Too Good to Be True?
An Examination of
Three Economic Assessments
of California Climate Change Policy

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Executive Summary

California's Global Warming Solutions Act of 2006 limits California's greenhouse gas (GHG) emissions in 2020 to their 1990 level. Global climate change is a pressing environmental problem, and the best possible public policies will be required to address it. Therefore, analyses of prospective policies must themselves be of high quality, so that policymakers can reasonably rely on them when making the critical decisions they inevitably will face.

In 2006, three studies were released indicating that California can meet its 2020 target at no net economic cost — raising questions about whether opportunities truly exist to substantially reduce emissions at no cost, or whether studies reaching such conclusions may simply severely underestimate costs. This paper provides an evaluation of these three California studies.

We find that although opportunities may exist for some no-cost emission reductions, these California studies substantially underestimate the cost of meeting California's 2020 target. The studies underestimate costs by omitting important components of the costs of emission reduction efforts, and by overestimating offsetting savings that some of those efforts yield through improved energy efficiency. In some cases, the studies focus on the costs of particular actions to reduce emissions, but fail to consider the effectiveness and costs of policies that would be necessary to bring about such actions. While quantifying the full extent of the resulting cost underestimation is beyond the scope of our study, the underestimation is clearly economically significant. A few of the identified flaws individually lead to underestimation of annual costs on the order of billions of dollars. Hence, these studies do not offer reliable estimates of the cost of meeting California's 2020 target. Better analyses are needed to inform policymakers.

While the Global Warming Solutions Act of 2006 sets a 2020 emissions target, critical policy design decisions remain to be made that will fundamentally affect the cost of California's climate policy. For example, policymakers must determine emission targets for the years before and after 2020, the emission sources that will be regulated to meet those targets, and the policy instruments that will be employed. The California studies do not directly address the cost implications of these and other policy design decisions, and their overly optimistic findings may leave policymakers with an inadequate appreciation of the stakes associated with decisions that lie ahead. As such, California would benefit from studies that specifically assess the cost implications of alternative policy designs.

Nonetheless, a careful evaluation of the California studies highlights some important policy design lessons that apply regardless of the extent to which no-cost emission reduction opportunities actually exist. In particular, policies should be designed to account for uncertainty regarding emission reduction costs, much of which will not be resolved before policies must be enacted. Also, consideration of the different market failures that lead to excessive GHG emissions makes clear that to reduce emissions cost-effectively, policymakers should adopt a market-based policy (such as a cap-and-trade system) as the core policy instrument. The presence of specific market failures that may lead to some no-cost emission reduction opportunities suggests the potential value of additional policies that act as complements, rather than alternatives, to a market-based policy. However, to develop complementary policies that efficiently target such no-cost opportunities, policymakers need better information than currently exists regarding the specific market failures that bring about those opportunities.

I.   Introduction

On September 27, 2006, Governor Arnold Schwarzenegger signed into law the California Global Warming Solutions Act of 2006. The Act sets a statewide greenhouse gas (GHG) emissions limit for 2020 that is equivalent to California's 1990 emissions level, and gives the California Air Resources Board (CARB) substantial discretion to establish policies to achieve that target.[1] Global climate change is a pressing environmental problem, and the best possible public policies will be required to address it. While there are divergent views about the merits of California's emissions objectives, most would agree on the importance of California developing policies that minimize the economic costs and risks associated with achieving those objectives. Toward that end, analyses of the costs of prospective policies can offer insights that inform the development of those policies. However, to be useful, such analyses must be of high quality so that policymakers can reasonably rely on them when making the critical decisions they inevitably will face.

Three studies (hereafter the "California studies") released in 2006, prior to the Act's passage, seek to quantify the emission reduction potential and costs of various measures that could be implemented in California. These studies were performed by California's Climate Action Team (hereafter the "CAT study"), the Center for Clean Air Policy (hereafter the "CCAP study"), and David Roland-Holst, a professor of economics at Mills College and an adjunct professor at the University of California at Berkeley (hereafter the "Berkeley study").[2] The California studies' common and overarching conclusion is that California's 2020 emissions target can be achieved through a portfolio of measures that would involve no net economic cost. That is, the studies find that California's target can be achieved through measures whose direct costs are outweighed by the offsetting savings they create, making them economically beneficial even without considering the emission reductions they may achieve.

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[1] On October 17, 2006, Governor Schwarzenegger issued Executive Order S-20-06, which orders the California Environmental Protection Agency (Cal/EPA) to take the lead role in developing climate change programs, raising questions about the respective roles of CARB and Cal/EPA in designing regulations to meet the 2020 target.

[2] Center for Clean Air Policy (CCAP) (2006); California Climate Action Team (CAT) (2006a); and Roland-Holst (2006a). Professor Roland-Holst later published an extension to his original study (2006b), but that second study's findings are driven largely by aspects of his analysis that were present in the original study. This paper therefore focuses on his original study.

Given the substantial emission reductions required to meet California's 2020 target, such findings are surprising and differ dramatically from the vast majority of economic analyses of the cost of reducing GHG emissions. The California studies' surprising findings and their influence on the California climate policy debate suggest that their reliability should be carefully evaluated. This paper provides such an evaluation. While of particular relevance to development of California climate policy, lessons that emerge from this evaluation have broader implications for similar studies that have been performed — and undoubtedly will continue to be performed — at the state and national level.

Although they differ from many other economic analyses of climate policy, the California studies' findings are reminiscent of similar studies by the U.S. Department of Energy (DOE) laboratories that were performed in the run-up to and aftermath of the Kyoto Protocol negotiations.[3] Like the California studies, the DOE studies suggested that substantial emission reductions could be achieved at no net economic cost.[4] Thus, the California studies once again raise questions that emerged previously in response to the DOE studies. Namely, do opportunities exist to substantially reduce GHG emissions at no (or even negative) cost? Or are there reasons to believe that studies reaching such conclusions significantly underestimate costs?

A distinguishing feature of the California and DOE studies is that they rely on "bottom-up" analyses of policy costs. That is, they build an estimate of an individual policy's costs from the bottom up by piecing together the components of those costs, including any offsetting savings resulting from the policy's implementation.[5] Researchers have highlighted several reasons why some past bottom-up analyses — including the DOE studies — substantially underestimated the cost of climate policy, including the omission or incorrect valuation of components of those costs (including any offsetting savings).[6] Since many of these flaws can be avoided (or their effects can be mitigated) through careful analysis, we evaluate whether the California studies represent an advance relative to previous analyses, or if they suffer from

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[3] Interlaboratory Working Group (1997) and Interlaboratory Working Group (2000).

[4] For example, the 2000 DOE study found that, by 2020, the United States could reduce its carbon dioxide (CO_2) emissions by up to 32 percent through a set of policies whose economic benefits (including savings on energy expenditures) are comparable to their overall cost. Interlaboratory Working Group (2000), pp. ES.1, ES.5.

[5] For brevity, we often refer to a policy's net costs — including offsetting savings — simply as its costs.

[6] For example, *see* Jacoby (1999); Sutherland (2000); and Jaffe, Newell, and Stavins (1999).

similar significant flaws. We find that many of the well-recognized problems present in prior bottom-up analyses are apparent in the California studies, leading those studies to overstate the emission reduction potential of policies that they examine, and to understate the cost of achieving those reductions. While quantifying the full extent of the resulting cost underestimation is beyond the scope of our review, we can conclude that the underestimation is economically significant, because just a few of the identified flaws individually lead to underestimation of annual costs on the order of billions of dollars. While some no-cost emission reduction opportunities may exist, it is clear that the California studies arrive at overly optimistic conclusions about the economic implications of meeting California's emissions target.

It is important to recognize that regardless of what the underlying cost of particular emission reduction measures may be, the cost of meeting California's 2020 target will be significantly affected by policy design decisions that policymakers must make in the coming years. For example, policymakers must determine emission targets for the years before and after 2020, the emission sources that will be regulated to meet those targets, and the policy instruments that will be employed — to name just a few key design decisions.

The California studies do not directly address the implications of alternative policy designs, and their overly optimistic findings may lead some policymakers to pay insufficient attention to the design decisions that lie ahead, the consequences of which could be dramatic. Indeed, California's own experience with electricity restructuring demonstrates how poor policy design and implementation can undermine achievement of well-intentioned policy objectives. Therefore, while it is important to recognize the California studies' shortcomings, it is even more important that future analyses assess the implications of alternative policy designs for achieving California's emissions objectives. In the meantime, our evaluation of the California studies highlights some important policy design lessons that apply regardless of the cost of emission reduction measures.

In Section II, we summarize the California studies' findings. In Section III, we describe how those studies overstate the emission reductions that would be achieved by the policies they examine. In the subsequent two sections, we address the California studies' assessments of emission reduction costs. The three studies' findings that substantial reductions can be achieved

at no cost are driven by assessments of energy efficiency policies. As such, the studies mark another chapter in the "energy efficiency gap" debate. Central to this debate are questions about the extent to which limited adoption of energy-efficient technologies reflects economic inefficiencies that public policy can beneficially address. In Section IV, we describe this debate and provide a framework for understanding both how some no-cost emission reduction opportunities can exist, and how analyses like the California studies can underestimate emission reduction costs. In Section V, we identify flaws in the California studies that lead them to underestimate significantly the cost of meeting California's 2020 emissions target. In Section VI, we discuss lessons for the design of climate policy that emerge from an evaluation of these studies, and we conclude in Section VII.

II. Overview of the California Studies

The amount of emission reductions necessary to meet the 2020 target established by the California Global Warming Solutions Act of 2006 remains uncertain. First, although the emissions target is California's 1990 emissions level, CARB has not yet made certain measurement decisions that are necessary to determine that level. Second, the amount of emission reductions required to meet the target depends on what emissions would be in 2020 if California did not establish emission reduction policies. That is, the amount of required emission reductions depends on the baseline, or business-as-usual, emissions level. While both the 2020 emissions target and the baseline emissions level are uncertain, California's Climate Action Team estimates that baseline emissions in 2020 would be 600 million metric tons of carbon dioxide equivalent (MMTCO$_2$e), and that 1990 emissions were 426 MMTCO$_2$e.[7] Thus, according to the CAT study, California will need to reduce its 2020 emissions by 174 MMTCO$_2$e (or 29 percent) from baseline levels in order to meet its target. To put California's target in the context of other climate initiatives, it is worth noting that the target's timetable and stringency (in

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[7] CAT (2006a), p. 64. A ton of CO$_2$ equivalent emissions is the amount of emissions of any GHG that has the same radiative impact as one ton of CO$_2$ emissions. This common measure of GHG emissions allows emissions of different GHGs to be compared and added together into a measure of total GHG emissions.

terms of the percentage reduction in emissions that is required) are very similar to the timetable and stringency of the target the United States would have faced under the Kyoto Protocol.[8]

The California studies seek to quantify the emission reduction potential and cost of numerous measures that might contribute to limiting 2020 emissions.[9] These measures range from standards that have already been developed by California regulatory agencies to actions that could be undertaken to reduce emissions, but for which an associated policy has not yet been developed. The measures examined by the CAT, Berkeley, and CCAP studies are estimated to reduce 2020 emissions by 195 $MMTCO_2e$, 96 $MMTCO_2e$, and 58 $MMTCO_2e$, respectively. Table 1 presents emission reduction estimates from these studies, grouped into major categories of emission sources and emission reduction measures. There is significant overlap in the measures examined. For example, the Berkeley and CAT studies both consider emission reductions from California's vehicle GHG emissions standards, and all three studies consider opportunities for sequestration of CO_2 through afforestation. In many cases, these studies rely on the same underlying analyses for estimates of the emission reduction potential and cost of particular measures.

