford group used six models to compare the total projected cost of two alternative emissions reduction time paths--one "frontloaded", the second more "backloaded". Both paths were designed eventually to stabilize atmospheric concentrations of CO₂ at double the pre-industrial level--550 ppmv.³ Although a high degree of uncertainty attaches to particular numerical estimates from individual models, the simulations nevertheless point to some robust qualitative conclusions. The major conclusion to be drawn from the EMF-14 comparison project is that an emission reductions path characterized by an aggressive initial phase is substantially more costly--3 to 10 times more costly--than a path with a slower takeoff but larger eventual reductions.

To enable a comparison of the costs of slow and rapid takeoff strategies, the EMF investigators asked each of six modeling groups to simulate the economic impacts of two alternative strategies to attain stabilization of CO₂ concentrations at 550 ppmv. The first strategy (the WG-1 path) corresponds to an emissions pathway published in 1994 by Working Group 1 (WG-1) of the Intergovernmental Panel on Climate Change (IPCC). Using the Wigley model of the carbon cycle, the working group computed a set of global CO₂ emissions pathways consistent with stabilization of concentrations at 550 ppmv and several alternative concentration levels. The WG-1 path entails an immediate departure from the baseline or "business as usual" emission path. Subsequently, Wigley, Richels and Edmonds (WRE) published an alternative set of emission profiles to achieve the same concentration targets. In contrast to the WG-1 paths, the WRE emission path was constructed to follow the baseline or "business as usual" scenario in the early years with sharper reductions after this initial phase. Wigley, Richels and Edmonds hypothesized that their slower-takeoff emissions pathways would yield identical environmental objectives with substantially lower economic costs, for the reasons discussed above. The EMF-14 exercise validates this hypothesis.

³ All energy models make numerous simplifications and approximations in order to describe the energy sector globally and over the span of a century or more. In particular, all of the models assume full employment, thereby abstracting from the likely short-run macroeconomic costs of an emissions reduction program.

The EMF-14 comparison project assessed the total costs to the OECD, the EEFSU (Eastern Europe and the former Soviet Union) and the non-Annex I countries of the WG-1 and WRE pathways to stabilization of CO₂ concentrations at 550 ppmv. The appropriate economic measure of total cost is the present discounted value of losses in future consumption relative to a "Business as Usual" scenario. Estimates of regional costs depend on the extent of burden sharing--namely, the assumed "division of labor"--between Annex-I and non-Annex I countries in controlling emissions as well as the extent of international emissions trading. Recall that, by the end of the next century--by 2100-- assuming "business as usual"--non Annex I countries will have more than 90 percent of CO₂ emissions. Thus, developing country participation is absolutely essential to achieving stabilization of concentrations. Consistent with the Berlin Mandate, the simulations assumed that the burden of emissions reduction would fall on Annex I countries exclusively during the early decades; that by 2030, non-Annex I countries would begin to participate; and by 2050, a full transition to targets based on equal per capita emission rights is assumed.

Figure 3 plots the OECD emissions paths in the WG-1 and WRE scenarios. Under the WG-1 scenario, OECD emissions begin to decline immediately and continue to decline for roughly four decades. For example, OECD emissions fall 10 percent below initial levels ten years after implementation--corresponding closely to 1990 by 2010, which requires a reduction of 12 percent reduction from current emissions. In contrast, OECD emissions along the WRE path continue to rise for roughly two decades--corresponding to a plan calling for emissions to peak around 2020--return to 1990 levels around 2040 and decline substantially further in subsequent decades.

Table 1 illustrates a robust conclusion that emerges from the EMF-14 comparison of the fast take-off WG 1 path and its slow take-off WRE counterpart: fast takeoff in emission reduction greatly increases the costs. Table 1 shows the discounted value of OECD consumption loss for the WG-1 and WRE paths--both with and without idealized international trading of permits. In 10 out of 12 simulations--for six different models with and without permit trading--the costs on the slow-takeoff WRE path is less than a third of the cost on the corresponding fast take-off path. The average ratio of relative costs for the 12 comparisons is less than 0.3. Taking account of the likely adverse short-run macroeconomic consequences of the aggressive WG-1 path would further strengthen this conclusion.

Table 2 illustrates a second, robust conclusion from the EMF-14 exercise: a viable system of international permit trading would very much reduce OECD costs. With global permit trading, the sharp, early emission reductions required on the WG-1 path by OECD countries would be avoided through the purchase of emission permits from countries with lower abatement costs. With one exception, all of the cost ratios reported--the cost with idealized permit trading relative to the cost without--are considerably less than one; the average ratio for the twelve simulation outcomes is 0.44.⁴

⁴ The computations in Table 2 verify that the WRE path, which permits emissions to depart relatively little from business as usual for several decades, is a substantially less costly than the alternative WG-1 path with its sharper immediate reductions. Since both paths are arbitrarily

chosen to conform with the 550 ppmv concentration target, a natural question concerns the characteristics of an optimal or least-cost path for achieving this concentration target. An important recent study by Alan Manne and Richard Richels uses their MERGE model (included in the EMF-14 project) to compute the least cost path with 550-stabilization in 2100 and international permit trading. The optimal path, while not identical to the WRE path, is similar in character. This least-cost path peaks approximately three decades after the initiation of the program and declines thereafter.

Finally, it is important to note that in most of the EMF models, policy actions to raise carbon emissions prices must be taken at the inception of the WRE program and a commitment to increasing emissions prices over time is required to achieve additional emission reductions. Naturally, the required initial carbon emissions price is substantially lower, at the outset, under the WRE than under the WG-1 path. Thus, although the WRE emissions path initially approximates the business as usual baseline, credible incentives must be put into place immediately, and strengthened over time, to achieve the needed investments in carbon-efficient technologies.

