

Program on Technology Innovation:
Economic Analysis of California Climate Initiatives:
An Integrated Approach
Volume 1: Summary for Policymakers



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Volume 1: Summary for Policymakers

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REPORT SUMMARY

The State of California has set ambitious climate policy goals to reduce greenhouse gas (GHG) emissions by 80% by 2050. These actions have attracted widespread attention and are likely to have significant influence on climate policies in other states and at the federal level. This study, the first of its kind, used a comprehensive model of the State's economy and U.S. electricity market and power grid to measure the potential gains or losses to the state's economic welfare of a range of implementation options.

Background

The California Global Warming Solutions Act of 2006 (AB 32) mandates reductions in future California greenhouse gas emissions so that 1990 levels are reached by 2020. Many key aspects of the policies California intends to implement to meet these goals remain unclear. EPRI's past research has shown that these details matter when it comes to limiting the overall costs of a given climate policy.

Objectives

To examine a range of policy implementation scenarios for the California Climate Initiatives with a high degree of analytical rigor and estimate the potential costs likely to be associated with each.

Approach

EPRI combined two widely accepted state-of-the-art economic models: the Multi-Region National (MRN) model and the North American Electricity and Environment Model (NEEM). Using these linked models, EPRI conducted a detailed analysis of 20 different implementation scenarios of various policy options, including industry-specific command-and-control regulations as well as market-based cap-and-trade programs. The linked model approach made it possible to understand the economy-wide impacts of specific climate policies while examining the specific impacts on the electricity sector in detail.

Results

- Implementation options based on a broad, market-based cap-and-trade program will likely be more cost-effective than a sector-specific program of command-and-control regulations or approaches that cover only one part of the State's economy.
- All scenarios analyzed showed real economic costs to the state, with costs increasing as future GHG emissions decrease. Depending on the implementation scenario, cumulative real costs to the State's economy could range from -0.2% to -1.2% (\$100 to \$511 billion discounted net present value from 2010 through 2050).
- Establishing a maximum price on CO₂ (an allowance price safety valve) reduces the economic uncertainty of a market-based cap-and-trade system. The safety valve would be a

way to limit economic costs if low-cost reduction options fail to achieve the desired reductions. However, under such a scenario, the GHG reduction target will not be met.

- California’s Climate Action Team Report (March 2006) suggests various in-state forestry activities that could provide offsets that would augment the cap. Using estimates from this report, EPRI found that forestry offsets provide a cost savings of \$33 billion through 2050.
- The role of out-of-state electric generation needs to be carefully examined. There is the potential for increased GHG emissions from nearby states (“leakage”) if those states shift low-carbon electricity to California and send higher-carbon electricity elsewhere.

EPRI Perspective

Although this study explored many key issues associated with California’s current climate policy, it is not an exhaustive treatment of the climate policy choices. The study focused on California initiatives, but inevitably climate policy will continue to evolve both within California and beyond its borders raising further issues. Some of high priority topics for further study include:

- The impact on the electricity sector of the wide use of electrified vehicles (such as Plug-In Hybrids) or vehicles using zero-carbon fuels such as hydrogen that would be produced with electricity
- How emissions from electricity imports and contracts are to be treated
- The relative inefficiency of command-and-control regulations in comparison to market-based approaches
- The effects on California of changes in federal, western states, and other regional climate policies
- How California’s policies might affect policy outcomes nationwide and the competitive position of California industry
- The effects of policies affecting the transportation sector, such as tightened fuel economy standards or introduction of low-emission fuels
- The costs of uncertainties about policy implementation and post-2020 targets and possible ways to lessen these uncertainties
- How allowance allocation would be carried out in a potential cap-and-trade program
- The impact of California’s climate policy on commercial transportation
- Offsets possibilities that go beyond those identified by the state’s Climate Action Team Report (March 2006) that offer the promise of significant cost-savings while achieving the goals of meeting the State’s emission targets.

Keywords

California climate initiatives
Greenhouse gases
Cap-and-trade

Climate policy implementation
California Global Warming Solutions Act (AB 32)
Price safety valve

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W. David Montgomery had overall responsibility for direction of the project for CRA.

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EPRI recognizes the important contribution of its review committee, which provided valuable feedback on our initial analysis of California's climate change policies. Their patient and careful reading of the draft report and many detailed comments were immensely valuable in improving the final product. The review committee consisted of the following people:

Ralph Cavanagh, Natural Resources Defense Council
Lawrence Goulder, Stanford University
Eric Haxthausen, Environmental Defense
Granger Morgan, Carnegie-Mellon University
John Reilly, MIT
Robert Stavins, Harvard University
James Sweeney, Stanford University
David Victor, Stanford University
John Weyant, Stanford University

The review committee provided EPRI with valuable comments and suggestions, but was not asked to approve the report or to endorse its methodology, findings or conclusions. The review committee met several times in 2006. The last meeting took place November 30, 2006 and the committee has not been consulted since then.

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EXECUTIVE SUMMARY

In undertaking this study, EPRI acknowledges the important leadership role being taken by California as it attempts to address the challenge of global warming by limiting emissions of greenhouse gases within the state. These actions have attracted widespread attention and are likely to have significant influence on climate policies in other states and at the federal level. Because such high stakes are involved, it is vital that the cost implications of such climate initiatives be thoroughly understood. In particular, California policymakers have set ambitious emission limits but intentionally provided considerable flexibility about how these goals are to be achieved. The purpose of this study was not to explicitly analyze California's greenhouse gas reduction goals. Rather, the purpose was to examine a range of policy implementation scenarios with a high degree of analytical rigor and estimate potential costs likely to be associated with each. The results of these analyses should be of value to the Climate Action Team and other stakeholders as the implementation of California's climate policies moves forward.

EPRI brings to this task nearly three decades of experience in economic analysis related to climate change and related policy implications, including a leading role in technical support to the Intergovernmental Panel on Climate Change (IPCC). Based on this experience, the present study is designed to move beyond previous analyses of California's climate initiatives in two important ways: It is the first study to use a comprehensive model that links a broad representation of the California economy, in the context of its trade with the rest of the United States, with a detailed model of the U.S. electricity market and power grid. Second, rather than measuring implementation costs only in terms of changes in gross state product (GSP), it focuses on potential gains or losses to the state's economic welfare. Such welfare impacts—defined in terms of changes in future consumption—provide a better measure of how policy implementation decisions will actually affect the average Californian¹. Figure 3-1 shows the relationship between GSP, investment, and consumption.

¹ The economic welfare measure used in this report is the discounted present value of the consumption of all goods and services plus leisure (economic well being) over the model horizon (2010 to 2050). The welfare cost is the amount of money (in discounted present value terms) that the state of California would need to be as well off as it would be without any climate change policies. Consumption includes the labor versus leisure trade-off. This economic measure places the study in the category of “cost-effectiveness” rather than cost/benefit because it specifically does not include any estimate of the environmental benefits provided by achieving the mitigation targets. The report should in no way be perceived as a cost benefit analysis of California climate policy. The focus is exclusively on the nature and costs of various abatement strategies required to achieve the state's GHG emission targets. No attempt has been made to assess the global or California damages avoided as a result of California climate policies.

The main conclusion of this study is that the proposed emission limits can, indeed, be achieved, but that the costs involved will vary widely depending upon the eventual approaches chosen to implement specific policy goals. EPRI does not advocate any specific approaches, but rather has attempted to present a broad spectrum of potential implementation scenarios and to determine the impact of each on California's economic welfare. EPRI has offered and is providing its analytical capabilities to support State agencies as they develop and implement programs for reducing greenhouse gases.

1.1 Introduction

California's current climate policy is shaped by several important measures that provide the framework in which future policy will develop, but leaves major uncertainties about how the policies will be implemented or modified in response to changing circumstances.

1.1.1 Background

During the last two years, both Governor Schwarzenegger and the California legislature have taken four important climate policy actions. These initiatives were intended not only to reduce the state's greenhouse gas (GHG) emissions but also to spur national and international efforts to counter global climate change as well as to provide a model for doing so. EPRI sponsored this study, conducted by CRA International, in order to ascertain the likely economic costs and emissions reductions of California's climate policy. The four state climate policy steps include:

- In June 2005, Governor Schwarzenegger signed Executive Order S-3-05, which sets targets to limit California's future greenhouse gas emissions.
- The state legislature passed and the Governor signed Assembly Bill No. 32, (AB 32 – the "California Global Warming Solutions Act of 2006"), which calls for enforceable interim emissions limits to be effective starting in 2012 and then gradually reducing emissions to a 2020 target of returning to 1990 emissions levels.
- The Governor's Executive Order S-20-06 directs the California Environmental Protection Agency (Cal/EPA) to develop an emission trading system as part of the implementation of AB 32.
- Senate Bill No. 1368 (SB 1368) established an interim emissions performance standard for greenhouse gas emissions from power plants serving California, whether inside or outside the state.

Taken together these four climate policy actions establish a legal framework in which California's climate policy will evolve, but offer limited guidance as to its future shape.

1.1.2 Uncertainties Related to Implementation of New Climate Policies

Although the new measures specify several norms to guide the regulators' choices, many possible directions for implementation of policies remain open. Among the most critically important uncertainties are:

- Will the policies emphasize market mechanisms, such as cap-and-trade programs, emphasize command-and-control regulations, such as efficiency standards, or will the policy be a mixed one?
- Will there be multiple emission control policies, what will be their details, and how might the policies interact? Or will there be one comprehensive policy?
- Will the legislated targets be implemented rigidly or will regulators temper them through the application of benefit-cost or other economic considerations (e.g., flexibility mechanisms such as safety valves or linkage with other emission trading systems)?
- What will be the post-2020 goals for emission reductions and how soon will the policy process establish them?

How California's government resolves these issues will affect the state's economy, its energy and electricity markets, those of the surrounding states, and the profits or losses that will accrue to the massive investments in power generation and other industries that must be made over the next decade.

1.2 The Analysis

To determine the effect of various policy options on California carbon emissions and on the state's welfare, an economic analysis was conducted on 20 scenarios, using a state-of-the-art model described in Section 3.8.2. These scenarios, we believe, represent a range of possible implementation options for AB 32 and related climate initiatives. Six of these scenarios are briefly described below. The analysis results—which encompass a wide spectrum of policy implications—are presented in Section 1.3. (A more detailed description of all the scenarios is presented in Section 4.1.3.) The six scenarios discussed in this Section include:

- **Pure_Trade** – Comprehensive cap-and-trade program including all sources of emissions to achieve the AB 32 target of reducing emissions below 1990 levels by 2020 and continuing this target to 2050. The Pure_Trade scenario assumes that California will implement AB 32 with market-oriented marginal costs across all sectors of the economy in order to achieve emission reductions in the most cost-effective manner. Standard assumptions about technology development are adopted, except that CA is assumed to neither import nor construct any new nuclear power. (Such construction is currently restricted in California, pending resolution of long-term waste disposal issues.)
- **SV_LCA** – Same as Pure_Trade but with a safety-valve set at the permit prices that result under the scenario with low-cost assumptions (LCA scenario²).
- **Trgt40** – In 2050, achieve 40% emissions reduction below 1990 levels, with the same technology development assumptions and the same comprehensive market approach as in the Pure_Trade scenario.

² The low-cost assumptions (LCA) include rapid and effective measures promoting energy efficiency, significantly reduced capital cost and rapid introduction of renewables (especially wind), and penetration of carbon-free transportation four times as great as for the Pure_Trade assumptions. LCA is a very optimistic but plausible scenario. The Safety-Valve could provide insurance against the economic risk that the optimistic assumptions of LCA turn out to be invalid.

- **Trgt80** – In 2050, achieve 80% emissions reduction below 1990 levels, as set forth in Executive Order S-3-25, with the same technology development assumptions and comprehensive market approach as in the Pure_Trade scenario.
- **Nuclear80** – Same as Trgt80, but with the assumption that nuclear plants will be built outside of California and that imports of power from these plants will not be restricted.
- **RPS 20** – Meet California’s previous Renewable Portfolio Standard of 20% renewable energy by 2020, but don’t impose an overall emissions cap.³

None of the scenarios assumed banking or borrowing of emission allowances. Sensitivity runs demonstrated that banking made very little difference to the economic impact. Borrowing could have a small but positive effect. Since the effects were small the analysis was conducted without either banking or borrowing in order to simplify the discussion.

The results of the analysis are reported in terms of impacts on California’s economic welfare. A comparison of how this measure differs from changes in GSP and investment is illustrated in Figure 3-2, Section 3.1.1. The analysis itself was conducted using an integrated approach that provides a unique and consistent modeling framework described in more detail in Section 4.1.2. During the course of the study, the study design and preliminary results were reviewed by an advisory committee of outside experts listed in the Acknowledgements section of this report.

