

**Peer Review of the Economic Supplement
to the AB 32 Draft Scoping Plan**

Major Peer Review Comments and Air Resources Board Staff Responses

November 2008

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November 26, 2008**

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Peer Review of the Economic Supplement to the AB 32 Draft Scoping Plan

Major Peer Review Comments and Air Resources Board Staff Responses

As required by AB 32, the Air Resources Board (ARB) conducted an economic analysis of the Draft Scoping Plan. At ARB's request the results of our analysis were submitted to peer reviewers for additional review. As indicated below, the major comments that we received from the reviewers can generally be grouped into several categories.

The purpose of this document is to describe the process that was used to identify peer reviewers for the Economic Supplement to the AB 32 Draft Scoping Plan, and provide a summary of the key issues raised by the peer reviewers as well as the ARB staff response. The document is organized by presenting the key issues raised by reviewers noted in bold, followed by the ARB staff response. The reviewer comments and curriculum vitae are attached at the end of this document.

The Peer Review Process

ARB used an established independent process, conducted by the Berkeley Institute of the Environment (BIE) and administered by staff of the State Water Resources Control Board for the California Environmental Protection Agency (CalEPA), to select peer reviewers for the Economic Supplement to the AB 32 Draft Scoping Plan. A total of six peer reviewers were selected, with the two reviewers from the Pew Center on Global Climate Change collaborating on their submittal. The selected reviewers were:

Dallas Burtraw, Ph.D.
Senior Fellow
Resources for the Future

Mathew E. Kahn, Ph.D.
Professor
University of California, Los Angeles
Institute of the Environment
Department of Economics
Department of Public Policy

Robert N. Stavins, Ph.D.
Professor
John F. Kennedy School of Government
Harvard University

Gary W. Yohe, Ph.D.
Woodhouse-Sysco Professor
of Economics
Wesleyan University

Janet Peace, Ph.D.
Director of Market and Business Strategy
Pew Center on Global Climate Change

Liwayway G. Adkins, Ph.D.
Senior Fellow, Economics
Pew Center on Global Climate Change

The panel was asked to comment on the methodology employed, key inputs and assumptions, results, and the interpretation of the results as presented in the Economic Supplement. The Panel was also asked to comment on additional analyses that ARB should consider incorporating during the implementation of the Scoping Plan

Major Peer Review Comments (Summarized and Paraphrased) and ARB Staff Responses

This section summarizes the major comments provided by the peer reviewers, focusing on issues raised by multiple reviewers, and provides the ARB staff response.

Baseline Issues

The economic analysis estimated the potential economic impacts of the Scoping Plan by comparing what the economy would be like in 2020 with the implementation of the measures in the Scoping Plan to what the economy would be like under a “Business-as-Usual” (BAU) Baseline. Several reviewers raised questions regarding how the BAU Baseline was developed and used in the analysis.

- 1) Several reviewers had particular questions about how BAU fuel price forecasts were factored into the BAU estimates. They questioned whether the price forecasts were used consistently throughout the analysis, and whether market responses to higher energy prices had been appropriately factored into the baseline and estimates of future fuel savings. (Stavins, Yohe, Burtraw, Pew)**

The impact of higher fuel prices should be carefully considered. Consumers will respond to higher projected gasoline prices by reducing demand over what would otherwise have been expected, due both to reduced driving as well as greater use of more efficient vehicles. This is particularly relevant with respect to the calculation of savings for the greenhouse gas motor vehicle regulation (Pavley I). In the economic analysis the estimated gasoline savings due to the Pavley regulation were not adjusted to reflect the fact that the forecast for gasoline prices in 2020 is higher than that upon which the fuel savings was originally estimated when the Pavley regulation was adopted by ARB. We also note that the overall effects of higher fuel prices would change the BAU economic and emissions forecasts in ways that are not captured by this analysis as the effects ripple through the economy.

Because it is difficult to break out the reduction in fuel consumption due to higher fuel prices versus the portion due to the Pavley regulation, we do not provide an estimate of the fuel price impact here. To address that impact we analyzed a case in which we assume as an upper bound that the fuel savings from higher prices are equivalent to the savings required by the Pavley regulations. To do this we incorporated the costs and savings we estimated for Pavley into the BAU baseline. As shown in Table 1, under this scenario the economic impacts of the plan are positive for most indicators other than gross state product, which experiences a slight decline.

Table 1. Effects of Scoping Plan Measures With Pavley I Savings in BAU Baseline

E-DRAM Results	Scoping Plan	Scoping Plan Compared to BAU that Includes Pavley I
Real CA Output	0.92%	0.13%
Gross State Product	0.27%	-0.20%
California Personal Income (SPI)	0.78%	0.11%
SPI Per Capita	0.43%	0.00%
Labor Demand	0.67%	0.20%

- 2) **Two reviewers raised questions about which policies and measures were included in or excluded from the BAU baseline and the economic analysis. One reviewer specifically suggested that the analysis should include key measures that are already underway in the BAU Baseline rather than in the plan. (Stavins, Pew)**

The current BAU Baseline is appropriate. In order to provide a full assessment of the impacts of the greenhouse gas reduction measures needed to meet AB 32’s goals, the Plan should reflect the emission reductions and the cost and savings for those reductions from a previously adopted measure when (1) it was adopted exclusively (or nearly exclusively) to reduce GHG emissions, and (2) the actions needed to achieve the anticipated reductions have yet to be implemented.

Consistent with this approach, such measures were not characterized as business as usual because they are an integral part of California’s effort to implement AB 32. This more clearly shows the impact of the full set of actions California is pursuing to meet AB 32’s greenhouse gas emission target, including actions that are already moving forward but are not fully implemented. Other adopted measures which have GHG co-benefits but which are principally being pursued to achieve other goals, while included in the GHG emissions reductions needed to achieve the 2020 target, were excluded from the cost and savings accounting in the economic analysis.

Under this approach, all emission reductions that occur from each of the measures included in the Plan are accounted for, but the costs and savings of adopted measures are only included when greenhouse gas emission reductions are the primary driver of the measure.¹ This approach provides the most appropriate evaluation of the overall effect of the State’s effort to meet AB 32 goals on California’s economy.

¹ For example, the Ship Electrification measure is being pursued to achieve air quality standards under the State Implementation Plan. The focus of this measure is to reduce emissions of smog-forming pollution by phasing out the use of on-ship generators burning diesel fuel while in port. By switching to cleaner power (electricity) the measure will reduce emissions of diesel particulate (as well as oxides of nitrogen) and therefore reduce the associated adverse health effects in the surrounding communities including premature death. It would be inappropriate to count either the costs or savings from this measure in evaluating the economic impact of the Scoping Plan.

The major measures that were adopted separate from AB 32 are the first round of the Light-Duty Vehicle Greenhouse Gas Standards (Pavley I), the 20 percent Renewables Portfolio Standard, the Solar Hot Water Heaters measure (implementation of AB 1470), and the Million Solar Roofs program (implementation of the California Solar Initiative and SB 1). Because the Pavley I standards were adopted specifically for the purpose of reducing greenhouse gas emissions and are called out explicitly in AB 32, it is appropriate to attribute their costs and savings to the AB 32 plan. The other noted measures achieve multiple benefits including substantial reductions in greenhouse gas emissions. Because these other measures were driven in substantial part by factors other than climate change, such as energy supply diversification, their costs and savings are not included in the economic modeling.

As noted in response 1 above we have conducted additional analysis to examine the implications of an alternative baseline that considered the Pavley I regulations as part of BAU. The results of this analysis are shown in Table 1 above.

It is important also to note that the inclusion or exclusion of a measure vis-à-vis the baseline does not affect the real world costs or savings experienced by Californians; rather it affects how those costs or savings are accounted for. The lower benefits from the Plan result from a change in the BAU forecast, not a change in the forecast economic conditions following implementation of the Plan.

Recognition of Uncertainty

- 3) Several reviewers emphasized that there are significant uncertainties that affect any modeling study, including in this case energy price forecasts, projections of economic growth, and estimates of the costs and savings of the measures. They recommended that sensitivity analysis be conducted to assess the impact of these uncertainties on the policy-relevant modeling outcomes. (Yohe, Kahn, Pew)**

As noted in both the Economic Supplement to the Draft Scoping Plan and the Proposed Scoping Plan, we recognize the value of conducting sensitivity analysis on key inputs. Additional work has been conducted to examine the sensitivity of the results to different energy price forecasts and different assumptions about the costs and savings of the measures. We note that the overall effects of higher energy prices would change the BAU economic and emissions forecasts in ways that are not captured by this analysis. As shown in Table 2 for energy price sensitivity, if prices are 50 percent higher or 50 percent lower than those used in our analysis, the Plan remains positive for most indicators in terms of its economic effects. In addition, under a higher energy price scenario there could be opportunities for additional cost effective reduction measures to achieve cost savings not included here.

For sensitivity around the cost and savings estimates, a number of cases with different combinations of higher or lower costs and savings were evaluated. As shown in Table 3, if all costs are increased by 25 percent and all savings are decreased by 25 percent as compared to the estimates in the Plan, the Plan essentially is neutral in its economic effect. Conversely, if costs are decreased by 15 percent and savings increased by the same amount then the Plan's benefits increase.

In addition, as the measures are developed through a stakeholder process over the next few years, estimates of both the costs and savings will be refined. The refined analysis will likely conclude that some of the current estimates of costs were low while others were high. For each regulatory proposal that is developed the Board will rely on the most current information to design measures that are both technologically feasible and cost-effective.

Table 2. Results of Sensitivity Analysis on Energy Prices

E-DRAM Results	Scoping Plan	50 Percent Increase in Energy Prices*	50 Percent Decrease in Energy Prices
Real CA Output	0.92%	0.43%	-0.09%
Gross State Product	0.27%	-0.12%	-0.10%
California Personal Income (SPI)	0.78%	0.26%	0.19%
SPI Per Capita	0.43%	0.08%	0.09%
Labor Demand	0.67%	0.36%	0.14%

* These results exclude the costs and savings from the Pavley I and II regulations based on the assumption that prices at this level will induce at least as much fuel savings as the regulations would have required.

Table 3. Results of Sensitivity Analysis on Cost/Savings Estimates

E-DRAM Results	Scoping Plan	25% Cost Increase/ 25% Savings Decrease	15% Cost Decrease/ 15% Savings Increase
Real CA Output	0.92%	-0.08%	1.5%
Gross State Product	0.27%	-0.23%	0.53%
California Personal Income (SPI)	0.78%	0.13%	1.1%
SPI Per Capita	0.43%	0.02%	0.65%
Labor Demand	0.67%	0.22%	0.91%

Characterization of Measure Costs and Savings

- 4) Several reviewers assert that ARB underestimated the costs and overestimated the benefits of the individual measures that were a key input to the economic modeling. Additionally, reviewers questioned why in some cases the costs and savings of various individual measures were omitted from the analysis. (Stavins, Kahn, Pew)**

The current estimates of the costs and savings of the measures are based on the best information currently available.

The estimates for the Pavley motor vehicle greenhouse gas reduction program were initially developed during the rulemaking process that led to adoption of those regulations, and were updated to reflect current fuel prices. The peer review comments suggest that our approach to reflecting an updated fuel price forecast with higher prices was too simple, and failed to account for the effect of higher prices on consumer vehicle choice and driving patterns. Additional analysis was conducted to explore this issue, and is discussed in the response to Comment 1 above.

The other major measures with substantial costs and savings that were commented on by peer reviewers are in the electricity sector: the 33 percent renewables target; increased energy efficiency; and combined heat and power. For these measures, cost estimates are based on work done in various energy proceedings at the CPUC and CEC. For all three of these measures, significant work remains to be done to fully develop the implementation strategies, which will affect their ultimate cost and savings. As implementation work moves forward for the measures in the Plan, ARB, in consultation with the CPUC and CEC, will make any adjustments needed to the measure design and the emission reduction estimates based on full evaluation of the cost-effectiveness of the different implementation options.

As noted by some reviewers, the costs and savings for a number of measures were excluded from the analysis. These measures are the 20 Percent Renewable Portfolio Standard, Ship Electrification at Ports, High Speed Rail, the California Solar Programs, and the Solar Water Heater Programs.² As discussed above, these measures achieve multiple benefits beyond their reductions in greenhouse gas emissions. Because these other measures were driven in substantial part by factors other than climate change, their costs and savings are not included in the economic modeling.

Sensitivity analyses of the costs and savings of the measures as a whole was also conducted, as discussed above in response to Comment 3.

² The Economic Analysis Supplement incorrectly indicated that the Goods Movement Efficiency Measure was also one whose costs and savings were excluded because the measure was being pursued for other reasons. While the Goods Movement Action Plan is intended to reduce criteria air pollutant and air toxic emissions, this measure is specifically defined as additional activities designed to reduce greenhouse gas emissions. ARB is still developing the specific strategies to achieve reductions from goods movement system-wide energy efficiency. The preliminary assumption is that costs and savings of this measure will be approximately equivalent.

Consistency of Results with Other Studies

5) Several reviewers cited other studies, such as the Third and Fourth Assessment Reports, that have shown climate change policies to have a net economic cost. They questioned why ARB's analysis is not consistent with those other studies. (Kahn, Yohe, Pew)

A number of studies have been conducted to analyze the economic impacts of climate policies. All such studies, including those cited by peer reviewers, begin from different origins and take different paths to reach different estimates. Key variables include the geographic scope of a particular program, its time horizon, level of detail, and a number of other critical assumptions.

As noted in the Draft Scoping Plan, some studies have concluded that implementation of various greenhouse gas reduction policies would have a slight negative impact on GDP. Conversely, other recent analyses have concluded that a package of greenhouse gas reduction measures similar to the Proposed Scoping Plan will provide net benefits to the economy.

The Maryland Commission on Climate Change issued its Climate Action Plan³ in August 2008. This Plan cites a study by the International Center for Sustainable Development (ICSD) that found energy efficiency can reduce energy costs to homeowners, businesses, institutions and government at a cost 60 to 70 percent cheaper than building new generating capacity in Maryland. This study also found that by developing clean energy industries, Maryland could create between 144,000 and 326,000 jobs over the next 20 years, contributing \$5.7 billion in wages and salaries to Maryland citizens and increasing gross state product by \$16 billion.

A similar plan released by Florida in October⁴ found that Florida could surpass its reduction targets for 2017 and 2025 by 11% and 34%, respectively, while Florida's economy would see a net benefit from an estimated net cost savings of more than \$28 billion from 2009 to 2025.

A recent review of state-level greenhouse gas reduction programs conducted by the Center for Climate Strategies⁵ found the following:

Twenty U.S. states have completed and begun implementation of comprehensive multisector greenhouse gas reduction plans with quantified costs and emission reduction benefits that cover over two thirds of the United States economy and population. Results from individual states, economic sectors, and policies vary; but all indicate a consistent pattern for cost effective achievement of near term and mid term greenhouse gas emissions reduction targets at science based

3 Maryland Commission on Climate Change. 2008. Climate Action Plan.

4 Florida Governor's Action Team on Energy and Climate Change. 2008. Florida's Energy and Climate Change Action Plan.

5 Climate Policy as Economic Stimulus: Evidence and Opportunities from the States. Center for Climate Strategies, November 2008.

levels (1990 levels or below by 2020). Preliminary national projections of this data suggest a net savings of \$20.8 billion in 2012 and \$85 billion in 2020, and from 2009 to 2020 cumulative savings of \$535.5 billion is possible through implementing a climate plan involving all U.S. states and economic sectors.

A recent study conducted by UC Berkeley Professor David Roland-Holst for Next 10⁶ examined the potential for innovation to reduce energy intensity and enhance economic growth. The study concluded that:

By including the potential for innovation, we find that the proposed package of policies in the state's Draft Scoping Plan achieves 100 percent of the greenhouse gas emission reduction targets as mandated by AB 32 while increasing the Gross State Product (GSP) by about \$76 billion, increasing real household incomes by up to \$48 billion and creating as many as 403,000 new efficiency and climate action driven jobs.

The Western Climate Initiative, of which California is a partner, released its economic modeling results⁷ in September 2008, as part of its program design document. The WCI analysis showed that the regional target of a 15 percent reduction below 2005 levels by 2020 (similar to the AB 32 target) can be achieved at a small overall savings, in large part resulting from increased energy efficiency leading to reduced overall energy expenditures.

The WCI background document also discussed how views differ on the extent to which "complementary policies" (i.e., direct regulations that achieve targeted reductions, such as the Pavley program or energy efficiency standards) can result in net savings⁸:

Complementary policies have also been examined as a means for addressing market barriers that would otherwise hinder the exploitation of low-cost GHG emission reduction opportunities (e.g., via improved energy efficiency). Thus, complementary policies can lower the overall cost of reducing GHG emissions. Analysts differ in their treatment of complementary policies, however. Some analysts allow for cost savings to be realized from complementary policies such as building codes, appliance standards, vehicle standards, and energy efficiency programs. A recent McKinsey analysis of GHG abatement costs in the United States provides one view of the potential for gains from complementary policies.⁹ McKinsey found significant opportunities to reduce GHG emissions while also saving money through investments in energy efficiency. The existence of opportunities to reduce

6 Energy Efficiency, Innovation and Job Creation in California, David Roland-Holst, UC Berkeley.. Executive Summary October 2008.

7 Design Recommendations for the WCI Regional Cap-and-Trade Program, Appendix B: Economic Modeling Results September 23, 2008

⁸ Design Recommendations for the WCI Regional Cap-and-Trade Program, Section 2, Background Report, pp. 58-59. September 23, 2008

⁹ Creyts, J., et al. (McKinsey). 2007.

GHG emissions at negative cost even in the absence of a cap-and-trade program suggests that complementary policies, such as energy efficiency standards and programs, can lead households and businesses to exploit such opportunities.

Other analysts start with the presumption that markets function efficiently, so that there is little or no opportunity for these complementary policies to lead to overall savings.¹⁰ Under these assumptions, any climate policies must impose economic costs. This divergence of views on the potential to realize savings from complementary policies is one of the primary factors that causes some studies to show a small net savings to the economy from climate policies, while others show a small net cost. What is important to recognize is that in virtually all analyses, well defined cap-and-trade programs with the cost-saving features listed above have been found to be consistent with continued robust economic growth in the U.S. and Canada. By coupling a cap-and-trade program with complementary policies, the WCI Partners expect to use the market to capture cost-effective reduction opportunities and drive innovation, while targeted complementary policies address barriers that might otherwise limit the adoption of least-cost emission reductions.

Role of Economic Analysis in Policy Development

6) Two reviewers expressed concern that ARB's analysis did not examine a broad range of policy designs to develop the Scoping Plan recommendations. These reviewers suggested that the analysis was designed too narrowly to allow identification of the most cost-effective approach to achieving the AB 32 emissions limit. (Stavins, Pew)

These reviewers assert that a far more expansive comparative evaluation of the economic impact of alternative approaches (e.g., much greater reliance on cap-and-trade; greater or lesser stringency of individual measures) should be conducted to determine if the staff recommendation is the most cost-effective approach.

The approach employed in the Proposed Scoping Plan is appropriate. An analysis of strategies that ignore the requirements of AB 32 and other statutes governing the Board's actions relative to reducing GHG emissions is not supportable, and would not be useful in guiding the Board's consideration of the Plan.

As the Draft Plan was developed, three major options – use of a cap-and-trade program together with complementary measures; use of a carbon fee together with complementary measures; and use of only sector-specific measures – were evaluated from a number of policy perspectives, which resulted in the preliminary recommendation to use a cap-and-trade program together with complementary measures. The policy rationale for recommending a California cap-and-trade

¹⁰ See generally Stavins, Robert et al. 2007. —Too Good to Be True? An Examination of Three Economic Assessments of California Climate Change Policy. AEI-Brookings Joint Center Working Paper No. 07-01.

program that would link to a wider regional market was described in the Proposed Plan:

By setting a limit on the quantity of greenhouse gases emitted, a well-designed cap-and-trade program will complement other measures for entities within covered sectors. Additionally, starting a cap-and-trade program now will set us on a course to achieve further emissions cuts well beyond 2020 and ensure that California is primed to take advantage of opportunities for linking with other programs, including future federal and international efforts.... (Proposed Scoping Plan, p. 31)

Participating in a regional system has several advantages for California. The reduction of greenhouse gas emissions that can be achieved collectively by the WCI Partner jurisdictions are approximately double what can be achieved through a California-only program. The broad scope of a WCI-wide market will provide additional opportunities for reduction of emissions, therefore providing greater market liquidity and more stable carbon prices within the program. The regional system also significantly reduces the potential for leakage, which is a shift in economic and emissions activity out of California that could hurt the state's economy without reducing global greenhouse gas emissions. Harmonizing the approach and timing of California's requirements for reducing greenhouse gas emissions with other states and provinces in the region can encourage retention of local businesses in the state. Further, by creating a cost-effective regional market system, California and the other WCI Partner jurisdictions will continue to demonstrate leadership in preparation for future federal and international climate action. (Proposed Scoping Plan, p. 33)

The Proposed Plan also discussed the role of the complementary measures. In this context, the Plan quotes the Economic and Technology Advancement Advisory Committee:

If markets were perfect, such a cap-and-trade system would bring enough new technologies into the market and stimulate the necessary industrial RD&D to solve the climate change challenge in a cost effective manner. As the Market Advisory Committee notes, however, placing a price on GHG emissions addresses only one of many market failures that impede solutions to climate change. Additional market barriers and co-benefits would not be addressed if a cap-and-trade system were the only state policy employed to implement AB 32. Complementary policies will be needed to spur innovation, overcome traditional market barriers (e.g., lack of information available to energy consumers, different incentives for landlords and tenants to conserve energy, different costs of investment financing between individuals, corporations and the state government, etc.) and address distributional

impacts from possible higher prices for goods and services in a carbon-constrained world.¹¹ (Proposed Scoping Plan, p. 19)

These provide the primary policy reasons for ARB's recommended comprehensive approach that combines a cap-and-trade program with complementary policies. The economic and public health analyses of the Plan's recommendation demonstrate that this approach to implementing AB 32 provides economic and noneconomic benefits to California. The analyses presented in the Plan sufficiently meet the requirement of AB 32 that "the state board shall evaluate the total potential costs and total potential economic and noneconomic benefits of the plan...." (HSC 38561(d))

Additionally, because many of the complementary measures included in the Plan implement established state policies they must be included in the final plan adopted by the Board. These include:

- The motor vehicle greenhouse gas reductions as mandated under AB 1493.¹²
- Reductions from improved land use and transportation planning consistent with the policies contained in SB 375.
- Development of a Low Carbon Fuel Standard as mandated by Executive Order S-01-07 and approved by the Board as a Discrete Early Action.
- The 33 percent Renewable Portfolio Standard target established for California by Executive Order S-14-08.