V. The Environmental Consequences of Slow versus Fast Takeoff.

While the excess cost of a fast compared to a gradual takeoff emissions reduction path has been shown to be large, the difference in projected global temperatures over the next century between the fast and the slow paths are quite small, both in absolute amount and relative to temperature changes expected from global warming. Under “business as usual” assumptions, increasing concentrations of greenhouse gases are expected to raise average global temperatures by about 1 degree Celsius by 2050 and about 2½ degrees Celsius by 2100. The emission reductions achieved by a path that would stabilize emissions at 1990 levels by 2010 and hold them at this level thereafter serves to mitigate this temperature increase by roughly 0.1 degrees by 2050 and 0.2 degrees by 2100. In contrast, an emissions path that peaks around 2015 and stabilizes at 1990 levels by 2040, again holding emissions constant at 1990 levels thereafter provides virtually the identical environmental benefits: the temperature differences between these two paths diverge by no more than .05 degrees over the next century. Similarly, the temperature differences along the aggressive WG-1 and less aggressive WRE paths designed ultimately to stabilize concentrations at 550 ppmv differ by a maximum of 0.2 degrees over the next several centuries.⁵

⁵ If a model assumes that sulfur dioxide emissions decline with the decline in carbon dioxide emissions under climate policy (as predicted, given the extent of sulfur emissions associated with fossil fuel combustion, and incorporated in the IPCC’s IS92 emissions projections), the WG-1 path will be *warmer* than the WRE path between 2000 and 2040. This result reflects the negative impact of sulfate aerosols on the greenhouse effect. Early and substantial cuts in fossil fuel combustion, while decreasing the carbon emissions that warm the atmosphere, also decrease the sulfate aerosols that cool the atmosphere.

The limited climatological impact of even an extremely aggressive emission reduction program measured in terms of temperature impacts during the next century results from extremely long lags involved in the underlying physical processes and the dependence of temperature on the total stock of carbon dioxide in the atmosphere, rather than the flow of emissions at a given time. Emissions reductions do matter to temperature, but over an extremely long horizon. The cumulative nature of the process points to a payoff from early action, but also suggests that there is little effect on global temperature from a slow rather than from a fast abatement takeoff. The addition to the total stock of carbon from a slow rather than a fast start to abatement adds relatively little to the total atmospheric stock of CO₂ between now and 2100 for four separate reasons: the difference in carbon emissions between a slow and a fast start over the initial decades of abatement is only a small fraction of total emissions in that period; the stock of CO₂ in the atmosphere is itself the result of many decades of emissions; some of the CO₂ emissions of the early decades will have been re-absorbed; and the most serious build-up in CO₂ under business as usual occurs late in the next century, as a consequence of burgeoning emissions from non-Annex I countries, so that Annex I emissions will not dominate that build-up.

The preceding analysis abstracts from the possibility of catastrophic environmental effects, such as the melting of the West Antarctic ice sheet, a runaway greenhouse effect (e.g., from release of trapped methane with the melting of the permafrost), or structural changes in ocean currents such as the Gulf Stream. However, even the potential for these disruptions does not fundamentally affect the basic trade-offs between the high costs of fast vs. slow takeoff paths. These factors do, however, add, perhaps greatly, to the urgency of adopting moderate long-term greenhouse gas concentration targets and a program involving an immediate, albeit moderate, increase in the price of CO₂ emissions.

VI. International Trading of Permits

As has already been noted, an effective system of international carbon emission permit trading among Annex I countries has the potential to substantially diminish the cost of a CO₂ abatement program, although such trading would likely result in substantial transfers to Eastern Europe and the former Soviet Union. An Annex I trading system could, potentially, reduce the cost to the United States of any emissions goal by about 50%. Moreover, joint implementation projects with non-Annex I countries hypothetically produces further gains of similar magnitude.

Although international trading and joint implementation--so-called "where flexibility"--has enormous advantages in theory, your economic advisers are concerned that substantial barriers would arise in implementing any workable analogue of such an idealized system--at least in the near term. Consequently, they would stress that Annex I international permit trading and joint implementation between the U.S. and nonAnnex I countries can realistically serve only a limited role in reducing the costs associated with meeting a "1990 by 2010" target.

A hypothetical example shows how an international trading system would work, and why it would reduce each participant country's abatement costs. Suppose, ideally, that every country adopts a domestic permit system to implement its Kyoto target. Absent international trading, the

price of emissions permits could differ across countries, reflecting differing marginal costs of abatement internationally. With different permit prices in different national markets, profit seeking traders would be motivated to buy permits in countries where they are cheap and resell them in countries where they are more expensive. Such arbitrage activities would create an international permit market, bringing permit prices into equality worldwide. This idealized system promotes global efficiency in achieving any worldwide abatement goal. Agents in countries with permit prices below world levels have the incentive to reduce emissions further in order to profit from international permit sales. As a consequence of such actions, low permit price countries would export permits and cut back their emissions beyond their Kyoto requirements. Similarly, agents in high abatement cost (high permit price) countries would reduce costs by importing permits, thereby relaxing their Kyoto emissions constraints. The U.S. government could avoid any direct participation in such a system as long as it deems foreign-issued permits presented to the U.S. government by U.S. carbon-emitting entities as valid as those issued by the U.S. government itself.

The preceding description of how an international permit trading system would work provides an idealized picture of its possibilities. But the actual benefits of such a system are apt to fall short of this utopian portrayal. One reason is that countries are not obliged to implement domestic permit trading schemes to fulfill their Kyoto commitments and few Annex I countries have indicated an intention to do so. Consider, for example, the potential for U.S. emissions trades with countries that decide to limit domestic emissions through energy taxes or command and control regulations. In either case, international trading would involve government to government negotiations, and difficult political decisions. In contrast, in the idealized system, trades result from profit oriented transactions among individuals, mediated through the market. For example, consider a government that has decided to limit domestic emissions through regulatory controls. International permit sales that result in tighter domestic constraints could well be politically unpopular so that a government would hesitate before selling its emission rights to the United States. Similarly, international permit sales by a country that is meeting its Kyoto obligations through domestic carbon or energy taxes requires a further hike in those taxes.

