PRELIMINARY
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ENERGY SECURITY IMPACTS OF CARBON EMISSION REDUCTION

WP 12.10

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January 1993

Energy Modeling Forum
Terman Engineering Center
Stanford University
Stanford, California

ENERGY SECURITY IMPACTS OF CO_2 EMISSIONS REDUCTION POLICIES: SUMMARY OF EMF 12 MODELS DURING THE PERIOD 1990 TO 2030[1]

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INTRODUCTION

Recent concern over the effects of rising concentrations of CO_2 in the world's atmosphere on the global climate and the environment has led to calls for policies that will stabilize or reduce CO_2 emissions relative to 1990 levels. Any significant cut in CO_2 emissions, such as those modeled in the Energy Modeling Forum 12 (EMF 12) study, will change the amount and mix of fuels consumed by the United States. This paper examines whether these changes adversely affect U.S. energy security.

Policies aimed at reducing CO_2 emissions will cause demand-side and supply-side adjustments in energy markets. On the demand side, these policies will encourage three types of conservation: the substitution of capital for energy (e.g., adding insulation to a building); changes in the industrial product mix of the economy (e.g., moving away from energy-intensive industries); and doing with less (e.g., turning down the thermostat). On the supply side, CO_2 reduction policies such as a carbon tax will encourage a transition away from carbon-intensive fuels such as coal towards non-carbon intensive fuels such as renewable fuels or natural gas. The analyses of the EMF 12 model results conducted for this paper consider these types of adjustments.

The paper is divided into two major sections. The first section defines energy security and offers a list of energy security indicator variables. Policy makers can monitor changes in these variables to see if the Nation's energy security is enhanced or diminished by different actions. The second section analyzes the results from different EMF 12 models during the time period 1990 to 2030 on the basis of many of these indicators.

Our analyses of the EMF 12 data do not reveal any significant adverse impacts on energy security associated with reducing CO_2 emissions. This conclusion must be tempered as several key energy security variables could not be addressed given the available data. In particular, this paper does not consider the effect of reducing CO_2 emissions on the OPEC market share of world oil supply, nor does it consider the effect of reducing CO_2 on the change in the GDP due to oil price shocks. A more comprehensive look at energy security might uncover energy security impacts that were missed.

DEFINING ENERGY SECURITY

A common misperception is that the Nation's energy security is synonymous with its level of oil imports, either measured by the millions of barrels per day (MMBD) imported or by the percentage of oil demands met by imports. Several studies have demonstrated energy security encompasses more than simply measuring the oil import level (Bohi and Montgomery 1982, U.S. GAO 1988, Fried and Blandin 1988, Sohn 1990). Oil imports are correlated with energy security, but it is possible for a nation to have a significant degree of energy security and high import levels. As was recalled in the National Energy Strategy (1991), the oil price shock caused by the 1979 Iranian revolution caused more economic damage to Great Britain, which imported very little oil, than to Japan, which imported all of its oil.

As a more comprehensive concept of energy security we propose the following.

Energy security increases as the economic damage the Nation is expected to suffer from energy supply disruptions over a given period of time decreases.

We have focused on energy security as negatively related to expected economic damage because it is the economic damage that underlies threats to world peace. The more *vulnerable* the economies of nations are to energy supply disruptions, the greater the actual or perceived threats to the energy supply system will lead to war. Presently, potential disruptions of oil supplies pose the greatest threat to energy security. In the future, usage and imports of other fuels (e.g. methanol) may play increasingly important energy security roles.

An important component of vulnerability is the sensitivity of economic activity to the price shocks associated with a supply disruption. In technical terms, this is measured as the elasticity of GDP with respect to the price of the disrupted fuel, e.g., the percentage change in to a percentage change in the world oil price. As this elasticity increases, so does vulnerability. Other measures of vulnerability can be developed from microeconomic-based concepts such as net changes in consumers and producers surplus. Regardless of how vulnerability is measured, it should reflect the degree of linkage between a economic well-being and price changes caused by supply disruptions.

Our concept of energy security is analogous to what Bohi and Montgomery (1981) term the "disruption component" of the oil import premium as opposed to the "demand component." The demand component refers to the ongoing transfer of wealth from the U.S. to oil exporters due to the "monopsony effect" or associated with purchases of oil imports. The demand component of the premium causes the domestic social cost of oil imports to exceed the private cost. Whether and how to correct this divergence is an important policy question, but not one that is related to energy security. In the context of this paper, energy security refers primarily to the macroeconomic losses caused by supply disruptions. Both the disruption component and the demand component need to be considered, however, when measuring the full oil price externality.

Some may argue that energy security refers to the Nation's ability to obtain the oil it needs in order to defend itself. At its most basic level, this is, of course, critical. But, it is not a central issue here because CO_2 emissions reduction policies will not deny the military access to a reliable fuel supply. Many sources of supply are available to the military in the event of a conflict including drawing down the strategic petroleum reserve or, in a severe conflict, expropriating supplies destined for non-military purposes. When these supply sources are juxtaposed against the relatively small share of total domestic oil consumption accounted for by military operations (3%), it is clear that CO_2 reduction policies will not directly reduce the Nation's military strength.

The notion of worldwide dependence on oil, however, cannot be overemphasized. Even if the United States develops a more flexible economic system that can better withstand oil price shocks, other countries might not. In such a situation, a conflict or war could develop over oil and the United States could easily be drawn into it.

It is plausible, however, that CO_2 emissions reduction policies could alter the probability of the country entering a military conflict. If CO_2 reduction policies increase the share of total worldwide energy needs met using oil, then more is at stake if an oil supply disruption occurs, and the probability of a conflict is increased. Further, whether the world oil market is "tight" or "slack" will affect the range of options open to world leaders in conducting foreign policy. Slack markets are characterized by significant excess production capacity in oil exporting nations and large inventory accumulations. Schlesinger (1991) notes that the slack oil market in 1986 made it easier for President Reagan to decide to use military force against Colonel Khadaffi because of Libya's support of terrorism. The slack market mitigated the possibility of a severe price spike, and its resulting economic damage, caused by the attack.

These considerations show that a comprehensive analysis of energy security must consider both international and domestic energy markets.

What Can Models Add to Energy Security Debates?

Energy models clearly cannot address every aspect of energy security. In order to focus our analysis of the EMF 12 data, we looked for consistent model results that pointed to increases in expected economic damage from energy supply disruptions. The expected economic damages from supply disruptions are affected by three major factors: 1) the probability of a disruption occurring; 2) the severity of a disruption as measured by the quantity of fuel disrupted and the magnitude of the resulting price shock, and 3) the ability of the world's economies to withstand the price shocks. Energy models are far better equipped to address the last of these factors.

The third factor encompasses two effects. First, it provides a direct link to the amount of economic damage caused by an oil price shock. From a narrow U.S. perspective, the U.S. economy's ability to withstand a price shock is critical. However, given our growing economic interdependence with other nations, the ability of other world economies to withstand a price shock is also important. Second, under the premise that wars are fought in part to protect economic interests, the third factor is correlated with the likelihood of a supply disruption leading to war. If the world economic system is flexible in terms of oil usage, supply disruptions are less likely to lead to war.

