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Beyond AB 32:
Post-2020 Climate Policy for California

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Beyond AB 32:

Post-2020 Climate Policy for California

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Beyond AB 32: Post-2020 Climate Policy in California

Executive Summary

Todd Schatzki and Robert N. Stavins[1]

January 2013

California is beginning the process of considering possible next steps for the State's climate policy beyond the 2020 emission target mandated in the Global Warming Solutions Act of 2006 ("AB 32"). As it proceeds along this path, it is very important for the State to consider the international, national, and in-state realities and consequences of its actions.

Internationally, California's intent to address global climate change should be considered in the context of three key factors. First, California, currently representing less than one percent of global GHG emissions, an amount that will surely decline with time, itself can do very little directly to address the problem. Meaningful action will require the participation of all major emitting countries, including more meaningful action nationally by the United States. Second, current negotiations are seriously fragmented due to severe challenges reaching consensus. Nations are pursuing domestic policies of greatly varied stringency and credibility. These efforts are less than needed to address the climate problem, in part, due to a basic challenge of the "global commons": although the costs of actions are incurred by the jurisdiction taking action, the benefits of those actions – the reduced risk of climate change – are spread globally.

Third, the Air Resources Board (ARB) has indicated that the State should aim to reduce GHG emissions to 80 percent below 1990 levels, a level of reductions that is consistent with scientific guidance on the actions needed to stabilize atmospheric GHG concentrations *if* achieved throughout the world. Within the State, the changes in infrastructure, equipment, and behavior that would be needed to meet this 2050 goal would be both broad and deep. The costs to achieve such targets are unknown, given the many technology uncertainties, but would likely be very significant. Thus, pursuing these targets, without reciprocal commitments from other nations, would likely impose large costs without achieving comparable benefits.

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California has previously indicated the intent to demonstrate leadership and encourage broader participation in addressing the climate problem, while balancing the economic health of the State's economy. Given the realities, as it moves forward with more costly actions required to achieve emission reductions, developing policy to maintain the balance between these goals will become more challenging. There are seven elements of such a policy that should be carefully considered.

First, given the fragmented status of domestic U.S. and international policy, California can preserve flexibility, while not limiting its ability to demonstrate leadership on climate policy. One approach to preserve flexibility is to avoid firm emission targets that go far into the future, which preserves the option to adjust targets given new information about climate benefits and mitigation costs.

Second, flexibility can also be maintained by making more aggressive targets conditional on reciprocal actions by other states or nations. Conditioning commitments can create significant incentives for other nations and states to take action, while avoiding outcomes whereby California takes aggressive actions that have little or no real climate impacts. Further research can assess these approaches including how best to balance the positive incentives of conditional commitments with provision of sufficient credibility and certainty over future regulatory requirements.

Third, California should carefully assess the environmental and economic performance (as well as distributional implications) of existing policies in the AB 32 scoping plan to determine whether existing policies should be modified or eliminated, and whether new policies should be developed. Over time, costs can be lowered by shifting from the current suite of policies to policies that achieve reductions through fuel-, technology- and sector-neutral incentives, while preserving policies addressing market failures unrelated to GHG emission impacts (such as certain energy efficiency policies). The GHG cap-and-trade program is the best approach for achieving cost-effective emission reductions.

Achieving emission goals cost-effectively will become increasingly important if the State pursues more aggressive emission reduction targets implied by the 2050 goals. Our assessment of the cap-and-trade policy and two complementary policies – the Low Carbon Fuel Standard and the Renewable Portfolio Standard – shows that opportunities for reducing costs exists, although careful assessment is needed to measure the actual economic performance of these policies. Moreover, these complementary policies do not increase emission reductions, but only shift emissions across sectors due to interactions with the cap-and-trade program. Sector-level policies and targets suffer from similar limitations. Achieving emission reductions cost-effectively not only limits negative economic impacts on California's citizens, but can also reduce others' perceived economic costs of climate policy, which can thereby lower political barriers to adoption by other nations (and states).

Fourth, linkages with other countries can further lower the costs of meeting GHG emission reduction targets, although the gains from trade can raise issues about how to allocate these cost savings between economies. Linkages can also reduce cap-and-trade allowance price volatility and opportunities for the exercise of market power by particularly large firms. The benefits from linkage would grow with increased reliance on the economy-wide cap-and-trade program.

Fifth, it is widely recognized that massive innovation in low-carbon technologies will be necessary for achieving GHG emission targets that would stabilize atmospheric GHG concentrations. Policies that promote innovation can advance this goal, while also lowering the cost of climate policy to other nations (and states), which can improve their incentives for taking reciprocal action. However, designing policies to create incentives for innovation (rather than for diffusion of particular, existing technologies) will bring challenges and face significant tradeoffs.

Sixth, to the extent that California pursues more aggressive policies without reciprocal commitments from other countries, leakage risks (that is, the shift in emissions to regions with less stringent regulation) will become a growing concern. Leakage risks reflect costs differences between economies, and do not necessarily dissipate over time if those cost differences remain. These issues have been controversial to date in the implementation of AB 32, but will need to be continually addressed to the degree that cost differences persist.

Seventh, cost-containment will become more, not less important. ARB has adopted cost-containment elements in several of its AB 32 Scoping Plan policies. The GHG cap-and-trade program includes multi-year commitment periods, allowance banking, offsets, and an allowance reserve, but the reserve is (unnecessarily) limited, thus creating risk that is fundamentally avoidable. Other programs, such as the RPS, also include mechanisms to limit excessive costs. Beyond 2020, California will need to focus further on these cost-containment measures, particularly if the stringency of targets increases and there is continued technology and economic uncertainty.

To a large degree, these issues reflect a restatement of sound principles for climate policy that have been under discussion throughout the development of the AB 32 Scoping Plan. However, the need for sound policy design (and the benefits from pursuing it) will be even greater if California adopts the more aggressive targets laid out in ARB's Draft Scoping Plan Update and in Executive Orders. Moreover, demonstrating effective climate policy can increase the likelihood that other nations and states will follow suit, which is necessary for California to have any effect on the broader climate problem.

Beyond AB 32: Post-2020 Climate Policy in California

Todd Schatzki and Robert N. Stavins[2]

January 2013

California is beginning the process of considering possible next steps for the State's climate policy beyond the 2020 emission target mandated in the Global Warming Solutions Act of 2006 ("AB 32"). Discussions about next steps are being initiated by the California Air Resources Board (ARB), the agency charged with implementing policies to achieve the AB 32 target of limiting the State's 2020 greenhouse gas (GHG) emissions to 1990 levels, through its AB 32 Scoping Plan Update (SPU). In the Draft SPU, ARB indicates that reducing the State's GHG emissions to 80 percent below 1990 emission levels by 2050 should be the long-run target for "continuing progress beyond 2020".[3] This 2050 target has been established in two executive orders (one covering only the transportation sector), but as of now the legislature has not identified GHG targets beyond 2020.[4] To achieve the 2050 target, the Draft SPU identifies significant equipment, infrastructure and behavioral changes that would be needed throughout all sectors of the economy.

In the near-term, ARB recommends a binding regulatory goal for 2030 that "aligns with the State's mid-century climate goal" to bring GHG emissions to 80 percent below 1990 levels by the year 2050.[5] According to ARB, this target would involve considerably more stringent reductions than the current AB 32 goals. While achieving AB 32 goals will require a 1 percent annual reduction in emissions, achieving the 2050 target would require a 5.2 percent annual emission reduction.[6]

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[3] California Air Resources Board (2013), "Climate Change Scoping Plan First Update: Discussion Draft for Public Review and Comment," October 1, p. 3 ("Scoping Plan Update").

[4] Executive Order S-3-05 established the goal of reducing economy-wide GHG emissions to 80 percent below 1990 emissions by 2050, while Executive Order B-16-2012 specified such a target for the transportation sector.

[5] Scoping Plan Update, p. 3.

[6] Scoping Plan Update, Figure 6.

The next steps taken by California on climate policy will have significant implications not only for the State, but also for successful progress in addressing the broader climate problem. California has previously indicated the intent to demonstrate leadership and encourage broader participation in addressing the climate problem, while balancing the economic health of the State's economy.[7] As it moves forward with more costly actions required to achieve emission reductions, maintaining the balance between these goals will become more challenging. Refining its policies to learn from past performance and accounting for actions beyond its borders are important elements of policies that can contribute to maintaining this balance.

This paper provides a preliminary assessment of key issues for California as it considers climate policy beyond 2020. It starts by considering the broader international and national context for California policies. Because California's policies can meaningfully address the climate problem only to the degree that they are accompanied by reciprocal actions by other nations, it is important to appreciate the broader context and how California's actions potentially affect outcomes beyond its borders. Next, the paper provides brief assessments of several AB 32 policies to identify factors the State should consider as it develops it long-run climate strategy. Finally, we offer some guidance for the State as it begins to chart a course for the development of its post-2020 climate policy, and consider how California can best *demonstrate* leadership and *encourage* broader international action, while *limiting* impact on its economy.

I. THE GLOBAL CONTEXT FOR CALIFORNIA CLIMATE POLICY

As California begins the process of defining the direction for state climate policy beyond the 2020 emission limits included in AB 32's enabling legislation, it is important to take stock of where California's actions have and will fit within the broader context of international climate policy. As a sub-national government, California does not have a formal seat at the international negotiations table. Moreover, California represents a very small fraction of global emissions, with current emissions amounting to less than 1% of the global total,[8] a share that will surely diminish over time, as emissions continue to increase from the large emerging economies of China, India, Brazil, Korea, Mexico, South Africa, and Indonesia, as well as other parts of the developing world, which are not regulated by existing international policy.

That said, California is a significant economic actor, with an economy as large as the eight largest country in the world.[9] More importantly, given the "bottom-up" and somewhat fragmented nature of current multi-national climate policy, California's role and influence in this international process is likely

[7] For example, AB 32 declares that the legislation will "continue this tradition of environmental leadership by placing California at the forefront of national and international efforts to reduce emissions" (¶38501(c)), while also stating that the law should be met "in a manner that minimizes cost and maximized benefits to California's economy" (¶38501(h)).

[8] *See* Table 1. World Resources Institute, "CAIT 2.0: World Resource Institute's Climate Data Explorer," Online Database, accessed November 2013. Available at http://cait2.wri.org/.

[9] Center for Continuing Study of the California Economy (2013), "California Poised to Move Up in World Economy Rankings in 2013," Numbers in the News, July.

greater than would be implied by its relatively small emissions profile and its lack of a formal role in the international negotiations.

A. International Climate Policy

In 2006, when California set out to address the climate change problem through the Global Warming Solutions Act of 2006, it was aiming to tackle a problem caused by emissions – and with consequences – far beyond its borders. Because greenhouse gas (GHG) emissions mix in the Earth's atmosphere, the adverse consequences of GHG emissions (along with the benefits of emission reductions) are independent of the geographic location of emissions. A unit of carbon dioxide (CO_2) or other GHG emissions has the same impact on global climate whether they are emitted in Los Angeles, London, or Beijing.

This "global commons" nature of the climate problem has created significant challenges to developing meaningful solutions to the problem. [10] While the direct benefits of actions taken by any single economy to reduce atmospheric GHG concentrations are spread globally, the costs of such actions are borne solely by the jurisdiction itself. These conditions severely limit the direct net benefits of unilateral actions, while encouraging "free riders" – that is, entities that reap the benefits of others' actions, without taking actions themselves. Moreover, the need for meaningful solutions to limit emissions from lower-wealth, higher carbon-intensity economies – such as the large emerging economies mentioned above – raises issues of fairness and effectiveness.

Because of these challenges, effective international climate policy has been slow to develop. Coordinated international action on climate change was first initiated in 1992 with the United Nations Framework Convention on Climate Change (UNFCC), which established a framework under which future international treaties could be negotiated to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[11] In 1997, under the UNFCC, countries signed the Kyoto Protocol,[12] which included quantitative, legally binding targets by 37 "developed" (Annex I) countries to lower emissions in aggregate to 5.2% below 1990 levels over the 2008-2012 period.[13]

The Kyoto Protocol has had mixed success, at best. On the positive side, the Protocol provided flexibility in how emission reductions could be achieved and promoted adoption of market-based approaches to achieving emission reductions, both of which encourage achievement of emission targets through cost-effective actions. However, the Kyoto Protocol failed to impose meaningful commitments on three of the five largest global GHG emitters: China and India, along with other developing countries,

[10] Compounding this, the "stock" nature of the problem – in which, atmospheric concentrations grow cumulatively and will persist for decades – creates challenges for clearly identifying a cause-and-effect relationship.

[11] The United Nations Framework Convention on Climate Change, Article 2.

[12] Kyoto Protocol of the United Nations Framework Convention on Climate Change.

[13] Aldy, Joseph and Robert N. Stavins (2008), "Climate Policy Architectures for the Post-Kyoto World," *Environment* 50(3): 7-17.

face no quantitative targets, while Russia's target is so lax that it has been met without any action. In addition, the United States did not ratify the agreement. With these four countries representing over 50% of the world's emissions, combined with the fact that developing countries are not covered by the agreement, the Protocol has failed to impose meaningful requirements on enough emission sources to begin to address the climate problem.[14]

In its second commitment period (2013-2020), the Protocol covers only 14 percent of global emissions.[15] Many key countries included in the first commitment period did not agree to participate in the second commitment period, including the United States, Japan, Russia, and Canada, and developing countries continue to have no commitments under the agreement.[16] With the goal of developing a more comprehensive international agreement, the countries of the world agreed in 2011 to the Durban Platform for Enhanced Action, which established a process to develop by 2015 a new international policy architecture for implementation in 2020.[17]

B. Domestic Climate Policy

Within the United States, efforts to develop comprehensive climate policy have also proceeded slowly. Through the first half of 2009, political momentum was building on several fronts. Regional initiatives within the United States and Canada included: the Western Climate Initiative, which originally encompassed seven U.S. states and four Canadian provinces; the Midwest Greenhouse Gas Reduction Accord, which included six U.S. states and one Canadian province; and the Regional Greenhouse Gas Initiative (RGGI), which included 10 northeast U.S. states. Nationally, federal legislation, which appeared poised to create a comprehensive U.S. climate policy including an economy-wide cap-and-trade system, passed the U.S. House of Representatives, but failed in the Senate.[18] Following this failure, comprehensive national climate legislation became politically unviable, and so the U.S. Environmental Protection Agency (EPA) began to develop regulatory approaches following a key ruling by the U.S. Supreme Court in *Massachusetts v. Environmental Protection Agency*.[19]

Outside of California, none of these domestic initiatives resulted in binding constraints on emissions, although some policies aimed at reducing GHG emissions have emerged. The RGGI resulted

[14] *See* Table 1. World Resources Institute, "CAIT 2.0: World Resource Institute's Climate Data Explorer," Online Database, accessed November 2013. Available at http://cait2.wri.org/.

[15] Aldy, Joseph and Robert N. Stavins (2008), "Climate Policy Architectures for the Post-Kyoto World," *Environment* 50(3), pp. 7-17. *See also*, Aldy, Joseph, Scott Barrett and Robert N. Stavins (2013), "Thirteen Plus One: A Comparison of Global Climate Policy Architectures," *Climate Policy*, volume 3, number 4, pp. 373-397.

[16] Doha Amendment to the Kyoto Protocol.

[17] UNFCC, "Establishment of an Ad Hoc Working Group on the Durban Platform for Enhanced Action", Decision 1/CP.17, December 11, 2011. *See also,* Stavins, Robert N. (2012), "An Unambiguous Consequence of the Durban Climate Talks," *Review of Environment, Energy and Economics*, March 9.

[18] American Clean Energy and Security Act of 2009 (ACES), (H.R. 2454, 111th U.S. Congress).

[19] This rulemaking process is included in a Climate Action Plan released by the Obama administration in June of 2013. Executive Office of the President (2013), *The President's Climate Action Plan*, June.

in a cap-and-trade system for CO_2 emissions from electric power generators in nine northeast states,[20] and multiple states have adopted Renewable Portfolio Standards (RPS), which mandate that a certain portion of electricity be produced from renewable sources, as well as energy efficiency performance standards, which mandate annual reductions in energy use by regulated utilities. However, to date, only California has imposed a binding constraint on its total GHG emissions.