Monitoring and enforcement issues are also likely to be paramount in insuring the workability of international trading. If domestic enforcement is effective in all countries, so that mechanisms operate to ensure that consumers and firms in each country actually limit emissions to the national permit levels, international permit sales by private agents in the country actually translate into lower domestic emissions. But consider the difficulties that can occur with imperfect enforcement. If the government of a country--country X--finds it difficult either to measure domestic emissions or to enforce the purchase of permits by domestic emitters, then reductions in X's emissions may be insufficient to reach the Kyoto target. Those agents in X that are lucky enough to have been assigned the rights to X's permits will be able to sell them, at a quick profit, on the international market. With imperfect enforcement, international sales, without corresponding domestic emissions reductions, could emanate from countries with the weakest systems of enforcement. To prevent such "paper trades", which profit some participants and increase emissions, many countries will want controls to ensure the integrity of international permits. Buyers, too, will want clear concrete guarantees of the validity of permits so as to be sure they will not be asked to reduce emissions on-site as well. These controls and guarantees

may raise the costs of participating in this market and make the estimated savings illusory. In fact, most of the benefits projected from the international sale of permits come from inducing emissions reductions from countries in Eastern Europe and the former Soviet Union--countries with particularly weak tax collection and enforcement mechanisms. Without such countries in the scheme the gains from international trading of permits will be very small.

Model results suggest that joint implementation with non-Annex I countries also has the potential to reduce the U.S. burden of attaining any given timetable. Prior to the adoption of quantitative targets by the developing countries, however, emissions trading is apt to occur on a project-by-project basis in situations where it is demonstrable that a given project has reduced emissions relative to business as usual. For example, US businesses could receive credit for the construction of nuclear, oil or natural gas electricity generation plants in China if it were confidently expected that China would instead have constructed coal-fired plants with much higher CO₂ emissions. Permits for such trades might be overseen by an international agency to ensure that the projects were emissions-replacing. Such a project by project system is likely the most that is feasible without quantitative targets, but the efficiency benefits are not likely to be as great as with an enforceable system of international permit trading. In contrast, model results concerning the benefits of joint implementation treat it as equivalent to full international trading.

VII. Recycling of Revenues

The ultimate economic cost of an emission abatement program depends upon how the revenues realized from carbon taxes or auctioned permits are used. It has been estimated that the efficiency loss from collecting an extra dollar of tax revenue amounts to around 30 cents. If the resulting revenues from a carbon tax or auctioned permits are used to reduce inefficient taxes inhibiting work or investment, there would be welfare gains that offset the micro efficiency losses from energy curtailment. According to some estimates, GNP would actually increase if the revenues were used to reduce taxes on capital. Simulations by Nordhaus show that the optimal size of an abatement program would depend on how the revenues are recycled. Abstracting from the potential incentive gains from recycling, Nordhaus has shown that an initial carbon taxes of about \$5 is optimal for the U.S., given his projections of abatement costs and environmental benefits. However when revenues are used to replace other taxes with an efficiency loss of 30 cents, the initial optimal carbon tax rises to almost \$60. The simple lesson is that the costs of emission abatement are greatly reduced if the revenues from the taxes levied can be put to good use.

So far we have approached the recycling of revenues from the standpoint of microeconomic efficiency. There is also the potential for using the revenues to abate the macroeconomic consequences of the emissions program. The oil shock is believed by many economists to have resulted in increased unemployment because workers resisted the fall in real wages that was associated with the inflationary impact of higher energy prices. Increased wage demands added inflationary pressures to the economy that could only be suppressed by tighter monetary policy. Thus it might be argued that the effects of the real wage shock on inflation and unemployment could be diminished by lowering payroll or other worker taxes to offset the real

wage losses from higher energy prices.

But England's experience points to the need for caution in assessing the potential for revenue recycling to allay the macroeconomic consequences of the rising energy costs. In 1979, immediately after her election, Margaret Thatcher increased the VAT tax and simultaneously decreased the income tax. These two policy changes had offsetting effects on real after tax incomes, and therefore might have been expected to have had no effect on wage bargaining. However, the increase in the VAT tax resulted in an immediately noticeable increase in the CPI. A wage-price spiral ensued as workers attempted to maintain their pre-tax real wages.

VIII. Policy Implications

The foregoing arguments point to the attractiveness, from both an economic and environmental standpoint, of a U.S. policy to raise the price of carbon emissions--either through a carbon tax or a system of auctioned permits--by a moderate amount--for example, between \$10 and \$25 per ton of carbon-- in the near term, with further increases scheduled over the longer term. Under this program, U.S. emissions would continue to rise for at least a decade before declining to current, then 1990 levels and below. Such a program could be defended as a significant policy action consistent with a strong U.S. commitment to attaining the ultimate objective of the Framework Convention--namely to stabilizing atmospheric concentrations of CO₂ and hence mean global temperatures.

A program involving gradual increases in the relative price of carbon emissions over time would avoid the possibly substantial macroeconomic consequences of a 1990 by 2010 program. The energy price increases associated with this program would have a modest impact on family income that could be offset by compensating cuts in other taxes.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Joseph E. Aldy (CN=Joseph E. Aldy/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:23-SEP-1997 17:24:36.00

SUBJECT: Senate EPW questions

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

CC: Michele Jolin (CN=Michele Jolin/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

CC: Randall W. Lutter (CN=Randall W. Lutter/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

CC: Jeffrey A. Frankel (CN=Jeffrey A. Frankel/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

Janet,

You mentioned that you had some comments on the draft answers Randy and I compiled for you. Would you like to go over them sometime in the near future?

Joe

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Peter R. Orszag (CN=Peter R. Orszag/OU=OPD/O=EOP [OPD])

CREATION DATE/TIME:23-SEP-1997 17:40:00.00

SUBJECT: Draft #2

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TO: DAVID.WILCOX (DAVID.WILCOX @ MS01.DO.treas.sprint.com @ INET @ LNGTWY [UNKNOWN])

READ:UNKNOWN

TO: JONATHAN.GRUBER (JONATHAN.GRUBER @ MS01.DO.treas.sprint.com @ INET @ LNGTWY [UNKNOWN])

READ:UNKNOWN

TO: Jeffrey A. Frankel (CN=Jeffrey A. Frankel/OU=CEA/O=EOP @ EOP [CEA])

READ:UNKNOWN

TEXT:

Please find attached the latest draft of this memo. Comments welcome.

