CALIFORNIA CLIMATE POLICY TO 2050

Pathways for Sustained Prosperity

David Roland-Holst | UC Berkeley

APRIL 28, 2015

Research Papers on Energy, Resources, and Environmental Economics

This report contributes to the basis of evidence on alternative climate policy pathways for the California economy. In addition to presenting original research findings, it is intended to support policy dialogue and public awareness about environment-economy linkages and sustainable growth. All opinions expressed here are those of the authors and should not be attributed to their affiliated institutions.

For this project on long term California climate policy, financial support from Next 10 is gratefully acknowledged.

Special thanks are due to the talented researchers who provided valuable inputs on this project: Drew Behnke, Alex Cheng, Elliot Deal, Sam Heft-Neal, and Sarah Jung, James Tinker, and Rachel Zhang.

Dallas Burtraw, Chris Busch, Jared Carbone, and Fredrich Kahrl offered many helpful comments. The author alone is responsible for opinions expressed here, as well as for any expository and interpretive errors.

ABSTRACT

It is becoming apparent to many that California can achieve its climate policy milestone at the end of this decade, reducing GHG emissions to levels not seen in two and a half decades. The fact that we have also more than doubled the size of the state economy during the same period sets the Golden State apart as a new global example for sustainable prosperity. Having said this, optimism for 2020 is somewhat tempered by uncertainties regarding the next phase of climate action, which calls for GHG emissions to fall 80% from their 1990 levels by 2050. The first phase of AB32 compliance was, frankly speaking, easier than many imagined, but looking ahead, we must acknowledge that even greater determination and creativity will be needed to reach the 2050 milestone. This report elucidates some of the challenges and opportunities ahead, with special reference to the goals of economic growth and environmental quality. The main message of our analysis is that these goals can be reconciled; indeed we show that climate action can be a potent catalyst for innovation and growth of the California economy.

Our study uses a long-term dynamic forecasting model, combined with the latest technology and economic data, to evaluate alternative policy mixes from now to 2050. Updating earlier contributions made to the original Scoping Plan, we explicitly model existing California climate policies, as well as some alternatives under active discussion such as intermediate GHG targets for 2030. Our results reveal how policies can be combined to account for diverse institutions and behavior, and how these can be complementary and improve policy effectiveness. We also show the importance of recognizing uncertainty and creating mechanisms to accommodate this during a long and pervasive structural adjustment process. As most experts already acknowledge, a truly low carbon economy will be very different from today's California economy. Our analysis reveals that this future pathway will not only be more environmentally sustainable, but also more prosperous.

EXECUTIVE SUMMARY

California’s commitment to reduce Greenhouse Gas (GHG) emissions has made the world’s seventh largest economy a leader in global climate policy. The first major milestone for its path breaking Global Warming Solutions Act (AB32) will come at the end of this decade, when the state is targeting emission levels not seen in thirty years. Given that California's 2020 real gross state product (GSP) is also expected to be more than double it's 1990 counterpart, this will be a great achievement in delivering prosperity while reducing environmental risks. Looking further ahead, California’s long-term climate goals will require that the rate of GHG reduction be significantly accelerated. Emissions from 2020 to 2050 will have to decline at more than twice the rate needed today to reach the 2050 statewide emissions limit.

Table ES 1: Main Findings

1. California can meet its 2050 climate goals in ways that achieve higher growth and employment, including GSP growth of over $300 billion and about a million additional jobs.
2. To do this will require a fundamental restructuring of the state's energy system, including electrification of the vehicle fleet.
3. Recognizing sector needs for flexibility, adjustment costs for this economic transition can be substantially reduced by implementing policies that are complementary to Cap and Trade.
4. With complementary policies, average long term industry compliance costs appear to be quite low.

To support a robust and informed examination of these ambitious policies, this report assesses the economic implications of alternative pathways to the 2050 targets, including compatible intermediate (2030) milestones. While substantive mitigation policy must entail some direct and indirect costs, the benefits from greater energy efficiency and improved environmental conditions can significantly outweigh these. The goal of this report is to strengthen the basis of evidence in this area, identifying policy alternatives and estimating their attendant costs and benefits.

Economic Assessment of Climate Action

This study uses a long-term dynamic forecasting model, combined with the latest economic and technology data, to evaluate alternative policy mixes from now to 2050. Updating earlier contributions made to the original Scoping Plan, we explicitly model existing California climate policies, as well as some alternatives being discussed for intermediate GHG targets and pathways. Our results reveal how policies can be combined to account for diverse institutions and behavior, and how these can be complementary and improve policy effectiveness. We also show the importance of recognizing uncertainty and creating mechanisms to accommodate this during a long and pervasive structural adjustment process. As most experts already acknowledge, a truly low carbon economy will be very different from today's California. Our analysis indicates that this future can be not only more environmentally sustainable, but also more prosperous.