1.3 Major Findings

The changes in carbon dioxide emissions associated with each of the six policy implementation scenarios just described are shown in Figure 1-1 and compared to a “business as usual” baseline. RPS 20 makes a relatively small contribution to emissions reductions, largely tracking the baseline but at a slightly lower level. SV_LCA initially causes emissions to fall quite rapidly, but does not meet the AB 32 standard and eventually allows emissions to rise again. Selection of the safety valve price affects the degree to which emissions reductions occur. Each of the other four scenarios does achieve the AB 32 requirement, but then they begin to diverge widely in the 2020-2050 timeframe. For Pure_Trade, emissions remain constant after 2020. Both Trgt80 and Nuclear80 achieve the 80% emissions reduction of Executive Order S-3-25 by 2050; the main difference between them is cost, as shown later. Trgt40 illustrates the results of an emissions policy roughly midway between Pure_Trade and Trgt80/Nuclear80.

Costs

Three major conclusions about costs can be drawn from the analysis:

- Policies that combine market-oriented abatement incentives with increased technological innovation are the most cost-effective.

³ After this research was underway, legislation accelerating the RPS deadline to 2010 (SB 107) was signed into law.

- All else being equal, for an emission control policy based on market-oriented policies, marginal (incremental) abatement costs increase with the stringency of the emission reduction targets.
- Costs increase more rapidly over time than do annual emission reductions.

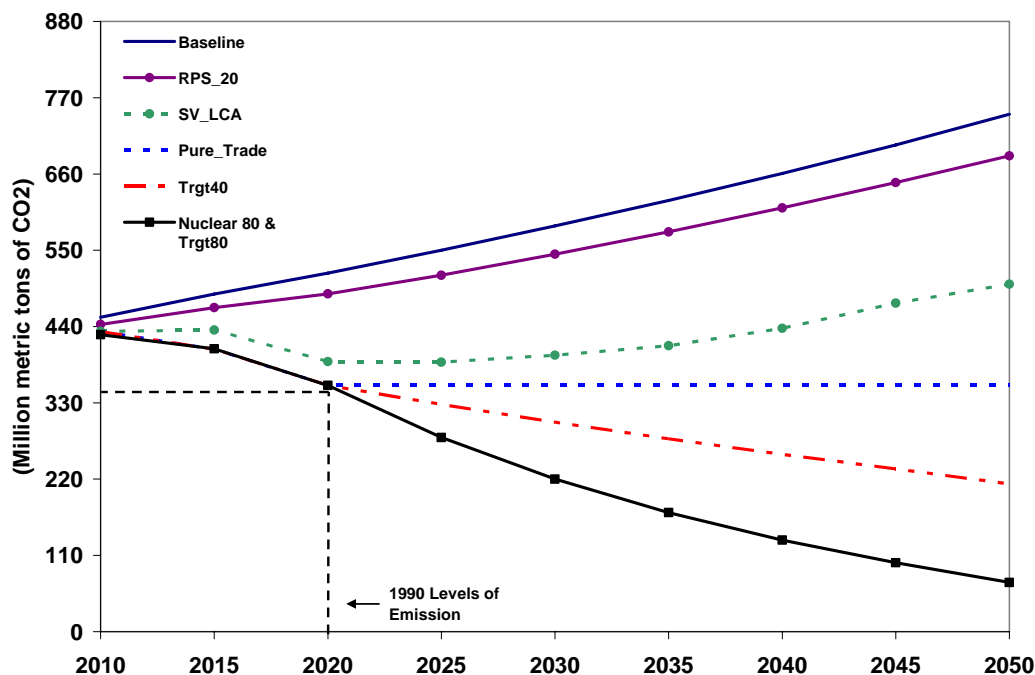


Figure 1-1
California Carbon Dioxide Emissions Under Different Scenarios

Figure 1-2 illustrates these points by comparing the costs of pursuing each policy implementation scenario, compared to business-as-usual, together with the cumulative emissions reductions achieved by each approach. RPS20 makes little difference to overall emissions, but its cost is modest. SV_LCA reduces state welfare by about \$134 billion, but does not meet AB 32 emission reductions requirements for 2020. Pure_Trade meets the standard, at a cost of about \$229 billion welfare reduction. The bars extending vertically from this point represent a range of costs of the other scenarios discussed more fully in Section 3, Table 3-2. These costs range from about \$147 billion to more than \$367 billion reduction in state economic welfare. For 2050, both Trgt80 and Nuclear80 meet the very stringent emission reduction requirements of Executive Order S-3-05, but the welfare cost of Trgt80 is about \$511 billion, compared to about \$444 billion in the Nuclear80 scenario. As expected, Trgt40 lies between Pure_Trade and Trgt80/Nuclear80. An additional scenario, LCA, is included in this graph to allow comparison with previous studies, which use optimistic Low Cost Assumptions and no safety valve. It is important to note that the SV_LCA scenario is a Pure_Trade policy with safety valve carbon prices to guard against economic uncertainty. In other words, if the low cost reduction assumptions fail to deliver the desired emission reductions, then a safety valve carbon price would protect the economy against higher than expected costs. If the safety valve carbon price were reached and exercised, then the state would not achieve the 1990 emission goals.

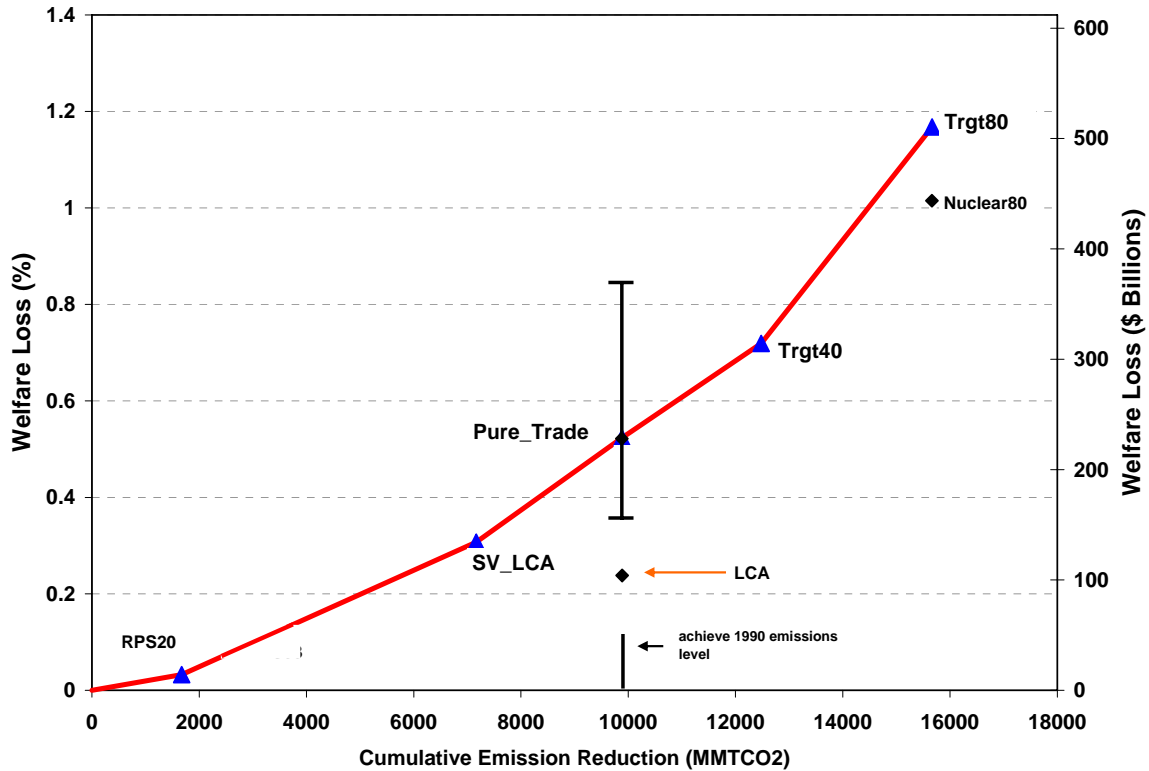


Figure 1-2
Comparison of Cumulative CA Emission Reduction and CA Welfare Change⁴

Implications

Taking into account all the scenarios analyzed (not just the six highlighted above), several key implications for California’s emerging climate policy can be identified:

- Although policies differ in the cost per ton of greenhouse gas (GHG) emissions avoided, all policies that significantly reduce GHGs will entail costs to the California economy. These costs will appear as reductions in economic welfare, consumption, and Gross State Product (GSP). The cost of meeting the stated 2020 emission reduction goal could range from \$104 billion to \$367 billion of reduced consumption (discounted present value through 2050).⁵
- Broad cap-and-trade programs are more cost-effective than are command-and-control regulations because the former can equalize the cost of avoiding an additional ton of emissions (marginal abatement costs) across all available options. In contrast, regulators cannot know the marginal cost of abatement across the array of emission reduction opportunities. Therefore, sector-specific command-and-control regulations will reduce

⁴ Refer to Table 3-2 for an explanation of the Low Cost Assumption (LCA) and other scenarios.

⁵ For context the California economy will produce \$43,709 billion of consumption (discounted present value) over the same period.

emissions too much in some sectors and too little in others. In addition, attempts to layer command-and-control regulations on top of cap-and-trade programs introduce complexity and potential redundancy or could actually degrade cost effectiveness by preventing affected parties from equalizing marginal abatement costs across disparate choices. As an indication of the stakes involved, specific regulatory approaches analyzed could increase costs by over 60% compared to comprehensive market-based approaches that preserve environmental gains and allow flexible choices to reduce costs.

- An allowance price safety valve could enhance a cap-and-trade plan's cost-effectiveness by allowing regulators to sell as many permits as demanded at a pre-specified price. Such an approach could reduce the economic costs by over 40%, if the state's GHG reduction targets should prove to rest on over-optimistic low-cost assumptions about abatement costs. A safety valve price can also dampen the sharp allowance price fluctuations that have proven to be an expensive feature of other cap-and-trade programs, such as the Clean Air Act's Title IV and the European Union's Emission Trading Scheme (ETS). By placing a ceiling on allowance prices, a safety valve also avoids imposing on businesses and consumers the price peaks that can be caused by weather, the business cycle, or shifting energy markets. However, triggering the safety valve price implies that the emission reduction targets will not be reached.
- Regulating emissions associated with electricity imports entails a trade-off between leakage of emissions and higher abatement costs. (In this case emission "leakage" refers to California climate policies that reduce in-state GHG emissions while inadvertently increasing out-of-state emissions.) In addition, the approach currently under development bases emissions calculations on the assumption that California utilities could shift long-term contracts for electricity supply from outside California, although such shifts could potentially result in significant leakage. (Under such contract "shuffling," for example, coal plants in other states could continue to operate at full capacity by selling in other markets, while hydro and other renewable resources are contracted to sell power to California.) Specifically, the analysis shows that, because of contract shuffling, for every ton of emission reduction from the electric sector in California, there could be an increase of 0.85 tons of electric sector emissions from the rest of the western states. Conversely, until full regional emission trading systems are created, regulatory efforts to prevent such contract shuffling could significantly increase costs to California ratepayers. The peak loss in GSP with maximum contract shuffling allowed is 1.0%, but increases to 1.4% if contract shuffling is prevented.
- California's Climate Action Team Report (March 2006) suggests various in-state forestry activities could provide offsets that would augment the cap. EPRI used the CAT estimate and found that these forestry offsets could provide a cost savings of \$33 billion through 2050. Expanding the program to out-of-state offsets could provide additional savings while achieving the intended emission targets.
- Current uncertainties about the future course of California's climate policy are likely to affect consumer behavior, business R&D spending, and investments in long lived capital assets. Failure to resolve these issues leaves firms and households uncertain about even relatively near-term investment decisions. Many investors faced with this situation may simply defer investment decisions until future regulatory policy becomes clearer, creating risks for the adequacy of electricity supply in particular.

2

INTRODUCTION: CLIMATE POLICY CHALLENGES AND CALIFORNIA'S POLICY RESPONSES

For any individual state, even one with an economy as large as California's, affecting the global problem of climate change is a daunting challenge. Choices about how the state implements its climate policies will affect the economic consequences of the effort to California, but national and international policy developments playing out beyond the state's borders will ultimately determine the extent to which climate change is mitigated.

2.1 A State Plan to Address a Global Problem

California is taking regional action on a global problem, adopting mandatory emission reductions in anticipation that other states and governments will follow suit. The large gap between the reach of California's policies and the problem's international roots, however, complicates the state's task. Analyzing the actions that might be taken by other states and governments is beyond the scope of this study.

These complexities of the climate problem have important implications for decisions about where and when emissions should be reduced in cost-effective policy responses. Since only cumulative emissions over long time periods matter for climate risk, mandatory caps that place specific limits on emissions in each year create significant cost risks. This suggests that a policy response ought to build in provisions to prevent undesirable near-term cost spikes, yet AB 32 provides for only limited means to adjust targets if costs to the economy of meeting its near term goals turn out to be higher than acceptable to the state.

Such considerations also suggest that an important long-term feature of any policy initiative is the impact it will have on investment in R&D and the development of new technologies to provide essentially carbon free energy at an affordable cost. The kinds of policies adopted in California are not likely on their own to bring about these technology changes.⁶ The cost of future technologies is highly uncertain and depends greatly on whether or not other states or nations follow California's lead, whether the state sticks to its stated long-term emission goals, and – not least – how difficult the scientific and technological challenges of developing a sufficient quantity of inexpensive, GHG-free energy technologies turn out to be. In any case, achieving California's stringent emission reduction goals will require widespread deployment of new technologies, and therefore a major commitment to research and development.