The sulfur dioxide section, I must stress, is likely to become more

balanced once EPA weighs in (e.g., on the fact that emissions are below

the required level, which would put upward pressure on the permit price,

etc.)===== ATTACHMENT 1 =====

ATT CREATION TIME/DATE: 0 00:00:00.00

TEXT:

Unable to convert ARMS_EXT:[ATTACH.D83]MAIL49746656N.216 to ASCII,

The following is a HEX DUMP:

DRAFT #2: CLOSE HOLD

September 26, 1997

MEMORANDUM FOR THE PRESIDENT

FROM:

SUBJECT: Climate change

This memorandum provides more detail on some of the issues raised during our climate change meeting with you on September 18. We will be holding a principals meeting today, and another one early next week, to pin down specific recommendations from the NEC/CEQ principals on targets and timetables, policy options to achieve those targets and timetables, and other issues of importance to them. We will then put together an NEC/CEQ recommendations memorandum and a briefing book that contains the underlying memoranda from the principals and other background materials. The recommendations memo and briefing book will be submitted to you by the end of next week, so that it can inform your thinking before the October 6 White House conference.

This memo:

- Outlines the sources of current emissions in the United States;
- Discusses the potential for technology to reduce the costs of emissions reductions, and highlights a possible technology program to address climate change; and
- Discusses several aspects of a tradeable permits system, including:
 - The benefits of a permits system relative to mandated standards;
 - The lessons offered by the SO₂ trading program;
 - Grandfathering versus auctioning with revenue recycling; and

→Where in the production stream the permit requirements would best be imposed.

I. Sources of emissions in the United States

Greenhouse gases of policy significance include carbon dioxide (C₂O), methane (CH₄), nitrous oxide (N₂O), ozone (O₃), and a variety of engineered chemicals, including chlorofluorocarbons (CFCs), and hydrochlorofluorocarbons (HCFCs). In 1995, gross U.S. emissions of these greenhouse gases amounted to 1.7 billion metric tons of carbon equivalent. Although measurement errors are large, the increase in forest cover and other natural "sinks" that absorb carbon reduced U.S. emissions by an estimated 117 million tons in 1995. Net emissions were therefore 1.6 billion tons.

Of the 1.7 billion tons in gross emissions, 1.4 billion tons (85 percent of the total) are due to carbon dioxide emissions. As the table below shows, roughly one-third of the CO₂ emissions come from transportation activities, one-third from buildings, and one-third from industry. (In this accounting, the CO₂ produced to generate electricity is charged to the sector using the electricity. Taken together, emissions from all electricity production amount to 36 percent of CO₂ emissions.)

U.S. CO₂ emissions are now more than 10 percent above 1990 levels, and are projected to be 28 percent over 1990 levels by 2010.

U.S.: Sources of CO₂ Emissions in 1995

Source	Current CO ₂ emissions (millions of metric tons, carbon-equivalent)
Transportation	436.6
Buildings	489.9
Industry	466.0
GROSS EMISSIONS	1,422.2**

*Source: *Climate Action Report 1997*, Table 3-2, page 60.

** Detail does not sum to total because of other small sources of emissions. Sinks reduce carbon-equivalent emissions by 117.0 million metric tons, implying net emissions of 1,305.2 million tons.

TRANSPORTATION

Transportation contributes 31 percent of U.S. CO₂ emissions. Its emissions are growing by about 2 percent (10 million tons) per year -- roughly twice as fast as industry and buildings -- because of increases in vehicle miles traveled and the increasing popularity of fuel-inefficient sport utility vehicles (which now account for almost half of all new passenger vehicle sales).

Transportation: Sources of CO₂ emissions

Source	Emissions in billions of tons (% of transportation emissions)	Notes
Automobiles	152 (34.9%)	PNGV initiative aims to raise fuel efficiency by factor of 3
Light trucks	101 (23.2%)	PNGV could be expanded to light trucks -- and could potentially double the efficiency of these vehicles
Heavy trucks	67 (15.4%)	PNGV could be expanded to heavy trucks -- and could potentially increase efficiency by 50 percent
Aircraft	57 (13.1%)	Goal of new NASA/FAA/DOD program is to cut fuel usage per passenger mile by 35 percent within 10 years
Other	59 (13.4%)	Largely oil and gas pipelines
TOTAL	436.6 (100.0%)	

BUILDINGS

Residential buildings produce 19 percent of U.S. CO₂ emissions, and commercial buildings account for another 15 percent -- implying that buildings account for over a third of total emissions. Emissions from both residential and commercial buildings are growing by 1 percent annually (2.6 and 2.1 million tons respectively). Energy demand in residential buildings is greatest for heating, electrical appliances, and air conditioning. In commercial buildings, demand is greatest for lighting, electric equipment, and air conditioning.

Buildings: Sources of CO₂ emissions

Source	Emissions in billions of tons (% of building emissions)	Notes
Space heat	211 (43.0%)	With improved building designs, new buildings can be much more efficient. Residential heating units can be made 10 to 25 percent more efficient. The "energy star" program aims to encourage energy-efficient buildings.
Appliances	98 (20.0%)	Refrigerator and freezer efficiency can be increased 25 to 30 percent using available technology.
Cooling	69 (14.0%)	Existing technology can reduce commercial air conditioning and ventilation by almost 50 percent.
Lights	69 (14.0%)	Energy for residential lighting can be cut by 50 percent and commercial lighting by 25 percent with existing technology.
Water heat	44 (9.0%)	Best available appliance technology can increase efficiency 25 to 30 percent.
TOTAL	489.9 (100.0%)	

INDUSTRY

Industries produce about a third of all CO₂ emissions. Emissions from this source are expected to increase at 0.8 percent per year (4 million tons). About 80 percent of all industrial CO₂ emissions come from petroleum refining, chemicals, paper, lumber and other forest products, and metals.

Industry: Sources of CO₂ emissions

Source	Emissions in billions of tons (% of industry emissions)	Notes
Machine drive/electrolytic	149 (32.0%)	Major potential for efficiency improvements through better control strategies, designs, and components
Steam	126 (27.0%)	Regulatory changes are needed to encourage high-efficiency, new units. Use of biomass instead of fossil fuel can lead to further gains.
Process heat	89 (19.0%)	
Off-road equipment	33 (7.0%)	New diesel technology can be applied to many of these uses.
Heat/air conditioning/light	28 (6.0%)	
Feedstocks/other	42 (9.0%)	
TOTAL	466 (100.0%)	

ELECTRICITY GENERATION

As noted, the CO₂ produced to generate electricity is charged to the sector using the electricity in the accounting above. Emissions from all electricity production amount to 36 percent of CO₂ emissions.