C. Policy Architecture

In international circles, there is on-going discussion and debate about the type of "architecture"[21] that should be adopted for a post-2020 agreement that can bring about meaningful action to address climate change.[22] However, it is clear that, over time, *de facto* international climate policy has evolved from efforts that focused on the centralized, "top-down" architecture that characterizes the Kyoto Protocol to a more bottom-up, decentralized architecture in which countries are developing domestic policies outside of binding obligations under an international agreement. These policies include actions both by national governments and sub-national jurisdictions. Action by sub-national governments is often undertaken to encourage action at the national level, as with actions taken by some U.S. states, such as California. The stringency and credibility of these national and sub-national efforts varies widely across countries and regions.

Table 1 summarizes GHG emission levels, emission targets and domestic policies for the twelve largest emitters, representing over 70 percent of global emissions. Each of these countries has adopted some form of explicit target, some under the aegis of an international agreement (in most cases, voluntary pledges under the Copenhagen Accords and the Cancun Agreements), and all have adopted a variety of domestic policies targeting GHG emission reductions in particular sectors and activities. Reliably and objectively assessing the stringency[23] and credibility of any individual country's commitment is challenging, which makes a comprehensive comparative assessment across countries very difficult.[24] However, there are clearly differences in the stringency of these targets and the credibility and leakage risks associated with the domestic policies undertaken to achieve these targets.[25] Achieving some targets,

[20] New Jersey, one of the original 10 states in the RGGI, subsequently left the initiative.

[21] In this context, one definition of architecture is "a unifying structure that restricts potential agreements in ways that both simplify negotiations and point them in desirable directions." Jacoby, Henry, Richard Schmalensee and Ian Sue Wing (1999), "Toward a Useful Architecture for Climate Change Negotiations," MIT Joint Program on the Science and Policy of Global Change, Report 49, May.

[22] *See* Aldy, Joseph and Robert N. Stavins (2007), *Architectures for Agreement, Addressing Global Climate Change in the Post Kyoto World*, Cambridge, U.K.: Cambridge University Press.

[23] From an economic standpoint, stringency reflects the (marginal) cost of actions required to achieve an emission target or implement relevant policies. More stringent targets imply higher costs and potentially economic transfers to other countries to the extent that national compliance can be met through actions outside the countries (for example, as with the Clean Development Mechanism or linkage of cap-and-trade systems).

[24] In addition, for some countries, information needed to make such assessments is lacking.

[25] Because the relative stringency of national (or sub-national) policies creates differentials in regulatory costs of compliance, relative stringency can affect the magnitude of emission (and economic) leakage. However, the type of

such as the EU's climate targets, has (and will) involve meaningful effort on the part of EU countries. By contrast, other targets are easily met under business-as-usual conditions, as with Russia's current target.

Along with creating practical challenges for enforcing international agreements, challenges with measuring policy stringency and verifying implementation suggests that the credibility needed to support multilateral action may only evolve gradually over time. This has potential consequences for the pace at which nations will adopt domestic policies. More research assessing these commitments and domestic policies could provide valuable information for efforts to adopt more meaningful climate policies. [26]

Many countries have adopted or plan to adopt market-based policies that place a price on GHG emissions. When economy-wide market-based policies are adopted, such policies can achieve cost-effective reductions in GHG emissions. Table 2 identifies cap-and-trade programs that are being adopted or planned. To date, cap-and-trade systems have been the most widely adopted market-based policies, with seven countries having such systems either in place or in planning stages. Some of these programs have been operating for multiple years, such as the European Union Emission Trading System (EU ETS) and the Regional Greenhouse Gas Initiative (RGGI). Developing countries, such as China and India, are beginning to develop programs, typically based on emission or energy intensity, rather than hard emission caps. A further opportunity to reduce the cost of achieving global GHG emissions is provided by the potential linkage of these various programs.[27]

Along with reducing emission reduction costs, market-based policies provide a means of addressing some of the information challenges associated with developing international agreements. Under market-based systems, GHG prices as reflected in allowance prices or GHG taxes provide a transparent signal that allows immediate comparison of the severity and credibility of policies across systems. While linkages between systems can complicate such comparisons, transfers of allowances across systems can be used as a metric for assessing relative stringency.

policies undertaken can also affect the relative costs faced by business and industry, along with the allocation of those costs (for example, whether they are born by business and industry, the government, or taxpayers/consumers).

[26] The "Climate Action Tracker", a project designed to provide "independent science-based assessment, which tracks the emission commitments and actions of countries," provides an illustration of the structure and type of information that could be provided by such an assessment. http://climateactiontracker.org.

[27] Ransom, Matthew and Robert N. Stavins (2013), "Linkage of Greenhouse Gas Emission Trading Systems: Learning From Experience," Harvard Project on Climate Agreements, Discussion Paper ES 13-2, November.

Table 1: National Climate Policies

Country 2010 Emissions (% of World Total)	2020 BAU Emissions	International Targets (2020)	Policy (Current and Planned)
China 10.08 $GtCO_2e$ (21.4%)	14.095-17.430 $GtCO_2e$	40% to 45% below 2005 (Intensity) **12.930-13.835 $GtCO_2e$** Other Targets: • Non-Fossil Electricity Target: 15% of by 2020 • Forest Targets (+40 Mha/+1.3 b m3)	• Cap-and-trade program(s) • 700 GW total renewable capacity targeted for 2020 (420 hydro, 200 wind, 50 solar, 30 biomass; 135 GW existed in 2006) • TOP 1,000 enterprises: 1,000 enterprises producing 33% of national emissions and 47% of industrial emissions (2004) were given energy intensity goals. They reduced their emissions by just over 150 million tons of coal equivalent. The program has expanded to "TOP 10,000," covering two thirds of China's energy consumption. • Efficiency standards for appliances, buildings and cars • Air Pollution Control Action Plan (bans new coal-fired in certain areas) • Solar thermal water heating, biogas, and biofuels targets • Ethanol blending mandate: 10% for ten provinces **Projected Emissions Under Policy**: 12.769-14.763 $GtCO_2e$
USA 6.78 $GtCO_2e$ (14.4%)	6.615-7.250 $GtCO_2e$	17% below 2005 (Emissions) **5.965 $GtCO_2e$**	• California and RGGI GHG cap-and-trade systems • Fleet Average Efficiency Standards for Light Vehicles • Appliance standards and Energy Star (labeling program) • New Source Performance Standard (CO_2 standard for new large sources; rulemaking for a similar standard for existing sources is on-going) • Renewable Fuel Standard: Increasing quotas for renewable biofuel consumption • Obama's Climate Action Plan (CAP) includes: doubling renewables, coal emissions limits, demand sector energy efficiency, measures around methane, and streamlining policies for permitting renewable energy. The CAP plan is likely needed to hit the international target. **Projected Emissions Under Policy**: 6.315-6.465 $GtCO_2e$
EU 4.82 $GtCO_2e$ (10.2%)	4.720 $GtCO_2e$	20% below 1990 (Emissions) **3.9-4.5 $GtCO_2e$**	• EU Emissions Trading System • Renewable electricity targets • Light Vehicle Efficiency Standards • Energy Efficiency Directive: efficiency target for all member states, renovate public buildings, oblige all utilities to achieve energy savings of 1.5% per year, mandatory energy audits for some companies, individual metering, and assessment of potential for high-efficiency cogeneration • Biofuels/ethanol blending mandate: 10% overall (20% target for 2020) **Projected Emissions Under Policy**: 4.170-4.500 $GtCO_2e$
Russia 2.32 $GtCO_2e$ (4.9%)	2.420-2.750 $GtCO_2e$	15% to 25% below 1990 (Emissions) **2.085-2.455 $GtCO_2e$**	• Emission Intensity Target: -40% relative to 2007 level (policies relating to -40% energy intensity are outdated; current projection is -26%) • Renewable electricity target: 4.5% by 2020 • Many building codes and heat efficiency laws, developed before 2003 • Government decree to reduce flaring from natural gas production to 5% (fines may be less than costs to comply) **Projected Emissions Under Policy**: 1.780-2.155 $GtCO_2e$

Table 1: National Climate Policies (continued)

Country 2010 Emissions (% of World Total)	2020 BAU Emissions	International Targets (2020)	Policy (Current and Planned)
India 2.3 $GtCO_2e$ (4.9%)	3.155-5.250 $GtCO_2e$	20% to 25% below 1990 (Intensity) **3.510-3.745 $GtCO_2e$**	• Perform, Achieve and Trade (PAT) cap-and-trade mechanism • Renewable Targets 2017: 41.3 GW renewable (27.3 wind, 4 solar, 5 biomass, 5 other) 2020: 72.4 GW renewable (38.5 wind, 20 solar, 7.3 biomass, 6.6 other) • State-level Renewable Performance Standards • State-level feed-in tariff schemes • Small renewables target (15%) • Biofuel targets: 20% biofuel/ethanol blending by 2020 **Projected Emissions Under Policy**: 2.655-3.795 $GtCO_2e$
Brazil 2.14 $GtCO_2e$ (4.5%)	2.480-3.235 $GtCO_2e$	36.1% to 38.9% below BAU (Emissions) **1.975-2.070 $GtCO_2e$**	• Emissions target was made a national law • Increase use of "new" energy including hydro and wind by three times (to 16%) • National Forest Code • Action Plan for Deforestation: 80% reduction in annual Amazon deforestation; 40% reduction in annual deforestation in savannahs • Biofuels mandates: 20% ethanol, 5% biodiesel **Projected Emissions Under Policy**: 1.500-1.630 $GtCO_2e$
Japan 1.3 $GtCO_2e$ (2.8%)	1.245-1.340 $GtCO_2e$	Originally 25% below 1990 (Emissions). Was revised in 2013 to 3.8% below 2005, roughly 3.1% above 1990 (Emissions) **1.306 $GtCO_2e$**	• 16% electricity from renewables by 2020 • Energy policy, including phasing out nuclear and fossil fuels, with mixed consequences for GHG emissions • Energy efficiency policies in transport, industry and buildings • Feed-in tariffs for renewables **Projected Emissions Under Policy**: 1.370-1.451 $GtCO_2e$
Indonesia 1.17 $GtCO_2e$ (2.5%)	1.585-2.950 $GtCO_2e$	26% below BAU (Emissions), largely from reducing deforestation **1.770-2.185 $GtCO_2e$**	• Green Energy Policy: renewable generation & biofuel quotas • Agreement to only export legally harvested timber to EU • 56% of reductions expected from land use • 15% renewable electricity in 2020 (mostly replacing oil, keeping coal) **Projected Emissions Under Policy**: 1.465-2.200 $GtCo_2e$
Australia 0.74 $GtCO_2e$ (1.6%)	615 - 650 $MtCO_2e$	5%, 15%, or 25% below 2000 (Emissions) **390-505 $MtCO_2e$**	• Carbon Pricing Mechanism fixed carbon price (July 2012) and evolving flexible ETS (2015). • Renewable Energy Target Scheme: 20% renewable generation by 2020 • Current Prime Minister has vowed to repeal both of the above policies and to limit spending to complying with reduction goal (5% reduction relative to year 2000 emissions) to AU$3.2. **Projected Emissions Under Policy**: 450-645 $MtCO_2e$ (595 MtCO2 if regulations repealed)

Table 1: National Climate Policies (continued)

Country 2010 Emissions (% of World Total)	2020 BAU Emissions	International Targets (2020)	Policy (Current and Planned)
Canada 0.73 $GtCO_2e$ (1.5%)	748-785 $MtCO_2e$	17% below 2005 (Emissions) **610 $MtCO_2e$**	• Quebec GHG cap-and-trade • Fuel efficiency standards for light duty vehicles • Carbon standards for new coal-fired power plants. • Ontario will phase out coal generation by 2014 (state-level policy). • Biofuels mandates: 5% ethanol, 2% biodiesel; three provincial mandates exceed federal requirements **Projected Emissions Under Policy**: 720-780 $MtCO_2e$
Mexico 0.71 $GtCO_2e$ (1.5%)	835-960 $MtCO_2e$	30% below BAU (Emissions) **670 $MtCO_2e$**	• The General Law for Climate Change and Natural Strategy on Climate Change confirmed targets as binding national law. The General Law establishes a system to translate the targets into concrete plans, but does not spell out the plans directly. • Renewable energy target of 35% renewables by 2024 • Support for renewable energy and solar heating • Green mortgage program • Reforestation programs **Projected Emissions Under Policy**: 800-845 $MtCO_2e$
South Korea 0.68 $GtCO_2e$ (1.4%)	775-805 $MtCO_2e$	30% below BAU (Emissions) **545 $MtCO_2e$**	• Target Management System (2012) started the Emission Trading System and covers 60% of emissions. Full ETS to go live in 2015 • 2012 Renewable Portfolio Standard is replacing previous feed-in tariff. Suppliers must meet targets of 2%, renewable electricity increasing up to 12% in 2022. • Renewable Homes Subsidy Program **Projected Emissions Under Policy**: 630-675 $MTCO_2e$
World Total 47.18 $GtCO_2e$			
California 0.45 $GtCO_2e$ (1.0%)	507 $MtCO_2e$	Return to 1990 levels (Emissions) **427 $MtCO_2e$**	ARB Scoping Plan, including: GHG cap-and-trade system, Renewable Portfolio Standard, distributed renewables programs, energy efficiency programs, Low Carbon Fuel Standard, and Vehicle Fleet Efficiency Standards

Sources: See list at the end of the paper.

Notes: [1] BAU – Business as usual. [2] Estimates of expected emissions in 2020 from PBL (2013). Estimates are generally consistent with the Climate Action Tracker, developed by Ecofys, Climate Analytics and PIK. Available at: http://climateactiontracker.org/.

Table 2: GHG Cap-and-Trade Systems

Country 2010 Emissions (% of World Total)	Cap-and-Trade Details
China 10.08 $GtCO_2e$ (21.4%)	**Established:** 2013 for initial regional pilot programs **Coverage:** For pilot program, large companies in each city/province (in total, 600 $MMTCO_2e$ by 2015) **Notes:** China's 12th Five Year Plan includes gradual development of a carbon trading market. Initially, pilot programs are being developed in seven cities/regions. Regional caps are set based on emission intensity targets particular to each region. The Shenzhen cap-and-trade program began in June 2013, and Beijing/Shanghai started in November 2013. Expanding regional programs to a nationwide cap-and-trade system for 2020 is being considered.
USA 6.78 $GtCO_2e$ (14.4%)	**Regional Greenhouse Gas Initiative (RGGI)** **Established:** 2009 **Coverage**: Electricity sector **Notes:** RGGI includes nine northeast states. Emission caps were revised downward in 2013. **California** **Established:** 2013 **Coverage**: Large sources (2013-2014), with fuels added in 2015; covers 85% of California's GHG emissions **Notes:** Declining cap, set at 1990 emission levels in 2020. The California and Quebec schemes will be linked starting in 2014.
EU 4.82 $GtCO_2e$ (10.2%)	**Established**: 2005 **Coverage**: Large emission sources (covers about 40% of GHG emissions/50% of CO_2 emissions) **Notes:** The EU Emissions Trading System (EU ETS) operates in 28 EU countries and three EEA-EFTA states (Iceland, Liechtenstein and Norway). The cap is set at 21% below 2005 emissions in 2020.
India 2.3 $GtCO_2e$ (4.9%)	**Established:** 2012 **Coverage**: Large emission sources in eight sectors (478 facilities, reflecting about 60% of industrial energy consumption) **Notes:** Perform, Achieve and Trade (PAT) Mechanism is a cap-and-trade plan, in which each facility receives an emission benchmark to be achieved March 2015. Facilities can sell credits if emissions are below their benchmark. On average, benchmarks are 4.8% below baselines set based on 2005-2010 emissions.
Japan 1.3 GtCO2e (2.8%)	**Tokyo** **Established:** April 2010 **Coverage:** Large emission sources **(**20% of Tokyo's CO_2 emissions; 40% of industrial and commercial CO_2 emissions) **Notes:** Applicable facilities must submit five-year reduction plans and annual progress reports. Facilities may leave the ETS is emissions fall below pre-determined thresholds. Allowances during the first compliance period (2010-2014) were freely distrubted, allocated based on past emissions. Credits are given only when a facility exceeds its target and banking is allowed between periods.
Australia 0.74 $GtCO_2e$ (1.6%)	**Established:** Carbon Pricing Mechanism (CPM), July 2012; Emission Trading System (ETS), July 2015 **Coverage:** Large emission sources (500 of largest emitters, about 60-66% of emissions) **Notes:** The CPM establishes a fixed carbon price, initially set at AU$23, rising at 2.5% per year. Regulation will shift from the CPM to the ETS starting in July 2015. Program status is uncertain given opposition by the recently elected (October 2013) government.