⁶ Montgomery, W. David and Anne Smith, "Price, Quantity, and Technology Strategies for Climate Change Policy," *Human Induced Climate Change: An Interdisciplinary Assessment*, Cambridge University Press, 2006.

The necessity of a coordinated national and global effort is acknowledged in the state government's Climate Action Team (CAT) report:

“A coordinated national approach to capping climate change emissions within an international framework would be the best approach for addressing this leakage [climate change] through the design of the program and ongoing efforts to coordinate with other action to reduce climate change emissions.”

2.2 Climate Policy Choices and the Stakes They Imply

California has become the first state to establish mandatory, enforceable caps on its future emissions of greenhouse gases. Being first to establish mandatory targets means that California must also be the first state to design a comprehensive set of policies sufficient to achieve those targets. It needs to design policies that are sound and offer cost effective solutions. AB 32 is primarily a “framework” bill, charging state regulatory agencies with the responsibility for developing implementation strategies. As a result, California is now at the beginning of a complex process of designing effective programs at a state level to address a policy problem that is global in nature, a process that will be observed attentively by other states and countries.

Thus major design decisions remain to be made over the next several years. Those decisions will have consequences for the California economy, for energy and electricity markets in the Western United States, and for the profits or losses that will accrue to the large investments in power generation and other industries that must be made over the next decade. How the California economy fares under these policies may well affect the willingness of other states to follow with their own action on greenhouse gas emissions.

The analysis, which is summarized in this volume (and described in much greater detail in Volume 2), finds that different policy choices carry widely varying costs as measured in losses in economic welfare of the state's citizens. It finds that California could modestly increase its renewable portfolio standard at little cost, although doing so would have a small impact on greenhouse gas emissions relative to the targets of AB 32. At the other extreme, reducing emissions by 80% from 1990 levels by 2050 would decrease welfare (discounted present value of consumption through 2050) by a total of \$511 billion in 2003 dollars. These costs are more than two times greater than those of maintaining emissions at 1990 levels for the entire 2020-2050 period.

At the same time, the various policy options also have disparate impacts on the state's greenhouse gas (GHG) emissions. Figure 2-1 illustrates the total California CO₂ emissions under 6 different scenarios analyzed by EPRI (in millions of metric tons of CO₂).

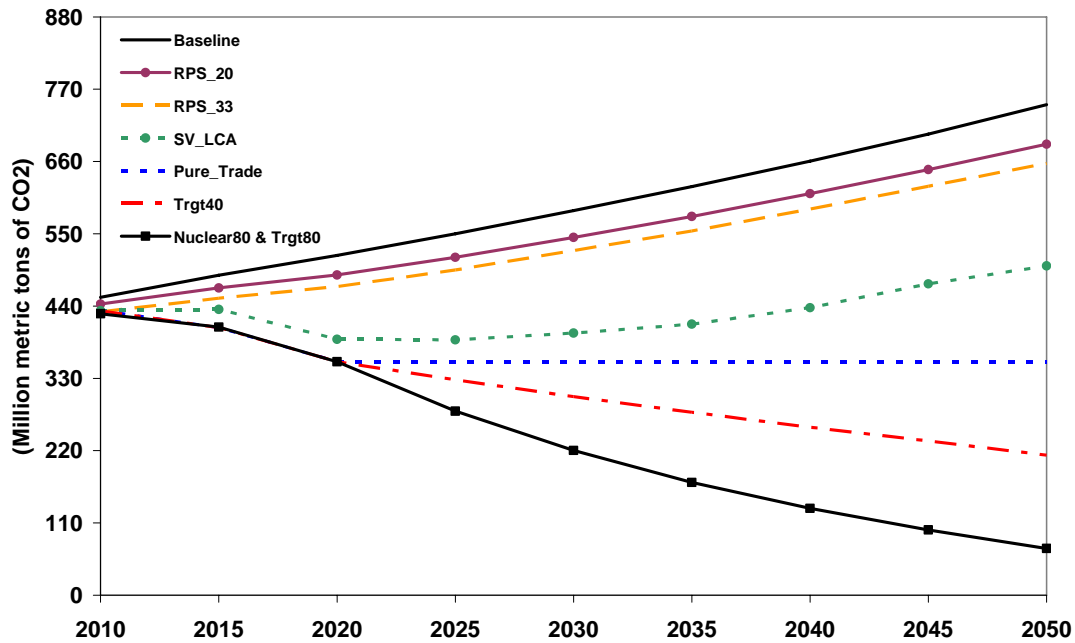


Figure 2-1
California Carbon Emissions Under Different Scenarios

Figure 2-2 displays the accompanying permit prices that would be required to achieve these emission reductions. Under the RPS scenarios (RPS_20 and RPS_33)⁷ no carbon cap is in place and therefore there are no permit prices. Under the cap-and-trade scenarios (SV_LCA, Pure_Trade, Trgt40, Trgt80 and Nuclear80), the permit price rises in the near term as the emission reductions increase indicating that each additional ton of abatement is more expensive than the previous one. In the medium term, the prices plateau as a low-carbon transportation “backstop” technology comes on-line. This unspecified technology—such as cellulosic ethanol, biodiesel, or plug-in hybrid electric vehicles (PHEVs)—is assumed to have lower emissions at a higher cost than the petroleum products it displaces. Under the Trgt40 and Trgt80 policies, emissions from the transportation sector drop to near zero in the long term. After that point it becomes very expensive to reduce emissions further from other sectors. Hence the marginal cost of abatement attains very high levels by 2050.

Detailed examination of the various scenario results reveals that several policy tools are likely to enhance the cost-effectiveness of climate policy options. In particular, the analysis suggests that measures emphasizing broad, market-oriented emission reductions, gradual emission reductions, and early certainty about future targets are likely to meaningfully reduce the total costs and impacts of meeting California’s climate policy objectives. The stakes in making these choices are large.

⁷ Table 3-2 describes all of the scenarios including RPS_20 and RPS_33.

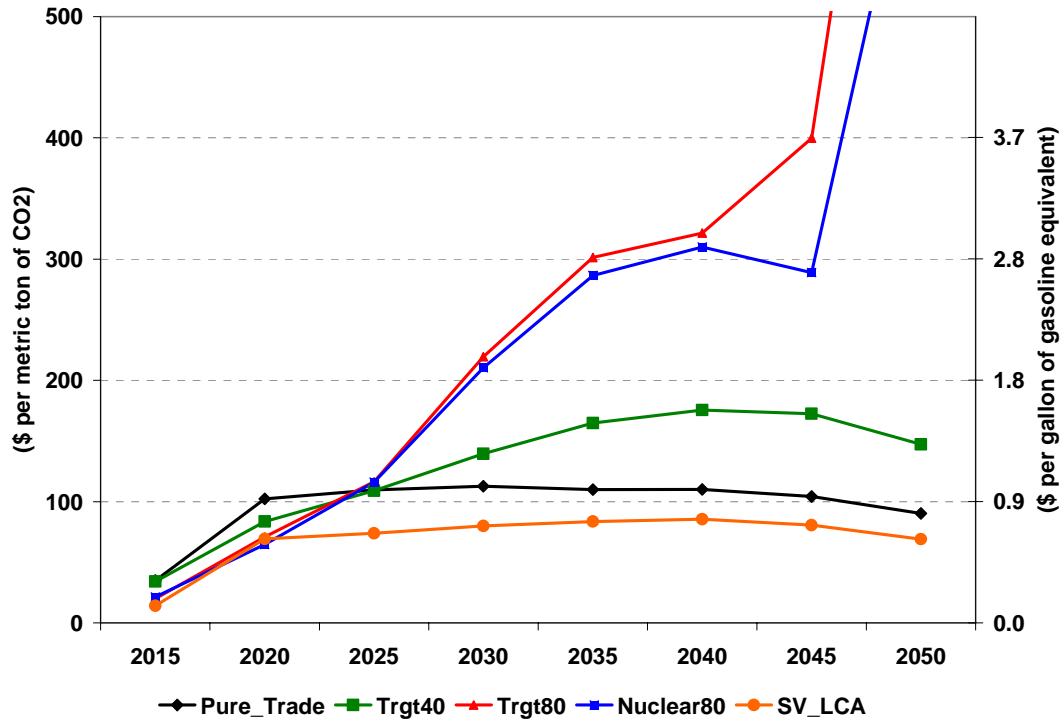


Figure 2-2
California Permit Prices Under Different Scenarios

2.3 California's Climate Policy Initiatives

During the last two years both Governor Schwarzenegger and the California legislature have initiated four important climate policy initiatives. ES S-3-05, AB 32, EO S-20-06, and SB 1368.

2.3.1 Executive Order S-3-05

First, on June 1, 2005, the Governor of California signed Executive Order S-3-05 which sets targets to limit California's future greenhouse gas emissions. Executive Order S-3-05 established targets looking out almost 50 years:⁸

- by 2010, reduce GHG emissions to 2000 levels;
- by 2020, reduce GHG emissions to 1990 levels; and
- by 2050, reduce GHG emissions to 80% below 1990 levels.

⁸ Although not explicitly mentioned in the EO, the targets set out by the Governor would reduce California's greenhouse gas emissions by 11% in 2010 and by 29% in 2020, relative to levels predicted without limits on greenhouse gas emissions. Since the targets are tied to levels that are yet to be determined and the "business-as-usual" level of emissions are dependent on model assumptions, the abatement level could vary.

This Executive Order directed the Secretary of the California Environmental Protection Agency (Cal/EPA) to coordinate the efforts of state agencies to develop a plan to meet its targets. This directive led to creation of a Climate Action Team (CAT), which released a report in March 2006 that discussed recommended measures and the Team's estimates of their impacts on the California economy. The CAT report envisioned a climate policy composed of numerous sector-specific and technology-specific regulations.

2.3.2 Assembly Bill No. 32

Second, the state legislature has embarked on a parallel initiative by enacting Assembly Bill No. 32 (AB 32 or the "California Global Warming Solution Act of 2006"). The new law calls for enforceable interim emissions limits to be effective starting 2012 and then gradually, by the 2020 target, a reduction of emissions to 1990 levels. AB 32 sets explicit caps on California's future greenhouse gas emissions, but leaves implementation to be determined by state agencies between February 2007 and January 2010.

AB 32 directs the Air Resources Board to approve a statewide emission limit equivalent to the state's 1990 emission level and to achieve that level by 2020. By January 1, 2011, "*the state board shall adopt greenhouse gas emission limits and emission reduction measures by regulation to achieve the maximum technologically feasible and cost-effective reductions in greenhouse gas emissions in furtherance of achieving the statewide greenhouse gas emissions limit, to become operative beginning on January 1, 2012.*" Also by January 1, 2011, "*the state board may adopt a regulation that establishes a system of market-based declining annual aggregate emission limits for sources or categories of sources that emit greenhouse gas emissions, applicable from January 1, 2012, to December 31, 2020, inclusive, that the state board determines will achieve the maximum technologically feasible and cost-effective reductions in greenhouse gas emissions, in the aggregate, from those sources or categories of sources.*"

2.3.3 Executive Order S-20-06

Third, the Governor signed Executive Order S-20-06 which directed the development of an emission trading system as part of the implementation of AB 32. Executive Order S-20-06 named Cal/EPA as the state leader for implementation of AB 32, and directed the Air Resources Board (ARB) to work with Cal/EPA to develop regulatory measures and market-based mechanisms on a concurrent and expeditious schedule. In particular, they were ordered to develop a market-based compliance program permitting trading with the European Union and the northeast states' Regional Greenhouse Gas Initiative. He also ordered the ARB to create a Market Advisory Committee composed of national and international experts to make recommendations on design of a market-based compliance program.

2.3.4 Senate Bill No. 1368

Fourth, Senate Bill No. 1368 (SB 1368) established an interim emissions performance standard for greenhouse gas emissions from power plants. It seeks to constrain the sources of electricity imported into California. SB 1368 requires the California Public Utilities Commission (PUC) to

conduct a rulemaking proceeding establishing a greenhouse gases emission performance standard for all base load generation of load-serving entities. It also requires the California Energy Commission (CEC), by June 30, 2007 to establish a greenhouse gases emission performance standard for all base load generation of local publicly owned electric utilities.

SB 1368 requires that the greenhouse gases emission performance standard not exceed the rate of emissions of greenhouse gases for combined-cycle natural gas base load generation. The bill prohibits the PUC from approving any long-term financial commitment by an electrical corporation unless any base load generation supplied under the long-term commitment complies with the greenhouse gases emission performance standard. The PUC in January 2007 issued a standard of 1,100 pounds of CO₂ per MWh.

2.4 Sources of Uncertainty

2.4.1 Ambiguity of the Current Policy

As things stand today, this array of initiatives has undefined elements that may create significant uncertainty in the marketplace. One of the most striking features of all these measures is their delegation of policy-making authority to regulatory agencies. While the new measures do specify several norms to guide the regulators' choices among the options available to them for implementation, there are inconsistencies in these guidelines. This delegation leaves the actual implications of the recently enacted and promulgated measures undefined until the regulatory bodies resolve the ambiguities.