Because of the many different dimensions of energy security, no single measure can be used to monitor it. The next section lists several different variables that are likely correlated with changes in energy security. As a first step, the effects of CO_2 reduction policies on energy security can be approximated by determining how the policies affect these variables.

Energy Security Indicator Variables

Oil Intensity: The more dependent the economy is on oil to meet its energy needs, the less energy secure it is. The potential economic damage from oil price changes depends primarily on oil consumption levels rather than oil import levels. The fuel mix (oil vs. other fuels) is tracked in most energy-economic models and should indicate whether energy security is affected by CO_2 reduction policies.

Oil Imports: All else being equal, the higher the import level, the greater the economic damage caused by a supply disruption. With high import levels, the amount of gain in domestic producers surplus arising from higher prices is small compared to the loss in consumers surplus. This is sometimes referred to as the "terms-of-trade" effect.

Energy Efficiency of Economy: This measure shows the dependence of the economy on energy in general as a factor of production. The most commonly used measure of energy efficiency is the British thermal unit (BTU) to GDP ratio. This ratio can be calculated for all fuels, and for oil alone. Some associate higher BTU/GDP ratios, especially for oil, with reduced energy security.

The BTU/GDP ratio can be misleading for measuring energy security for two reasons. First, it does not directly measure the elasticity of GDP with respect to oil price. A lower BTU/GDP ratio does not necessarily mean price shocks will result in smaller GDP losses. The amount that GDP will fall in response to a price shock depends on the productivity of the oil displaced and the degree to which oil substitutes are readily available. In an energy-efficient economy, oil demand might be inelastic because there is less slack in the energy system. With inelastic demand, a supply disruption could cause a relatively large price rise and a significant reduction in GDP even if only a small amount of oil is being used. Second, a falling BTU/GDP ratio in the U.S. may be associated with a rising BTU/GDP ratio in other countries. This is apt to occur if the United States imports a larger share of energy-intensive goods as a means of meeting its CO_2 reduction targets. The rise in the energy intensiveness of other economies may offset any energy security benefits associated with increased U.S. energy efficiency.

Imports of Other Fuels: Currently, the import level of other fuels is not as important as oil. However, if policies to reduce CO_2 result in an economy that is dependent on imports of other fuels, particularly natural gas, then the import level of these fuels may signal changes in energy security.

Fuel Switching Capabilities: Enhanced fuel switching capabilities increase energy security in two ways. First, if oil prices rise in response to a supply disruption, then many oil-dependent activities can switch to other fuels, thereby reducing the economic loss. Second, the fuel switching itself will depress oil demand and reduce the size of the price shock. This will benefit all oil-dependent activities, even those that cannot switch.

Excess Production Capacity and Stockpiles: The amount of worldwide excess production capacity will also affect how much prices will rise in response to a supply disruption. For example, the price rise associated with the 4 million barrels per day shortfall caused by the Iraqi invasion of Kuwait in 1990 was mitigated by the excess production capacity in the rest of the world, particularly Saudi Arabia. The Strategic Petroleum Reserve in the U.S. and similar reserves in other nations also helped reduce the price rise. Excess production capacity and the size of the world's crude oil stockpiles, especially as measured relative to worldwide consumption, are critical energy security variables that were not considered by the EMF 12 models.

Concentration of Production in a Single Region: The more concentrated oil production becomes in a single region of the world, the more unstable energy security becomes. This is especially true if production is concentrated in an unstable area such as the Middle East. With more oil coming from the Middle East, the probability of a significant disruption would likely increase. Further, with oil production concentrated in a single region a supply disruption by one nation could adversely affect the supply capabilities of neighboring nations. For example, two nations could use a common pipeline which, if damaged, would reduce exports from both nations. These linkages between exporting nations diminish security because they increase the likelihood of a large supply disruption. The EMF 12 models did not identify whether oil production was becoming more or less concentrated.

ENERGY SECURITY IMPACTS AS INDICATED BY THE EMF 12 MODELS

In the EMF 12 study, fourteen modeling teams employing a wide variety of analytical techniques studied the effect of reducing CO_2 emissions under a standardized set of assumptions. By looking across models, a range of possible energy security impacts can be examined.[2]

This analysis summarizes the energy security impacts of the three first-round CO_2 emission control scenarios studied in EMF 12. The impacts are identified by comparing the value of selected energy security indicator variables under these three scenarios to the EMF 12 reference case. Not all of the indicator variables were considered because the necessary data were not generated during the EMF 12 model simulations. Changes in the selected indicator variables as compared to the reference case are used to identify possible energy security impacts of controlling CO_2 emissions.

Scenarios

The reference case and the three control scenarios are as follows.

Scenario 1 (Reference Case): No CO_2 control and an increase in emissions as indicated by the respective models.

Scenario 2 (20% Reduction): A 20 percent reduction in CO_2 emissions in the developed countries and no more than a 50 percent increase in the developing countries relative to 1990 levels by 2010.

Scenario 3 (50% Reduction): Same as #2, but developed countries must also reduce CO_2 emissions by 50 percent compared to 1990 levels by 2050.

Scenario 4 (Stabilization): Developed nations must stabilize CO_2 emissions at 1990 levels by 2000 and developing nations are again held to no more than a 50 percent increase by 2010.

Models Analyzed

Although 14 models were used in the EMF 12 study, only 10 were analyzed in this paper. Three of the models were excluded because the results from their runs were not available to us (CETA by Peck and Teisberg) or because they did not separate oil and gas (DGEM by Jorgenson and Wilcoxen and Goulder's model). The remaining eleven models analyzed were: Edmonds/Reilly, Global-Macro, Global 2100, IEA, TGAS, MWC, CRTM-RD, U.S. Markal, Fossil2, OECD-Green, and Gemini.[3]

The time frame for analyzing the model results was 1990 to 2030, since only four of the ten models had results beyond 2030. For the purposes of examining energy security impacts, looking beyond 2030 is overly speculative.

Results

Primary Energy Use and Fuel Mix: Figure 1 shows the total primary energy usage in the U.S. and the fuel mix averaged across the EMF 12 models for the years 1990, 2010, and 2030. Although using averages masks model-by-model variation, a comparison of Scenarios 1 and 2 succinctly summarizes the typical effect of the CO_2 reduction scenarios on energy supply and demand.

In the base year of the model runs, 1990, the U.S. consumed 83.2 exajoules of primary energy. Of this total, 41.8 percent came from oil (34.8 exajoules), 23.0 percent from gas (19.13 exajoules), 23.3 percent from coal (19.34 exjoules), and 11.9 percent (9.8 exjoules) from non-fossil fuels, which includes hydropower, nuclear, geothermal, and renewable fuels (non-fossil fuels are labeled as "other fuels" in Figures 1 and 2).

Under Scenario 1, the Reference Case, total primary energy usage grows at an average annual rate of 1 percent per year and reaches 122.1 exajoules by 2030. This is a cumulative increase of 46.8 percent. Under Scenario 2, the 20 percent reduction case, the growth in primary energy consumption is much slower. By 2030, under Scenario 2 primary energy consumption reaches only 95.9 exajoules, an increase of only 15.3 percent. Thus a major effect of the CO_2 reductions is a decrease in the growth rate in domestic energy consumption.

