ECONOMIC IMPACTS OF LIQUID FUEL MITIGATION OPTIONS

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EXECUTIVE SUMMARY

The world is consuming more oil than it is finding, and at some point within the next decade or two, world production of conventional oil will likely peak. In addition to peaking, there are widespread concerns about the growing U.S. dependence on oil imports from both an energy security and a balance of payments standpoint.

This study considered four options that the U.S. could implement for the massive physical mitigation[1] of its dependence on imported oil:

- Vehicle fuel efficiency (VFE)
- Coal liquefaction (coal to liquids or CTL)
- Oil shale
- Enhanced oil recovery (EOR)

Our objective was to better elucidate the implications of the mitigation programs, e.g., the time required to save and produce significant quantities of liquid fuel, related costs, and economic, fiscal, and jobs impacts. We studied crash program implementation of all options simultaneously because the results provide an upper limit on what might be accomplished under the best of circumstances. No one knows if and when such a program might be undertaken, so our calculations were based on an unspecified starting date, designated as t_0.

This study builds on one completed by the authors in 2005 which addressed the issue of world oil peaking.[2] The current study deals exclusively with physical mitigation options for the U.S. The options analyzed in both studies are consistent and are shown in Table EX-1.

Our analysis showed that the mitigation options that we considered can contribute significantly to the saving and production of U.S. liquid fuels, although decades will be needed for significant impact (Figure EX-1) and related costs will be in the trillions of dollar range. The cumulative 20 year impacts of such a massive crash program would be:

- Savings and production of 44 billion barrels of liquid fuels
- Requirement for over $2.6 trillion of investment

[1]We term these “physical” mitigation options because they are designed to either save or produce large quantities of liquid fuels and will require massive, continuing capital costs, investments, and consumer expenditures. We distinguish these from more strictly policy-oriented options -- such as the 55 mph speed limit or odd/even gas station days.

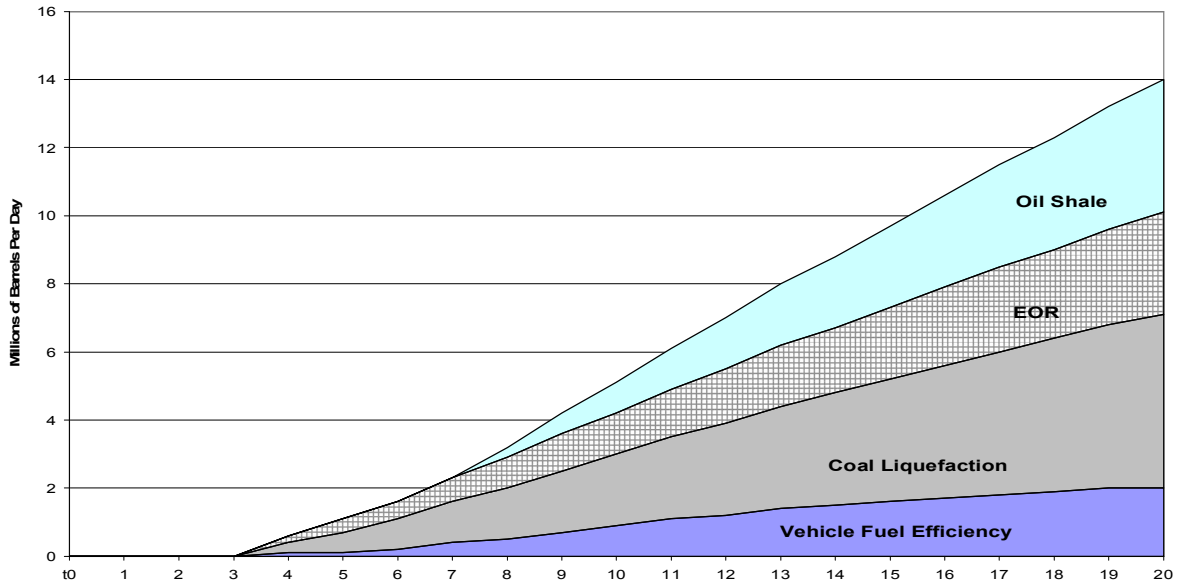
[2]Robert L. Hirsch, Roger H. Bezdek, and Robert M. Wendling, *Peaking of World Oil Production: Impacts, Mitigation and Risk Management*, U.S. Department of Energy, National Energy Technology Laboratory, February 2005.