The table below shows that coal accounts for 50 percent of electricity generated in the U.S., but 77 percent of CO₂ emissions from electricity generation. Coal produces 72 percent more greenhouse gases than natural gas per unit of energy delivered -- which is why a carbon emissions reduction program would have a much larger impact on coal prices than on natural gas or other energy prices.

On average, the electric energy produced by an electric generator is only about a third of the energy input -- the other two-thirds is released as waste into the air or nearby waters. As more generation occurs closer to industrial and commercial sites, it should be easier to capture more of the heat from electric generation that would otherwise be wasted.

Electricity

Source	Share of electricity CO ₂ emissions	Share of electricity generation
Oil	1.9%	1.5%
Natural gas	20.7%	23.0%
Coal	77.4%	50.1%
Nuclear	--	15.8%
Hydro & renewables	--	9.6%
TOTAL	100.0%	100.0%

II. The Role of Technology

Over the long-run, all your advisers concur that advances in technology are crucial to reducing greenhouse gas emissions. Since the world economy is likely to grow by several multiples during the next century, the ratio of greenhouse gas production to economic activity must be cut dramatically to reconcile continued economic growth with reduced greenhouse gas emissions. According to your science advisers, three kinds of technologies seem promising:

- Technologies that use energy and materials more efficiently -- like the PNGV car;
- Technologies that produce energy using solar cells, plants and wood waste, and other methods that do not result in net production of greenhouse gases; and
- Technologies that can sequester or permanently store greenhouse gases in deep aquifers or in other ways.

There is agreement that a package of technology options should be a component of any U.S. climate strategy. Options could include direct government expenditures, tax breaks for R&D, or regulatory standards. *But your advisers have sharp disagreements about how much we can reasonably expect of technological advances without the spur of a price increase.*

- Some of your advisers believe that the cost estimates presented above are too high because even without an increase in the price of energy, there are numerous opportunities for energy-saving technologies to be developed and applied. For example, one controversial study conducted by five of the Department of Energy's national laboratories concluded that even without an increase in the price of carbon, "cost-effective energy efficiency alone can take the nation 30 to 50% of the way to 1990 levels" by 2010.
- Your economic advisers raise a series of significant methodological objections to the study mentioned above. They also stress the importance of market incentives for technological advances, and the substantial body of evidence that markets respond to such incentives. They argue that technology will clearly be one of the conduits for meeting an emissions reduction target, but that both theoretically and historically, the most rapid technological advances come in response to significant increases in the relative price of energy.

For instance, over the entire postwar period, the fossil-fuel efficiency of the U. S. economy has improved at slightly more than one percent per year. Between 1970 and 1986, during which time the economy suffered two oil-price shocks, fossil-fuel efficiency grew by more than 2½ percent per year. The pace of efficiency improvement has slowed down, but not stopped, since the late 1980s, as the relative price of energy has fallen.

The degree of disagreement on this crucial topic, however, can easily be exaggerated. Despite ongoing debates over

the precise role of technology, therefore, *there is broad technical agreement that a significant price signal is crucial to achieving emissions reductions of the sort being considered in international fora.* In other words, it is impossible to achieve 1990 emissions levels by 2010 without a substantial increase in carbon prices.

III. Tradeable Permits

During our meeting with you, we discussed a tradeable permits system for reducing carbon emissions. This section examines several questions related to tradeable permits. The first is why a tradeable permits system facilitates less costly reductions than mandated standards (e.g., that every car must have a fuel efficiency higher than some level).

Tradeable Permits Versus Mandated Standards

A natural question about tradeable permits is why they reduce the costs associated with meeting a given emissions reduction objective. Wouldn't it be easier and more straightforward to mandate standards on items such as automobile fuel efficiency?

Mandated standards are generally a more costly approach than market-based systems to reducing pollution. The reason is that standards often require *all* purchasers of new capital to improve the efficiency with which they use energy, regardless of the cost, and then offer no incentive to improve environmental efficiency beyond the given standard. A tradeable permits system, on the other hand, focuses directly on GHG emissions, allows reductions to take place wherever they are cheapest, and imposes no arbitrary constraint on incentives for further improvement. And in most cases, a tradeable permits system is less administratively costly.

An illustrative example

An example may be helpful. Assume that there are two types of coal-fired plants, both of which emit 100,000 tons of carbon per year. The first type can easily switch to less carbon-intensive fuels (such as natural gas), and thereby reduce carbon emissions even for a given level of energy output (since natural gas has less carbon per BTU than coal). To be more specific, this first type of power plant can achieve carbon emissions reductions at a cost of \$25 for every carbon ton reduction. The second type, however, was designed in a manner that makes it extremely difficult to switch fuel to reduce emissions: it can achieve emissions reductions only at a cost of \$150 per ton.

The average cost of mandating that carbon emissions at all plants fall by 30 percent is therefore \$2.6 million per plant (\$0.75 million at the first type, and \$4.5 million at the second). Under a permit system, however, the total cost would be dramatically reduced by allowing the second type of plant to buy permits from the first type. This way, a 30 percent reduction in total emissions would cost only \$1.5 million per plant (all of the 60,000 ton reduction would occur at the first type of plant, at a cost of \$25 per ton). In this example, the permit system produces a cost saving of over 70 percent *to achieve the same*

environmental goal. This level of cost saving is not unrealistic: studies by environmental economists often find that market-based systems reduce the cost of environmental regulations by as much as 90 percent.

CAFE standards

It may also be worthwhile examining the specific case of fuel efficiency standards. Federal regulation began in 1976 through Corporate Average Fuel Efficiency (CAFE) standards. When the CAFE standards first went into effect, new vehicle average fuel efficiency was 17.2 miles per gallon (mpg). That figure rose 10 mpg over the next ten years. Fuel efficiency levels have since stabilized at around 28 mpg. Proponents of fuel efficiency standards argue that currently available technologies could markedly improve motor vehicle efficiency. Indeed, the Congressional OTA has reported that regulatory pressure could raise average new car fuel efficiency by about 13 percent in 2000 and 22 percent by 2005.

A debate is ongoing over the effectiveness of the CAFE standards. While the improvement in new car fuel efficiency between 1975 and 1986 is not disputed, some analysts have noted that real gasoline prices increased by 70 percent between 1973 and 1981. Thus, they argue that the increase in fuel efficiency resulted from consumer demand for high-mileage vehicles in the face of rising fuel prices -- not from the CAFE standards. Opponents of standards also note that simply increasing fuel efficiency, without changing the price of gasoline, reduces the cost of driving additional miles and thus induces people to drive more miles -- so that the positive effects of increased fuel *efficiency* will be at least partially offset by an increase in *miles driven*.