Further, other energy-related measures, which were designed in consultation with the Public Utilities Commission and the Energy Commission, are also important to include in the Plan adopted by the Board.¹³

Finally, as noted three broad approaches for getting the emission reductions required to meet the goals of AB 32 were evaluated. Each approach included the needed measures outlined above: a cap-and-trade program together with complementary measures; a carbon fee together with complementary measures; and complete reliance on sector-specific measures. Each of these is presented in the Economic Evaluation Supplement to the Draft Scoping Plan. However, as discussed in the Supplement, ARB learned that there are no macro-economic models currently in use that can estimate the potential differences between

¹¹ Recommendations of the Economic and Technical Advancement Advisory Committee (ETAAC), Final Report. *Technologies and Policies to Consider for Reducing Greenhouse Gas Emissions in California*. February 14, 2008. pp. 1-4 <http://www.arb.ca.gov/cc/etaac/ETAACFinalReport2-11-08.pdf> (accessed October 12, 2008)

¹² AB 32 requires that if those regulations do not remain in effect the ARB must implement alternative regulations to control mobile sources of greenhouse gas emissions to achieve equivalent or greater reductions.

¹³ AB 32 requires ARB to consult with the Public Utilities Commission and the Energy Commission on all elements of the plan that pertain to energy related matters. The recommendations in the proposed plan for expanded energy efficiency, 33 percent renewables, increased use of combined heat and power and reliance on a regional cap-and-trade system are consistent with the adopted joint recommendations of these agencies.

traditional direct regulations and market-based regulations such as cap-and-trade. ARB relied on advanced, comprehensive modeling tools appropriate for addressing the impacts of the Plan on the California economy...

7) Several reviewers expressed concern that ARB’s analysis focused only on 2020, and did not consider the short-term transition costs and savings that would result from implementing the measures in the Plan. (Stavins, Yohe, Pew)

Further analysis has been conducted to evaluate the near- and mid-term economic implications of the Proposed Scoping Plan recommendations. This analysis estimated both the initial capital requirements and the anticipated cash flow requirements for the different measures included in the Plan, taking into account the fact that the initial investments would be financed such that annual expenditures to repay the loan would be less than the initial investment. As shown in Table 4, the measures that take effect before 2012 require an initial capital outlay of \$2.4 billion between 2009 and 2011. However, in terms of the cash flow requirements, when evaluated at a real interest rate of 5 percent the savings of \$1.9 billion outweigh the payments of \$0.9 by about \$1 billion during this period. For the first phase of the full program, 2012 to 2014, the initial capital required would be \$29 billion, but the savings of \$21 billion would outweigh the expenditures of \$12 billion.

The Plan includes a variety of measures, most of which are anticipated to be phased-in over several years (e.g., the Pavley I regulations were adopted by the Board in 2004 and are intended to be phased in over a period of 7 years beginning in 2009) requiring limited up-front investment. Of those that do require substantial investment in equipment, the affected sectors primarily consist of large entities, such as utilities, commercial real estate developers, or oil companies. Smaller businesses would experience incremental costs for more efficient technology when they replace equipment, or higher rents for more efficient buildings. However, neither of these examples requires a large capital outlay, but rather are reflected in monthly payments that occur coincident with the energy savings. As each regulation is developed through a stakeholder process more detailed estimates of the capital costs and their timing will be developed.

Table 4. Near- and Mid-Term Costs and Savings (\$B)

	Investment	Expenditures	Savings
2009-2011	\$2.4 B	\$0.9 B	\$1.9 B
2012-2014	\$29 B	\$12 B	\$21 B

Conclusion

The peer review comments provide a number of critiques and suggestions on aspects of our analysis. In some cases, we agree with the suggestions for improvement, while in others we believe that our approach is appropriate. Economic modeling is not an exact science, and there will always be different opinions about assumptions and how to apply the available tools. This is to be expected. Overall, the additional work performed shows that even taking into account the major points raised, the economic impact of the Proposed Plan is positive for most indicators.

Meanwhile, a key factor that was not weighed in the economic analysis is the potential cost of doing nothing. As a state, California is particularly vulnerable to the costs associated with unmitigated climate change. A recent U.C. Berkeley study¹⁴ of the impact of climate change on California found that climate risk – damages if no action is taken – would include tens of billions per year in direct costs, even higher indirect costs, and expose trillions of dollars of assets to collateral risk. The study estimated that the public health sector alone faces from \$4 billion to \$24 billion in additional annual costs associated with climate change impacts. When these costs are taken into account, the benefits associated with implementing a comprehensive plan to cut greenhouse gas emissions become even clearer. California cannot avert the impacts of global climate change by acting alone. We can, however, take a national and international leadership role in this effort.

¹⁴ Research Paper No. 08102801, California Climate Risk and Response, Fredrich Kahrl and David Roland-Holst, University of California, Berkeley, November, 2008.

Attachment 1:

Transmittal Memo Providing Peer Review Comments to ARB



Linda S. Adams
Secretary for
Environmental Protection

State Water Resources Control Board

Division of Water Quality

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Arnold Schwarzenegger
Governor

TO Richard Corey
Assistant Chief, Research Division
California Air Resources Board

FROM Gerald W. Bowes, Ph.D.
Manager, Toxicology and Peer Review Section
DIVISION OF WATER QUALITY

DATE OCT 31 2008

SUBJECT REQUEST FOR PEER REVIEWERS: ECONOMIC MODELING ANALYSIS
FOR GREENHOUSE GAS REDUCTION SCOPING PLAN

In response to your request for peer reviewers for the subject identified above, I am pleased to provide you with the names and affiliations of six external reviewers, and the reviews they have recently submitted. These individuals were among those identified by the University of California as qualified to perform this assignment. The approved reviewers are listed below.

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OCT 31 2008

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Attachments to this memorandum include the following:

1. A copy of my September 18, 2008 letter sent to each reviewer transmitting the material to be reviewed. This letter included three enclosures:

OCT 31 2008

Enclosure 1: Letter of request to me for reviewers, signed by Richard Corey, California Air Resources Board (CARB). This request included three attachments, the second of which provided focus for the review. I emphasized the importance of this directive in my letter to reviewers: **“Please note that the focus of your review will be Attachment 2. Each topic must be addressed, as expertise allows.”**

Enclosure 2: “Rules of conduct” guidance for staff and reviewers.

Enclosure 3: Subject for Review: Economic Analysis Supplement, including five Appendices. Undated. Received from CARB September 17, 2008.

2. External peer reviews. Drs. Adkins and Peace have submitted a co-authored review. All reviewers, save one, placed their comments under the most appropriate of the six topic titles identified by CARB as a focus for the review, and in the order listed in Attachment 2 to the request letter to me, noted above.
3. Biographical information for each reviewer.

In the spirit of maintaining the integrity of the Cal/EPA external peer review process, which is based on an “At-Arm’s-Length” distance between the requesting organization and the reviewers, I recommend that you transmit clarifying questions to me which I will forward to the appropriate reviewer. At this point in the external peer review process, we must ensure that there is no perception independent reviewers are being asked to become advisors in a collaborative relationship.

Enclosures (3)



Linda S. Adams
Secretary for
Environmental Protection

State Water Resources Control Board

Division of Water Quality

1001 I Street • Sacramento, California 95814 • (916) 341-5455
Mailing Address: P.O. Box 100 • Sacramento, California • 95812-0100
Fax (916) 341-5584 • <http://www.waterboards.ca.gov>



Arnold Schwarzenegger
Governor

September 18, 2008

Dear

EXTERNAL SCIENTIFIC PEER REVIEW OF ECONOMIC MODELING ANALYSIS DOCUMENT, PREPARED BY CALIFORNIA AIR RESOURCES BOARD (CARB)

In my capacity as Cal/EPA Program Manager for External Scientific Peer Review, I have approved you as a reviewer of the document noted above. This approval is based on information provided in your Conflict of Interest form and supplementary information you may have provided at my request.

Your agreement to perform this important review is much appreciated.

I am forwarding this request for review to you on behalf of CARB, and ask that you submit your review directly to me, as well as any questions you might have.

You were originally contacted by Dr. Dan McGrath, Executive Director, University of California Berkeley Institute of the Environment (BIE) to discuss your potential candidacy for this review. Dr. McGrath indicated that the review period would be 30 days. That is now going to present a problem because California does not have an approved budget for FY 2008-2009, and almost all State contracts have been suspended, effective August 1. The Interagency Agreement for External Scientific Peer Review between Cal/EPA and the University of California, which will support the requested review, was included in the suspension order. That means no review can be performed until the suspension on this Interagency Agreement has been lifted.

I am sending the material to you now to have it in your hands. I will contact you immediately after the new State budget has been approved, at which time the review can begin.

CARB would prefer the reviews to be returned by October 10, 2008. It also recognizes that the longer the budget is not approved, the shorter the time for review will be. We will have to take this on a day-to-day basis. After I give you the "green light" to begin work, and recognizing what may be a compromise period for review, you may want to mark your review "Draft".

Enclosed with this letter are the following:

California Environmental Protection Agency

Enclosure 1

Letter of request to me for reviewers, signed by Richard Corey, CARB. The letter has three attachments, slightly revised from the attachments sent to you previously by Dr. McGrath during the reviewer solicitation process.

Please note that the focus of your review will be Attachment 2. Each topic must be addressed, as expertise allows.

- Attachment 1. Summary of document to be reviewed.
- Attachment 2. Description of topics to be reviewed.
- Attachment 3. List of individuals who participated in development of draft document.

Enclosure 2 – Guidelines Provided in Response Letters to Organizations Which Have Requested External Peer Reviewers.

These “rules of conduct” represent an updated version of what I sent you during the Conflict of Interest review process.

Normally, I send these to the organizations when I approve reviewers for them. They would then contact the identified reviewers and send the review material to them. In the present circumstance, I will be managing the review for CARB which will not know the identity of the reviewers until the reviews have been submitted to me.

Enclosure 3 – Subject of Review: “Economic Analysis Supplement”, Pursuant to AB 32, The California Global Warming Solutions Act of 2006.

The Supplement consists of 25 pages. It is accompanied by five Appendices.

Time allowing, CARB has indicated that it may request a summary review to be written. Professor Inez Fung, Co-Director, BIE, has indicated that in this situation, she would convene the reviewers as a panel, appoint the Chair, and manage the process independent from Cal/EPA. This process may be accomplished through telephone conference calls.

If I can provide additional help, feel free to contact me at any time during the review process, once it begins, or before if need be. I can be reached at (916) 341-5567 or gbowes@waterboards.ca.gov.

Sincerely,

Original signed by

Gerald W. Bowes, Ph.D.
Staff Toxicologist (Sup.)
Manager, Toxicology and Peer Review Section
Division of Water Quality

Enclosures



Linda S. Adams
Secretary for
Environmental Protection

Air Resources Board

Mary D. Nichols, Chairman
1001 I Street • P.O. Box 2815
Sacramento, California 95812 • www.arb.ca.gov



Arnold Schwarzenegger
Governor

ENCLOSURE 1

TO: Gerald W. Bowes, Ph. D., Staff Toxicologist
Toxicology and Peer Review Section
State Water Resources Control Board

FROM: Richard Corey, Assistant Chief
Research Division
California Air Resources Board

DATE: June 27, 2008

SUBJECT: REQUEST FOR PEER REVIEW OF ECONOMIC MODELING

The purpose of this memorandum is to request a peer review of the economic modeling analysis to support the Scoping Plan developed in response to the provisions of the California Global Warming Solutions Act of 2006. As you know we have discussed the need for this peer review over the past months. The Scoping Plan is a non-regulatory item that will be considered by the Board at its November 20, 2008 meeting.

The economic modeling analysis is a very important component of the Scoping Plan. The analysis will be used to inform different policy options that will be considered. Specifically, the economic modeling analysis will be used to assess the potential impacts of the policy options on the economy including impacts on jobs, income, gross state product, as well as the cost of energy.

Background orientation material (draft Scoping Plan, model documentation) can be provided as soon as the peer review panel is established. Further, it is anticipated that a supplemental analysis that will provide the key economic modeling analysis will be available by the end of July with a review period of 30 days. Thus, comments are due by August 30, 2008. Providing the comments within this timeframe will afford the ARB the opportunity to incorporate changes into the final draft before being considered by the Board at its November 20, 2008 meeting. Providing there is sufficient time, the draft final report will also be submitted for peer review in early October for a review period of 30 days. Thus, comments on the economic modeling analysis in the final draft Scoping Plan would be due by November 1, 2008.

The primary expertise needed for the peer review is economics. Further, experience with the use of economic models as well as the interpretation of results is particularly relevant. Peer reviewers should also have national as well international experience with respect to the economics of climate change as well as carbon markets.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our website: <http://www.arb.ca.gov>.

California Environmental Protection Agency

Gerald W. Bowes
June 27, 2008
Page 2

If you have any questions on this request, please contact:

Fereidun Feizollahi, Manager
Economic Studies Section
Research Division
California Air Resources Board
(916) 323-1509
ffeizoll@arb.ca.gov

Please cc the below individuals on any transmittals concerning the peer review. In addition, due to the compressed timeline, we are requesting that you send a weekly brief status report (an email) regarding the progress with establishing the panel. Thank you for your assistance with establishing this peer review panel to support the Scoping Plan. Please contact us should you have any questions.

cc: Bart Croes, Research Division
Robert Jenne, Executive Office
Richard Corey, Research Division
Tony Andreoni, Research Division
Fereidun Feizollahi, Research Division

Attachments

Attachment 1
Revised (July 10, 2008)

**Peer Review of the Economic Modeling Analysis of the
California Air Resources Board Greenhouse Gas Reduction Scoping Plan
Required by the California Global Warming Solutions Act of 2006**

The California Global Warming Solutions Act of 2006 (AB 32) requires the California Air Resources Board (ARB) to develop a greenhouse gas (GHG) Scoping Plan to meet the 2020 GHG emissions limit set at the 1990 levels. AB 32 also requires that ARB evaluate the potential impacts of the State's Scoping Plan on California's economy, environment, and public health. This assessment is to be undertaken using the best available economic models, emission estimation techniques, and other appropriate scientific methods.

The objective of the peer review is for experts to review the economic modeling work done to support the Scoping Plan. The economic modeling work is an important element of the Scoping Plan as it will help to inform the policy options that are considered (e.g., performance-based regulations, fee-based measures, a cap and trade strategy, as well as various combinations of these approaches. The models that will be used to support the effort are Energy 2020, E3 GHG Model, BEAR Model, and EDRAM. The review will consist of:

- 1) An assessment of the theoretical basis of the models;
- 2) An assessment of the appropriateness of the models to support the evaluation of the policy scenarios to reduce emissions of GHGs;
- 3) An assessment of the key data sets (e.g., energy consumption forecasts) upon which one or more of the models rely;
- 4) An examination of the assumptions for their validity and practicality;
- 5) An assessment of the key variables to which the model is most sensitive and a qualitative assessment of how alternative assumptions could impact the results; and
- 6) Commentary on the reasonableness of the models' results as well as their interpretation as presented in the analysis including commentary on how subsequent modeling efforts can be improved.

**Attachment 2
(Revised July 10, 2008)**

**Peer Review of the Economic Modeling Analysis of the
California Air Resources Board's
Greenhouse Gas Reduction Scoping Plan Required by the
California Global Warming Solutions Act of 2006**

The statute mandate for external peer review (Health and Safety Code Section 57004) states that the reviewer's responsibility is to determine whether the scientific portion of the proposed rule is based upon sound scientific knowledge, methods, and practices.

We request that you made this determination for each of the following issues that constitute the scientific basis of the proposed regulatory action. An explanatory statement is provided for each issue to focus the review.

For those work products which are not proposed rules, such as the case with the review that is the subject of this document, reviewers must measure the quality of the product with respect to the same exacting standard as if it was subject to Health and Safety Code Section 57004.

The California Global Warming Solutions Act of 2006 (AB 32) requires the California Air Resources Board (ARB) to develop a greenhouse gas (GHG) Scoping Plan to meet the 2020 GHG emissions limit set at the 1990 levels. AB 32 also requires that ARB evaluate the potential impacts of the State's Scoping Plan on California's economy, environment, and public health. This assessment is to be undertaken using the best available economic models, emission estimation techniques, and other appropriate scientific methods.

A peer review of the economic assessment – the theory and its application, economic modeling inputs and other assumptions, and the conclusions of the modeling results – is requested by the California Air Resources Board to assure that the best economic analyses and available models are appropriately used and interpreted. The specific deliverables of this project are to provide to ARB:

The Scoping Plan development includes analyses of several scenarios that are based on the extent of direct vs. market-oriented measures, as well as possible coordination with other states and Canadian provinces. The ARB selected two main models to assess the economic impacts of the Plan. They are: 1) the Energy2020 Model developed by ICF International and System Solutions, Inc., and 2) the Environmental Dynamic Revenue Assessment Model (E-DRAM), developed by Professor Peter Berck of the University of California, Berkeley Department of Agricultural and Resource Economics. The Energy 2020 and E-DRAM models have been harmonized and coordinated with the electricity sector modeling performed by Energy, Environment, and Economics Consultants (E3) for the California Public Utilities Commission. An additional macroeconomic analysis of the Plan is being performed using the BEAR Regional Economic Model by Professor David

Roland-Holst of the UC Berkeley Department of Agricultural and Resource Economics (see Appendix 1 for a more detailed discussion of the above economic models).

The ARB's Board received a presentation on the draft proposed Scoping Plan at its June 26, 2008 meeting. The Scoping Plan will describe the programs and measures that, when implemented, would achieve the 2020 GHG emission limit. It will also include several assessments and evaluations, including economic and business impact assessments using the models described above. A final draft of the Scoping Plan is scheduled to be considered by the Board at its November 20-21, 2008 hearing.

Prior to the release of the revised Scoping Plan in October 2008, the ARB will release a supplement document. The supplement document is expected to be released late July and will present the results of the economic modeling analysis. The analysis will evaluate the macroeconomic impacts of different policy options as presented in the supplement with the expectation that the economic modeling analysis presented in the final Scoping Plan (planned to be released early October) will also be reviewed providing there is sufficient time. The analysis will also include an assessment of the impacts on small business as well individual consumers resulting from implementation of the plan.

The peer review will consist of:

1. An assessment of the theoretical basis of the models.

The purpose is to comment on the underlying basis for the models noting particular strengths or weaknesses. Other modeling tools that may be helpful in future analyses would also be noted. The key models that will be relied upon are as follows:

The models to be reviewed in the proposed economic peer review panel are briefly described here.

A. The Energy2020 Model

Energy2020 is a multi-sector energy analysis model that simulates the supply, the demand, and the equilibrium price for all fuels, covering the North American economy, energy market, and emissions with multiple U.S. and Canadian regions. The model solves to equate the supply and demand for energy markets. The demand is specified by end-use sectors. The supply covers electricity, petroleum, and natural gas energy sources. The model solution also includes GHG emissions and criteria air pollutants.

B. Environmental Revenue Dynamic Assessment Model (E-DRAM)

E-DRAM is a computable general equilibrium model of the California Economy, originally developed to assess the revenue impacts of tax and other State policies for the Department of Finance. It has subsequently been used by the California Energy Commission and ARB to assess impacts of reducing

petroleum dependency (AB 2076) and by ARB for the Vehicle Climate Change Standards, the State Implementation Plan analysis, and the previous Climate Action Team analysis.

C. Berkeley Energy and Resources Forecasting Model (BEAR)

BEAR is a dynamic computable general equilibrium model designed to support a broad spectrum of policy analyses, including energy and climate change policies such as trading and offset mechanisms. BEAR differs from E-DRAM by explicitly tracking the path of development of the economy over time as policies are implemented. The BEAR model has been previously used to assess the economic impacts of California greenhouse gas control policies.