- Over 10 million employment years of jobs created
- Total industry sales of over $3 trillion
- Over $125 billion of industry profits
- Over $500 billion in federal government tax revenues
- Nearly $300 billion in state and local government tax revenues

Table EX-1
Implementation Assumptions

Mitigation Technology	Assumption for the World in the Previous Study	Assumptions for the U.S. in This Study
Vehicle fuel efficiency	Ramping up to a 50% increase in vehicle fuel efficiency after 8 years	Ramping up to a 50% increase in vehicle fuel efficiency after 8 years
Coal-to-liquids	5 new 100,000 bpd plants/yr. 4 years to build	3 new 100,000 bpd plants/yr. 4 years to build
Enhanced oil recovery	World oil production increased by 3 MM bpd after 10 years	175,000 bpd added each year after 4 years preparation
Oil sands/heavy oil	2.5 MM bpd of incremental production achieved 13 years from a decision to accelerate	None
Gas-to-liquids	1 MM bpd achieved in 5 years	None
Oil shale	None	3 new 100,000 bpd plants/yr. 8 year delay

Figure EX-1
Total Liquid Fuel Impacts

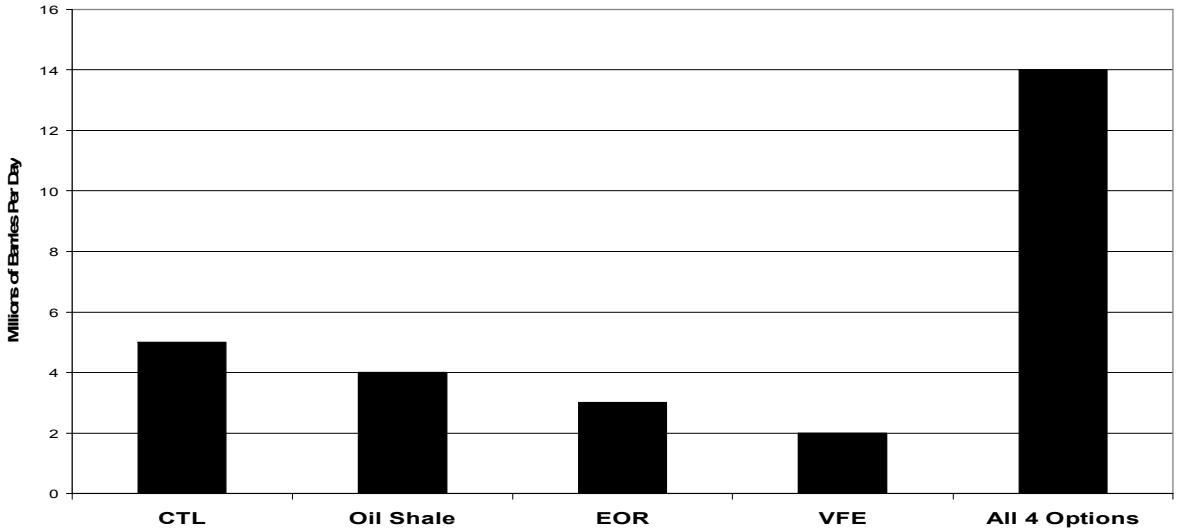


These estimates should be considered as minimum, "best case" estimates, because the final numbers may turn out to be much higher. For

example, the $2.6 trillion investment figure does not include cost escalations during the early years of such a program. Related costs could easily double. Further, as all four options are initiated simultaneously, inflationary pressures in specific industries and labor markets could increase costs considerably.

The mitigation options considered herein would have widely differing annual impacts, as illustrated in Figure EX-2 for year t_0+20**.** Impacts will increase continuously over the 20 year scenario period. Relatively small fuel savings and production, sales, jobs, profits, and tax revenues will be generated in the early years, and the impacts will increase every year through year t_0+20. For all of the mitigation options combined, the maximum annual impacts occur in t_0+20.