Tighter CAFE standards should not be viewed as a costless approach to reducing carbon emissions in the United States. For example, standards would have to be substantially tightened on sport utility vehicles and other light trucks as well as passenger cars to ensure effectiveness. Such vehicles now comprise almost half of new vehicle sales in the U.S., arguably as a way to sidestep the current standards, and tighter standards would therefore force consumers to forgo their obvious attraction to these (relatively) fuel-inefficient vehicles. Also, since the standards only apply to *new* cars and the median expected life of a passenger car is now 14 years (16 years for trucks), the full impact of any change in CAFE standards would not be felt by 2010.

Several studies have estimated the cost of reducing carbon emissions with CAFE standards. Krupnick *et al.* (1992) estimated the implied cost of carbon reductions from increasing the CAFE standard to 37.5 miles per gallon at \$106 per ton of carbon reduced. Charles River Associates estimated a carbon price of \$104 per ton in raising CAFE standards to 40 miles per gallon.

The SO₂ Example: How Much Can We Learn From It?

Another natural question regarding a carbon emissions permit trading system is what we can learn from the sulfur dioxide (SO₂) allowance trading program. The SO₂ permit program evolved out of the Clean Air Act Amendments of 1990, which required a 50 percent reduction in SO₂ emissions from electric-utility boilers. To accomplish this goal, a fixed number of emission allowances were allocated to electric utilities based on historical fuel use. (In addition, a small number of allowances are now auctioned every year.) Allowances may be traded to any party anywhere, and may be “banked” for use in future years. Regulated entities must monitor their emissions continuously, and report on them annually. Penalties are imposed if an entity does not hold sufficient allowances to cover its emissions.

Around the time that the 1990 Amendments were enacted, a commonly held view was that achieving the targeted reduction in SO₂ would require the price of emissions to rise above \$400 per ton, and possibly as high as \$1,000 per ton. Today, the price of SO₂ allowances ranges between \$90 and \$120 per ton. Many observers have interpreted the discrepancy between predicted and actual prices as indicating that significant reductions in carbon emissions could likewise be attained at surprisingly low cost.

The Treasury Department, however, argues that the comparison is not a valid interpretation of the historical record.

- First, Treasury argues, most of the price estimates failed to distinguish between Phase I of the SO₂ program (1995-99, when only electric utilities are required to participate) and Phase II (2000 and after, when large industrial emitters will be brought into the program). Analysts who did recognize this distinction issued much lower predictions for the price of permits during Phase I, ranging from about \$250 per ton to about \$400 per ton -- roughly half the more commonly quoted range.
- Second, Treasury argues, early estimates of permit prices were based on inaccurate guesses as to the provisions of the final bill. For example, the EPA ended up distributing an extra 3.5 million bonus allowances (allocated to plants installing scrubbers) beyond the level that had been anticipated earlier. The last pre-enactment estimate (from an EPA/ICF study) -- the one with the best information about the legislation that would actually be passed -- projected that the Phase I permit price would be between \$170 and \$200 per ton.
- Third, the remaining discrepancy between predicted and actual permit prices partially reflects the deregulation of the freight-carrying railroads and the consequent reduction in rates -- a development that had nothing to do with the SO₂ program. It would be imprudent to assume that any similarly favorable factors will emerge with respect to a carbon trading program. Certainly, there is no deregulatory action on the horizon that could bring the price of a carbon program down by a comparable amount.
- Finally, Treasury notes, careful analysis has shown that actual abatement costs to date have averaged about \$200 per

ton, and thus have substantially exceeded the currently prevailing permit price. The discrepancy between abatement costs and the permit price could result from implicit (from general public opinion) and explicit (from Public Utility Commissions) restrictions on the ability of utilities to purchase permits, or from overinvestments in long-term contracts for low-sulfur coal and in SO₂ scrubbers. Utilities have continued to operate their installed scrubbers notwithstanding the unexpectedly low price of permits because the *variable* cost of operating a scrubber is only about \$75 per ton.

Two other distinctions between the SO₂ program and any prospective carbon program are worth noting:

- A greenhouse program would dwarf the SO₂ program: Whereas the annual stock of permits under the SO₂ program is worth less than \$1 billion, the annual stock of permits under a carbon trading program might be worth between \$30 billion and \$150 billion. The difference in aggregate permit values reflects the fact that achieving a significant reduction in carbon emissions will require *fundamental changes* in the structure of the American economy. For example, a long-term solution to the carbon problem will require moving away from combustion of petroleum-based fuels in the transportation, utility, and manufacturing sectors. By contrast, in the case of SO₂, there were proven technologies on the shelf, waiting to be called forth when the necessary price signals were given.
- A meaningful greenhouse gas control program will be more complicated to administer than the current SO₂ program. The SO₂ trading program will cover approximately 2,000 utility sources when fully in operation (Phase II); a greenhouse gas trading program will have to cover substantially more sources. Even if the number of sources were minimized by placing the permit requirement as far upstream as possible -- that is, at the primary fossil fuel processor level -- the number of sources could range from 3,000 to nearly 1 million.

Grandfathering Versus Auctioning-With-Revenue Recycling

Another issue related to a permit system, and one we touched upon in our meeting, is whether the permits should be auctioned or grandfathered. To summarize the cases for and against grandfathering:

- Auctioning would raise revenue -- potentially more than \$100 billion a year -- that could be used to reduce other taxes, fund the adjustment programs favored by the labor unions, offset the regressivity of the emissions reduction scheme, or raise national saving. As some rough examples of what could be done under a revenue-neutral auction approach, \$100 billion raised from auctioning permits could be used for one of the following:
 - Exclude over \$6,000 of payroll from both the employer and employee part of the OASDI tax;
 - Cut the employees' OASDI payroll tax (currently 6.2 percent) in half;

→Reduce the 15 percent income tax rate in the lowest bracket to 10.2 percent; or

→More than double the standard deduction (currently \$6,700 for married couple)

- By contrast, grandfathering in effect confers an enormous amount of wealth on corporations -- possibly upwards of \$100 billion per year, or about 20 percent of total after-tax corporate profits. By giving away this wealth to corporations, grandfathering precludes a “tax waste, not work” strategy.