As part of their advanced Scoping Plan and implementation activities, CARB and CalEPA organized a comparison project featuring the leading economic assessment tools applied to AB32 since its passage in 2006. Included among these was the same Berkeley Energy and Resources (BEAR) model used in the present study. Eight years ago, BEAR predicted that the state's unprecedented Cap and Trade program would not only be feasible, but affordable in terms of its market-based mitigation costs. In particular, BEAR predicted carbon permit prices well below $20/MTCO2e. Some other studies also predicted carbon permit prices in this range, while some industry-sponsored estimates in some cases exceeded $100. Today, even after incorporating all transport fuels in the cap, California's carbon prices are in the low teens, a reminder of the importance of independent research to the public interest.

To assess prospects for the next three decades, BEAR has been completely updated and re-calibrated to the latest economic data and policy information. The model itself has been peer reviewed and fully documented elsewhere, and we summarize its main findings below.

Scenarios Evaluated

For purposes of policy comparison, BEAR was used to evaluate a variety of generic scenarios reflecting different degrees of climate action and combinations of instruments (Table ES 2). In addition to reference cases of no action (BAU), a Baseline incorporating existing policies, and an extrapolation of historical efficiency trends, we looked at three policy instruments: An enhanced (50%) Renewable Portfolio Standard, Cap and Trade, and tradable Mitigation Credits (defined below). Finally, we look at a scenario that assumes complete electrification of the state’s light duty vehicle fleet by 2050.

Table ES 2: Policy Scenarios

Name	Description	Post-2020 C&T target	Mitigation credits	Complementary policies
1. BAU	Business as Usual	No	N/A (not applicable if no post-2020 C&T target)	Frozen at current levels
2. Baseline	Existing Complementary Programs	No	N/A	Existing with AB 32 plus others
3. EffTrend	Continued efficiency trends	No	N/A	Adds new EE
4. RPS50	Extend RPS to 50% by 2030	No	N/A	New EE plus 50% RPS
5. Incremental C&T	Cap and Trade - Fixed increments after 2020	Linear trend to 2050	No	New EE plus 50% RPS
6. Progressive C&T	Cap and Trade - Fixed Percent (5.2) from 2020	Accelerated reductions to 2050	No	New EE plus 50% RPS
7. Deferred C&T	Cap and Trade - Delayed response after 2020, but attaining to the 2050 target	Delayed reductions, symmetric with accelerated scenario	No	New EE plus 50% RPS
8. Mitigation Credits	Allowances from outside the system, equal to the difference between the Deferred and Progressive Pathways	Accelerated reductions to 2050 (Progressive plus credits)	Yes	New EE plus 50% RPS
9. EV Adoption	Phase out ICE and PHEV with BEV by 2050.	Accelerated reductions to 2050 (Progressive plus credits)	Yes	Adds transportation electrification to new EE plus 50% RPS

Renewables Deployment

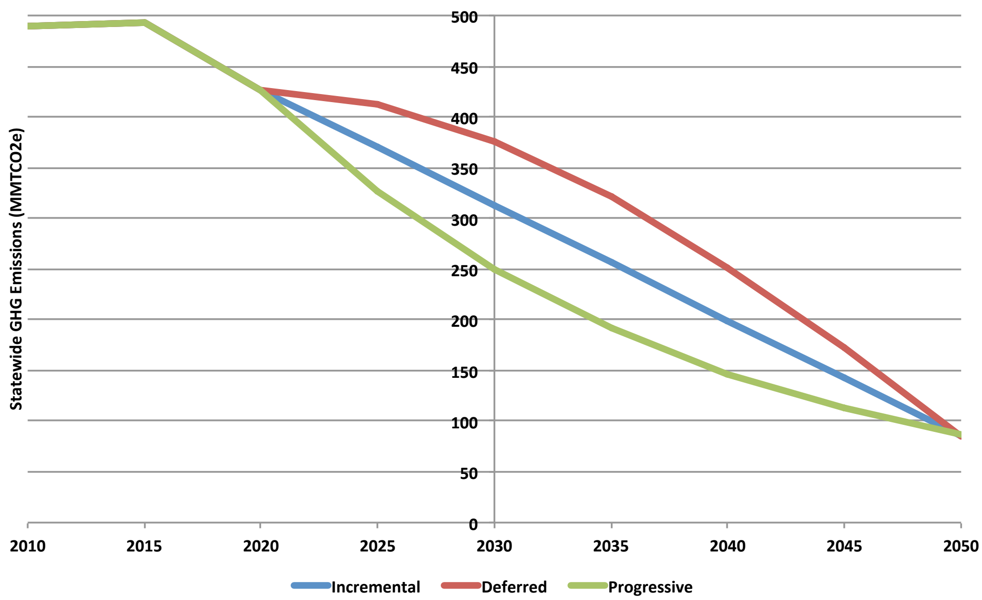
Renewable energy is playing a rapidly growing role in climate policy, and California set an ambitious 33% Renewable Portfolio Standard as part of its