Based on their analyses, the studies suggest that California can meet its 2020 emissions target through measures that, on net, achieve economic gains. For example, the CAT study identifies emission reduction opportunities that exceed the 174 $MMTCO_2e$ of reductions that it estimates are necessary to achieve the 2020 target. In so doing, the CAT study concludes that, "in 2020 the implementation of the [emission reduction] strategies is expected to increase jobs and income by an additional 83,000 and $4 billion, respectively…."[10] The Berkeley study finds that more than half of the emission reductions needed to meet the 2020 target can be achieved while increasing California's gross state product (GSP) in 2020 by $55 billion.[11,12] Professor

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[8] The U.S. Department of Energy's (DOE) Energy Information Administration (EIA) estimated that the United States' Kyoto Protocol target of seven percent below its 1990 emissions level would have required emissions to be reduced to about 30 percent below business-as-usual levels less than 15 years after the Protocol was negotiated. U.S. DOE, EIA (1998), p. xiii.

[9] In some cases, these studies evaluate the emission reduction potential and cost of particular *actions*, rather than of the *policies* that are necessary to bring about those actions. As we discuss in Section V.B, this distinction is important because a policy's cost can significantly exceed the cost of the actions that it seeks to encourage.

[10] CAT (2006a), p. 65.

[11] Roland-Holst (2006a), p. 2-8.

Roland-Holst subsequently released an extension to that study in which he finds that the additional reductions necessary to meet the 2020 target can be achieved while still yielding comparable economic gains.[13]

Table 1
Emission Reductions in 2020 from Measures Examined by the California Studies[1]
(MMTCO$_2$e, with percent of total estimated reductions in parentheses)

Category	CAT Study		Berkeley Study[2]		CCAP Study[3]	
Transportation Emissions						
Motor Vehicle GHG Emissions Standards	30	(15.4%)	31	(32.3%)		
Measures to Reduce Vehicle Miles Traveled Through Improved Land Use and Transportation Infrastructure	27	(13.9%)			11	(18.9%)
Other Measures to Reduce Vehicle Emissions (Including Alternative Fuels)	14	(7.1%)				
Electricity Sector Emissions						
Measures to Reduce the Carbon Intensity of Electricity Generation	34	(17.6%)				
Programs and Standards to Increase Energy Efficiency in Buildings	30	(15.3%)	24	(25.0%)		
CO$_2$ Sequestration and Non-CO$_2$ GHG Emissions						
Measures Targeting Forestry and Agricultural Practices	34	(17.5%)	13	(13.5%)	14	(23.6%)
Measures to Reduce Methane Emissions	6	(3.1%)	14	(14.6%)	17	(28.5%)
Measures to Reduce HFC, PFC, and SF$_6$ Emissions	11	(5.4%)	11	(11.5%)	15	(25.6%)
Other Measures	9	(4.7%)	3	(3.1%)	2	(3.3%)
Total	**195**	**(100.0%)**	**96**	**(100.0%)**	**58**	**(100.0%)**

Notes:

1. Categories represent our categorization of specific measures described in the underlying studies, and not necessarily categories used by those studies. Blank entries indicate that the study did not investigate measures within a given category. While the underlying studies provide some estimates to the first decimal place (hundreds of thousands of tons), estimates are reported here in millions of tons.
2. The Berkeley study estimates are based on the "ambitious scenarios" evaluated by that study.
3. The CCAP study estimates are for those emission reductions that the CCAP study estimates to have costs of less than $30 per metric ton of CO$_2$ equivalent. The total estimate does not match the sum of the categories because of rounding.

While the California studies focus on the aggregate economic impact of the portfolio of measures they examine, their findings are largely driven by a subset of measures that target

[12] The California studies use economic impacts in 2020 as a proxy for determining whether Californians are made better off by emission reduction measures. However, this is an insufficient basis for concluding that Californians would be better off, as it does not account for economic conditions in prior or subsequent years. For example, a policy that forces individuals to sacrifice current consumption in order to make particular investments may increase GSP in a future year (e.g., in 2020) as a result of those investments. But the lost value of current consumption that is necessary in order to make those investments may outweigh any positive impact of the investments in future years.

[13] Roland-Holst (2006b). As noted previously, that second study's findings are driven largely by aspects of his analysis that were present in the original study. We therefore focus on the original study.

improvements in energy efficiency. In particular, the net economic gains estimated by the Berkeley and CAT studies result from their estimates of the impact of California's vehicle GHG emissions standards — which will increase vehicle fuel economy — and programs and standards to improve energy efficiency in buildings (e.g., utilities' energy efficiency programs).[14] The Berkeley study estimates that these measures alone would increase GSP by $64 billion in 2020, while the remaining measures it examines are estimated to *reduce* GSP by $8.5 billion in 2020.[15] Similarly, whereas the CAT study finds that the vehicle GHG emissions standards and energy efficiency programs and standards offer annual savings of $10 billion in 2020, it finds that the remaining measures it examines impose a net annual cost of $1 billion.[16] The CCAP study does not directly estimate the economic impact of the vehicle GHG emissions standards and energy efficiency programs and standards. Moreover, the specific measures that the CCAP study does examine are found to impose a net cost on California. But CCAP combines its estimates of the costs of the measures that it does examine with others' estimates of net savings from the energy efficiency measures to conclude that California's 2020 target can be achieved at no net cost.[17] Because estimates of the economic impact of energy efficiency measures drive the California studies' findings, much of our assessment of the studies focuses on their analyses of those measures.

To estimate the aggregate emission reduction potential and economic impact of the measures it examines, the CCAP study simply sums the emission reduction and cost estimates

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[14] While there are limited other means by which manufacturers can reduce vehicles' GHG emissions, the predominant means is by improving fuel economy to reduce the amount of gasoline that vehicles burn.

[15] Roland-Holst (2006a), p. 2-8. Professor Roland-Holst estimates that the vehicle standards alone will increase GSP by $50 billion. In developing this estimate, he relies on the results of analyses that CARB conducted to support the development of those standards. However, Professor Roland-Holst's estimate of the standards' impact in 2020 is approximately ten times greater than CARB's own estimate of the annualized net savings from the standards. Professor Roland-Holst offers no explanation for this dramatic difference. For CARB's analysis, see CARB (2004a), as revised in CARB (2004b).

[16] Note that these values do not sum to the aggregate economic impact estimated by the CAT study. This is because these values are based on estimates of each measure's independent economic impact that the CAT study uses as inputs to its subsequent economic modeling of the aggregate impact of all measures. The CAT study does not offer estimates of the ultimate economic impact of each individual measure that emerges from that modeling. It only offers an estimate of the aggregate impact of all measures. Nonetheless, these input values offer a reasonable means of determining which measures drive the CAT study's findings. Also, the CAT study does not offer any estimate of the economic impact of certain measures that it examines, such as improvements in transportation infrastructure, effectively treating them as if they have no cost. CAT (2006b).

[17] CCAP (2006), p. 13.

that are independently developed for each measure. By contrast, the CAT and Berkeley studies use results from independent analyses of each measure as inputs to a computable general equilibrium (CGE) model. These studies' CGE modeling serves as a means of aggregating the individual emission reduction measures' direct effects, while accounting for some of the indirect effects of those measures on statewide economic activity and emissions.

There are significant shortcomings associated with how the Berkeley and CAT studies estimate the aggregate effects of emission reduction measures through CGE modeling. Meeting California's 2020 target will lead to substantial changes in California's economy, and its energy markets in particular. For example, adjustments in energy supply and demand associated with meeting the 2020 target will lead to changes in energy prices. As a result of these changes, a given measure's economic impact, which depends on energy prices, may differ significantly from what it would be if the measure were the only one being implemented and energy prices remained unchanged. That is, there will be important interactions among measures necessary to meet California's 2020 target. Properly executed CGE modeling can capture these interactions by calculating each measure's effects while accounting for the implications of all other emission reduction measures. But the Berkeley and CAT studies estimate the direct effects of key emission reduction measures outside of the CGE models they employ, as if those measures were being conducted in isolation from one another. The studies then use these estimates of the emission reduction measures' direct effects as inputs to their CGE modeling. As a result, the studies fail to account for important interactions among those measures in estimating their aggregate cost and emission reduction potential.

Although there are significant flaws in the CGE modeling that the California studies perform, we focus on the individual analyses of each emission reduction measure that serve as inputs to that modeling, as these underlying analyses ultimately drive the models' results. However, in Section III we do address some of the interactions among policies that the studies fail to consider in estimating the total emission reduction potential of those policies.

III. Factors Causing the California Studies to Overstate Emission Reductions

The California studies fail to account for a number of factors that lead them to overstate the emission reduction potential of the measures they examine. One key omitted factor is

emissions leakage, which has long been recognized as a phenomenon that can limit the effectiveness of climate policy. Leakage occurs when market adjustments resulting from a regulation cause an increase in emissions that offsets some (or all) of the emission reductions directly achieved by that regulation. While the measures that the California studies examine will likely lead to emissions leakage in several ways, the studies do not account for leakage in quantifying impacts of many of those policies. For example, policies considered by the CAT study to reduce consumption of out-of-state coal-fired electricity generation would not have the expected effect on emissions if that generation is simply reallocated to serve demand in other states.[18] Leakage will be particularly problematic for California's policies because of their narrow geographic scope. Of course, emissions leakage will hinder achievement of California's statewide emission targets only if it leads to offsetting increases in emissions within (rather than outside of) the state. But, regardless of whether leakage leads to offsetting increases in in-state or out-of-state emissions, it diminishes the ultimate impact of California's policies on global emissions, and hence their environmental benefits.

Interactions among policies introduce additional opportunities for emissions leakage. Specifically, emission reductions resulting from one policy may diminish the amount of additional reductions that regulated entities must achieve (either in-state or out-of-state) to meet another policy's requirements. Given the policies examined by the California studies, the most significant example of this type of leakage is likely that resulting from interaction between California's vehicle GHG emissions standards and federal fuel economy standards. California's standards have the effect of requiring auto manufacturers to increase the average fuel economy of vehicles sold in California. However, those manufacturers also must meet federal Corporate Average Fuel Economy (CAFE) standards. Because CAFE standards are average nationwide standards, sales of more fuel-efficient vehicles in California make it possible for manufacturers to sell less fuel-efficient (higher emitting) vehicles in remaining states while still meeting federal CAFE standards. That is, California's standards may lead to increased vehicle emissions elsewhere in the United States, relative to what those emissions would have been absent California's standards.[19] Hence, while California's vehicle GHG emissions standards may

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[18] CAT (2005), p. 64.

[19] For example, as a result of federal CAFE standards finalized in 2006, by 2011, light truck manufacturers will have to achieve an average fuel economy that is 16 percent more stringent than the 20.7 mile per gallon standard that was

achieve emission reductions within California, they may simply concentrate the costs of meeting federal CAFE standards on Californians while having a far smaller net effect on national emissions.[20]

Interactions among certain policies also can lead to leakage that creates offsetting increases in in-state emissions. For example, the CAT study includes emission reductions from policies specifically promoting biomass electricity generation and from increasing the stringency of a renewable portfolio standard (RPS) for electricity generators.[21] However, since biomass is a renewable fuel, if the former set of policies increases biomass electricity generation, this will lead to an offsetting reduction in the amount of generation from other renewables that is needed to meet the RPS requirement. Therefore, while biomass policies may shift the composition of renewable generation used to meet the RPS, they would not increase the total amount of renewable generation (or resulting emission reductions) beyond what would be achieved by the RPS alone. Yet, the CAT study adds together the individual effects of each policy without considering this interaction.