Figure EX-2
Liquid Fuels Saved and Produced in Year t_0+20

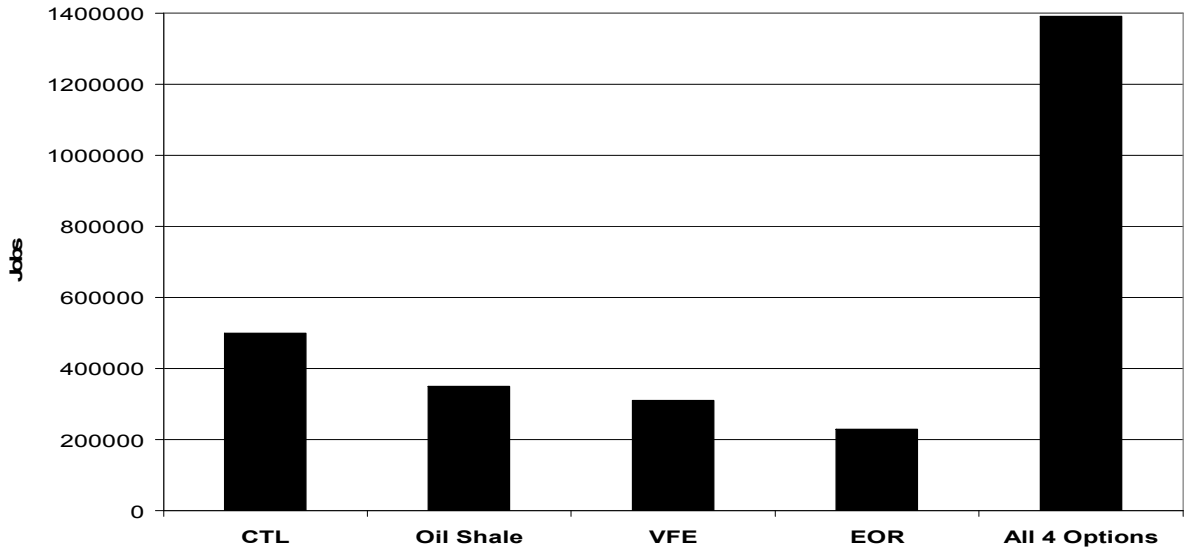


In terms of employment, jobs are created throughout the period, but the character and timing of those jobs are very much a function of time. For example, design and construction of substitute fuels plants requires related personnel until a plant is completed, but since new plants are being continuously started, the requirements for these jobs and skills will be continuous over the period. However, O&M employment begins only after substitute fuel plants are completed and come into operation, but as more plants begin to operate, related O&M employment increases continually. Thus, in the early years of the mitigation programs, most of the jobs created will be in the design and construction industries and related occupations, but, over time, more and more jobs will be created in operations, maintenance, support, and related fields. The total number of jobs will increase over the 20 years, and the maximum number of jobs will be created in year t_0+20**.** As illustrated in Figure EX-3, in that year:

- CTL creates the most jobs – about 500,000
- Oil shale creates 350,000 jobs

- VFE creates 310,000 jobs
- EOR creates the least number of jobs – about 230,000
- In total, the four options create 1.4 million jobs