D. E3 Electricity Sector GHG Model

The E3 Electricity Sector GHG Model evaluates GHG emissions implications of alternative energy resources plans for the California electricity sector. The model uses a spreadsheet to calculate the GHG emissions for a specified resource plan to meet the 2020 targets specified by AB 32. The E3 model was developed from electricity production simulations using a dispatch model called PLEXOS of the entire area covered by the Western Electricity Coordinating Council (WECC).

2. An assessment of the appropriateness of the models to support the evaluation of the policy scenarios to reduce emissions of GHGs.

The purpose is to comment on the appropriateness of the models used. Are they the correct models given the objective? Where the models used correctly? Are any limitations clearly identified?

3. An assessment of the key data sets (e.g., energy consumption forecasts) upon which one or more of the models rely.

The purpose is to comment on the appropriateness of the data sets upon which the models are based. These include information on emissions, electricity generation, and economic growth under business as usual. Are there other data sets that should be considered? Are any limitations with the data sets used clearly identified?

4. An examination of the assumptions for their validity and practicality.

The purpose is to comment on the appropriateness of the assumptions upon which the modeling is based. Are the assumptions clearly identified? Are the assumptions reasonably consistent those used by the scientific community for similarly exercises? The assumptions include information on emissions, electricity generation, and economic growth under business as usual.

5. An assessment of the key variables to which the model is most sensitive and a qualitative assessment of how alternative assumptions could impact the results.

The purpose is to comment on the sensitivity of the model to changes in the values for key variables. This includes commenting on the variables that have the greatest impact on the results as well as the degree to which the uncertainties of the variables have been acknowledged and or evaluated.

6. Commentary on the reasonableness of the models' results as well as their interpretation as presented in the analysis including commentary on how subsequent modeling efforts can be improved.

Are the results of the modeling effort and the associated interpretation supportable? Are there important scientific caveats that are not reflected? Reviewers are asked to provide comment as to what improvements might add to the robustness of the economic modeling analysis.

The Big Picture

Reviewers are not limited to addressing only the specific issues presented above, and are asked to contemplate the following questions:

- a) In reading the staff technical reports and proposed implementation language, are there any additional scientific issues that are part of the scientific basis of the proposed rule not described above? If so, please comment with respect to the statute language given above.
- b) Taken as a whole, is the scientific portion of the proposed rule based upon sound scientific knowledge, methods, and practices?

Reviewers should also note that some proposed actions may rely significantly on professional judgment where available scientific data are not as extensive as desired to support the statute requirement for absolute scientific rigor. In these situations, the proposed course of action is favored over not action.

The proceeding guidance will ensure that reviewers have an opportunity to comment on all aspects of the scientific basis of the proposed Board action. At the same time, reviewers also should recognize that the Board has a legal obligation to consider and respond to all feedback on the scientific portions of the proposed rule. Because of this obligation, reviewers are encouraged to focus feedback on the scientific issues that are relevant to the central regulatory elements being proposed.

Attachment 3

Peer Review of the Economic Modeling Analysis of the California Air Resources Board Greenhouse Gas Reduction Scoping Plan Required by the California Global Warming Solutions Act of 2006

**Individuals Involved in the development of the economic modeling to support the
Scoping Plan.**

Consultants:

Glen Wood, Ralph Torre, ICF International
Jeff Amblin, Systematic Solutions, Incorporated

Academic Community

David Roland-Holst, University of California, Berkeley
Peter Burke, University of California, Berkeley

Cal/EPA External Scientific Peer Review Program

Guidance Provided in Response Letters to Organizations Which Have Requested External Peer Reviewers

Guidance to Staff:

1. Revisions. If you have revised any part of the initial request, please stamp "Revised" on each page where a change has been made. Clearly describe the revision in the cover letter accompanying your request. The approved reviewers have only seen your original request letter and attachments during the solicitation process, and must be made aware of changes.
2. Documents requiring review. All important scientific underpinnings of a proposed science-based rule must be submitted for external peer review. The underpinnings would include all reports (including conference proceedings) and raw data upon which the proposal is based. If there is a question about the value of a particular document, or part of a document, I should be contacted.
3. Documents not requiring review. The Cal/EPA External Peer Review Guidelines note that there are circumstances where external peer review of supporting scientific documents is not required. An example would be "A particular work product that has been peer reviewed with a known record by a recognized expert or expert body." I would treat this allowance with caution. If you have any doubt about the quality of such external review, or of the reviewers' independence and objectivity, that work product – which could be a component of the proposal - should be provided to the reviewers.
4. Implementation review. Publications which have a solid peer review record, such as a US EPA Criteria document, do not always include an implementation strategy. The Cal/EPA Guidelines require that the implementation of the scientific components of a proposal, or other initiative, must be submitted for external review.
5. Identity of external reviewers. External reviewers should not be informed about the identity of other external reviewers. Our goal has always been to solicit truly independent comments from each reviewer. Allowing the reviewers to know the identity of others sets up the potential for discussions between them that could devalue the independence of the reviews.
6. Panel Formation. Formation of reviewer panels is not appropriate. Panels can take on the appearance of scientific advisory committees and the external reviewers identified through the Cal/EPA process are not to be used as scientific advisors.

Note for Review of Economic Modeling Analysis Document: Air Resources Board staff earlier had referred to a panel for this review. Professor Inez Fung, UC Berkeley Institute of the Environment (BIE) Co-Director and UC Project Director for the Peer Review Interagency Agreement with Cal/EPA, has addressed this potential request. Professor Fung would agree to a panel writing a summary review. She would appoint the selected reviewers as members of a review panel, and will appoint one of the panel members as chair. In this process, BIE will manage the process of panel assembly. Conduct of the panel will adhere to the guidelines for reviewers to ensure the independence of the panel from possible inappropriate

influence by or communication with any Cal/EPA staff members. If such a request for a panel is made, it will be directed to Dr. Gerald Bowes who will forward it to Professor Fung.

7. Conference calls with reviewers. Conference calls with one or more reviewers can be interpreted as seeking collaborative scientific input instead of critical review. Conference calls with reviewers are not allowed.

Guidance to Reviewers from Staff:

1. Discussion of review. Reviewers are not allowed to discuss the proposal with individuals who participated in development of the proposal. These individuals are listed in Attachment 3 of the review request.

Discussions between staff and reviewers are not permitted. Reviewers may request clarification of certain aspects of the review process or the documents sent to them.

Clarification questions and responses must be in writing. Clarification questions about reviewers' comments by staff and others affiliated with the organization requesting the review, and the responses to them, also must be in writing. These communications will become part of the administrative record.

The organization requesting independent review should be careful that organization-reviewer communications do not become collaboration, or are perceived by others to have become so. The reviewers are not technical advisors.

2. Disclosure of reviewer Identity and release of review comments. Reviewer identity may be kept confidential until review comments are received by the organization that requested the review. After the comments are received, reviewer identity and comments must be made available to anyone requesting them.

Reviewers are under no obligation to disclose their identity to anyone enquiring. It is recommended reviewers keep their role confidential until after their reviews have been submitted.

3. Requests to reviewers by third parties to discuss comments. After they have submitted their reviews, reviewers may be approached by third parties representing special interests.. Reviewers are under no obligation to discuss their comments with any third party, and we recommend that they do not. All outside parties are provided an opportunity to address a proposed regulatory action during the public comment period and at the Cal/EPA organization meeting where the proposal is considered for adoption. Discussions outside these provided avenues for comment could seriously impede the orderly process for vetting the proposal under consideration.

4. Reviewer contact information. The reviewer's name and professional affiliation should accompany each review. Home address and other personal contact information are considered confidential and should not be part of the comment submittal.

Attachment 2:

Peer Review Comments from:

**Dallas Burtraw, Ph.D.
Resources for the Future**

**Mathew E. Kahn, Ph.D.
University of California, Los Angeles**

**Robert N. Stavins, Ph.D.
John F. Kennedy School of Government
Harvard University**

**Gary W. Yohe, Ph.D.
Wesleyan University**

**Janet Peace, Ph.D. and Liwayway G. Adkins, Ph.D.
Pew Center on Global Climate Change**

October 10, 2008

Dallas Burtraw, Resources for the Future

Burtraw@RFF.org

Comments on:

Climate Change Draft Scoping Plan: Economic Analysis Supplement

California Air Resources Board

These comments are organized to address six topics set forth in the statement of work. In summary, I find the suite of models being used to provide economic analysis for the implementation of AB32 are comparable in quality to the best modeling being used to provide analysis to government or the private sector anywhere in the world. No single model can address the relevant economic questions from all the perspectives that are useful to policy makers, but the suite of models reviewed here does a good job of providing a rounded perspective.

An important point when considering the use of model in policy analysis is that, frankly, all models are wrong. Models cannot provide a specific forecast for how institutions and human behavior will interact, and they certainly cannot predict unexpected natural and economic events, so forecasts of prices and costs from even an ideal model is unlikely to be accurate. However, models can provide internally consistent projections of how changes in policies and other variables will affect the future, even though the actual future remains uncertain. Therefore policy makers need to contribute additional perspective. The suite of models being used to analyze AB32 are especially useful because they address an unusually broad set of issues that should be of concern to policy makers and they do so in a competent way.

Nonetheless there are serious limitations to models in general and this suite of models is no exception. The use of a group of models is helpful because it introduces more capabilities. However, it would be more helpful if an explicit effort were made to identify areas where the models disagree rather than to solely emphasize harmony among the models, as does the Economic Analysis Supplement. The explanation of the model results and assumptions in the Supplement and appendices is adequate, but only just so. The written explanation of methods used in the models could be more transparent and the documentation could be improved. Accomplishing this takes time and resources and the development of a template that is refined only after repeated studies and applications of the models, which may not be relevant in this case. In my comments I occasionally state my understanding of the modeling assumptions where I harbored uncertainty about what was actually assumed, although usually I was eventually able to gain confidence about what was done by continuing to read through the documentation. Some of these assumptions are sufficiently important that they should be made clearer in the main body of the report.

The most significant limitation to the modeling is the absence of a partial equilibrium model that addresses investment and retirement as well as system operation in linked markets that are affected by AB32. Although they have their own strengths in the nature of their completeness, the general equilibrium models operate at a level that lacks technological detail. The E3 model has excellent detail and credible assessments of how markets are likely to operate given existing or forecast capacity and infrastructure

constraints. However, the E3 model does not solve for evolving market equilibrium with endogenous assessments about the kinds of decisions that investors are likely to make in the market environment. Perhaps the missing model Energy 2020 will provide this capability. It is noteworthy that at the federal level this kind of capability is the central basis for modeling that is used to support regulations and legislation. The suite of models used to support AB32 offer capabilities that accommodate questions that are generally outside those addressed by the main models used at the federal level, but there is room for improvement about the central question of how energy markets are likely to evolve in California and the western region.

1. Theoretical basis of the models

Has the Analysis accounted for costs properly?

The marginal cost of emissions reductions are reported to be \$10/ton CO₂ and this is described as the expected price of emissions allowances in 2020. This price represents the marginal cost of emission reduction opportunities that have been identified by CARB and by the economic models, and it is asserted that a cap and trade program would efficiently select from the identified options in order to achieve the emissions cap.

The estimate of the *price of emissions allowances* can be expected to reflect the marginal cost of options identified by the trading program. The cost of the last option actually implemented determines the marginal cost, but this is not necessarily the marginal cost of the most expensive option implemented under the program overall. There is a large set of options that are identified as prescriptive measures that will be implemented independent of the incentives provided by the market price of emissions allowances. If the marginal cost of each of these items was below forecast allowance price then the allowance price would reflect the marginal cost of the most expensive item implemented under the program. It might follow that prescribing specific measures would be unnecessary because the allowance market might be expected to identify these same measures. In this case, all of the prescriptive measures lay inside the marginal cost frontier identified by the market (e.g. \$10/ton).

However, it appears that the prescriptive measures are not all ones that would be chosen under the market.¹ If some measures have marginal costs greater than the identified allowance price then these measures are outside the set of cost-effective measures. There may be many justifications for the inclusion of prescriptive measures that are outside the set of measures that would be identified by the market, such as market or institutional barriers that inhibit the ability of a market to identify and implement these measures, network externalities, ancillary environmental or environmental justice concerns, etc. However, the inclusion of these measures makes it problematic to interpret the market price as the marginal cost of the program. A program organized only around

¹ This distinction is salient in the schedule of emissions reduction opportunities recently developed by Sweeney, Jim and John Weyant 2008. Analysis of Measures to Meet the Requirements of California's Assembly Bill 32: DRAFT, Stanford Precourt Institute for Energy Efficiency (September 27).

identifying cost-effective measures as recognized by the market would identify a different set of measures with a *higher* marginal cost than is reported in the analysis. In the absence of market barriers and network externalities — which I recognize is the justification for prescriptive measures — the market would also lead to a *lower* overall cost.

A prominent example of measures that are outside the set of measures that would be chosen under only a market-based program with an allowance price of \$10 is California's commitment to a renewable portfolio standard. This standard will require the development of renewable energy resources that have an implied emissions reduction cost well above \$10. Nonetheless, the development of these resources will move the state a long way toward its emissions targets, with the consequence that fewer emissions reductions need to be identified from other measures. This will have the appearance of lowering marginal cost and allowance price in a market. Policy makers and the general public may take this as a signal about the cost of the program, but this measure does not reflect adequately the actual cost of the program.

Has the modeling accounted for the benefits of incentive-based approaches such as cap and trade properly?

The analysis asserts that the modeling underestimates the benefits of emissions trading because it does not adequately capture the heterogeneity in costs among opportunities to reduce emissions. In general, models employ a cost schedule for industries that is aggregated across sources. A bottom-up schedule could be constructed that lists each available option at all facilities. An estimated schedule of options might be found by fitting a line through the population of options at all facilities. This approach would lose some representation of the heterogeneity of options but it would preserve a general trend of increasing cost among options. Alternatively, the model might use an average cost estimate for each measure that is identified explicitly, or it may not identify components and opportunities for emissions reductions explicitly and instead use average costs for broad classes of actions across measures or facilities. This latter method appears to be the one identified in the documentation, which indicates that a uniform cost is used for each measure that is the average costs of controlling emissions from a source category. Presumably, the cost average is relevant only up to some fraction of uncontrolled emissions, which I will refer to as the *identified emissions reductions* from the source category.

There are two ways that the use of average costs for a source category is relevant. If the identified emissions reductions from a source category were to be entirely eliminated by prescriptive policies or to be entirely eliminated by the introduction of a CO₂ price under the cap, then the average cost times the amount of reductions would be equal to the total cost of these emissions and the model estimates would be accurate. However, all of the supplemental identified emissions reductions are not mandated, but rather how much of these reductions are achieved is left to the emissions market. Only some of these reductions may be realized by the introduction of the CO₂ price. In this case, since the average cost for identified emissions from a source category may be above the allowance price predicted in the model, then the model would predict that it would not be selected in the market. But if there are heterogeneous costs within this source

category, then some of the ‘low hanging fruit’ may be captured by a trading program, thereby lowering the overall costs below that predicted in the model.²

Another way that models may predict erroneous cost estimates is by their inability to represent issues associated with technology adoption and diffusion, regulatory and siting issues, etc. The documentation mentions the incentive for innovation under cap and trade, and the incentive to identify new measures that cannot be anticipated by planners in advance of the policy. These factors also suggest that costs may be overestimated.

However, there are also factors that could lead costs to be underestimated. Typically models predict a smooth and seemingly frictionless introduction of new technologies when specified cost thresholds are achieved, but this is unlikely to occur in practice. Regulatory issues, liability and public attitudes will plague the siting of new supply side resources including wind and solar thermal facilities and the transmission lines necessary to bring these resources to market. These issues also plague the siting of new nuclear or carbon capture and storage facilities. It is noteworthy that siting is increasingly difficult for uncontrolled coal plants as well, suggesting that baseline forecasts may mistakenly forecast the opportunity cost of renewable technologies relative to fossil-fuel technologies. In each case models are likely to predict a time path for new investment that may be overly optimistic. Moreover, the problem is not limited to supply-side resources. The identification of opportunities for end-use efficiency measures also run into a plethora of implementation challenges. An important consideration in the evaluation of the projected costs of AB32 is how the models anticipate these barriers and how the program design helps overcome these barriers. The economic analysis is not equipped to address this issue.

Many observers claim that the prescriptive measures identified as part of the overall Scoping Plan provide a method to overcome the market barriers that would inhibit penetration of various technologies in an emissions trading market. While this may be true, the prescriptive measures are not guaranteed to have identified the least cost opportunities and furthermore, as discussed previously, the signal of costs that comes from the allowance market does not necessarily reflect actual social costs when prescriptive measures (such as the RPS) have been implemented preemptively, some of which have costs that exceed the forecast allowance price of \$10/ton.

2. Appropriateness of the models to support the evaluation of the policy scenarios

Are there other ways that economic models inherently measure costs incorrectly?

A major source of benefits in the analysis stem from reduced payments for imported fuel. In an institution-free representation of the global economy this benefit category would appear to be measured incorrectly. The principle of comparative advantage would suggest that an economy such as California might be better off specializing in the production of goods and services and importing much of its energy. There are several ways that the principle can be misleading. The political economy of

² Burtraw, D. and M. Cannon. 2000. “Heterogeneity in Costs and Second-Best Policies for Environmental Protection?” Resources for the Future Discussion Paper 00-20.

energy obviously has many institutional details that are outside an economic model, so that the strategic interests of the state (and nation) diverge from the path suggested by simple comparative advantage. A large portion of the benefits of AB32 and related policies rests on the reduction in payments for fuel. Economic analyses would typically find the imposition of this outcome to have negative welfare implications because if it were in the interests of consumers to reduce fuel payments they would do so without government interference. The justifications for California policy rests on institutional detail that is outside this economic reasoning. It is argued that markets do not offer a variety of products including fuel-efficient vehicles that enable consumers to make choices in their own best interest, or that consumers may not recognize their own best interests. Economic models are calibrated to recent observed consumer choices that are taken as a proxy for preferences. However, preferences might be expected to change, much as ideas about using seat belts or smoking have changed over recent decades, but this is well outside the domain of mainstream economic models. Another way that the measurement of revealed costs may not capture actual social cost has to do with labor supply, which typically is represented by a single type of labor. Stratified income and employment opportunities suggest that economic development may result from jobs that are created in end-use efficiency because these jobs fall to less-skilled workers and workers just entering the work force. These are a set of workers who often lack points of entry to higher-paying jobs in the economy and relatively labor-intensive investments in energy infrastructure can provide such opportunities. The E-DRAM model usefully accounts for different labor/wage categories, but it does not have a dynamic labor market representation that accounts for the accumulation of human capital.

There are potential benefits from the use of allowance value that should be explicitly addressed. The Scoping Plan does not provide a final template for how the value will be used, so this makes the economic analysis more challenging. A crucial assumption in the modeling is that allowance value is “allocated back to consumers.” Is this done on an equal per capita basis? Economic efficiency would be improved and the overall social costs on the economy would be reduced if the value were used to offset preexisting taxes. Recent contributions to public finance have emphasized that new environmental regulations including the introduction of a price on CO₂ will raise the cost of goods and services and thereby reduce the real wage. Consequently, workers would be expected to respond to the lower real wage with a reduced contribution to the work force, which can have substantial economic costs. This effect can be largely remedied if the policy harnesses the revenue (allowance value) that is raised under a cap and trade program and directs the revenue to offset preexisting policies that also reduce the real wage. For example, if allowance revenue is used to reduce the labor income tax then the reduction in the real wage from the CO₂ policy could be largely offset. This possibility is not explored in the modeling.

However, if the value were simply returned to households on a lump-sum basis this may have an important stimulus effect on the economy, much as the stimulus checks from the federal government in 2008 were intended to do. This scenario is included in the model results, I believe. Moreover, it may be possible to coordinate the return of revenue with other programs that provide incentives for consumers to make investments in energy-efficiency or renewable technologies. Another option that appears within the vision of the Scoping Plan is to direct some of the allowance value to program-related

efficiency measures. It is not clear the degree to which these options have been explored or are included in the analysis. The models should have the capability to do this, potentially with the exception of some investments such as efficiency measures because of the difficulty in anticipating accurately the program costs and achievements in an expanded efficiency program.

Measuring the baseline

One of the most significant challenges in economic modeling is to identify assumptions relevant to baseline business-as-usual conditions against which the influence of policies can be measured. As I note in my introductory remarks, a model can never be accurate in this regard. Nonetheless, the description of the baseline is very important because the costs of the program should account for how the baseline is expected to change in the future. A changing baseline can make the program more or less expensive than appears from a contemporary perspective. Reviews of previous environmental regulations that have used incentive-based approaches in particular have found a general tendency to overestimate the costs of the program *ex ante*.³ The reason usually has to do with the failure to recognize that many changes in the baseline typically take society in the direction of more efficient economic activity, which has positive dividends for the environment. If some of the environmental gains might be expected to occur anyway in the baseline, then overall costs of the program could be expected to be less than anticipated and it is likely that marginal costs also would be less than anticipated. The degree to which these gains are captured hinges to some extent on the use of incentive-based approaches such as cap and trade.

3. Key data sets

The data used for the general equilibrium modeling is standard. The use of data on business activity in the BEAR model is nice. The data used by E3 has been originally compiled, with some public review. That process is not guaranteed to result in the most accurate data if the public review has imposed overly optimistic or pessimistic projections, the process has been transparent and that is useful for the general modeling exercise.