As a result, the shape of California's climate policy remains unclear. Will it depend on market mechanisms, or on command-and-control regulation? Will it combine several mechanisms? If so, which ones and what will be their structure?

In the coming years, California's government must resolve these issues. How it does so will profoundly affect California's economy, its energy and electricity markets, those of the surrounding states, and the profits or losses that will accrue to the massive investments in power generation and other industries that must be made over the next decade. Care in answering these key questions is obviously appropriate, but delay prolongs uncertainty, which itself creates costs in deferred investment or investments that become stranded assets.

AB 32 allowed the use of market-based instruments, such as a cap-and-trade system, but the law explicitly provides for consideration of regulatory approaches. For example, there is a provision (Section 38574) that the Air Resources Board (ARB), tasked with developing market-based mechanisms, has no authority "to alter any programs administered by other state agencies for the reduction of greenhouse gas emissions," presumably including regulatory measures. Thus, even within AB 32, the role of market-based mechanisms is highly uncertain and ambiguous.

AB 32 leaves ambiguity on a couple of other crucial implementation matters beyond the role of market-based approaches:

- Although the legislation states that the law envisions additional emission reductions post 2020, it is silent on the extent of those reductions and the means of achieving them, except for a reference to future recommendations of the state Air Resources Board (ARB). This language mentions market-based mechanisms as one of many approaches, including other regulatory and command-and-control measures that might be adopted to achieve reductions.
- AB 32's section 38561(d) directs the state ARB to evaluate total potential costs and benefits of the emission reduction plan. It is also to consider the plan's impacts on small business and to establish a *de minimis* emission threshold below which emission limits will not apply. The law is silent on what is to happen if the collection of "maximum technologically feasible and cost-effective" reductions from covered sources is insufficient to meet the targets. The Governor is given limited authority to delay the schedule for emission reductions – one year at a time in the event of extraordinary circumstances.

2.4.2 The Changing Climate Policy Environment

These unresolved points leave a good deal of uncertainty about how California's climate policy will be implemented, yet implementation choices can be expected to substantially affect the impact of the policy. However, even if California's government were to resolve these issues tomorrow, the future implications of its policy would remain uncertain and subject to risk of higher than anticipated costs.

Then too, other climate policy players—most notably the U.S. Federal Government and the governments of California's neighboring states—may act in ways that constrain California's future climate policy choices. It is possible that the U.S. Congress will enact GHG controls within the next few years. How such legislation would relate to California's remains highly uncertain. Federal action could preempt California's, be layered on top of it, or mesh somehow with it. California's neighboring states may also enact policies. The international GHG control regime remains even more speculative, especially with regard to the period beyond the end of the first commitment period of the Kyoto Protocol.

Actions by other governments, especially those within the borders of the U.S., can have considerable impact on California. This impact can take surprising and unexpected forms. For example, Federal or other state policies favoring renewable energy may increase the premium that California must pay to implement its preferred policies. Other jurisdictions' GHG controls outside of the electricity sector may also increase the costs to California of its climate policies. Such out-of-state controls discourage the leakage of non-power sector emissions. However, reductions in leakage will increase the cost to Californians of its state climate policies.

3

MAJOR FINDINGS

Implementation of California's climate programs will impose costs on the state's economy. The greater the cumulative amount of GHG emissions avoided, the greater will be the economic costs. Selecting more gradual emission reduction targets and more cost-effective policy tools, however, can minimize the costs that are to be borne for any particular choice of cap stringency.

3.1 GHG Controls will Impose Costs on California

3.1.1 *The Pattern of GHG Controls Costs*

The study finds all forms of policies to restrict California's GHG emissions will entail economic cost through both the 2020 and 2050 time horizons of this study. California's new laws will reduce GHG emissions relative to business-as-usual for most of the State's major industrial sectors, depress real wages, negatively affect the state's terms of trade, and diminish consumption. In one scenario, where the emissions are maintained at 1990 levels through an emissions trading program (Pure_Trade), the gross state product of California is projected to be reduced from business-as-usual levels by \$32 billion (1.35%) in 2020 and by \$37 billion (1.17%) in 2030. As the costs of GHG reductions cause selected industries to contract, they will weaken demand for labor and real wages will fall. Reductions in wage earnings, coupled with a decrease in net export earnings for California, mean that California would have fewer resources to spend on consumption of goods and services.

In addition, Californians are expected to forego current consumption (when the carbon cap is less stringent) for future consumption (when the carbon cap stringency is greater). In the Pure_Trade scenario, in which the state returns to 1990 emission levels and maintains them through 2050, aggregate consumption is projected to decline by 1.26% in 2020 and by 1.42% in 2030. This decrease in consumption can be translated as a financial cost of \$1,170 per household in 2020 and \$1,600 per household in 2030.⁹ (The Pure_Trade scenario assumes that California will implement AB 32 with market-oriented marginal costs across all sectors of the economy in order to achieve emission reductions in the most cost-effective manner.) Projected consumption decreases are also accompanied by projected reductions in investment in California. As the economy contracts because of the carbon policy, California becomes less attractive for investment, compared to other regions that are free of any emission constraint. In the Pure_Trade scenario, aggregate investment in California is projected to decrease by almost 1% in 2020,

⁹ The population data for California based on State of California, Department of Finance, Race/Ethnic Population with Age and Sex Detail, 2000-2050, Sacramento, CA, May 2004. The household number was computed assuming that each household in California is made up of 2.87 persons (State & County QuickFacts, U.S. Census Bureau).

while the investment in the rest of country outside the West would increase by about 0.1%.¹⁰ In this scenario, investment in California is projected to become more favorable in the long-run as investment is needed to support new, less carbon-intensive technologies in both the electric and transportation sectors.

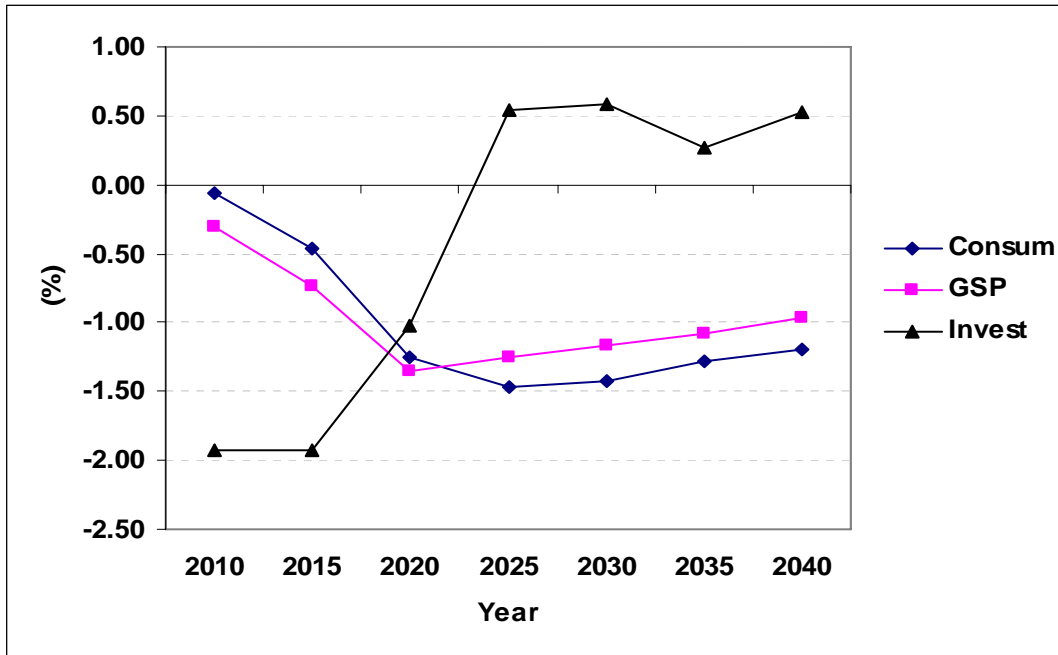


Figure 3-1
Percent Change in Consumption, Gross State Product, and Investment Under the Pure_Trade Scenario

In the Pure_Trade scenario, investment eventually reaches 0.5 % *above* baseline levels.¹¹ The multi-regional national (MRN) macro-economic model (described in Section 4.1.2)

¹⁰ The economic effect on the Arizona area and the Northwest region are also adversely impacted by the California policy. Thus investment in these regions also decreases in the short run.

¹¹ The pattern for investment is somewhat driven by the assumption that the backstop technology described earlier will be produced in California from investments by California consumers and firms. This assumption is a bit unrealistic, but accepts assumptions by the sponsors of AB 32 that California will be the sole benefactor of increased investment in new technology as a result of California’s adopting climate change policies. This is the most optimistic possible assumption regarding the benefits of AB 32, and it is highly uncertain. Therefore, we also considered the case in which investment in the backstop technology could come from all states. Under this case, California investment would decrease in absolute terms, compared to the alternative assumption. Under the original assumption, that the backstop technology is a California-built and -owned technology, total California investment increases in the long-run, as this fuel-based transportation technology becomes more profitable in the face of increasing costs of using conventional fuel. However, under the assumption that the technology is produced throughout the U.S.—implying that some of this technology would be imported—then the long-term investment pattern for California is quite different. The overall investment in California decreases by half a percent by the end of the model horizon, which is in contrast to an increase of half a percent in the Pure_Trade case. The decrease in investment if new technology were to be imported accompanies a further decline in California’s gross state product.

captures the projected technological improvement, but the model finds that its potential benefit is outweighed by the adverse impact of the contraction of the economy. At its worst, the gross state product (GSP) of California is projected to decrease by 1.35% in 2020, and although the reduction in GSP is projected to ameliorate after 2020 due to the assumed technological improvement, it is projected to remain negative through 2050, where the economic impact simulation ends.

The costs of GHG controls will worsen California's terms of trade. For example, imposing GHG controls in California will increase in-state production costs thereby permitting out-of-state businesses to raise the prices that they charge California customers and still remain competitive. For California exporters, on the other hand, although GHG controls will increase their production costs, they will find it difficult to raise prices for their out-of-state customers, as long as their out-of-state competitors do not face the same policy-driven cost increases. These changes erode the purchasing power of Californians, which will decrease their consumption and economic well-being. The scale of this impact depends upon the severity of the policy and how industrial competitiveness changes across the regions. (Such conclusions are implicit in all of the scenarios.)

Net terms-of-trade effects due to implementation of a mandatory 1990 carbon cap in California would benefit regions that compete with California's energy-intensive industries, and be particularly harmful to energy-intensive producers within California, such as chemicals and cement. Investment will shift from California to regions with lower energy costs, especially for the production of energy-intensive goods, and net imports of those goods will increase to satisfy demand unmet as a result of reduced California production.

The relative impacts across industries are closely correlated with their energy intensity. In the Pure_Trade scenario, the energy-intensive sector (EIS) output is projected to decline by 2.8 % and 2.1% in 2020 and 2030, respectively. Refining oil (OIL) and commercial transportation services (TRN) are projected to see substantial decreases of 15.4% and 8.6%, respectively, in 2020. Nevertheless, the service sector (SRV) – California's largest sector – a relatively less energy-intensive sector, is also projected to experience economic impacts and to reduce output marginally. Figure 3-2 shows how a number of representative policies would change the distribution of output among the various sectors of California's economy under the Pure_Trade scenario.¹²

¹² The following acronyms are used to define the model sectors - AGR: Agriculture, EIS: Energy-intensive sectors, MAN: Manufacturing, SRV: Services, TRN: Commercial transportation, OIL: Petroleum refining, COL: Coal extraction and delivery, ELE: Electric generation, GAS: Natural gas extraction and delivery, and CRU: Crude oil extraction.