The reductions also change the fuel mix. The changes are most dramatic for coal and non-fossil fuels. In Scenario 1, domestic coal usage primarily to generate electricity rises to 49.7 exajoules in 2030 and accounts for 40.7 percent of total primary energy consumption. In contrast, under Scenario 2 coal usage falls to 15 exajoules and accounts for only 15.6 percent of total primary energy consumption. Some of the drop in coal under Scenario 2 is offset by increases in the usage of non-fossil fuels. By 2030, consumption of non-fossil fuels is 34.3 exajoules (an increase of 250 percent from 1990) and accounts for 35.8 percent of primary

Figure 1

USA Primary Energy Consumption by Fuel: EMF12 Average

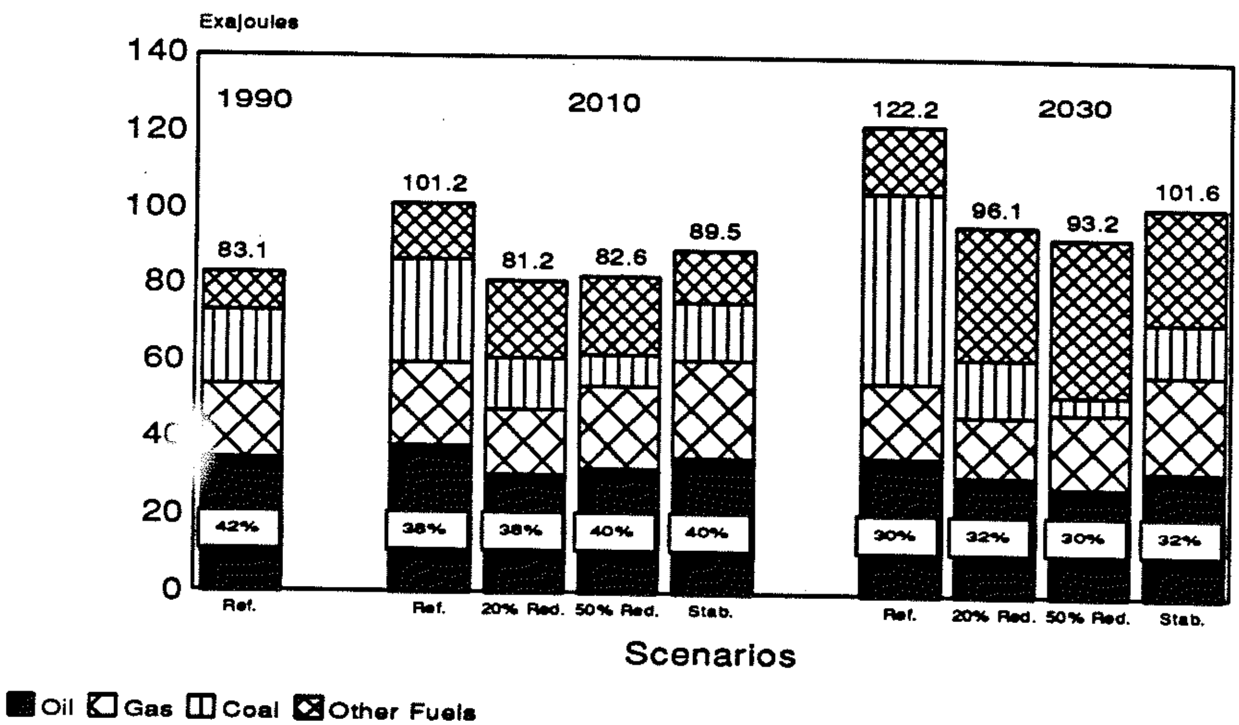
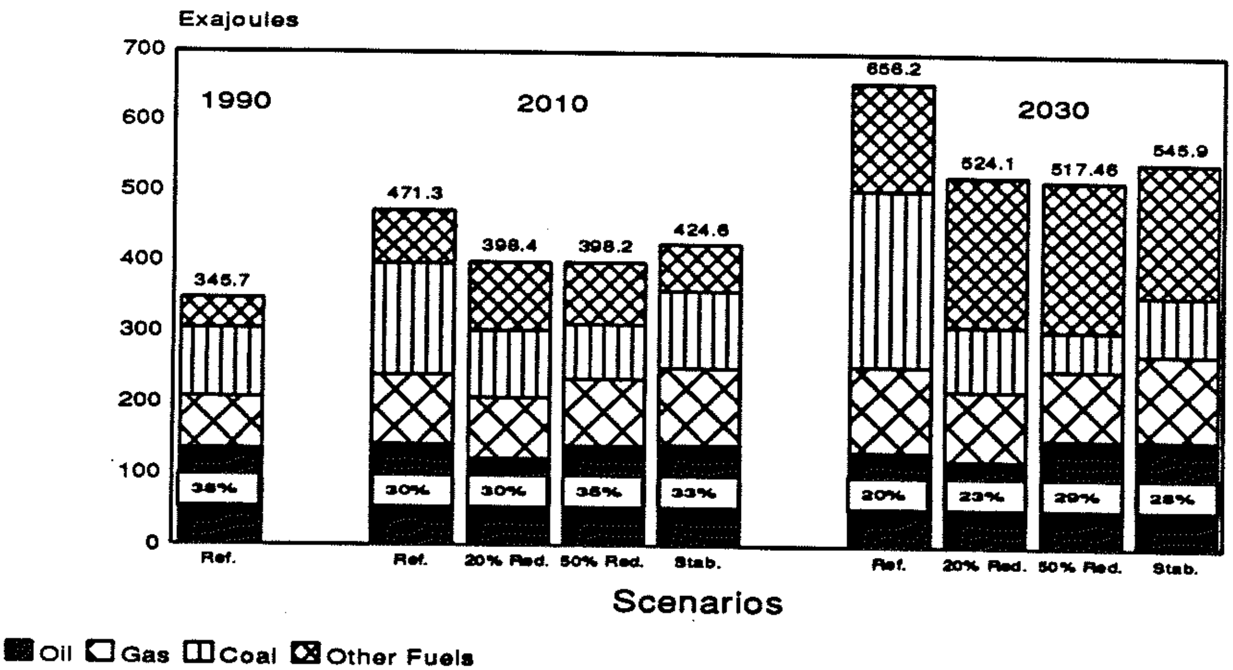


Figure 2

World Primary Energy Consumption by Fuel: EMF12 Average



energy consumption. Under Scenario 1, usage of non-fossil fuels only reaches 17.35 exajoules which accounts for only 14.3 percent of consumption. These figures show reducing CO_2 causes coal usage to decrease dramatically and use of non-fossil fuels to increase.

The effect of the CO_2 reductions on oil and gas is much less pronounced. Under Scenario 2, oil and gas usage fall relative to Scenario 1 by about the same proportion as overall energy usage, so their share of total primary energy consumption remains approximately the same.

The effect of Scenarios 3 and 4 on domestic energy consumption and the fuel mix relative to the Reference Case is similar to Scenario 2, but the changes are more pronounced for Scenario 3 (50% reduction) and less pronounced for Scenario 4 (stabilization). Figure 2 shows the same information as Figure 1, except that it graphs world energy usage.[4] The results are similar to the U.S. results. Reducing CO_2 emissions decreases world energy consumption and encourages a switch away from coal and towards non-fossil energy sources. The absolute consumption of oil under the CO_2 restrictions is relatively constant, though the restrictions actually increase its market share.