AB32 initiative. A large part of the renewable energy mix: solar, wind, and geothermal, represents a fundamentally new energy supply paradigm. Because they are exhaustible resources, fossil fuel supplies and prices are determined primarily by scarcity, while these renewables represent essentially boundless resources relative to today's energy requirements. In the latter case the constraint to supply is not scarcity, but technological change. Recent trends in renewable technology show that these costs can fall dramatically with scale and learning. For our 4th and subsequent scenarios, we assume California steps up its RPS to achieve 50% renewable sourcing of electric power by 2030. Our cost assumptions are detailed in the full report.

Cap and Trade Pathways

Although the policy has a brief history, California's Cap and Trade program has been quite successful, providing market based incentives for mitigation and innovation at relatively modest cost across a very diverse economy. Going forward, we assume that the cap will be the primary indicator of the state's mitigation targets, leading us to an 80% GHG reduction from 2020 to 2050. While the destination of 2050 is an ambitious focal point, the pathway getting there is of course more relevant to most decision making. As the following figure suggests, that pathway can also make a big difference to the primary determinant of global warming, the stock of GHG in the atmosphere. If we follow the Progressive rather than the Deferred pathway, California will contribute up to 30% less global warming pollution to the atmosphere. The question we ask is, can this environmental benefit be achieved at reasonable cost? Scenarios 5-7 evaluate a simple linear (Incremental) pathway and compare this to more (Progressive) and less (Deferred) ambitious GHG reduction strategies.

Figure ES -1: Cap and Trade Pathways



Mitigation Credits – An important source of flexibility

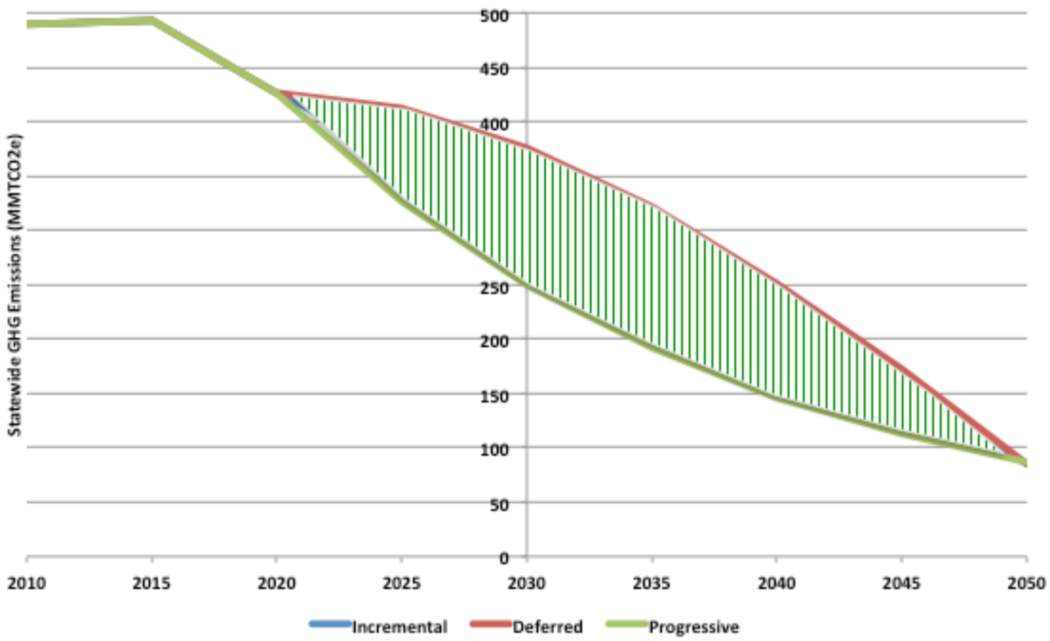
Flexibility is one of main attractions of market-based emission reduction mechanisms like Cap and Trade, permitting covered entities a choice between direct spending on permits and investments that would lead to lower emissions. While this encourages more efficient firms to innovate, it is important to recognize that, because of progress already made, the marginal cost of mitigation in California is high by global standards. Given that the global warming impact of a 1MTCO2e emission reduction is the same regardless of where it is realized, it is reasonable to ask if there are more cost-effective ways for Californians to reduce global GHG stocks.[1] In scenarios 8 and 9, we consider a prominent example of one such policy, allowance for out-of-state mitigation credits against in-state emissions above the cap.