→ One way to think about the difference between grandfathering and auctioning is to recognize that grandfathering is functionally equivalent to auctioning the permits, and then giving the proceeds of the auctions back to existing emitters.

- Although firms are likely to pass most of the cost through to consumers, auctions ostensibly force them to pay large costs simply for the right to maintain their business-as-usual operations. *Regardless of whether the permits are auctioned or grandfathered, though, consumers are likely to bear most of the costs involved in reducing emissions (through higher energy prices).* Ironically, grandfathering thus protects corporations even though they do not need protection -- since they will pass on most of the cost increase -- and gives away the funds that could protect consumers, who will bear most of the costs from adjusting to the emissions reduction scheme.
- The prospects for support from key businesses -- such as those you met with last month -- are much higher with grandfathering than an auction. The theoretical benefits of auctions as a means of distributing the permits will be much less salient to the CEO of a large corporation than the necessity of having to purchase permits to continue operations.
- Grandfathering is much less likely to be characterized as a tax than an auctioned permit system.
- While grandfathering may reduce corporate opposition, it would also attract many claimants. Deciding which claimants deserve the permits could prove very difficult, and the lobbying behavior inherent in attempts to capture the permit wealth could make the entire system inefficient. Furthermore, pressure for grandfathered permits is likely to be strongest among mid-stream firms -- such as electric utilities and perhaps large energy-intensive manufacturers. As discussed below, however, this may not be the optimal point in the production cycle to impose the permit requirement.

Where To Impose the Permit Requirement

A key policy decision in a tradeable permits system is where in the production process to impose the permit requirement. This question is related to the grandfathering question discussed above: for example, if we grandfather permits by giving them to manufacturers, it would seem incongruous to impose the permit requirement further upstream (e.g., at the well-head).

The two principal possibilities for imposing the requirement include the primary fuel and the sectoral level:

- ***Imposing the Requirement on Primary Fuel Producers.*** Under a program in which primary fuel producers are required to hold allowances, permits would be required for the carbon dioxide (CO₂) emission potential contained in fuel. Primary fuel and refined product imports and exports would also need to be accounted for in such a system. A primary fuel permit program could be imposed at the level of:

→Extraction: the total number of companies involved would be 2,000 oil and natural gas producers and 3,600 coal companies;

→Distribution: e.g., natural gas distributors, and gasoline and other petroleum product distributors. The number of such sources is extremely large; or

→Processing: e.g., natural gas processors, coal blending/cleaning facilities, and petroleum refiners. There are approximately 200 oil refineries, 3,600 coal blending/cleaning facilities and 623 natural gas processing facilities. (Coal processors are typically affiliated with mines, so there is little practical difference between requiring permits at the point of extraction or processing for coal.)

- ***Imposing Permit-Holding Requirements by Sector.*** An alternative approach, which is consistent with permits being grandfathered by sector, would be to require participants in each sector to hold and use permits. Although this system would be most comparable to the current SO₂ emissions allowance trading system, it would be fundamentally more difficult to implement because of the number of emitters.

A sectoral emission allocation approach could be applied only to large emitters, but at the cost of a substantial loss in coverage. Including the six largest *industrial*/CO₂ emitting sectors (including electric utilities, but excluding the transportation sector) in a sectoral trading program would encompass about 20,000 market participants -- but only 51 percent of total U.S. CO₂ emissions. In order to cover the literally millions of small emitters, permit requirements would probably have to be shifted upstream in a manner that would mimic the permit requirements for primary fuel processors discussed in the previous section. Requiring the permits at an earlier stage of this chain offers administrative advantages and the ability to comprehensively cover all emissions. Appendix B provides additional background on sectoral issues.

Appendix A

U.S. Experience with Emissions Trading

The United States has had experience with a number of emissions trading schemes other than the SO₂ trading.

Water Effluent Trading: The US generally has regulated surface water quality through a system of discharge limits for large sources of water pollution. In addition, states have standards for ambient water quality that are often not attained even after large dischargers apply "best technology" because small sources (such as runoff from farms) contribute significantly to water pollution. A number of state and local governments are employing trading systems for watersheds that either allow trading among large dischargers, or allow large dischargers to fulfill their requirements by controlling small sources. Examples include the Fox River in Wisconsin, the Dillon Reservoir in Colorado, and the Tar-Pamlico River in North Carolina. The latter two programs are designed to reflect expected economic growth in the future, so the quantity of effluent allowances allocated exceeds current discharge levels. Once growth consumes this excess, trading is expected to reduce compliance costs.

Inter-refinery Lead Trading: EPA operated a lead trading program from 1983 to 1987 as it phased out lead from gasoline. Lead trading allowed refiners and importers to trade lead reduction credits to meet limits for the lead content of gasoline. The quantity of allowances to which a firm was entitled was determined by the amount of leaded fuel produced by the firm and the contemporaneous EPA standard. Those who bettered the standard could sell their credits to others. Some 10 billion grams of lead were traded during the course of the program, at prices ranging from 0.75 to 5 cents per gram. Allowing the trading of lead credits reduced the costs of the program by approximately 20 percent.

Criteria Air Pollutant Trading: EPA first began incorporating aspects of emissions trading in its air program in 1974, when it allowed a modified source to use "credits" earned by another source within the same plant to avoid additional regulatory requirements. Since then, emission trading has substantially expanded. Trades have numbered in the thousands and have been estimated by Hahn and Hester (1986) to have saved between \$525 million and \$12 billion.

Market Mechanisms for Chlorofluorocarbon (CFC) Phaseout: Under the 1987 Montreal Protocol to limit stratospheric ozone depletion, the U.S. required the phase out of the production of CFCs by 1996. As part of its program, the U.S. adopted a tradable permit regime covering CFC manufacturers and importers. These allowances were allocated based on each firm's 1986 market share. As the market for CFCs declined, the system allowed firms to allocate production among different facilities according to the least-cost pattern of supply. It also gave CFC users the flexibility to switch between different CFC compounds, within the overall limit on allowances. This program helped reduce the costs of the phaseout. In 1988, EPA estimated that the cost to *halve* CFC use would be \$3.55 per kilogram. By 1993, it became clear that all uses could be *eliminated* by 1996 at a cost of \$2.45 per kilogram.