Oil Intensity: Figures 3 and 4 highlight the effect of the CO_2 reductions on U.S. oil usage. Figure 3 plots the average percentage of primary energy supplied by oil during the period 1990 to 2030 for all four scenarios. Inspection of these plots reveals that they are all similar. In the out years, there is some tendency for the oil share to increase when CO_2 restrictions are in place. However, the divergence is fairly small and the absolute amount of oil usage is decreasing.

Figure 4 specifically contrasts oil intensity under Scenarios 1 and 2 and shows the range of results obtained from the nine EMF 12 models included in this analysis. To graph Figure 4, the percentage of total primary energy supplied by oil under Scenario 1 was subtracted

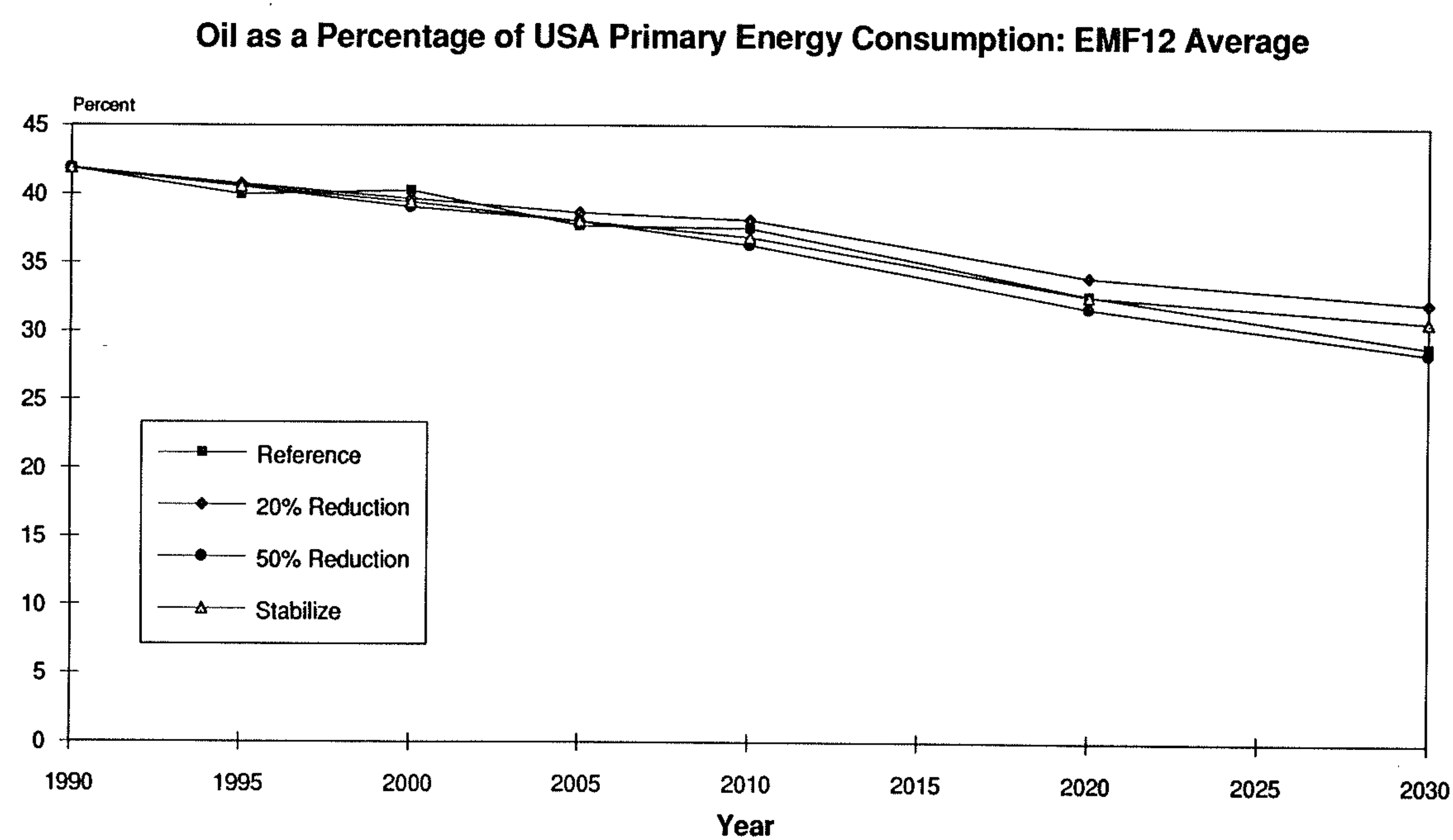

Oil as a Percentage of USA Primary Energy Consumption: EMF12 Average
Percent
45
40
35
30
25
20
15
10
5
0
1990
1995
2000
2005
2010
2015
2020
2025
2030
Year
Reference
20% Reduction
50% Reduction
Stabilize