Other policy interactions can diminish the total emission reductions achieved by a portfolio of policies. A policy that reduces an activity's emissions intensity also diminishes the emission reductions that can be achieved by a policy that reduces the level of that activity, and *vice versa*. Therefore, implementation of both policies will have a lesser effect on emissions than the sum of each policy's independent effect. For example, according to an analysis by CARB, improvements in vehicle fuel economy resulting from California's vehicle GHG emissions standards will reduce vehicle emissions by 18 percent in 2020, and 27 percent in 2030.[22] While the CAT study incorporates these estimated effects of the standards in its analysis, it also estimates that "smart land use and intelligent transportation" policies can achieve

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in effect until 2004. However, compliance with California's more stringent standards will reduce the extent to which the fuel efficiency of light trucks sold elsewhere in the United States must be improved in order to meet the new federal standards. U.S. Department of Transportation, National Highway Traffic Safety Administration (2006).

[20] Alternatively, it is possible that California's standards may lead to increased fuel economy in other states because of other states' regulatory actions in response to those standards, or because of manufacturers' marketing decisions in response to California's standards. However, if California's standards lead to increased fuel economy in other states, those improvements will be accompanied by additional costs that also would need to be considered.

[21] CAT (2006a), pp. 49, 61.

[22] CARB (2004a), as revised in CARB (2004b), Table 8.2-1.

significant emission reductions by substantially reducing vehicle miles traveled.[23] However, improvements in vehicle fuel economy will diminish the emission reductions that are achieved by reducing vehicle miles traveled, and *vice versa*. Similar interactions would exist among policies examined in the CAT study that reduce the emissions intensity of electricity generation and those that reduce electricity use. Given that the CAT study's estimates of emission reduction potentials are based on independent analyses of each policy, it is unclear whether that study accounts for these interactions.

In summary, the total emission reduction potential of policies like those examined by the California studies is diminished by emissions leakage and policy interactions, some of which introduce new opportunities for leakage. By failing to account fully for these effects, those studies overstate the aggregate impact of the examined policies on state and, more importantly, national and global GHG emissions.

IV. The "Energy Efficiency Gap" Debate: A Framework for Evaluating the California Studies

Assessments of energy efficiency measures drive the California studies' findings that California's 2020 GHG emissions target can be met at no net cost. As a result, in many respects, those studies represent a new chapter in an on-going debate about the so-called "energy efficiency gap."[24] An understanding of this debate provides a useful framework for evaluating the California studies' estimates of emission reduction costs.

It is widely recognized that existing technologies can substantially improve the economy's energy efficiency and, in so doing, reduce emissions. There are broadly two perspectives on the cost of more widespread adoption of these technologies. One group, sometimes referred to as "technologists," asserts that numerous *market barriers* impede widespread adoption of these technologies. Moreover, they assert that government initiatives to overcome these barriers and thereby improve energy efficiency could reduce emissions and also realize substantial cost savings through resulting reductions in energy expenditures. On the other hand, most economists maintain that, while technology diffusion is typically a gradual process,

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[23] CAT (2005), p. 38.

[24] One of the most extensive discussions of this debate appears in the October 1994 issue of *Energy Policy. See* Huntington, Schipper, and Sanstad (1994). Jaffe, Newell, and Stavins (1999) offer a more recent discussion.

energy efficiency improvements that truly yield cost savings largely will be adopted without the need for government intervention.[25] Moreover, economists note that many of the barriers that slow or prevent broader adoption of more energy-efficient technologies reflect real economic costs associated with their adoption. Where this is the case, policy intervention that requires or encourages adoption of those technologies would be socially costly. However, some of the barriers inhibiting technology adoption reflect true *market failures* that, if corrected, may both improve energy efficiency and yield economic gains. Figure 1 depicts how efforts to address market failures and other market barriers affect energy efficiency and economic efficiency.[26]

Individuals and firms typically voluntarily undertake investments and actions that reduce their costs or increase their profits. But a few types of market failures may inhibit realization of some cost-saving energy efficiency improvements.[27] For example, economically desirable energy efficiency investments may be foregone because of poor information about the value of energy savings they offer. Moreover, because those who provide new information may be unable to capture much of its benefits (i.e., information is a public good), there may be insufficient incentives to provide this information.[28] Cost-saving energy efficiency investments also may be foregone because of principal-agent problems, such as when the individual financing the investment is different from the individual directly benefiting from that investment (e.g., a landlord's investment may reduce a tenant's electricity bill). In such cases, various factors may prevent those individuals from establishing mutually beneficial agreements to facilitate such investments. These and other market failures imply that some opportunities may exist for "no-cost" or "negative-cost" policies that improve energy efficiency, reduce emissions, and increase

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[25] Technology diffusion represents the third of three stages that Josef Schumpeter (1942) distinguishes in the process by which new, superior technologies permeate the marketplace. The first stage is invention, or the development of a scientifically or technically new product or process. The second stage is innovation, or the commercialization of a new product or process. *See* Jaffe, Newell, and Stavins (2003).

[26] Improvements in energy efficiency involve reductions in energy use per unit of economic activity. Improvements in economic efficiency entail reductions in the cost of existing goods and services, or improvements in their quality.

[27] For further discussion of these market failures, *see* Jaffe and Stavins (1994).

[28] Similarly, experiences of early technology adopters provide useful information to others considering similar investments. However, early adopters are unlikely to be compensated for providing this information. Therefore, when deciding whether to invest in new technologies, individuals and firms do not fully account for the value of the public information that such investments create. As a result, they may not undertake some socially beneficial investments in new technologies that would improve information or reduce costs for later adopters.

economic efficiency through resulting cost savings.[29] In Figure 1, implementation of such no-cost policies is reflected by northeasterly movement (along path A) relative to current conditions.

Of course, in seeking to address market failures, policymakers must recognize that sometimes the cure is worse than the disease. That is, the cost of a corrective policy may outweigh any savings gained by addressing targeted market failures. Thus, although energy efficiency would be increased by going beyond implementation of no-cost policies to eliminate *all* market failures affecting energy efficiency, such efforts would impose net costs and reduce economic efficiency, as is indicated by northwesterly movement (along path B) from the "Implementation of 'No-Cost' Policies" box in Figure 1. Moreover, while Figure 1 suggests that eliminating all market failures may bring about an improvement in economic efficiency relative to current conditions, it is possible that the cost of doing so could instead reduce economic efficiency relative to current conditions.

Figure 1
Changes in Energy Efficiency and Economic Efficiency Resulting from Policies
That Eliminate Market Barriers and Failures

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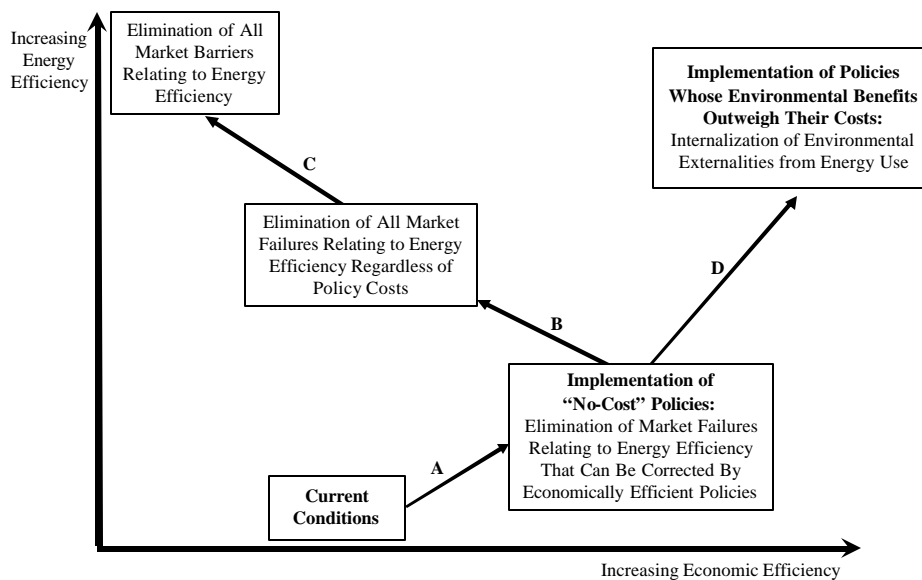
[29] *See* Jaffe, Newell, and Stavins (2005).

While voluntary adoption of some energy efficiency improvements may be limited by market *failures* whose elimination also can improve economic efficiency, many other market *barriers* to voluntary adoption of energy efficiency improvements are factors that cause those improvements' economic costs to be greater than they may at first appear. Examples include the adverse effects that energy efficiency improvements can have on valued attributes of affected technologies (e.g., reduced power in more fuel-efficient vehicles) and the costs of learning about and adapting to new technologies. Because such barriers represent real economic costs, overcoming them to improve energy efficiency reduces economic efficiency. This is represented by northwesterly movement (along path C) in Figure 1 from elimination of all market *failures* to elimination of all market *barriers*.

In summary, the presence of market failures affecting energy efficiency may offer some opportunities for no-cost policies that achieve cost savings while reducing energy use and associated emissions. But the extent of such opportunities is more limited than some have suggested.[30] Many improvements in energy efficiency may be socially costly for one of two reasons. First, energy efficiency improvements may be impeded by market barriers that represent real economic costs, rather than by market failures. Second, even where market failures are present, the cost of policies to address them may exceed resulting savings.

In evaluating a study that claims to find no-cost emission reduction measures, several questions arise that require careful analysis. Has the study truly identified a market failure that provides an opportunity to improve economic efficiency through policy intervention? Or, has the study instead incorrectly estimated the economic costs of the examined measures? Put simply, if opportunities truly exist to reduce costs while reducing emissions, why would potential beneficiaries of these opportunities not undertake them voluntarily? Also, if a market failure is present, can policies address that failure without imposing costs that exceed resulting savings?

While some no-cost emission reduction opportunities may exist, policymakers should not lose sight of the fact that costly emission reductions still can be socially beneficial on net if they offer sufficient environmental benefits. Compared with the contentious debate about the extent of market failures that offer opportunities for no-cost emission reduction policies, there is

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[30] *See* Jaffe, Newell, and Stavins (1999).

universal agreement that the core market failure leading to excessive GHG emissions is the failure of emitters to internalize the social cost of their emissions, and thereby the social benefit of emission reductions. As Figure 1 depicts, consideration of environmental benefits from emission reductions offers additional opportunities to reduce emissions, improve energy efficiency, and increase economic efficiency (by moving along path D) — even though such efforts will impose direct costs on those that undertake them. However, justification of emission reductions and energy efficiency improvements on these grounds requires critical evaluation of both their costs and environmental benefits. Unfortunately, debates about the extent of no-cost emission reduction opportunities that have been reinvigorated by the California studies distract attention from important questions about the benefits of emission reductions, and the level of costs that those benefits justify.

V. Factors Causing the California Studies to Underestimate the Costs of Achieving Emission Reductions

The presence of market failures that affect energy efficiency decisions implies that some opportunities for no-cost emission reduction policies may exist. However, economists have identified several flaws that caused prior analyses claiming to identify substantial opportunities for such policies to significantly underestimate those policies' real economic costs. As we describe in this section, many such flaws are apparent in the California studies, causing them to severely underestimate the cost of meeting California's 2020 emissions target.