Figure EX-3
Jobs Created in Year t_0+20



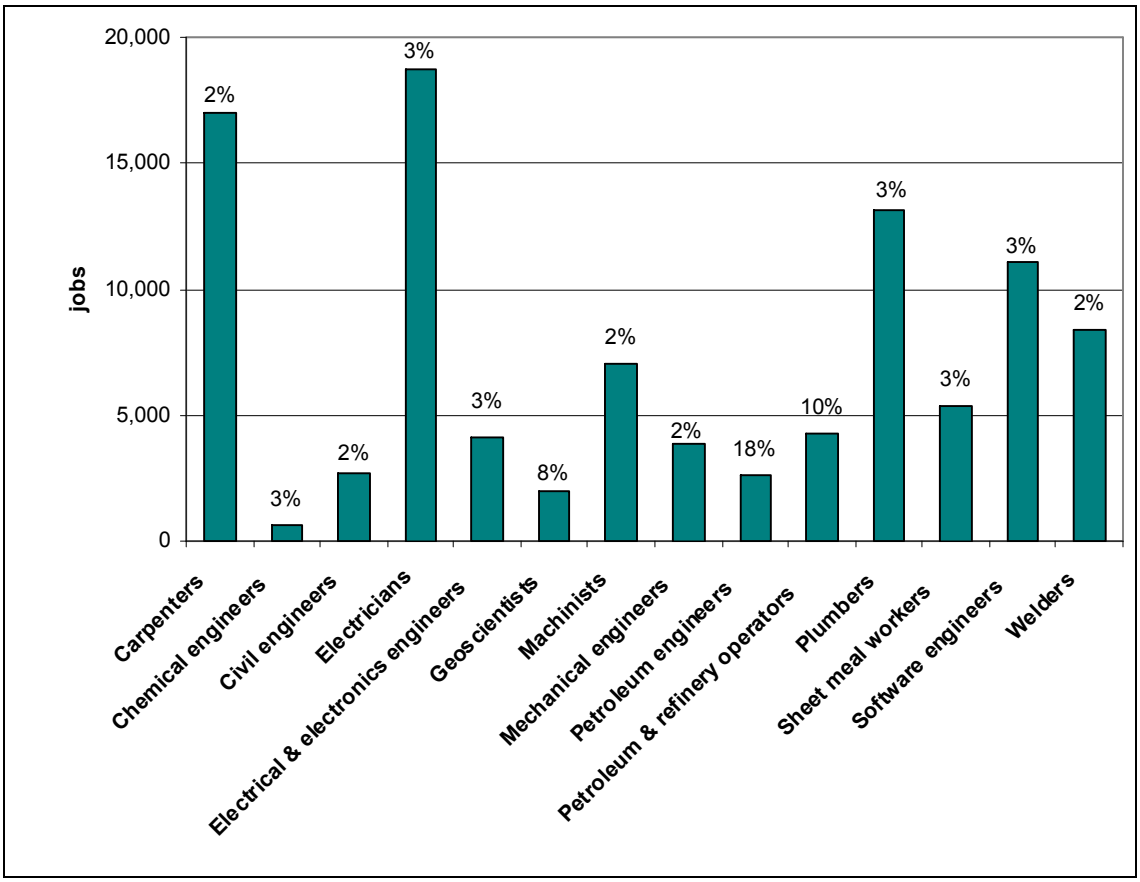
We disaggregated the employment generated by mitigation option into occupations and skills, as illustrated in EX-4 for selected occupations in year t_0+20. The jobs generated are concentrated in fields related to the construction, energy, and industrial sectors, reflecting the requirements of the mitigation options and their supporting industries. Thus, disproportionately large numbers of jobs will be generated for professional, technical, and skilled occupations such as civil engineers, electricians, geoscientists, machinists, mechanical engineers, petroleum system and refinery operators, plumbers, and software engineers. These requirements could cause labor shortages in some industries and professional and skilled occupations, such as chemical, mechanical, electronics, petroleum, and industrial engineers; electricians; sheet metal workers; geoscientists; computer software engineers; skilled refinery personnel; tool and die makers; computer controlled machine tool operators; industrial machinery mechanics, plumbers and pipefitters; oil and gas field technicians, machinists, engineering managers, electronics technicians, carpenters; and others.

The economic activity stimulated and the jobs created will generate substantial tax revenues for the federal, state, and local governments. In year t_0+20:

- CTL will generate $30 billion in tax revenues
- Oil Shale will generate $23 billion in tax revenues
- VFE will generate $22 billion in tax revenues

- EOR will generate $18 billion in tax revenues
- The four mitigation options combined will generate $93 billion in tax revenues

Figure EX-4
Selected Occupational Requirements for the Four Mitigation Options in Year t_0+20
Percentages Represent Demands Compared to 2004 Employment



The scale of U.S. oil consumption is enormous and making massive changes quickly will require a gigantic, expensive crash program effort and at least two decades. Fortunately, the U.S. is endowed with needed geological resources, capital, labor, and management to undertake such an effort. Further, there are very significant economic benefits that will result from the mitigation programs. For example, in year t_0+20 the combined mitigation options considered in this study will generate:

- Investments of $175 billion
- A total fuel savings and production contribution of 14 MM bpd
- 1.4 million jobs
- $315 billion in industry sales
- $15 billion in industry profits
- $60 billion in federal government tax revenues
- $30 billion in state and local government tax revenues

Future impacts will depend critically on the date that such a national effort is initiated. For example, if the efforts described herein were initiated in 2006, the cumulative U.S. impact in 2026 would be roughly 14 million barrels per day, as illustrated in Figure EX-5. If program initiation was delayed a decade to 2016, the 2026 impact would be only about 5 million barrels per day (Figure EX-6).