[1] It should be emphasized that we only consider global GHG benefits in this case. Offsets may lead to higher local pollution costs, as well as outsourcing of innovation benefits that might arise from more stringent local emission standards.

Sometimes referred to as offsets, mitigation credits in these scenarios are assumed to be available at the same price as permits (although they would generally be cheaper). In addition we assume they are verifiable, additional, and tradable on an annualized basis, representing (e.g.) 1MTCO2e of annual reduction in an atmospheric flow (mitigation) or stock (sequestration). Such credits could be made available through a variety of mechanisms, but this is the subject of a separate study. For the moment, we merely assume there exists an international financial market for sovereign mitigation certificates, like the sovereign bond market. These "climate bonds" would trade at prices reflecting the underlying costs of providing mitigation/sequestration services, with appropriate risk discounts that reflect the credibility of the issuer.[2]

[2] International instruments like this, if effectively supported by financial markets, could be a substantial improvement over more ad hoc negotiated arrangements like CDM, Debt for Nature, REDD, etc. The latter tend to be plagued by moral hazard and other agency problems. Given cost advantages for lower income countries in both mitigation and sequestration investments, this market could also become a very important source of North-South transfers to support climate adaptation.

Figure ES-2: Mitigation Credit Allowances (shaded area)



For our sample scenarios, we look at and allowances of credits equal to the difference between the Progressive an Deferred emission pathways (Figure ES-2). Obviously, an infinite variety of allowance schemes are possible, but the importance of this one is that, while offering flexibility over the transition period, it leads to the same 2050 emission target (flow) and achieves the same global GHG stock reduction as the Progressive pathway. Thus we achieve both the state's ultimate goal and a more ambitious mitigation pathway for overall GHG reductions. As we shall see, we also do this much more cost effectively.

It should also be noted that mitigation credits, by outsourcing emission reductions, might forsake opportunities for in-state innovation. Local pollution is an important issue because of the unequal distribution of many criteria emissions around the state, but these are also being targeted at specific mitigation policies that look to be at least as stringent as overall GHG emission standards. The foregone innovation issue may also be a important drawback for a higher income, technology-intensive economy like California. The primary drivers of the Golden State's superior growth over the last two generations have been education and innovation, going hand-in-hand to make the state a knowledge-intensive leader in the global economy. First in information and communication technology (ICT), then in biotech, and now with clean technology, the state's R&D supply chain has delivered solutions for the most dynamic and profitable sectors of modern times. With the benefits of local environmental quality and innovation in mind, perhaps a modest premium on abatement cost could be justified.

Uncertainty

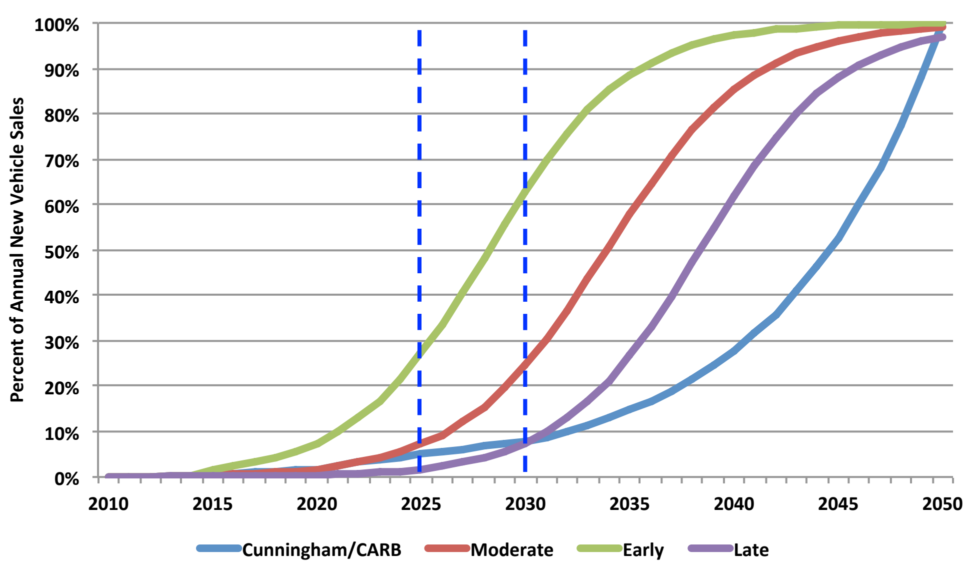
A final issue addressed in this analysis is the role of uncertainty. In the past, most economic assessments are delivered as point estimates, implying somehow that the forecasting profession can offer deterministic guidance. Particularly when looking at dynamics in energy markets and long term adjustment processes, such a perspective is increasingly untenable. For this reason, we implement an explicit Monte Carlo framework, evaluating each of our scenarios repeatedly under varying assumptions about three important data uncertainties: energy prices, technology costs, and price sensitivity of electricity demand. The technical details of this approach are set forth in the full report, but suffice for the present to say that each scenario was evaluated in 1000 replications around a distribution of the three variables just mentioned.