Of course, studies finding opportunities for no-cost policies are not the only ones that may incorrectly estimate costs. The points raised in this section should be carefully considered in evaluating analyses of any policy. In fact, some of these points relate to the California studies' assessments of policies found to have positive costs.

Analyses like those relied on by the California studies seek to estimate a policy's overall economic costs by building an estimate of those costs from the bottom up. Execution of these "bottom-up" analyses requires identifying and correctly estimating each individual component of costs, including any offsetting savings, and it requires aggregating those components over individuals and firms, as well as over time. Aggregation of costs and savings over time requires

discounting future costs and savings to make comparable costs and savings that occur in different years. Thus, analysts must estimate how individuals and firms discount future cash flows.

Well-executed bottom-up analyses can, in principle, develop reliable estimates of emission reduction policies' costs. However, in light of the complexities described above, it is not surprising that the California studies incorrectly estimate costs. Analyses can underestimate the costs of emission reduction policies by underestimating the costs of the actions and investments that are necessary to reduce emissions, and/or by underestimating the costs of policies necessary to bring about those actions and investments. As we describe below, the California studies suffer from both types of flaws.

A. Underestimation of the Costs of Actions and Investments to Reduce Emissions

Analyses may underestimate the costs of emission reductions by omitting important components of those costs. Also, emission reductions arising from improvements in energy efficiency generate offsetting savings in the form of reduced future energy expenditures. Analyses therefore may underestimate net costs by measuring these future savings incorrectly, or by employing inappropriately low discount rates in determining how those savings compare with upfront costs. As we describe below, the California studies underestimate costs both by omitting important components of costs and by overstating offsetting savings.

i. Omitted Costs

Omitted costs can range from those that are readily apparent to those that are more subtle and difficult to quantify. In some cases, studies may consider the costs borne by the government to administer a policy, but fail to account for costs that individuals and firms incur to achieve the emission reductions that the policy targets. The California studies commit this mistake in analyzing the impact of electric utility and state energy efficiency programs. These programs, often referred to as demand-side management (DSM), achieve reductions in electricity use by offering rebates and other incentives that encourage individuals and firms to undertake energy efficiency improvements.[31] In response to these programs, individuals and firms undertake

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[31] Some DSM programs raise awareness about opportunities to improve energy efficiency without providing direct incentives that target those improvements.

energy efficiency improvements because the costs of those improvements are outweighed by the combined value of any incentives they receive and the resulting electricity savings.

There is much debate about the true costs and effectiveness of DSM programs.[32] But putting this debate aside, it is clear that the California studies fail to account fully for those programs' costs. While accounting for the incentives offered by those programs and the resulting electricity savings, the California studies ignore the actual costs that individuals and firms incur to undertake the targeted actions or investments.[33,34] While difficult to measure, these omitted costs can be as great as, or even greater than the value of the electricity savings that the studies attribute to DSM programs. This is because individuals and firms would still enjoy net savings — and thereby presumably still be willing to undertake the improvements — as long as the costs of their actions or investments are no greater than the combined value of both the incentives they receive and the resulting electricity savings.

Another common category of omitted costs relates to the impact of emission reduction efforts on the quality of affected goods and services. For example, all else equal, making an air conditioner more energy efficient may increase its size and weight, and making a car more fuel efficient may reduce its acceleration. While more difficult to quantify than a consumer's out-of-pocket expenses for a new technology, costs associated with impacts on the quality of a good can be just as important. In evaluating costs related to quality impacts, one must estimate the value that individuals and firms place on those attributes of a good or service that are lost by reducing emissions. Estimates of those costs can be developed through economic (hedonic) analysis, but they typically are ignored in bottom-up studies that rely primarily on engineering cost analysis. For example, in its analysis of emission reduction opportunities, the CCAP study includes emission reductions from adding limestone to Portland cement. CCAP finds that use of such

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[32] See Loughran and Kulick (2004) and Gillingham, Newell, and Palmer (2006).

[33] The Berkeley study explicitly acknowledges that it does not account for these private adoption costs. Roland-Holst (2006a), p. 2-16. The CAT study provides less methodological documentation. However, comparison of its estimates of the per-kilowatthour cost for these programs with other estimates of the cost of funding such programs suggests that the CAT study also considers only the costs incurred by utilities or the state to fund the programs, and ignores costs borne by individuals and firms.

[34] While imposing a cost on the state or utilities that fund them, the incentives themselves do not represent a social cost. Rather, they are a transfer from the ratepayers or taxpayers that fund the programs to those that receive the incentives. But even if the California studies incorrectly treat these incentives as costs, they may still underestimate the total cost of these programs if the actual costs of undertaking the targeted actions or investments, which those studies omit, exceed the value of the incentives. As we describe below, this is quite likely.

limestone cement blends would reduce both emissions and production costs. Yet, it also notes that "Cal Trans has raised questions about the structural integrity of limestone blends."[35] While including the estimated cost savings from limestone blends in its analysis, CCAP does not estimate the cost of reduced structural integrity or of measures that cement users might undertake to mitigate these potentially adverse effects.

Some bottom-up analyses attempt to account for impacts that emission reductions may have on the quality of affected goods, but even these efforts often fall short of fully accounting for those impacts. For example, the California studies' estimates of the economic impact of California's vehicle GHG emissions standards are based on CARB's analysis of those standards. CARB estimates the cost of meeting the standards while maintaining vehicle acceleration, weight, and other attributes at levels anticipated in 2009 — the year that the standards come into effect.[36] However, this approach fails to consider the standards' impact on the costs of and opportunities for further improvements in vehicle performance beyond 2009 levels. If Californians place any value on further improvements in vehicle performance beyond 2009 levels, and the standards raise the costs of or reduce opportunities for those performance improvements, CARB will have omitted a significant component of its standards' economic cost.

There are several other sources of emission reduction costs that bottom-up analyses like the California studies can overlook. For example, in adopting new technologies, individuals and firms may incur costs to learn about and adapt to using those technologies. While such costs may be quite small for any one individual or firm, they can significantly affect the aggregate cost of a technology's widespread adoption. Indeed, estimates of the substantial nationwide or statewide cost savings that can result from adopting more energy-efficient technologies often represent the aggregation of very small individual or firm-level savings.[37] Thus, these small individual or firm-level savings could be outweighed by equally small costs associated with learning about and adapting to new technologies.

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[35] CCAP (2005b), p. 6.

[36] CARB (2004a), p. 58.

[37] Sanstad, Hanemann, and Auffhammer (2006) note that the "magnitudes of [energy efficiency] savings may be quite modest … from the individual's perspective, what's on the sidewalk may not be a $20 bill but rather a penny or a nickel."

ii. Overestimation of Future Savings from Reduced Energy Use

The net cost of some emission reductions, particularly those from energy efficiency improvements, reflects both new costs and offsetting reductions in future energy expenditures. Thus, analyses can underestimate the net cost of emission reduction measures by overestimating the value of the energy expenditure savings that those measures create.

Analyses can overestimate the reduction in energy use realized from adopting more energy-efficient technologies, in part because such estimates often are based on highly controlled studies that do not reflect typical real-world conditions.[38] Moreover, even if a study accurately estimates the reduction in energy use enjoyed by those undertaking energy efficiency improvements, differences between the price that consumers would have paid for the conserved energy and the actual cost of producing that energy can cause resulting *private* cost savings to differ from corresponding *social* cost savings. That is, emission reductions that are no-cost opportunities for the individuals and firms undertaking them will not necessarily be no-cost opportunities from a societal standpoint, and *vice versa*.

The California studies significantly overestimate the social cost savings from energy efficiency measures by focusing on the private savings enjoyed by those undertaking the measures, and failing to account for substantial differences between those private savings and the actual social cost savings that the measures create. For example, the CAT study estimates that electricity efficiency measures can reduce annual electricity use by 51 million megawatt-hours by 2020.[39] The study values these annual savings at $5.6 billion by multiplying the reduction in electricity use by a forecast of the electricity rate that consumers would pay in 2020, which is 11 cents per kilowatt-hour (kWh).[40] This approach is a reasonable method of estimating private cost savings from electricity efficiency measures. However, it leads the CAT study to overestimate social cost savings from those measures because retail electricity rates that consumers pay cover both electricity generation costs and fixed costs, such as transmission, distribution, and administrative costs. Energy efficiency improvements reduce electricity

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[38] For example, *see* Metcalf and Hassett (1999).

[39] CAT (2006b).

[40] For example, *see* CAT (2006b), p. 21. The Berkeley study's description of how it estimates savings from these measures suggests that it takes a similar approach. Roland-Holst (2006a), p. 2-16.

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generation, and thereby reduce generation costs, but have a more limited (and perhaps no) effect on fixed costs that utilities recover through electricity rates. As a consumer reduces her electricity use, a significant portion of her savings therefore comes at the expense of other ratepayers, who must bear a greater share of those fixed costs (such as through increased rates). In light of this, use of California's retail electricity rates overstates the value of the social costs that can actually be avoided (i.e., the social cost savings that can be realized) by electricity efficiency measures examined in the California studies.[41]

Some indication of the extent to which the California studies overstate social cost savings from electricity efficiency measures is offered by a 2003 California Energy Commission (CEC) report.[42] This report, which examines opportunities for such efficiency measures in California, specifically addresses the *social* cost savings from those measures. For the efficiency measures that the report deems to be economical, the average cost of the electricity generation that can be avoided by those measures is 7 cents per kWh of demand reduction.[43] This estimate of *social* cost savings is nearly 40 percent less than the electricity rate of 11 cents per kWh used by the CAT study, which captures the *private* savings from reductions in electricity use. Had the CAT study instead focused on social cost savings by using the CEC's estimates of avoided generation costs, the CAT study's estimate of annual savings from electricity efficiency measures in 2020 would be reduced by about two billion dollars.[44]

The California studies also incorrectly measure the social cost savings from reductions in gasoline consumption that would result from California's vehicle GHG emissions standards. For

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[41] During periods of peak electricity demand (e.g., afternoon hours in the summer), the cost of electricity generation can exceed electricity rates, so that those rates understate the social cost savings from reducing electricity demand. However, the vast majority of demand reductions from potential energy efficiency measures that have been identified in California would occur during the "base load" period when total electricity demand (and the incremental cost of generation) is at its *lowest*. California Energy Commission (2003).

[42] CEC (2003).

[43] The CEC develops three estimates of the cost of avoided electricity generation that differ depending on whether that generation is avoided during periods of base load, shoulder, or peak electricity demand. Our 7 cent per kWh estimate is a weighted average of these three cost estimates. The weight assigned to each estimate reflects the corresponding demand period's share of the total demand reduction that the CEC finds to be achievable through economical energy efficiency measures. CEC (2003), pp. 7-11.