4. Validity and practicality of assumptions

Attention is given to measures affecting low-income households and small business (P.10). Typically these are not where the least-cost emissions reductions have been found in previous efficiency programs. Low-income households have ample opportunities to improve efficiency, but program costs associated with reaching these households have been greater than for upper-middle income households. Similarly, industrial class customers and large businesses typically offer the lowest cost options outside the residential sector. Therefore, efforts designed to achieve distributional goals

³ Harrington, Winston, Richard D. Morgenstern, and Peter Nelson, 2000. "On the Accuracy of Regulatory Cost Estimates," *Journal of Policy Analysis and Management*, 19(2): 297-322.

associated with reaching the low-income and small business populations may raise costs. This is noted in Appendix V.

Another assumption of concern is the annualized cost of capital equation, which uses a social cost basis for analysis. The payback period is equivalent to the economic life of the capital, rather than the accounting life of the capital. The accounting life plays a large role in private decisions. I feel the economic lifetime is the proper assumption but its implication should be explored.

There are demand elasticities in the model, but no accounting for bounceback behavior, wherein consumers change their behavior (e.g. increase consumption) when the cost of energy services falls due to improved end-use efficiency.

I find there is a weakness in how the modeling approach is communicated. The discussion in the main report is not sufficient to be able to summarize in this way, but the information in the E-DRAM appendix leads me to understand the following. The modeling of cap and trade places a price on CO₂ emissions from all activities and industries covered under the cap including those industries affected by prescriptive measures. The additional emissions reductions that are identified are those that can be achieved from the list of supplemental measures at a cost less than the CO₂ price. The CO₂ price also leads to demand reduction from carbon-intensive industries throughout the economy, which in turn produces emissions reductions. An iterative process is used to find a CO₂ price that achieves emission reductions from the supplemental prescriptive measures and demand reduction to achieve the emissions target, which occurs at a CO₂ price of about \$10/ton. The demand reductions that are achieved presumably involve both substitutions among inputs in production in the CGE model, as well as substitutions in consumption by downstream producers and household.

However, the price effect does not engender any technological change or improvement except through input substitution.

Does the capital cost associated with prescriptive measures and investment in energy efficiency get accounted for in E-DRAM? Is this done by increasing proportionally the rental cost of capital for each affected sector?

5. Key variables to which the model is most sensitive and how alternative assumptions could change the results

The modeling framework has the ability to report estimates in welfare as measured by utility-theoretic compensating variation. Instead, the report relies on estimates of changes in income, expenditure and employment. One reason for doing this is that these measures have the most relevance to the policy audience. Furthermore, one might be skeptical of the structure of preferences as revealed in current consumption activities if one believes that information problems or market barriers constrain the choices available to consumers. For example, one might argue the current vehicle mix does not provide consumers with the choices that may become available in the future. Moreover, preferences may be expected to change in ways that cannot be anticipated. However, there is an important limitation to reporting just expenditure changes, because it does not reflect any measure of the loss in welfare associated with reduction in consumption. In principle a change in price could cause expenditure to rise or to fall,

depending on the elasticity of demand. If demand was elastic, the introduction of a CO2 price could lead to a large reduction in demand and expenditure and give the appearance of economic gain. It would be helpful for the report to indicate where, if ever, demand elasticities could lead to this misinterpretation.

The appendix indicates that some results should be interpreted with caution because the model does not have adequate detail. For example, “most utility sector jobs are linked to the delivery of power and maintaining the system...” and so predicted shifts in employment may not materialize. There are further considerations, especially in this sector and in construction. The policies including the RPS that are emerging will lead to substantial expansion in distributed generation with associated need for transmission. Also, the capital/fuel/labor intensity of various technologies for electricity generation to differ substantially and this may have an important influence on the result.

6. Reasonableness of the models and direction for subsequent efforts

In general, a computable general equilibrium approach in general is not suited to identify emissions reductions within an industry but steps can be made to by disaggregate industries according to technology and emissions characteristics. It is unrealistic to impose such a standard in this case because it is not widely practiced or developed fully elsewhere, but it would be a useful extension in the future if supporting data can be found.

Documentation on page II-21 has embedded comments that should be fixed.

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Journal of Industrial Economics

Journal of Regulatory Economics

Land Economics

Resource and Energy Economics

and various state, federal and international research agencies.

Matthew E. Kahn, Ph.D.

Peer Review of the Economic Modeling Analysis of the California ARB Greenhouse Gas Reduction Scoping Plan

Reviewer: Matthew E. Kahn, UCLA Institute of the Environment, Department of Economics, Department of Public Policy and the National Bureau of Economic Research

Introduction

This memo provides my answers to the set of questions that I have been asked to comment on. Before I present my views I would like to state that I am a 100% supporter of the goal of significantly reducing California's greenhouse gas emissions by 2020 and achieving even greater emissions reductions by 2050. I want to see the ARB succeed in implementing cost effecting regulations to achieve these greenhouse gas mitigation goals. By pursuing this effort, California will reaffirm its world leadership in tackling environmental issues. By acting as a "guinea pig", the state will help to educate governments around the world on cost effective techniques for reducing carbon emissions.

While I support the Governor's broad AB32 goals, I am troubled by the economic modeling analysis that I have been asked to read. AB32 is presented as a riskless "free lunch" for Californians. These economic models predict that this regulation will offer us a "win-win" of much lower greenhouse gas emissions and increased economic growth. According to my arithmetic and the information provided in Table I-2 of the Economic Evaluation Supplement, the 33% Renewable Portfolio Standard, the Pavley Light Truck regulations, the Low Carbon Fuel Standards and the building energy efficiency programs will together mitigate 95.6 MMTCO₂ (57% of the AB32 2020 mitigation goal) at a net negative cost of \$132 million per

MMTCO₂ per year.¹ This would be a large free lunch! I would like to believe this claim but after reading through the Economic Analysis and the five appendices there are too many uncertainties and open microeconomic questions for me to believe this.

The net dollar cost of each of these regulations is likely to be **much larger** than what is reported in Table I-2 of the http://www.arb.ca.gov/cc/scopingplan/document/economic_appendix1.pdf. In this review, I will highlight why I believe the current modeling exercise underestimates the cost of meeting AB32's goals. I will present a research methodology for cheaply collecting the necessary data to test whether the optimistic numbers reported in Table I-2 of http://www.arb.ca.gov/cc/scopingplan/document/economic_appendix1.pdf could be accurate estimates of the expected net costs of this regulation.

In this review, I will point to other economic modeling efforts being conducted by leading economists who conclude that the introduction of carbon pricing will entail small but significant costs on our nation's economy. I will also highlight the fundamental uncertainties we face because of the ambitious 33% Renewable Portfolio Standards. Nowhere in this economic document could I find any mention of the words "risk" and "uncertainty". Yet, each day we buy insurance and hold "safe" portfolios (i.e U.S Treasury Bills) to protect us against unforeseen contingencies. We are risk averse. AB32 is a gamble. It will force us to deviate from our "business as usual" ways of living our day to day life. This offers potential large benefits but it

¹ I calculated this based on a weighted average of the net costs using the carbon reduction as the weights.

also raises the potential for bad scenarios whose probabilities and costs if they ensue have not been quantified and reported in the documents that I have read through.

Finally, this report will emphasize the need for more data collection and for field experiments to be conducted so that we can learn about how different real Californians and California firms will respond to the incentives embedded in AB32. Whether AB32 offers “negative costs” hinges on a number of micro-economic factors that the documents I have been asked to review do not touch on.

My bottom line is that this Economic Supplement provides an incomplete report on what we know and need to know about the economic consequences of this important regulation.

1. An Assessment of the theoretical basis of the models

A. Energy 2020 model

Based on information I found here http://www.energy2020.com/model_overview.htm, the Energy 2020 model appears to be a competent model. The devil is in the details. An equilibrium electricity market model requires the modeler to make numerous assumptions. I will return to this point below. I could not find a clear description of the set of assumptions that are built into this model. For example, as Californians become richer over time, how much will this increase their per-capita demand for electricity? Technically, what income elasticity of demand for electricity is used in this analysis?

As stated at the bottom of page 4 of the Economic Supplement document (http://www.arb.ca.gov/cc/scopingplan/document/economic_analysis_supplement.pdf), there are currently no results from this model. This is a major omission. It is difficult to judge AB 32's economic impacts without knowing the output of this model. I see that the E3 model output is used extensively throughout in this Economic Analysis. Are the results from Energy 2020 and the E3 model perfect substitutes? Put simply, do the two models estimate the same variables and thus it is not a major loss not to have the Energy 2020 model results? I am surprised that the Economic Analysis Supplement could be written without the output of this Energy 2020 model.

B. EDRAM model

This is a sophisticated, high quality model. It yields a series of useful outputs related to how major sectors of the California economy will be affected by carbon mitigation strategies such as a positive carbon price. According to the discussion on page II-19 of Appendix II, the E-DRAM model was built by Berck, Golan and Smith in 1996. It would interest me to know the specifics concerning what improvements to the model have been made over the last 12 years. For example, Google didn't exist 12 years ago. Yet, now it is a key innovative company in California. Does the growth of such new firms in specific industries mean that some of the structural equations in the model are out of date? Or put differently, does the growth of the "new economy" affect the model's underlying equations?

On a theoretical basis, how do expectations of future increases in carbon prices affect investment in this model? The E-DRAM model estimates that businesses will face a \$10 price per ton of carbon in the year 2020. I realize that a CGE model endogenizes key economic

parameters such as the price of carbon but I would like to see a simulation of how economic outcomes such as state per-capita income and employment are affected if this equilibrium carbon price is higher. After all, investment is durable and businesses are forming expectations in the year 2020 of the next 30 years including the regulatory tightening under AB32 to achieve the more stringent 2050 goal of a 80% reduction in greenhouse gases below 1990 levels. In Figure 6 of this paper

http://www.brookings.edu/~media/Files/rc/papers/2007/10carbontax_metcalf/10_carbontax_metcalf.pdf , Gilbert Metcalf of Tufts University predicts that the national carbon tax price will be \$60 per ton (year 2005 \$) in the year 2050. If California businesses anticipate this, how does this affect their investment decisions? Am I right that the E-DRAM model is a static model? If real world Californian firms base their investment decisions on today's price of carbon and on expectations of the future price of carbon, and if this price is expected to rise over time as shown in Metcalf's figure, then are the E-DRAM investment equations seriously mis-specified? Can a rational expectations dynamic investment function be introduced into this model?

According to page 39 of the Scoping Plan, there are 1.5 million people employed in manufacturing in California. Thus, a key issue is how this sector will be affected by AB 32 regulation. The results reported in Table II-8 claim that manufacturing employment will grow by .4% because of AB32 regulation. Given that electricity prices are expected to rise by 14%, this is a surprising finding. The micro-econometrics literature has concluded that increased energy prices retards manufacturing employment growth. The manufacturing results reported here contradict the findings from the micro-econometric literature on firm locational and employment choice (see Carlton 1983 and Davis and Haltiwanger 2001 see http://www.bsos.umd.edu/econ/haltiwanger/davis_haltiwanger_01.pdf). In his detailed study of

the Fabricated Plastic Products Industry (SIC 3079), Communications Transmitting Equipment (SIC 3662), and Electronic Components (SIC 3679), Carlton demonstrates the importance of metropolitan area electricity prices as a factor in attracting job growth. Cities with high electricity prices lose jobs in each of these industries (see Carlton 1983 available at <http://faculty.chicagogsb.edu/dennis.carlton/research/The%20Location%20and%20Employment%20Choices%20of%20New%20Firms.pdf>).

C. The BEAR Model

This is a rigorous CGE model that relates equilibrium economic dynamics to environmental outcomes and that can be used to evaluate how different carbon mitigation policies will affect the real economy.

Unlike the output reported by the EDRAM model, results from this model predict that a \$12 dollar carbon permit price will lead to a slight decline in state aggregate personal income. While this estimate is quite small, the EDRAM and BEAR modelers should explain why their two models are yielding different predictions (compare Table II-2 of Appendix II with Table III.4 of Appendix 3). They should also report what their predictions for state macro-economic outcomes would be if the cap and trade price of carbon is higher such as at \$20 or \$30 a ton. The equilibrium price of permits may be predicted to be \$12 but it is still important to know what the model predicts economic aggregates will be if the true price of carbon in the Western Climate Initiative is higher than predicted.

Can the BEAR model predict within sample pollution dynamics? I am impressed that the model has the capacity to track 13 different pollution categories (see Table III.1). Given that the Air Resources Board collects ambient readings on the actual levels of many of these pollutants such as the criteria air pollutants, I would like to see the BEAR modelers confirm that their model predictions co-move with the actual pollution data. So, I would ask the BEAR researchers to choose a baseline year such as 1990 to calibrate their model. Using this baseline, the BEAR model should be used to predict the time series of emissions of particulates, sulfur dioxide, oxides of nitrogen, and carbon monoxide between 1990 and 2005. Using these 16 data points, a simple graph could be made to see if BEAR model's predictions for each of these emissions measures match the **true** ambient pollution dynamics. If the percent annual changes in the BEAR model match the true dynamics then my confidence in this model would increase. If the model fails this test, then I would be concerned about this model's ability to predict greenhouse gas dynamics as a function of economic activity.

D. the E3 electricity model

This model appears to be well suited to answering the core questions of how much GHG emissions are created from using different energy resources. This model is also quite important for predicting how equilibrium energy prices are affected by AB32's introduction of a 33% Renewable Portfolio Standard and by placing the state's electric utilities in a cap and trade program in the Western Climate Initiative. E3's model predicts an increase of 14% in statewide electricity prices (see footnote #3 on page IV-3 of Appendix IV) and an equilibrium permit price of roughly \$10 per ton.

One concern that I have with this model is how it handles high frequency, day to day uncertainty caused by random events such as weather shocks. Consider the introduction of wind turbines as a key piece of the portfolio to meet the 33% RPS standard. The actual power they generate each day is a random variable. On summer days that are hot and not windy, they generate very little power. E3 would need an excellent day by day model of climate and wind conditions to provide precise estimates of the actual day to day power generation created by solar and wind. In the absence of an electricity storage technology, these day to day differences in supply matter. A power blackout in the middle of a streak of hot summer days becomes more likely if we are relying on wind power for a larger share of our power. Ironically, if climate change makes summer heat waves more likely, then the combination of climate change **and** AB32's 33% RPS increases the likelihood of blackouts as electricity demand exceeds system supply. It would be useful to have an engineer actually estimate the marginal increase in this probability of summer blackouts. Does the E3 model predict the likelihood of such events? If electricity prices are allowed to freely fluctuate with supply and demand conditions, then prices will spike on these days. If the state had natural gas power plants ready to provide power on those peak demand days, then blackouts would be less likely. But, keeping such plants "on call" would be costly and would raise the state's carbon emissions factor from power plant generation.

The prospects of more summer blackouts may pose serious costs to businesses and consumers but I see no evidence that the E3 Model produces estimates of these costs. A model that is explicit about uncertainty would make statements such as; "there is a 5% chance during the summer months that the actions taken to meet the RPS standard will cause energy prices to rise to \$143 per megawatt hour" or "there is a 7 percentage point increase in the probability of

blackouts during summer months because of the 33% RPS standard". I see no probabilistic statements in the documents I have read through.

More generally, I would like to see a theoretical analysis that provides confidence intervals around the key price predictions and I would hope that the model could provide estimates of how the price of electricity will vary by month in the presence of the RPS standards. Right now predictions are made as if the E3 model is clairvoyant. Given the Californian population's risk aversion, it would be more useful to see the distribution of predicted outcomes under different scenarios and realizations of random variables such as climate patterns. If Californians were risk neutral, then it would be fine to merely report your best guess of the future. (http://en.wikipedia.org/wiki/Risk_neutral)

A second basic theoretical question I have focuses on the cost of delivering electricity to California's diverse, spread out population. As population growth takes place in the distant suburbs, in hotter counties such as Riverside and San Bernardino, do these trends boost the need for more expensive transmission capability? What is the spatial distribution of where renewable power will be sited versus where does the population live and what is the cost of connecting the two? What urban planning challenges will arise in siting transmission cables? How costly will it be to resolve such NIMBY issues?

On the household demand side, California's demographics continue to change. Does the increase in the percentage of Californians who are young and Hispanic and old and white affect any of the consumer electricity demand equations? As population growth takes place in the suburbs, in hotter counties such as Riverside and San Bernardino, do these trends boost electricity demand? In my own research with Ed Glaeser of Harvard, we have documented the

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differences in Californian city greenhouse gas production when the average household lives in different cities (see <http://www.nber.org/papers/w14238>) as a function of household electricity consumption and transportation behavior.

One surprising omission in the model output is the absence of the electric utility cap and trade system from Table I-2 of http://www.arb.ca.gov/cc/scopingplan/document/economic_appendix1.pdf. How cost effective is this program?

2.An Assessment of the appropriateness of the models to support the evaluation of the policy scenarios to reduce emissions of GHGs

Given the caveats stated above, the EDRAM model, the BEAR model and the E3 model all have significant strengths for evaluating the policy scenarios that AB32 proposes.

While I salute the effort embodied in these models, I would like to elaborate on two modeling concerns I have. One relates to how the BEAR Model and the EDRAM Model incorporate uncertainty about carbon policies pursued by the rest of the nation. The second relates to how firms respond to uncertainty that is created by AB32 regulatory efforts.

A key unknown in thinking about California job dynamics in the presence of AB32 is “what is the rest of the country doing”? Special interests groups lobbying the U.S Congress make this a random variable. Senators Obama and McCain both claim that they support national cap and trade carbon programs. But will they fight for this? How stringent will the cap on U.S aggregate emissions be? Will it be set at the 2008 level or at 50% below the 2008 level? If as

President these men do not pursue aggressive carbon mitigation, then firms who are deciding whether to locate in California or some other location in the United States will see that locating in Nevada will offer them cost advantages relative to locating in California.

My reading of the BEAR model and the EDRAM model is that neither model tackles the tough issue of strategic interactions between California and the rest of the United States. Put simply, if California unilaterally regulates carbon while the rest of the nation does nothing, do the optimistic “negative cost” results stand up? What firms will leave California? What new firms who would have moved to California in the absence of AB32, will now choose to locate in a state without carbon regulation?

AB32 is an enormous undertaking with many unknowns. Neither the EDRAM nor BEAR models appear to explicitly acknowledge the uncertainties that lie ahead. While some of these random events may be great news (i.e discovering new technologies that significantly reduce carbon emissions), there are also random events that can create significant potholes. If economic decision makers are risk averse and anticipate uncertainty but the researcher ignores this, can the researcher predict the behavior of the decision maker?

Why might AB32 make California a less attractive location for employers? Firms do not like regulatory uncertainty. Firms must make investment decisions years ahead of when they actually sell products to consumers. If firms know that they do not know what the regulatory environment will be in the year 2020 and later, then they will decide to delay such irreversible investments (Avinash Dixit and Robert Pindyck Investment Under Uncertainty, Princeton University Press 1994). Neither the EDRAM model nor the BEAR model discusses investment under uncertainty and the option value of delay. Reliance on renewable creates possibilities of

price spikes and brownouts. Firms that cannot afford such undependable access to electricity might avoid California. Neither the BEAR model nor the EDRAM model can tackle the difficult modeling issue of how firms choose investment levels when they are uncertain about what a government regulator (the California Air Resources Board) will do today and leading up to 2050.

3. An assessment of the key data sets upon which one or more of the models rely. Are there other data sets that should be relied upon?

The models use standard high quality data sources to calibrate the models. Such information on likely population growth and per-capita income growth all look quite reasonable to me.

As a micro-economist, I am curious about whether there would be a payoff from further investigation of likely trends within California. The population is agglomerating in the Southern part of the state. The growth is taking place inland further from the coast. The population share of Hispanics is rising. Do any of these demographic trends have any implications for the costs of meeting AB32's goals? An aggregate analysis has to ignore some details. To me these trends matter because, holding population and income constant, they affect electricity consumption, transportation demand and the cost of supplying electricity to different communities.

The E3 model predicts that AB 32 will cause a 14% increase in electricity prices but that household and business electricity expenditure will decline by 5%. This means that this model has built into it that electricity consumers are quite responsive to changes in electricity prices. I

hope that this is a valid assumption but peer reviewed energy economics papers suggest that the elasticity of energy demand is small. Frank Wolak of Stanford reports much smaller demand estimates for industrial and commercial electricity users (see Figure 5 of <ftp://zia.stanford.edu/pub/papers/rtpap.pdf>).

If the elasticity of demand for electricity is small, how does this affect the net cost calculations reported in Table I-2? Electricity consumers would face a higher electricity expenditure bill and this will reduce their real income.

The ARB could easily access utility data to test this key elasticity of electricity demand assumption. To repeat my question, when the price of electricity increases by 14%, how much does electricity demand decrease by? Do different demanders respond differently to this price incentive? The state's electric utilities have monthly electricity bills for residential consumers and commercial and industrial energy consumers. If a representative sample of such consumers' monthly bills could be collected, a simple research project would identify key dates when due to unexpected supply shocks the price of electricity changed for reasons unrelated to demand. This would represent a "natural experiment" opportunity to measure Californian's elasticity of demand for electricity. By studying how this demand elasticity varies across geographic locations (i.e North versus South) and across different types of households and firms, the ARB could explicitly address the issue of how heterogeneous economic decision makers respond to price incentives. This is quite valuable information for explicitly including in the CGE models.