Figure 3

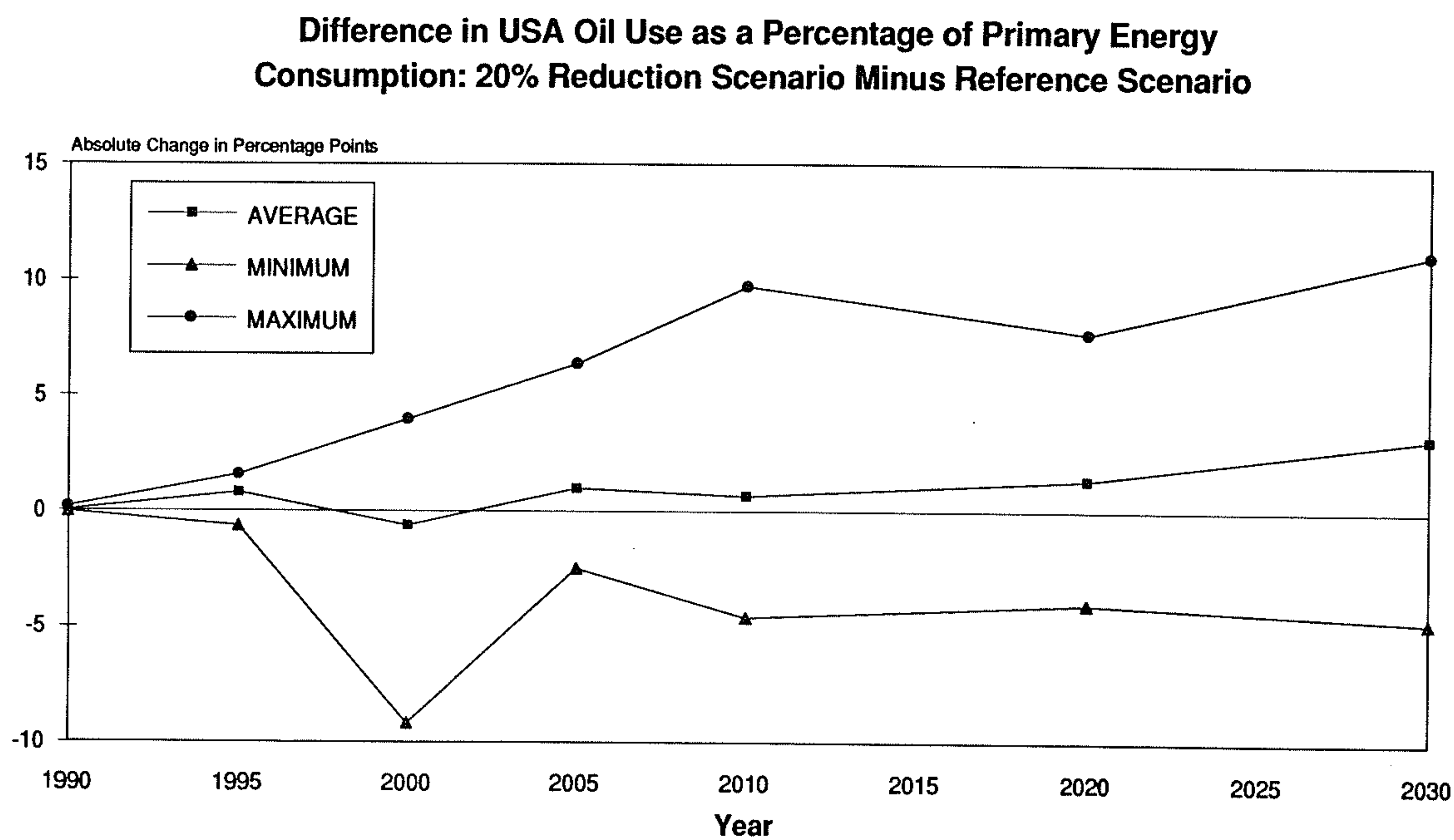

Difference in USA Oil Use as a Percentage of Primary Energy Consumption: 20% Reduction Scenario Minus Reference Scenario
Absolute Change in Percentage Points
15
10
5
0
-5
-10
AVERAGE
MINIMUM
MAXIMUM
1990
1995
2000
2005
2010
2015
2020
2025
2030
Year

Figure 4

from the corresponding percentage under Scenario 2 (Scenario 2 minus Scenario 1). A positive difference shows the U.S. is becoming more dependent on oil. The average, minimum, and maximum differences are shown on Figure 4.

The maximum and minimum lines on Figure 4 show there is significant inter-model variation in the results. For example, in 2030 the Global-Macro model shows the oil percentage increasing by 11.1 percent under Scenario 2 compared to Scenario 1; in the same year the Fossil2 model shows the oil percentage decreasing by 4.8 percent. If the Global-Macro model is correct, it could be interpreted as an adverse energy security impact. However, the average of results for the EMF 12 models suggests there is no significant energy security impact.

Figure 5 plots the average world oil intensity under the four scenarios. The plots show that the CO_2 controls do not impact the share of world energy supplied by oil, except in the years 2015 and beyond. In these later years, the percentage rise is small (7 percent maximum), and the absolute change in oil usage is even smaller or in the opposite direction, i.e., less oil is used. From a world perspective, the CO_2 controls do not appear to cause a significant increase in oil dependency.

Energy Efficiency of Economy: Figure 6 and 7 plot the oil efficiency of the U.S. and world economies, as measured by the number of exajoules of primary energy consumed per trillion dollars of GDP. For the U.S. economy, the CO_2 controls decrease the amount of oil used per unit of GDP. Although it is not graphed, the controls also decrease overall energy usage per unit GDP. For the world economy, Figure 7 shows no clear pattern regarding whether the CO_2 controls increase or decrease world oil efficiency. A reasonable conclusion is that the CO_2 controls leave world oil use per unit of GDP unchanged[5].