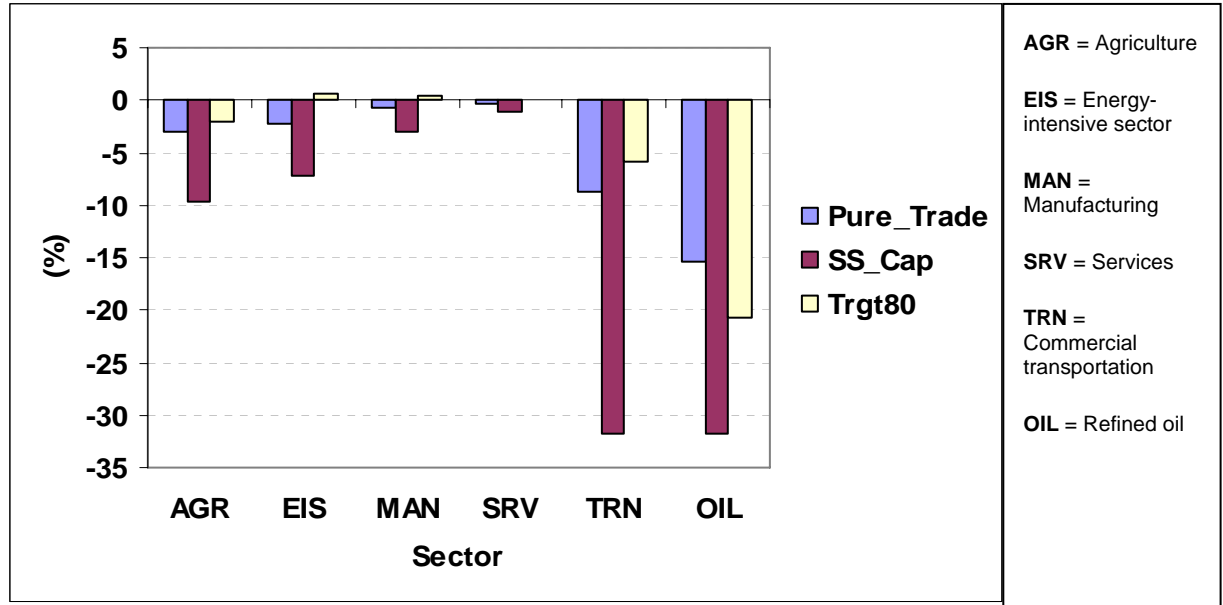


Figure 3-2
Percent Change in Industrial Output in 2020 by Sector¹³

3.1.2 Assumptions of Low Abatement Costs

Contrary to the findings of this study, some recent economic studies have suggested that California might be able to achieve its GHG reduction targets without incurring significant costs. A careful assessment by Stavins, Jaffe, and Schatzki reaches a different conclusion. Their assessment concludes:

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.¹⁴

¹³ SS_Cap refers to Sector Specific Cap and is described (later in the Report) along with all of the other scenarios in Table 3-2.

¹⁴ Robert N. Stavins, Judson Jaffe, and Todd Schatzki, “Analyses of California Climate Change Policy: Are They Too Good to Be True?,” January 2007.

To explore the issues raised by the Stavins et al. analysis in more detail, our study analyzed a scenario (LCA – Low Cost Assumptions) that incorporated assumptions similar to those used in the earlier optimistic California studies, while noting the strong challenge to their realism. For example, the LCA scenario included the assumption that electricity consumption will be kept in check by existing measures promoting energy efficiency, that regulations will engender new technologies able to reduce or eliminate net costs of reducing energy use, and that costs of all new technologies will fall rapidly once they are introduced.

The LCA scenario helps to understand how pervasive the no-cost emission reductions would need to be to support optimistic assumptions about the cost of meeting emission targets. Under the LCA assumptions, costs of meeting the climate targets are reduced by a factor of 54% compared with those projected in the Pure_Trade scenario to reach and maintain 1990 levels. This would happen only if ample no-cost emission reduction options are available and if peak carbon marginal costs of abatement are reduced to \$93 from \$111 per metric ton of CO₂. There is considerable uncertainty about whether, in fact, costs will be this low; and if they are not, the burden on the California economy could turn out to be much larger than anticipated.

3.2 Cap-and-Trade Versus Command-and-Control

3.2.1 The Importance of Equalizing Marginal Abatement Costs

Although all greenhouse gas (GHG) control policies in this study exact economic costs, broad and uniform (GHG) emission disincentives—such as those provided by a comprehensive cap-and-trade system (or a carbon tax)—are more cost-effective than are command-and-control regulations. Cost effectiveness requires that the cost of avoiding an additional ton of emissions (marginal abatement costs) be equalized across all decisions relevant to greenhouse gas emissions. A broad-based and well designed cap-and-trade system would achieve this objective.

In contrast, regulators cannot know the marginal cost of abatement across the vast array of possible emission reduction opportunities. Because of regulators' inadequate knowledge, any regulatory efforts that specify particular types of controls on particular types of businesses will almost inevitably engender higher policy costs than cap-and-trade systems to achieve the same emissions reductions. This also applies to modelers. The businesses and households making real decisions about energy use and fuel choice have information and choices that no modeler can completely characterize. Thus, models also oversimplify the decisions actually being made and therefore, miss many of the ways in which command-and-control regulations will fail to equalize marginal costs and raise overall economic losses. Therefore several scenarios in this study are constructed to illustrate the differences between command-and-control and market-based approaches, but none even come close to comprehending how large the avoidable costs of an across-the-board regulatory approach would be.

The differences in the percentage emission reductions by sector illustrate the great differences in abatement costs across sectors (see Table 3-1). That is, for 2030, the marginal cost of abatement between the electricity and household sectors is equalized once the electricity and household sectors have reduced their emissions by 81% and 23%, respectively. The table is constructed using the Pure_Trade scenario, where “baseline” means a business-as-usual projection into the future.

Table 3-1
Percentage Change in Emissions by Sectors

Sector	Baseline - MMTCO ₂		Reduction from Baseline MMTCO ₂		Reduction from Baseline %		Sectoral Share of Reduction	
	2020	2030	2020	2030	2020	2030	2020	2030
AGR Agriculture	12.8	13.9	-2.9	-3.9	-23%	-28%	2%	2%
C Households	197.8	223.0	-34.4	-50.2	-17%	-23%	21%	22%
EIS Energy-intensive	53.2	58.0	-12.4	-16.1	-23%	-28%	8%	7%
ELE Electricity	129.5	154.7	-88.3	-125.8	-68%	-81%	55%	55%
G Government	6.2	6.6	-1.1	-1.4	-18%	-21%	1%	1%
GAS Gas distribution	0.1	0.1	0.0	0.0	-30%	-34%	0%	0%
MAN Manufacturing	7.8	8.4	-1.7	-2.2	-21%	-26%	1%	1%
OIL Refined oil	6.3	6.7	-1.9	-2.5	-30%	-37%	1%	1%
SRV Services	24.1	26.5	-5.2	-7.0	-22%	-26%	3%	3%
TRN Commercial Transportation	79.1	87.2	-13.8	-20.8	-17%	-24%	9%	9%

An efficient cap-and-trade system would cover even sectors with relatively small potential for near term emission cuts. Even though electric power generation is the largest single source of emission reductions, by 2030 the other sectors' *cumulative* contributions are nearly equal to that sector's. Second, as technology changes and capital plants age, the scale of abatement opportunities will also change.

3.2.2 The High Costs of Sector-Specific Regulation

Broad uniform incentives for abatement are substantially more efficient than controls imposing similar percentage emission reductions on sectors with varying abatement costs. One scenario, as a proxy for the kind of decisions that emerge under command-and-control, assumed that regulators required equal percentage emission reductions from various economic sectors (SS_Cap). To achieve a comparable emission reduction goal, such a program would diminish economic welfare 30% more than would a comprehensive cap-and-trade system. Another scenario found that, under certain plausible assumptions, a mandatory energy conservation (Demand Side Management, DSM_Cost) program also entailed roughly a 61% higher cost. These findings are generally consistent with the extensive body of economic literature indicating that command-and-control regulations usually cost more per unit of emissions controlled than do cap-and-trade or tax systems.¹⁵

3.2.3 Layering Regulation Atop Cap-and-Trade

Attempts to combine cap-and-trade with regulatory systems—such as automobile fuel economy standards, Renewable Portfolio Standards (RPS), and the Demand Side Management (DSM) programs—may diminish overall cost-effectiveness. Efficiency requires that marginal abatement costs be equalized across all decisions relevant to greenhouse gas emissions. A broad-based cap-and-trade system does just that, but layering regulations on top of cap-and-trade restricts and interferes with businesses' and households' abilities to equate marginal GHG reduction costs across new car buying, electric power generation, and electricity consumption.

¹⁵ A. Denny Ellerman, Paul L. Joskow, and David Harrison, Jr., « Emissions trading in the U.S. : Experience, Lessons, and Considerations for Greenhouse Gases, » prepared for the Pew Center on Global Climate Change, May 2003.

Limiting these choices can increase the costs of meeting an emission reduction goal. For example, the analysis finds that under the assumption that the market for electricity conservation functions optimally, a mandatory DSM program (DSM_Cost) could increase the costs of reaching the emission reduction goal by 61%. The analysis of the RPS indicates that these policies, by themselves, have only a small impact on GHG emissions but, when combined with emission caps, they can add unnecessarily to costs by restricting technology choices. Thus, combining a 33% RPS level with a cap-and-trade program achieving 1990 emission targets creates a scenario (RPS_33) that causes wind energy projects to displace lower cost advanced coal technology with carbon capture and storage—both in-state and out-of-state—even if the latter technology controlled emissions at a lower cost.

Views differ on the whether demand side management (DSM) programs are likely to yield net benefits. One view is that properly designed DSM programs can provide economic benefits as well as emission reductions by identifying cost-effective conservation opportunities that households and businesses would otherwise ignore. Another view is that DSM programs succeed by providing subsidies to induce adoption of costly conservation measures, which are funded at a net cost through higher electricity rates charged all consumers. These two views are presented in two scenarios, one of which (already discussed) assumes that a costly DSM program is mandated in addition to a comprehensive cap-and-trade policy, leading to inefficient choice of measures and significant cost increases.

The other DSM scenario embodies the assumption that programs designed to remedy specific market failures¹⁶ could reduce electricity consumption by 10% and leave consumers with exactly the same energy services (lighting, space conditioning, appliance use, etc), so that consumers would gain a net benefit equal to 10% of their electricity bill. Adding such a DSM program (DSM_Benefit) to the cap-and-trade program reduces overall household costs by about 10% compared to a policy that maintains emission at 1990 levels. In other words, our models show that if there are market failures associated with electricity use, and if DSM programs remedy the market failures directly, then DSM may provide economic benefits as well as emission reductions. However, DSM cannot provide large enough emission reductions or economic benefits to make it possible to achieve targets without cost. Overall losses to the California economy still amount to \$29 billion in 2020.

3.3 Choosing the Post-2020 Goal

Increasing the stringency of the long-term emission reduction target raises the program's total costs. Compared to maintaining the 1990 emission levels after 2020 (as in Pure_Trade), lowering the 2050 target a further 40% (Trgt40) raises the policy's economic welfare impact by 37%. Setting the 2050 target 80% below the 1990 level (Trgt80) would increase economic welfare costs by 123%, compare to Pure_Trade. Clearly, a very stringent 2050 target would have a large impact on costs.

¹⁶ See for example Loughran D. and J. Kulick. 2004. "Demand side management and energy efficiency in the United States." *Energy Journal*. 25(1):19-41 and Gillingham, K., R. Newell and K. Palmer. 2006 "Energy Efficiency Policies: A Retrospective Examination." *Annual Review of Environment and Resources*. 31: 161-192.

3.3.1 Near-Term Consequences of Long-Term Expectations

Expectations about the post-2020 policy can have economic implications today. Households may adjust their savings to some degree in response to expectations about the stringency of future emission limits. Businesses' expectations of future climate policy are likely to affect R&D spending on new low GHG technologies and the technologies embodied in long lived capital assets. With a cap-and-trade program that allows banking of emission allowances, expectations of more stringent future controls would encourage firms to control more than what would be needed to meet current caps.

3.3.2 The Costs of Regulatory Uncertainty

Failure to specify long term targets leaves firms and households uncertain about even relatively near-term investment decisions. Uncertainty can boost the risks that investment costs will not be recuperated and lead to stranded assets, and the risk of stranded assets can chill the investment climate, especially in power generation and other energy-intensive industries. The analysis found that, for the electric power sector in particular, the severity of the post 2020 emission target heavily influenced the choice of technologies for pre-2020 investments. Thus, uncertainty or inconsistency about the long-term goal is especially detrimental to ensuring timely and efficient investment choices. The history of economic deregulation of the power generation sector suggests how easily policy uncertainty can chill investment and the potential consequences for energy supply.

3.4 Enhancing Cost-Effectiveness through a Price Safety Valve

3.4.1 An Allowance Price Safety Valve and the Risk of Unexpectedly High Abatement Costs

An allowance price “safety valve” would allow regulators to sell as many permits as demanded at a pre-specified price, thus providing an automatic adjustment of emission caps if costs exceed some expected level. This course of action has two important implications:

- First, a safety valve mechanism enables policymakers to put a limit on abatement costs and thus take economic uncertainties into account.
- Second, if the safety valve price is triggered, the emission targets will not be met as anticipated.

Specifically, a safety valve can reduce the economic sacrifices otherwise inevitable should the state's GHG reduction targets prove to rest on overly optimistic assumptions about abatement costs. Some studies of California's climate policy options have posited abatement costs much below those developed by this report, but a recent analysis has challenged the validity of these

studies' findings.¹⁷ Faced with this important uncertainty, California could set a safety valve price for allowances designed to correspond to the abatement costs assumed in setting the emission reduction targets. Should actual abatement costs turn out higher than expected, such a safety valve could substantially reduce losses in economic welfare.

To illustrate this concept, the study analyzed a scenario with an allowance price safety valve (SV_LCA) set to approximate the carbon price estimated in the optimistically low cost assumption scenario (LCA) that was discussed in Section 3.1.2. With the allowance price set in this way, the safety valve would have no impact on emission reductions or costs if the optimistic cost assumptions were to be borne out in reality. It would, however, reduce losses in welfare, consumption, and GSP by 41%, 36%, and 31% respectively in 2020, if abatement costs were equal to those of the Pure_Trade scenario which maintains emissions at 1990 levels.