[44] The Berkeley study does not provide the values that it employs to estimate savings from these measures. But its estimate of the annual net impact of these measures (accounting for upfront costs and offsetting electricity savings) is nearly $14 billion in net savings. This suggests that the overstatement of annual savings that would result from its focus on private, rather than social, cost savings would be in the billions of dollars. Roland-Holst (2006a), p. 2-19.

example, the CAT study estimates savings from those standards based on the reduction in gasoline expenditures that drivers are expected to enjoy.[45] However, a significant share of the price of gasoline in California is attributable to state and federal taxes. This share of the reduction in gasoline expenditures enjoyed by drivers does not represent a true cost savings, as the savings to drivers are offset by a corresponding reduction in state and federal tax receipts. While accounting for the savings directly enjoyed by drivers, the CAT study fails to account for this offsetting effect on tax receipts, thereby overstating savings from the standards. Given current state and federal gasoline excise taxes (37.6 cents per gallon), the standards' forecasted effect on gasoline use in 2020 would reduce annual receipts of those taxes by about one billion dollars, affecting both California's state budget and its receipt of federal highway funds.[46]

iii. Incorrect Valuation of How Individuals and Firms Discount Future Savings

Analyses also may improperly estimate how individuals and firms discount the value of future energy savings. Numerous economic studies of individuals' and firms' energy efficiency investments have found that the value of future savings is discounted considerably more than is typically assumed in bottom-up analyses of proposed policies. For example, in one of the first such studies, Hausman found that consumer choices among air conditioner models imply discount rates of 15 to 25 percent.[47] More recently, Anderson and Newell found that manufacturers' energy efficiency investment decisions suggest discount rates as great as 80 percent.[48] By contrast, the California studies employ discount rates as low as four percent.[49] Use of such a low discount rate may improperly increase the estimated value of future savings.

Many studies have estimated discount rates by examining individual and firm decisions regarding upfront investments that yield future energy savings. The tradeoffs between upfront costs and future savings that are revealed by these decisions imply specific discount rates.

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[45] CAT (2006b), p. 6.

[46] American Petroleum Institute (2006). This estimate of taxes includes an underground storage tank fee, but excludes sales tax. While there is a sales tax on gasoline in California, sales tax receipts depend on gasoline prices, and loss of these receipts may be offset by increased consumer expenditures on other taxed goods. The Berkeley study's description of how it estimates the impact of these standards suggests that it also fails to account for their effect on excise tax receipts. Roland-Holst (2006a), p. 2-19.

[47] Hausman (1979).

[48] Anderson and Newell (2004).

[49] For example, CCAP (2006), p. 4.

However, investment decisions that suggest high discount rates actually may reflect the effect of market failures on investment decisions. For example, a firm with a low discount rate may fail to invest in a beneficial energy efficiency improvement because of inadequate information about the savings from that investment. Its choice to forgo this investment may therefore be interpreted incorrectly as evidence of a high discount rate. In such a case, it may be appropriate to use a lower discount rate to evaluate a policy's impact, even though the firm appears to use a higher discount rate in valuing the investment targeted by the policy.

However, high implicit discount rates do not necessarily indicate the presence of market failures. There are well-established reasons why firms and individuals should use higher discount rates in evaluating some investment decisions.[50] Also, high estimated discount rates have been found to be consistent with the rates that firms indicate they intend to use in evaluating investments, calling into question the idea that high estimated rates imply a failure to properly value future savings.[51] Moreover, regardless of the underlying cause of high estimated discount rates, analyses using lower rates to estimate the value that individuals and firms place on future savings may overestimate the effectiveness of some policies that create incentives for particular emission-reducing investments, but do not require those investments.

B. Underestimation of the Cost of Policies Necessary to Achieve Emission Reductions

The direct cost of particular emission reduction efforts may be of little relevance if policies cannot elicit those efforts effectively. Moreover, policies can introduce additional costs above and beyond the direct costs of undertaking the emission reduction efforts they target. As we noted in Section IV, even if certain actions or investments to reduce emissions may yield cost savings, the cost of a policy necessary to bring about those actions or investments may exceed the value of those cost savings. Further, cost savings from emission reductions can only be attributed to a policy if those reductions would not occur without that policy. Therefore, the costs of a policy that targets potentially cost-saving measures can be underestimated (i.e., savings

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[50] For example, individuals and firms face uncertainty about the return that energy efficiency investments will earn. If an investment's value cannot be fully recovered in the event that the investment is later deemed undesirable (i.e., the investment involves a sunk cost) and an individual or firm has the option to delay that investment, a higher expected return may be necessary to justify making the investment rather than delaying the investment decision. *See* Metcalf and Rosenthal (1995); Hassett and Metcalf (1995); and Sanstad, Blumstein, and Stoft (1995).

[51] Anderson and Newell (2004).

from that policy can be overestimated) by failing to account for the reality that some of those cost savings would be realized even without the policy. The California studies offer several examples of how analyses can underestimate the cost of meeting an emissions target by giving inadequate attention to the effectiveness and cost of the actual policies necessary to achieve emission reductions.

i.   Failure to Consider the Effectiveness and Cost of Necessary Policies

Some of the emission reductions contemplated by the California studies could be achieved by adjusting existing policies. But many of the emission reductions would require implementation of new policies whose effectiveness and cost is not well understood. At one extreme, nearly 15 percent of the 2020 emission reductions estimated by the CAT study come from "measures to improve transportation energy efficiency" and "smart land use and intelligent transportation", including "encouraging high density … development."[52] The study provides no estimate of the economic impact of such changes in development patterns (e.g., the impact of smaller lot sizes), or of the cost and effectiveness of policies that would seek to achieve those changes.

In other cases, the California studies estimate the cost of particular actions that would achieve emission reductions, but do not consider the cost and effectiveness of the policies that are necessary to elicit those actions. For example, all California studies consider opportunities to sequester CO_2 through land use changes, such as afforestation. However, as the CCAP study notes, significant challenges remain in developing policies that can effectively bring about such land use changes.[53] For example, even if their land offers low-cost sequestration opportunities, some landowners may not participate in programs designed to achieve sequestration because of associated administrative burdens and transaction costs. Also, policies may incur costs by subsidizing some land use changes that would have occurred even without those policies. Finally, efforts to achieve sequestration through land use changes may suffer from leakage. That is, land use changes in one area may bring about changes elsewhere that have offsetting effects on sequestration, increasing the cost of achieving a given increase in sequestration. While estimating the cost of particular land use changes, the California studies do not quantify how

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[52] CAT (2006a), pp. 58-59.

[53] CCAP (2005a).

factors like those described above would limit the effectiveness and increase the cost of policies that are necessary to bring about those changes.[54] Absent an assessment of the effectiveness and cost of policies necessary to bring about the hypothesized changes, the California studies' evaluations of emission reduction measures are of limited use. While such evaluations may identify promising areas for future research, they should not be interpreted as estimates of the cost of actually realizing emission reductions.

ii. Failure to Characterize Baseline Behavior Appropriately

A critical step in estimating a policy's impact is determining an appropriate baseline against which the policy's effects are measured. This baseline represents the anticipated behavior of individuals and firms in the absence of the policy. Given particular baseline behavior, a policy will only impose costs or create savings to the extent that the targeted emission reduction measures would not already be adopted in that baseline (i.e., to the extent that the policy actually has a binding effect on the behavior of regulated entities). For example, if consumers would purchase more fuel-efficient vehicles even without a fuel economy standard, the savings and emission reductions from purchasing those vehicles are not attributable to the standard because they would have occurred even in its absence.

Economic analyses often assume that, in their baseline behavior, individuals and firms will voluntarily adopt any emission reduction measures that have net cost savings. Thus, by design, such analyses will not find opportunities for cost-saving emission reduction policies. In these analyses, rather than creating cost savings, policies would have no net economic impact on those firms and individuals for whom the required measures reduce costs, as the analyses would assume that those cost-saving measures would be adopted in the baseline. But, as we described in Section IV, certain market failures can prevent voluntary adoption of some cost-saving emission reduction measures, presenting opportunities for cost-saving policies. Therefore, analyses assuming that all cost-saving opportunities are realized in the baseline may overestimate a policy's costs (by underestimating opportunities for cost savings) if such market failures are present and significant, and can be addressed efficiently through policy intervention.

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[54] Recognizing the important implications of these factors, other analyses have at least made admittedly *ad hoc* adjustments to their cost estimates. For example, in estimating the cost of a U.S. climate policy proposed in Senate Bill 139 (the Climate Stewardship Act of 2003), the EIA assumed that only half of the estimated agricultural and forestry sequestration opportunities would be available at any given cost. U.S. DOE, EIA (2003), p. 245.

Whereas many economic analyses of climate policies assume that market failures that offer cost-saving opportunities are not present, analyses like the California studies *depend on* the presence of such market failures to reach the conclusion that policies would create cost savings. That is, they assume baseline behavior that — according to their own estimates — does not take advantage of all cost-saving opportunities, and thereby leaves opportunities for cost-saving policies. However, the extent to which baseline behavior would not take advantage of cost-saving opportunities depends fundamentally on the nature and extent of relevant market failures, about which there is substantial uncertainty and much debate (see Section IV). Indeed, as is the case with the California studies, analyses that find opportunities for cost-saving policies typically do not rely on explicit characterizations of relevant market failures in estimating baseline behavior and resulting cost savings from a policy.[55] Rather, such analyses' assumptions about baseline behavior and estimates of resulting cost savings from a policy *imply* that unspecified market failures are present and sufficiently large to make the assumed baseline behavior and estimated policy cost savings plausible. Thus, in principle, these analyses may overestimate (underestimate) the cost savings and emission reductions from a policy if they assume baseline behavior that overstates (understates) the extent of relevant market failures.

The possibility that baseline behavior may be characterized incorrectly is a particularly significant source of potential error when seeking to estimate a policy's impact many years into the future. In fact, there is a tension in many studies that find substantial opportunities for cost-saving emission reduction policies. These studies often assume that technological advances will reduce relevant technologies' costs in future years, creating substantial cost-saving opportunities. But the studies simultaneously assume that market failures are sufficiently large that those opportunities will not be realized without policy intervention. Consequently, even if such studies develop accurate estimates of the future costs of emission-reducing technologies or actions, they nonetheless may underestimate the cost of (overestimate cost savings from) emission reduction *policies* by incorrectly characterizing the extent of market failures and resulting baseline behavior. That is, these studies may incorrectly attribute particular emission reductions and

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[55] By contrast, other market distortions, such as taxes, can be (and are) explicitly and quantitatively characterized in analyses in order to estimate their implications for baseline behavior and for a proposed policy's economic impact.

associated cost savings to a policy when, in fact, those reductions and savings would occur even without that policy.[56]

The California studies' estimates of the impact of California's vehicle GHG emissions standards offer an example of how flawed forecasts of baseline behavior can lead to significant overestimation of savings from a policy. The studies' estimates are based on CARB's analysis of those standards. In turn, to estimate the standards' effects, CARB forecasts the future baseline behavior of California consumers, including the fuel-efficiency of vehicles that they would purchase and the amount that they would drive in the absence of those standards. Together with estimates of future gasoline prices and technology costs (among other factors), CARB's forecast of baseline behavior leads to its estimate of net cost savings resulting from the standards. In its original analysis, CARB's forecast of baseline behavior and its resulting estimate of net cost savings from the standards are based, in part, on its assumption that future gasoline prices would be $1.74 per gallon.[57] In light of the recent higher level of gasoline prices, CARB performed an additional analysis in which it assumes a higher gasoline price of $2.30. Yet, despite using a gasoline price that is 32 percent higher than that in its original analysis, CARB does not revisit its assumptions about consumers' baseline vehicle purchases and driving habits. That is, the only adjustment that CARB makes to its analysis in order to account for a much higher gasoline price is to proportionately increase its estimate of the *value* of gasoline savings from those standards, while assuming that the *volume* of gasoline savings remains the same.[58] The CAT study takes the same approach in adjusting CARB's original analysis to account for the Climate Action Team's expectation that gasoline prices in 2020 will be $2.12, rather than CARB's original estimate of $1.74.[59]

Neither CARB nor the CAT study consider that significantly higher gasoline prices would cause consumers to voluntarily adopt more fuel-efficient vehicles and to drive less,

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[56] While inaccurate forecasts of baseline behavior would lead to incorrect estimates of the amount of emission reductions that is attributable to a policy, they would not necessarily lead to incorrect estimates of the absolute level of emissions resulting from a policy's implementation. A policy may ensure that a particular emissions level is achieved (e.g., by setting a cap on emissions) regardless of the extent to which emission reductions necessary to meet that level are attributable to the policy, rather than to baseline behavior.

