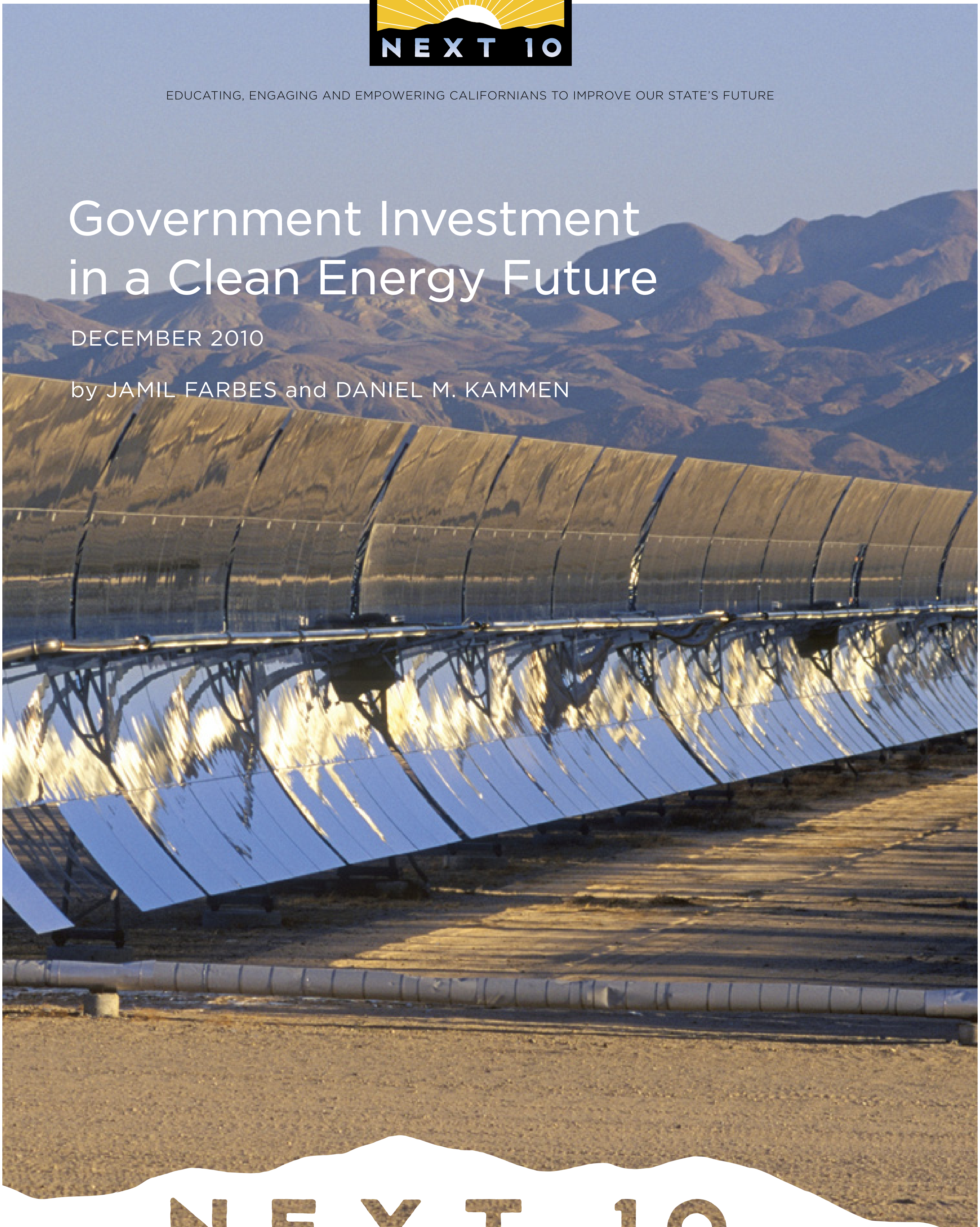
NEXT 10

EDUCATING, ENGAGING AND EMPOWERING CALIFORNIANS TO IMPROVE OUR STATE'S FUTURE



Government Investment in a Clean Energy Future

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by JAMIL FARBES and DANIEL M. KAMMEN

NEXT 10

Next 10 Report

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Acronyms

ACESA	American Clean Energy and Security Act Of 2009
AB 32	Assembly Bill 32, California's Global Warming Solutions Act Of 2006
BAU	Business as Usual
CARB	California Air Resources Board
CEC	California Energy Commission
CPUC	California Public Utilities Commission
C&T	Cap and Trade
EAAC	Economic and Allocation Advisory Committee
ETAAC	Economic and Technology Advancement Advisory Committee
EJAC	Environmental Justice Advisory Committee
FiT	Feed-In Tariff
GHG	Greenhouse Gas
LCFS	Low Carbon Fuels Standard
NRC	National Research Council
OBF	On Bill Financing
PACE	Property Assessed Clean Energy
PIER	Public Interest Energy Research
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Portfolio Standard
RD&D	Research, Development and Demonstration
VMT	Vehicle Miles Traveled

1 Introduction

With the passage of Assembly Bill 32 (AB 32), the Global Warming Solutions Act of 2006 (Nunez 2006), the state of California continued its long history of staying a step ahead of the federal government on environmental issues. California's AB 32 legislation differs dramatically from American Clean Energy and Security Act of 2009 (ACESA) passed by US House of Representatives (Waxman and Markey 2009) as well as other unsuccessful federal climate bills. AB 32 depends on state agencies to design and implement measures to combat climate change, whereas ACESA largely contains legislatively-designed policies for federal agencies to carry out. Weighing in at a paltry thirteen pages compared to ACESA's fourteen hundred plus, AB 32 sets a target for 2020 emissions together with a timeline for California Air Resources Board (CARB) to complete its task of implementing measures to reach the target while also meeting key criteria.

While there are some legislative actions which aid AB 32 in its effort to reduce greenhouse gas (GHG) emissions, the bill relies entirely on the regulatory process to create policies driving emission reductions. The requirement of CARB to create a scoping plan which details potential avenues for meeting the emissions target together with the rulemaking process has enabled a number of committees, shareholders and individuals to weigh in on CARB's process of implementing AB 32. CARB's Scoping Plan features a cap-and-trade system (C&T) as a central component of the agency's multifaceted effort to reduce California's GHG emissions to 1990 levels by the year 2020. By imposing a limit on the total amount of emissions from sectors included under the C&T system and requiring regulated entities to acquire emission allowances which cover their emissions during compliance periods, C&T seeks to make the privilege to pollute GHG's into an increasingly scarce resource. The program continually decreases the number of allowances available, and allows entities to trade allowances with one another which will create a market for allowances. The total allowance value from 2012 to 2020, the life of the Scoping Plan C&T program, will be on the order of tens of billions of dollars.

This work, as a part of a larger research effort coordinated by the organization Next 10, seeks to fit into this process of implementing AB 32 by conducting research pertinent to CARB's proposed measures. The Next 10 commissioned research on climate policy in the state will examine different approaches to allocating the value of allowances from the C&T program. As a subset of that effort, this work focuses on using some portion of allowance value to fund government investments. Specifically this work seeks to answer the following two questions:

1. How should government investments of AB 32 allowance value be prioritized?

2. What would an "aggregate social benefit" metric of comparison between investments look like?

It should be noted that while these two questions are important, they immediately beg the larger question of what is the appropriate amount of allowance value to direct towards government investments. The motivation for the first research question is to inform the discussion of this larger question of how much value. Through the course of thinking about prioritizing government investments the second research question naturally arises as a potential means of quantifying merits of different state government directed investments which seek to further AB 32's goals.

1.1 AB 32

The signing of Assembly Bill 32 in the fall of 2006 was preceded by the Governor issuing executive order #S-3-05 (Schwarzenegger 2005) in the summer of 2005 which set targets for GHG reductions. The order calls for the reduction of emissions to 2000 levels by the year 2010, further reduction to 1990 levels by 2020 and finally reduction to 80 percent below 1990 levels by 2050. The 2050 target of 80 percent below 1990 levels seems to be in relatively wide consensus on the national level, with numerous pieces of legislation establishing equivalent targets (Parker and Yacobucci 2008; Waxman and Markey 2009; Cantwell and Collins 2009). AB 32 establishes a target of 1990 emission levels by 2020, but does not address emissions beyond 2020. Averting dangerous climate change will require concerted effort through 2050, and likely for the remainder of this century. While AB 32 has a much shorter time scale, its goals will require policies which consider the long view.

The C&T program is a major element in CARB's Adopted Scoping Plan, but it is not the entirety of CARB's efforts and it will not cover every sector which emits GHGs. The Scoping Plan recommends a number of policies which target sectors which are not covered by C&T as well as a number of policies designed to complement the price on GHG emissions arising from the C&T program. These policies are included under the justification that while a price on GHG emissions will produce a lasting signal for investment, a C&T system alone is not the most efficient manner to mitigate emissions (California Air Resources Board 2008, 18). Some of these complementary policies will require additional authority through legislative action, but many of these policies will progress through CARB's rule making process. [1]

A number of committees have been formed as a part of the ongoing implementation of AB 32. Each of these committees has been tasked with focusing on different facets of the implementation process. AB 32 explicitly directs the formation of two committees: the Economic and Technology Advancement Advisory Committee (ETAAC) and the Environmental Justice Advisory Committee (EJAC). After the process of creating the Scoping Plan had commenced, the California Environmental Protection Agency together with the Air Resources Board appointed the Economic and Allocation Advisory Committee (EAAC). These committees have played a prominent role by crafting and compiling recommendations for CARB, yet different committees have had varying degrees of success in seeing their recommendations integrated into the CARB's Adopted Scoping Plan.

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[1] For instance the automotive standards required by the "Clean Car Standards, Assembly Bill 1493", or the Pavley standards, are a legislative action which the Scoping Plan accounts for as a complementary policy and includes projected emission reductions from the standards in its analysis.

1.2 Next 10 Context

The Next 10 commissioned research effort on California climate policy draws on multiple disciplines to provide macroeconomic assessments of policy scenarios associated with AB 32 together with research and recommendations on different potential uses of allowance value. EAAC's work serves as a starting point for an in-depth discussion of how allowance value should be used. A central goal of the Next 10 research effort is to inform the process as well as public opinion before final regulations for the C&T program are set by the end of 2010.