In addition, a safety valve price can dampen the sharp allowance price fluctuations that have proven to be an expensive feature of other cap-and-trade programs, such as the Clean Air Act's Title IV and the European Union Emission Trading Scheme. By placing a ceiling on allowance prices, a safety valve avoids imposing on businesses and consumers the price peaks that can be caused by weather, the business cycle, or shifting energy markets. In one scenario explored in this study, by stabilizing allowance prices the safety valve reduced the program's costs by 66%, compared to a policy that maintains emissions at 1990 levels.

3.4.2 The Problem of Allowance Price Volatility

In contrast, "hard caps" (no safety valve provision) can lead to highly volatile allowance prices.¹⁸ In the USEPA regulatory programs that cap emissions of nitrogen oxides (NO_x) and sulfur dioxide (SO₂), allowance prices have fluctuated widely and rapidly. Even in the mature (12-year old) Federal SO₂ emissions reduction program known as Title IV, allowance prices skyrocketed in 2005 from about \$500/(short) ton to over \$1500/(short) ton (see Figure 3-3). One year later, prices for the same allowances had fallen again, dipping below \$400/(short) ton, with no change in underlying regulatory requirements or technology.

The current allowance price gyrations within the European Union's Emission Allowance Trading Scheme (EU-ETS) are exactly what this history teaches one to expect (see Figure 3-4).

We have preliminary indications that European trading prices for CO₂ are highly volatile, fluctuating in a band ... +50% over the last year. More extensive evidence comes from the history of the U.S. sulfur-emissions trading program. SO₂ trading prices have varied from a low of \$70 per (short) ton in 1996 to \$1500 per (short) ton in late 2005. SO₂ allowances have a monthly volatility of 10% and an annual volatility of 43% over the last decade.¹⁹

¹⁷ Robert N. Stavins, Judson Jaffe, and Todd Schatzki, "Analyses of California Climate Change Policy: Are They Too Good to Be True?," September 2006.

¹⁸ Anne Smith, "Emissions Market—Planning for Compliance", presented at the 2006 Spring Coal Forum of the American Coal Council Birmingham, AL, May 24, 2006.

¹⁹ William D. Nordhaus, "After Kyoto: Alternative Mechanisms to Control Global Warming," FPIF Discussion Paper, March, 2006.

Major Findings

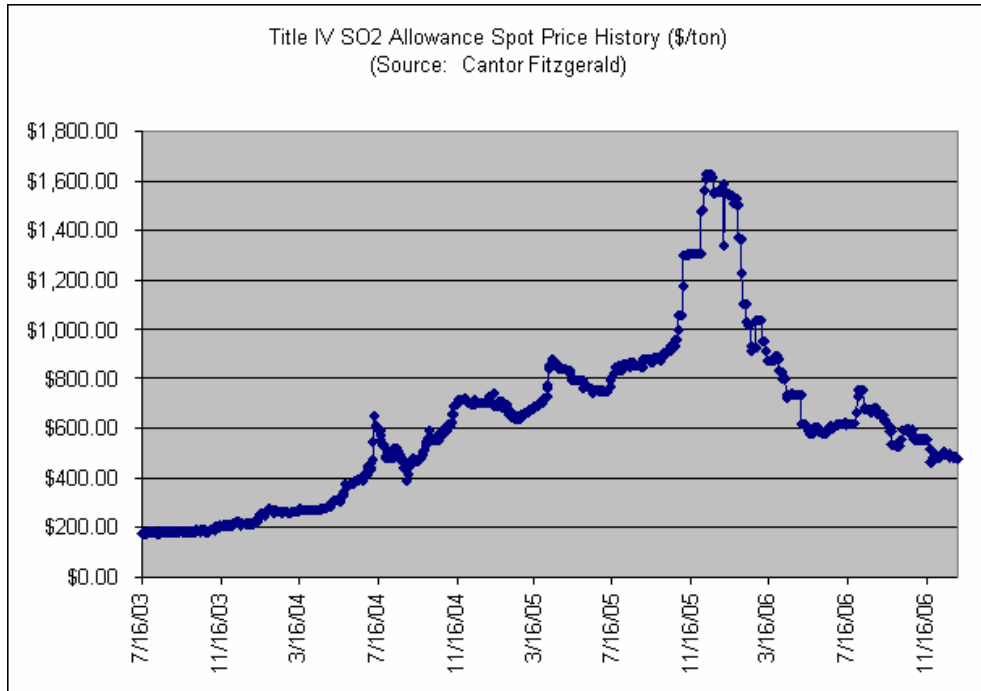


Figure 3-3
Sulfur Allowance Prices



Figure 3-4
Allowance Prices in the EU-ETS²⁰

²⁰ Source: www.PointCarbon.com

We developed two scenarios to explore how much allowance price volatility is possible under hard caps, and the implications of reducing that volatility. One scenario analyzes possible volatility in allowance prices that could appear under a hard cap if electricity demand and natural gas prices turn out different from those projected in advance. In this scenario, average demand growth and natural gas prices remain the same as in the Pure_Trade case but during each time period, demand and gas prices fluctuate above and below the trend by 3% and 10%, respectively. These percentages are well within historical fluctuations in both these drivers of cost.

Since only cumulative emissions over long time periods matter for climate risk, this shortfall could be made up in future years, especially if some form of banking provides an incentive to make larger emission reductions in years when costs are low. This suggests that policies that allow flexibility to prevent undesirable near-term cost spikes, like a safety valve, can be designed in ways that reduce costs with no sacrifice in achieving climate goals. A more detailed explanation of this phenomenon is provided in a study by Jacoby and Ellerman²¹.

3.4.3 Other considerations

While these policy tools can enable a cap-and-trade program to more closely approximate the economic efficiency of a carbon tax, objections to them have been raised on various grounds.

First, a low safety valve price may diminish future allowance prices and, hence, dampen future marginal costs of abatement. Insofar as the safety valve has this effect, it may weaken private sector incentive to engage in R&D to develop new lower cost emission control technologies. The importance of this feature depends on many factors including the following:

- Do future abatement technologies require the kind of R&D that the private sector is likely to produce, *i.e.* are the payoffs sufficiently near-term and can the intellectual property involved be protected enough to justify the costs and risks of R&D investment?
- How much do the provisions lower the expected future allowance prices and thereby diminish the potential profits of successful private sector R&D?
- If allowance prices would be very high, absent a safety valve, would those future prices be credible to potential private sector entities considering R&D investments?

Second, a safety valve involves missing annual emission deadlines. Indeed, the provision's entire point is that it allows the economy to exceed annual emission targets when the costs of reaching them would be excessive, as deemed by policy makers.

3.5 Other Cap-and-Trade Design Issues

Although the safety valve in particular could provide a very broad gauge protection against price shocks, other provisions could provide additional protection and help to enhance the policy's

²¹ H.D. Jacoby and A.D. Ellerman, "The Safety Valve and Climate Policy," *Energy Policy* 32(4): 481-491, 2004.

cost-effectiveness. Comprehensive coverage of emission sources and appropriate reliance on offsets are examples. Since the climate problem is global, the most effective policies should be comprehensive and global. Patchwork policies on a state-by-state basis will be sub-optimal. Linkage to other GHG cap-and-trade systems, in this sub-optimal setting, may produce unexpected and undesirable results.

3.5.1 Upstream Versus Downstream is Connected With the Breadth of Coverage

For reasons already considered, a cap-and-trade system should seek to cover all important sources of greenhouse gas emissions. Broad coverage, however, suggests that the point of regulation—i.e., where regulators require submission of allowances—should be “upstream”. That is, the most cost-effective approach for covering CO₂ emissions across the economy would be for regulators to focus on requiring the producers, importers, or refiners of fossil fuels to submit allowances equal to the carbon content of those fuels. Although designing such a system would require some care, it could discourage emissions from the myriad of “downstream” households, businesses, and vehicles that cannot be practically monitored despite their great cumulative importance. This principle is further explained in EPRI’s Climate Brief on “Upstream and Downstream Approaches to Carbon Dioxide Regulation.”²²

3.5.2 The Importance of Offsets

The CAT Report²³ suggests some possibilities for offsetting some of California’s carbon emissions through various forestation activities. For our alternate (Off_Sets) scenario, we include these offsets from the CAT report and augment the cap by their amount. We assume that these offsets exist in all future years and, therefore, the cap is set at 1990 levels plus the 27.4 million metric tons of CO₂ (or 7.5 million metric tons of carbon) that come from forestation activities.

Furthermore, the CAT report quantifies reductions of other GHGs from various activities. Because our model only accounts for CO₂ emissions, we could also add in additional offsets from the reduction of non-CO₂ GHGs below 1990 levels. But, for several reasons, we chose not to assume that any additional offsets from non-CO₂ GHGs were available. First, the PIER study²⁴ finds the marginal cost of reducing non-CO₂ GHGs slightly below 1990 levels in 2020 to be about \$50/metric ton of CO₂. Second, options for reducing emissions below 1990 levels are available in 2020, but as the economy grows, these options may be insufficient and new, more costly options may be required. Third, there is great uncertainty as to the historical level of non-CO₂ GHGs and also the forecasted levels.

²² <http://www.epriweb.com/public/00000000001007762.pdf>

²³ http://www.climatechange.ca.gov/climate_action_team/reports/index.html

²⁴ *Emission Reduction Opportunities For Non-CO₂ Greenhouse Gases In California*, Prepared for California Energy Commission Public Interest Energy Research Program, Prepared by ICF Consulting, July 2005, CEC-500-2005-121.

This case sheds light on how much the inclusion of offsets could reduce costs. It also highlights the benefits of being able to reduce non-CO₂ GHGs at no cost or at lower cost and points out the risks if reducing non-CO₂ GHGs is difficult. If reducing non-CO₂ GHGs is easy, then costs of compliance would decline; but if not, then more CO₂ emissions must be abated, which will drive up costs.

3.5.3 Linkage to Other Cap-and-Trade Systems

In EO S-20-06, Governor Schwarzenegger ordered development of plans to link California's greenhouse gas trading system to the Regional Greenhouse Gas Initiative (RGGI) in the Northeast and to the European Union's Emission Trading Scheme (EU-ETS). There are a number of legal and economic issues involved. For the EU-ETS, these issues center on the linking directive of the EU, which controls how emission permits generated outside the EU may be used to meet the EU-ETS requirements. California cannot sell credits to the EU, however, unless the U.S. were to become part of the Kyoto Protocol. Since the EU is expected itself to need to be a net purchaser of permits from CDM or other parties to meet its targets under the Kyoto Protocol, it is unlikely that California would be able to buy permits from the EU. In terms of RGGI, any such agreement could be construed to be an Interstate Compact requiring a specific form of Congressional approval. This important issue needs to be explored further but is beyond the scope of the present study.

More fundamentally, expectations of what such linkage could accomplish may be unrealistic. The key question is whether, prior to linkage, carbon prices will be higher in California or in the regions with which California trades. Permits will be sold from the jurisdiction with lower prices to the jurisdiction with higher prices. At this point, it is very likely that RGGI will have lower prices than California. In its own assessment of economic impacts RGGI cites regional CO₂ prices of \$13 per metric ton of CO₂ in 2024. An analysis by Resources for the Future (RFF) of the RGGI program estimates CO₂ prices of \$20 per metric ton of CO₂ in 2025.²⁵ This contrasts to our estimate of California CO₂ prices of about \$110 per metric ton of CO₂ in the same year for the Pure_Trade Scenario.

The RGGI system has been designed as a compromise among a number of considerations. At this time, RGGI contains no provisions to limit leakage, relying instead on emission caps that are expected to keep permit prices low enough that there will be little incentive to substitute imported power for that produced in the region. A "circuit breaker" attempts to keep prices down by providing that the tightening of the caps will be suspended if prices rise above a specified level. But there is no true safety valve. All this implies that if California were to link with RGGI, it would probably be a buyer of permits from RGGI, driving up carbon prices in the Northeast and driving down carbon prices in California. Payments would flow from California to RGGI, allowing higher emissions and less development of low-carbon energy sources in California. In contrast, in the Northeast generation costs and electricity prices would rise, which might in turn stimulate a reaction against the emission trading program from those facing higher bills.

²⁵ RGGI's estimates are found in <http://www.rff.org/Documents/RFF-DP-05-55.pdf>. The RFF estimates are provided in Dallas Burtraw, Danny Kahn, and Karen Palmer, "CO₂ Allowance Allocation in the Regional Greenhouse Gas Initiative and the Effect on Electricity Investors," RFF DP 05-55 December 2005.

Given the lack of any provision to prevent leakage in the RGGI program, other than delay in tightening caps, leakage could become a real problem in the RGGI region, with lower-cost coal-fired generation from the Mid-West being imported in preference to building new low-emissions advanced coal plants with carbon capture or no-emission wind farms, within the Northeast. Thus one possible consequence of linking RGGI with California would be that California would, in effect, be importing coal-fired power from the Mid-West that it cannot, under the import policy discussed next, import from Arizona. Taking all these considerations into account, there may be difficulties in creating such a linkage.