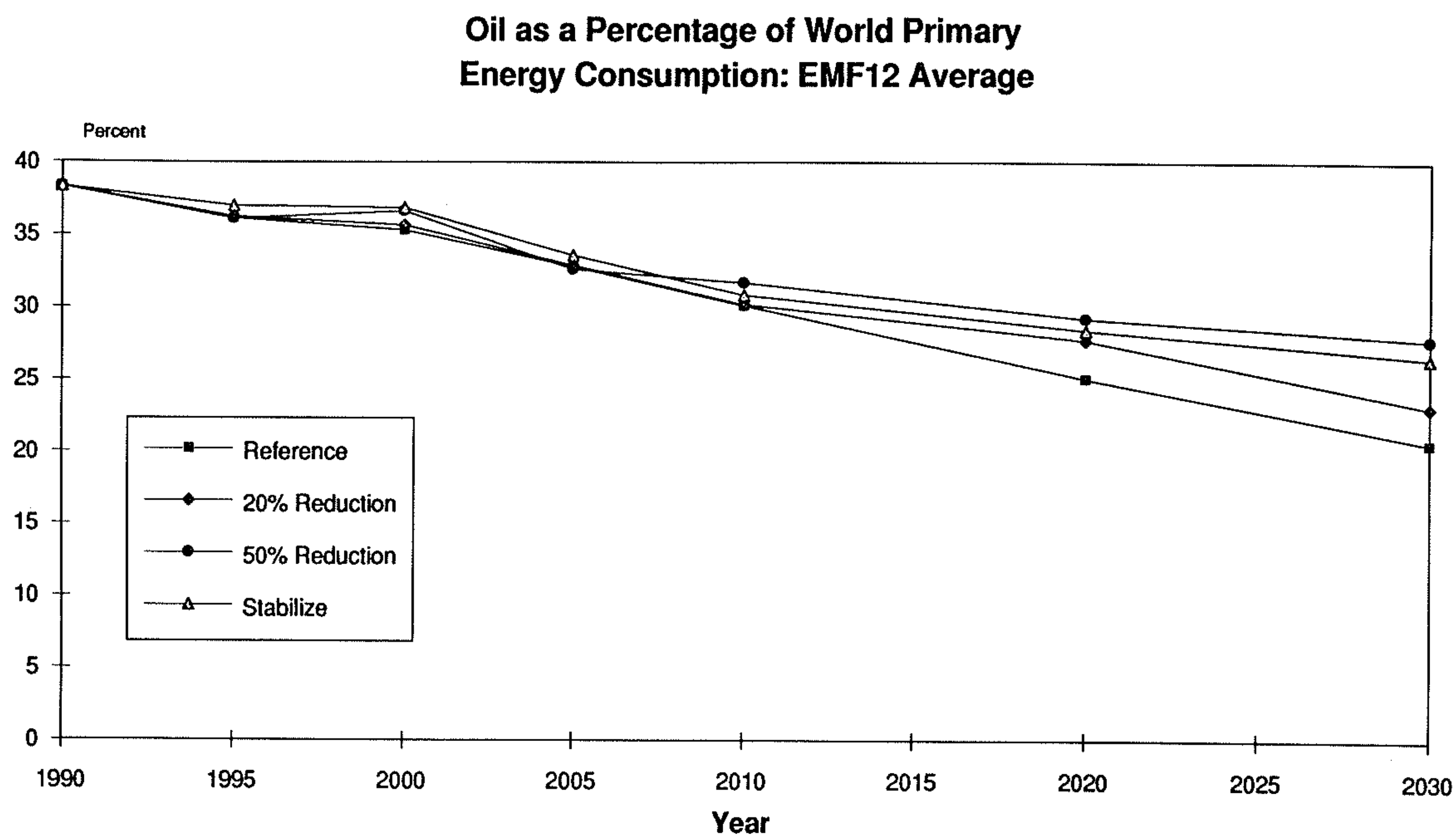
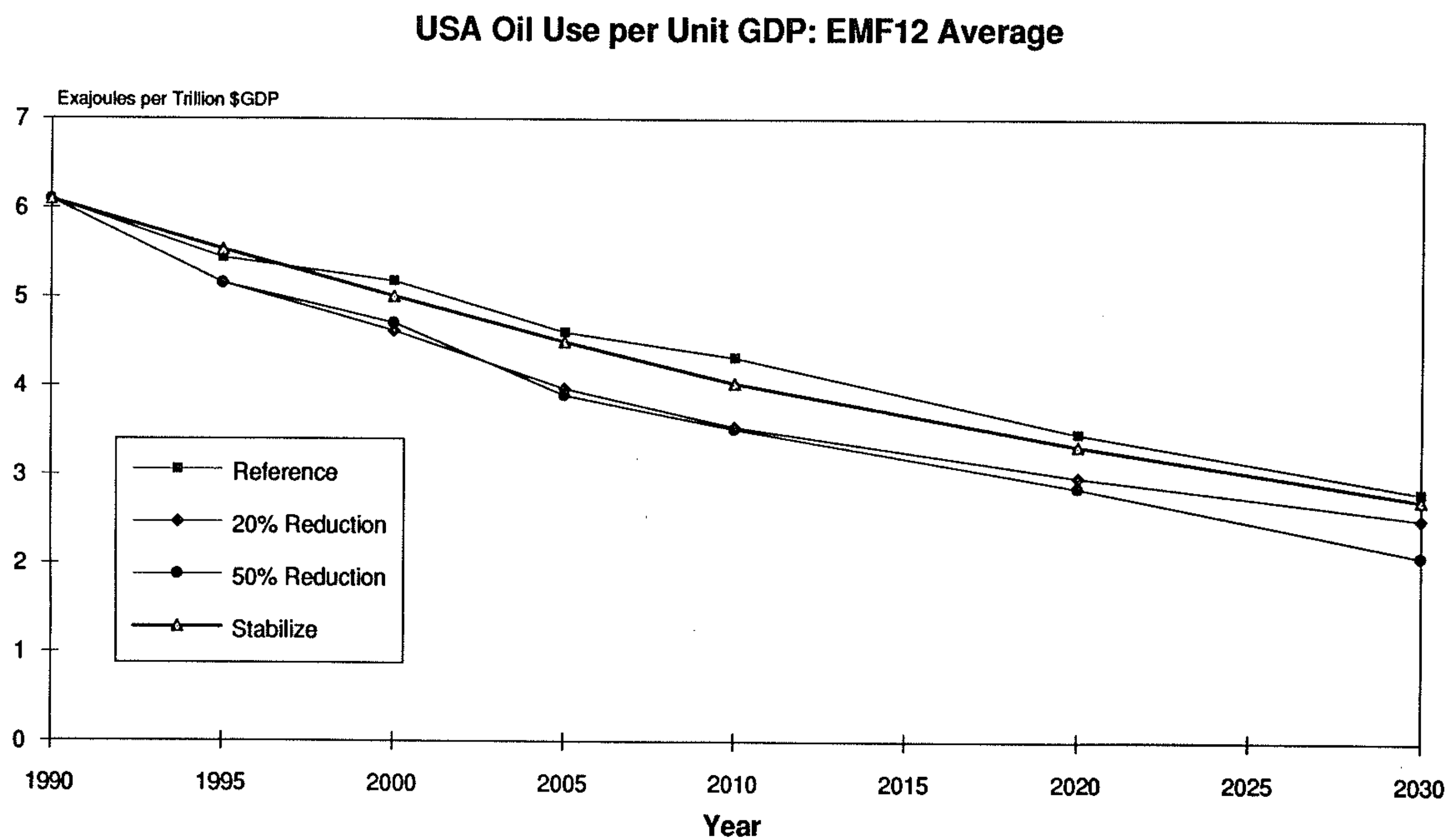

Oil as a Percentage of World Primary
Energy Consumption: EMF12 Average
Percent
40
35
30
25
20
15
10
5
0
1990
1995
2000
2005
2010
2015
2020
2025
2030
Year
Reference
20% Reduction
50% Reduction
Stabilize

Figure 5


USA Oil Use per Unit GDP: EMF12 Average
Exajoules per Trillion $GDP
7
6
5
4
3
2
1
0
Reference
20% Reduction
50% Reduction
Stabilize
1990
1995
2000
2005
2010
2015
2020
2025
2030
Year
Figure 6