I would also like to see the E3 model conduct more micro-econometric research on whether the income elasticity of demand for electricity is changing over time. Over time, we keep discovering new things to do with electricity such as personal computers and entertainment

systems. As California grows richer per-capita, how much will electricity demand grow by? Is this income elasticity of demand increasing over time? This hypothesis could be easily tested using annual county level data. The electric utilities would provide data on average household electricity consumption in each county in each calendar year from 1990 until the present and this could be merged to county economic data from the REIS data base

(<http://bea.doc.gov/bea/regional/reis/>) to study the relationship between county per-capita income and electricity consumption to study whether the relationship is stable over time.

New data could and should be collected to determine whether building energy efficiency programs will deliver the negative net costs presented in page 6 of the Economic_Appendix 1. As reported in row entry E1, building and appliance programs offer a huge “free lunch” at \$-106 million dollars per MMtCO₂ mitigated. The Scoping Plan proposes to achieve an annual reduction of 15.2 MMtCO₂ using this strategy. If this negative net cost estimate is correct, then this is a great idea. I have a practical suggestion for exploring whether this optimism is warranted. The Air Resource Board should commission a series of field experiments to determine whether in the real world such proposed gains are realized. For example, the ARB could randomly give households “green” new energy efficient appliances in exchange for their old fridge and then track how the household’s monthly actual electricity consumption changes. Energy efficient refrigerators represent just one example. The ARB could cheaply collect additional data by explicitly describing each of the proposed appliance programs, energy efficiency programs and conservation efforts and then test the effectiveness of these respective “treatments” in the real world by using a treatment group/control group comparison study where households would be randomly selected to participate in the program. Once in the experiment, households would be randomly assigned to either the “treatment group” (those who receive the

free green durables and energy audits etc) and those assigned to the “control group”. This approach could be conducted both with residential consumers and industrial and commercial electricity consumers. By comparing the typical electricity reductions for the “treatment group” relative to the electricity reductions for the “control group” the ARB would learn about whether the entries in E-1 of the matrix are valid. (see

[http://www.bus.ucf.edu/wp/content/archives/Glenn\(2\)03-12Field%20Experiment.pdf](http://www.bus.ucf.edu/wp/content/archives/Glenn(2)03-12Field%20Experiment.pdf)). For example, if a “green” refrigerator costs \$700 and lasts for 20 years, and the experiment estimates that the average household who is assigned this product reduces its electricity consumption by 1 megawatt hour per year, then combining this information with the expected price path for electricity and an estimate of the real interest rate, it would be easy to calculate whether such a treatment has a net negative cost for the average household.

4. An examination of the assumptions for their validity and practicality

Earlier I discussed my skepticism about the assumption that the elasticity of demand for electricity is quite price responsive. In section 3 above, I sketched out a low cost research strategy for testing this assumption.

Earlier, I also questioned whether \$10 will be the equilibrium price per ton of carbon in the carbon market in 2020. I would encourage the BEAR and E-DRAM modelers to compute their economic model output based on a range of values for this parameter. For example, how would California’s per-capita income be affected if the permit price is \$20 a ton or \$30 a ton?

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Now, I would like to turn to discuss item by item, the key major carbon reduction policy measures embodied in AB32.

The 33% Renewable Portfolio Standard: I would now like to raise some new issues about the E3 model concerning the cost of meeting the 33% RPS goal by the year 2020. What assumptions is the E3 model making about the cost of siting new large transmission lines? What assumptions are being made about the purchase price of land for siting wind turbines and solar panels? Thousands of megawatts of new renewable generation, including wind, solar and geothermal are under development in California to help meet the state's RPS goals. Getting this "green" power on the grid creates challenges since the areas that are richest in renewable resources are often very remote. "These potential transmission projects, intended to connect and deliver renewable resources to the grid, are estimated to cost a total of approximately **\$6.5 billion** (+/- 50% accuracy) in 2008 dollars." (see <http://www.caiso.com/2007/2007d75567610.pdf>). The California ISO is offering a confidence interval here on their cost estimate. They are acknowledging that future costs associated with meeting the RPS standard represents a random variable. I would like to see the E3 model be equally transparent about the uncertainty associated with output from its model.

A useful guide for appreciating the uncertainty embodied in the 33% RPS is provided by the July 2008 Renewable Portfolio Standard Quarterly Report from the CPUC (http://docs.cpuc.ca.gov/word_pdf/REPORT/85936.pdf)

Permit me to offer some direct quotes from this document:

"Since the legislation adopting the RPS program was passed in 2002, the CPUC has approved 95 contracts for 5,900 MW for new and existing RPS-eligible capacity. Of these contracts, 61

are for new projects, totaling 4,480 MW. Were all this capacity to come online by 2010, we would more than achieve our RPS target. Furthermore, the response to RPS solicitations has been robust and increasing, one indication that the market is maturing. IOUs are finalizing the short-lists resulting from their 2008 solicitations for RPS-eligible energy, and will shortlist for negotiation more than 10 times their annual incremental requirements. It appears, therefore, that the RPS procurement process is working.

Despite the increasing response to RPS solicitations and the large number of signed contracts, RPS progress, which is measured on the basis of eligible *delivered* energy, has been slow. Only 14 contracts for ~400 MW have come online; California's IOUs would need about 3,000 more new MW in next 2 years to be able to meet 20% in 2010. Overall, RPS generation has not kept pace with overall load growth, as demonstrated in Table 1." "It is worth noting that reaching the 20% goal in 2013 would leave the IOUs only 7 years to achieve the 60% increase in RPS generation needed to reach a 33% target in 2020."

It appears that the PUC is saying that the state is unlikely to meet its 2020 RPS goal.

Whether the state meets this future target is unknown today and thus is a random variable. If this goal is not met, then will be cap be tightened in the electric utility cap and trade program. If the cap is tightened, won't the equilibrium permit price rise? If the permit price increases, won't the economic costs of AB32 be higher?

The following paragraph from the July 2008 PUC Report is crucial:

"While California has vast untapped renewable potential, many of the state's lowest cost resources – the low-hanging fruit – have already been developed. California must consider whether a 33% by 2020 mandate may accelerate the increasing costs of large scale renewable procurement, and what impacts such increases may have on ratepayers. Reaching a 33% target will require the procurement of more expensive renewables. Preliminary analysis by E3 indicates that such a target may require a state investment of about \$60 billion in generation and transmission."

Do the cost estimates generated by the E3 model reported in row E-3 of Table I-2 of Appendix I of the Economic Analysis Supplement (see page I-7) reflect this previous paragraph's points? In Table I-2 of the Economic Analysis Supplement, the entry in row E-3

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says that the 33% RPS will cost \$3.7 billion. In a state with roughly 40 million people, this works out to roughly \$100 per person per year. I wonder if this estimate is too small.

The Low Carbon Fuel Standard: I now focus on the implicit assumptions built into the Low Carbon Fuel Standard (LCFS). As shown in row T-2 of Table I-2 of Appendix I of the Economic Analysis Supplement (see page I-6), this program is modeled to be a net zero cost program. One peer reviewed academic economics paper claims that under plausible scenarios, this well intended program will have the perverse effect of raising carbon emissions! This claim is made in a forthcoming paper in a leading academic economics journal. The paper is titled “Greenhouse Gas Reductions under Low Carbon Fuel Standards?”. The authors, Stephen P. Holland, Jonathan E. Hughes and Christopher R. Knittel, argue that the LCSF taxes dirty fuels but subsidizes clean fuels. The net effect of this policy is that carbon emissions can rise because people may drive more using the “cleaner” ethanol fuel but this fuel still has carbon content. Their study highlights that a issue is whether the production of the “clean” fuel sharply increases due to the introduction of the LCSF. For the ARB report to estimate a net cost of zero means that it is ruling out ex-ante some of the key cases that the Holland et. al. paper emphasize as being likely to play out in the real world. I would encourage the ARB’s staff to carefully read the Holland et. al. paper and to contact the authors concerning the likelihood of different *positive cost* scenarios that they pinpoint in their subtle analysis.

Building Energy Efficiency: I would now like to discuss the implicit assumptions built into the optimistic view that building energy efficiency programs offer negative costs. Again, this is possible and I hope that this is true but assumptions are being made. The hopeful view here is

that households and firms will thank the ARB for regulating them as they discover electricity cost savings that they had ignored in the absence of regulation.

Why have self interested households and firms missed cost-effective opportunities to lower their costs for free? Implicit in the belief that there are *negative costs* from building energy efficiency programs is the belief in “behavioral economics”. Put simply, this school of economic thought argues that we are lazy procrastinators. Behavioral economists have documented fascinating facts. One prominent study of inertia and retirement saving behavior documents that the status quo default option played a key role in determining the type of portfolio decision that workers made (see <http://www.nber.org/papers/w7682>). When faced with many different types of choices such as retirement savings options or health insurance options to choose from, households tend to stick with the default option. Behavioral economists have seized upon such findings and concluded that people are not ruthless optimizers but instead are lazy and prone to delegating important choices to others.

(http://papers.ssrn.com/sol3/papers.cfm?cfid=371831&cftoken=32179229&abstract_id=245828)

If people are lazy and prone to inertia, then it is certainly possible that programs such as AB32 that spur action could offer net negative costs.

But, there are alternative explanations for why self interested individuals may not quickly embrace energy technologies that energy engineers believe are much better than their status quo choices. People may be highly impatient and prefer avoiding upfront expenditures even if it results in later energy savings. The upfront “retrofitting” requirements for existing buildings may be larger than the engineers have predicted. People may not be convinced that the “energy efficient” products are truly more energy efficient day in day out. This could be studied using

survey data and by running the field experiments I described above where households would be randomly assigned the energy efficient durable and then by tracking their electricity bill before and after they received such “green products”, we could easily test for what are the electricity savings from “going green”. Research by Paul L. Joskow the President of the Alfred P. Sloan Foundation and Professor of Economics at MIT has disputed the notion that there are “free lunches” here. Joskow in his 1993 Science article argues that real world tests of the energy efficiency gains from utility energy efficiency programs yield much smaller estimates than are predicted in engineering studies (also see Paul Joskow and Donald Marron, What Does a Negawatt Really Cost? Further Thoughts and Evidence, The Electricity Journal). This certainly merits further research before we conclude that the programs promoted under AB32 offer such large cost savings per ton of carbon abated.²

Light Truck Fuel Economy: The final set of implicit assumptions that I would like to highlight pertains to the Pavley Light Duty Vehicle Standards (row T-1) of Table I-2 of the Economic Evaluation Supplement (see page I-6). According to this document , http://www.climatechange.ca.gov/events/2008_conference/presentations/2008-09-08/Daniel_Sperling.pdf, the Pavley Bill would raise the fuel economy standard to 44 miles per gallon by 2020. Today, there are vehicles such as the Toyota Avalon whose fuel economy is way below this standard. While, I cannot know for sure how Toyota would respond to this regulation, I predict that they would produce fewer Avalons if they faced this regulation.

Families who own the Toyota Avalon today are revealing themselves to be a type of consumer

² For a subtle economics study on additional issues here also see “Too Good To Be True? A Examination of Three Economic Assessments of California Climate Change Policy” by Robert Stavins, Judson Jaffe and Todd Schatzki, NBER Working Paper #13587 November 2007.

who values this type of vehicle. If the Pavley Bill means that they can no longer buy such new vehicles in 2020, then they have been made worse off. To suggest that the Pavley Bill offers “negative costs”, the ARB must be implicitly assuming that today’s buyers of big fuel inefficient vehicles (including Governor Arnold Schwarzenegger and his Hummer collection) will suffer no happiness loss from having their consumption choices shrunk by this regulation. To repeat my point, there is an implicit assumption here that the set of vehicles produced in 2020 will be identical along all dimensions except that they will be more fuel efficient. I hope that this is the case but I’m not sure that I believe this. I predict that those households who have a taste for large vehicles will suffer because of this Pavley rule. Their costs from having their choice opportunities shrunk do not appear to be included in row T-1. The vehicle manufacturers will also have to change their production processes and re-direct their research and development efforts to meet this regulation’s mandate. How do we estimate their expected costs of this new regulatory mandate?

Given the importance of the transportation sector as a leading cause of California’s greenhouse gas emissions and given ongoing growth in population and income and ongoing suburbanization (that all encourage more driving), I am surprised that the Scoping Plan’s main transportation section focuses mainly on new vehicle emissions. We all know that new vehicles are a small share of the stock. It takes years for new vehicle regulation to affect the “average” vehicle on the roads. The average vehicle in California is roughly 10 years old. On page 38 of the Scoping Plan, there is a high quality discussion of the benefits of a Pay as You Drive Insurance program. If drivers paid for vehicle insurance per mile of driving, this would act as an incentive program that would affect all vehicles, and reward households who live a “new urbanist” lifestyle of driving little. This incentive program would encourage a densification of

our cities. By discouraging driving, this incentive system would reward households who drive less and would reducing CO2 emissions from the transport sector. It is true that per-mile insurance would not directly improve the fuel economy of the fleet but the Pavley Bill will eventually address this. If a gasoline tax is not a viable option, then the ARB should be considering bundling various transportation policies (for example charging for insurance per mile driven and raising the fuel economy standards) to achieve its objectives. For a favorable analysis of the efficiency benefits of “pay as you drive” incentives and their relationship to local pollution and greenhouse gas emissions see Ian Parry’s paper posted at http://www.aeaweb.org/annual_mtg_papers/2005/0107_1015_0402.pdf.

The important point here is that a CGE model is unlikely to yield plausible estimates of how the simultaneous adoption of a more stringent fuel economy standard and a PAYD insurance program would affect aggregate gasoline consumption for California’s drivers. A micro-economist would argue that one would need a good statistical model of how diverse households choose what vehicle to drive and how much to drive it as a function of the set of new vehicles offered at different prices, the expected price of gasoline and the price of insurance per mile of driving. Only by estimating this micro model can we judge how cost effective this bundle of transport regulations would be at mitigating carbon emissions.

- 5. An assessment of the key variables to which the model is most sensitive and a qualitative assessment of how alternative assumptions could impact the results**

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We know that the E-DRAM model's findings of net economic benefits from AB32 are not robust based on a series of national CGE models being conducted by some of the top economists in the nation. Five leading national CGE models have each independently concluded that carbon taxes do impose small but real economic costs on the economy. I do not know why these models generate different results than the E-DRAM model but I would strongly urge ARB to figure this out. The Scoping Plan highlights that the ARB is aware of some of these studies. They are briefly discussed on page 53 of the Scoping Plan.

These models are based on the national economy as a whole but given that California is roughly 25% of the nation's economy, the results should be similar. I am aware that California has less employment in manufacturing and relies less on coal fired power plants than the rest of the nation but such differences are worth explicitly stating. This would increase confidence in the E-DRAM model's results.

Here I discuss results from Dale Jorgenson's research. Professor Jorgenson is University Professor at Harvard University. A copy of his CGE study is available here.

<http://www.pewclimate.org/docUploads/economic-costs-market-based-climate-policy-june2008.pdf>

In his Table Eight, he cites four other CGE models that all reach the same conclusion that he does. Each of these studies contract the E-DRAM's key finding. Carbon pricing imposes small costs on the economy.

The other models are:

1. The Multi-region National and Multi-sector, Multi-region Trade (MRN & MSMRT) Models of Charles River Associates (CRA).
2. The National Energy Modeling System (NEMS) of the U.S. Energy Information Administration (EIA).
3. The Emissions Projection and Policy Analysis (EPPA) Model of the Massachusetts Institute of Technology's (MIT's) Joint Program on the Science and Policy of Global Change.
4. The Applied Dynamic Analysis of the Global Economy (ADAGE) Model of the Research Triangle Institute International (RTI).

Let us focus on Professor Joregenson's findings

<http://www.pewclimate.org/docUploads/economic-costs-market-based-climate-policy-june2008.pdf>). The policy he studies is constraining the nation's carbon emissions starting in the year 2010 back to the year 2000 level. So, starting in the year 2010 into the indefinite future, emissions would not exceed the year 2000 emissions. He uses his CGE model to evaluate how the U.S economy would be affected by reducing U.S greenhouse gases by 16% from the year 2010 forward.

According to his model's results: "The overall economic impacts from a modest initiative such as described in this report are estimated to be small. By 2020, the annual losses in real GDP from implementing a similar GHG policy are in the range of 0.5 to 0.7% and reach 1.2% by 2040. The effects on household spending, as measured by foregone consumption, are less than half of these income effects. This translates into losses of \$150 to \$300 per household by 2020, approaching \$700 by 2040."

As shown by Professor Jorgenson's model's results, there is a national consensus that carbon pricing is not a "free lunch". We need a clear explanation for how it could be the case that the national models indicate that there are costs to mitigating carbon while the California E-DRAM

model and ARB's key economic document (see http://www.arb.ca.gov/cc/scopingplan/document/economic_analysis_supplement.pdf) predict that it will have negative net costs.

Returning to this issue of alternative assumptions: I encourage the modelers to study how their estimates of economic costs are affected by;

- Being explicit about uncertainty over the true cost of reaching the RPS Standard
- Simulating the effects of carbon taxes at \$10, \$20, \$30.
- Testing how the model's results change if energy demand by households, industry and the commercial sector is much more price insensitive than has been assumed.

6. Commentary on the reasonableness of the models' results as well as their interpretation as presented in the analysis including commentary on how subsequent modeling efforts can be improved

Subject to the caveats I have listed above, I do find many aspects of the E-DRAM and BEAR models to be quite reasonable. I am surprised that no Energy 2020 results have been generated. Given the large uncertainties about the future California regulatory environment in the year 2020, I am surprised that the E3, E-DRAM and BEAR modelers have not offered explicit confidence intervals for their economic predictions.

I would like to see explicit acknowledgement of the most important uncertainties and unknowns in this process. It is quite plausible that these models have generated accurate predictions of the most likely scenario for 2020 but a risk averse population needs to know what may happen in the “worst case” scenario and what is the probability of such events. I do not see how the models discussed here can be used to estimate such probabilities.

I hope I am wrong about this but it appears that the model is based on “best case scenario” planning. I look at the negative net cost estimates reported in Table I-2 of the Economic Evaluation Supplement and I wonder how these numbers would look under alternative assumptions related to the points I raised in section 5.

The Big Picture

The California Air Resources Board has a very difficult, very important assignment. To its credit, the ARB has cleared a number of early hurdles in getting AB32 up and on its way to implementation. If California can come close to achieving its 2020 goal and sets its sights on the more ambitious 2050 carbon mitigation goal, then California will play a key role as a worldwide “guinea pig” demonstrating that ambitious carbon reductions can be achieved without sacrificing significant economic growth.

While AB32 offers California and the world as a whole benefits, it also will impose costs on different parts of our local economy. The E-DRAM model optimistically states that this last sentence is incorrect. The ARB’s Economic Supplement states that AB32’s short run 2020 goals offer carbon mitigation and enhanced economic state growth (see http://www.arb.ca.gov/cc/scopingplan/document/economic_analysis_supplement.pdf). I hope

this is true but our current knowledge base is too limited for me to believe these claims.

California has a well defined objective to reduce greenhouse gas emissions under the AB32 mandate. There are many different possible strategies for achieving this goal. According to page 56 of the Scoping Plan,

“An important requirement of AB 32 is that cost-effectiveness must be considered. This requirement is found in several provisions of the Act. The Act requires the Board to approve a Scoping Plan for achieving the maximum technologically feasible and cost-effective reductions in greenhouse gas emissions (HSC §38561). The Act also requires the Board to adopt rules and regulations to achieve the maximum technologically feasible and cost-effective greenhouse gas emission reductions, and to “consider the cost-effectiveness of these regulations” (HSC §38560 and §38562).”

The current economic models have not generated sufficient information to identify the upper and lower bounds on the cost-effectiveness of different regulations listed in Table I-2 of the Economic Evaluation Supplement. If we take seriously the net costs per ton of carbon abatement reported in Table I-2, then the ARB should drop the RPS program entirely. It is not cost effective relative to the other negative cost programs reported in this Table. To make up for its 21.2 MMTCO₂E, the other “negative cost” programs could be scaled up.

The ARB has trusted “macro” modelers with conducting the main pieces of the analysis. Such models have strengths but they also have significant weaknesses. In this review, I have emphasized how applied microeconomics can inform the policy analysis. Micro economists are always skeptical when we are told that any public policy offers the public a “free lunch”. In this review, I have offered several concrete, relatively cheap approaches for testing whether the proposals listed in Table I-2 of the Economic Evaluation Supplement truly offer net negative costs. The concrete data suggestions I offered in Section III above would take about 6 months to implement and could be conducted for roughly \$250,000 or less if the electric utilities share

their data. I guarantee that the insights generated by this extra effort to collecting new data would be money and time well spent.

The micro insights generated by this research would help to inform the CGE modeling efforts and the state would face less ex-ante uncertainty about the true consequences of pursuing AB32's objectives. I have devoted several sections of my review offering concrete suggestions for how the CGE models can be augmented with new data about real Californian households and firms to generate more credible estimates of the real net costs of AB32.