The EAAC report makes a number of recommendations, which are addressed in detail in sections 2.2.2 and 3.1.3, which naturally raise the question of how to best implement these recommendations. One of EAAC's central recommendations is that roughly three quarters of revenue from auctioned allowances should be returned to California residents in some fashion while the remainder should be directed to government investments. The report does not give a recommendation as to what is the most effective manner to return allowance value to households. The report also makes a recommendation of using aggregate social benefit, which would include the value of ancillary benefits like lower health and environmental burdens from decreased fossil fuel use, analyze possible investments but it does not address how to implement such a metric nor does it explicitly identify specific government investments which merit priority.

The Next 10 research effort seeks to examine a number of questions relating to assumptions underlying, prioritization and implementation of, and potential impacts arising from these recommendations. In that vein, researchers working with Next 10 will look at six different issues which tie directly back into EAAC recommendations:

1. Modeling the macroeconomic impacts on the state economy under a variety of different allocation scenarios
2. Seeking insights into competitiveness concerns, including emissions leakage and border adjustments
3. Considering various means of consumer protection, and possible benefits of returning revenue to households by offsetting existing taxes
4. Analyzing how redistributing allowance value as dividends to households can be done in a manner which incentivizes households to reinvest dividends to further AB 32 goals
5. Identifying priority government investments, as well attempting to operationalize an aggregate social net return criterion to provide insight into the right level of government investment.

This work seeks to address this final line of inquiry. It is important to recognize that there is a substantial amount of overlap between these efforts. Each line of inquiry is largely being done in parallel efforts by separate researchers and each is being conducted on its own schedule.

2 Allowance Value & Uses

Understanding the process by which allowances obtain value and the flow of this value over time helps to motivate the arguments for different possible uses of allowance value as well as the rationale for using a portion of allowance value for government investments. This section discusses the theory of the creation of allowance value, the range of widely considered possible uses of allowance value, and the arguments upon which directing allowance value to government investments are justified.

2.1 Allowance Value

We can think of the price of an allowance at a given time under C&T as being set by the marginal abatement cost for the particular level of emissions allowed at that moment. This can be represented graphically as a curve of marginal abatement costs, for which marginal cost increases as the amount of emissions permitted decreases (Figure 2-1). Allowance value for a given point in time is simply the product of the price of allowances and the total quantity of allowances distributed. Even if allowances are freely allocated to emitters, they possess value and can be sold on the secondary market. By design, in a C&T system the number of allowances for covered sectors will decrease over time. Economic intuition suggests that the lowest cost abatement opportunities will be undertaken first, moving toward progressively more expensive measures as the stringency of the cap increases. Of course thinking of permit markets in this simple manner fails to capture the complexity of actors buying or selling in the market due to behavioral and strategic considerations, but it supplies the theoretical underpinning for allowance value

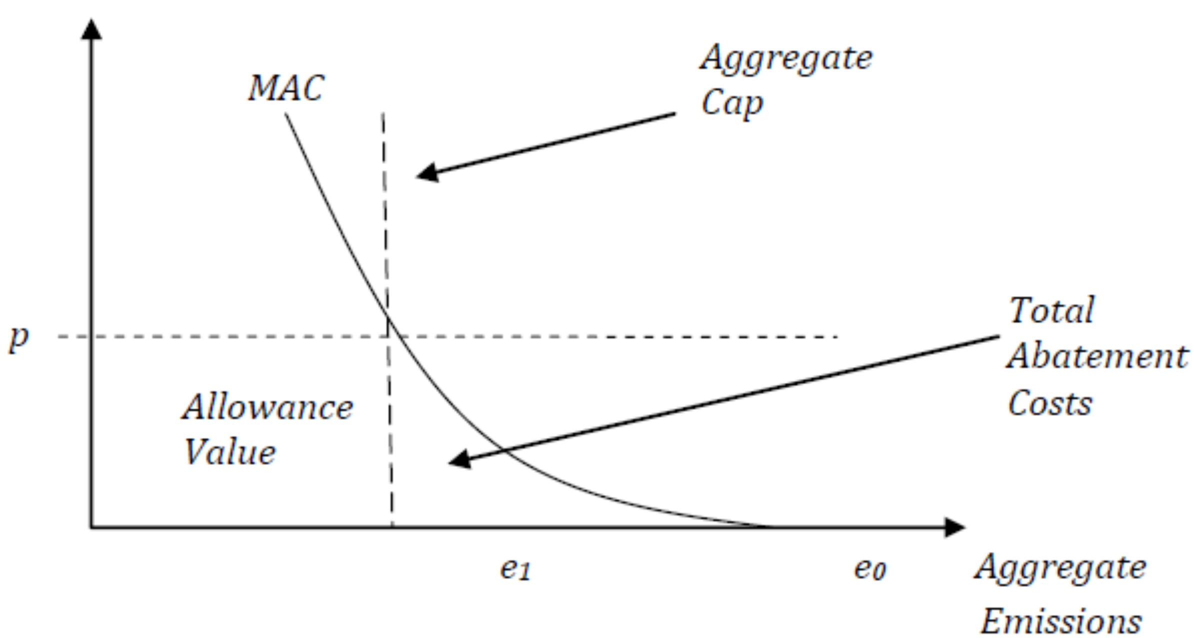

Figure 2-1: A stylized representation of the marginal cost of reducing emissions. *MAC* is the marginal abatement cost, *p* represents the price for the emissions limit, e_1, while e_0 represents the point on the graph where there is no emissions limit (Economic and Allocation Advisory Committee 2010, 22).

For the first few decades of having a program in place the real annual value of allowances is expected to rise as allowance prices are expected to increase faster than the number of available permits decreases (Economic and Allocation Advisory Committee 2010, 22). Annual allowance value is likely to be on the order of billions of dollars per year. While there is likely a relatively small range of possible final annual allowance quotas, firmly estimating allowance value is impractical as the price of allowances will be determined by the market. Modeled predictions of allowance price vary widely (Economic and Allocation Advisory Committee 2010). If an allowance price floor were set at $10/ton of CO_2e, the same price which ACESA sets as the reserve, this floor would set a lower bound for total allowance value on the order of $30 billion.

2.2 Options for Allowance Value Use

The C&T program will potentially create tens of billions of dollars worth of value in just under a decade raises the important question of how this value should be utilized. The Scoping Plan integrates a number of committee suggestions and lists a number of options as well as recommendations from various groups on the utilization of allowance value. EAAC also offered a number of recommendations on the use of this value after the adoption of the Scoping Plan.

A reoccurring theme throughout the discussion of how allowance value should be used is whether or not allowances should be freely given to emitters or auctioned to generate revenue from allowance revenue. Free allocation of allowances to polluters is a use of allowance value and as such it precludes other uses. Free allocation of allowances in the European system has been shown to generate windfall profits for polluters (D. Ellerman 2009; Sijm, Neuhoff, and Chen 2006). For the purpose of this work, discussion of any allowance value use other than free allocation implies use of revenues from auctioning allowances, or allowance revenue. This sub-section looks at recommendations for allowance value use as well as other models which are proposed or in use outside of California.

2.2.1 Scoping Plan Recommendations

In attempting to ensure that the measures selected for final regulations are fitting with the goals and guiding factors laid out in AB 32, CARB lays out a number of key criteria: "cost effectiveness; overall societal benefits like energy diversification and public health improvements; minimization of leakage; and impacts on specific sectors like small business and disproportionately impacted communities" (2008, ES-7). CARB presents these criteria and the Scoping Plan as a comprehensive effort to balance amongst these and other factors, and also recognizes that the use of allowance revenue can also play a major role in achieving that balance.

The Scoping Plan acknowledges the joint recommendation of the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC) that most appropriate use of allowance value in some cases may be returning that value to the sectors which raised the revenue (2008, 70). In practice returning revenue to the sectors which raised it may be implemented by simply freely allocating value to these sectors, but in the context of the electricity sector depending on how allocation is handled it could mean the CPUC has some discretion over how that value would be used.

The Scoping Plan also includes a list of suggested uses which fit with its key criteria: reducing costs of emissions reductions or achieving additional reductions, achieving environmental co-benefits , incentives to local governments , consumer rebates, direct refund to consumers, climate change adaptation programs, subsidies, RD&D funding, worker transition assistance, administration of a greenhouse gas program, and direct emission (2008, 70-71).

2.2.2 EAAC Recommendations

As the EAAC recommendations were produced after the adoption of the Scoping Plan they contain more detail than earlier committee recommendations. EAAC also introduces a set of key criteria for considering uses of allowance value:

- Cost effectiveness: achieving environmental targets at minimum cost.
- Fairness: avoiding inequitable distribution of any adverse impacts of AB 32.
- Environmental effectiveness: assuring that desired in-state emissions reductions are in fact achieved, and that they are not offset by policy-induced increases in other locations.
- Simplicity: assuring that the policies introduced are transparent (Economic and Allocation Advisory Committee 2010, 62).

In fitting with their stated criteria, EAAC offers a case for auctioning:

> "The [California Air Resources Board] should rely principally, and perhaps exclusively, on auctioning as a mechanism for distributing allowances …. Auctioning is an especially transparent mechanism for allowance distribution, and it facilitates discovery of the actual costs associated with emissions abatement. It has the same potential as free allocation for achieving distributional or fairness objectives, since nearly every objective or conferral of allowance value sought through free allocation of allowances can be achieved through auctioning and the associated use of auction proceeds. In contrast with free provision, auctioning yields revenue and thereby can reduce the extent of the government's reliance on ordinary taxes for financing expenditures; this can help reduce the overall costs of AB 32" (Economic and Allocation Advisory Committee 2010, 3).

EAAC makes a number of recommendations on allowance value use, as well as the merits of free allocation versus auctioning, but does not address the design of the proposed C&T system. The authors note that the appropriate distribution and provision system critically depends on whether or not there is a regional or national climate program and that California's efforts should account for those possibilities. EAAC recommendations for the provision of allowance value are summarized in Appendix A.

The committee recommends that total allowance value spanning from 2012-2020 should be roughly apportioned in the following manner: a small portion of value should be earmarked for contingencies, leakage, environmental remediation and avoiding impacts to low-income households. The remaining allowance value, which is expected to represent the bulk of total value, should be split with roughly 75%

returning to households and 25% going towards financing investments and other public expenditures. EAAC notes that the ratios between these two should likely change over time, with investments receiving a larger share of total value in early years when allowance value is expected to be low (Economic and Allocation Advisory Committee 2010, 69-70). This work, as well as the larger Next 10 research effort, takes the EAAC suggestions, particularly the rough 1:3 split of total allowance value, as the foundation around which further analysis is merited.