Electric Vehicle Adoption

Most informed observers now recognize that California cannot realistically expect to achieve 80% decarbonization without a fundamental transition of its transportation system to electric power. Alternative fuels can be important sources of mitigation in the near term, but they cannot displace enough conventional fuel emissions to get us to 2050 with current population growth trends and known technologies for biofuel production and distribution. Hydrogen is an emerging technology that may play an important role, but we do not evaluate it here.

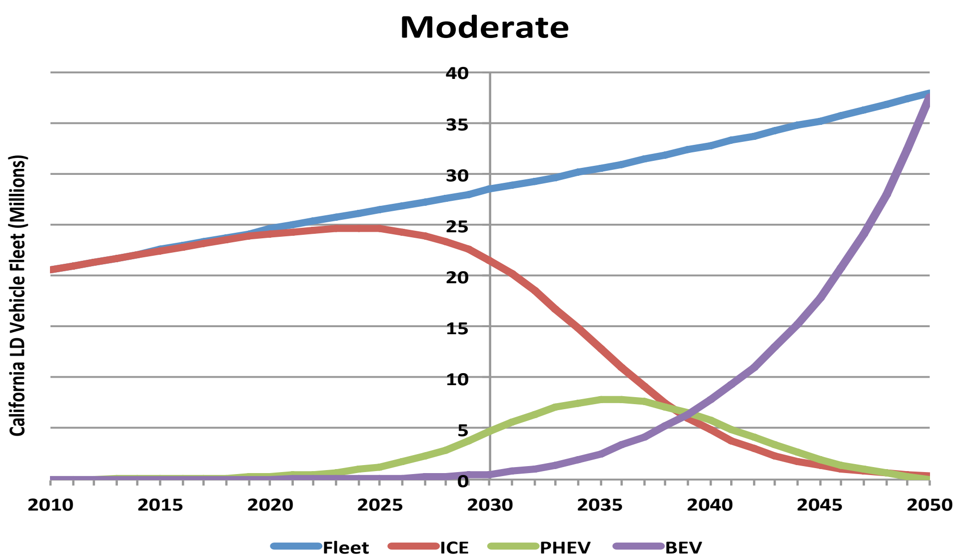
Our last scenario considers one of many possible adoption pathways for 100% light duty vehicle fleet electrification, or Battery Electric Vehicle (BEV) adoption, the Moderate profile in Figure ES-3. This calls for about 7% of new vehicles sales to be EV by 2025, increasing to 25% by 2030 and 100% by 2050. For comparison, we also illustrate a CARB proposal for more gradual early adoption, rapidly accelerating in the final decade.

Figure ES-3: Scenarios for Battery Electric Vehicle Adoption



Assuming the Moderate adoption profile for BEVs, along with an assumption of phasing out hybrid vehicles, we obtain the vehicle fleet transition implemented in Scenario 9 and illustrated in Figure ES-4. With respect to current levels of BEV market penetration, this is obviously a very different transportation sector, with far reaching implications for complementary technologies, infrastructure, electric power capacity, etc. All these issues require detailed evaluation to be most effectively supported by public policy and, in turn, for leading private stakeholders to effectively support climate policy. The state's ambitious goals have the best chance of success if they are based on this kind of constructive engagement.

Figure ES-5: California Vehicle Fleet – Moderate BEV Adoption Profile



Source: Author estimates. Vehicle classes are Internal Combustion Engine (ICE), Plug-in Hybrid Electric Vehicles (PHEV), and 100% electric or Battery Electric Vehicles (BEV)

Aggregate Economic Impacts

When the BEAR model was applied to the nine scenarios, aggregate economic impacts indicate that the state can achieve its medium and long term climate goals while promoting economic growth. Put differently, the aggregate net economic beneftis are positive under all seven climate action scenarios considered. As will be apparent in the discussion below, the primary driver of the these growth dividends is multiplier effects from economy wide energy savings. In the medium and long term, these savings outweigh the costs of new technology adoption, and those net savings are passed on by households and enterprises to the rest of the state economy, stimulating indirect income and job creation. Because aggregate gains are based on the scope of distributed efficiency measures, the benefits increase with time and with the degree of emission reduction, conferring the largest dividends by 2050.

The role of uncertainty in our results is indicated by the color of the cells for changes in real Gross State Product (GSP). A cell colored green contains a result that, subject to 1000 randomized experimental variations in energy costs and behavioral parameters are positive with probability exceeding 95%. Thus the pure efficiency scenario, which essentially extrapolates the state's past trends of "no regrets" efficiency improvements, is extremely likely to be growth positive. Also, if Californians actually do transition to a pure electric light vehicle fleet, the aggregate efficiency gains are virtually certain to outweigh AB32 compliance costs.