3.6 Electricity Imports: Tradeoffs Between Cost and Leakage

3.6.1 The Importance and Difficulty of Policy on Electricity Imports

Emissions associated with generating electricity imported into California are included in the caps set by AB 32 and subject to the emissions performance standard (EPS) of 1,100 lbs/MWh contained in the PUC order regulations implementing SB1368. The California PUC and the Energy Commission are tasked with implementing these requirements for the shareholder-owned utilities and for municipal utilities, respectively. They both face a difficult task because electric energy does not come with tags to indicate where it was generated. Moreover, California power providers (called load serving entities or LSEs) purchase most of the electricity they deliver in markets or under contracts which specify only the amount of power delivered, not where it is generated. Thus, it is necessary to develop procedures for measuring the emissions associated with imported power. California is attempting to manage imports by regulating both California LSEs' ownership of out of state power plants and their long-term contracts for purchasing out of state power.

The question of regulating imported power presents the state with several choices.

It now appears that California intends to measure emissions from imported power based on the type of contract between the LSE and the generator. This approach, combined with the lack of extraterritorial jurisdiction over out-of-state power plants, creates a tradeoff between cost and leakage. If no restrictions are placed on LSE's behavior, the rational economic response is likely to be to divest all current ownership or contracts with coal fired units and to buy up long-term contracts for all the electricity from existing hydro, wind and renewables that can be sent to California. If additional imports were needed, they could be provided by gas fired units or by imports purchased on short term markets and accounted for at the average emission factor.

To prevent the shifting of emissions to other states that would result from this contract shuffling (discussed more fully in the next section), California could further restrain the choices of LSE's—allowing them, for example, only to sign contracts with *new* power plants that meet the EPS. Finally, the problems with dealing with contracted power may have the effect of pushing California away from long-term power contracts and back to reliance on the more volatile spot market.

3.6.2 Key Policy Choices on Imports

AB 32 recognizes that a significant share of the emissions associated with California's energy use is produced outside the state in plants that generate power imported into California. Dealing with these emissions is inherently difficult because it is impossible to tell in any technical sense where the electricity crossing the California border originated. Electric energy does not have "made from coal" tags or shipping manifests, like freight on trucks or trains. And California has no authority over power plants outside the state, or authority to compel accounting or reporting of emissions. It can only regulate the purchasing activities of the load serving entities within the state and the kind of contractual relationships they enter into with entities outside the state. This limitation leads to an inevitable tradeoff between cost and leakage, which it may only be possible to eliminate through a full regional emission trading system.

Based on precedents now being set in rulemakings at the CPUC, it is assumed in all scenarios discussed thus far that emissions associated with electricity imports are accounted for in one of two ways. If a California LSE has a long-term contract with a generating unit in another state, it will be responsible for the actual emissions from that generating unit under the California cap-and-trade system. All other electricity imported into the state will be assumed to have emissions calculated based on the average emissions for all power plants in the region from which it originates.

It is also necessary to specify what kinds of long-term contracts California utilities will sign under this kind of rule. This opens up the possibility of "contract shuffling." Right now a great deal of power in the West is generated by hydroelectric and wind facilities that do not produce any greenhouse gas emissions. Much of that power is now under contract to utilities outside California. If California utilities were to sell off the contracts they now have with coal-fired units outside the state and buy up all the contracts for power from hydro and wind facilities, it would be possible to greatly reduce the emissions attributed to California's imports. Every ton of emissions associated with imports counts against the AB 32 emission caps and, therefore, requires that a ton of emissions be eliminated somewhere else in the state. Thus, shuffling contracts to reduce emissions associated with imports greatly eases the cost of meeting emission targets and lowers cost to the state. But, at the same time, this contract shuffling allows significantly more emissions to take place outside the state (leakage) as a result of actions by California to reduce its own emissions.

In order to examine this cost-versus-leakage tradeoff, different assumptions were made about how California might attempt to limit contract shuffling. The cases discussed thus far include the assumption that California utilities may not buy up any existing contracts for power from existing hydro or wind resources, but are allowed to maintain their long term contracts with coal-fired units and import that electricity, if it remains economic to do so with the high carbon penalty on coal-fired generation. At the opposite extreme, it is assumed that California utilities can buy up all the generation from existing hydro and wind resources. The difference is dramatic. In terms of leakage, with the extreme of contract shuffling, emissions from electricity generation in the rest of the West increase by an amount equal to 82% of the reductions in emissions associated with electricity generation for California in 2020. At the extreme of allowing *no* contracts with existing hydro or wind, emissions outside California actually fall by an amount equal to 20% of the reductions achieved inside California. Actual implementation of policies is likely to fall somewhere between, with California utilities allowed to continue

Major Findings

importing power from existing hydro and wind resources that they now have under contract, but discouraged from buying up hydro resources, in particular, that now provide other parts of the West with carbon-free energy.

Where in this spectrum the outcomes will be depends on many, possibly informal, decisions yet to be made. The costs associated with different choices are also substantial, with the increase in electricity prices to households about twice as large in the minimal contract shuffling case as in the maximum contract shuffling scenario over the 2015-2035 timeframe. Overall economic losses increase from 1.0% of GSP in 2020 in the maximum contract shuffling case to 1.2% of GSP in 2030 in cases where contract shuffling is prevented.

Very different choices about what kinds of new generation to build, both outside and inside California, are made in these two cases. With maximum contract shuffling, outside California there is 25% more coal-fired generation without carbon capture and sequestration in 2030, and 55% less generation from new resources based on wind and advanced coal plants with carbon capture and sequestration. California is able to meet most of its import needs with long-term contracts with existing hydro and wind resources, which would otherwise have served load outside California. As a result, California utilities do not need to contract for that amount of energy from new renewable resources or advanced coal units with carbon capture and sequestration.

The choices yet to be made by California regulators – and potentially the legislature – will have profoundly different impacts on Western electricity markets. If California chooses to lean against contract shuffling, investments made today in new conventional coal-fired generation could become stranded assets taking significant capital losses. On the other hand, if California chooses to allow contract shuffling, those assets would be quite valuable, and wind and advanced coal plants with carbon capture and sequestration might become stranded assets.

Moreover, the choices have profound implications for whether investors in generation will find takers for long-term power purchase agreements, or if the buyers will prefer shorter-term contracts and spot markets. It is possible that, due to high emission penalties on long-term contracts with coal-fired resources, California utilities would rely more on the short-term market where, especially for purchases from the Pacific Northwest, the average emission factor is rather low. A market dominated by shorter-term deals will likely exhibit much more price volatility, and investors in new generation will have to find methods of financing that do not depend on long-term power purchase agreements (PPAs) to secure debt.

A regional emission trading system would provide a route to avoiding the tradeoff of leakage or elevated cost by making it possible to shift to a generation-based regulatory system in which generators—rather than purchasers—of electricity were put under emission caps and responsible for trading, rather than the load-based system now being developed. It is also possible that a system of real time imputation of the emissions associated with electricity imports might be developed that would determine the emissions per kWh from the marginal source of energy to the state at that time. Use of these emission factors could support efficient pricing of emissions associated with electricity imports in a spot market, but integration with a market in long-term power contracts could be difficult.

3.7 Conclusions

Combining analyses done as part of this study can help illustrate some of the studies principal findings. Three such conclusions emerge. These are:

- Policies that combine market-oriented abatement incentives with increased technological innovation are the most cost-effective.
- All else being equal, for an emission control policy based on market-oriented policies, marginal abatement costs increase with the stringency of the emission reduction targets.
- Costs increase as the emission target becomes more stringent. Costs increase rapidly, in a disproportionate manner, as the target moves beyond the level associated with the safety valve price that matches the low cost assumptions (scenario SV_LCA).

Figure 3-5 illustrates these points using scenarios described in Table 3-2. The table summarizes the different scenarios and their assumptions about: cap-and-trade programs (including long-term caps and flexibility mechanisms like safety valves), the availability and cost of lower emitting technologies, the availability of electricity imports, and inclusion of command-and-control programs such as DSM and RPS.

The line in the figure that joins Trgt80, Trgt40, and SV_LCA traces an economically efficient frontier—that is, any policy within this envelope (i.e., above the line) is a less economically efficient policy. Such policies may emerge as a result of inefficient policy design. For example, SS_Cap and DSM_Cost represent less than optimal economically efficient scenarios, meaning that the same cumulative emissions reduction can be achieved at lower cost with more effectively designed policies. On the other hand, outcomes below the line in Figure 3-5 result from more optimistic assumptions about costs, or inclusion of additional flexibility measures that lower costs.

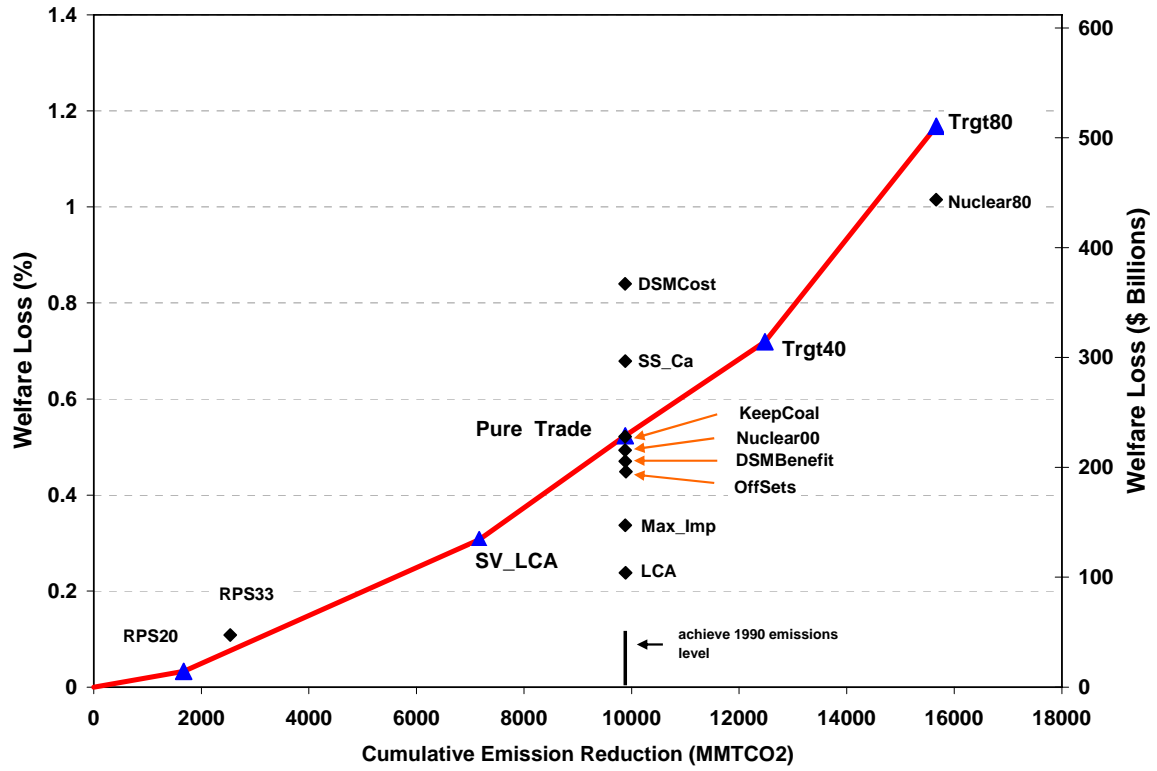


Figure 3-5
Comparison of Cumulative CA Emission Reduction and CA Welfare Change

Table 3-2
Scenario Descriptions (a Shaded Box Implies the Assumptions for the Respective Column are Identical to those of the Pure_Trade Scenario)

Scenario	Cap and Trade	Technology	Elec. Import	Long-term	Notes
Name	Program	Assumptions	Assumptions	2050 Targets	Differences from Pure_Trade
Pure_Trade	Comprehensive No Safety Value (SV) or offsets	Standard backstop No new nuclear	Renewables only over tie-lines; Existing coal contracts OK; No new coal contracts	1990 Levels	
Pure_Trade_33					33% RPS limit layered onto the policy
Trgt40				40% below 1990 Levels	Tighter long-term caps
Trgt80				80% below 1990 Levels	Tightest long-term caps
Nuclear00		Limited construction of nuclear power			Allows CA to limit imports of power from nuclear generators
AltBackStop		Higher cost backstop			Higher backstop price
Nuclear80		Unlimited construction of nuclear power		80% below 1990 Levels	Same as Trgt80 except allow unlimited of nuclear power
LCA		Lower Cost Renewables Faster intro of backstop			Low Cost Assumptions: Increased autonomous energy efficiency index (AEEI); reduced capital costs for renewables; faster introduction of the backstop; and doubling of the DSM benefits to those in DSM_Benefit
SV_LCA	SV = Carbon price in LCA				SV price path set to level of permit prices in LCA
Keep_Coal			Coal allowed		Allow CA to keep existing coal contracts and import coal-fired generation
Max_imp			No restrictions on imports		Maximum contract shuffling allowed. CA can import as much generation from renewable sources as available.
NoCoalImp			No coal imports		No imports from coal-fired generation - neither existing nor new contracts
DSM_Cost					DSM programs assumed to reduce CA demand by 10% with accompanying loss of services
DSM_Benefit					DSM programs assumed to provide cost benefits and reduce CA demand by 10%
Off_Sets	Forestry Offsets				Forestry and land-use offsets allowed
SS_Cap	No trading across sectors				Sector specific caps - no permit trading among sectors and resource mix in existing production remains unchanged
RPS_20	N/A		N/A	N/A	No carbon cap; RPS only at 20%
RPS_33	N/A		N/A	N/A	No carbon cap; RPS only at 33%
HighVol_NoSV					NEEM only run with varying electricity demand and gas prices
HighVol_SV	Safety valve to match reduction of NoSV				NEEM only run with varying electricity demand and gas prices and SV to smooth effect of shocks

4

ABOUT THE ANALYSIS

4.1 Study Methodology

4.1.1 Model Requirements

AB 32 addresses greenhouse gas emissions from all sectors of the California economy. Abating greenhouse gas emissions will lead to significant changes in California's economy and consumer behavior as industry and households significantly change their energy-use patterns. Because of the size of California's economy, AB 32 will affect neighboring states as well as the rest of the U.S. Finally, addressing greenhouse gas emissions is a long-term policy and therefore requires long-term investment decisions.