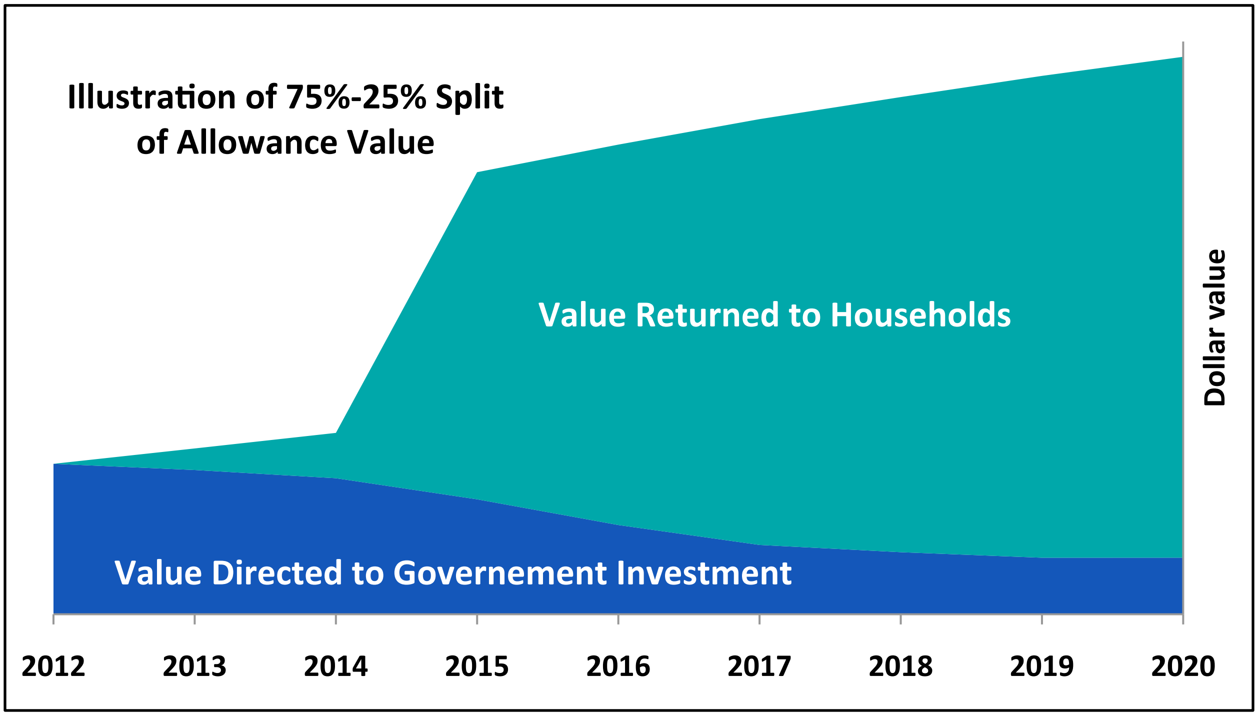

Figure 2-2: A hypothetical illustration of how government investments might be front loaded over the life of the C&T policy assuming a linear increase in allowance prices over the life of the program. The government investment portion of the graph represents 25% of the total value, but accounts for the majority of allowance value in early years of the program, and accounts for less than 25% of total value in later years of the program. The rise in total value corresponds to the broadening in C&T scope with the beginning of the second phase of the program.

2.2.3 Other Models of Value Use

At least succinct recognition of other models of allowance value use is merited. ACESA represents a possible federal model for the usage of allowance value. The states participating in the Regional Greenhouse Gas Initiative (RGGI) have each adopted their own model for the use of allowance value.

Federal Model

ACESA covers a similar number of sectors as compared to AB 32, and while federal goals differ somewhat from state goals, the program faces a number of similar objectives. ACESA considers revenue in terms of distribution of allowances rather than in terms of allowance value. A schedule of allowance distribution allows for predictable split of annual value from year to year, but without the foresight of allowance price, the schedule tells us little about the actual quantity of allowance value following to different uses when comparing different years.

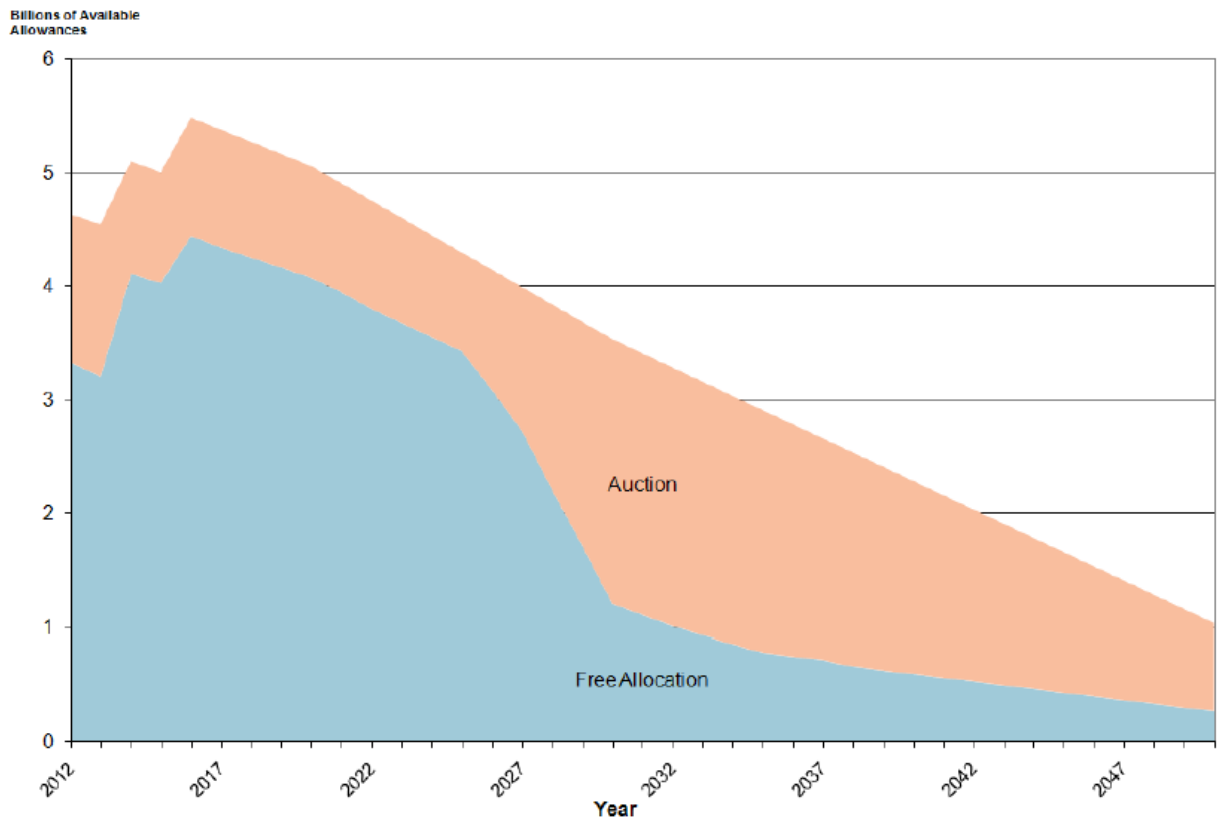

Figure 2-3: The ACESA scheduled split of allowances between free distribution and auction over the life of the program, where the vertical axis is billions of allowances (Pew Center on Global Climate Change 2009, 1).

ACESA freely allocates 60 percent of total allowances and auctions the remainder. Free allocation is how the majority of allowances are distributed until approximately half way through the life of the program. Some of these freely allocated permits have stipulations that the recipients must use their value to benefit consumers. Counting theses free allocation allowances together with low-income protection and the 20 percent of all allowances auctioned to be returned as dividends, the bill cumulatively distributes 58 percent of all allowances to consumers while the remainder goes towards a number of program implementation and government investment related efforts (Pew Center on Global Climate Change 2009).

Models in Other States

The RGGI has 10 states participating and only covers the electricity sector. In the context of the limited coverage of this C&T system it makes sense that many of the uses of allowance value are closely related to electrical energy concerns, primarily energy efficiency, as compared to a system with a cap that covers a broader scope. Each participant state passed its own variant on the RGGI model rule though its respective legislature, and as such each state has slightly different implementations and different uses for allowance value. All states auction at least 60 percent of allowances, with three states using auctions as the sole means of distribution (Pew Center on Global Climate Change 2008). Currently all but two states direct the majority of allowance revenue toward energy efficiency related programs. Through the first six quarterly auctions some $270 million, roughly 55% of total revenue, has been marked to be directed to energy efficiency. Maryland is the only state where a large portion of revenue is returned to households in the form of rebates (Environment Northeast 2010).

2.3 Rationale for Government Investment

There are a number of reasons why it might be desirable to use allowance value to fund government investment. There are several issues stemming from the combustion of fossil fuels as well as pervasive problems in the energy sector which likely justify some level of government investment. These issues underpin ETAAC, Scoping Plan and EAAC recommendations for using a portion of allowance value to fund government investments. While ACESA and the EAAC recommendations direct the majority of allowance value back to households, the remainder of the value is directed to government investments.

There are compelling arguments for government investments to address: RD&D, incentives for deploying technologies together with support programs which can enable emissions reductions like land use planning, adverse impacts, adaptation as well as other public goods, and support for environmental justice goals. This report classifies justifications for government investment into the following groups: non-greenhouse gas externality investments, fairness and equity investments, public good investments and market barrier removal investments.

There are also a number of arguments as to why allowance value should be directed to fund these government investments. While some may argue existing programs targeted at addressing the above issues are currently sufficiently funded, the implementation of climate change policy, particularly a C&T system, will alter what is the appropriate balance of funding. For instance the introduction of a carbon price should raise the desirable level of energy conservation from the previous status quo established in large part through CEC standards seeking to correct historic market failures. The Scoping Plan offers another argument that allowance value should be used to meet the policy objectives of the state's climate change program (California Air Resources Board 2008, 36). The following subsections consider specific justifications.