Table 2: GHG Cap-and-Trade Systems (Continued)

Country 2010 Emissions (% of World Total)	Cap-and-Trade Details
Canada 0.73 $GtCO_2e$ (1.5%)	**Quebec** **Established:** 2013 **Coverage:** Large sources (2013-2014), with fuels added in 2015 **Notes:** The California and Quebec schemes will be linked starting in 2014. **Alberta** **Established:** 2007 **Coverage:** Large emission sources (emissions > 100,000 tCO_2, except biomass) **Notes:** Alberta has an emission trading scheme based on facility-level GHG emissions intensity. Goal is to reduce annual emissions intensity 12% below a 2003-2005 average baseline. New facilities are benchmarked based on their first three years of commercial operation. **British Columbia** **Established:** 2008 **Coverage:** Fuels (at the point of sale) **Notes:** British Columbia has a carbon tax that has increased from $10 per $MTCO_2e$ in 2008 to $30 per $MTCO_2e$ in 2012. Revenues from the carbon tax were used to reduce tax rates on personal and business income and provide certain tax credits
South Korea 0.68 $GtCO_2e$ (1.4%)	**Established:** Planned implementation in 2015 **Coverage**: All industrial and power installations with emissions higher than 25 $ktCO_2e$ and any company with over 125 $ktCO_2e$ (490 of the largest emitters) **Notes:** The emissions cap is expected to be in line with international pledge. Allowances will be freely allocated to emitters in the first compliance period. In the second and third compliance periods, 97% and 90% of allowances will be freely allocated, with the remainder being auctioned.
Kazakhstan 0.25 $GtCO_2e$ (0.5%)	**Established:** Pilot programs (no non-compliance penalties) started 2013 **Coverage**: Phase I: 178 companies (55% GHG emissions, 77% CO_2 emissions) **Notes:** The Kazakh Emission Trading System (K-ETS) cap in 2013 is 147 $MtCO_2e$, freely distributed to companies initially covered by the regulation, plus a 20.6$MtCO_2e$ reserve. A second pilot program, Phase II, will extend from 2014-2015. During the pilot period, there is not a penalty for non-compliance.
New Zealand 0.08 $GtCO_2e$ (0.2%)	**Established:** 2008 **Coverage:** All GHGs emissions, with certain exceptions (e.g., HFCs, PFCs) **Notes:** Sectors were phased in over time to the ETS. Allowances are allocated freely to organizations who earn them (such as owners of forests that absorb GHG) and industries potentially subject to leakage.

Sources: See list at the end of the paper.

Among the countries adopting domestic climate commitments, some have established conditional commitments that depend on the actions of other countries, including their willingness to accept meaningful climate targets. Table 3 identifies nations that have made such explicit conditional commitments. One approach is a two-tier, conditional commitment, including a lower level reflecting actions to be taken unilaterally, regardless of actions taken by other countries, and a higher level reflecting actions to be taken conditional on development of a broad, multi-national agreement. The most notable among such commitments is the European Union's pledge to strengthen its 2020 GHG emission target from 20 percent to 30 percent below 1990 emissions if developed countries commit to comparable efforts and developing countries contribute according to their capabilities.[28] Developing countries have also adopted commitments that are conditional on financial support for their actions from other countries.

D. Factors Affecting Participation in International Agreements and Adoption of National or Sub-National Climate Policies

The fundamental environmental and economic characteristics of the climate problem pose challenges to the development of effective, sufficient action at the international and national levels. As California considers the possibility and nature of post-2020 climate policy, it is essential to keep these characteristics in mind so that California's policies can increase the likelihood of broader international action, while protecting the economic well-being of the State's citizens.

1. Four Key Characteristics

First, there is the "global commons" problem. Policy decisions by individual nations (or sub-nations) are driven, in large part, by a policy's net benefits – that is, the benefits created in excess of costs. Because the cost of actions to reduce GHG emissions are born solely by the jurisdiction taking action, while the benefits of those actions are shared globally, actions based solely on unilateral initiatives that produce positive net benefits for the respective jurisdictions will be demonstrably insufficient to the global task – that is, there will be too little effort expended to address the global commons problem. However, if nations/sub-national jurisdictions make *reciprocal commitments*, greater levels of effort are possible. Broad participation is necessary in order to reduce the gap between the levels of effort justified by each country's self-interest and the levels of effort needed to sufficiently address the climate problem.

Second, there is the "free rider" problem. Incentives for free riding create the risk of unwinding or preventing the development of reciprocal commitments by other jurisdictions (whether through explicit multi-lateral agreements or tacit agreements). As more countries take on commitments, the benefits of defecting – reaping the global effects of others' efforts while avoiding the costs of action – increase. The possibility of economic leakage, the shift in economic activity – and emissions – from one region to another due to higher costs of regulatory compliance, reinforces these incentives. Along with offsetting the environmental gains achieved by a country imposing new regulations, leakage provides economic benefits to a country that does not impose regulations, thus creating an added incentive to limit climate policy commitments.

[28] Copenhagen Accord of the United Nations Framework Convention on Climate Change, Appendix I.

Table 3: Climate Policies and Targets Conditional on External Commitment or Support

Country 2010 Emissions (% of World Total)	Unconditional 2020 Target	Conditional 2020 Target	Description of Trigger for Conditional Target	Type of Condition
EU 4.823 $GtCO_2e$ (10.2%)	20% below 1990 levels	30% below 1990 levels	Developed countries commit to comparable efforts and developing countries contribute according to their capabilities	Commitment
Brazil 2.136 $GtCO_2e$ (4.5%)		36.1% to 38.9% below BAU	Pledge was made internationally contingent on adequate financial and technological support, but subsequently adopted as national law without conditions	Support
Indonesia 1.170 $GtCO_2e$ (2.5%)	26% below BAU	41% below BAU	Adequate financial and technological support	Support
Australia 0.737 $GtCO_2e$ (1.6%)	5% below 2000 levels	15% below 2000 levels 25% below 2000 levels	In November 2013, Australia announced that it will no longer pursue conditional targets due to a lack of binding commitments from other nations. Prior to this, the conditions were: If a global agreement is reached (with major developing country participation) stabilizing atmospheric GHG above 450 ppm CO_2e, target would be set at 15% below 2000 levels If a global agreement is reached stabilizing atmospheric GHG below 450 ppm CO_2e, target would be set at 25% below 2000 levels	Commitment
Mexico 0.706 $GtCO_2e$ (1.5%)		30% below BAU	Provisions of adequate financial and technological support	Support
South Africa 0.560 $GtCO_2e$ (1.2%)		34% below BAU 42% below BAU by 2025	A fair, ambitious and effective Climate Change convention agreement; provision of support from the international community	Commitment and Support
Ukraine 0.383 $GtCO_2e$ (0.8%)		20% below 1990 levels	Achievement of agreed emission reductions by Kyoto Annex I Parties; continued status as "Economy in Transition" under Kyoto Protocol; ability to carry over credits (AAUs) from first commitment period	Commitment
Kazakhstan 0.246 $GtCO_2e$ (0.5%)		15% below 1990 levels	Carry-over surplus credits (AAUs) from first commitment period; demonstration of environmental integrity of Kyoto Protocol; a mid-term 2013-2015 review aimed at increasing the level of ambition in emission reductions; access to flexible Kyoto mechanisms	Commitment and Support
Chile 0.092 $GtCO_2e$ (0.2%)		20% below BAU	International support	Support
Belarus 0.087 $GtCO_2e$ (0.2%)		8% below 1990 levels	Access to flexible Kyoto mechanisms, technology transfer and capacity building	Support
New Zealand 0.082 $GtCO_2e$ (0.2%)	5% below 1990 levels	10 to 20% below 1990 levels	A global agreement setting the world on track to keep temperature within 2° C of pre-industrial levels, with all parties making comparable or adequate efforts and an effective set of LULUCF rules; full recourse to a broad and international carbon market	Commitment
Switzerland 0.050 $GtCO_2e$ (0.1%)	20% below 1990 levels	30% below 1990 levels	A global agreement with developed countries taking similar action and developing countries contributing according to their capabilities	Commitment
Norway 0.045 $GtCO_2e$ (0.1%)	30% below 1990 levels	40% below 1990 levels	A global agreement with major parties setting the world on track to keep temperature within 2° C of pre-industrial levels	Commitment
Costa Rica 0.007 $GtCO_2e$ (0.0%)		carbon neutral by 2021	International financing	Support
Iceland 0.004 $GtCO_2e$ (0.0%)		15% below 1990 levels / 30% below 1990 levels	Keep current Marrakesh Accords on LULUCF Commitment by other developed countries to comparable efforts and by developing countries according to their capabilities	Commitment

Third, the costs and benefits of climate change mitigation vary widely across the economies that must be included in meaningful solutions to the problem. Given current energy sources and current (and future) dependence on energy use for economic growth, the costs of accepting limits on emissions growth varies significantly across countries. Benefits also vary significantly. Some countries face major risks, particularly developing countries in tropical regions and small island states, with impacts ranging from land lost for coastal populations to reduced agricultural productivity. Some other countries will likely benefit from warmer weather and increased agricultural productivity. Ability to pay varies due to differences in wealth and income. As a consequence, the issue of potential economic transfers between countries that are needed to gain reciprocal commitments looms large in climate negotiations. Difficulty in measuring other countries' benefits and costs ("asymmetric information") contributes to difficulties in reaching agreement on mutual commitments.

Fourth, the benefits and costs of climate policy are not the only factor affecting nations' decisions to make meaningful climate policy commitments. Other factors tied to broader international relations can also affect these decisions. For example, the desire to maintain constructive international relations on other policy issues such as trade and security can create incentives for countries to enact policies that are consistent with evolving international norms of conduct. As more countries take on obligations, the "costs" of failing to adopt these international norms likely increases.

2. Unilateral Policy Developments

In parallel with negotiations on international climate cooperation, many nations (and some sub-national jurisdictions) are developing climate policies at the domestic (or state- or provincial-level) level. These policies vary greatly in stringency and credibility, with some nations (and sub-national jurisdictions) having taken unilateral actions that go well beyond the average stringency of measures adopted by other jurisdictions. The decision to undertake such unilateral action has economic consequences for the nation/sub-nation taking the action, as well as for other countries that do not take (as stringent) action. These consequences are important to consider when any entity considers unilateral action.

Within the jurisdiction taking action, climate policy creates both potential benefits and imposes costs. Any sort of meaningful unilateral policy – that is, a policy that goes beyond what others are doing – will likely result in costs that will by necessity exceed the direct benefits to the entity that undertakes these policies. Leakage can further disadvantage economic conditions in the nation taking unilateral action, although specific policy instruments are available to lessen the extent of leakage.[29]

Even if net costs are imposed in the short-run, unilateral action could provide a means of facilitating the development of broader (and more ambitious) multi-national action on climate change that would lead to positive net benefits in the long-run. With this long-run goal in mind, it is therefore

[29] For example, the updating output-based allocation approach used for directing industry assistance under California's GHG cap-and-trade program is one approach to mitigating leakage risks. Border adjustments for both imports and exports (based on carbon content), which is being used for electricity imports into California, is another approach.

important to consider the impact that any unilateral action may have on the incentives for other nations to undertake reciprocal actions. This type of understanding can help inform decisions on the levels and types of unilateral actions that are most likely to lead to positive actions by other governments.

Unilateral action can both positively and negatively affect incentives for other nations to undertake more meaningful climate policies. On the positive side, unilateral action can help improve incentives for reciprocal action through several mechanisms: fostering technological innovation that lowers costs for other nations; demonstration of cost-effective and environmentally effective climate policies; and shifting international norms.

Policies that lead to technological innovation in low-GHG technologies can lower the costs to other nations of undertaking climate policies, thus increasing the likelihood of their undertaking such actions. Policies vary in the degree to which they promote the development of new technologies, as opposed to the diffusion of existing technologies. While the latter outcome may lower emission reduction costs in the short-run, it will not help lower emission reduction costs in other countries.

Unilateral action can provide valuable information on policy effectiveness that can be used by other countries in the design of their climate policies. Information can include a policy's environmental effectiveness (that is, level of emission reductions achieved), direct (and indirect) costs, interactions with other policies, and other unintended or unanticipated consequences. With this information, other countries can undertake domestic policies with less uncertainty over environmental and economic outcomes.

Policy design choices can affect the extent to which unilateral actions provide positive lessons for other nations about the likely economic consequences of adopting meaningful climate policies. Policies that achieve emission targets at least cost create the greatest incentives for other nations to take action by minimizing expected economic costs, which in turn can reduce domestic political obstacles. Similarly, policies that demonstrate environmental effectiveness and the ability to achieve pre-determined emission targets can provide confidence that policies are providing environmental benefits, along with increasing the likelihood that the credibility of reciprocal action can be verified. Market-based policies, particularly the cap-and-trade programs being adopted in many nations and sub-nations, are the most reliable approach to achieving these objectives. Linkages between programs, particularly with cap-and-trade systems, can further lower costs.

Finally, unilateral action may encourage reciprocal action through moral suasion, political pressure and negotiating leverage at international climate negotiations.

On the negative side, unilateral action can reduce the economic incentives for other countries to take reciprocal action by raising their costs of taking action. If unilateral action creates a "competitive advantage" for other countries (due to the differences in regulatory costs), then the economic consequences for another country to reciprocate such a commitment (without any further unilateral action) becomes larger because it reflects not only the cost of undertaking the action, but the loss of the competitive advantage gained through the first-mover's unilateral actions.[30] While countries can take actions to reduce the extent of this competitive disadvantage and the resulting emission leakage, some degree of this economic leakage from unilateral climate policies is inevitable, particularly as the gap between relative policy stringency.

In addition to leakage through competitive (comparative) advantage, leakage can also arise through a "price effect". A unilateral policy aimed at reducing demand for fossil fuels (or any GHG-intensive good or service) can lower regional or global energy prices. If this occurs, the lower energy prices may increase demand from consumers and industry in other regions. In this case, emission reductions achieved through reduced demand for fossil fuels can be offset by increases in fossil fuel use – by consumers and by industry – in other regions due to lower fossil fuel prices. The magnitude of leakage effects depends on the proportion of countries that have adopted commitments (and the characteristics of those economies that have not adopted commitments), but will generally decline as more countries adopt mutual commitments.[31]

Unilateral action may also affect the benefits to other countries from undertaking reciprocal action. Because unilateral action makes the problem less severe, it potentially diminishes the urgency to address the problem or the perceived benefits from further action to mitigate the problem.[32] Should this occur, it could actually reduce the incentives for other nations/sub-national jurisdictions to take further action.

Better understanding of how these factors play out would be of great value as a government, such as California's, considers actions in the hope of causing other countries to make more ambitious commitments. A number of factors are particularly worthy of further consideration as California contemplates climate policy beyond 2020:

1. The value of demonstrating environmental and economic effectiveness of various policies to other countries, particularly to the extent that cost-effective measures can reduce the costs expected by other nations from adopting reciprocal commitments;

2. The implications of opportunities for linkages between national systems, which can further lower costs for other countries;

[30] For examples of analyses that estimate the magnitude of these effects, *see* Brechet, Thierry et al., (2010) "The impact of the unilateral EU commitment on the stability of international climate agreements," *Climate Policy* 10(2); Underdal, Arild et al. (2012), "Can conditional commitments break the climate change negotiations deadlock?", *International Political Science Review* 33(4): 475-493.

[31] For example, Di Maria and van der Werf (2005) report that analyses of the Kyoto Protocol generally found leakage rates ranging from 5 to 20 percent, although some analyses reported levels as high as 60 percent. Di Maria, Corrado and Edwin van der Werf (2008), "Carbon Leakage Revisited: Unilateral Climate Policy with Directed Technical Change," *Environmental and Resource Economics* 39(2): 55-74.

[32] This assumes that the marginal benefits to further action are decreasing at lower atmospheric GHG concentrations. That is, as more action is taken to reduce GHG emissions, the benefit to incremental emission reductions tends to diminish.

3. Potential cost reductions given realistic expectations for technological innovation in low-GHG emission technologies provided by various strategies;

4. The incentive effects of conditioning commitments on reciprocal actions by other governments; and

5. The implications of various levels of unilateral commitment – that is, policy stringency – for factors affecting incentives for reciprocal commitments (for example, leakage, free-riding incentives and conformance with international norms).