As I discussed above, the E-DRAM and BEAR modelers have more work to do. They need to reconcile their results with work by the nation's experts such as Professor Dale Jorgenson. They should re-calculate their estimates based on the prospects of higher carbon prices. They should study the robustness of their results to the more realistic assumption that energy demand is inelastic, and they should explicitly discuss how uncertainty can be introduced into their models. For example, how will different firms' investment decisions be affected by uncertainty introduced by AB32 regulation? We need to see the results from the Energy 2020 model. The E3 modelers need to be explicit about the potential negative contingencies related to the 33% RPS standard.

My bottom line is that the ARB deserves ample credit for its efforts up until this point but this Economic Supplement provides an incomplete report on what we know and need to know about the economic consequences of this important regulation.

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Education

- 1988-1993. University of Chicago, Ph.D. in Economics.
- 1986-1987. London School of Economics, G.C. in Economic History.
- 1984-1988. Hamilton College, B.A. in Economics.
- 1980-1984. Scarsdale High School

Employment

- January 2007 Professor, UCLA Institute of the Environment, Department of Economics and the Department of Public Policy
- 2006-2007. Professor of Economics, Fletcher School and Department of Economics, Tufts University
- 2003-2004. Visiting Associate Professor of Economics, Stanford University
- 2000-2006. Associate Professor of Economics, Fletcher School, Tufts University (tenure granted in May 2002)
- 2000. Visiting Fellow, Public Policy Institute of California
- 1999-2000. Associate Professor of Economics and International Affairs, Columbia University
- 1996-1998. Visiting Assistant Professor of Economics, Harvard University
- 1993-1999. Assistant Professor of Economics and International Affairs, Columbia University

Awards and Service

National Science Foundation Grant #9906165, The Concentration of Urban Poverty, 9/11/2000-

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8/31/2002. (Co-Principal Investigator with Ed Glaeser) \$100,612

National Institute of Health grant R01 AG19637, 9/1/2002-8/31/2007. Senior Investigator, *Older Age Health and Longevity: A Long-Term View*. (Dora Costa is the Principal Investigator). Total direct and indirect \$725,335

Environmental Stress, Social Networks, and Older Age Health and Mortality. NIH grant R01AG027960, Sept 1, 2007-Aug 31, 2012. Senior Investigator. (Dora Costa is the Principal Investigator). Total direct and indirect \$1.2 million

Distinguished Fellow, Bing Center for Health Economics at the Rand Institute 2006.

Alfred P. Sloan Foundation Dissertation Fellowship 1993.

Associate Editor of Journal of Regional Science 2003-, special editor of the February 2007 issue of the Journal of Regional Science on environmental issues

Co-Editor of Journal of Regional Science 2007-

Associate Editor of Regional Science and Urban Economics 2004-

Associate Editor of Journal of Urban Economics 2007-

Suggested back cover for the October 2003 and October 2006 issues of the Journal of Political Economy

Member of Environmental Economics Working Group and Cohort Studies Working Group at the National Bureau of Economic Research 2002-

Research Associate of the NBER Environmental and Energy Economics Group, 9/2007-

Books

Green Cities: Urban Growth and the Environment published September 1st 2006 by the Brookings Institution Press (see <http://www.brookings.edu/press/books/greencities.htm>), ISBN 978-0-8157-4816-8 , 2007 Planetizen Top Ten book of the year. Translated into Chinese by CIDEC in 2008.

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Energy in the Modern Economy (UCLA)

California Sustainability Challenges (UCLA)

Environmental Policy Seminar (UCLA)

Gary Yohe, Ph.D.

External Review Report

Economic Analysis Supplement

**Economic Modeling Analysis of the California Air Resources Board Greenhouse
Gas Reduction Scoping Plan**

The California Global Warming Solutions Act of 2006

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October 17, 2008

The Supplement reports the result of what was intended to be a “thorough assessment of the economic impact of the recommended greenhouse gas emission reduction measures on California”. Some caveats are described, but the Supplement argues on the basis of one static model (comparing two “snapshots” in time and whose results are roughly “confirmed” by a second dynamic model) that the implementation of the Preliminary Recommendation in the draft Scoping Plan *will* (my emphasis) benefit California’s economy above “business as usual” in 2020 by:

- An additional \$27 billion in productive activity (above \$3,597 billion);
- An additional \$4 billion in Gross State Product (above \$2,586 billion);
- An additional \$14 billion in personal income (above \$2,093 billion);
- An additional \$200 in per capital income (above \$47,560); and
- An addition 100,000 jobs (above 18,410,000).

Before proceeding, I must admit that it is, to me, almost beyond belief that the Supplement would report these numbers instead of a succinct conclusion of “essentially no change” in California’s economic position as a result of the climate measures. Put another way, any consideration of significant figures would set all of the estimates recorded above at zero.

1. Theoretical basis for the models:

Computable general equilibrium models of the sort employed in this analysis are widely used throughout the economics literature to trace the implications of any number of policy adjustments across a developed economy whose fundamental underpinnings are built on solid and mature markets. Their assumptions are widely understood, as are the caveats that must accompany any communication of their results. The Supplement records these caveats in various places but without much emphasis. That is fine, especially since the incrementally evolving schematic description of the model structure is so well done.

Emphasis is placed on the limitations in macroeconomic models like E-DRAM to account for micro-level interactions with specific program designs and detailed portraits of cost-effective energy technologies (with and without the climate policy initiative). That is fine, as well, though the statement that these models “tend to understate the

benefits afforded by market-based policies” needs a little more support. Why, for example, cannot systematic errors be corrected by recalibrating the aggregate formulations in the model? Detailed portraits would still be missing, but aggregate economic indicators would be improved.

The “Cost and Savings Analysis” framework is fine, as well, even though it uses a truncating approximation for a standard discounted approach. It might be interesting to see if the associate errors for short time horizons (the roughly 12 year’s time between now and 2020) are larger than the reported differences with and without policy intervention. More importantly, the forecasted energy prices for 2020 used in the cost and savings estimations (Table I-1) have to be a significant source of risk. They are highly uncertain, and the sensitivity of the cost and savings estimates has to be extraordinary. This is one place where some serious sensitivity analysis for alternative futures is a necessity.

2. Appropriateness of the models to support the evaluation of the policy scenarios.

My reading of the Supplement suggests that the analysis based on E-DRAM essentially relies on three snapshots of the California economy in time – one for current conditions and two for conditions that would be forthcoming without and with the climate initiative in place. Those results are then confirmed (or at least increased confidence is claimed) by noting that the more dynamic BEAR model supports very similar descriptions of 2020. Surely the 2020 endpoint must be highly sensitive to trajectory taken – sensitive not only to the timing of the climate policy but also to the timing of changes in other driving variables including energy prices and other events that will occur in the “rest of the world”.

In that regard, I wonder about exactly how the dynamic model is calibrated to exogenously determined GDP. The dynamics of the model are driven by accumulation of productive capital and population growth, shifts in technology, and an assumed putty/semi-putty specification of that technology. That is fine; it is just the adjective “exogenously” that worries me. Can the authors argue persuasively that the calibration does not inappropriately limit the variability in macroeconomic outcomes. As an aside, it would be good if the “Sector-Specific Measures” results reported in Table III.6 reported at least the shadow price of carbon.

3. Assessment of the key data sets.

Not being from California, I am not really in a position to judge their quality. They have, though, supported other analyses that have appeared in the peer-reviewed and grey literatures over a period of time. There is therefore no reason to doubt either their quality or their consistency with the bases for other policy analyses conducted for the state.

4. *Examination of the assumptions for validity and practicality.*

Comments about this are interspersed throughout. In general, though, the models conform to the state of the art for computable general equilibrium exercises. My only real concerns lie in a lack of alternative scenarios over which some important sensitivity analysis should be conducted and the spurious precision with which the results for even one scenario are reported. The former concern finds its origins in missing completely any information that decision-makers would have about what futures could, as they evolve, lead the state to a 2020 future completely different from the one depicted. Those decision-makers are therefore uninformed about what to monitor in the intervening 12 years so that they could, if need be, make “mid-course corrections” before they become too expensive.

5. *Assessment of key variables to which the model is most sensitive and a qualitative assessment of how alternative assumptions could impact the results.*

This is difficult to answer because sensitivities have not been explored. On an intuitive level, however, it is impossible to believe that alternative assumptions about behavior across the rest of the world in import/export markets AND the development of carbon-saving technologies would not make a significant difference. In particular, not all of the new technology will emerge from California, so not all of the rent will stay at home in a global (even general equilibrium) reaction to what will be global policy. The potential participation by the United States, China and perhaps India in international mitigation regimes are all sources of variability that need to be considered – not only with respect to whether or not, but also when. The inclusion of a range of possible futures could be accomplished through alternative trajectories for economic variables that abstractly represent alternative political-economy without specific details, but they need to be evaluated. California is vulnerable to climate change, its own climate policy, and the policies of others.

Many others have conducted analyses designed to explore the relative importance of the underlying drivers of economic models designed to produce distributions of emissions trajectories with and without policy intervention. Early analyses by Edmonds and Reilly or Nordhaus and Yohe come to mind. Uncertainty-based model comparisons have been conducted periodically by the Energy Modeling Forum out of Stanford. Perhaps most recently, the authors of the Stern Review, not to mention Chris Hope, himself, have examined relative sensitivities with Hope’s PAGE2002 model (the model that Stern used). In every case, to my memory, specifications of (1) differential rates of technological change across various sectors (carbon-based versus non-carbon based or more detailed disaggregation), (2) differential elasticities of substitution across energy sources (although CES is a problem with more than two inputs in this regard), and (3) differential specifications of the parameters that set the geographic boundary conditions over space and time are always on the top of the list.

6. *Reasonableness of the models' results and their interpretation including commentary on how subsequent modeling efforts can be improved.*

I have already commented on spurious precision.

The result that permits would clear at \$10 per ton of CO₂-eq seems absurdly low for a 28% reduction in emissions against the business as usual baseline. It is far out of line with other estimates. It may be right, but its source needs to be clearly articulated. Economic analyses that supported the Third Assessment Report put the marginal cost of reductions on the order of 25-30% in the \$30 per ton range (converting to 2007\$). The latest Nordhaus work places the tax for the Kyoto trajectory at around \$50 per ton (2007\$) in 2020. The Fourth Assessment Report places the cost of CO₂-eq between \$50 and \$100 per tonne for 20-40% reductions from the A1B baseline in 2030 and \$50 per ton from the B2 baseline. For these last estimates, bottom-up estimates of cost are lower than top-down, but not by much.

These estimates may not be perfectly comparable to the results for California (given different scales and scopes), but they raise many points (beyond the one already noted – that more support of the credibility and robustness of the \$10 per ton estimate is necessary). One is that the claim that macro models overestimate policy costs may be overstated. The second is that the price of permits (or the shadow price of other controls) depends on the baseline; thinking about scenarios that would produce different baselines is therefore essential, as well. A third notes that estimates from any particular baseline are uncertain, as well. It follows that sensitivities with respect to variables noted by any and all reviewers, as well as the authors themselves, must be explored not only with respect to the policy scenarios from a specific baseline, but also with respect to the baseline, itself.

It should also be noted that all of these estimates for the price of CO₂-eq come with estimates of potentially significant economic cost expressed in terms of GDP even though 2020. The AR4 results, for example, can say little more than economic cost would be less than 3% of GDP (in 2030, admittedly) along emissions trajectories that peak in the next decade and fall to 2000 levels by 2020. This is not a surprise, but another reason for more justification. Again, the comparison is not exact, but I am aware of a state analysis for Connecticut conducted by Charles Rivers. It showed significant costs for a similar policy proposal even within a regional cap and trade program. I expect that these results should be comparable, and they are clearly not compatible with the Supplement's main conclusion.

Perhaps all of this could be resolved not only by significant sensitivity analysis, but also by a careful comparative literature search across a range of studies that have offered cost estimates for mitigation in the range of the 28% reduction in emissions considered here. Exploring differences and similarities would put my mind at relative ease, especially if their sources could be explained (or at least hypotheses offered).

As a bottom line, it seems to me that the conclusion of “no-harm” offered by the Supplement must surely be sensitive to a wide range of assumptions about how the future might unfold over time calibrated in terms of a wide range of parameters. This sensitivity (and associated robustness) needs to be thoroughly explored if this is to be a “thorough analysis” in part to display the range of results and in part (more importantly) to determine which futures produce good news and which produce bad news.

While my review of the Supplement raises some issues, however, I sincerely hope that my comments will not be construed, interpreted, or reported as expressing opposition to the policy program, itself. They are, instead, directed simply and exclusively at improving its analytical underpinnings so that the policy can be implemented more effectively over its relatively short time horizon and thereby increase the likelihood of success over the longer term.

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1974 M.Phil. Yale University, Economics
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July 2001 – June 2006: John E. Andrus Professor of Economics, Wesleyan University
July 1985 – June 2001: Professor of Economics, Wesleyan University
June 1994 – June 1999: Director of Research and Sponsored Programs, Wesleyan University
July 1992 - June 1996
and July 2002 – June 2004: Director, Andrus Center for Public Affairs, Wesleyan University
July 1978 - June 1985: Associate Professor of Economics, Wesleyan University
July 1977 - July 1978: Assistant Professor of Economics, Wesleyan University
Aug. 1975 - Aug. 1977: Assistant Professor of Economics, SUNY Albany
Fall 1981 & 1983: Visiting Associate Professor of Economics, Yale University
Fall 1987 & 1989;
Spring 1991 & 1995: Visiting Professor of Economics, Yale University

Fellowships and Awards

Phi Beta Kappa, University of Pennsylvania
Yale University Fellowship
Elected member of Connecticut Academy of Science and Engineering
Elected member-at-large of Sigma Xi
Co-recipient, as a senior member of the Intergovernmental Panel on Climate Change for the Third and Fourth Assessment Reports, of the 2007 Nobel Peace Prize.

Selected Publications:

Articles:

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Member of Climate Change Science Program Product Development Advisory Committee for the United States Department of Energy by the Secretary of Energy. 2006-present.

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FROM: Robert Stavins*

DATE: October 20, 2008

RE: ***Comments on Economic Analysis Supplement, Pursuant to AB 32, California Global Warming Solutions Act of 2006, Prepared by the California Air Resources Board***

1. Introductory Comments

I have been asked to provide comments on the California Air Resources Board's economic analysis of the costs of implementing policies intended to achieve the objectives of AB 32, the California Global Warming Solutions Act of 2006.

Global climate change is an important environmental threat which merits serious attention by policy makers around the world. In order to address climate change in a meaningful way, serious public policies will be required in order to move the world's economies onto significantly less carbon-intensive growth paths. This will not be easy, and it will not be cheap. Indeed it will be costly, as clearly indicated by economic analyses that have been carried out around the world, and have been summarized — to some extent — in the second, third, and fourth assessment reports of the Intergovernmental Panel on Climate (IPCC).

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Because of the magnitude of the challenge and the significant costs of addressing it, the best, most cost-effective public policies will be required, and — pursuant to that — the best economic analyses are essential if governments are to design and adopt such policies. These are lessons that I have learned through several decades of work on the economic dimensions of environmental policy, including extensive research on the economics of global climate change policy.

Indeed, the role of economic analysis in environmental policymaking has been a focus of my research and my public policy engagement with Federal and state governments for several decades. I am a former Chairman of the U.S. Environmental Protection Agency's (EPA) Environmental Economics Advisory Committee, which provides expert advice to the EPA Administrator on economic issues related to environmental decision making. I was appointed Chairman by Administrator Carol Browner during the Clinton Administration, and re-appointed Chairman by Administrator Christie Todd Whitman during the George W. Bush Administration. As Chairman, I directed the review of EPA's revised *Guidelines for Preparing Economic Analyses*, EPA's guidance document for development of regulatory impact analyses of EPA rulemakings. As Chairman, I also directed reviews of EPA's methods of economic analysis. At Harvard, I teach courses that address the theory, method, and practice of benefit-cost analysis. In addition, I have served as a Lead Author of the Second and Third Assessment Reports of the Intergovernmental Panel on Climate Change, where my work focused on climate policy instruments.

2. *Overview of CARB's Economic Analysis*

The California Air Resources Board (CARB) merits credit for having provided an economic analysis of its "Draft Scoping Plan" for achieving AB 32's targets, but for the reasons I describe in this brief memo, I have come to the inescapable conclusion that the economic analysis is terribly deficient in critical ways and should not be used by the State government or the public for the purpose of assessing the likely costs of CARB's plans. I say this with some sadness, because I was hopeful that CARB would produce sensible policy proposals analyzed with sound scientific and economic analysis.

Early on in this process, I conveyed to CARB my view that an outside panel of experts, such as the one on which CARB asked me to serve, could be most helpful to the work of CARB if we were to consult with CARB's economic analysis staff at an early stage. This would have allowed outside experts to help the internal staff construct a solid economic analysis, identify any problems as the staff began to carry out the analysis, and then help the staff improve and refine the analysis. Instead, we have been completely uninvolved in the process until we were sent the economic analysis as it became public.

The result is two-fold. First, the analysis is severely flawed, and hence not useful for the purpose for which it was intended, as I explain below. Second, I fear that at this stage of the process, CARB will find itself in a position of being compelled to publicly defend its economic analysis from critiques such as my own, rather than significantly amend it in response to expert commentary. Both of these outcomes are very unfortunate.

Below I highlight just a few of the most glaring and severe errors and deficiencies in CARB's economic analysis. Because of the schedule I've been given, I cannot go into detailed explanations, nor can I hope to cover the many other problems with CARB's analysis. However, I will be pleased to follow up with CARB staff, if they wish to develop an economic analysis that is useful and reliable.

3. *CARB's Economic Analysis Cannot Be Used to Identify a Cost-Effective Set of Policies*

Even if one accepts the cost estimates that CARB produces, which I believe are significant understatements of the true costs for the reasons I outline below, the estimates are still useless for identifying a cost-effective portfolio of policies to achieve the ambitious objectives of AB 32. This is because there is no comparison of the costs of CARB's chosen portfolio of policies with alternative policies, nor with different stringencies and/or weightings of the policies in its portfolio. Hence, it is absolutely impossible to use the present economic analysis to determine whether CARB's Scoping Plan represents a truly cost-effective means of reducing California's contribution to greenhouse gas concentrations in the atmosphere.

For example, although CARB recognizes some of the economic and environmental merits — greater environmental achievement and lower economic costs — of a cap-and-trade system as a key element of its plan, the economic analysis does not assess what the anticipated impact on cost would be of greater (or, for that matter, lesser) reliance on cap-and-trade within the overall plan.

Likewise, an examination of critical policy design issues — which, I believe, ought to be at the heart of CARB's economic analysis (instead of a flawed set of claims about negative costs) — is impossible given CARB's failure to assess the costs of alternatives to its chosen design. As just one example, some have proposed limiting the use of offsets quantitatively and/or in terms of their geographic origin. I have written elsewhere about the inherent flaw in addressing concerns about the *quality* of offsets by limiting their use either quantitatively or on the basis of their geographic origin. The harshest critics of the use of offsets, such as David Victor and Michael Wara of Stanford University, have likewise written about the fact that the problem of the *quality* of offsets cannot and should not be addressed through *quantitative* or *geographic* constraints, but through employment of better *quality* criteria. CARB fails to analyze the cost implications of quantitative and geographic offset limits, nor have they considered the implications of employing quality criteria instead.

4. *CARB's Economic Analysis Uses a Systematically Biased Baseline Which Leads to Significant Under-Estimates of Costs*

At the heart of an economic analysis of virtually any prospective public policy — as described both in the U.S. Environmental Protection Agency's *Guidelines for Preparing Economic Analyses* as well as in the U.S. Office of Management and Budget's economic analysis guidelines under Presidential executive orders which date back to the Carter administration — is a comparison between anticipated actions and behavior with *and* without the policy in question. It is the difference between those two sets of estimates — that is, the policy scenario and the baseline

(sometimes called the business-as-usual or BAU) scenario — that constitutes the estimated impacts of the policy, whether in regard to its benefits or its costs.

CARB develops a baseline for its analysis which is systematically biased (and remarkably, internally inconsistent) in ways which lead to potentially severe underestimates of costs. In particular, CARB does not include in the baseline some very important existing policies that would be adopted whether or not AB 32 is implemented. One important example are the so-called Pavley standards. Thus, the impacts of the Pavley standards are incorrectly attributed to CARB's Scoping Plan, and the energy-efficiency gains that those standards are believed to yield constitute the vast majority of the net cost savings that CARB attributes to the Scoping Plan.

Interestingly, CARB takes an inconsistent approach with some other policies which it acknowledges *would* impose serious costs, such as the Renewable Portfolio Standard. CARB places these in the baseline scenario, thereby not including their cost in the cost estimate for the Scoping Plan. Thus, CARB has *selectively* included and excluded various non-AB 32 policies in its baseline precisely in ways that lead *systematically* to under-estimating the cost of the Scoping Plan.