[57] CARB (2004a), p. xi.

[58] CARB (2004a), as revised in CARB (2004b), Table 12.7-1.

[59] CAT (2006b), pp. 3, 6. While the CAT study reports its gasoline price assumption in constant 2003 dollars, here we report that price in constant 2004 dollars to make it comparable with CARB's price forecast.

reducing the standards' effect on gasoline consumption, and thereby reducing cost savings from the standards. Thus, assuming that CARB's original forecast of baseline behavior is appropriate for a $1.74 gasoline price scenario, both CARB's analysis of the $2.30 price scenario and the CAT study overestimate net cost savings from the standards by failing to account for how baseline behavior would adjust to much higher gasoline prices.[60]

Careful analysis is needed to evaluate precisely how alternative fuel prices would affect baseline behavior and the resulting impact of California's standards. However, simplified calculations can offer an indication of the extent to which the California studies overestimate savings from those standards under higher fuel price scenarios. In particular, we focus on CARB's overestimation of savings under the $2.30 gasoline price scenario.

To estimate how a higher gasoline price could change baseline fuel economy levels and vehicle miles traveled (VMT), we use estimates of the price elasticity of fuel economy and VMT that the Congressional Budget Office (CBO) employed in a 2003 study.[61] Given these elasticity estimates, the 32 percent increase in the price of gasoline from $1.74 to $2.30 per gallon would lead to a 6.4 percent increase in baseline fuel economy and to a 5.5 percent reduction in VMT.[62] CARB estimates that its standards will increase the average fuel economy of vehicles that are in use in 2020 to 21 percent above its forecast of baseline fuel economy when gasoline is $1.74 per gallon.[63] Thus, the standards would only increase fuel economy by 14 percent relative to the higher baseline fuel economy level that would result from a $2.30 gasoline price. Moreover, the effect of this fuel economy improvement on gasoline consumption would be diminished by the reduction in baseline VMT. All told, the adjustment in baseline behavior in response to a $2.30

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[60] The CCAP study relies on CARB's $2.30 price scenario analysis. CCAP (2006), p. 13. The Berkeley study does not indicate whether it relies on CARB's $1.74 price scenario analysis or its $2.30 price scenario analysis.

[61] The price elasticities of fuel economy and VMT measure the percentage change in fuel economy and VMT, respectively, that results from a one percent increase in gasoline prices. The CBO assumed that, in the long-run, a one percent increase in gasoline prices would lead to a 0.22 percent increase in average fuel economy, and to a 0.2 percent reduction in VMT. Together, these estimates imply a long-run price elasticity of demand for gasoline of -0.39, which is consistent with other existing estimates of that price elasticity. CBO (2003), p. 12.

[62] These values assume that the price elasticities of fuel economy and VMT are constant across all price levels.

[63] This value is derived from CARB's estimate of the standards' effect on 2020 vehicle emissions (which are related to fuel consumption). CARB (2004a), as revised in CARB (2004b), Table 8.2-1. The percentage increase in average fuel economy continues to grow beyond 2020 because the standards are not fully phased-in until model year 2016. The standards' full effect will not be realized until all earlier model year (less fuel-efficient) vehicles are replaced by vehicles meeting the 2016 standards.

gasoline price would reduce CARB's estimate of the volume of fuel savings attributable to the standards in 2020 by more than 35 percent.[64] Without accounting for any adjustment in baseline behavior under the $2.30 price scenario, CARB estimates that the standards will offer drivers $7 billion in fuel savings in 2020.[65] Therefore, assuming that CARB's original forecast of baseline behavior under the $1.74 price scenario is correct, our calculations indicate that the California studies overstate annual savings from the vehicle GHG emissions standards by billions of dollars because they fail to account for the effect of higher gasoline prices on baseline behavior.[66]

Our calculations also demonstrate that the total value of fuel savings from the standards under some higher fuel price scenarios can be *lower* than the value of savings under lower price scenarios. That is, the reduction in the volume of fuel savings from the standards under a higher fuel price can outweigh that higher price's effect on the value of those savings. Based on our calculations, the value of annual fuel savings attributable to the standards in 2020 under the $2.30 price scenario would be nearly one billion dollars *less* than the savings under the $1.74 price scenario.

iii. Implications of Cost Uncertainty for the Reliability of Deterministic Analyses of Cost-Saving Policies

The California studies' overstatement of cost savings from the vehicle GHG emissions standards highlights another reason why analyses finding cost-saving policy opportunities may underestimate costs. Even if an analysis of a cost-saving policy correctly forecasts baseline behavior in the scenario it examines, it may underestimate the policy's expected costs by failing to account for the implications of cost uncertainty, and particularly how baseline behavior may adjust to greater-than-anticipated cost savings.

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[64] The corresponding reduction in the volume of fuel savings under the CAT study's forecast of future gasoline prices would be more than 25 percent.

[65] CARB (2004a), as revised in CARB (2004b), Table 12.7-1.

[66] Along with reducing fuel savings attributable to the standards, adjustments in baseline fuel economy would reduce the standards' incremental effect on vehicle costs. However, under the $2.30 price scenario, CARB estimates that the value of fuel savings resulting from the standards is more than five times greater than the corresponding increase in annualized vehicle costs. Moreover, some of the reduction in fuel savings attributable to the standards under the higher fuel price scenario result from changes in baseline VMT, rather than changes in baseline fuel economy. Thus, the reduction in fuel savings attributable to the standards that results from these adjustments in baseline behavior would be far greater than the corresponding reduction in the standards' impact on vehicle costs.

As is the case in the California studies, a policy's costs are typically estimated using a deterministic analysis, which develops a single cost estimate based on "point estimates" of relevant underlying determinants and a single forecast of baseline behavior. For example, CARB's analysis of California's vehicle emissions standards estimates costs relative to one baseline scenario based on point estimates of technology costs, fuel prices, and other cost determinants. But there is typically significant uncertainty in the determinants of a policy's costs, including baseline behavior.

In principle, by failing to account for this cost uncertainty, a deterministic analysis can either underestimate or overestimate the expected (or average) value of a policy's potential future costs (or savings).[67] However, in the case of policies targeting cost-saving emission reduction opportunities, deterministic analyses will tend to overestimate systematically the expected value of a policy's cost savings (i.e., underestimate the expected value of its costs). This conclusion arises from a full consideration of how baseline behavior responds to changes in the magnitude of emission reduction opportunities.

If cost savings from targeted emission reduction measures turn out to be greater than anticipated, baseline behavior will likely adjust to realize some (if not all) of those cost-saving opportunities, mitigating the extent of cost savings that the policy itself offers. At the extreme, when the cost savings offered by targeted actions are greatest, a policy may have no binding effect on individual or firm behavior, and therefore no economic impact. As a result, while a deterministic analysis would overstate a policy's cost savings if cost-saving opportunities turn out to be lower than expected, that analysis may not understate the policy's cost savings to the same extent if cost-saving opportunities turn out to be greater than expected. Indeed, in the latter case a deterministic analysis would *overstate* the policy's cost savings if cost-saving opportunities turn out to be so great that they would be realized without policy intervention. Thus, accounting for the full distribution of possible policy impacts suggests that deterministic analyses will tend to overestimate the expected cost savings (i.e., underestimate the expected costs) of seemingly cost-saving policies.

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[67] The expected value of a policy's costs can be estimated more accurately by using a probabilistic analysis, which estimates the full distribution of potential costs (based on uncertainties in underlying determinants). For a discussion of circumstances in which deterministic estimates can differ from the expected value of a policy's costs, *see* Jaffe and Stavins (2004).

A simplified example of a fuel economy standard illustrates the problem. Assume there are two vehicles with different fuel efficiencies and that a proposed standard would require consumers to purchase the more fuel-efficient vehicle. Given expected technology costs and fuel prices, a deterministic analysis finds that the more fuel-efficient vehicle offers the typical consumer savings of $100 over the vehicle's lifetime, accounting for both the vehicle's higher cost and resulting fuel savings (see Table 2). The analysis also finds that, because of a market failure, the consumer nonetheless would choose the less fuel-efficient vehicle absent the standard. The deterministic analysis therefore estimates that the standard would yield $100 in savings for the typical consumer. However, assume there are two additional equally likely scenarios. In the second scenario, where technology costs are lower and/or fuel prices are higher than anticipated, the consumer would save $600 by purchasing the more fuel-efficient vehicle. In the third scenario, where technology costs are higher and/or fuel prices are lower than anticipated, the consumer would incur $400 in costs by purchasing that vehicle.

In this example, the deterministic estimate of the standard's impact is the same as the expected value of the savings from adopting the more fuel-efficient vehicle, given the three possible future scenarios. That expected value is $100 in savings — the average of $600 in savings, $100 in savings, and $400 in costs. But the deterministic estimate of the standard's impact will equal the expected value of the standard's impact *only if* the typical consumer would not voluntarily purchase the more fuel-efficient vehicle under any of the scenarios. This is because it is only under those circumstances that the expected value of the standard's impact is the same as the expected value of the savings from adopting the more fuel-efficient vehicle. If, however, the opportunity for $600 in savings would cause a typical consumer to purchase the more fuel-efficient vehicle voluntarily, then the standard would not affect her behavior in that scenario, and thereby would offer no savings. As a result, while a deterministic analysis would suggest that the standard offers the typical consumer $100 in savings, the expected value of the standard's impact would, in fact, be a *cost* of $100 — the average of $0 (no impact), $100 in savings, and $400 in costs.

As the above example demonstrates, if individuals' and firms' baseline behavior adjusts to changes in the level of cost-saving opportunities from emission reduction measures — and economic analysis shows that it typically does — then deterministic analyses of seemingly

Table 2

Comparison of Deterministic Estimate of the Cost of a Hypothetical Fuel Economy Standard with the Expected Value of that Standard's Cost Under Different Assumptions About Consumers' Baseline Behavior

(Cost Estimates Account for Technology Costs and Offsetting Fuel Savings and Are for a Typical Consumer)

	Probability	Relative Cost of More Fuel-Efficient Vehicle*	Cost of *Standard* Requiring More Fuel-Efficient Vehicle*	
			If Consumer Never Voluntarily Chooses More Fuel-Efficient Vehicle	If Consumer Voluntarily Chooses More Fuel-Efficient Vehicle When Savings Are Greatest
Deterministic Analysis of Cost:				
Average Technology Cost/ Average Fuel Price	**100%**	**-$100**	**-$100**	**-$100**
Full Distribution and Expected Value of Possible Costs:				
Low Technology Cost/ High Fuel Price Scenario	33%	-$600	-$600	$0
Average Technology Cost/ Average Fuel Price Scenario (Basis for Deterministic Estimate)	33%	-$100	-$100	-$100
High Technology Cost/ Low Fuel Price Scenario	33%	$400	$400	$400
Expected Value from Three Scenarios (Probability-Weighted Average)		**-$100**	**-$100**	**$100**

*Note: Negative values indicate net savings.

cost-saving policies will tend to underestimate those policies' expected costs. The extent of such underestimation will depend on how sensitive baseline behavior is to changes in cost-saving opportunities, among other factors. In turn, the sensitivity of baseline behavior to changes in cost-saving opportunities will depend, in part, on the nature and extent of market failures that affect baseline behavior. Thus, accurate estimation of the impacts (and desirability) of potentially cost-saving policies requires both consideration of cost uncertainty and a far better understanding of the market failures that those policies seek to address than currently exists. The California studies do not explicitly account for cost uncertainty, which raises additional concerns regarding the reliability of their estimates.