II. ISSUES FOR AB 32 POLICIES EXTENDED BEYOND 2020

The design of climate policy has important implications for environmental effectiveness, economic effectiveness, and distributional outcomes. Market-based policies, such as the California's GHG cap-and-trade program, offer the potential to achieve GHG reduction targets cost-effectively, while ensuring achievement of predetermined targets. The AB 32 Scoping Plan, designed to reduce GHG emissions to 1990 levels by the year 2020, includes many other, so-called "complementary" policies designed to achieve reductions in emissions from particular types of activities. These policies, when targeted at market failures unrelated to GHG emissions, can enhance economic efficiency, but other policies that target activities that are under the cap-and-trade program can increase social costs while generally achieving no additional emissions reductions. Careful attention needs to be paid to such interactions between policies, particularly between the GHG cap-and-trade system and other policies that target sources covered by cap-and-trade. Emission leakage and various forms of commodity "reshuffling" can also adversely affect policies' environmental performance.

Much has been said and written about the importance of these design issues in the context of developing policies aimed at achieving AB 32's 2020 emissions requirement.[33] As California moves beyond 2020, these issues will not only continue to be relevant, but will grow in importance. Careful policy design will become even more important if California pursues increasingly stringent climate targets, as advocated in ARB's SPU, which would most likely lead to considerably higher costs. Higher costs would have potentially great implications for the citizens of and businesses in California, but would

[33] Regarding cap-and-trade program design, *see* Hahn, Robert and Robert N. Stavins (2012), "The Effect of Allowance Allocations on Cap-and-Trade System Performance," *The Journal of Law and Economics* 54(4):S267-S294*;* Stavins, Robert N. (2007) "A U.S. Cap-and-Trade System to Address Global Climate Change," Hamilton Project, Discussion Paper 2007-13, Washington, D.C.: The Brookings Institution, October. Regarding policy interactions, *see* Schatzki, Todd and Robert N. Stavins, "Implications of Policy Interactions for California's Climate Policy," August 2012; Hood, Christina, (2013) "Managing interactions between carbon pricing and existing energy policies, Guidance for Policymakers," International Energy Agency, Insights Series, Regarding linkage, *see* Ranson, Matthew and Robert N. Stavins (2013), "Post-Durban Climate Policy Architecture Based on Linkage of Cap-and-Trade Systems," *Chicago Journal of International Law* 13(2): 403-438, Winter. Regarding leakage, *see* Stavins, Robert N., Jonathan Borck, and Todd Schatzki (2010), "Options for Addressing Leakage in California's Climate Policy," white paper, February.

also, as emphasized above, have implications for the likelihood that other jurisdictions would adopt reciprocal efforts to mitigate climate change.

At present, the cost of achieving AB 32's 2020 target is unknown. While there was considerable debate and analysis regarding costs leading up to the implementation of AB 32,[34] economic and technological conditions continue to change, and program implementation can provide real-world data in place of assumptions embedded in prior analyses. As a result, the usefulness of those past estimates diminishes over time. Continued assessment throughout AB 32 implementation can provide exceptionally valuable information.

Looking beyond 2020, many factors will affect actual costs, including uncertain technological change and economic growth. That said, more stringent targets will likely result in more than proportionately higher costs (consistent with increasing marginal abatement costs). Businesses (and individuals, for that matter) complying with environmental regulations tend to pursue the least costly actions first, moving on to more costly opportunities only after less costly opportunities have been exhausted. This is true within programs, for example, as progressively less productive and more distant wind resources are developed to comply with the Renewable Portfolio Standard (RPS), and can also be true across programs, as regulators first pursue reductions through cost-effective requirements, and are forced to turn to less attractive requirements over time. While there are countervailing factors, particularly technological change, which can lower costs of existing technologies and introduce new cost-effective technologies, such factors cannot be relied upon to lower costs of achieving more stringent targets over time.

Moreover, achieving the 2050 targets considered by ARB and established in Executive Orders – that is, reducing GHG emission to 80 percent below 1990 levels by 2050 – will require widespread changes in infrastructure, increased reliance on technologies that are currently more costly than alternatives, and advancement of technologies not yet widely used in the market. In the SPU, ARB draws on a number of recent studies[35] to identify key changes it believes are necessary to achieve this target. In many cases, ARB concludes that particular technology changes are needed, such as a transportation sector relying almost solely on electrification of on-road vehicles and near-zero electric power supply relying on

[34] Stavins, Robert N., Judson Jaffe and Todd Schatzki (2007), "Too Good to be True? An Examination of Three Economic Assessments of California Climate Change Policy." Washington, D.C.: AEI-Brookings Joint Center for Regulatory Studies, January. Particular analyses include: ARB (2010), "Updated Economic Analysis of California's Climate Change Scoping Plan," Staff Report to the Air Resources Board, March 24; Charles River Associates (2010), "Analysis of the California ARB's Scoping Plan and Related Policy Insights," March 24; Roland-Holst, David (2010), "Climate Action for Sustained Growth, Analysis of ARB's Scoping Plan," April 21.

[35] California Council on Science and Technology (CCST) (2011), "California's Energy Future – the View to 2050, Summary Report," May; Wei, Max et al. (2012), "California's Carbon Challenge: Scenarios for Achieving 80% Emissions Reduction in 2050," Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, October 31; Jacobson, Mark et al. (2013), "Evaluating the Technical and Economic Feasibility of Repowering California for all Purposes with Wind, Water and Sunlight," May 22.

renewable energy sources backed up by gas-fired power plants with carbon capture and sequestration and electricity storage.[36]

ARB's focus on these technological futures for 2050 raises several very important issues for policy design. First, while ARB relies on these studies as it seeks to demonstrate the technological feasibility of achieving the 2050 target, there is, in fact, significant uncertainty about whether such targets are technically feasible, let alone economically sensible.[37] Thus, going forward, policies that can maintain flexibility to adjust to new information about the costs (and benefits) of emission reductions can more effectively balance those benefits and costs of climate policy. Second, even if one assumes technical feasibility, there is significant uncertainty about which set of technologies will achieve these types of deep reductions in GHG emissions in the most cost-effective fashion. Thus, policies that provide uniform incentives across activities that create GHG emissions can achieve targets most cost-effectively, rather than establishing fuel, technology, or sector-specific policies that result in wide differences in incremental (marginal) emission reduction costs. In light of the likely high costs of achieving the vast changes in infrastructure and system changes proposed in these analyses, the potential cost savings from achieving these targets through the most cost-effective actions (and policy instruments) could be tremendous.

Policies aimed at achieving emission reductions beyond 2020 would presumably build off efforts in the AB 32 Scoping Plan undertaken to bring emission to 1990 levels by 2020. Evaluation of these efforts is necessary in order to improve on the performance of the initial suite of policies. Such evaluation could point to whether existing policies should be modified or eliminated, and whether new policies should be developed. The Scoping Plan Update (SPU) indicates that the Air Resources Board (ARB) is in the process of developing approaches for performing such assessments. This information will also be valuable input for the economic analysis of post-2020 emission targets that ARB indicates will be performed.[38]

With this in mind, we provide brief assessments of three AB 32 Scoping Plan policies: the GHG cap-and-trade system, the Low Carbon Fuel Standard (LCFS), and the Renewable Portfolio Standard (RPS). This review is necessarily preliminary, because many of the AB 32 Scoping Plan policies have only recently been implemented or are still under development. It is also not comprehensive, but rather aims to make key points and raise important questions that need to be addressed in the coming years as California determines how it will proceed on climate policy. We hope these points and questions will help inform more comprehensive assessments of current and possible future climate policy efforts.

[36] Scoping Plan Update," p. ES-4.

[37] For example, the CCST study concludes that reductions below 60 percent of 1990 GHG levels would require "significant innovation and advancements in multiple technologies that eliminate emissions from fuels." Even achieving reductions to 60 percent below 1990 emissions would require carbon capture and sequestration technology for existing dispatchable electricity generators, which, while technically feasible, has not yet sufficiently met many technical and regulatory hurdles needed to be relied on within the market CCST (2011), p. 3-4.

[38] Scoping Plan Update", p. 104.

We consider three key issues: policy costs; environmental effectiveness; and innovation. With respect to costs, we provide empirical estimates where available (the GHG cap-and-trade system and the LCFS), and discuss issues related to developing reliable cost estimates where such estimates are not available (the RPS). In this paper, we do not consider other potential economic rationales for complementary policies. In particular, complementary policies that mitigate market failures unrelated to the impact of GHG emissions or complimentary policies that target emissions that are not covered by the cap of the cap-and-trade system can increase economic efficiency. For example, energy efficiency can address market failures that prevent households and businesses from undertaking all cost-effective investments to reduce energy use.[39] Such failures include the so-called "principal-agent" problems that affect landlord and tenant incentives to invest in energy efficiency.

With respect to environmental performance, we identify ways in which environmental performance can be thwarted, including leakage and "reshuffling," and discuss the critical importance of focusing on such performance as California moves beyond 2020. Addressing these issues requires careful attention to policy interactions, which are potentially problematic when two conditions occur: first, a state policy creates more stringent requirements that overlap with a "broader" state or federal policy ("overlap criteria"); and, second, the broader federal or state policy provides flexibility to meet requirements through adjustments across sectors or states ("flexible policy criteria"). These flexible policies can include quantity-based policies (such as, cap-and-trade) and policies that average performance (such as, renewable portfolio standards or renewable fuel standards.) Such policy interactions are highly relevant for certain AB 32 Scoping Plan elements.

We also consider induced innovation in low-GHG technologies, which all policy observers, including ARB, recognize as necessary to achieving long-term climate goals. Policies differ greatly in their effectiveness in inducing innovation. If California is contemplating further unilateral efforts, it is important to consider potential tradeoffs between innovation of new technologies, which may lower costs for California and for other jurisdictions in the long run, and diffusion of existing technologies, which may be less costly in the short-run for California, but do not bring down costs over time nor reduce costs for other jurisdictions.

A. GHG Cap-and-Trade

Under a cap-and-trade program, allowance prices directly reflect the marginal costs of emission reductions.[40] Consequently, the marginal cost of abatement under California's GHG cap-and-trade

[39] Jaffe, Adam and Robert N. Stavins (1994), "The Energy Paradox and the Diffusion of Conservation Technology," *Resource and Energy Economics* 16: 91-122; Jaffe, Adam, Richard Newell and Robert N. Stavins, "The Economics of Energy Efficiency", in *Encyclopedia of Energy*, ed. C. Cleveland, Amsterdam: Elsevier, pp. 79-90; Gillingham, Kenneth, Richard Newell and Karen Palmer (2009), "Energy Efficiency Economics and Policy," *Annual Review of Resource Economics* 1:597-620, June.

[40] If allowances prices were lower than marginal abatement costs, market participants would increase their demand for allowances, thus bidding up the price for allowances until it reflected marginal abatement costs. Likewise, if allowance prices were above marginal abatement costs, market participants would sell allowances and undertake abatement instead until the allowance price reflected marginal abatement costs.

system can be directly inferred from the level of allowance prices.[41] Moreover, because the GHG cap-and-trade system allows unlimited banking, this price also generally reflects future marginal costs of the program.[42] Hence, absent exogenous factors, allowance prices and marginal costs are expected to remain constant in real terms, after allowing for a risk-adjusted rate of return for holding allowances. Stated differently, it is expected that real allowance prices will increase over time at the risk-adjusted rate of interest.

At present, allowance prices under California's GHG trading program are near the auction price floor, currently set at \$10.71 per $MTCO_2e$. In the most recent ARB auction, current allowances cleared the market at \$11.48 per $MTCO_2e$, while 2016 vintage allowances cleared the market at \$11.10 per $MTCO_2e$. Allowance prices reflect the *marginal* cost, not the *average* cost, of emission reductions achieved by cap-and-trade. That is, allowance prices indicate the cost of the most costly actions taken to comply with the LCFS requirements, whereas average costs reflect the cost across all actions taken. From an economic standpoint, marginal costs provide the best means for making comparisons across policies.

These results may appear to suggest that the marginal cost of emission reductions undertaken to comply with the emissions cap are fairly low. But this cost does not reflect the cost of all emission reductions undertaken to achieve the AB 32 emission cap, because there are many "complementary policies" in place which may require emission reductions that are more costly than those undertaken comply with the emissions cap. As we discuss below, this is likely the case for both the LCFS and RPS. From the standpoint of the cap-and-trade program, these "above market" emission reductions can depress the price of cap-and-trade allowances (by suppressing allowance demand) if they displace emission reductions that would otherwise occur as a consequence of higher allowance prices. This can be illustrated by a simple example. Consider a regulation that immediately banned the use of fossil fuels for electric power generation (that is, a 100% RPS). While this policy would certainly impose significant costs, it would eliminate the need for other emission sources regulated by cap-and-trade to take any action to comply with the cap, which would drive allowance prices down to their minimum level (that is, the price floor).

The environmental performance of the GHG cap-and trade program will depend on the effectiveness of provisions designed to reduce emission leakage. ARB has taken two primary approaches to address leakage. The first approach provides free allowance allocations to industrial emission sources through an "updating, output based mechanism," whereby allowances are allocated based upon product output in a prior time period. Such allocations are designed to neutralize the competitive disadvantage created by the cap-and-trade compliance obligation, and thus mitigate leakage risk by reducing the incentive to shift economic activity from California to business outside the State. The second approach

[41] Average costs of emission reductions would be lower because, with increasing marginal abatement costs, many emission reductions would be less costly than actions taken on the margin to reduce emissions.

[42] Because market participants can arbitrage the value of allowances over time (that is, buy and hold allowances for use or sale in future periods), the price of allowances is expected to rise at the risk adjusted rate of return over time. For programs facing significant regulatory risk (that is, the risk that compliance requirements change over time), such risk may significantly increase required returns to holding allowances.

consists of a set of provisions designed to address the risk of "contract shuffling" in the electric power sector. Under contract shuffling, actual power generation outside of California remains unchanged, but existing contracts for more carbon-intensive power imports are substituted with contracts for less-carbon intensive imports. Provisions to address contract reshuffling require monitoring of import power transactions to identify contract activity that is designed to avoid allowance costs. There is uncertainty about how effective these provisions will be at limiting reshuffling.

The effects of any climate policy on technological innovation are key to bringing down long-term costs for California and other jurisdictions, but identifying technological innovation that may have occurred as a consequence of the GHG cap-and-trade program is exceptionally challenging. Because GHG cap-and-trade provides diffuse incentives for innovation that affect all aspects of economic activity, correlating particular measures of innovation to cap-and-trade outcomes (and establishing causation) will be very difficult. Moreover, given low current allowance prices combined with the limited scope of California's market (that is, covers only activity in California), such innovation may be severely limited.

B. Low Carbon Fuel Standard

At present, transportation fuels in California are regulated by two programs: California's Low Carbon Fuel Standard (LCFS) and the federal Renewable Fuel Standard (RFS). The LCFS was undertaken as part of the AB 32 Scoping Plan largely with the aim of reducing GHG emissions. Policy rationales unrelated to climate change have been offered for the RFS, including energy security and support of rural economies.

The LCFS requires reductions of at least 10 percent in the carbon intensity of California's transportation fuels by 2020 relative to the traditional petroleum-based fuels. The current rule maintains the regulatory requirement after 2020, although the average carbon intensity benchmark remains fixed at the 2020 level. The LCFS achieves this goal by imposing increasingly stringent standards for aggregate carbon intensity (CI) of transportation fuels sold in the State. Compliance with the standard reflects the average CI of all fuel sold. Each supplier must comply with the annual standard, but suppliers whose average CI exceeds the standard can purchase credits from suppliers that have over-complied. The LCFS incorporates advanced transportation technologies, such as compressed natural gas, electric vehicles, and hydrogen vehicles, as well as fuels used in traditional combustion engines, such as gasoline, ethanol, and biodiesel.