2.3.1 Non-GHG Externalities

There are a number of benefits, for the environment as well as to health, which arise from zero and low emission technologies which are not reflected in private returns (Economic and Allocation Advisory Committee 2010, 48). Pricing the GHG externality captures only one facet of these positive benefits, and failing to appropriately value these technologies will result in deploying them at a level below the social optimum.[2]

A recent National Research Council (NRC) study addresses the topic of unpriced consequences of energy use and production (2009). The study examines "beneficial or negative effects that are not reflected in energy market prices [and these effects] are termed 'external effects' by economists. In the absence of

[2] This section of justifications is focused on negative externalities other than the GHG externality. The spillover effect of RD&D is a positive externality and is an issue which merits government investment; however it is treated in the Market Barrier section for the sake of simplicity.

government intervention, external effects associated with energy production and use are generally not taken into account in decision making" (2009, 3). The research committee estimated that for the US there was over $120 billion dollars in damages in the 2005. This number excludes damages related to climate change, ecosystems, infrastructure and security, with the damages principally being driven by the health impacts of emitting NO_x, SO_2, and particulate matter. Given these exclusions, as well as a number of uncertainties in the analysis, $120 billion is undoubtedly an underestimate.

The compounds driving these health damages are all co-pollutants related to the emission of GHGs from the combustion of fossil fuels. While there are several negative non-GHG externalities, the co-pollutant/health externality is likely the largest driver of damages not accounted for by addressing GHGs alone. The price on GHG emissions created by C&T attempts to effectively internalize the cost of emitting pollutants which drive climate change, but it does not directly address the health externality caused by these co-pollutants. Currently CARB works extensively to establish standards and regulations to minimize the health impacts of GHGs and their co-pollutants. The implementation of a climate change program changes the existing approach to controlling co-pollutant emissions and burdens in that low and zero emission technologies are expected to be deployed more widely over time. These technologies offer the possibility dramatically reducing or even eliminating health damages from these co-pollutants while abating GHG emissions.

2.3.2 Fairness and Equity

AB 32 requires CARB, insofar as it is feasible, to "direct public and private investment toward the most disadvantaged communities in California" (California Health and Safety Code §38565). The Scoping Plan explicitly states that considerations of disproportionately impacted communities need to be weighed in implementing any plan to reach the 2020 target. In a recent report on how to jointly address disproportionate impacts expected from climate change in California as well as existing environmental justice concerns, the authors found that communities of color are disproportionately impacted by large stationary GHG sources, particularly oil refineries (Pastor et al. 2010). The fact that these communities are disproportionately carrying health impacts caused by these major polluters is an often cited case of environmental injustice.

As the EJAC sharply noted in its recommendations, and the authors of the *Minding the Climate Gap* report echoed, pricing emissions though a trading mechanism opens the possibility that emissions from certain sources may not decline. Even though the overall cap will be lowering, it is possible that emissions from these sources could increase as these emitters are able to comply with regulations by acquiring more allowances. These are legitimate concerns which C&T will not remedy alone.

The fairness argument for government investment simply recognizes that in the process of implementing policies to meet the goals of AB 32 steps need to be taken to ensure that no groups suffer disproportionately large impacts. This argument for fairness is closely tied to the arguments for equity, essentially making the case that the impacts of the policy should be equitably distributed. The particular groups which may need protection from adverse impacts are low-income households and possibly carbon-intensive industries which compete with out of state firms that do not face compliance costs associated with mitigating GHG emissions (Economic and Allocation Advisory Committee 2010, 33).

2.3.3 Public Goods

There are a number of public goods related to efforts to transition to a low carbon economy as well as managing unavoidable impacts from climate change and efforts to combat it. Infrastructure improvements, environmental remediation, adaptation and some forms of job training are all public goods (Economic and Allocation Advisory Committee 2010, 67). As public goods, without government investment these things are likely to be underfunded (Samuelson 1954).

Adaptation in particular likely deserves special consideration as a public good (Adger, Arnell, and Tompkins 2005). Individuals, groups and governments will have to undertake actions to adjust their behavior and institutions in reaction to a changing climate. This process is broadly termed adaptation. Many of these actions on a government scale, like conservation of habitats and biodiversity, will primarily have to do with public benefits. It follows that a logical use of revenue generated from efforts to prevent climate change is to fund government investments for adaptation.

2.3.4 Market Barriers

It has been widely and repeatedly documented that there are a range of market barriers in the energy sector (Economic and Technology Advancement Advisory Committee 2009; Brown et al. 2007; Golove and Eto 1996). ETAAC's report on opportunities, barriers and policy solutions focuses extensively on market barriers specific to the state (see Appendix B for the full list) and classifies them into four general categories: cost and market related barriers, information related barriers, industry structure and infrastructure related barriers and government related barriers. The committee cites the cost and market category as being the most frequent and severe of all categories, while the industry structure and infrastructure category has several frequent and severe barriers. Their frequency and severity make both of these categories targets for government investment (2009).

The chicken and egg problem of market supply and demand is one example of a cost and market type of barrier. Without sufficient demand for low-carbon technologies they may not be supplied to the market at sufficient scale to reach full commercialization. Spillover to competitors from private investment in demonstration projects is another example of a cost and market barrier, where the inability to completely capture the return on demonstration projects disincentivizes private investment.[3] The upfront cost of many low or zero carbon technologies are often prohibitive for many small firms and households. Lack of existing infrastructure to deploy renewables on a very large scale is yet another example of the kind of market barriers that will require government investment.

Many of these market barriers have been recognized for decades. California has become a leader amongst states in energy efficiency and addressing these market barriers in large part due to the work

[3] Spillover in this context is an example of the positive externality of RD&D investments. Being routinely recognized as a market barrier it has been included in this section for the sake of simplicity.

of the CEC which was formed over 35 years ago. There were compelling reasons to undertake these measures and establish vehicle and appliance standards even before considering climate implications. Factoring in the need for emissions reductions makes all of the above barriers, as well as updating and strengthen existing measures and standards important areas for government investment. Efforts to decarbonize the state's economy will change many aspects of energy production and consumption, and as such it is reasonable to expect that there will be a large number of market barriers, beyond those listed here, which when remedied will offer net benefits.

Many of the complementary policies laid out in the Scoping Plan build on past efforts to remove market barriers. These complementary policies seek to address the cost and market category as well as industry structure and infrastructure category to varying degrees, but additional government investment will likely be needed to comprehensively address market barriers. The Scoping Plan's renewable portfolio standard (RPS) works toward remedying some of these market failures, but additional policies, for instance a feed-in tariff (FiT) or on bill financing (OBF), could support deployment while also addressing market barriers.

Another major concern related to market barriers can be seen in the often cited McKinsey report which examines the cost and magnitude of potential abatement measures (2007). The report found that there are number of measures which could reduce emissions at a savings with no price on the GHG-externality. Even in the state of California, which has been working to remove barriers and realize cost effective energy saving measures since the 1970's, analysis shows there are measures which could reduce emissions for overall savings (Sweeney 2009, 5). The fact that these opportunities exists, as well as numerous other energy efficiency opportunities (Golove and Eto 1996), indicates that failure to address major market barriers will result in a higher total cost of implementation. Market barriers left unaddressed will require higher prices before firms undertake actions that would have been cost effective in lower price regimes had the barriers been removed.

3 Government Investments of Revenue

Thus far various potential uses for allowance value have been discussed, and through this discussion a number of possible government investments have been raised. This section is devoted to looking explicitly at these government investments as well as noting specific investments which can address the following five allowance value uses, all of which are all forms of government investment:

Forms of Government Investment	Justifications
1. Research, Development and Demonstration	Market Barriers
2. Incentives & Support[4]	Market Barriers, Non-GHG Externalities
3. Addressing Adverse Impacts	Fairness and Equity
4. Funding Adaptation and other public goods	Public Goods
5. Supporting Environmental Justice Goals	Fairness and Equity, Non-GHG Externalities

Table 3-1

3.1 Committee Recommendations on Investment

The committees and the Scoping Plan lay out a number of different possible uses for allowance value, many of these recommendations are forms of government investment. Recommendations for government investment from the Scoping Plan and the committees, and what form of investment they represent, are addressed in this section.

3.1.1 Scoping Plan Suggestions

The Scoping Plan includes a number of policies which complement C&T. The rationale for these complementary policies has a good deal of overlap with the justification for government investments funded by allowance value (Market Advisory Committee 2007; Economic and Technology Advancement Advisory Committee 2008). Many of these policies are actually standards or mandates rather than explicit government investments, like the Light-Duty Vehicle Greenhouse Gas Standards as well as the RPS. The only major existing government investment program in the Scoping Plan is a program offering incentives for rooftop solar, the Million Solar Roofs Initiative (California Air Resources Board 2008, 20).

3.1.2 ETAAC Recommendations

ETAAC makes a number of recommendations relating to government investments, and proposes the creation of a California Carbon trust as a vehicle to direct these investments:

> "A California Carbon Trust could serve four important roles as the manager of an incentive fund for carbon and other GHG emission reductions in California. Its primary purpose would be to achieve GHG emission reductions beyond those coming from the AB 32 caped sectors, helping California to reach its ambitious reduction targets. The second purpose, closely linked to the first, would be to further the Environmental Justice goal of empowering communities to take part in achieving emission reductions of both carbon and other criteria toxic pollutants…. And the fourth role would be to fund University research and "first project" demonstration financing in areas where private sector funding is lacking. The Trust's activities could start prior to 2012, jump-starting GHG emission

[4] Note the distinction between incentives and support. In this context support is specifically referring to funds enabling certain actions to take place. Support should be thought of as funding land use and transit planning as well as energy efficiency programs which are not explicitly targeting increased demand, like low-income weatherization. Incentives refer to funds and/or programs which attempt motivate a certain course of action, for example rebates for energy efficient lighting.

reductions in California, helping to establish an early price signal for carbon and other GHG emissions" (2008, 2-4).

The committee notes that there is value in having an institution responsible for directing investments which can maintain perspective on the bigger picture of combating climate change past 2020. Modeled after the UK Carbon Trust, ETAAC envisions this entity as managing various functions relating to the carbon market as well as undertaking several different government investment efforts. The authors suggest the Trust would work toward environmental justice goals by explicitly considering and valuing co-benefits as well as GHG abatement when considering projects and investments. Additionally the Trust would be tasked with fostering RD&D by funding universities as well as demonstration/first-production facilities.

RD&D and deployment incentives are both a major focus of ETAAC. The committee particularly focuses on bridging gaps between demonstration and commercialization in the financing of new technologies. ETAAC cites analysis done by the UK Carbon Trust which finds that deployment of technologies requires 40 times amount of resources that are required for RD&D of projects (2009, 1-8). As a part of an overall effort to make a commitment to RD&D, ETAAC suggests: supporting demonstration finance, targeting RD&D funding for carbon reductions, investing in California's centers of innovation and engaging the private sector. ETAAC also offers a number of suggestions relating to innovative financing strategies. These strategies, like OBF and property assessed clean energy (PACE), could be established for relatively low cost while their actually financing would come from other sources (Economic and Technology Advancement Advisory Committee 2009).