Figure EX-5. Mitigation Impacts if Initiated in 2006

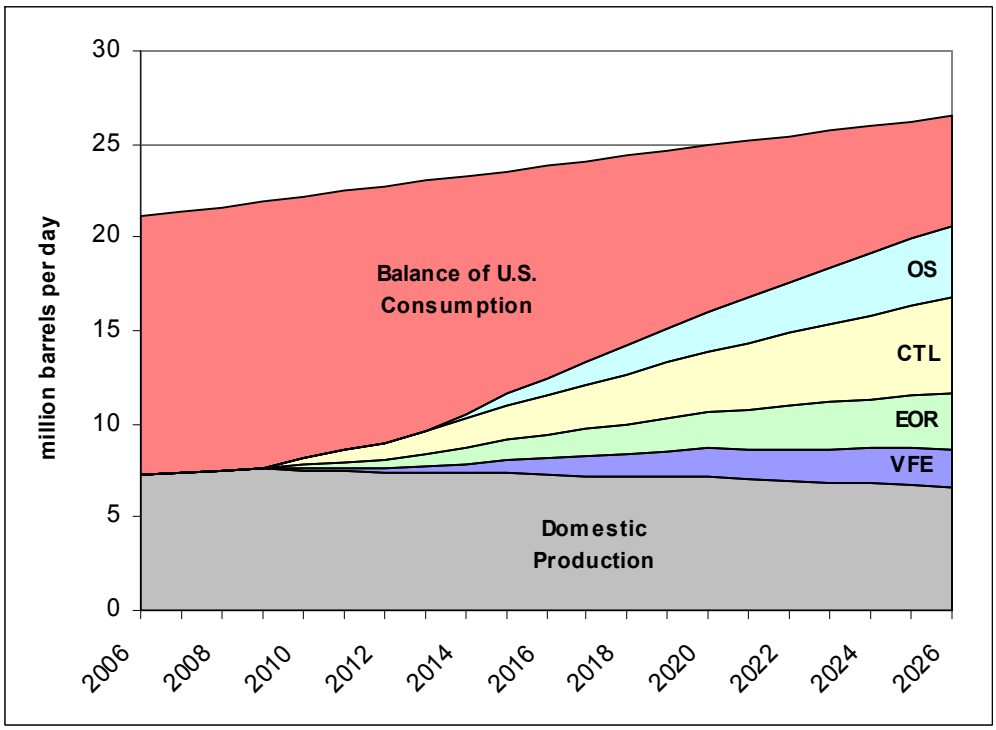
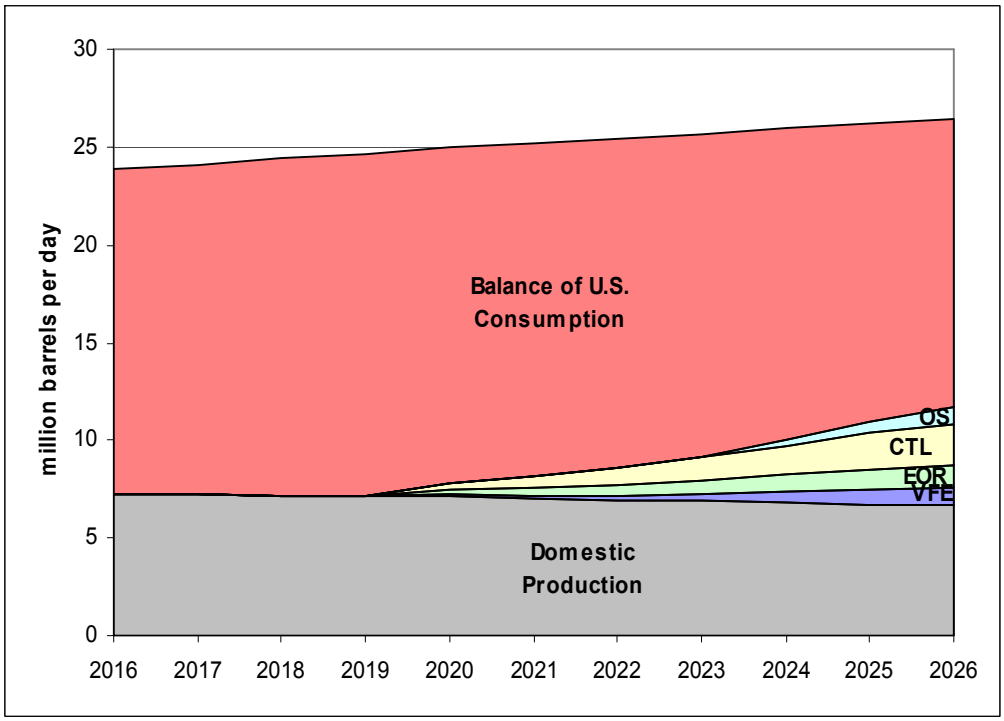