For the middle scenarios, the average economic impact across 1000 replications is positive, but not so strongly that they could not be reversed by large swings in energy policy or behavior. As a practical matter, this uncertainty has important implications. It means, for example, that we need to better understand the non-economic benefits that motivate climate policy, as these might justify zero or even positive net costs for the policies considered. These include, for example, induced innovation and other technological change, climate benefits or reduced damages, co-benefits, and national/international leadership. Another immediate implication of the uncertainty in the C&T scenarios is that we need complementary policies, especially to move behavior (like BEV adoption) in directions that make net growth more likely.

Table ES 3: Macroeconomic Impacts

2030	Efftrend	RPS50	Incremental	Deferred	Progressive	Offset	EV Mod
GSP	1%	1%	1%	1%	1%	2%	2%
Consumption	2%	2%	1%	1%	1%	1%	2%
Employment	1%	1%	2%	2%	2%	2%	2%
FTE ('000)	203	244	273	270	275	281	341
CPI	0%	-1%	-1%	-1%	-1%	-1%	-1%
GHG(MMTCO2e)	557	429	394	313	376	250	250

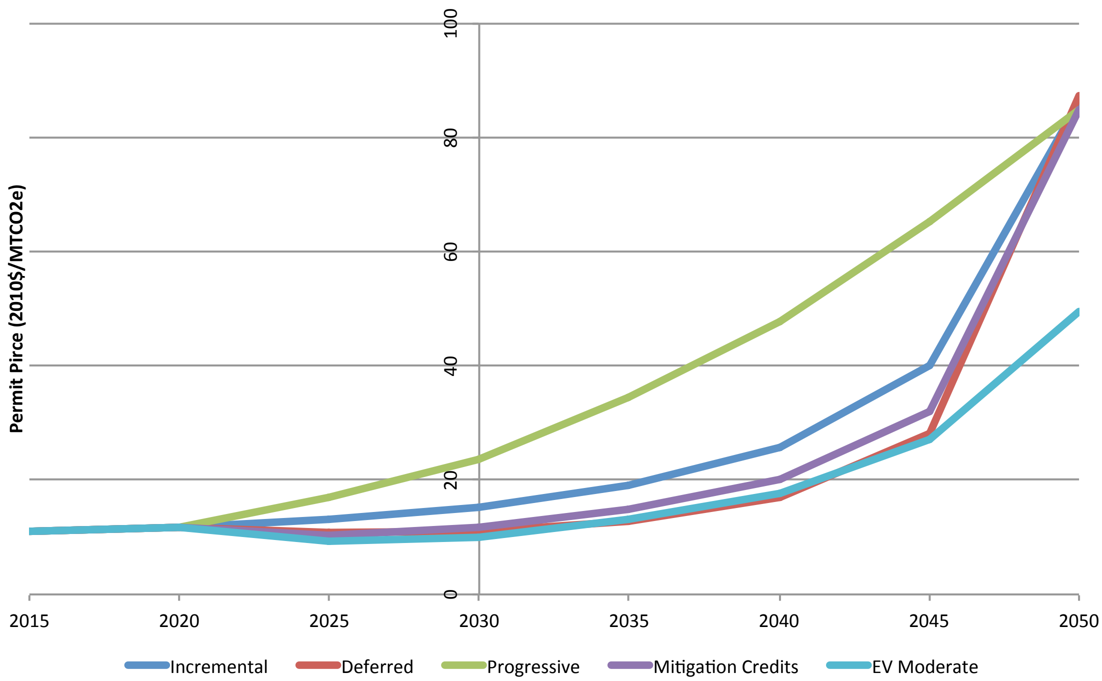
2050	Efftrend	RPS50	Incremental	Deferred	Progressive	Credits	EVMod
GSP	2%	2%	3%	3%	3%	4%	6%
Consumption	3%	3%	3%	2%	3%	3%	6%
Employment	2%	2%	3%	3%	3%	3%	4%
FTE ('000)	406	457	738	729	747	767	915
CPI	0%	-1%	-1%	-1%	-1%	-1%	-1%
GHG (MMTCO2e)	644	384	328	85	85	85	85

Notes: All impacts except GHG represent changes from Baseline in the year indicated, in percentage or the units given in parantheses. GSP and Consumption are measured in constant (2010) dollars. Employment chages are measured in Full Time Equivalent (FTE) annual jobs. GHG measures the level of annual emissions for the given year and scenario.