3.1.3 EAAC Recommendations

The EAAC authors build on the numerous recommendations generated in the process to date and offer the greatest range of potential government investments. Their recommendations are explicitly broken up by form of investment.

RD&D

The EAAC recommendations on research, development and demonstration largely echo the ETAAC recommendations without much specific detail. The authors note that there is some spillover where other parties can benefit from RD&D investments in new technologies and as a result there is often under-investment. The overall suggestion is that additional funding may be necessary to bring projects through the demonstration/pre-commercialization phase of the product lifecycle (2010, 51).

Deployment Incentives and Support

The authors make a number of recommendations related to incentives and support for the deployment of technologies and implementation of emission reductions. The report notes that the Scoping Plan does not explicitly address some aspects of residential energy efficiency, and that there is no program for industrial energy efficiency. Both of these areas are possibilities for government investments directed at supporting efficiency efforts (2010, 51). EAAC also recommends considering investment tax credits to motivate earlier adoption of technologies, as well as low or zero cost loans to help small businesses facing high up-front costs (2010, 55). The authors suggest investing to support land use planning and public transit. Land use planning efforts, which take place on local and regional scales, have long time horizons but generate large savings (Cambridge Systematics 2009; Sacramento Area Council of Governments and Valley Vision n.d.). The authors note this long payback and recommend that these investments should be undertaken as early as possible (2010, 52).

The authors also suggest leveraging local and regional government entities' ability to effectively target local emission reduction efforts and aid disadvantaged communities by making these entities into vehicles for government investments (2010, 55). Similarly there is recommendation for CARB to establish an Investment Advisory Board which would serve as means of comparing investments and applying the criteria of: cost effectiveness, fairness, environmental effectiveness, simplicity, transparency, and accountability (2010, 56).

Adverse Impacts

In the report there are a number of recommendations focused on limiting adverse impacts with suggestions for possible courses of action to protect low-income households, prevent emissions leakage, fund environmental remediation and aid workers with transition assistance. Other researchers working with Next 10 will be exploring emissions leakage in depth, and as such this work will not address government investments directed at remedying this problem. It is unclear to what extent funds to address environmental remediation will be needed, and the EAAC proposes a contingency fund specifically for this issue (2010, 47). With regard to worker transition assistance the report notes that there is an existing infrastructure from the Federal Trade Adjustment Assistance program which aids workers who lose their jobs or fulltime status due to firms leaving for foreign production or purchasing from foreign suppliers (2010, 47).

Pricing the GHG externality will be regressive as lower-income households spend a greater percentage of their income on energy (Boyce and Riddle 2009). Initial analysis suggests that a very small portion of total allowance value will be needed to protect low-income households from these regressive impacts (Kunkel and Kammen 2009). Drawing on the Kunkel and Kammen work EAAC found that the total allowance value needed would be on the order of one percent (2010, 40) which suggests that it safe to assume low-income protect will be in the range of ten percent of total value if not much less. EAAC recommends addressing low-income impacts with financial transfers directly to low-income households (2010, 65-66).

Adaptation and Public Goods

EAAC notes the importance of investing in adaption in the face of the potential consequences facing the state due to climate change impacts (California Natural Resources Agency 2009). Through the process of creating a climate adaptation strategy for the state, a number of areas in need of greater research as well as investments in adaptation have been identified. EAAC recommends directing some allowance value towards these efforts to ensure agencies are adequately funded to carry out the adaption strategy (2010, 54). The report also suggests using some allowance value for investments in job training to ensure that the state has a sufficient supply of workers adequately trained for jobs created in the green economy (2010, 53).

Support for Environmental Justice Goals

EAAC recommends directing investments toward disadvantaged communities where substantial improvements can be made by addressing disproportionate environmental burdens. Specifically EAAC recommends the creation of a Community Benefits Fund which could serve as vehicle to direct investments to these communities. The CBF could channel funds to projects which are focused on reducing emissions of both GHGs and co-pollutants as part of a process of minimizing public health impacts caused by climate change. Activities might include things like: "upgrade energy efficiency in schools, senior centers, and low-income housing; improve the quality and accessibility of public mass transit, including fare subsidies to commuters; engage in transportation and land use planning" (2010, 54).

3.2 Types of Investments

Of the five different forms of allowance use for government investments laid out at the beginning of this section (Table 3-1) we can think about broadly separating them into two categories. One category is made up of investments which are targeted at driving the mitigation of climate change, and the other is made up of investments related to managing the impacts of both mitigation and climate change itself. The RD&D, and incentives & support forms of allowance use can be thought of as fitting in the former category while addressing adverse impacts, funding adaption and public goods fall into the latter category. Generally speaking using allowance value to support environmental justice goals should be considered in the category of investments managing impacts, but it is worth noting that a subset of this form value use, like the proposed CBF, relates to investments driving mitigation.

3.2.1 Investments Driving Mitigation

By investing a dollar of government money today on deployment of an existing technology we are effectively investing in a reduction of emissions today. Whereas directing that same dollar toward research and development would be effectively investing in a reduction of emissions tomorrow. It is useful to think about these two different types of investments in the driving mitigation category as representing a continuum. Using allowance value to fund RD&D investment clearly trends towards the "abatement tomorrow" end of this continuum, where as incentives for currently deployed technologies represents the opposite end of the continuum, "abatement today."

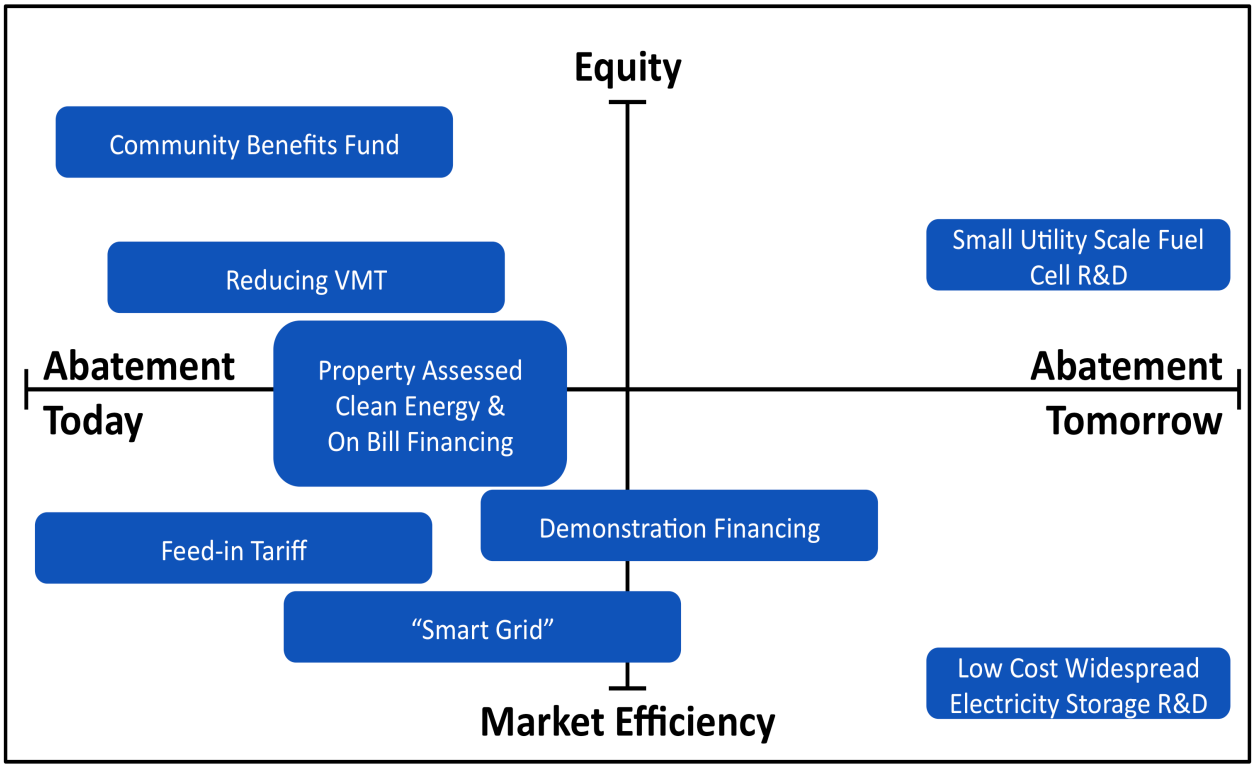

Figure 3-1: A selection of possible government investments to illustrate the space of possible types of investments.

Directing allowance value to mitigation investments for equity considerations, like environmental justice goals, or to investments in an effort to remove market barriers can also be thought of in terms of a continuum. If we combine these two continuums they span a space which represents the different types of possible government investments for driving mitigation as depicted in Figure 3-1.

For example we might think of the CBF falling towards the “abatement today” and “equity” ends of the continuums and as such representing the abatement-today–equity quadrant of this space at some distance from the intersection of axes. The fund would be focused on selecting projects which immediately reduce emissions in disadvantaged and or disproportionately impacted communities. This would be contrasted by something like investing dollars today in R&D for low-cost widespread storage of electricity. At some distance from the intersection of axes in the abatement-tomorrow–market-efficiency quadrant, this sort of investment seeks to drive emissions reductions in the future once the technology is deployed and focuses on making electricity markets more efficient.

3.2.2 Investments Managing Impacts

In contrast with the driving-mitigation category, there are two distinct sub-types of investments in the category aimed at managing impacts. Investments addressing adverse impacts can be thought of the type of investments in this category which are managing the impacts of the policy to combat climate change. Whereas the other major type of investments are those which attempt to manage the impacts climate change, namely adaptation.

4 Aggregate Social Benefit

Having addressed the two different categories of investment, a means of comparing the value of different investments would be very useful in prioritizing investments of interest. We can capture a portion of the value of mitigation investments by simply considering the cost of abatement as compared to market price of allowances. However as the rational for government investment section noted, there are additional issues which represent a cost or benefit to society associated with each possible investment. When considering the value of investments which attempt to manage impacts, which may translate very poorly, if at all, into terms of dollars per ton of abatement, the usefulness of some uniform metric of comparison becomes all the more evident.

In proposing an Investment Advisory Board the EAAC discusses a cost-effectiveness criterion which would be a net measure of cost and benefit that is "more comprehensive than what is sometimes applied. In addition to capturing the direct investment cost (the setup cost and present value of operating costs), [the metric] needs to account for the costs of removing the relevant market barriers as well as the various external benefits from the investment" (Economic and Allocation Advisory Committee 2010, 56). This expanded measure of cost-effectiveness, or aggregate net social benefit which represents the aggregated social benefit less the costs, would be a useful means of comparing different potential government investments.