There is another way in which CARB comes up with a biased baseline and hence biased estimates of costs. In response to the recent rise in energy prices — in particular, gasoline prices — CARB employs a much greater time path of future energy prices in its baseline and policy scenarios than in previous analysis. The result of this, of course, is an increase in the estimated cost savings from the fuel efficiency improvements that CARB attributes to its Plan, since each gallon saved is worth more. However, this higher anticipated price of energy should also result in predictions of very significant changes in future energy efficiency in the baseline scenario (i.e., even without new policies), due to changes in consumer behavior. This would then *reduce* proportionately the economic gains from energy efficiency policies, possibly offsetting the effect that higher energy prices would otherwise have on those gains. There are extensive literatures in theoretical and empirical economics which validate this point. Because of time, I do not reference that literature here, but — of course — I can do so in the future, if CARB wishes to correct its analysis.

Thus, there is *internally inconsistent* use in CARB's analysis of predictions of future fuel prices, and this inconsistency leads CARB to *systematically under-estimate the costs* of its Scoping Plan.

5. *CARB's Economic Analysis Cannot Be Used to Estimate Competitiveness Impacts*

There is considerable concern regarding the impact of AB 32 implementation on businesses located in California. In its economic analysis, CARB seeks to assess such so-called competitiveness impacts. However, for reasons I lay out below, CARB's analysis is not useful for this purpose.

First of all, the CARB economic analysis — flawed and biased for the reasons I have outlined above — is essentially a long-term analysis. It does not address and does not seek to address the short-term, possibly greater transition costs that can occur as firms are required to undertake significant investments in order to meet the various requirements of the portfolio of policies that are contemplated.

Second, CARB's cost analysis is an aggregate examination in which CARB seeks to estimate overall impacts (or what could be described as average impacts). For example, the analysis suggests that electricity prices will increase by approximately 11 percent. As explained in my comments above, this and other cost elements are under-estimated as a result of fundamental problems with CARB's analytical approach (see section 4, above). However, even putting that aside for the moment, there is another problem with CARB's use of these numbers in its competitiveness analysis. CARB claims that the Scoping Plan will actually improve the competitiveness of California business, because increases in energy efficiency will more than compensate for the induced increases in energy prices. But, at best, this is a claim about overall or average impacts. CARB does not provide any evidence whatsoever that decreases in electricity use will compensate for increased electricity prices in the case of *every* business in the state. A competitiveness analysis must examine the specific distributional, not simply the average, impacts of the portfolio of planned policies.

Thus, CARB's analysis of the competitiveness implications of its Scoping Plan is analytically flawed and empirically misleading.

6. Conclusions

In my review of CARB's Economic Analysis Supplement, prepared pursuant to AB 32, I have found, first, that the analysis cannot be used to identify a cost-effective set of policies to achieve the environmental goals of AB 32, because the analysis provides no comparison of the costs of the chosen portfolio of policies with alternative policies, nor with different stringencies and/or weighting of the policies in its portfolio. Hence, it is impossible to use the analysis to determine whether CARB's Scoping Plan represents a cost-effective means of reducing California's contribution to greenhouse gas concentrations in the atmosphere or whether modifications of the plan would result in achieving the same objectives at lower cost.

Second, the analysis as developed cannot be used to examine critical issues of policy design, such as proposals to limit the use of offsets both quantitatively and with regard to their geographic origin, despite the fact that this could severely drive up compliance costs without addressing concerns about the quality of offsets.

Third, CARB's economic analysis systematically under-estimates costs. It does this in a variety of ways, one of which is by employing a flawed and biased baseline that inappropriately excludes important existing public policies, such as the Pavley standards, the impacts of which are thereby incorrectly attributed to CARB's Scoping Plan, accounting for the vast majority of CARB's

claim of net savings due to AB 32 implementation. The economic analysis selectively includes or excludes various existing non-AB 32 policies in its baseline precisely in ways that lead systematically to under-estimating the cost of the Scoping Plan.

Fourth, by ignoring the impacts on consumer behavior of the higher energy prices it anticipates, CARB inflates the value of the efficiency gains it claims are due to the Scoping Plan and at the same time exaggerates the magnitude of those efficiency gains by claiming much larger impacts of the Scoping Plan on energy efficiency than are reasonable if one accounts for the behavioral changes that are consistent with CARB's forecast of higher energy prices. This internal inconsistency in CARB's analysis regarding its own predictions of future energy prices and baseline behavior is another cause of CARB systematically under-estimating the costs of its Scoping Plan.

Fifth, CARB's competitive analysis fails for a variety of reasons, including the fact that it ignores the short-term transition costs that firms incur when they make significant investments to meet the requirements of the AB 32 policies.

Sixth, more broadly, CARB's analysis cannot be used to examine competitiveness impacts because it is an aggregate analysis of total impacts. That is, CARB examines average impacts, and ignores the tremendous diversity of firms that will be affected by its regulations, and thereby the great heterogeneity of impacts and costs.

As I said at the outset, global climate change is an important environmental threat that merits serious attention by policy makers. Because of the magnitude of the challenge and the significant costs of addressing it — as validated by a wide range of studies, including the Second, Third, and Fourth Assessment Reports of the Intergovernmental Panel on Climate Change — sound economic analyses are essential if sensible public policies are to be designed and implemented. For the reasons I have laid out in this memorandum, the economic analysis on which I have been asked to comment is deficient, flawed, and ultimately biased.

As I also noted above, I regret very much this inescapably negative conclusion, because of my desire to help CARB develop and execute a sound economic analysis. The approach taken by CARB with its peer review process unfortunately did *not* allow for the outside experts, such as myself, to help the internal staff construct a solid economic analysis, identify problems as the staff carried out its analysis, and then help improve and refine the analysis. Sadly, the result is that the analysis is severely flawed and not useful for the purpose for which it was intended.

I remain hopeful that CARB will seek to develop and carry out a sound economic analysis, consistent with basic principles of economic analysis as reflected in guidelines as diverse as the U.S. Environmental Protection Agency's *Guidelines for Preparing Economic Analyses*, the decades-long-series of Presidential executive orders on regulatory impact analysis, the U.S. Office of Management and Budget's guidelines, as well as the practice employed by successive rounds of economic analysis by the Intergovernmental Panel on Climate Change. I remain willing to help CARB in the future if it wishes to develop an economic analysis that is truly useful and reliable.

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"Forecasting the Size Distribution of Farms: A Methodological Analysis of the Dairy Industry in New York State." M.S. thesis, Cornell University, Ithaca, New York, May 1979.

SELECTED PRESENTATIONS

Presentations at universities, research institutes, Federal and state government agencies, Congressional committees, foreign governments, international organizations, foundations, non-profit groups, corporations, and trade associations, including the following (partial list): American Council on Capital Formation, American Economic Association, American Enterprise Institute, American Paper Institute, American Petroleum Institute, Analysis Group, Association for Public Policy Analysis and Management, Brookings Institution, Canadian Cabinet, Carnegie-Mellon University, CF Industries, Chevron Corporation, Coolidge Center for Environmental Leadership, Cornell University, Democratic Leadership Council, Eisenhower Exchange Fellowships, Environmental Law Institute, Environmental Defense Fund, Environmental and Energy Study Institute, Executive Office of the President, Ford Foundation, Foundation for American Communications, Georgia Conservancy, Harvard School of Public Health, Harvard College, Harvard Committee on University Resources, Harvard Institute for International Development, Harvard Law School, Harvard-Japan Energy and Environment Workshop, Harvard-Repsol Conference, Heinz Family Endowments, Intergovernmental Panel on Climate Change, International Public Economics Congress, John F. Kennedy School of Government, Jones, Day, Reavis & Pogue, Lincoln Institute of Land Policy, Massachusetts Institute of Technology, McKinsey & Company, McKinsey Global Institute, Mexican Cabinet, Missouri Department of Natural Resources, Morgan Stanley & Company, National Bureau of Economic Research, National Recycling Congress, Northwestern University, Pew Charitable Trusts, Polish Ministry of Environment, Political Economy Research Center, President's Council of Economic Advisers, Princeton University, Progressive Policy Institute, Rand Corporation, Reason Foundation, Resources for the Future, Rockefeller Foundation, Royal Institute for International Affairs, Scripps Institution of Oceanography, Smithsonian Institution, St. Lawrence University, Stanford University, U.S. House of Representatives, U.S. Environmental Protection Agency, U.S. Department of Energy, U.S. Department of the Interior, U.S. Department of State, U.S. Office of Management and Budget, U.S. Senate,

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U.S. Army Corps of Engineers, University of California (Berkeley, Los Angeles, and Santa Barbara), University of Maryland, University of Michigan, University of Texas, University of Toronto, Vermont Agency of Natural Resources, Vermont Law School, W. Alton Jones Foundation, the White House, the World Bank, the World Economic Forum (Davos), and Yale University.

PROFESSIONAL EXPERIENCE:

Albert Pratt Professor of Business and Government, John F. Kennedy School of Government, Harvard University, 1998-present (Professor of Public Policy, 1997-98; Associate Professor, 1992-1997; Assistant Professor, 1988 - 1992).

Chairman, Environment and Natural Resources Faculty Group, 1998 - present.

Director, Harvard Environmental Economics Program, 2000 - present.

Director of Graduate Studies for Doctoral Program in Public Policy and Doctoral Program in Political Economy and Government, Chairman of the Kennedy School Ph.D. Committee, and Chairman of the Graduate School of Arts and Sciences (GSAS) Standing Committee on Higher Degrees in Public Policy, 2006 - present.

Co-Chair, Harvard Business School-Kennedy School Joint Degree Programs, 2007 - present.

University Fellow, Resources for the Future, Washington, D.C., 1989 - present.

Research Associate, National Bureau of Economic Research, 2007 - present.

Editor, *Review of Environmental Economics and Policy* (Oxford University Press), 2006 - present.

Chair, Environmental Economics Advisory Committee, Science Advisory Board, U.S. Environmental Protection Agency, 1997-2002 (Member, 1992 - 2003).

Member, Board of Directors, Resources for the Future, Washington, D.C., 2003 - present.

Member, Executive Board, Science Advisory Board, U.S. Environmental Protection Agency, 1997-2002; 2004-2007.

Chairman, Executive Office of Environmental Affairs Scientific Advisory Board, Commonwealth of Massachusetts, 2005 - 2007.

Editor, *Journal of Wine Economics*, and Vice President, American Association of Wine Economists, 2006 - present.

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Faculty Chair, Environment and Natural Resources Program, John F. Kennedy School of Government, Harvard University, 1997-2002.

Member, Board of Directors, Association of Environmental and Resource Economists, January 1996 - December 1998.

Member, Executive Committee, Harvard University Center for the Environment (formerly Harvard University Committee on the Environment), 1999-2004; Member, University Working Group on Environment, Harvard University, 1990 - 1992.

Member, Board of Directors, Robert and Renée Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University, 1997-present.

Member, the Board of Academic Advisors, AEI-Brookings Joint Center for Regulatory Studies, August 1998-present.

Member, Editorial Board, B.E. Journals of Economic Analysis & Policy, 2001-present.

Member, Editorial Board, Land Economics, 2001 - 2006.

Member, Board of Editors, Resource and Energy Economics, 1998 - 2005.

Member, Editorial Council, The Journal of Environmental Economics and Management, 1996 - 2004.

Contributing Editor, Environment, 1997 - 2007.

Member, Advisory Board, Environmental Economics Abstracts, 1996 - present.

Member, Editorial Board, Economic Issues, 1996 - present.

Member, Advisory Board, Environmental Law and Policy Abstracts, 1996 - present.

Member, Subcommittee on Energy, Clean Air, and Climate Change, Clean Air Act Advisory Committee, U.S. Environmental Protection Agency, 1997 - present.

Lead Author, Working Group III, Intergovernmental Panel on Climate Change (IPCC), United Nations Environment Program and World Meteorological Organization, 1993 - present.

Member, Reducing Risk Project Steering Committee, Science Advisory Board, U.S. Environmental Protection Agency, 1996 - present.

Member, External Review Panel, Department of Agricultural and Resource Economics, University of California, Berkeley, October 1995.

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Member, Workshop Committee, Association of Environmental and Resource Economists (AERE) 1996-1999 (chair in third year of appointment).

Member, Eco-Efficiency Task Force, President's Council on Sustainable Development, 1994 - 1995.

Member, Energy Modeling Forum Working Group on Energy Conservation (EMF 13), Stanford University, 1992 - 1994.

Member, Advisory Panel on Emissions Trading, Sierra Club, Washington, D.C., 1994 - 1995.

Affiliated Faculty Member, Harvard Center for Risk Analysis, Harvard School of Public Health, Boston, Massachusetts, 1991 - present.

Academic Advisor for Environmental Journalism Program, Foundation for American Communications, 1992 - 1998 (Lecturer, 1989 - present).

Director, Project 88 and Project 88/Round II, co-sponsored by U.S. Senators Timothy Wirth (D-Colorado) and John Heinz (R-Pennsylvania), 1988 - 1992.

Principal, Harvard-Japan Project on Energy and the Environment, 1992 - 1995.

Member, Governor's Task Force on Energy and Environmental Policy, Massachusetts, 1992 - 1994.

Consultant to foundations, private industry, non-governmental organizations, state & local governments, Federal government departments and agencies, and international bodies on environmental economics.

Referee, The American Economic Review, The Quarterly Journal of Economics, The Economic Journal, The RAND Journal of Economics, The Review of Economics and Statistics, The Journal of Environmental Economics and Management, Land Economics, The Energy Journal, Energy and Resource Economics, Energy Policy, The Journal of Policy Analysis and Management, Economic Inquiry, Science, Policy Studies Journal, The Journal of the Air and Waste Management Association, and Harvard University Press.

Member, Risk Reduction Committee, Science Advisory Board, U.S. Environmental Protection Agency, Washington, D.C., 1989 - 1990.

Member, Working Group on Human Interactions with Global Change, National Research Council, Washington, D.C., 1989 - 1990.

Staff Economist, Environmental Defense Fund, Berkeley, California, 1982 - 1983.

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Consultant, Public Interest Economics Foundation, Inc., Berkeley, California, September 1980 - June 1982.

Economist, Giannini Foundation of Agricultural Economics, University of California, Berkeley, 1979 - 1981.

Research Specialist, Department of Agricultural Economics, Cornell University, 1977 - 1979.

Agricultural Representative, Peace Corps Recruitment, Champaign, Illinois, September 1975 - August 1976.

Peace Corps Volunteer, Ministry of Agriculture and Natural Resources, Sierra Leone, West Africa, 1969 - 1973.

AWARDS, HONORS, AND GRANTS:

Principal Investigator, grant from the Doris Duke Charitable Foundation, "The Harvard Project on International Climate Agreements," July 2007 - June 2009 (\$750,000)

Principal Investigator, grant from the U.S. Environmental Protection Agency, "Regulating Pollution Through Information Disclosure: Facility Response to the Toxics Release Inventory," July 2002 - June 2005 (\$395,459)

Principal Investigator, grant from the National Science Foundation, "Climate Change Response Strategies for Water Resources: Price and Non-Price Demand Management," March 2001 - February 2003 (\$238,000)

Principal Investigator, grant from AVINA Foundation, "Land Use and Climate Change," September 2000 - January 2003 (\$125,000)

Principal Investigator, grant from the U.S. Department of Energy, "The Effects of Government Policies on the Invention, Innovation, and Diffusion of Energy-Efficient Technologies," October 1, 1998 - December 14, 2001 (\$519,000)

Principal Investigator, grant from the U.S. Department of Energy, "Land-Use Change and Carbon Sinks: Econometric Estimation of the Carbon Sequestration Supply Function," December 15, 1998 - December 14, 2001 (\$200,000)

Principal Investigator, grant from the U.S. Department of Energy, "Energy-Efficiency Innovation and the Economic and Regulatory Environment," September 1995 - November 1998 (\$461,000)

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Principal Investigator, grant from the U.S. Environmental Protection Agency, "Estimating a CO2 Sequestration Supply Function," June 1993 - August 1994 (\$130,000).

Principal Investigator, grant from the W. Alton Jones Foundation, "Environmental Policy Reform in the First 100 Days of the New Administration," February 1993 - May 1993 (\$40,000).

Principal Investigator, grant from the Office of Research and Development, U.S. Environmental Protection Agency, "Evaluating the Relative Effectiveness of Economic Incentives and Direct Regulation for Environmental Protection: Impacts on the Diffusion of Technology," September 1991 - August 1993 (\$186,000).

Principal Investigator, grant from the W. Alton Jones Foundation, "Project 88 -- Round II, Incentives for Action: Implementing Market-Based Environmental Policies," November 1990 - August 1992 (\$75,000).

Principal Investigator, grant from the Pew Charitable Trusts, "Project 88 -- Round II, Incentives for Action: Implementing Market-Based Environmental Policies," January 1991 - August 1992 (\$75,000).

Principal Investigator, grant from the Surdna Foundation, "Project 88 -- Round II, Incentives for Action: Implementing Market-Based Environmental Policies," March 1991 - August 1992 (\$50,000).

Principal Investigator, grant from the U.S. Environmental Protection Agency, "Project 88 -- Round II, Incentives for Action: Implementing Market-Based Environmental Policies," March 1991 - August 1992 (\$50,000).

Principal Investigator, grant from Carnegie Corporation of New York, "Economic Incentives for Environmental Protection: A Public Policy Sequel to Project 88," June 1990 - September 1991 (\$97,600).

Principal Investigator, grant from Resources for the Future, "Wetland Losses and Willingness-to-Pay for Fishing Opportunities," 1990-1991 (\$20,905).

Project Director, grant from the Richard King Mellon Foundation, Pittsburgh, Pennsylvania, "Harvard-Project 88 Conference," 1989 (\$35,000).

Project Director, grants from the Carnegie Corporation of New York, the Richard King Mellon Foundation, the Rockefeller Family and Associates, and the Keystone Center/Madison Associates, "Project 88 - Harnessing Market Forces to Protect the Environment: Initiatives for the New President," 1988-89 (\$50,000).

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Principal Investigator, grant from the Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C., "Welfare Analysis of Alternative Uses of Forested Wetlands," 1987-88 (\$10,000).

Research Grant from the National Center for Food and Agricultural Policy, Resources for the Future, Washington, D.C., 1986-87 (\$15,000).

Mentorship Grant in Humanities and Social Sciences, Harvard University, Cambridge, Massachusetts, Fall 1986. With H. S. Houthakker (\$10,000).

Dissertation Research Grant from the National Center for Food and Agricultural Policy, Resources for the Future, Washington, D.C., 1985-86 (\$15,000).

Principal Investigator, grant from U.S. Department of the Interior, Washington, D.C., "Impact of Federal Programs on Wetlands," 1985-86 (\$100,000).

Outstanding Master's Thesis - 1979. National competition of the American Agricultural Economics Association, Champaign, Illinois, July 18, 1980.



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October 31, 2008

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Subject: Review of Economic Modeling Analysis

Dear Dr. Bowes:

Thank you for the opportunity to review and comment on the Economic Analysis Supplement to the Climate Change Draft Scoping Plan. We appreciate the work that the California Air and Resource Board has put into assembling the Preliminary Recommendations for reducing California's GHG emissions and the innovative tools that they have used to assess the economic implications. The Pew Center believes that economic modeling is an important tool which should be used to assess policy options because it provides a logical and consistent framework for considering the implications of different policy design elements. Multiple types of models, including CGE, electricity dispatch, and energy combined as ARB has done, typically provide the most robust type of evaluation and policy insights. Unfortunately, the Economic Analysis Supplement, in its current form, gives the appearance of justifying the chosen package of regulatory measures rather than evaluating it or looking at policy options.

A thorough review of the economic modeling, however, was not possible with the documents provided (including appendixes I-V). Detailed model documentation for E-DRAM, BEAR, ENERGY 2020 and the E3 GHG model were not included in the packet nor were detailed modeling results, including sensitivity runs, provided. In addition, while the summary of E-DRAM and BEAR conclusions, the basic energy price forecast (Table I-1) and the estimates of the net cost savings from the Recommended GHG reduction measures (Table I-2) were useful, they were not sufficient. Because the results from economic modeling are highly dependant on the assumptions, definitions, and structure of the models, as well as the data that are used as inputs, a thorough review requires more extensive model documentation and more access to the modeling results. Further, an assessment of key model drivers requires at least some access to sensitivity analyses – which again were not included. As a result, the attached review is based only on the information provided and a general knowledge of the types of economic models that have been used to assess the Preliminary Recommendations.

Our review follows as an attachment to this letter and is organized according to the information requested on the following issues:

Janet L. Peace, Ph.D./Liwayway G. Adkins, Ph.D.

- 1) An assessment of the theoretical basis of the models;
- 2) An assessment of the appropriateness of the models to support the evaluation of the policy scenarios to reduce emissions of GHGs;
- 3) An assessment of the key data sets (e.g., energy consumption forecasts) upon which one or more of the models rely;
- 4) An examination of the assumptions for their validity and practicality;
- 5) An assessment of the key variables to which the model is most sensitive and a qualitative assessment of how alternative assumptions could impact the results; and
- 6) Commentary on the reasonableness of the model results as well as their interpretation as presented in the analysis including commentary on how subsequent modeling efforts can be improved.

Again, thank you for the opportunity to review and comment. We appreciate your efforts on this important topic.