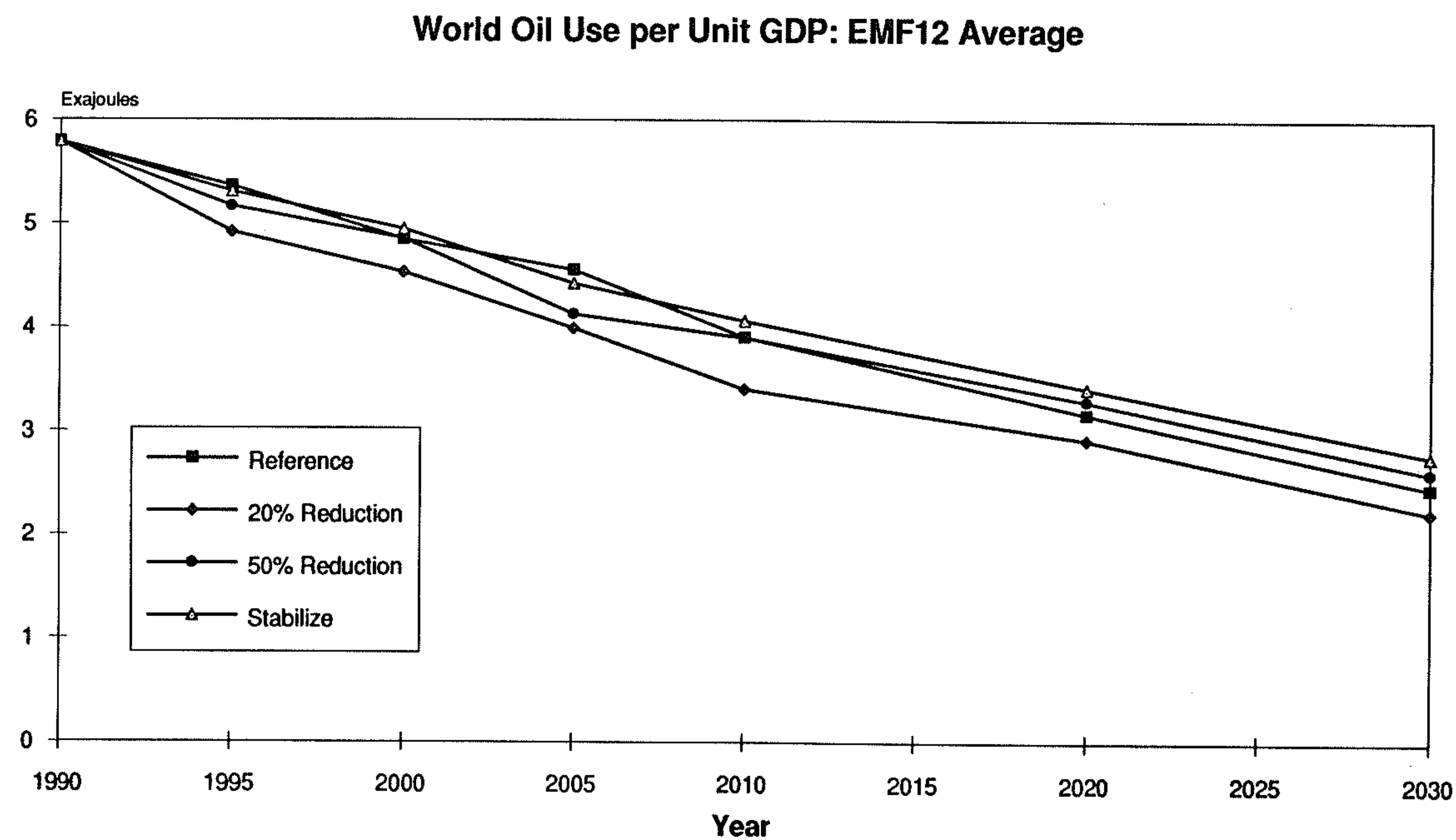

World Oil Use per Unit GDP: EMF12 Average
Exajoules
6
5
4
3
2
1
0
Reference
20% Reduction
50% Reduction
Stabilize
1990
1995
2000
2005
2010
2015
2020
2025
2030
Year

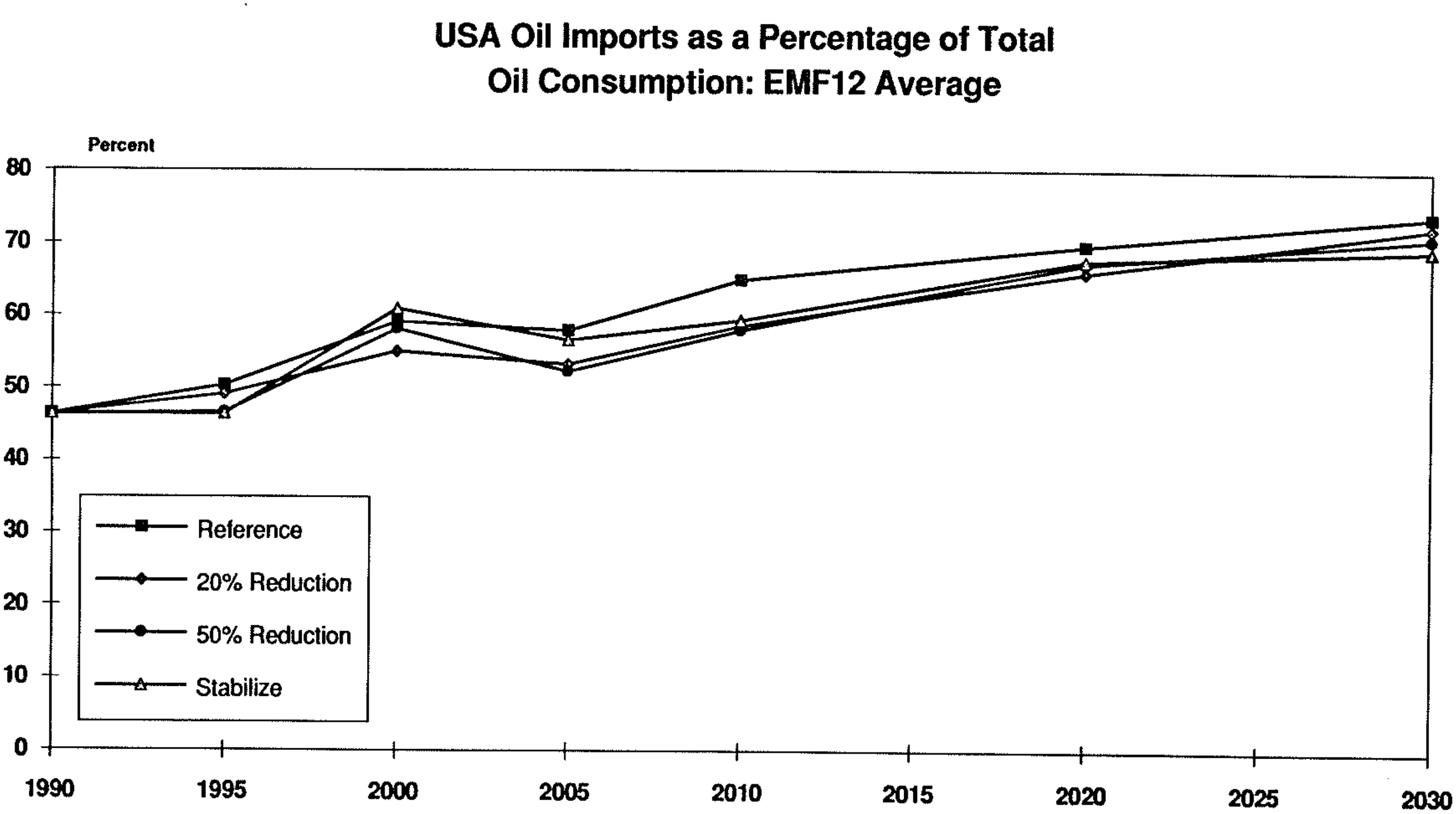
Figure 7

Without more detailed information on the elasticity of GDP with respect to energy and oil prices, it is difficult to determine the effect of these efficiency changes in oil and energy efficiency on energy security. The effect of oil price shocks on GDP has been the subject of considerable investigation and controversy (Bohi 1991, Hogan and Mossavar-Rahmani 1987, U.S. Department of Energy 1987). The conclusions regarding the sensitivity of GDP to oil price shocks are mixed. Regardless of the correct answer to this question, the EMF 12 results do not point to fundamental changes in oil or energy efficiency that would increase U.S. vulnerability to price shocks.

Oil Imports: Figure 8 plots the average EMF 12 U.S. oil import percentage under all four scenarios. That figure shows that oil imports are slightly higher under Scenario 1 than for any of the other scenarios. Figure 9 shows the range of results reported by the EMF 12 models by contrasting Scenarios 1 and 2. To graph this figure, the oil import percentage under Scenario 1 is subtracted from the corresponding percentage in Scenario 2 for each EMF 12 model. The average, minimum, and maximum of these differences are shown on Figure 9. A positive number indicates the U.S. is becoming more dependent on imported oil as a result of reducing CO_2 emissions.

For all of the years of the analysis, the average difference is negative. By 2030 the average difference is -1.5 percent. The average would have been significantly lower, except that the Global-Macro model showed an 11.5 percent upturn in the import percentage in 2030. At the other end of the spectrum is Fossil2, with the import percentage falling by 8.9 percent compared to Scenario 1.