4.1 Compiling Aggregate Social Benefit

A well constructed measure of aggregate net social benefit should capture all of the expected major drivers of benefit in addition to the costs of possible government investment. With a well functioning carbon market we would expect allowance prices to act as a reference point for any proposed measure of abatement. And while the setup costs and present value operating costs of abating a ton of emissions are generally easily to quantify, the cost of overcoming market barriers and the value of external benefits for different government investments are much harder to quantify. Estimates of ancillary benefits from GHG mitigation policies suggest that these benefits are likely to be on the same order of magnitude as the climate benefits (Muller, Groosman, and Oneill-Toy 2009; Berk et al. 2006). While studies of this nature demonstrate that we can expect non-trivial ancillary benefits from mitigating emissions, these macro-estimates are of little value in comparing actual potential investments. A macro-estimate which aggregates the benefits of all possible investments would not distinguish between the timing or scale of ancillary and climate benefits of individual investments.

It is likely most effective to separately assess the components which are expected to be major drivers of ancillary value. This work has identified five major components: health benefits, green job benefits, non-climate ecological benefits, social and community benefits, and market barrier benefits. Each of these benefits has uncertainties and associated difficulties with quantifying the actual value arising from a particular investment. If it is possible to quantify the value arising from each of these benefits while also accounting for timing and scale, then total sum of these benefits for a given investment could be thought of as one simple formulation of aggregate benefit.

4.2 Health Benefits

A number of large studies have looked at the externalities associated with energy, particularly the combustion of fossil fuels, and health damages from air pollutants make up the majority of damages arising from these externalities (National Research Council 2009; Burtraw and Toman 2000; Davis, Krupnick, and McGlynn 2000). The NRC undertook a particularly comprehensive study which calculated damages from criteria pollutants arising from various forms of energy consumption. That study found that natural gas-fired electricity had mean damages of 0.16 cents per kWh, which was an order of magnitude less than coal-fired damages, and mean transportation damages covered a range, 1.2-1.7 cents per Vehicle Miles Traveled (VMT), depending on vehicle class (2009).

Of course these values contain a large amount of uncertainty, but we could calculate health benefits for potential investments on a simple basis of fossil fuel kWh avoided by sources which do not produce criteria pollutants or VMT reduced.[5] It is worth noting that for health damages there is a tight spatial and temporal linkage between the pollution and its impacts. The study underlines that the above figures are mean values and notes that for electricity the distribution is highly skewed toward high damage plants and for transportation the lifecycle damages of the fuel are averaged over the county where the fuel is consumed. The averaged metrics may overestimate or underestimate health damages, given the distributions and modeling assumptions together with the tight spatial linkage to damages for transportation in California underestimation appears to be more likely. However when this kind of health benefit calculation can be carried out it is much easier to quantify as compared to some of the other drivers of the aggregate benefit, even when accounting for the uncertainties.

4.3 Green Job Creation

Large scale energy efficiency efforts together with large scale deployment of low carbon technologies will create new jobs in the green economy. One study found that low carbon and renewable energy sectors generate more jobs on a per unit of energy delivered basis than the fossil fuel-based sector (Wei, Patadia, and Kammen 2010), while another study indicates that clean-energy investments yield more jobs than investments in carbon based fuels for an equivalent amount of money (Pollin, Heintz, and Garrett-Peltier 2009). While AB 32 will impose new costs on many industries and there is a possibility some jobs may be in jeopardy in carbon-intensive sectors, the bill is expected to generate a net increase in jobs with growth in green sectors (Zabin and Buffa 2009; Roland-Holst 2008). With both job creation and potential job loss it is important to consider whether the effect will occur over the short run or the long run. We might expect potential job loss to occur quiet gradually as tighter emissions budgets have an increasing impact on carbon-intensive sectors. Similarly we would expect green jobs creation

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[5] It would also be possible to calculate the benefit of improved light duty vehicle efficiency by using the damages/gallon values in the report, 23 to 38 cents per gallon (with gasoline vehicles at 29 cents per gallon). The report notes that interpretation of damages per gallon is not as straightforward as damages per VMT, with higher fuel efficiency fuel/technology combinations appearing to have markedly higher damages per gallon than those with lower efficiency, solely due to the higher number of miles driven per gallon (National Research Council 2009, 10).

gradually over the long run. While many of government investments discussed thus far may have some positive short run job effects, this report only focuses on the aforementioned gradual long run effects for green job creation benefits.

To the extent that new jobs expand the workforce or otherwise lower unemployment then they can be thought of as an ancillary benefit of particular investments. The meta-study conducted by Wei, Patadia, and Kammen reviewed 15 recent studies on the job creation potentials of energy efficiency, renewables, and low carbon sources of power (2010). The paper finds average numbers for jobs per total capacity of technology installed, jobs per average capacity (nameplate capacity de-rated by the capacity factor) and person-years of full time employment per gigawatt-hour. If this job creation is greater than the fossil-fuel alternative, then the difference represents a net job creation benefit. In comparing levels of different job creation from different investments, it will be important to consider the differences in estimating direct jobs created (jobs from designing, manufacturing, constructing/installing, managing, operating and maintaining) from estimating indirect jobs created (jobs from upstream and downstream supplier effects) from estimating induced jobs (jobs arising from expenditure effects in the general economy from economic activity and spending of direct and indirect employees).

A number of studies have also examined what types of jobs are likely to be created (Pollin, Heintz, and Garrett-Peltier 2009; Henton et al. 2008; Zabin and Buffa 2009; Roland-Holst 2008). By identifying types of jobs, average wages per job, or an average wage per job for a given technology can be determined. Determining which particular jobs should be considered additional as compared to a fossil-fuel alternative is likely a complicated task, and it may be as effective for the purposes of comparing between different government investments to use the mean of total job value. In this instance the green job benefit would be represented by the additional jobs multiplied by the mean wage. This calculation would be highly dependent on comparing uniform units between investments, either on a per unit energy or a per unit of capacity basis. As with the other benefits, this calculation would contain a good deal of uncertainty, but it would provide readily quantifiable values.

4.4 Ecological Benefits

As compared to health benefits and green jobs benefits non-climate ecological benefits will likely be more difficult to assess through a common denominator like damages per VMT or dollars per job created by wind power deployment. Benefits realized from ecological improvements are likely to be on smaller temporal scale than benefits of mitigating climate change, but likely a larger spatial and temporal scale than health or job benefits. Diffuse benefits are further complicated by a need to understand the key economic and ecological relationships to be able to attempt to quantify benefits. On this point an NRC report on valuing ecosystem services argues the difficulty of understanding these economic and ecological relationships “strongly suggests that the valuation exercise will be very context specific and that a single, ‘one-size-fits all’ or ‘cookbook’ approach cannot be used. Instead, the resource manager or decision maker who is conducting a study or evaluating the results of a valuation study must assess how well the study is designed in the context of the specific problem it seeks to address” (National Research Council 2004, 15-16).

And while there are estimates of global ecosystem services (Costanza et al. 1997), as well as a growing number of tools to attempt to value ecosystem functions (de Groot, Wilson, and Boumans 2002; Cropper 2000) these valuations do not readily translate into understanding what a 5 percent change in ecosystem services might mean for a change in the value of those services. The NRC report on the hidden costs of energy recognizes these factors and leaves its discussion of non-climate ecological impacts to a largely qualitatively one. The report notes some specific cases of ecological impacts which relate to practices and localities, like raptor deaths at wind farms in the state (2009, 103), but these are not readily averaged across large areas nor treated on a macro-scale.

Ecological benefits should be assessed on a project-by-project basis. The ecological benefit from investment to investment will likely vary dramatically as the specifics the location and the duration of its effect matter greatly.

4.5 Social & Community Benefits

Using allowance value to target environmental justice goals is likely to generate some social benefit for disproportionately impacted communities. With regard to this potential effect as a result of a CBF, the EAAC report states: “a variety of organizations focusing on low-income and minority community empowerment (e.g., The California Utilities Diversity Council and the Ella Baker Center for Human Rights) have found that investments in job training and initial seed capital can benefit the wider community by boosting economic activity and by reducing premature school-leaving and unemployment and the associated social costs” (2010, 54). These benefits are likely very difficult to value, but argue for a recognition that investments into low-income and minority communities may well generate greater social benefit than similar investments elsewhere.

However, at least in the near-term, social and community benefits are likely to be dominated by the health benefits of reducing disproportionate health damages in the process of working toward environmental justice goals. While C&T is built around a recognition that GHGs, particularly CO_2, are long-lived, well mixed pollutants and their impacts to the climate lag significantly behind the time of their emission, neither of these factors hold for co-pollutants creating health damages. With regard to social and community benefits of lessening these co-pollutant damages, the ratio of co-pollutant damages to CO_2 emissions varies across regions, sectors and polluters (Boyce 2009, 3). The county level health damages cited in the health benefits section do not capture this distinction as do not directly relate CO_2 emissions to co-pollutant burdens. Additionally sources with high CO_2 emissions and typically very high ratios of co-pollutants to CO_2 have a disproportionate impact on communities of color (Pastor et al. 2010). Many of these sources are refineries, and because the health damages figures for transportation are averaged over the county of fuel consumption rather than the county of fuel production this disproportionate impact is not captured.

One way to capture this facet of social and community benefits could be to weight investments which further environmental justice goals more heavily than investments that do not. The Minding the Climate Gap report constructs a pollution disparity index which ranks polluters by the extent that their emissions lead to disproportionate burdens as compared to other polluters (Pastor et al. 2010). This index could be used as a weighting factor for investments that may lower emissions from the sources with the greatest pollution disparity. This would effectively recognize both that health benefits of investments reducing emissions at these sites are undercounted as well as the fact that these investments are working towards remedying historical inequitable distributions of environmental burdens. Constructing this weighting factor would be a complicated exercise, as it would create an implicit value of addressing disproportionate pollution burdens which undoubtedly would be hotly contested.