Figure EX-6. Mitigation Impacts if Initiated in 2016

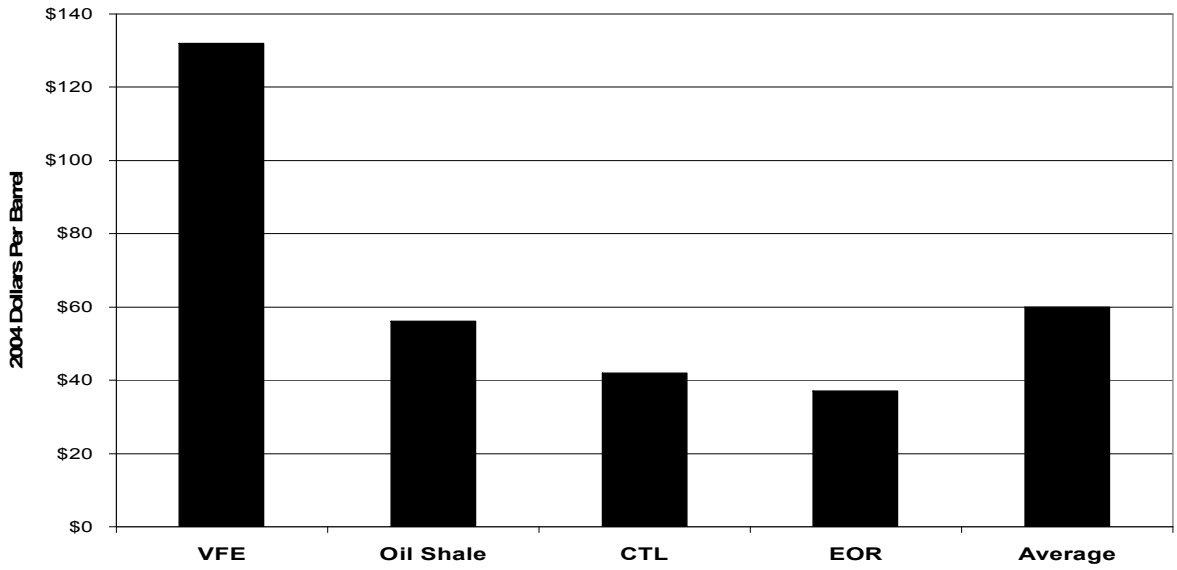


Cumulatively, over the entire 20 year period through year t_0+20, the average cost of a barrel of fuel saved or produced for all of the options is about $60.[3] However, the cost effectiveness of each option differs considerably, as illustrated in Figure EX-7. As illustrated, contrary to conventional wisdom and to some published studies, transportation efficiency may not be the most effective mitigation option.[4] However, the cost estimates for the supply options – especially oil shale and CTL – are subject to a high degree of uncertainty, whereas the cost estimates for the VFE option are likely more accurate. In addition, our analysis at year t_0+20 was truncated, and higher efficiency vehicles will continue to save liquid fuels throughout their life of another 15 years or more. Further, we did not assume further vehicle fuel efficiency improvements after year t_0+8, which may be a limiting assumption.

[3]The total estimated costs of the mitigation options over the 20 year period divided by the total estimated liquid fuel savings over the period.