Best regards,

Janet Peace, Ph.D.
Vice President for Markets and Business Strategy
Pew Center on Global Climate Change

and

Liwayway Adkins, Ph.D.
Senior Economist
Pew Center on Global Climate Change

Pew Center Evaluation of Economic Analysis Supplement October 31, 2008

1. Assessment of the theoretical basis of the models

E-DRAM and BEAR

E-DRAM and BEAR are CGE models, which are well suited for capturing linkages between markets across the entire economy and are in general appropriate for assessing economy-wide impacts of GHG reduction strategies, including impacts on individual sectors and household groups. CGE models have also been used extensively to model environmental and climate policies at state, federal, and global levels. While CGE models have their strengths, they are very dependent on the quality of external data inputs from appropriate sector models.

The current analysis employs both CGE models, which can be helpful in comparing and contrasting results for different simulations and for discerning which design features of particular policies can have the greatest impact on results. (Many U.S. EPA analyses, such as those for recent climate legislation, present results from two CGE models.) E-DRAM has somewhat more sectoral disaggregation, but overall BEAR appears to be the more appropriate model of the two for the questions being addressed. BEAR is a dynamic-recursive model and while not fully forward-looking, the dynamics are still a major strength over the static E-DRAM model. This is especially true for the analysis of GHG reduction strategies that will be implemented over a long time horizon and will affect the accumulation of capital.

Energy 2020 model

Energy 2020 is a proprietary model and no documentation was provided. As it was not employed in the current economic analysis of the Draft Scoping Plan, no assessment is made here. In principle, it appears able to provide richer detail on energy markets and how they would be impacted by the regulatory measures under consideration that are not captured in the CGE models. Its use would potentially have improved the analysis.

E3 Electricity GHG model

The E3 model appears not to have been employed in the current analysis of the Draft Scoping Plan, so no assessment is made here.

Other modeling tools

Like other top-down models, CGE models are not rich in sectoral detail, particularly in the energy sector which is a key sector for the analysis of policies to reduce GHG emissions. They can be complemented with appropriate sector models that can offer a more detailed specification of energy markets and emission reduction possibilities at the facility level. Limited documentation was provided in the Economic Analysis Supplement on the proposed use of sector models such as Energy 2020 and E3 and how they might feed in and interact with the CGE models, but it seems likely that their use would improve the analysis.

2. Appropriateness of the models to evaluate the policy scenarios to reduce the emissions of GHGs

a) Are they the correct models given the objective?

CGE models are appropriate for part of the economic analysis being conducted. This is especially true of models like BEAR that can examine the dynamic adjustment path of the program. However, for this type of analysis, CGE models cannot be used alone and are dependent on the inputs from other models, such as more detailed models of the energy sector. Were the other two models to be incorporated in the future, we feel that the analyses would be improved.

b) Were the models used correctly?

The relevant question is not whether the models were used correctly per se, as their theoretical basis is conventional for this class of models and appears to be sound. The results from economy-wide CGE models are highly dependent on the inputs from external sources that feed into them. Questions remain about the quality of the inputs being fed into the models, particularly the direct cost estimates of the regulatory measures (about which some summary information is provided in Appendix I). Concerns about the estimation of the net costs of these measures have been raised elsewhere (e.g., Stavins et al. 2007). Specifically, it has been noted that there are compelling reasons why these bottom-up net cost estimates may have underestimated costs, overestimated savings, and overstated emission reduction potentials. From the discussion provided in the Economic Analysis Supplement, it is not clear that the current economic analysis has addressed these shortcomings at all.

Also, results from CGE models will depend upon the specific scenarios that were examined. These models can be used to perform environmental- and cost-effectiveness analyses of alternative policy proposals. This did not appear to be the objective of the current economic analysis as presented, but would have constituted a more appropriate use of the available models.

c) Any limitations clearly identified?

Some valid limitations of the available models are provided in section 1.2.1 of the Economic Analysis Supplement. For instance, because CGE models usually use a highly aggregated sector specification, they are not capable of capturing abatement cost heterogeneity across individual sources within the same sector and will thus underestimate the cost savings that a cap-and-trade program can deliver (underscoring the need for interaction with appropriate sector models to complement the analysis, such as those that model the electric power sector in detail).

Other stated limitations require some qualification. For instance, one stated limitation of the CGE models concerns the assumption that all resources are efficiently allocated. Although

assorted market failures in energy efficiency are widely recognized, the current analysis assumes that inefficiencies of this sort are rife throughout the economy and this assumption undergirds the entire analysis. As such it is a major driver of results. Despite this, little if any justification for the existence of these inefficiencies is provided. Nor is a complete assessment made of how effective or costly the proposed regulatory measures (from Table I-2) may be at correcting them, since the focus is on the measures themselves and not the actual policies that would bring them about. Another limitation identified is that CGE models are not able to fully capture how individual consumers can and will take steps to pursue lower costs options. However, the vast majority of the emission reduction reductions under the Draft Scoping Plan result from implementation of regulatory measures which on their own may not create incentives for the kinds of behavioral changes suggested. For example, fuel efficiency standards lower emissions per mile driven, but they also reduce the cost per mile driven (since vehicles are more fuel efficient). Consequently, consumers have the incentive to drive more not less.

3. Key data sets

a) Information on emissions, electricity generation, and economic growth under business-as-usual

Projected BAU emissions and economic growth under business-as-usual in 2020 are provided in Table 1 (p. 11), however, no documentation of how these projections were made is provided. Sensitivity of results to alternative projections would also have been useful.

b) Should other data sets be considered?

At the very least, recent economic events and the downturn in the U.S. economy may reduce longer-term economic growth and emission forecasts and consequently, the cost of achieving reduction goals will be lower.

Technology assumptions should also be clearly identified and compared with the assumptions of other modeling work.

c) Are any limitations with the data sets used clearly identified?

Limitations on the data sets are generally discussed. However, the limitations that surround the assumptions of emissions and net costs associated with the regulatory measures deserve more focus. As pointed out in Stavins et al. (2007), projected gasoline prices will influence baseline behavior regarding the voluntary purchase of fuel-efficient vehicles and miles driven, impacting gasoline consumption and thus the cost savings from vehicle fuel efficiency standards. The projected price of gasoline for 2020 in the economic analysis is \$3.685 per gallon, which is considerably higher than past price projections used in previous CARB analyses of the same vehicle fuel efficiency standards. However, it is not clear whether the current analysis has accounted for the behavioral impacts of this now considerably higher price, in terms of the resulting drop in gasoline consumption that would likely ensue under the

baseline which would reduce the estimated cost savings from proposed vehicle fuel efficiency standards. There was no discussion of this issue in the economic analysis. Nor was there any discussion of how the energy and fuel price projections provided in Appendix I were determined. It is unclear whether new federal CAFE standards (2007) are accounted for in the baseline.

4. Examination of assumptions for validity and practicality

Are the assumptions appropriate clearly identified, and reasonably consistent with those used by the scientific community for similar exercises?

Many of the underlying assumptions – concerning the underlying structure and specification the models used, the external information on the cost and efficacy of reduction measures being fed into them, and the mechanics of how this actually works within the models – are not clearly identified within the Economic Analysis Supplement. For example, it is noted on p. I-4 of the Economic Analysis Supplement that “additional details on the derivation of the costs and savings estimates for each measure are provided in the Draft Scoping Plan Measures Documentation Supplement.” This supplement was not readily available for review. Additional examples where information was lacking include how emissions leakage was handled and how regions outside of California were treated.

In terms of whether the assumptions included are “appropriate and reasonably consistent”, we found that many are not reasonably consistent with those used by the scientific community for similar exercises. For instance, it is claimed in multiple places in the Economic Analysis Supplement, such as p. 7, that “The limitations of the available modeling tools noted above prevent a comparison between market-based approaches and alternative strategies, such as one that relies only on direct regulation... to our knowledge, no previous work has such a comparison in any rigorous way that incorporates the costs and savings specific reduction measures.” However, Pizer et al. 2006, using a CGE model of the U.S. economy in conjunction with sector models, find that the use of non-market policies such as fuel economy standards and a renewable fuels requirement can raise costs by a factor of ten as compared to a market-based approach. The current analysis is fundamentally incomplete because it did not provide results for a state economy-wide cap-and-trade (or other market-based) approach to meeting the 2020 GHG emissions target as one of the policy scenarios under consideration. One of the best uses of models such as those used here is the examination of comparative policy designs, and the current analysis does not do this. As such it gives the appearance of justifying the chosen options rather than evaluating them.

As a general template for the analyses of climate and environmental policies, U.S. EPA regulatory impact analyses or EIA’s policy analyses, such as those carried out for the Lieberman-Warner Climate Security Act of 2008, the Clean Air Interstate Rule (CAIR), and the retrospective and prospective analyses of the Clean Air Act, would provide useful guidance. In these analyses sensitivity results are provided, model results are compared, and technology assumptions are identified and discussed.

5. Assessment of the key variables to which the model is most sensitive and a qualitative assessment of how alternative assumptions could impact the results

a) Variables that have greatest impact on the results

Variables with the greatest impact on the results would logically include projected energy and fuel prices because they can have significant impacts on the baseline and estimated energy cost savings of the regulatory measures. The carbon price is also a key variable. (Ideally, these models would determine the carbon price endogenously as part of a cap-and-trade simulation, but this was not the chosen modeling approach.).

b) Degree to which the uncertainties of the variables have been acknowledged or evaluated

Sensitivity analysis is critical to assessing the uncertainties in the model but these are not provided in the Economic Analysis Supplement. This is a standard exercise for simulation models in order to gauge the sensitivity of model results to key parameters (like production and demand elasticities used to calibrate the CGE models) and inputs such as those mentioned in part “a” above. For example, in a recent study by Deutsche Bank (2008) that examined the Draft Scoping Plan, carbon credits in California are expected to be in the \$15-\$60 per ton range between 2012 and 2020. These estimates are considerably higher than the \$10 per ton price used in the current analysis.

In addition, the current analysis is taking place in a policy vacuum. It can be expected that federal and world climate policy will evolve during the period of analysis and this can be expected to have significant implications for California’s state program. At the very least a qualitative discussion of this issue should have been included.

6. Reasonableness of the models’ results as well as their interpretation as presented in the analysis and how subsequent modeling efforts can be improved

a) Are the results and associated interpretation supportable?

The overall result that the combination of regulatory measures in the Draft Scoping Plan, in combination with a limited cap-and-trade program, can achieve the 2020 emissions target for California at no net cost to the state economy is highly counter-intuitive. The current analysis also suggests that the larger the scope of the cap-and-trade program, the smaller will be the economic benefits – in effect suggesting that command-and-control measures are more cost-effective than market-based approaches. These results and others in the current analysis contradict a wide body of economic modeling that has repeatedly confirmed several key results. These results are: (1) no matter what form a climate policy takes (i.e. non-market regulatory measures or a market-based approach), policy-induced GHG emissions reductions will reduce aggregate measures of economic activity and welfare (when environmental benefits are not accounted for); (2) market-based mechanisms like cap-and-trade programs are more cost-effective than command-and-control, regulatory standards-based approaches; and

(3) policies to reduce GHG emissions are likely to have regressive impacts on low-income households.

Because the overall results are highly counter-intuitive and contrary to a wide body of theoretical and empirical work, the current analysis should have done more to explain and justify these results. In particular, it appears that the results are being driven by the net cost (in many cases, net savings) calculations of specific regulatory measures that are inputs to the models, as well as the limited set of policy simulations conducted. Furthermore, the report in many places claims that results are conservative but does not provide comparison for this assertion. As such, the analysis gives the appearance of justifying the chosen package of regulatory measures rather than evaluating it.

A major criticism of the current analysis is that it provides only a single-year snapshot of the impacts of the Draft Scoping Plan on the California economy in 2020. This is by no means a complete picture of the full impact of the Draft Scoping Plan, which will be implemented over all of the interim years. The current analysis essentially models a positive productivity shock in the models, in which less energy is now needed for the same productive capacity. Usually, analyses of this sort assume the opposite, that environmental regulations draw productive resources away from other sectors and create a drag on economic growth by reducing the accumulation of capital and dampening productivity growth. It is reasonable to ask how proposed measures such as those in the Draft Scoping Plan are going to affect the economy on a yearly basis (or other appropriate interval) over time, since they can be costly in early years and less so further into the future. These transitional adjustment costs can be important and are neither examined explicitly nor discussed in a qualitative sense in the current analysis. The BEAR model appears capable of telling a dynamic story along these lines but such an analysis is not presented.

b) Are there important scientific caveats not reflected?

See question “a”.

c) What might add to the robustness of the economic modeling analysis?

More thorough documentation on the models, external data inputs, and specifics of the simulation conducted is necessary.

In addition, a more varied set of policy simulations should be run for the same emission reduction target, comparing a standards-based approach (using the suite of proposed regulatory measures in the Draft Scoping Plan), an economy-wide cap-and-trade approach (with an endogenous allowance price and assorted design options like offsets, banking, and borrowing as variants), and hybrid scenarios of the two. For each simulation, results for key variables should be provided in a side-by-side comparison of the two models.

The potential exists for important interactions among the proposed regulatory measures in the Draft Scoping Plan (and with current and possible future federal regulations) and these should be accounted for as they will have both environmental and cost implications. Both the E-

DRAM and BEAR models use as inputs external estimates of the net costs (or savings) of proposed reduction measures that are computed separately, as if those measures were being implemented individually rather than as a package. As a result, the analysis conducted by these models will fail to account for important interactions among those measures in estimating their aggregate cost and emission reduction potential.

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Stavins, Robert N., Judson Jaffe, and Todd Schatzki, 2007. "Too Good to Be True? An Examination of Three Economic Assessments of California Climate Change Policy." AEI-Brookings Joint Center for Regulatory Studies, Related Publication 07-01, Washington, D.C.

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CLIMATE CHANGE POLICY SPECIALIST with experience in U.S. and International policy development, economic analysis, government relations, emissions trading, industry and consumer outreach, and sensible balancing of natural resource/environmental protection and economic development.

Well-versed in a wide array of environmental/natural resource policy tools including the design of permit trading systems (tradable development, water or GHG emissions) at the state, federal, and international levels. Have researched, written and taught about the technical, economic and policy issues associated with climate change policy, land protection, solid waste management, recycling, emissions trading, and energy. Have researched and contributed to the technical design of federal, state (e.g., RGGI) and international (EU and Canada) GHG trading programs. Broad based knowledge of environmental and resource issues/policies in agriculture, forestry, air quality, renewable energy, water quantity/quality issues, solid waste, mining, conventional energy, and geological sequestration.

Up-to-date on the major economic models, modeling assumptions and model limitations associated with evaluating the costs and benefits of policy.

Initiated, established and led multi-province cross-governmental climate change team to develop rules for greenhouse gas trading and offsets. Founding Co-Chair of the Canadian National Offsets Quantification Team. Significantly contributed to the implementation of a greenhouse gas trading program for Alberta/Canada that promoted cost effective emission reductions as part of Canadian implementation of their Climate Change plan. Requested by Alberta government in June 2007 to be part of an international Expert Panel to discuss Alberta's Climate policy course beyond 2012.

EXCEPTIONAL COMMUNICATOR who can adapt presentation and writing style to target audience.

- ◆ Have briefed Congressman, Senators, Ministers, hill staff and state/provincial bureaucrats on climate policy, offsets and economics
- ◆ Extensive public speaking experience; Can connect with a wide variety of audiences
- ◆ Significant teaching experience in large (+250) and small groups settings.
- ◆ Skilled writer of technical reviews/reports, briefing notes, marketing material and non-technical reports/articles for the general public.

STRATEGIC PROGRAM MANAGER with a career track record of program/project development and implementation.

- ◆ Coordinated Pew Economic Program for maximum effectiveness with respect to research, timing and coverage of relevant issues.
- ◆ Developed strategic partnerships to complementary groups including Point Carbon and RFF.
- ◆ Conceptualized and developed strategies for industry engagement in Canadian climate change issue including: establishment of a subscription newsletter, a speaker series, trading simulations, and multiple outreach workshops on manure management, agriculture, forestry and GHG offsets.
- ◆ Identification and development of cost-effective offset projects (including forestry, acid-gas

reinjection, coal bed methane, and landfill gas methane oxidation).

Education

Ph.D. Mineral (Resource) Economics, Colorado School of Mines, Golden, Colorado, 1994.

M.S. Mineral (Resource) Economics, Colorado School of Mines, Golden, Colorado, 1990.

B.A. Geology, University of Colorado, Boulder, 1985.

Professional History

PEW CENTER ON GLOBAL CLIMATE CHANGE, Washington, DC

04/05 – present

Director of Markets and Business Strategy

Program manager for the Markets and Business Strategy Group overseeing the Center's Business Environmental Leadership Council (BELC), the largest US-based association of companies devoted to climate-related policy and corporate strategies, comprising 42 major corporations with combined market capitalization of \$2.8 trillion.

- ◆ Significant involvement in the US Climate Action Partnership through co-chairing the cost-containment subgroup, chairing the offsets subgroup and facilitating the economic modeling work for the initiative.
- ◆ Responsible for the Centers engagement in the Offset Quality Initiative, a multi-group effort to address a key climate policy element believed by the Center to be necessary for a credible and robust carbon market.
- ◆ Responsible for the Center's research on the economics of climate change policies. Coordinated modeling efforts for all Pew staff and with senior economists from Harvard, Stanford, MIT, and RFF
- ◆ Pew “point person” on the subjects of economics, market design, the EU-ETS, CCX, GHG offsets and Canadian policy. Led the cost containment work group, the offset subgroup and the economic subgroup for US Climate Action Partnership.
- ◆ Responsible for communication of carbon market analysis, economic issues, and modeling results to reporters, policy-makers, academic researchers and business leaders, by means of reports, briefings, and presentations.
- ◆ Project manager for the Pew Center/Point Carbon conference 2007 (speaker engagement, logistics, panel moderator, etc.).

CLIMATE CHANGE CENTRAL, Calgary, AB

09/01 – 05/05

Program Director: Offset Development and Industry Relations

- ◆ Essential member of 5 person core management team, responsible for overall company direction, operation, fund development, program selection/funding and board engagement.
- ◆ Designed, implemented and managed major program area for unique Canadian Non-Profit Company
- ◆ Worked with all levels of government (Federal, Provincial and Municipal) and all industrial sectors (with significant emphasis on energy sector) to evaluate policy options and investigate strategies for GHG control increased use of renewables and improved energy efficiency.
- ◆ Projects included forestry, acid gas reinjection for enhanced oil recovery, landfill gas capture and utilization, landfill gas oxidation, manure management, bio-energy, reduced gas flaring, intermodal switching (truck to train) and fuel switching (biomass and diesel to solar).

UNIVERSITY OF CALGARY, Calgary, AB

9/95 – Present

Assistant Adjunct Professor of Economics

- ◆ Courses taught - Natural Resource Economics I and II, Environmental Economics, and Microeconomics

Janet L. Peace, Ph.D./Liwayway G. Adkins, Ph.D.

- ◆ Donner Foundation Research Grant-Stakeholder Based Land Use Planning: A Comparison of Policies in B.C. and Alberta.

U.S. GENERAL ACCOUNTING OFFICE, Denver Regional Office
Program Evaluator Natural Resource Policy (NRM/RCED)

9/91 to 9/94

U.S. GEOLOGICAL SURVEY, Branch of Geochemistry, Denver
Geologist

2/85 to 11/90

References Available on Request

CURRICULUM VITAE

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EDUCATION

Ph.D., Economics, University of Virginia, Charlottesville, VA, 2006. Dissertation: “Coordinating Global Trade and Environmental Policy: The Role of Pre-Existing Distortions.” Fields of concentration: environmental and natural resource economics, international economics, and industrial organization.

M.A., Economics, University of Virginia, Charlottesville, VA, 1990.

B.S., Economics, Carnegie Mellon University, Pittsburgh, PA, 1989. Junior year abroad in Paris, France.

EMPLOYMENT

Senior Fellow, Economics, Pew Center on Global Climate Change, Arlington, VA, 2008-present.

Economist, U.S. EPA, Office of Policy, Economics, and Innovation, Washington, DC, 1997-2005.

Consultant, Adkins Associates, Inc., Vienna, VA, 1994-95.

Consultant, World Bank, Washington, DC, 1990-1991.

Teaching Assistant, Department of Economics, University of Virginia, Charlottesville, VA, 1989-90.

Research Assistant, Department of Economics, University of Virginia, Charlottesville, VA, 1989.

Research Intern, Federal Energy Regulatory Commission, Washington, DC, 1989.

SELECTED PAPERS AND PRESENTATIONS

“Coordinating Global Trade and Environmental Policy: The Role of Pre-Existing Distortions” (with Richard F. Garbaccio). Presented at the Conference on Global Economic Analysis, Purdue University, West Lafayette, IN, June 7, 2007.

“Simulating the Effects of the FTAA on Global Carbon Emissions: A General Equilibrium Analysis” (with Richard F. Garbaccio). Presented at the International Conference on Policy Modeling, Istanbul, Turkey, July 4, 2003.

“The Effects of the Proposed FTAA on Global Carbon Emissions: A General Equilibrium Analysis” (with Richard F. Garbaccio). Presented at the Second World Congress of Environmental and Resource Economists, Monterey, CA, June 26, 2002.

“Financial Infrastructure: Issues for Developing Countries” (with Ashok Khanna). World Bank Institute working paper 19695, 1992.

“Emissions Trading and Pollution Control of Electric Utilities.” Office of Economic Policy, Federal Energy Regulatory Commission, Washington, DC, August 1989.