4.6 Market Barrier Benefits

There is a cost to correcting and overcoming market barriers. As EAAC notes, this is one reason why a number of measures which have been identified as leading to net savings have not been undertaken (2010). The authors also explicitly call for the inclusion of these costs when establishing the cost-effectiveness of a particular measure or investment. While a number of measures have been identified as creating large savings per unit of abatement yet have not been undertaken due to the cost of market barriers (McKinsey & Company 2007) collective action, through government investment, will likely be more efficient than individual action for overcoming these barriers. Many of the standards set by the CEC offer an example of collective action yielding net benefits where individual efforts largely had not overcome barriers. Under C&T, we would expect the marginal cost of abatement to be higher with market barriers in place than if these barriers were removed. For individual measures, a market barrier represents a cost. But for policies targeted at removing or lessening these barriers the cost savings from the resulting lower carbon prices over time represent a benefit.

While several modeling efforts have been undertaken to look at the total cost of implementing AB 32 using various scenarios of complementary policy implementation (California Air Resources Board 2010; Roland-Holst 2010; Charles River Associates 2010), this research found no efforts to explicitly address how complementary policies targeted at removing market barriers might impact carbon prices over time. Results vary between models, with some models suggesting complementary policies lower the cost of implementing AB 32 (California Air Resources Board 2010) while others find the benefits of lower carbon prices are lost to higher total costs of implementation (Charles River Associates 2010). The value of removing market barriers would be spread across all capped sectors, not just those subject to the market barrier, as it should effectively shift the marginal cost of abatement curve. This value can be thought of as persisting over the life of the C&T program, which makes it preferable to remove market barriers early in the program. AB 32 sets a target for 2020, but removing market barriers in this decade should continue to yield savings as the state strives for even deeper abatement to reach 2050 targets.

Calculating the market barrier benefit of particular polices will require macro-economic modeling efforts which compare scenarios with the policy in question and scenarios without the policy. The difference in carbon costs between these sets of scenarios can be thought of as representing the value of removing that particular market barrier.

5 Priority Investments

Thus far recommendations coming out of the various committees have all represented a number of priorities. This section notes some additional matters which likely merit consideration as priorities for government investment as well as an incomplete list of priority investments by allowance value use.

5.1 State Specific Considerations

While many of the recommendations throughout the process thus far might be argued as having similar importance in a different state or in a federal policy, there are some considerations that are specific to California which have not yet been addressed. There are two considerations for California which merit discussion, state level funding of energy R&D and transportation.

5.1.1 State Energy R&D

California spending on energy R&D is significantly less than federal funding for energy related R&D (DeCillis 2008). Many innovations in the energy sector arise out of basic research and development which requires a scale of sustained funding that can only be achieved on the federal level, and even greater funding will be needed moving forward to meet challenging GHG reduction goals (Nemet and Kammen 2007). State energy R&D is typically focused on achieving somewhat different ends than federal energy R&D. The Public Interest Energy Research (PIER) program typically represents the majority of energy funding administered by the state and carries out research that is not adequately provided for by competitive and regulated markets (see table 7 in Appendix C). PIER was created in 1996 and is supported by surcharges on natural gas and electricity consumption. The CEC annually administers roughly $85 million annually to support research on topics like demand response through PIER (California Energy Commission 2010).

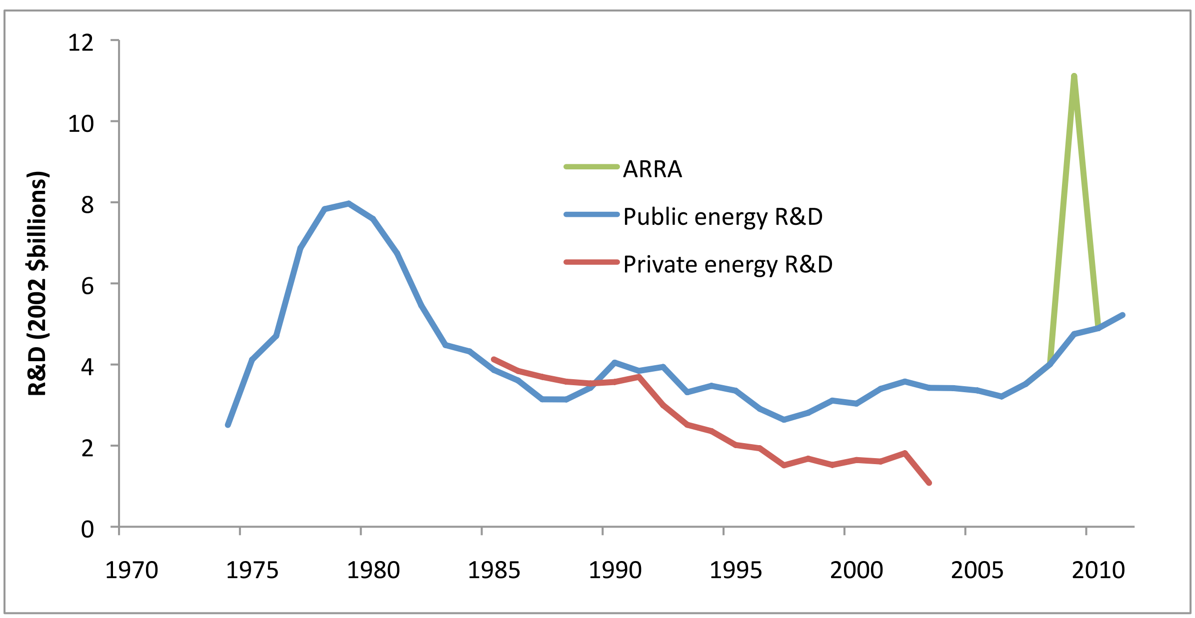

Figure 5-1: An updated version of a figure from the Nemet and Kammen paper (2007) including funding through estimates in 2011. Note the American Recovery and Reinvestment Act funds in 2009, as well as the scale of investment as compared to

approximately $100 million per year from the CEC (DeCillis 2008). Updated data from (Gallagher and Anadon 2010), see Appendix for more information on federal and state R&D programs.

It is also important to consider the contrast in stability between federal and state. Both PIER and the recently created Alternative and Renewable Fuel and Vehicle Technology Program[6] depend on stable sources of funding rather than a budgeting and appropriations process. Contingent on how allowance value is divided between government investment and other uses, allowance value as a source for R&D funding could be just as stable a source of funding as existing current state programs or it could be less predictable. However it is likely that allowance value as a source of funding will be more stable than federal funding.

While ETAAC has called for directing some allowance value use to California universities and colleges to foster low-carbon RD&D, the broader range of recommendations have emphasized a wide variety of investments. Assuming the status quo for energy funding continues, and given the stable nature of existing state R&D it is likely defensible to prioritize some other government investments over state energy R&D. This isn't to say that energy R&D is anything less than vital to ensuring continued innovation and bringing new low and zero emission technologies in the future. If other government investment goals appear to be achievable and there is remaining allowance value sufficient to fund additional energy R&D on the same order of magnitude as PIER and with similar consistency then using this value to fund R&D should be a high priority. There are numerous vehicles already established to direct energy R&D funding in the state. Additionally, there should be some consideration to dramatically reprioritizing uses and shifting funding if federal energy R&D efforts in the state, which are numerous, are materially disrupted or prove to otherwise be unstable.

[6] Details in Appendix C

5.1.2 Transportation in California

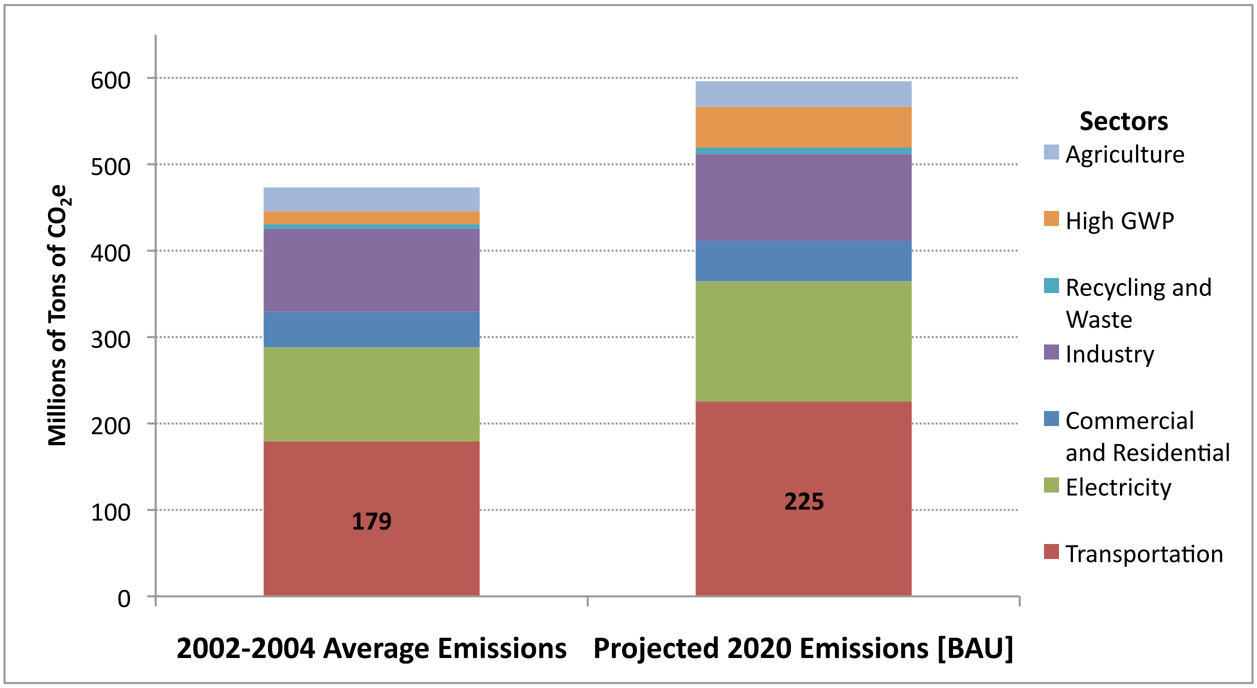

Figure 5-2: Transportation made up 38% of California's emissions for the average emissions over 2002-2004. The Scoping Plan projects transportation will still make up 38% of all emissions in 2020 under business as usual (BAU) (California Air Resources Board 2008, 12).

Transportation will likely prove to be one of the most difficult sectors to drive GHG abatement in California. Transportation emissions make up just under 40% of total GHG emissions in the state, over 70% of which is from light duty vehicles, and transportation emissions are projected to represent the same share of total emission in 2020 (Figure 5-2). A simple back of the envelope calculation shows that every dollar per ton of CO_2e equates to roughly an additional cent on the price of a gallon of gasoline.[7] Given the relative inelasticity of VMT per fuel price (Parry, Walls, and Winston Harrington 2007) it seems very unlikely that pricing carbon alone will greatly reduce emissions from the transportation sector. The decreasing carbon content of fuels, spurred in large part by the Low Carbon Fuels Standard (LCFS) complementary policy, should help ameliorate pressure to lower VMT. However technological implementations of lower carbon fuels may face the hurdle of slow infrastructure deployment and slow turnover times for the vehicle fleet. Finally, oil refineries are a major cause of disproportionate environmental burdens and reducing their emissions will work toward supporting environmental justice goals (Pastor et al. 2010).