Appendix B

Sectoral Emissions Trading Issues

Requiring manufacturers to hold permits to emit would greatly increase the complexity of a trading system, compared with the system of requiring primary fuel producers to hold permits.

1. Electric Utilities

The electric utility sector emits about one-third of the CO₂ in the United States, with emissions of 495 MMTC in 1994. The number of utility point sources is limited and well defined, totaling about 2,115 generating units in 1995. As a result of the SO₂ program, the electric utility sector is one of the few in the U.S. that is familiar with permit trading programs.

The definition of what constitutes a "source" under an electric utility program has an influence on coverage, the degree of leakage, and the administrative and monitoring costs. A source could be defined as a combustion unit, a plant, or a corporate entity (which may own multiple units and plants). Units covered by the acid rain program are already required to report carbon emissions data to the EPA. It is also possible to target a trading program at the company level based on total fuel inputs. This type of company level allocation could also be applied to independent power producers (IPPs), many of whom own several facilities. Smaller entities (e.g., municipals, IPPs owning one or a few small generators) could be excluded based on annual emissions levels.

Covered sources could be limited to those fired by coal, natural gas, and fuel oil. Alternative-fuel fired units, such as those burning municipal solid waste, refuse derived fuels, or waste fuels (such as wood chips) may or may not be included as well.

2. Heavy Manufacturing Industries

The industrial sector emitted approximately 293 million metric tons of carbon in 1994 from the combustion of fossil fuels and industrial processes. There is no single industry sector (excluding the electric utility sector) that generates the majority of CO₂ emissions. Paper and allied products is the largest sector (including direct emissions from by-products), followed by chemical and allied products, primary metals, and petroleum refining. [[Cement manufacturers are the fourth largest source category among the manufacturing sector. In 1994, calcining cement manufacture (a non-combustion process by which limestone materials are converted to lime) accounted for 9.5 million metric tons of carbon emissions, while fuel combustion accounted for another 6 million MMTC.]]

The industry sectors listed above represent about 58 percent of industrial emissions, and about 12 percent of total U.S. CO₂ emissions. Individually, each represents less than five percent of total US emissions. A CO₂ regulatory program including electric utilities and the 17,000 industrial sources in the sectors listed above would thus capture about 90 percent of total industrial emissions (including utilities) and about 51 percent of total US CO₂ emissions.

The scope and effectiveness of a manufacturing sector program would depend on what level emission caps were

placed, and the types of sources and fuels included. These issues parallel those in the utility sector and are discussed below.

Allocation Basis. An emissions trading program could be implemented at the corporate or facility level, or for specific sources (e.g., boilers). Corporate level fuel consumption data may be more comprehensive than industrial source data, which may not currently be tracked.

Coverage. A manufacturing trading program could be limited to specific sources, including industrial boilers, on-site electricity generation and cogeneration, and carbon (or other greenhouse gas emissions) from industrial processes (such as cement manufacture).

Source Size. Within a source category (e.g., boilers), exemptions may be granted based on size (e.g., industrial boilers smaller than 25 MMBtu/hour). Exempting small units may involve a certain amount of leakage, as utilization may be shifted from affected boilers to unaffected ones. Regulations could be designed to address this issue.

Data quality could determine the scope of a manufacturing program. Most large industrial companies probably maintain data on purchases of natural gas, coal and fuel oil at the facility or corporate level. It would be difficult to verify the accuracy of these reports and emissions monitoring may be impractical for all but the largest sources. Boiler level data would be easier to verify. However, boiler-level fuel input data is typically currently maintained by only the largest industrial sources.

3. Transportation

Motor vehicle manufacturers consumed only 0.5 percent of US manufacturing energy consumption (netting-out emissions associated with the sector's electricity use). This sector's direct combustion may be captured in a trading regime, depending on the program's scope. Much more important are the carbon emissions associated with the fleet of private, commercial, and other transportation sector equipment (such as off-road vehicles, buses, trains and planes) manufactured. The transportation sector is responsible for approximately 32 percent of US CO₂ emissions.

Unlike utility or heavy industrial sources however, the transportation sector is comprised of millions of individual sources. Effective control of transportation emissions could involve alternative approaches directed at the equipment manufacturers, fuel producers or end-user. Manufacturers could be required to hold permits covering the CO₂ emissions associated with the automobile fleet (and other equipment). The level of allowances required could be determined based on several factors, including:

Average fuel consumption (miles per gallon) for the vehicle fleet, weighted by sales of each vehicle or equipment type

Estimated annual average vehicle miles traveled (VMT) per car in the fleet, for each fuel type

Estimated average lifetime of a car in the fleet

CO₂ emission rates for gasoline, diesel, and other fuels.

The problem with this approach is that it does not focus on emissions, but rather fuel efficiency. An automobile that gets 10 miles to the gallon but is driven only 1,000 miles a year would bear greater cost than a 40 mile per gallon automobile that is driven 40,000 miles, despite the fact that the latter emits 10 times as much CO₂.

RECORD TYPE: PRESIDENTIAL (NOTES MAIL)

CREATOR: Randall W. Lutter (CN=Randall W. Lutter/OU=CEA/O=EOP [CEA])

CREATION DATE/TIME:23-SEP-1997 11:50:09.00

SUBJECT: Figure 1: Chart of OPEC-induced price hike

TO: Janet L. Yellen (CN=Janet L. Yellen/OU=CEA/O=EOP @ EOP [CEA])

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TEXT:

----- Forwarded by Randall W. Lutter/CEA/EOP on 09/23/97
11:48 AM -----

Daniel K. Chang

09/23/97 11:49:09 AM

Record Type: Record

To: Randall W. Lutter/CEA/EOP, Joseph E. Aldy/CEA/EOP

cc: Adele C. Morris/CEA/EOP

Subject: Chart of OPEC-induced price hike

These two charts show how a 150% increase in price led to a 25% decrease in demand for oil.

The OPECHART.PRE file is a Freelance document. The gray OPECHART.WPG file contains the same information, but has been formatted for WordPerfect.

-Dan

===== ATTACHMENT 1 =====
ATT CREATION TIME/DATE: 0 00:00:00.00

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