(green)	High Confidence P(x>0)>0.95
(yellow)	Uncertain

Generally speaking, complementary policies fall into three categories. The first are policies targeting specific behavior, e.g. sector-specific incentives for compliance like the decoupling policies developed in collaboration with California utilities decades ago. A second category addresses situations where prices alone cannot achieve the intended mitigation, such as mpg and other efficiency standards. Finally, a broader set of complementary policies, such as the proposed mitigation credits, creates system flexibility that can push down allowance prices and help preserve the competitiveness of California goods and services in the national economy. It is not difficult to develop a laundry list of such measures, but careful research is needed to determine their real potential and appropriate implementation.

Figure ES-6: Estimated Permit Prices



Another important feature of our results is explicit projection of permit prices that would result from Cap and Trade operating under the scenarios considered. Figure ES-6 illustrates these in 2010 dollars per MTCO2e, and several salient findings are immediately apparent. Firstly, permit prices are generally relatively low, extending the current state of this market and suggesting that direct (permit) and indirect (investment) compliance costs are manageable even under the more ambitious Progressive mitigation pathway. Depending on discount rates, however, an investment approach to compliance would seem to be increasingly attractive, which should provide impetus to the innovation community. Finally, these results do not take explicit account of the current commitment to a price floor of $26.50 in 2030, but all our scenario results are below this level.

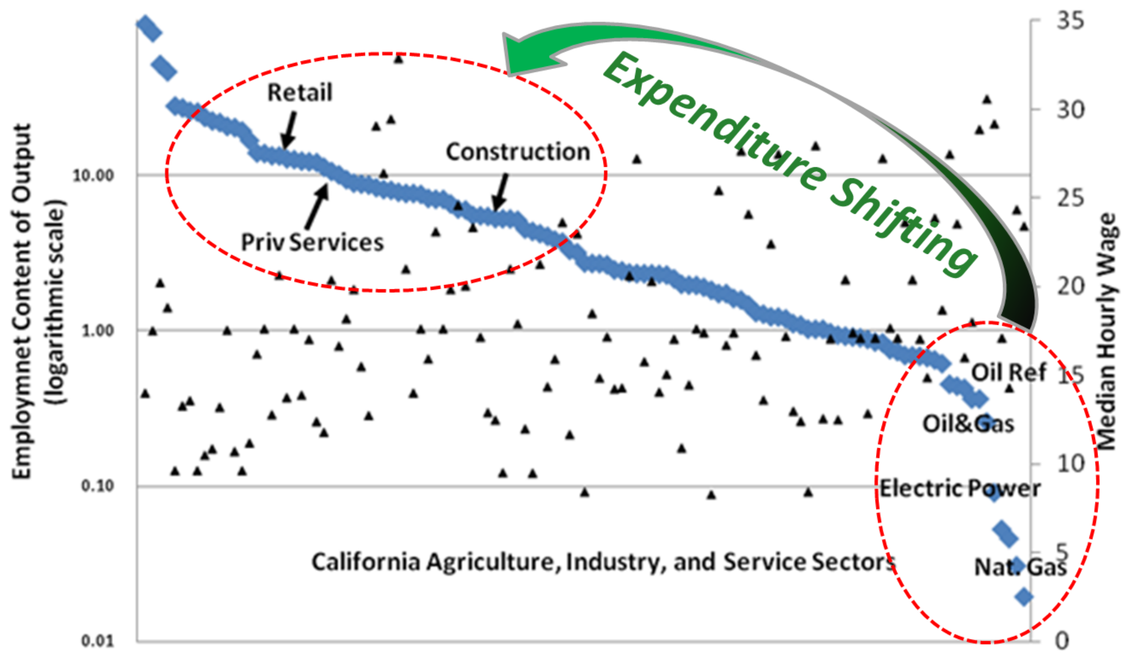
Secondly, it is clear that a more flexible approach to recognizing mitigation can be cost effective for California. Even in the (unlikely) event that mitigation credits are the same price as AB32 auction permits, access to the former would reduce direct compliance costs by about half for the Progressive policy scenario. Third, note that permit prices rise sharply for the less ambitious pathways because they share the same 2050 target. The same is true as mitigation credits are ended by 2050 (Scenario 8), although this is by assumption and in principle the credits could be continued. The Deferred pathway sees the biggest jump because it has more catching up to do, Progressive prices smooth compliance costs, and the incremental approach falls in between. Finally, large scale BEV adoption makes a substantial and lasting contribution to statewide GHG mitigation, reducing the burden of emission reduction that must be achieved by Cap and Trade.