C. Summary of Flaws Causing the California Studies to Underestimate Costs

The California studies suffer from numerous flaws that cause them to underestimate significantly the true cost of meeting California's 2020 emissions target. In estimating the cost of emission reduction efforts, these studies omit key components of costs and overstate the social value of savings from resulting reductions in energy use. In addition to underestimating the cost of particular actions that can reduce emissions, the California studies also underestimate the cost and fail to consider the effectiveness of some of the policies that are necessary to bring about those actions. This is particularly problematic for those policies that are known to face significant implementation challenges. Furthermore, the policies examined by the California studies can yield cost savings only if market failures prevent individuals and firms from voluntarily undertaking the cost-saving measures that those policies target. Otherwise, one would expect that those cost-saving measures would be realized even without the policies. But the California studies do not offer any evidence that market failures are sufficiently large to make the estimated cost savings plausible. Thus, even if the California studies' cost estimates for particular technologies or actions were correct, the studies may incorrectly forecast baseline behavior, leading them to underestimate policies' costs by overstating any savings that those policies may offer. In fact, the studies clearly underestimate the cost of California's vehicle GHG emissions standards as a result of a flawed forecast of consumers' baseline behavior.

We have not attempted to quantify the implications of all of the problems that we have identified. However, our analyses found that a few of these flaws each lead to underestimation of annual costs on the order of billions of dollars. Other problems, whose effects we could not

quantify, may have equally significant implications. Thus, as a result of the cumulative effect of these flaws, the California studies do not offer a reliable basis for estimating the cost of meeting California's 2020 emissions target.

Despite the issues described above, some of the measures examined by the California studies may nonetheless offer cost-effective means of achieving California's 2020 target. That is, while they may be more costly than the California studies suggest, some of the measures still may be among the least costly means of achieving that target. But additional improved analyses are needed to better inform policymakers regarding the economic implications of such measures.

VI. Policy Lessons from Evaluating the California Studies

The ultimate cost of California's climate policy will depend fundamentally on policy design decisions that have not yet been made. While California's Global Warming Solutions Act of 2006 sets a target for 2020 emissions, it leaves many critical aspects of policy design unresolved, such as emission targets for the years leading up to and following 2020, the emission sources that will be covered by regulation, and the policy instruments that will be used to achieve emission targets (e.g., market-based policies or performance and efficiency standards). These and many other important design decisions will be made in the coming months and years.

The California studies do not directly examine the economic implications of alternative policy designs. Moreover, by suggesting that the 2020 target can be achieved at no cost, they may foster a policymaking approach that does not reflect the significant stakes associated with the decisions that lie ahead — both in terms of unnecessary costs that may be incurred and savings that may be foregone if policies are poorly designed. In light of this, analyses focusing on the implications of alternative policy designs are particularly needed. In the meantime, some important lessons emerge from our evaluation of the California studies. In this section, we discuss lessons relating to uncertainty regarding the cost of meeting emission targets, and to the design of cost-effective policy. As we describe below, some of the most important policy design lessons do not depend on the extent to which opportunities for no-cost emission reduction polices exist, or whether the California studies have substantially underestimated costs.

A. Uncertainty Regarding the Cost of Meeting Emission Targets

Even if the flaws identified in the California studies are corrected and additional analyses are performed, significant uncertainty will remain regarding the cost of meeting California's 2020 emissions target. This is because further analysis cannot resolve many sources of uncertainty that are inherent in forecasts of future costs, such as uncertainty regarding future fuel prices, technological advances, and economic growth.

It is particularly important for policymakers to recognize the magnitude of cost uncertainty because the consequences of imprecisely estimating emission reduction costs are far greater for some policy designs than for others. For example, in the presence of cost uncertainty, rigid adherence to particular standards or emission targets increases the risk that policies will cause undesirable economic consequences. An inflexible cap on NO_x emissions established under California's RECLAIM program led to a dramatic increase in that program's costs in 2000, which contributed to California's electricity crisis.[68] Similarly, in the presence of cost uncertainty, sector-specific standards can present greater economic risks than would a broad-based (i.e., economy-wide) emissions cap-and-trade system. Compared with an economy-wide cap-and-trade system, such standards give regulated entities less flexibility to respond to unexpectedly high costs by adjusting the distribution of emission reduction efforts across and within sectors.

B. Importance of Considering the Cost-Effectiveness of Individual Policies

In evaluating a set of policies designed to achieve a particular objective, such as California's 2020 emissions target, policymakers should carefully evaluate the cost-effectiveness of each policy. By focusing on the aggregate impact of a portfolio of policies, the California studies divert attention from the question of which individual policies should be pursued to achieve California's 2020 emissions target at least cost. Nonetheless, careful examination of the California studies demonstrates just how important it is for policymakers to consider the individual merits of each component policy. For example, while the Berkeley study estimates that the vehicle GHG emissions standards and building energy efficiency programs and standards will yield significant cost savings, three of the remaining six policies that it examines are

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[68] *See* Joskow (2001).

estimated to have an average impact of *reducing* 2020 GSP by about \$300 per ton of CO_2 equivalent.[69] It makes little sense to conclude that these relatively costly measures are desirable simply because they are grouped with other measures that are estimated to create economic benefits. The significant variation in the estimated cost-effectiveness of policies examined by the California studies reinforces the fact that the choice and design of specific policy measures will critically affect the cost of California's climate policy.

C. A Cost-Effective Framework for Climate Policy

Much of the debate spurred by analyses like the California studies focuses on the costs of meeting specific emission targets. In addition to leading policymakers to flawed conclusions about the costs of meeting emission targets, such studies also may lead policymakers to ill-informed conclusions about the relative merits of alternative policy instruments for achieving those targets. As in the case of the California studies, those bottom-up analyses that yield significantly lower cost estimates than do many other economic analyses of climate policy often do so when analyzing a standards-based, sectoral policy approach. By contrast, other economic analyses that find higher costs often focus on analyzing market-based policies, such as cap-and-trade systems. Yet the differences in cost estimates and in the types of policy instruments examined by these analyses *should not* be interpreted as an indication that a standards-based, sectoral approach to climate policy would be a less-costly *alternative* to economy-wide market-based policies. In fact, regardless of one's beliefs about the extent of no-cost emission reduction opportunities, careful consideration of the different market failures that cause excessive GHG emissions should lead to the same conclusions about a cost-minimizing policy framework.

Emission reductions can be achieved by addressing several fundamentally different market failures. The core market failure contributing to excessive GHG emissions is the failure of individuals and firms to internalize the social cost of their emissions. Bottom-up analyses concluding that no-cost emission reduction opportunities exist reach this conclusion because of assumptions about an additional set of market failures. These additional market failures may prevent individuals and firms from making certain cost-saving decisions — such as with regard to energy efficiency investments — that would also reduce emissions.

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[69] Roland-Holst (2006a), Tables ES-1 and ES-2.

The fact that the core market failure leading to excessive emissions is the failure of individuals and firms to internalize the cost of their emissions suggests that a market-based policy, such as a cap-and-trade system, should be the core policy instrument employed. By creating a price signal that reflects the social cost of emissions, market-based policies can address this core market failure far more cost-effectively than can standards or other policy approaches. The economic logic leading to this conclusion is completely independent of debates about the prevalence of no-cost emission reduction opportunities.

Whereas a market-based policy should cover as many emission sources as possible in order to minimize the costs of meeting a given emissions target, the possibility that there may be some no-cost emission reduction opportunities suggests that *additional*, carefully targeted policies should be considered. Such policies should serve as *complements,* rather than alternatives, to a market-based policy because they address fundamentally different market failures. For example, even if a firm internalizes the cost of its emissions, inadequate information may still cause it to forego some cost-saving energy efficiency investments that would reduce emissions. Similarly, even if policies effectively address a market failure that prevents a firm from making some cost-saving investments, that firm's emissions still will be too high if it does not internalize the cost of those emissions. Moreover, while complementary policies addressing these additional market failures may offer some no-cost emission reduction opportunities, none have claimed that those opportunities are sufficiently abundant to permit achievement of long-run emission goals.

Additional policies also can be established to cover emission sources and sinks that cannot be targeted effectively by a core market-based policy. For example, difficulties measuring and monitoring biological sequestration of CO_2 and some non-CO_2 GHG emissions may hinder their direct inclusion in a cap-and-trade system. As we noted earlier, in part because of these difficulties, the California studies underestimate the cost of policies targeting sequestration and reductions in some non-CO_2 GHG emissions. Nonetheless, in concluding that these opportunities are important sources of low-cost reductions in net emissions, the California studies are consistent with prior analyses of national climate policy.[70] Thus, in this respect, the

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[70] *See* U.S. DOE, EIA (2003); U.S. DOE, EIA (2005); Reilly, Jacoby, and Prinn (2003); Stavins and Richards (2005); and Lubowski, Plantinga, and Stavins (2006).

California studies are valuable in reinforcing the need to explore how climate policy can effectively bring about sequestration and non-CO_2 GHG emission reductions.

The policy framework described above would ensure that policy costs are minimized, regardless of the extent to which no-cost opportunities exist. However, several points should be considered in evaluating complementary policies that target no-cost emission reduction opportunities. To be efficient, such policies must be tailored very carefully to reflect the specific market failures that they seek to address. For example, if property owners forego cost-saving energy efficiency investments because of inadequate information, this may call for different corrective policies than if they forego such investments because they would not receive sufficient compensation from their tenants. Moreover, unlike the failure of individuals and firms to internalize the social cost of their emissions, market failures that create no-cost emission reduction opportunities often call for narrowly targeted policy interventions. For example, a frequently cited market failure that may offer no-cost emission reduction opportunities is the fact that landlords may not have appropriate incentives for energy efficiency investments if their tenants pay the utility bills.[71] Yet less than one-quarter of U.S. residential energy consumption occurs in rented — as opposed to owner-occupied — housing units.[72]

To develop complementary policies that efficiently target no-cost opportunities, policymakers need better information about the nature and extent of the market failures that lead to those opportunities. Bottom-up analyses like the California studies have the potential to inform the development of such policies, but caution is in order. First, while bottom-up analyses may suggest the presence of market failures by finding cost-saving opportunities, they typically do not offer definitive evidence of such failures. These analyses may incorrectly identify no-cost opportunities because of flaws such as those described in Section V. Second, even if market failures are present, bottom-up analyses rarely offer any clear insight regarding the nature and full extent of those failures. But such information is essential for the evaluation of policy options. The cost of standards that might be developed to address these market failures depends critically on the nature and extent of those failures. Finally, if complementary policies would affect emission sources that are also covered by a market-based policy, such as a cap-and-trade

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[71] For example, *see* Brown (2001).

[72] U.S. DOE, EIA (2001).

system, evaluations of such complementary policies would need to focus on the policies' incremental effects. Energy efficiency investments that regulated entities would make in response to a cap-and-trade system presumably would diminish remaining opportunities for no-cost investments that complementary policies could target.