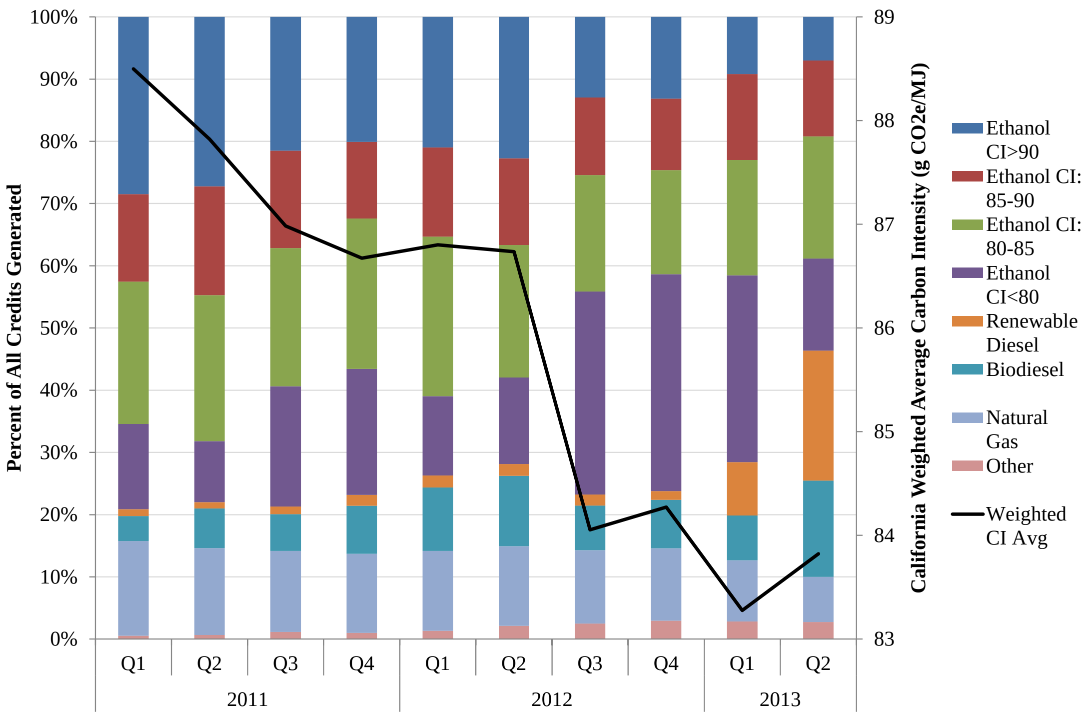
The federal RFS specifies quantities of renewable fuel that must be used each year, with separate targets for non-corn-based biofuels, cellulosic ethanol, and biodiesel.[43] These fixed quantities are translated into renewable fuel percentage requirements that each supplier must meet. As with the LCFS, the RFS allows trading of renewable fuel obligations ("RINs") among suppliers to help lessen the

[43] The Renewable Fuel Standard was originally legislated under the Energy Policy Act (EPAct) of 2005. This program was expanded to the current program under the Energy Independence and Security Act (EISA) of 2007.

program's aggregate cost.[44] At present, fuel suppliers in California must comply with both the LCFS and the RFS. However, fuel substitution (for example, increased use of ethanol in place of gasoline) can be used to comply with both programs.

The LCFS creates more efficient incentives for GHG reductions than the RFS, which does not account for the carbon intensity of renewable biofuels used to achieve RFS targets. The LCFS has led to a shift in the carbon intensity of non-traditional fuels used in the State. This effect is illustrated in Figure 1, which shows the mix of biofuels (and other fuel types) used to comply with the LCFS over time. The average carbon intensity of biofuels (and other non-petroleum fuel types) used in California has gradually fallen, from 88.5 to 83.82 gCO2e per MJ from 2011: Q1 to 2013:Q2.

Figure 1: Mix of Fuels Used to Comply with the LCFS and Average Carbon Intensity of Renewable Fuels Used to Comply with the LCFS



Sources: [1] California Air Resources Board,"media_request_093013.xls," <http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm>

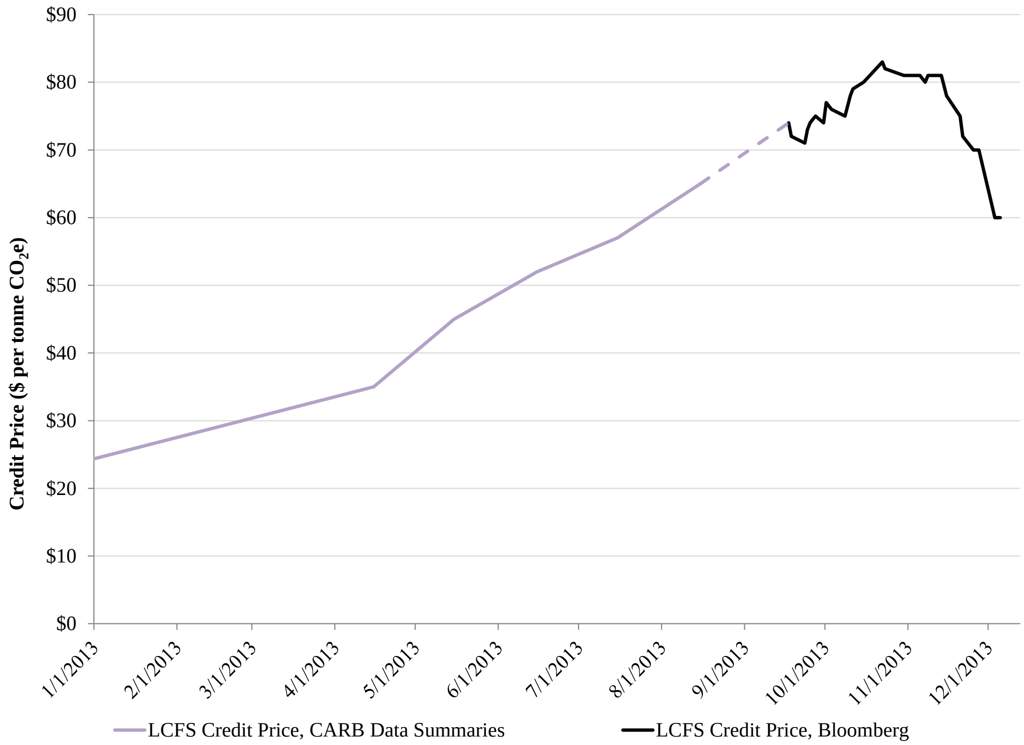
However, emission reductions achieved through the fuel substitutions illustrated in Figure 1 come at an economic cost. Credits for the LCFS are traded commodities with market prices that, in principle, reflect the marginal costs of fuel substitutions that suppliers could make instead of purchasing credits.[45]

[44] Fuel producers receive RFS credits, referred to as Renewable Identification Numbers, or RINS, for renewable fuels generated for compliance with the RFS.

[45] Because banking provisions differ between the two regulations, the information on marginal costs provided by credit prices differs between the LCFS and RFS. Under the RFS, banking is limited – only 20 percent of annual

LCFS credit prices are expressed as the price per ton of CO_2 equivalent (tCO_2e). As shown in Figure 2, the price of LCFS credits, which was below \$20 per tCO_2e in 2012, had grown to about \$80 per tCO_2e by November 2013 before declining to about \$60 per tCO_2e more recently. Thus, these (marginal) costs are well above the (marginal) cost of emission reductions achieved under the GHG cap-and-trade system, indicating that the LCFS is likely displacing less costly emission reductions that would otherwise occur from cap-and-trade were the LCFS not in effect.

Figure 2: LCFS Credit Prices



<u>Sources:</u> [1] California Air Resources Board, LCFS Reporting Tool Quarterly Data Summaries; [2] Bloomberg, L.P.

Several aspects of these cost estimates require fuller explanation. First, LCFS credit prices reflect the *marginal* cost, not the *average* cost, of emission reductions. Thus, LCFS credit prices provide a metric for comparing the cost of actions being taken to comply with the LCFS, as compared with other policies, such as the cap-and-trade program.

Second, these estimates, in a sense, reflect the long-run cost of emission reductions over the entire program period. Because the LCFS allows unlimited banking, future costs are likely to reflect current prices and costs (in real terms). Thus, in principle, future costs should reflect current credit prices, with

compliance can be met through allowances from the prior year. Consequently, RIN prices will tend to reflect the short-run cost of renewable fuel substitutions. By contrast, the LCFS allows unlimited banking. Thus, LCFS credit prices reflect (expected) long-run marginal costs, which will be equalized across years in real terms (at the appropriate risk-adjusted cost of capital).

an allowance for a (risk-adjusted) return on capital. In fact, there has been significant banking of LCFS credits in the program's early years, which was a consequence of an intentional decision in the design of the trajectory of annual average carbon intensity requirements.[46] However, a consequence of the large increase in the stringency of CI targets through 2020 is that actions needed to comply with the current targets provide little information about actions needed to comply with the CI target in 2020, when the program is at its most stringent. Thus, in practice, there is significant uncertainty about future actions, and therefore the costs of complying with the program.

Third, LCFS credit prices reflect the cost of complying with the LCFS requirement, but do not account for interactions with RFS compliance. Accounting for the full cost of actions taken to comply with both LCFS and RFS requirements would require accounting for many complexities due to interactions between the two policies. For example, RFS requirements could actually lower the apparent cost of LCFS compliance by creating surplus RINs that could be sold to suppliers outside of California. Further research should aim to better understand the underlying cost of reductions achieved by fuel substitution in compliance with the LCFS and RFS.

The cost of LCFS emission reductions represented in Figure 2 reflect emission reductions from the direct substitution of one fuel for another, but does not account for interactions between policies. However, interaction between the LCFS and California's GHG cap-and-trade program, which both regulate emissions from industrial facilities used in upstream processing (refining and biofuel production), are likely to reduce significantly the quantity of emission reductions achieved by the LCFS.[47] Assuming that the GHG cap-and-trade system is binding, any emission reductions created by reducing the refining of traditional gasoline in California will be offset by increases in emissions from other sources (sectors) covered by the cap. That is, the LCFS may shift emissions from traditional refineries to other sources covered by the cap, but aggregate emissions of sources covered by the cap will remain *unchanged*. Due to these interactions, the actual impact of the LCFS on GHG emissions depends, in part, on the extent to which production is shifted from California refineries, which are covered by the cap-and-trade system, to biofuel producers, some of which may not be in California.[48] If production shifts from California refineries to out-of-state biofuel producers, the LCFS could actually *increase* net emissions, rather than decrease emissions.[49] Our previous analysis of compliance scenarios found that leakage rates

[46] LCFS Advisory Panel, "Low Carbon Fuel Standard 2011 Program Review Report," December 8, 2011, p. 15; ICF International, "California's Low Carbon Fuel Standard: Compliance Outlook for 2020," June 2013, p. 2.

[47] For a more complete description of these interactions, *see*: Schatzki, Todd and Robert N. Stavins, "Implications of Policy Interactions for California's Climate Policy," August 2012.

[48] We presume that process emissions from biofuel producers in California would be regulated under cap-and-trade, although it is possible that smaller producers would not be regulated.

[49] Another factor is that biofuels are exempt from the cap-and-trade system. This decision likely reflects the partial offset of biofuel combustion emissions by the sequestration of carbon from crop growth.

could range from 51 percent to 167 percent.[50] Analysis of leakage given how suppliers have actually complied would provide valuable information for California as it considers the future of the regulation.

In terms of innovation, it is unclear whether either the LCFS (or RFS) have had much success, partly because both programs have been in effect for limited periods of time. First, both policies have aimed to induce biofuel innovation through two different mechanisms. The RFS established explicit targets for "advanced biofuels," with nested targets within this category for cellulosic ethanol and biodiesel. Since the start of the program, the annual target for cellulosic ethanol has been revised downward substantially in each year to account for the limited production of fuels that meet the relevant standard. For example, for 2013, the EPA has required the use of 6 million gallons of cellulosic biofuels, as compared with the legislative target of 1.0 billion gallons.[51] In fact, the required quantity for 2013 was 31% below the 8.65 million gallons required for 2012.[52] Thus, the targeted RFS mandates for cellulosic ethanol has to date had limited success in stimulating market-scale production, and new production facilities currently in development appear both highly uncertain and unable to provide capacity to meet the original targets.[53]

The advanced biofuels target has been met largely through supplies of biodiesel and non-corn ethanol. Production technology for biodiesel is relatively mature, although the LCFS and RFS fuels programs have improved economic competitiveness of biodiesel production.[54] Renewable diesel is a newer technology that been used in increasing quantities in California recently.[55]

Second, compliance with the LCFS to date has relied primarily on use of low-carbon-intensity ethanol, and there is no evidence that this is the result of more innovative production processes, as opposed to the use of more costly processes to lower carbon intensity with existing technology.[56]

[50] The leakage rate reflects the percent of direct emission reductions achieved by the LCFS that are offset by increased emissions from other sources not regulated by the LCFS. A leakage rate of 100 percent implies that the LCFS has no impact on GHG emissions. Schatzki, Todd and Robert N. Stavins (2012), "Implications of Policy Interactions for California's Climate Policy," August.

[51] U.S. EPA, Regulatory Announcement (2013), "EPA Finalizes 2013 Renewable Fuel Standard," Regulatory Announcement, EPA-420-F-13-042, August.

[52] U.S. EPA (2011), "EPA Finalizes 2012 Renewable Fuel Standard," Regulatory Announcement, EPA-420-F-11-044, December.

[53] U.S. Energy Information Administration (EIA) (2012), "Biofuel Issues and Trends," October; EIA (2013), "Cellulosic biofuels begin to flow but in lower volumes than foreseen by statutory targets," Today in Energy, February 26.

[54] ICF (2013), "California's Low Carbon Fuel Standard: Compliance Outlook for 2020," prepared for the California Electric Transportation Coalition, June; EIA (2012), "Biofuel Issues and Trends," October.

[55] California Air Resources Board,"media_request_093013.xls," <http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm>

[56] For example, ethanol carbon intensity can be reduced if distillers grains (a bi-product of ethanol production) are sold wet rather than dried with natural gas. This approach reduces carbon intensity, which makes it more valuable for compliance with the LCFS, but does not represent a "new" technology. EIA (2012), "Biofuel Issues and Trends," October p. 20.

Compliance has also been achieved through increased use of sugar cane ethanol produced in Brazil, although the Brazilian sugar cane industry is well-established, having produced significant quantities of fuel for decades. Moreover, because of "fuel shuffling," increased sugar cane ethanol used in California may simply reflect the reshuffling of biofuels in the United States (with lower-CI fuels being used in California, and higher-CI fuels being used in other parts of the country) that does not lead to a net aggregate increase in demand for sugar cane ethanol in the United States.

C. Renewable Portfolio Standard[57]

A Renewable Portfolio Standard (RPS) establishes annual regulatory requirements for the portion of electric energy that must be supplied from designated types of renewable sources. In California, an RPS was first established in 2002, with the legislature mandating that 20 percent of total electricity use be provided by renewable energy production by 2017.[58] These requirements have been modified over time, with the current rule mandating that 33 percent of electricity be supplied by renewable sources by the year 2020.[59] These requirements are now imposed on all retail suppliers of electric power, including the State's three major independently owned utilities (IOU's) (Pacific Gas & Electric, San Diego Gas & Electric, and Southern California Edison), municipally operated systems,[60] community choice aggregators, and retail providers. The State also has many other renewable programs that affect the mix of total resources developed, including the California Solar Initiative (CSI), Net Metering rules, and various renewable procurement mechanisms.

The RPS includes several provisions aimed at containing costs. First, compliance can be met through purchase of renewable power or Renewable Energy Credits (RECs) generated by resources outside the state of California, although use of RECs is constrained.[61] Second, the California Public Utilities Commission (CPUC) implements mechanisms to limit high procurement costs. At present, the CPUC is charged with establishing new limits (or mechanisms) for procurement expenditures, although earlier implementation included a more explicit mechanism based on a market benchmark.[62]

Determining the cost of achieving the State's renewable portfolio standards (and other renewable policies) is complicated due to a number of factors, particularly the complex market and system interactions within the power grid between loads and resources that supply electricity and other services

[57] The Renewable Portfolio Standard is but one of the many programs and policies in California creating incentives for the adoption of renewable resources. Other programs include the California Solar Initiative and other renewable procurement programs operated by California's regulated utilities.

[58] California Senate Bill 1078 (2002).

[59] California Senate Bill 2 (2011) ("SB2").

[60] These include the Los Angeles Department of Water and Power and Sacramento Municipal Utility District.

[61] SB2 created a somewhat complex system of limits that reflect three categories of renewable power supply. RECs are in the most limited category, and can be used to meet at most 10 percent of the 2020 compliance requirements.