In estimating the impacts of climate change policy, it is imperative to use a model that captures all these economic interactions and effects. A model requires the basic capabilities and features found in most computable general equilibrium models. These include:

- Household decisions should be based on consistent ranking of consumption alternatives;
- Business decisions should be based on maximizing profits subject to a production function;
- All factor inputs (i.e., capital, labor, materials, and energy) into production should be accounted for so that all costs are included; and
- The model's supply and demand equilibrium should support efficient use of limited resources unless there are specific market failures represented in the model.

Detail on decisions and technologies within the model should be sufficient to differentiate the impacts of alternative policy approaches.

- Climate policy analysis dictates a detailed representation of the electricity sector, since this sector is the subject of the most complex and critical regulatory interventions, especially in the near-term;
- The model should treat key technologies whose availability influences costs of meeting targets—such as nuclear power, carbon capture and sequestration, and transportation fuels—explicitly;
- The time horizon should be sufficiently long to account fully for effects of policies on investment decisions; and
- The model should be fully dynamic so that agents (i.e., consumers and producers) correctly anticipate future price trends and policy decisions.

Finally, because of the likely large spillover effects of and opportunities for leakage in CA's policy on the rest of the U.S., the model should incorporate sufficient regional detail to capture important regional interactions and differences.

4.1.2 MRN NEEM Overview

The Multi-Region National-North American Electricity and Environment Model (MRN-NEEM) integrated approach used in this study provides a unique and consistent modeling framework to examine the California carbon policy in detail. This integrated model structure has the following important features that are necessary to accurately assess the impacts of climate change policies:

MRN-NEEM is a fully integrated, top down-bottom up model that meets all of the criteria noted above. The model combines a top-down computable general equilibrium model, MRN, with a bottom-up detailed electricity sector model, NEEM. The model covers the entire economy and also provides generator-level detail on the electricity sector. The model's horizon extends to 2050 so that the full impact of short-term decisions is captured, as well as expectations about the long-run policy. The long horizon also helps to account for the transitory effects and avoids large terminal effects, which could potentially yield incorrect responses.

The electricity sector for California, as well as for the entire Western Electricity Coordinating Council (WECC) region, is modeled in great detail as a bottom-up model because this sector, under the modeling assumptions employed, will account for the majority of the emissions reductions. Therefore it is important to capture the mechanisms and technologies that will be employed to reduce emissions from this sector.

NEEM is formulated as a quadratic program that minimizes the cost of meeting electricity demand while complying with emission caps. NEEM models the evolution of the North American power system - taking account of demand growth, available generation, and environmental technologies, and environmental regulations both present and future. The North American interconnected power system is modeled as a set of regions (generally NERC regions and NERC sub-regions, but can be specified in any level of detail required for analysis) that are connected by a network of transmission paths. NEEM accounts for the effect of changes in the price of electricity on electricity demand.

Environmental regulations affect decisions about: (1) the mix and timing of new capacity, (2) retirement of existing units, (3) the mix and timing of environmental retrofits at existing facilities, (4) fuel choice, primarily by coal units, (5) dispatch of all units, (6) maintenance scheduling for all units, and (7) the flow of power among regions. NEEM captures all of these impacts in the process of optimizing unit responses to environmental policies.

We complement this detailed technology representation by linking to a top down state of the art multi-region national (MRN) model of the entire economy. This computable general equilibrium (CGE) macro-economic model and models like it, when dealing exclusively with private costs, postulate that markets will lead to efficient resource allocation. CGE models like MRN capture these efficient allocations. Costs are measured by the foregone output, or reduction in consumer wellbeing, due to a policy.

A well-specified CGE model like MRN uses observations of actual behavior to infer how, for example, demand for fuels responds to prices and how much output can be produced by businesses from a given set of available inputs. These behavioral responses provide a basis for estimating costs of policies that change resource allocation – by requiring or leading to different sources of energy or choices about how much energy to use. It also captures the dynamics of the CA energy market impacts – energy prices, fuel switching, price impacts, industrial output impacts, and California’s terms of trade with its neighbors.

Furthermore, MRN has enough regional and sectoral detail to capture the important interactions and differences among the sectors of the economy and trade among the regions. In particular, MRN identifies industries that gain from additional investment to create cleaner fuels and reduce energy use, as well as industries that decline due to higher costs and lower demand, thus giving a full picture of the net effect of climate policies. The MRN-NEEM model captures spillover effects that result under climate change policies because of the regional detail of the model both in the electricity sector and in the macroeconomic model. MRN-NEEM accounts for the migration of industry out of California as production costs rise and the change in California’s trade pattern in terms of importing final goods.

The MRN-NEEM integrated model was used to compare the results of numerous policy scenarios. The comparisons characterize the impacts of a wide range of climate policy options available to California and sensitivities about technology assumptions.

4.1.3 Summary of the Scenario Descriptions

We designed our analysis to study the economic impacts of different possible implementations of California’s climate policies on the state’s economy in general and the electricity sector in particular. Many of the details regarding the implementation of these statewide policies as well as the policies after 2020 are currently undecided. However, much attention has been focused on implementing a cap-and-trade program to regulate greenhouse gas emissions as this is viewed by many as the most cost-effective policy to address greenhouse gas emissions. Therefore, our analysis focused on such programs. We began our analysis by constructing a basic, plain vanilla cap-and-trade scenario (Pure_Trade), which assumes one possible implementation of current law and follow-on policies. We then consider modifications to this policy scenario. For this scenario, the cap-and-trade program is comprehensive – emissions from all sectors fall under one cap and all sectors can trade permits among themselves – but it excludes many of the flexibility mechanisms such as offsets and safety-valves.

In addition to assumptions about flexibility mechanisms, there are other implementation choices that could greatly affect the cost effectiveness of any cap-and-trade program. Another important determinant of the cost effectiveness will be the cost and availability of carbon-free or low carbon-emitting technologies and the ease in which consumers can reduce their energy use. The following lists a few other key assumptions that will have the largest potential impact on policy costs:

- The availability of imported power from existing coal contracts, new coal contracts, and renewable power;
- The cost of alternative, non-carbon emitting transportation fuels (or backstop fuel);

- The availability and cost of nuclear power;
- The cost-effectiveness of demand-side management (DSM) programs; and
- The long-term emissions target for California.

Hence, we developed scenarios that looked at alternatives to these four assumptions to study the cost-effectiveness of cap-and-trade programs subject to sensitivities about the above assumptions. For the Pure_Trade scenario, we assumed the following:

- Imports: California can retain existing coal contracts, but cannot enter into new contracts with coal-fired generators. California can import generation from renewable sources only over designated tie-lines.
- Backstop fuel costs: Non-carbon emitting transportation fuels are assumed to cost four times that of conventional fuels and decline to one and a half times that of conventional fuels over time.
- Nuclear power: California would neither build nuclear power within the state nor import any new nuclear-fired electricity generation.
- Demand-side management (DSM): DSM takes place through autonomous energy efficiency improvement and therefore is costless.
- Long-term target: From 2020 onward, California's carbon cap is set at 1990 emission levels.

Compared to Pure_Trade, the other scenarios differ according to the flexibility mechanisms associated with the cap-and-trade program (banking, offsets, safety-valve, and trading), the level of the renewable portfolio standard, the ability of California to import power from neighboring power pools, technology assumptions, and long-term emission targets. All the scenarios are summarized in Table 3-2.

4.2 Future Inquiries

This study explored many key issues associated with California's current climate policy. It identified important uncertainties and suggested options for minimizing the costs of achieving the state's objectives. It is not, however, an exhaustive treatment of the climate policy choices. Moreover, the continuing evolution of climate policy within California and beyond its borders will inevitably raise further issues. Some of high priority opportunities for further study include the following:

- Impacts on the electricity sector could be substantially altered by the appearance of technologies allowing vehicles to be electrified (such as Plug-In Hybrids), or of using zero-carbon fuels that would be produced with electricity (such as hydrogen). Such new technologies could increase the importance of developing comprehensive, fuel and sector-neutral policies and avoiding limitations in technological options for generation.

- A critical element design issue affecting the impacts of implementing California's emission limits is how emissions from electricity imports and contracts are to be treated. Some of the ways that emissions might be assigned to non-contracted power imports also produced perverse outcomes, such as undermining the development of clean power outside of California. More analysis needs to be done to consider yet other possible imported-emissions accounting structures, and to try to provide clear analyses of specific proposals for such accounting as they are offered into the policy debate.
- It is very difficult for any model to incorporate sufficient detail about decisions influencing energy use and choice of fuels to fully capture the relative inefficiency of command-and-control regulations in comparison to market-based approaches. Developing more complete representations of these decisions within MRN-NEEM is necessary to gain a more realistic picture of how large the costs of a regulatory approach might be.
- Both federal and regional climate policy are evolving rapidly. As this analysis was being completed, several western states announced their intention to form a regional GHG trading agreement and Congress was considering numerous proposals including cap-and-trade, carbon taxes, and plans to foster development of technological solutions to climate change. The further development of these proposals will affect California's current policies and suggests the usefulness of additional analysis of interactions between federal, regional and state level policy options. This analysis would have to include a full specification of those policies, including how allocations to California were determined and how California's existing targets and policies would be accommodated.
- This study noted that California's example may influence climate policy beyond the state's own borders and that California's policies can affect the competitiveness of California industries relative to the rest of the country and the world. In both these areas there is uncertainty about whether the effects will be beneficial or harmful. Further study could systematically explore the outcome of how California's policies might affect policy outcomes nationwide and whether the results are more likely to improve or harm the competitive position of California industry.
- A more detailed analysis of policies affecting the transportation sector, such as tightened fuel economy standards or introduction of low-emission fuels is needed. Treatment of personal transportation with an integrated model of the motor vehicle purchase and use decision would facilitate such analysis.
- Uncertainties about policy implementation and post-2020 targets were seen to have significant effects on investment decisions made over the next few years. The analysis did not, however, quantify the costs of that uncertainty or explore potential remedies, although it did observe that devising effective remedies would require careful evaluation. This is one of the most important outstanding challenges facing California and merits additional systematic study.

- In any cap-and-trade program, allowance allocation is a crucially important and contentious issue. Many previous programs have used the free allocation of allowances to offset the economic losses experienced by interests that were disproportionately affected by emission controls. In the case of GHG controls, many important questions about the correct implementation of this concept remain unresolved. Economists have also often proposed auctioning some allowances and using the revenues to reduce the marginal rates of economically distorting taxes. Others have proposed using allowance auction revenue to foster development of technological solutions to climate change. Examining these concepts could clarify one of the most important issues associated with the cap-and-trade option.
- The high energy intensity of commercial transportation suggests that this sector may be seriously affected by GHG control policies. In the freight transportation sector, logistics management practices are already in rapid flux and may well respond further under the incentives created by state and regional climate policy measures. Moreover, California is considering several climate and other policy steps that might affect this sector in important ways. A detailed study of California's climate policy and its impacts on commercial transportation could answer some of the important outstanding questions.
- The current study noted that some earlier analyses had posited the existence of energy related market failures (unrelated to environmental externalities). The studies suggested that those market failures caused systematic over-consumption of energy and, therefore, occasioned GHG emissions that could be eliminated at no costs or at low costs. Although other analyses challenge these claims, it might be possible to clarify the controversy by exploring what market failures might operate and what policies might remedy them, as well as estimating the costs and any ancillary benefits of the possible proposed remedies.
- Offsets offer the promise of significant cost-savings while achieving the goals of achieving the states emission targets. Further modeling and data development might be able to elucidate better the potential for offsets and potential reductions from non-CO₂ emissions and the role they may or may not be able to serve in meeting AB 32 targets. This would allow a more precise understanding of the costs of the overall policy, the relative importance of more comprehensive approaches to implementation of AB 32, and also valuable areas for R&D.

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