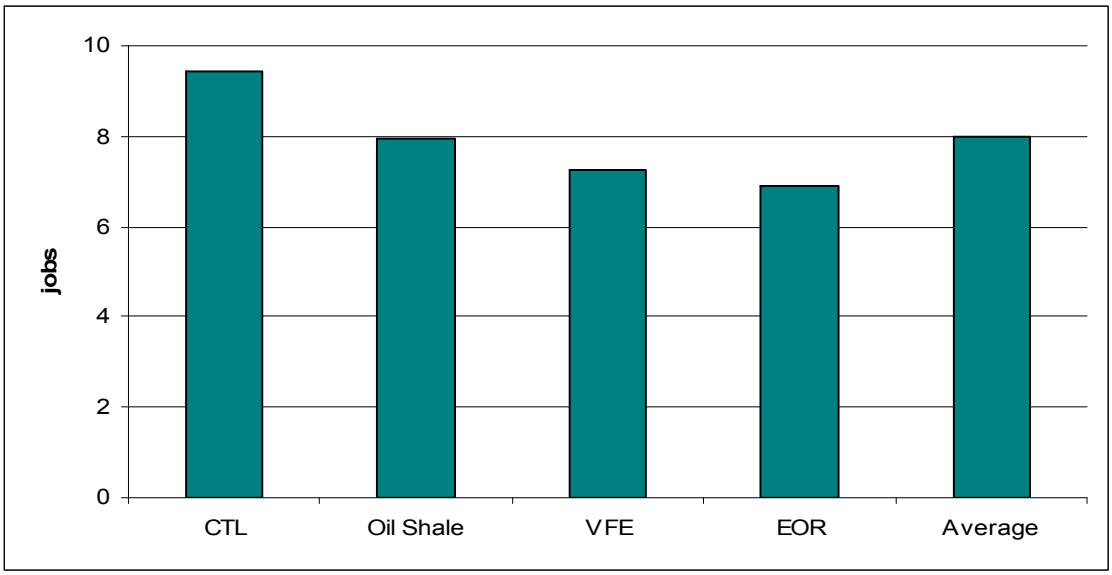
[4]See, for example, National Research Council, National Academy of Sciences. *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards*. Washington, D.C.: National Academy Press, 2002; John DeCicco, Feng An, and Marc Ross, *Technical Options for Improving the Fuel Economy of U.S. Cars and Light Trucks by 2010-2015*, American Council for an Energy Efficient Economy, July 2001; Union of Concerned Scientists, *Drilling in Detroit: Tapping Automaker Ingenuity to Build Safe and Efficient Automobiles*, UCS Publications, Cambridge, MA, June 2001.

Figure EX-7
Relative Costs of the Mitigation Options



Mitigation options can be evaluated on the basis of various criteria. As illustrated in Figure EX-8, in terms of jobs created per dollar of direct investment, the impacts of the mitigation options differ relatively little: The average is about eight jobs per $1 million invested, with CTL creating the most jobs per dollar of expenditure and EOR the least.

Figure EX-8
Total Employment Impact per $1 Million of Direct Costs



In his 2006 State of the Union Address, President Bush stated that the U.S. is "addicted to oil," and he articulated a goal of reducing U.S. oil imports from the Middle East by 75 percent by 2025. While we did not specifically address the question of Middle Eastern oil imports, in terms of reducing total U.S. oil imports we found that, if the mitigation crash programs were to be initiated in 2006, it may be possible to begin to noticeably reduce U.S. oil imports by 2010.[5] In fact, the mitigation options may eventually reduce the total level of U.S. imports from the current 13 MM bpd to:

- 11 MM bpd in 2016
- 5 MM bpd in 2026

However, these relatively optimistic findings depend critically upon the crash mitigation option programs being started in 2006. If they are delayed, the oil import gap may not be closed for nearly two decades. For example, if crash program implementation is delayed ten years, until 2016, then by 2026, these mitigation options may contribute about 5 MM bpd but imports would still rise to about 15 MM bpd.

If the U.S. becomes seriously motivated to decrease its dependence on oil imports, then multiple paths will be required, even paths beyond those considered in this study. The purpose of this study was to bracket what would be required in what we defined as the best, limiting case of physical mitigation. Using the information generated in the previous study and herein, people will hopefully be able to make more informed decisions, should they decide to embark on massive physical mitigation.

It is important to note that initiation of all of the options simultaneously does not even satisfy half of the U.S. liquid fuels requirements prior to 2025. If the peaking of world conventional oil production occurs before 2025, the U.S. may not have a choice in terms of a massive national physical mitigation program. Even with the most optimistic assumptions and assuming crash program implementation, physical mitigation will require decades and trillions of dollars of investment to make substantial contributions.

[5]Based on the EIA forecasts of future U.S. oil demands.