[62] Prior to changes made in SB2, IOUs were not obligated to purchase renewable power to meet RPS requirements if the cost of contracts for such power exceeded a market benchmark, referred to as a "Market Price Referent."

and loads, and regulations designed to ensure reliable grid operation and delivery of electricity. Fully accounting for all of the impacts of an RPS creates challenges due to the complexity of these factors:

1. *Production cost impacts*. The value of renewable power reflects changes in production costs, which depend, in part, on the time of day renewable electricity is produced. Power produced during peak periods provides greater value, because it displaces higher cost electricity, while power during off-peak periods provides lesser (and even negative) value.[63] Many analyses that calculate the cost per MWh (so-called "levelized costs") fail to account for the differences in the value of power provided by different resources.[64] Variation in output from certain types of renewables due to weather conditions and other factors ("intermittency") can result in "integration" costs that reduce the level of production costs savings;[65]

2. *Capacity cost impacts*. While renewable resources typically produce power at a low cost relative to dispatchable, natural gas-fired resources, the cost of constructing generation resources (for example, wind turbines or photovoltaic cells) is typically higher;

3. *Transmission cost*. For many renewable resources, particularly wind power and utility-scale solar power, locations providing the highest quality resource conditions are distant from customer loads. Consequently, delivering power to customers requires the construction of additional power transmission infrastructure;

4. *System Requirements and Reliability Impacts*: Because many renewable resources (for example, wind and solar) deliver power intermittently, they can have implications for the quantity of resources required to maintain reliable electric system operations. These resources include reserves maintained in the event of unexpected system contingencies and resources needed to ensure that customer loads can be met reliably at all times. While system operators have improved their ability to mitigate intermittency risks (for example, through improved forecasting), risks remain, and could grow with greater reliance on intermittent renewables.[66]

[63] Borenstein, Severin (2008), "The Market Value and Cost of Solar Photovoltaics Electricity Production," Center for the Study of Energy Markets, CSEM WP 176, January; Fripp, Matthias and Ryan Wiser (2008), "Effects of Temporal Wind Patterns on the Value of Wind-Generator Electricity in California and the Northwest," IEEE Transactions on Power Systems, June; Gowrisankaran, Gautam, Stanley Reynolds and Mario Samano (2011), "Intermittency and the Value of Renewable Energy," NBER Working Paper No. 17086, May; Schmalensee, Richard (2013), "The Performance of U.S. Wind and Solar Generating Units," NBER Working Paper No. 19509, October.

[64] Joskow, Paul L. (2011), "Comparing the Costs of Intermittent and Dispatchable Generating Technologies," *American Economic Review* 100(3):238-241.

[65] An assessment of existing empirical studies found that integration costs typically do not exceed $12 per MWh, and are often below $5 per MWh. Increased use of renewables can also increase balancing reserve requirements (need to ensure a continuous balance between supply and demand), with impacts ranging from less than 5 percent to nearly 30 percent. Wiser, Ryan and Mark Bolinger (2013), "2012 Wind Technologies Market Report," U.S. Department of Energy, August.

[66] California ISO (2013), "What the duck curve tells us about managing a green grid"; California ISO (2012), "Renewables Integration Study Update," February 10. Another analysis, using the same underlying model, found costs of $88 per $MTCO_2e$, reflecting a scenario with a 33% RPS and high goals for energy efficiency. Energy and

While additional non-intermittent resources can mitigate these risks, it remains to be seen whether residual risk will persist, or whether the cost of maintaining the same level of reliability will require tradeoffs between cost and reliability;

5. *Subsidies*. When accounting for the economic costs of alternative resources, it is important not to include revenues received through government subsidies, such as the federal Production Tax Credit and Investment Tax Credit for certain types of renewables.

In its Scoping Plan, ARB estimated that the 33% RPS would reduce GHG emissions at a cost of \$84 per $MTCO_2e$.[67] This estimate does not account for policy interactions which, as we discuss below, reduce the emission reductions achieved by the RPS. The estimate has not been updated in nearly five years, despite multiple market and system changes that would affect costs. These same factors would also affect costs of RPS modifications aimed at further increasing renewable penetration beyond 2020.

On the one hand, the cost and efficiency of renewable technologies could improve in future years. In recent years, changes in construction and development costs have varied significantly across technologies. Figure 3, which illustrates trends in solar photovoltaic (PV) module installation costs in California, shows that the total cost of new PV installations have fallen by 47 to 50 percent from 2002 to 2012.[68] The declines in total installation costs reflect reductions in both module costs, driven by technology advances, economies of scale and, more recently, excess production capacity, and non-module costs, potentially reflecting greater competition and efficiency in the solar installation industry. Despite the significant declines in installation costs, solar photovoltaics remain higher cost than gas-fired power generation.[69] Thus, the resulting cost of GHG emission reductions going forward remains uncertain. In comparison with other states, installed prices for solar PV systems in California have tended to be high.

Environmental Economics (2008), "Electricity & Natural Gas GHG Modeling, Revised Results and Sensitivities," May 13.

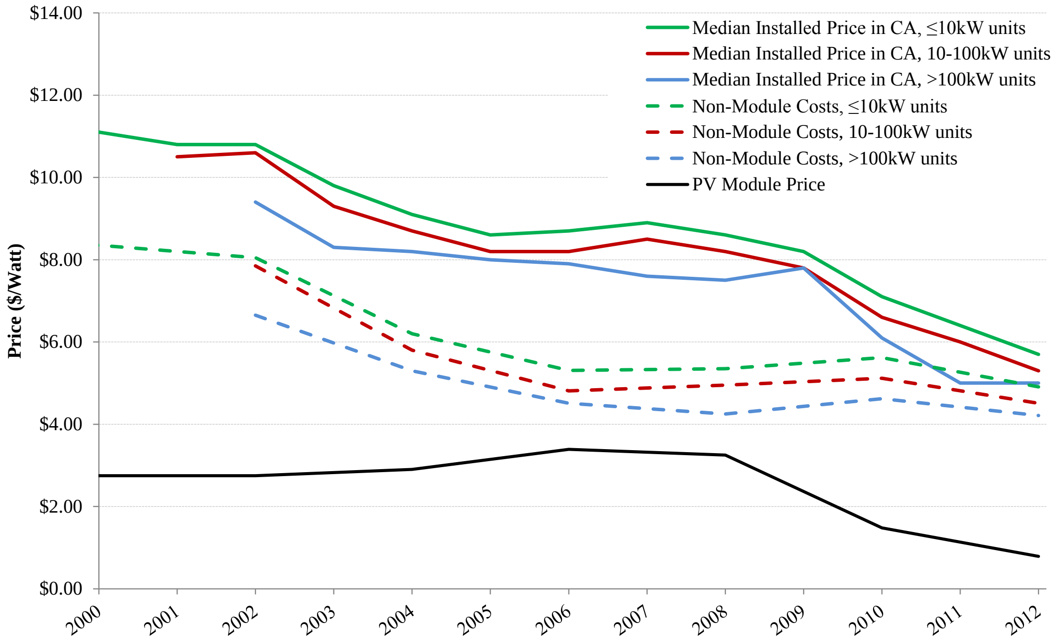
[67] ARB (2008), "Climate Change Scoping Plan Appendices," Volume II: Analysis and Documentation, December, Appendix I-29-30.

[68] Figure 3 reflects the costs of roof-top solar PV through California Solar Initiative, which does not contribute to meeting the 33% RPS requirement.

[69] For example, the prices for renewables procured by utilities under PPAs remains above estimates of the price of power procured from gas-fired generation, as reflected in the CPUC's Market Price Referent (MPR). For example, in 2012, the MPR ranged from \$0.0629 per kWh for a 5-year contract to \$0.09274 for a 25-year contract. (These prices assume a contract with a fixed price in nominal terms for the duration of the contract, and assume carbon compliance costs of \$16.27 per $MTCO_2e$ in 2013, \$26.08 per $MTCO_2e$ in 2015, and \$36.64 per $MTCO_2e$.) California Public Utilities Commission (CPUC) (2011), Resolution E-4442, December 1. By comparison, prices for new contracts made during 2012 were, on average, \$0.098 per kWh for solar PV, \$0.0956 per kWh for wind, and \$0.821 per kWh for geothermal. Direct comparison of PPA prices does not reflect all cost elements identified above, but does reflect federal production tax subsidies for certain technologies. CPUC (2013), "The Padilla Report to the Legislature, The Cost of Renewables in Compliance with Senate Bill 836 (Padilla, 2011), March. Recent announcements of PPA prices suggest that prices could decline below announced average prices from recent procurements. For example, the City of Palo Alto recently entered into a PPA for solar power at a price of \$0.069 per kWh. City of Palo Alto (2013), "Council Approves Major Renewables Solar Electric Purchase Agreements," press release, June 18.

A recent study found that California had the fourth highest prices of 21 states for small systems (less than 10 kW), the third highest prices of 19 states for medium systems (10 to 100 kW), and the second highest prices of eight states for large systems (greater than 100 kW).[70]

Figure 3. Solar Photovoltaic Costs



Sources: [1] Barbose, Galen et. al, "Tracking the Sun VI: A Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012," July 2013; [2] Mints, Paula, "Solar PV Profit's Last Stand," March 20, 2013, <http://www.renewableenergyworld.com/rea/news/article/2013/03/solar-pv-profits-last-stand>.

Deployment of solar PV has been encouraged through the California Solar Initiative and other programs, in addition to the RPS. Because solar deployed through certain programs, such as the California Solar Initiative, do not contribute to compliance with the RPS, they do not directly affect its cost-effectiveness. However, by providing economic support for particular technologies (for example, solar PV under the CSI) or technologies meeting particular characteristics (for example, “distributed resources” under the Renewable Auction Mechanism), the suite of policies supporting renewable technologies can have important consequences for the *mix* of renewables used within California, and the overall cost-effectiveness of compliance with AB 32 targets and any post-2020 targets. These policies should be included in the assessments performed to inform post-2020 climate policy, even if these policies are outside the scope of policies formally implemented by ARB in compliance with AB 32.

The cost of other renewables technologies, such as wind and geothermal power, have not dropped significantly as solar PV in recent years, suggesting that further reductions as a result of technological

[70] Barbose, Galen, et al. (2013), “Tracking the Sun VI, An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012,” Environmental and Energy Technologies Division, Lawrence Berkeley National Laboratory, July.

innovations may be less likely. Figure 4 shows that while costs of constructing wind turbines (the Blue line) fell through 2004 with improvements in technology (after pre-2000 costs above $3,000 per kW), costs have not fallen (and even increased) in subsequent periods. Many factors have affected these costs trends, including: materials (for example, steel and other metals), energy and labor costs; exchange rates; manufacturer and developer profitability (reflecting cycles in market supply and demand conditions), and changes in turbine size.[71] The price paid in purchase power agreements (PPAs) for power delivered from wind resources has followed this trend, reflecting additional factors improving resource economics (such as improved turbine efficiency) and worsening resource economics (such as siting in less productive locations). Some analyses suggest that the levelized cost of wind turbines (reflecting private rather than full social costs) has begun to decline again and has already fallen below historic lows reflected in Figure 4, although any such declines do not appear yet to have lowered PPA prices.[72] While these studies also forecast future reductions in levelized wind power costs, in practice, accounting for the net effect of these many factors into the future faces many uncertainties.[73]

Figure 4 also demonstrates that the price paid for wind power delivered to Western states, including California, has exceeded prices in other parts of the country by a significant degree. Prices paid by California IOU's have typically been higher than the Western prices shown in Figure 6.[74] The largest contributing factor to these differences is location – more favorable resource conditions in other parts of the country, particularly the central Plains states, provide higher output (capacity factors), which in turn lowers levelized costs. However, other factors, such as labor rates and suitability of siting turbines, can also vary. Some have suggested that the more aggressive renewables policies in states such as California may put developers in a stronger bargaining position, thus raising PPA prices.[75]

[71] Wiser, Ryan and Mark Bolinger (2013), "2012 Wind Technologies Market Report," U.S. Department of Energy, August.

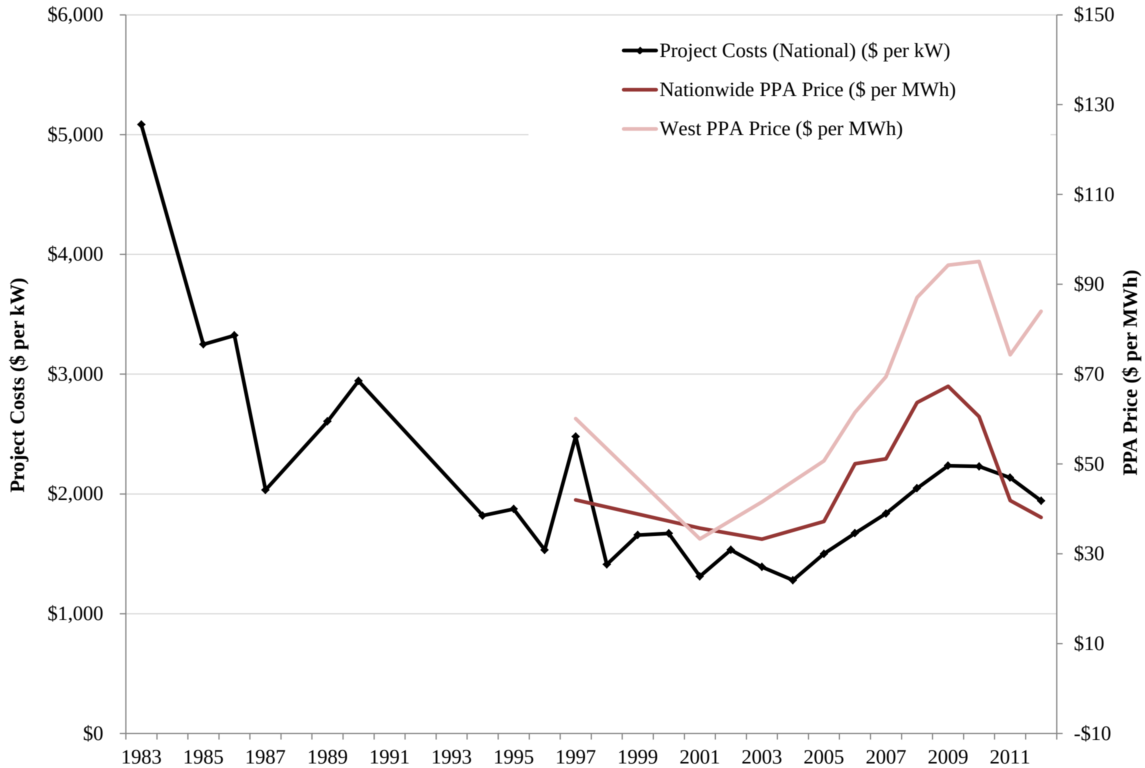
[72] These reductions result from improvements in turbine efficiency sufficient to offset cost increases and siting in less productive locations. Wiser, Ryan et al. (2012), "Recent Developments in Levelized Cost of Energy from U.S. Wind Power Projects," prepared for the U.S. Department of Energy, February.

[73] Lantz, Eric at al., (2012), "The Past and Future Cost of Wind Energy," IEA Wind Task 26, National Renewable Energy Laboratory, Technical Report, NREL/TP-6A20-53510, May.

[74] California Public Utilities Commission, "The Padilla Report to the Legislature, The Costs of Renewables in Compliance with Senate Bill 836 (Padilla, 2011)," March 2013. Methods used to calculate prices reported in this CPUC report may differ from those used by Wiser and Bolinger (2013).

[75] Wiser, Ryan and Mark Bolinger, "2012 Wind Technologies Market Report," U.S. Department of Energy, August 2013, fn 50. In many years, the average prices for new wind PPAs have exceeded $10 per MWh for each of California's three major IOUs.

Figure 4. Wind Power Project Costs ($ per kW) and Purchase Power Agreement Prices ($ per MWh)



<u>Notes:</u> [1] Project Costs reflects the total installed costs reported by wind power projects in the U.S., including turbine purchase and installation, balance of plant and any substation and/or interconnection expenses; [2] Prices reflect the prices paid for power delivered from wind power under purchase power agreements. The terms and conditions of these agreements may not be uniform across projects or over time.
<u>Sources:</u> [1] Wiser, Ryan and Mark Bolinger, "2012 Wind Technologies Market Report," U.S. Department of Energy, August 2013.