How AB32 Promotes Growth

The BEAR model may be a highly complex research tool, but it is not a Black Box. Using a state-of-the-art behavioral model, BEAR is calibrated to the most up-to-date information on the California economy, emissions, and technology costs. This forecasting tool tracks interactions between 50 sectors and attendant patterns of demand, supply, employment, trade, investment, and many other variables, forecasting annually over a 40-year period. Despite many technical details, however, the macroeconomic impacts we estimate from climate action can be explained with the simplest economic reasoning: Enterprises and households save money on conventional energy resources, and these savings are recycled to stimulate more job-intensive employment and income growth.

Energy efficiency results in economic savings if the economic benefit reduced energy use outweighs the cost of adopting the more efficient technology. The best evidence available on this is California itself, which has maintained a combination of appliance and building standards and utility incentive programs since the early 1970's. In response to this, and even before AB32, the state went from parity to household electricity use levels that were 40% below the national average. These savings diverted household and enterprise expenditure form the carbon fuel supply chain to (mainly) services and manufactures, both of which significantly more employment intensive (Figure ES-7).

Figure ES-7: How Energy Efficiency Creates Jobs



Source: Roland-Holst:2008, "Energy Efficiency, Innovation, and Job Creation in California," Next10.org.

To assess the economy wide impacts of our efficiency and electric vehicle scenarios, we calibrated our model to the most recent information on present and future energy technology costs. These estimates, produced by ICF (2014) and E3 (2015), show net long term savings for both those who adopt electric vehicles and, because of capacity grid adjustments resulting from large scale EV adoption, reduced system wide electricity rates. Including their estimates of these incremental microeconomic benefits in our economy wide model leads to gains for individual households and enterprises, amplified by multiplier effects from recycling their energy savings into other expenditures. Taken together, these effects make out long term climate policy scenarios growth positive for California. Simply put, if you take a dollar out of the gas pump and give it to an average California household, they will spend it on goods and services that average 16 times the employment potential in terms of jobs per dollar of revenue.

Trade Issues

Lower expenditures on conventional energy reduce California's dependence on imports of raw energy fuels from other states and overseas. This trade effect has aroused concern that our export oportunties might likewise be reduced. The fact is that lowering conventional energy fuel imports will increase state employment as long as it results from efficiency. California transport fuels are only partially traded. Not only does California produce 20% of its own oil, but imported transport fuels add two-thirds of their final value inside the state. Unfortunately, however, these activities (refining and distribution) have extremely low employment potential. For example, dollar spent on California gasoline generates less than 10% as many jobs as the average dollar of consumer spending ($.70 of which go to services). Even if California's exports fell by an amount equal to the reduction in raw energy fuel imports, the net job creation effect would be strongly positive.

The mercantile criticism also ignores three other effects of fuel savings to households and enterprises:

1. Spending fuel savings creates its own import demand. If CA imports are about 15% of GSP (US average, but probably higher), this would offset about half the trade effect of reduced energy imports.

2. Service spending has larger in-state multipliers than energy fuel spending.

3. Innovation benefits of new fuel and vehicle technologies.

Market Failure Issues

Another type of skepticism regarding the benefits of AB32 and other climate policies is based on a presumption of market efficiency. Simply put, this perspective holds that to justify intervention, we must identify specific market failures that are inhibiting otherwise voluntary mitigation efforts and/or technology adoption. Otherwise, markets know best and we are already using or pursuing the most cost-effective solutions.

In reality, of course, market imperfections in the climate change context are so numerous that nearly every AB32 supporter can point out a different favorite. Of course the most important one is the global carbon externality, an inconvenient disconnect between the private benefit of energy use and the public cost of the greatest environmental risk in human history. If this isn't enough to justify intervention in today's energy systems, we can also acknowledge universal subsidies to conventional modes transport, as well as oligopolies and/or monopolies in vehicle, conventional fuel, and electric power sectors.

Fortunately, California hasn't been listening to the efficient markets argument for a long time. Indeed, so called command and control policies have been a hallmark of the state's environmental leadership, and the economic benefits have been many. For example, CEC estimated that electric appliance standards netted California households a dividend of $54 Billion over thirty years, and an early

Next 10 report (Roland-Holst: 2008) showed how this created multiplier benefits of almost equal magnitude, contributing an additional 1.4 million FTE jobs to the state's long term growth.

Employment Issues

The positive job creation resulting in our scenarios of course requires that supply conditions are conducive to new hiring. To be clear, BEAR is not a "full employment" model because California historically as had an elastic supply of labor. Coming out of an adverse national macro cycle, the state happens to have structural unemployment now and, like most economies, this will likely continue intermittently. Over the long term, however, California has a higher than average elasticity of labor supply because of sustained inward migration. We take explicit account of this and, while it may not benefit the national economy, this kind of job and income creation has always benefitted California.[3]

[3] Borenstein: 2015 is among prominent experts who caution about the risk of overestimating national benefits from state-specific job creation. This skepticism is certainly well founded, but states tend to place self-interest first when it comes to jobs and income growth.