Considering the range of results reported, reducing CO_2 emissions does not appear to be associated with rising import percentages. The EMF 12 average results point towards a falling


USA Oil Imports as a Percentage of Total
Oil Consumption: EMF12 Average
Percent
80
70
60
50
40
30
20
10
0
Reference
20% Reduction
50% Reduction
Stabilize
1990
1995
2000
2005
2010
2015
2020
2025
2030
Year
Figure 8

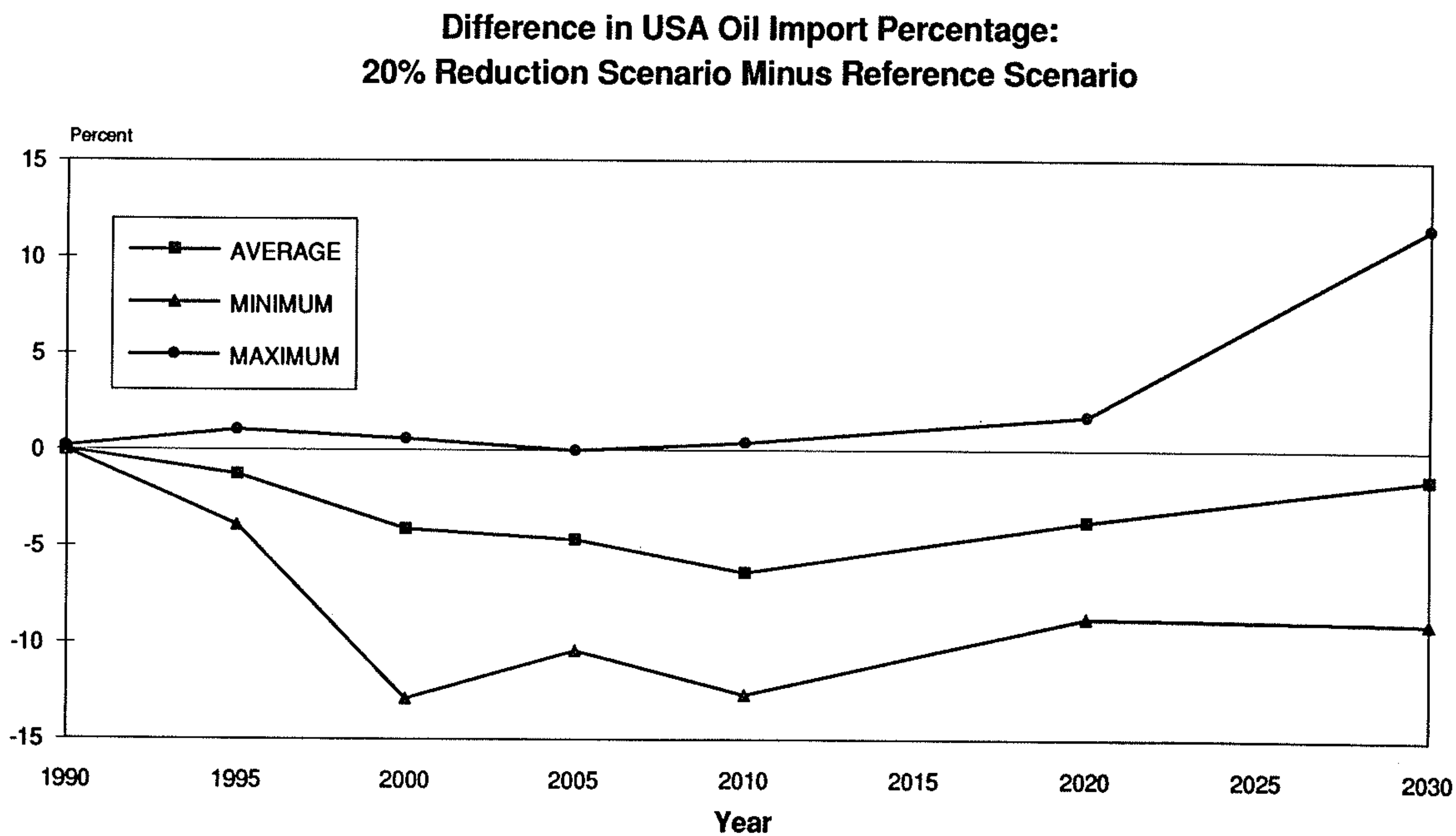

Difference in USA Oil Import Percentage:
20% Reduction Scenario Minus Reference Scenario
Percent
15
10
5
0
-5
-10
-15
AVERAGE
MINIMUM
MAXIMUM
1990
1995
2000
2005
2010
2015
2020
2025
2030
Year

Figure 9

U.S. import percentage during the period 1990 to 2030 under EMF 12 assumptions. From an energy security perspective, this is beneficial.

CONCLUSIONS

Energy security cannot be adequately measured by simply recording the number of barrels of oil imported. A more comprehensive measure would show the expected economic damage to the economy from supply disruptions over a specified period of time. The principal way energy-economic models can help measure expected economic damage from supply disruptions is to generate estimates of the economy's overall dependence on oil. Although such estimates do not account for broader, international concerns such as worldwide oil production becoming concentrated in the Middle East or the amount of worldwide excess production capacity, they can help identify adverse energy security impacts.

From the EMF 12 results analyzed in this paper, it does not appear that reducing CO_2 emissions would cause a significant threat to energy security. The EMF 12 models indicate that reducing CO_2 emissions causes overall energy usage to fall and causes coal to be replaced by non-fossil fuels. The effects of these reductions on U.S. and world oil dependence are minor. With CO_2 restrictions in place, the share of world energy derived from oil increases slightly, but world oil use per unit of world GDP is unchanged. In the U.S., the oil share is also up slightly, but absolute consumption of oil is down. For the U.S., the CO_2 reductions cause both oil use per unit of GDP and the oil import percentage to fall slightly. These findings are the primary basis of our conclusion that the EMF 12 model results do not show any adverse energy security impacts from reducing CO_2 emissions.

The limitations of this analysis must be kept in mind when considering the conclusion that these are no significant adverse energy security impacts. This analysis does not address international concerns, nor does it consider the fuel switching capabilities of the economy. The international concerns are of paramount importance because they will affect the probability of a supply disruption occurring and the regions of the world where oil supply is concentrated. How OPEC would respond to CO_2 reduction policies is unknown, and could significantly alter the energy security impacts of those policies. If OPEC cuts prices in an effort to sustain market share in the face of falling demand, it would encourage the concentration of oil production in the Middle East and could reduce worldwide excess production capacity. These key issues could not be analyzed within the context of the EMF 12 data available to us. In light of these limitations, the results and conclusions presented in this paper are best viewed as one part of an ongoing multi-part analysis.

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ENDNOTES

1. The views expressed in this paper are those of the authors and do not reflect the views of the U.S. Department of Energy.

2. The EMF12 study did impose a set of standardized assumptions for key variables such as population growth, GDP growth, and the resource base. This imparts a degree of uniformity in the models that likely reduces the variability in model results. Notwithstanding these common assumptions, the models represent a variety of analytical approaches that help identify a range of possible energy security impacts.

3. The OECD-Green model does not have data on non-fossil fuel production. Thus, it was excluded from analyses where data on total energy consumption was needed.

4. Data on world energy usage are drawn from five models: Edwards-Reilly; Global-Macro; Global 2100; Model of Warming Commitment; and CRTM-RD.

5. The Figure 7 lines seem inconsistent because the 20 percent reduction case shows a decrease in oil use per unit GDP relative to the reference case in 2030, whereas the 50 percent reduction case shows an increase. This occurred because not every model studied every reduction scenario. Thus, different models are included in the averages for 20 percent and 50 percent reduction cases. Had each model been compared only to itself, most of these inconsistencies would have disappeared. The drawback of this approach, however, is that it would no longer be possible to display the actual value of the average EMF12 result.