There are also many factors that would tend to increase costs. With respect to production costs, several factors would tend to reduce savings created by renewable resources. First, natural gas prices have fallen significantly since 2008, when the prior analyses were performed. With lower fuel costs, the production cost savings from displaced natural gas-fired generation will be diminished. Second, the production cost savings achieved by incremental renewable supplies will tend to decline as the share of renewables in the market increases. This occurs because of increasing marginal costs of production – initial renewable supplies tend to displace the most costly resources, while additional (marginal) resources will displace increasingly less costly resources. Thus, the incremental production cost savings from further renewables will tend to diminish over time under more stringent RPS requirements. Analyses indicate that the magnitude of this effect could be significant.[76] For example, based on two studies of the

[76] Table 2 in Hirth (2013) summarizes estimates of the value factor, reflecting the average price earned by renewable output relative to the average price over all hours. Hirth, Lion (2013), "The market value of variable renewables: The effect of solar wind power variability on the relative price," *Energy Economics* 38: 218-316, July.

California electricity market, an increase in renewable use from 20 percent to 33 percent would result in roughly a 9 percent reduction in the value of wind power, and a 41 percent reduction in the value of solar power.[77]

Increased reliance on renewable power is also likely to have increasingly significant impacts on efforts required of system operators to maintain reliability. In particular, concerns have been raised about potentially significant integration challenges by 2020 under the 33% RPS.[78] These challenges are driven, in part, by the timing of output from solar power, which, at higher penetration levels, leads to large differentials between minimum net loads during mid-day and peak net loads during morning and evening. The resulting swings in demand for dispatchable power can be significant – for example, forecasts indicate that, at certain times of the year, demand for power from dispatchable resources could nearly double within a one hour period.[79] Such large and rapid shifts in demand for output create challenges for maintaining reliability with dispatchable resources under system operator's control.[80] To address these reliability concerns, California's grid operator – the California Independent System Operator (CAISO) – is undertaking a stakeholder process aimed at developing a regulatory mechanism to assure adequate supply of "flexible" resources able to quickly ramp up and down output to meet large swings in net load.[81]

Given changes in technology, electricity markets and renewable integration, an update to the economic assessment of the RPS can provide current estimates of emission reduction costs and valuable information for the most effective direction for policy going forward. Moreover, analyses to date have only considered the 33% RPS targets, not the higher levels of renewable penetration considered by ARB to achieve a near-zero emission electric power supply.

In terms of innovation, it is difficult to identify a clear impact from the RPS. While the cost of certain renewable technologies has declined significantly, as shown by the decrease in solar photovoltaic prices in Figure 5, the effect of demand from California in inducing such change is unclear. Not only is it difficult to distinguish price-induced (endogenous) from non-price-induced (exogenous) change, but

[77] Lamont, Alan, (2008), "Assessing the Long-Term System Value of Intermittent Electric Generation Technologies," *Energy Economics* 30(3): 1208-1231; Mills, Andrew D. and Ryan Wiser, "Changes in the Economic Value of Renewable Generation at High Penetration Levels: A Pilot Case Study of California," LBNL-618E, March 2013. Calculation based on reported values from Hirth (2013), which excludes balancing costs.

[78] Olson, Arne (2013), "Reliance on Renewables: A California Perspective," presented to the Harvard Electric Policy Group, December 13, 2013.

[79] For example, *see* Rothleder, Mark, "Long Term Resource Adequacy Summit," California ISO, February 26, 2013.

[80] Many types of power generation facilities cannot change output levels quickly. Increased "cycling" (that is, frequently increasing and decreasing output) of resources can have adverse consequences for mechanical performance.

[81] The current process aims to establish resource adequacy flexible capacity requirements and provisions for availability, must offer obligations and failure to procure sufficient resources.

California's share of aggregate global demand is small – for example, only 2.5 percent of installed solar PV capacity globally is located in California.[82]

The reliability challenges created by increased renewable supplies are leading to innovations in market and system operations necessary to sustain higher levels of renewables. These innovations are being met out of necessity in order to meet the 33% RPS – increases in renewable requirements would likely lead to further market and operational changes. Increased renewable reliance is also prompting other policies aimed at developing technologies to address the intermittency of power output. For example, the CPUC recently established a procurement process through which IOU's will be required to obtain electricity storage to back intermittent resources.[83]

The environmental performance of the RPS is affected by policy interactions with the GHG cap-and-trade system, which also covers emissions from the electric power sectors. Any reductions in GHG emissions achieved by the RPS will allow a corresponding increase in emissions by other sources covered by other sources covered by the cap. Thus, the RPS will have no impact on total emissions.[84]

III. IMPLICATIONS FOR THE DESIGN OF CALIFORNIA CLIMATE POLICY

Given the current state of international climate negotiations and domestic politics, California's ability to meaningfully affect the climate problem clearly depends on the State's ability to influence the actions of other jurisdictions, both within the United States and internationally. But, along with these broader implications, California's climate policy also has significant consequences for the State's citizens, given climate policy's economic consequences. Given these perspectives, we explore the implications in terms of seven key design issues: (1) emission targets that preserve flexibility; (2) policies conditioned on actions taken by other jurisdictions; (3) cost-effective market-based policies; (4) linkages with other economies through cap-and-trade; (5) policies that promote technological innovation; (6) policies to reduce leakage risks; and (7) cost containment mechanisms.

1. Emission Targets that Preserve Flexibility

In principle, there is potential merit to establishing long-run emission targets, because such long-run policies can provide greater certainty to investors financing infrastructure changes and technology research needed to achieve cost-effective emission reductions. On the other hand, long-run targets can

[82] California represented 35 percent of 7.2 GW of solar PV installed in the United States through the end of 2012. Worldwide, there were 100 GW of solar PV installed by the end of 2012. REN21, "Renewables 2013, Global Status Report," Renewable Energy Policy Network for the 21st Century, 2013, p. 40, 96.

[83] CPUC (2013), Decision Adopting Energy Storage Procurement Framework and Design Program, Rulemaking 10-12-007, September 3.

[84] The RPS could contribute to additional emission reductions if the cap is not binding (for example, if prices are at the price floor). When the cap is not binding, complementary programs could contribute to reducing total emissions below the pre-determined cap.

limit flexibility to respond appropriately to new information about the benefits and costs of emission reductions. Moreover, unless long-run targets are credible (that is, unlikely to be modified by later political decisions), they provide little of the desired certainty for investors.[85]

Given these trade-offs, combined with the current state of international negotiations, there ought to be great concern about prematurely putting in place long-term targets (for example, beyond 2030). First, understanding of the impacts associated with climate change continues to evolve, and information on the costs (and benefits) of more severe reductions in GHG emissions needed to meet increasingly aggressive targets will evolve over time as various new measures are explored and implemented.

Second, the current state of international negotiations suggests that the type of international climate policy architecture that could support long-run national climate policy commitments is unlikely to develop in the near-term. The implications for individual nations, and sub-national jurisdictions such as California, is that a strategy of incremental commitments may be the most practical and sensible strategy, so as to reduce the risk of an outcome in which it proceeds with stringent and costly actions that do little to address the aggregate problem, while imposing significant economic impacts on its citizens. This does not mean that some unilateral action will not have benefits, but rather that unilateral actions likely have declining marginal returns (through impacts on other jurisdictions via moral suasion and demonstration of credible commitment) and increasing marginal costs (through higher abatement costs and greater leakage). Indeed, unilateral policies that result in adverse economic outcomes may force greater caution on the part of other jurisdictions considering more stringent commitments.

ARB's Draft SPU makes the long-run emission target of reducing GHG emissions 80 percent below 1990 emission levels by 2050 the centerpiece of "continuing progress beyond 2020". However, its recommendation for binding regulatory action is to establish more near-term regulatory goals – a 2030 emission target that "aligns with the State's mid-century climate goal".[86] This recommendation for a 2030 target is more in line with these concerns about over-commitment than a longer-term 2050 target.

2. Policies Conditioned on Actions Taken by Other Jurisdictions

Many countries have begun to condition their policies on development of meaningful multi-national climate commitments. Sometimes this approach involves a country committing to policies in line with the actions taken by other countries, and/or indicating that more stringent commitments will be undertaken if other countries adopt specific targets or if a meaningful international climate regime emerges.

Given the current state of international climate negotiations, establishing policy targets that are conditional on reciprocal commitments by other countries offers many advantages. First, they create incentives for other nations to take action, because those actions will then trigger incremental policies by

[85] In practice, all long-run policies, however well- or weakly-defined, are to some degree subject on on-going adjustments over time.

[86] Scoping Plan Update," p. 3.

others. While a conditional commitment from California would be relatively small in a global context (given California's small emissions), it is also true that if a sufficient number of countries were to make similar conditional commitments, the combination could create conditions that would help lead to the adoption of meaningful policies by a coalition of countries large enough to have a consequential impact on climate change. Second, conditional policies can greatly mitigate the risk of undertaking unilaterally a more stringent policy, by avoiding the adoption of climate policies that are not matched by others. Thus, by making future climate policy conditional on the adoption of reciprocal policies in other countries, California can avoid an outcome in which it bears the cost of stringent policies that have little or no real impact on the aggregate climate problem. Third, conditional policy commitments may afford greater leverage in multi-party climate negotiations, because the party is not locked into further unilateral action.[87]

ARB does not recommend a particular 2030 GHG emission target, although it states that "California needs a 2030 target that is consistent with the level of reduction needed in the developed world to stabilize warming at 2°C and aligns with targets under consideration elsewhere."[88] Such a target would require much more stringent reductions than the current AB 32 goals. According to ARB estimates, achieving AB 32 goals will require a 1 percent annual reduction in emissions through 2020, while achieving the 2050 target would require a 5.2 percent annual emission reduction.[89] ARB notes that other governments (the European Commission, the Netherlands, United Kingdom and Germany) have "recommended" or "endorsed" targets for 2030, but only the United Kingdom has committed to a target beyond 2020.[90] Thus, while it is likely that these (and other) countries will develop post-2020 targets, there are many aspects of these future commitments that are uncertain, including the stringency and conditionality of the targets, and the extent to which, given the number and size of countries adopting targets, such commitments will meaningfully address the problem.

These factors suggest that California, when designing post-2020 climate policy, should consider the employment of commitments that are conditional on reciprocal action by other countries as an element of its policies. Research is needed to identify potential issues that could arise with the use of conditional commitments, and to determine how best such issues can be addressed. One issue is the implication of conditional commitments for market uncertainty regarding future requirements, the economic consequences of such uncertainty, the tradeoffs between these costs and the flexibility gained, and how best to mitigate such uncertainty. One approach to examine is setting a deadline for any conditional commitment, after which the more stringent targets would not be adopted if the criteria for

[87] The European Union was virtually left out the key negotiations that led to the development of the Copenhagen Accords in December, 2009, because it had already pre-committed, that is, pledged specific, ambitious emissions reductions. In practice, the option a party has to rescind a prior commitment (such as a unilateral policy), also can afford some leverage, although the ability to deliver on such a threat may be limited by domestic/internal politics.

[88] Scoping Plan Update," p. 77.

[89] Scoping Plan Update," Figure 6.

[90] The United Kingdom has domestic legislation committing it to a five-year carbon budget needed to limit emissions to 80 percent of 1990 levels. Gault, Adrian (2012), "GHG Mitigation in the United Kingdom: An Overview of the Current Policy Landscape", Working Paper, World Resources Institute, November.

adopting the more stringent target is not met. For example, in November 2013, Australia indicated that it would no longer consider its conditional commitment to more stringent targets for 2020.[91]

Other important issues include how best to define triggers for conditional targets and how to identify the most effective means for establishing credible conditional commitments. For California, assessment of the latter issue would include an examination of how best to implement such commitments within California, given the State's legal and regulatory structure.

3. Cost-Effective In-State Policy

In developing the Scoping Plan designed to achieve AB 32's 2020 emission targets, ARB has relied on a suite of policies covering nearly all sectors and activities that lead to GHG emissions. These policies achieve AB 32's 2020 emission goals through proscribed reductions from specified activities, such as use of renewable power (through the RPS, CSI and other programs), changes in the carbon intensity of fuels (through the LCFS), and changes in the fuel efficiency of cars (through the Pavley standards). The Scoping Plan also includes the GHG cap-and-trade program, which provides uniform economic incentives to reduce GHG emissions across all sectors and activities. As we described above, these overlapping programs can produce perverse policy outcomes.

As it moves beyond 2020, ARB should aim to improve the cost-effectiveness of the policies designed to achieve GHG emission targets. To this end, California's climate policies can aim to create more uniform incentives that are fuel, technology and sector-neutral, not only within particular activities, but across activities. Through more uniform incentives, costs can be reduced by avoiding wide discrepancies in the cost of emission reductions achieved across activities and sectors. This is important not only for maintaining the health of the California economy, but also for providing incentives for the adoption of climate commitments by other governments, as those countries will be more likely to adopt commitments if they can be achieved with minimum economic sacrifice.

The cap-and-trade program is the policy best able to meet this goal. As illustrated above in the analysis of three AB 32 policies, the cost of emission reductions achieved varies across policies, and is much larger for the two complementary policies evaluated. Greater reliance on cap-and-trade can reduce the differentials in the costs of emission reductions that are likely occurring across the broad suite of policies being implemented by ARB. Policies focused at the sector-level – for example, sector-level caps or targets[92] – offer no advantages, and are likely to drive up aggregate costs by resulting in differences in the cost of emission reductions across sectors.

In addition, as discussed above, interactions between these policies can result in consequences that need to be considered when developing policies beyond 2020. When complementary policies impose

[91] This change in policy also coincided with a change to a government less supportive of climate policy. Taylor, Lenore (2013), "Abbott government abandons emission reduction target range," theguardian.com, November 12, http://www.theguardian.com/world/2013/nov/12/abbott-government-abandons-emissions-reduction-target-range.

[92] For example, Executive Order B-16-2012 adopts a 2050 emission target for the transportation sector alone.

incremental requirements on emission sources already covered by cap-and-trade, these policies fail to generate net emission reductions, but raise the costs of achieving emission targets by requiring more costly actions than would otherwise happen under cap-and-trade. Emission reductions from complementary policies also drive down allowance prices, thereby reducing incentives for technological change.[93] Interactions with existing federal "averaging" policies (for example, the RFS program) have similar consequences.

As it considers policies beyond 2020 (and existing policies through 2020), ARB should perform thorough assessments to determine whether and how they should be modified. These assessments should consider costs, emission reductions (and other environmental benefits), policy interactions, distributional consequences, and other market failures that the policy may address. This last factor is particularly important, because policies that address market failures unrelated to GHG emission can improve the efficiency of economic outcomes even if those policies interact with other policies, particularly the GHG cap-and-trade program.

For example, the cost of emission reductions achieved by the LCFS suggests it is prohibitively expensive compared with reductions achieved by other programs, including GHG cap-and-trade. Costs of the RPS are uncertain at this point, and our review highlights the many issues that need to be addressed to properly account for RPS costs. It is also important to consider the benefits of pursuing an RPS as compared with relying on cap-and-trade, particularly given California's electricity regulatory structure. This structure includes the California ISO markets which provide a mechanism for GHG allowance costs to directly affect operational decisions about which resources to use to supply electricity. It also includes CPUC regulation of utility procurement of resources needed to maintain reliability, with clear and transparent mechanisms for incorporating GHG allowance costs into resource decisions.[94] Given these issues, a thorough assessment of the tradeoffs between maintaining and eliminating the RPS (and other renewables policies) should be considered.

ARB's assessment should include all policies within the existing AB 32 Scoping Plan, not only those that interact with the cap-and-trade policies, as economic and environmental effectiveness does not depend solely on policy interactions. Some policies that interact with the cap-and-trade program may address market failures unrelated to GHG emissions, and thus improve the efficiency of economic decisions. For example, utility energy efficiency programs can improve the efficiency of household and business energy use decisions by addressing market failures, such as principal-agent issues between landlord and tenants or certain behavioral phenomena.

Likewise, policies that target activities that are not covered by the cap-and-trade program (which covers about 85 percent of California's emissions) are not necessarily cost-effective. Such policies could reduce emissions at a cost far higher than cap-and-trade or other policies targeting activities outside the

[93] Schatzki, Todd and Robert N. Stavins (2012), "Implications of Policy Interactions for California's Climate Policy," August.

[94] In fact, current planning and procurement procedures require that utilities follow a "loading order" when procuring resources that considers renewable resources before fossil fuel-fired resources.

cap. In this case, the policy is warranted to the extent that it contributes to achieving emission reductions at the least cost, such that reductions across policies are achieved at comparable (marginal) cost.