D. A Safety Valve Allows Policy Design to Account for Different Beliefs About Costs

While consideration of the different market failures that lead to excessive GHG emissions should point to the same cost-effective policy framework regardless of one's beliefs about no-cost emission reduction opportunities, undoubtedly it will be difficult to reach agreement on appropriate emission targets within that framework. However, it may be easier to reach agreement on the maximum cost that should be incurred to achieve near-term emission reductions, given the long-term nature of the climate problem. In light of this, a cap-and-trade system can be designed in a way that bridges the gap between those who believe that aggressive near-term targets can be met at no cost, and those who believe that such targets may impose unacceptable economic consequences. A cap could be set to reflect the aggressive targets that some analyses (like the California studies) suggest can be achieved at minimal or no cost, and a safety-valve provision could ensure that costs do not exceed what both groups deem to be the maximum acceptable level. A safety valve achieves this cost protection by guaranteeing that an unlimited number of emission allowances would be made available by the government at a pre-determined price. While firms would still undertake all emission reductions necessary to meet the cap that are less costly than the safety valve's "trigger price," the safety valve ensures that allowance prices — and thereby costs incurred to reduce emissions — will never rise above this trigger price. Although the debate about emission reduction costs cannot be easily resolved, a cap-and-trade with a safety valve can at least reduce the stakes of that debate by dramatically reducing the consequences of underestimating costs.

VII. Conclusions

Analyses of the costs of emission reduction policies offer important insights that can inform the development of climate policies in California and elsewhere. Economic analysis indicates that while most emission reduction measures will impose costs, the presence of market failures affecting energy efficiency may present some opportunities for low-cost or even no-cost

emission reduction policies. But there is substantial debate about the extent of such market failures and about our ability to address them through economically efficient policy intervention.

Some analyses suggest that these market failures present opportunities to achieve substantial emission reductions at no net cost. The three California studies that we evaluate in this paper are the latest to make this claim. But analyses finding substantial no-cost opportunities may reach such a conclusion by incorrectly calculating the true economic costs of emission reduction policies. Indeed, a careful examination of the California studies reveals that they underestimate the cost of meeting California's 2020 emissions target as a result of numerous flaws. While quantifying the full extent of this cost underestimation is beyond the scope of our study, that underestimation is clearly economically significant. A few of the flaws individually lead to underestimation of annual costs that is on the order of billions of dollars. The California studies also overstate the emission reduction potential of the policies that they examine, in part because they fail to account for offsetting increases in emissions (i.e., emissions leakage) that those policies would bring about within and outside of California. As a result, we conclude that the California studies do not offer reliable estimates of the cost of meeting California's 2020 emissions target. Better analyses are needed to inform policymakers.

The ultimate cost of meeting California's 2020 emissions target will depend both on the underlying cost of emission reduction measures and on many aspects of the design of California's policies that remain to be determined. The debate about opportunities for no-cost emission reduction policies is unlikely to abate, but this debate is irrelevant to some important lessons for climate policy design. Specifically, in designing policy, policymakers should recognize and account for the substantial uncertainty that characterizes emission reduction costs. Even if debates about the accuracy of particular analyses were to be resolved, many other critical and unresolvable sources of cost uncertainty would remain.

Also, debate about opportunities for no-cost emission reduction policies should not influence the choice of an appropriate framework of policy instruments to minimize the cost of achieving emission targets. Market-based policies, such as cap-and-trade systems, are the most cost-effective means of addressing the core market failure leading to excessive GHG emissions:

the failure of emitters to internalize the social cost of their emissions. A market-based policy should therefore be the core policy instrument employed to achieve California's emissions target.

The California studies' findings of no-cost emission reduction opportunities emerge from assumptions about different market failures. To the extent that these other market failures exist, they call for additional policies that could complement a market-based policy. However, to develop complementary policies that efficiently target no-cost opportunities, policymakers need better information and analysis than currently exists regarding the market failures that bring about those opportunities.

While the debate about opportunities for no-cost emission reductions will undoubtedly continue into the future, a well-designed market-based policy can facilitate consensus on climate policy despite this debate. By setting aggressive caps and establishing a safety valve to protect against cost uncertainty, a cap-and-trade system can bridge the gap between those who believe aggressive near-term emission targets can be met at no cost, and those who maintain that achieving such targets will impose unacceptable economic consequences.

REFERENCES

American Petroleum Institute. 2006. "State Gasoline Tax Reports." October.

Anderson, Soren and Richard Newell. 2004. "Information Programs for Technology Adoption: The Case of Energy-Efficiency Audits." *Resource and Energy Economics* 26(1): 27-50.

Brown, Marilyn. 2001. "Market Failures and Barriers as a Basis for Clean Energy Policies." *Energy Policy* 29(14): 1197-1207.

California Air Resources Board (CARB). 2004a. *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions From Motor Vehicles*. August 6.

_____. 2004b. *Addendum Presenting and Describing Revisions to: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*. September 10.

California Climate Action Team (CAT). 2005. *Draft State Agency Work Plans*. December 8.

_____. 2006a. *Climate Action Team Report to Governor Schwarzenegger and the Legislature*. March.

_____. 2006b. *Documentation of Inputs to Macroeconomic Assessment of the Climate Action Team Report to the Governor and Legislature*. January.

California Energy Commission (CEC). 2003. *Proposed Energy Savings Goals for Energy Efficiency Programs in California*. 100-03-021. October.

Center for Clean Air Policy (CCAP). 2005a. *Activities and Policies to Enhance Forest and Agricultural Carbon Sinks in California*. October 14.

_____. 2005b. *Reducing CO_2 Emissions from California's Cement Sector*. October 14.

_____. 2006. *Cost Effective GHG Mitigation Measures for California: Summary Report.* January 19.

Congressional Budget Office. 2003. *The Economic Costs of Fuel Economy Standards Versus a Gasoline Tax*. December.

Gillingham, Kenneth, Richard Newell, and Karen Palmer. 2006. "Energy Efficiency Policies: A Retrospective Examination." *Annual Review of Environment and Resources* 31: 161-192.

Hassett, Kevin and Gilbert Metcalf. 1995. "Energy Tax Credits and Residential Conservation Investment: Evidence from Panel Data." *Journal of Public Economics* 57(2): 201–217.

Hausman, Jerry. 1979. "Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables." *The Bell Journal of Economics* 10(1): 33-54.

Huntington, Hillard, Lee Schipper, and Alan Sanstad. 1994. "Editors' Introduction." *Energy Policy* 22(10): 795-797.

Interlaboratory Working Group. 1997. *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond*. Oak Ridge, Tennessee and Berkeley, California: Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory. September.

_____. 2000. *Scenarios for a Clean Energy Future*. Oak Ridge, Tennessee and Berkeley, California: Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory. November.

Jacoby, Henry. 1999. "The Uses and Misuses of Technology Development as a Component of Climate Policy." In *Climate Change Policy: Practical Strategies to Promote Economic Growth and Environmental Quality.* Washington, DC: American Council for Capital Formation Center for Policy Research. May.

Jaffe, Adam, Richard Newell, and Robert Stavins. 1999. "Energy-Efficient Technologies and Climate Change Policies: Issues and Evidence." In *Climate Change Economics and Policy: An RFF Anthology*, ed. Michael Toman. Washington, DC: Resources for the Future Press.

Jaffe, Adam, Richard Newell, and Robert Stavins. 2003. "Technological Change and the Environment." In *Handbook of Environmental Economics*, Volume I, ed. Karl-Göran Mäler and Jeffrey Vincent, Chapter 11, 461-516. Amsterdam: Elsevier Science.

Jaffe, Adam, Richard Newell, and Robert Stavins. 2005. "A Tale of Two Market Failures: Technology and Environmental Policy." *Ecological Economics* 54(2-3): 164-174.

Jaffe, Adam and Robert Stavins. 1994. "The Energy Efficiency Gap: What Does It Mean?" *Energy Policy* 22(10): 804-810.

Jaffe, Judson and Robert Stavins. 2004. "The Value of Formal Quantitative Assessment of Uncertainty in Regulatory Analysis." Washington, DC: AEI-Brookings Joint Center for Regulatory Studies, *Related Publication 04-22*. September.

Joskow, Paul. 2001. "California's Electricity Crisis." *Oxford Review of Economic Policy.* 17(3): 365-388.

Loughran, David and Jonathan Kulick. 2004. "Demand-Side Management and Energy Efficiency in the United States." *Energy Journal* 25(1): 19-41.

Lubowski, Ruben, Andrew Plantinga, and Robert Stavins. 2006. "Land-Use Change and Carbon Sinks: Econometric Estimation of the Carbon Sequestration Supply Function." *Journal of Environmental Economics and Management* 51(2): 135-152.

Metcalf, Gilbert and Kevin Hassett. 1999. "Measuring the Energy Savings from Home Improvement Investments: Evidence from Monthly Billing Data." *The Review of Economics and Statistics* 81(3): 516–528.

Metcalf, Gilbert and Donald Rosenthal. 1995. "The 'New' View of Investment Decisions and Public Policy Analysis: An Application to Green Lights and Cold Refrigerators." *Journal of Policy Analysis and Management* 14(4): 517–531.

Reilly, John, Henry Jacoby, Ronald Prinn. 2003. *Multi-Gas Contributors to Global Climate Change: Climate Impacts and Mitigation Costs of Non-CO$_2$ Gases*. Arlington, Virginia: Pew Center on Global Climate Change. February.

Roland-Holst, David. 2006a. "Economic Assessment of Some California Greenhouse Gas Control Policies: Applications of the BEAR Model." In *Managing Greenhouse Gas Emissions in California*, ed. Michael Hanemann and Alexander Farrell, Chapter 2. University of California at Berkeley: The California Climate Change Center. January.

_____. 2006b. "Economic Growth and Greenhouse Gas Mitigation in California." University of California at Berkeley: The California Climate Change Center. August.

Sanstad, Alan, Carl Blumstein, and Steven Stoft. 1995. "How High Are Option Values in Energy-Efficiency Investments?" *Energy Policy* 23(9): 739–743.

Sanstad, Alan, Michael Hanemann, and Maximillian Auffhammer. 2006. "End-Use Energy Efficiency in a 'Post-Carbon' California Economy: Policy Issues and Research Frontiers." In *Managing Greenhouse Gas Emissions in California*, ed. Michael Hanemann and Alexander Farrell, Chapter 6. University of California at Berkeley: The California Climate Change Center. January.

Stavins, Robert and Kenneth Richards. 2005. *The Cost of U.S. Forest-Based Carbon Sequestration*. Arlington, Virginia: Pew Center on Global Climate Change. January.

Schumpeter, Josef. 1942. *Capitalism, Socialism and Democracy*. New York: Harper.

Sutherland, Ronald. 2000. "'No Cost' Efforts to Reduce Carbon Emissions in the U.S.: An Economic Perspective." *Energy Journal* 21(3): 89 - 112.

United States Department of Energy (DOE), Energy Information Administration (EIA). 1998. *Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity*. October.

_____. 2001. *2001 Residential Energy Consumption Survey*.

_____. 2003. *Analysis of S.139, the Climate Stewardship Act of 2003*. June.

_____. 2005. *Impacts of Modeled Recommendations of the National Commission on Energy Policy*. April.

United States Department of Transportation, National Highway Traffic Safety Administration. 2006. "Average Fuel Economy Standards for Light Trucks Model Years 2008-2011; Final Rule." *Federal Register* 71(No. 66, April 6): 17566.