As noted above, complementary policies also have the effect of depressing cap-and-trade allowance prices. This may provide the appearance that California's climate policies are being achieved at minimal costs, but, as suggested by our analysis of two complementary policies, a more likely explanation is that the quantity of emission reductions achieved by complementary policies is sufficiently large that this nearly eliminates the need for the GHG cap-and-trade program to achieve any emission reductions – thus, the depressed allowance price.

In the short-run, such low carbon prices may diminish political opposition to the cap-and-trade program, as well as the broader climate policy, but in the long-run, this is an undesirable outcome, because it raises costs to California of achieving its climate objectives.

What are the implications for post-2020 climate policy? One implication is surely that California should consider shifting the burden of its climate policies away from the suite of policies currently in place to the cap-and-trade program. Such a shift would require a larger proportion of emission reductions to be achieved through cap-and-trade price signals, which would reduce overall costs and increase allowance prices over time. This does not necessarily mean eliminating every complementary policy, since some may address market failures other than the externality arising from GHG emissions (for example, the market failures that affects some household decisions regarding energy efficiency).

However, as discussed earlier, given the significant changes in infrastructure, technology, and behavior needed to achieve ARB's (and Executive Order) long-term climate goals, policies that avoid mandating reductions from particular sectors, technologies, or fuels will provide greater flexibility for the market to determine which approaches to achieving GHG reductions will be the least costly means of meeting emission targets. Potential cost savings from this flexibility will become more significant over time, given the broad changes in technology and behavior required, and the significant uncertainty about which approaches will achieve reductions at the lower cost.

As the carbon price increases, California will also need to consider the best ways to use the revenues generated through the cap-and-trade program.[95] Programs to address economic and emissions leakage require only a fraction of total emission allowances. A potentially significant opportunity is to use these revenues to reduce other distortionary taxes, such as personal or corporate income taxes. This option has long been favored by economic research, given the significant economic benefits this use of allowance revenue can provide. Furthermore, this approach also has potential political benefits, because it can defuse arguments about "cap-and-tax" that have sometimes defeated efforts to use prices to encourage changes in energy use.

4. Linkages with Other Economies Through Cap-and-Trade

[95] Schatzki, Todd and Robert N. Stavins (2012), "Using the Value of Allowances From California's GHG Cap-and-Trade System," August 27.

With the recent linkage agreement reached with the Canadian province of Quebec, California has begun the process of linking its cap-and-trade system with systems operated in other nations and sub-national jurisdictions. Such linkages offer many potential benefits to California and the linked jurisdictions.[96] In terms of economic and market outcomes, linkage offers three important benefits. First, linkage can reduce the aggregate costs of achieving emission reductions across the combined linked economies, although the gains from trade can raise issues about how to allocate these benefits between economies (and about potential gamesmanship around the setting of country-level caps). Second, linkage can reduce price volatility by increasing the scope of the market and diminishing the impact of any particular event or circumstance on aggregate market outcomes. Third, linkage can reduce market power of individual firms by increasing the number of entities participating in the market, which reduces the ability of any individual market participant to affect market outcomes.

In terms of multi-national climate policy, linkage may provide a “bottom up” mechanism by which broader coordination of climate policies emerges. Over time, through incremental linkage of national (and sub-national) policies, a multi-national architecture may emerge. However, linkage offers tradeoffs, and decisions about the appropriate time to link with other programs should reflect a broader international strategy. In particular, linkage can limit changes in future policy to measures that are in harmony with economies linked through cap-and-trade. On the other hand, harmonization of policies across countries reduces incentives for countries to rescind their commitments, because the consequences of such policy reversal would potentially affect all linked countries.

5. Policies that Promote Innovation in Low-GHG Technologies

It is widely recognized that very significant technological innovation will be required to meet ambitious targets that would stabilize atmospheric GHG concentrations at levels consistent with acceptable levels of climate change. For example, scenarios for California to achieve the 80% reduction in GHG emissions by 2050 specified by Executive Order S-3-05 (2005) require substantial technology innovation for these targets to be technically feasible, let alone economically sensible. Key areas for potential innovation include: carbon capture and storage (CCS) (or other low-carbon dispatchable resources to back up intermittent renewables), nuclear power, electricity storage, vehicle battery storage, and advanced “second generation” biofuels production.[97] Outside of California, these innovations – and others – are essential for many countries’ ability to taken on meaningful commitments for GHG emission

[96] Ranson, Matthew and Robert N. Stavins (2013), “Post-Durban Climate Policy Architecture Based on Linkage of Cap-and-Trade Systems,” *Chicago Journal of International Law* 13(2): 403-438, Winter.

[97] Wei et al. (2012), “California’s Carbon Challenge: Scenarios for Achieving 80% Emissions Reduction in 2050,” October 31; California Council on Science and Technology (2011), “California’s Energy Future: The View to 2050,” May; International Panel on Climate Change (2007), “Climate Change 2007, Mitigation of Climate Change,” Working Group III Contribution to the Fourth Assessment Report, Cambridge University Press: Cambridge, U.K., p. 10.

reductions, particularly for developing countries currently relying heavily on fossil fuels and anticipating continued economic development (examples include China and India,).[98]

Policies within California that promote innovation offer the potential to lower costs and achieve increased emission reductions not only in California but throughout the world. By contrast, policies that rely on increased use ("diffusion") of existing technologies may be able to achieve near-term climate targets at lower short-run costs. Given California's apparent goal of providing leadership on climate policy (and given the limited scope of California's emissions), policies that focus on innovation rather than diffusion would seem to be more with stated objectives.

However, developing sound policies that promote innovation is easier said than done. Given the small scale of California's market in a global context, California should undertake serious discussion about the potential for State policies to promote meaningful innovation in low-GHG technologies, and what such decisions should look like. For example, although California has adopted many ambitious programs to support solar PV, including the CSI, California represents only 2.5 percent of installed solar PV capacity globally, much of it developed within the past two years.[99] Therefore, it is unlikely that demand for solar power sources in California has been pivotal to achieving reductions in costs or increases in performance of PV cells in recent years. Moreover, for incentives designed to support technologies through initial development stages, an important issue becomes when and how such incentives should be diminished as the emerging technology achieves broad market penetration. Continuing support to further lower the costs of existing technologies, such as solar cells (photovoltaics), utility-scale solar power generation, and wind power generation, potentially comes at the expense of providing financial incentives for other potential low-carbon technologies that could be stimulated through uniform (technology- and fuel-neutral) incentives for innovation, or through incentives targeted at earlier-stage research.

Alternative policy designs can offer the potential to shift scarce resources to the development of new emerging technologies. For example, funds that would otherwise be spent complying with the LCFS could be directed toward research in cellulosic ethanol technologies or other alternative transportation fuels.[100] In this regard, the CPUC's recent decision to require the procurement of electric power storage illustrates an example of how policy can provide support for particular technologies at crucial periods of

[98] International Energy Agency (2012), "CO2 Emissions from Fuel Combustion, Highlights," 2012 Edition.

[99] See fn. 82. REN21 (2013), "Renewables 2013, Global Status Report," Renewable Energy Policy Network for the 21st Century, p. 40, 96.

[100] An alternative fuels policy targeting innovation could provide subsidies for fuels meeting certain criteria (for example, cellulosic ethanol). Such a policy could be designed so that subsidies decline over time with greater market penetration and lower costs. The CSI program, which included declining subsidies to homeowners and businesses that installed solar PV, was designed in a similar manner.

market development (although the possible merits of this particular initiative depend on the specifics of the technologies involved).[101]

Of course, policy efforts to advance research and development have their own risks and limitations, but fuller consideration of these options should be part of discussions regarding post-2020 climate policy. Moreover, targeting incentives at more basic innovations could result in fewer emission reductions within California as compared with strategies that seek to achieve emission reductions in the most cost-effective fashion, largely relying on existing technologies. However, the development of post-2020 climate policy would be a good time for serious thought about what strategies are feasible and in the interest of the broader, longer-term objectives of California's climate policies.

6. Leakage Risks

So long as other economies do not adopt climate policies with commensurate financial consequences for business and industry, the risk of economic and emission leakage will exist. These risks are a consequence of the differential in costs created by regulations imposed in one jurisdiction but not in another. Thus, assuming that commitments by other counties remain unchanged, leakage risks are likely to become more severe if and when California pursues more stringent climate policies. This is a necessary outcome of the fact that more stringent policies are likely to result in higher costs in California, which will further reduce the competitiveness of in-state business, so long as other economies, including economies in other U.S. states as well as other nations, have not undertaken commensurate actions. Policies that achieve targets in the least costly manner can mitigate these leakage risks by reducing differences in the costs of production across economies. It is difficult to determine precisely the relative stringency of other countries' policies, although certain types of policies can make the degree of stringency easier to measure (in particular, cap-and-trade, with its revealed allowance price). However, while circumstances may change by 2020, it is clear that some of California's policies create leakage risks, particularly given the lack of reciprocal policies by other parts of the United States.

Leakage risks, and policies that ARB should undertake to mitigate such risks, have been important – and controversial -- topics in discussions regarding AB 32 implementation. ARB has adopted certain measures aimed at mitigating leakage from the GHG cap-and-trade program, including updating output-based allowance allocations to affected industries. Other alternatives, including exemptions and border adjustments, were considered but not adopted.[102] ARB is undertaking research to better understand leakage risks, which can provide valuable information to help inform future policies.

7. Cost Containment in the Cap-and-Trade System

[101] CPUC (2013), Decision Adopting Energy Storage Procurement Framework and Design Program, Rulemaking 10-12-007, September 3.

[102] Stavins, Robert N., Jonathan Borck, and Todd Schatzki (2010), "Options for Addressing Leakage in California's Climate Policy," February.

With GHG allowance prices near the auction price floor, the necessity for adding provisions to mitigate the risks of high allowance prices may seem low. But circumstances can change quickly, and if as recommended above, California increases its reliance on the GHG cap-and-trade program, price increases may be a (desirable) outcome in the future. With higher allowance prices, the risk of prices that rise excessively high – that is, higher than the likely benefits of emission reductions – can emerge. While the potential for such price increases can be an important incentive for investment in emission reductions, excessive price risks can create economic disruption and political backlash that can undermine program objectives.

The current cap-and-trade design includes an allowance reserve, which can supply allowances at pre-determined prices. However, the reserve provides a finite supply of allowances.[103] If this supply were exhausted, prices could increase above the allowance reserve prices, and there would be no mechanism to limit their increase, short of a market intervention by ARB. This approach unnecessarily exposes California's economy to excessively high prices.[104] It also exposes the program to political risks that have led to the dismantling of other programs that have experienced significant price spikes.[105] While these risks may currently be low, this is not a satisfactory rationale for failing to adopt now a mechanism that avoids such undesirable outcomes in the future.

Other mechanisms can also help contain costs. The cap-and-trade program includes provisions for the use of emission offsets in place of allowances. Offset provisions can reduce cap-and-trade implementation costs by allowing less costly emission reductions that can be achieved outside the cap to substitute for more costly emission reductions under the cap. But offset markets under AB 32 have been slow to develop. While low allowance prices will create challenges for these markets, ARB should continue its efforts to develop viable offset markets, because this can mitigate program the cost of cap-and-trade compliance in California in the event that allowance prices increase, as well as provide valuable lessons for other countries developing cap-and-trade systems. As with the allowance reserve, effective offset policies will become more important if California increases its reliance on the GHG cap-and-trade system to achieve emission targets.

IV. CONCLUSIONS

As California pursues climate policy beyond 2020, carefully considering the international, domestic (U.S.), and in-state consequences of its actions will offer the opportunity to achieve better outcomes for the State's citizens. While the AB 32 Scoping Plan appears likely to achieve its target of reducing emissions to 1990 levels by 2020, this policy has come at some cost. California would do well

[103] Schatzki, Todd and Robert N. Stavins (2013), "Three Lingering Design Issues Affecting Market Performance in California's GHG Cap-and-Trade Program," January 29.

[104] Schatzki, Todd, "Can Cost Containment Raise Costs?", July 2012.

[105] For example, the RECLAIM trading in the South Coast Air Quality District was dismantled after significant price spikes for RECLAIM allowances contributed to a broader crisis in California's electricity markets.

to better understand that cost, and to better understand that the benefits of its climate policy, which are still to be determined, depend, in large part, on actions outside of the State. While California may achieve its emission target, broad and meaningful domestic and international action on climate policy, commensurate with California's efforts, has not yet arisen. Thus, as it moves beyond 2020, this broader international context, and the importance of reciprocal action to achieving real policy benefits, ought to be an important factor in shaping California's own climate change policies.

Sources for Tables 1 to 3

California Air Resources Board (2010), "California GHG Emissions - Forecast (2008-2020)," October. Available at http://www.arb.ca.gov/cc/inventory/data/tables/2020_ghg_emissions_forecast_2010-10-28.pdf.

California Air Resources Board, "ARB emissions inventory." Available at http://www.arb.ca.gov/ei/ei.htm.

Climate Action Tracker, "All Countries", Website Pages Updated Between November 2012 and November 2013. Available at http://climateactiontracker.org/countries.html.

Climate & Development Knowledge Network (2013), "Creating market support for energy efficiency: India's Perform, Achieve and Trade scheme," January. Available at http://cdkn.org/wp-content/uploads/2013/01/India-PAT_InsideStory.pdf.

ECOFYS Consultancy (2012), "Greenhouse gas emissions reduction proposals and national climate policies of major economies: Policy brief," November. Available at http://www.ecofys.com/files/files/ecofys_pbl_iiasa_2012_analysis_of_domestic_climate_change_policies_new.pdf.

Fekete, H., F. Mersmann, and M. Vieweg (2013), "Climate change mitigation in emerging economies: From potential to actions." Available at http://www.umweltbundesamt.de/publikationen/climate-change-mitigation-in-emerging-economies.

The Guardian (2013), "Abbott government abandons emissions reduction target range," November. Available at http://www.theguardian.com/world/2013/nov/12/abbott-government-abandons-emissions-reduction-target-range.

Industrial Efficiency Policy Database, "Top-10,000 Energy-Consuming Enterprises Program." Available at http://iepd.iipnetwork.org/policy/top-10000-energy-consuming-enterprises-program.

International Emissions Trading Association (2013), "Looking to the future of carbon markets". Available at http://www.ieta.org/assets/Reports/ghgreport2013-web.pdf.

International Emissions Trading Association (2013), "European Union - The World's Carbon Markets: A Case Study Guide To Emissions Trading," 2013. Available at: http://www.ieta.org/assets/Reports/EmissionsTradingAroundTheWorld/edf_ieta_eu%20ets_case_study_may_2013.pdf. (Similar Case Studies for Australia, Alberta, China, India, Kazakhstan, New Zealand, South Korea, and Tokyo.)

PBL Netherlands Environmental Assessment Agency (2013), “Assessment of Climate and Energy Policies of Major Emitting Countries, Background Study,” The Hague. Available at: http://www.pbl.nl/sites/default/files/cms/publicaties/PBL_2013_Assessment-of-climate-and-energy-policies_1096.pdf.

Republic of Kazakhstan (2012). Information by Parties included in Annex I listed in annex 1 to decision 1/CMP.7 on their quantified emission limitation or reduction objectives for the second commitment period under the Kyoto Protocol

United Nations Framework Convention on Climate Change Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (2012), "Information by Parties included in Annex I listed in annex 1 to decision 1/CMP.7 on their quantified emission limitation or reduction objectives for the second commitment period under the Kyoto Protocol," May. Available at http://unfccc.int/resource/docs/2012/awg17/eng/misc01.pdf.

WantChinaTimes (2013), "Beijing, Shanghai to open carbon trading markets next week," November. Available at http://www.wantchinatimes.com/news-subclass-cnt.aspx?cid=1202&MainCatID=12&id=20131122000055.

Wisner, Robert (2013), "Biofuels Mandates Outside the U.S.," AgMRC Renewable Energy & Climate Change Newsletter, February. Available at: http://www.agmrc.org/renewable_energy/biofuelsbiorefining_general/biofuels-mandates-outside-the-us/#.

World Resources Institute (2013), "GHG Mitigation in Australia: An Overview of the Current Policy Landscape," Working Paper, August. Available at http://pdf.wri.org/ghg_mitigation_in_australia_overview_of_current_policy_landscape.pdf.

World Resources Institute (2013), "CAIT 2.0: World Resource Institute's Climate Data Explorer," Online Database, November. Available at http://cait2.wri.org/.

Worldwatch Institute (2007), "Worldwatch Report: Powering China's Development," November. Available at http://www.worldwatch.org/node/5491.