Any policies that can effectively aid in reducing emissions from the transportation sector should be seriously considered. The Scoping Plan integrates vehicle efficiency and low carbon fuel standards, but additional policies should be examined. One possible candidate is a fee-bate policy. Fee-bates impose a fee on higher emitting vehicles within a class and uses that revenue to offer a rebate on lower emitting

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[7] There are 2.42 kg of carbon per gallon of gasoline, which is equal to 8.87 kg of CO_2 per gallon, which equates to approximately one hundredth of a ton per gallon of gasoline.

vehicles in that same class, and it has the potential to increase the efficiency of all vehicles, regardless of size (Mims and Hauenstein 2008). With a very small amount of allowance value a fee-bate program could be implemented and administered; the program could also potentially add a small subsidy to the rebates using a fraction of total allowance value. Land use planning should also be fully funded to enable some of the structural changes needed to allow for reductions in VMT.

5.2 Early Investment in Lasting Impacts

Early investment in areas with long but potentially very large paybacks should be a priority for early government investments as efforts to mitigate climate change begin to ramp up. Efforts to fund land use and transit planning as well as policies which target market barriers hold promise as early investments with lasting positive benefits. EAAC cites several studies indicating "that investing in land use planning is highly cost effective" generating savings in both infrastructure and mitigation costs (Economic and Allocation Advisory Committee 2010, 52). Similarly investments in transit planning should be expected to generate long lasting savings. Ensuring that land use and transit planning taking place on the regional and local level is sufficiently funded for the implementation of SB375 should be a relatively straightforward and inexpensive process.

Working to removing the market barriers early in the program also presents the possibility of creating persistent savings by lowering the costs of numerous mitigation options. A number of policy measures, like OBF, PACE and other novel financing mechanisms, can address some market failures at a relatively low cost. However many other policies targeting market barriers will consume a comparatively large portion of total government investment, and will likely be more complicated to implement. While there are complementary policies in the Scoping Plan which can be thought of as targeting market barriers, most notably the RPS and the LCFS, there may be additional measures which could aid in cost effectiveness and environmental effectiveness goals for AB 32. One possibility is a targeted expansion and revision of California's existing feed-in tariff (FiT) program.

A FiT program offers guaranteed payments, or contracts, over a set term with specific operating conditions to eligible participants. The upfront certainty around these contracts is intended to motivate private investment by effectively decreasing the risk associated with projects. On a superficial level, these contracts may seem un-necessary while GHG emissions are being priced through a C&T system. With the volatility we expect from an allowance market, like any commodity market, and have seen in the European Union Emissions Trading Scheme (Denny Ellerman and Joskow 2008) fixed price contracts can offer value to investors. An expanded but targeted FiT could be useful for technologies which face otherwise difficult to address market barriers or are expected to reach much wider and cheaper deployment as greater installations push them down the cost curve.

FiT programs have been much more common in Europe than the US, and Germany is often cited as an example of their success in driving deployment. Using a FiT program Germany increased total generation coming from renewables from 6.3 percent in 2000 to 11.9 percent in 2006 which was just shy of their 12.5 percent target for 2010 (Rickerson, Sawin, and Grace 2007). The debate over whether FiT or other measures, most often a variation on an RPS, is the most effective means of incentivizing deployment and innovation has been contentious in Europe (Butler and Neuhoff 2008; Fouquet and Johansson 2008; Menanteau, Finon, and Lamy 2003). However several studies suggest that FiT programs can be designed to work synergistically with an RPS (Cory, Couture, and Kreycik 2009; Rickerson, Sawin, and Grace 2007; Couture and Cory 2009).

There are some advantages of using FiTs to as a targeted approach incentivizing to certain technologies or sectors. In the context of Europe numerous studies argue that they have the ability to deliver larger scale and more cost effective deployment than alternative policies (Stern et al. 2006, 366; Lipp 2007; Butler and Neuhoff 2008; de Jager and Rathmann 2008). Other work suggests that FiTs can spur innovation across a wider variety of technologies (Fouquet and Johansson 2008) and generate greater incentives for producers to drive innovation (Menanteau, Finon, and Lamy 2003) as compared to alternative policies. Analysis of the German program suggests that it is cost effective largely on account of increased exports and job creation arising from growth in renewable industries (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2008).

Creating a cost effective FiT as an additional complementary policy funded by allowance value will depend critically on the design of the remuneration model as well as the eligible technologies. As is the case with the current FiT program in California, the program should be targeted at specific technologies. The goal of the expansion FiT should not be to incentivize the deployment of proven technologies, but rather to address demonstration costs and risks barriers while also stimulating private RD&D in promising fields. Funding FiT contracts with allowance value would be a departure from the model most prevalent in Europe, where the contract rates paid to participants are funded by ratepayers. Using allowance value is effectively like having energy consumers, rather than just ratepayers, fund the program.

The remuneration model will also be important in a cost effective expansion of the existing FiT program. Several novel implementations of FiTs have been discussed in literature (Lesser and Su 2008; Couture and Gagnon 2010). A spot gap remuneration model, where a price for energy is guaranteed to participants when the market price is below that contract rate otherwise participants receive the market price (Couture and Gagnon 2010), could take advantage of the expected price rises in energy from pricing GHGs while limiting government commitments to long term contracts. The rational for this model is that the certainty provided by these agreements early on in the C&T program would allow for certain technologies and their accompanying barriers to be addressed and to simulate innovation earlier than otherwise would have been the case. The actual process of funding long term contracts with allowance value would likely be complicated, particularly as the C&T program is currently only slated to run through 2020 while many FiT contracts last for 15 or 20 years. This makes careful design of a remuneration model all the more important.

5.3 Priority Forms of Investment

Having established the different forms of allowance use, types of investment and the priorities for government investment it is now possible to list some of the investments which are high priorities. It is important to recognize that there are numerous goals and efforts contained within AB 32 all of which work toward a larger goal of abating emissions. This broad set of goals is the basis for a wide range of justifications for government investment. Given this range of justifications, it wouldn't be reasonable to select only a few investments to identify as priorities.

The table below represents a collection of the numerous recommendations, grouped by form of investment, reviewed throughout this document and should not be interpreted as a comprehensive list. The "Relative Share of Investment" category represents a qualitative estimate of the total share of government investment which is expected to be necessary for that particular investment or program to produce a net social benefit. These investments are still relatively broad categories, and ideally as details are worked out and sufficient data is available an aggregate social net benefit metric could be used to assess different options within each particular form of value use.

Investment	Relative Share of Investment	Description
Research, Development and Demonstration		
Demonstration Support	Moderate to Large	Investments directed at supporting demonstration can help technologies through the gaps in funding which often occur during the demonstration/pre-commercialization portion of a product's lifecycle (Economic and Allocation Advisory Committee 2010, 51). A targeted FiT can aid in this effort (Cory, Couture, and Kreycik 2009; Rickerson, Sawin, and Grace 2007; Couture and Cory 2009).
Incentives And Support		
Financing Mechanisms	Small	Relatively small amounts of allowance value would be needed to setup useful large scale financing mechanisms like PACE and OBF (Economic and Technology Advancement Advisory Committee 2009).
Land Use and Transit Planning	Small	Land use and transit planning have long payback periods with high payoffs and as such they should be funded early. Additionally a number of beneficial plans are currently underfunded (Economic and Allocation Advisory Committee 2010, 52).
Fee-bates	Small	With refineries creating some of the highest pollution disparity in the state (Pastor et al. 2010), and transportation likely being the most difficult sector to generate major GHG reductions every policy which can effectively help reduce emissions in the sector should be considered. Fee-bates can be highly effective, and can be structured to be revenue neutral (Mims and Hauenstein 2008).
Addressing Adverse Impacts		
Low-Income Protection	Small	In addition to being explicitly called for in the text of AB 32, analysis suggests that protecting low-income households require a very small share of total allowance value (Kunkel and Kammen 2009).

		Protection should come in the form of direct transfers, not as energy price subsidies (Economic and Allocation Advisory Committee 2010, 65-66).
Adaptation And Public Goods		
Contingency Fund	Moderate	A contingency fund can ensure means are available to address unintended environmental consequences of implementation. If these consequences are not realized the funds could be redirected to another use (Economic and Allocation Advisory Committee 2010, 68).
Adaptation Fund	Moderate	Funding is needed to support research and implementation of the state's adaptation strategy (Economic and Allocation Advisory Committee 2010, 54; California Natural Resources Agency 2009). Revenue arising from efforts to combat climate change is a logical source for funding adaptation.
Support For Environmental Justice Goals		
Community Benefits Fund	Large	A Community Benefits Fund could serve as a vehicle for investments targeting disadvantaged communities and addressing disproportionate environmental burdens as well as reducing emissions. Investments might include things like energy efficiency for schools and low-income housing, improving and subsidizing public mass transit (Economic and Allocation Advisory Committee 2010, 54).

Table 5-1

It is also worth noting that there is likely a great deal of value in having a single entity to weigh investments against one another. This value arises both from ensuring a uniform methodology in constructing a metric of comparison as well as the ability to consider the relative share of allowance value flowing to different forms of investment. There are a number of proposals as to what this entity might be. EAAC suggests an Investment Advisory Board which would have a primary focus on government investments while ETAAC proposes a Carbon Trust which could take on the responsibility in addition to numerous others.

6 Practicalities

This section introduces topics for future consideration, which will need to be addressed as the process of implementation moves forward. The details around the flow of funding into government investments may matter a great deal for effective implementation these measures. This section is devoted to an initial consideration of the certainty of allowance value as well as the magnitude and timing of government investments.

6.1 Certainty

As the market will determine the price of allowances there is uncertainty around the value of future allowances. There is good reason to expect some amount of price volatility in the price as a result of the process of price discovery as well as general economic fluctuations. This expected variation in price together with the uncertainty of future prices presents a problem for efforts to split total allowance value with roughly a quarter it going to government investment and three quarters of it going back to households. Even knowing the future quantities of allowances available, sustained price swings could mean that the bulk of allowance value could be spread over a relatively small number of years or that it may be almost uniformly distributed across all years.

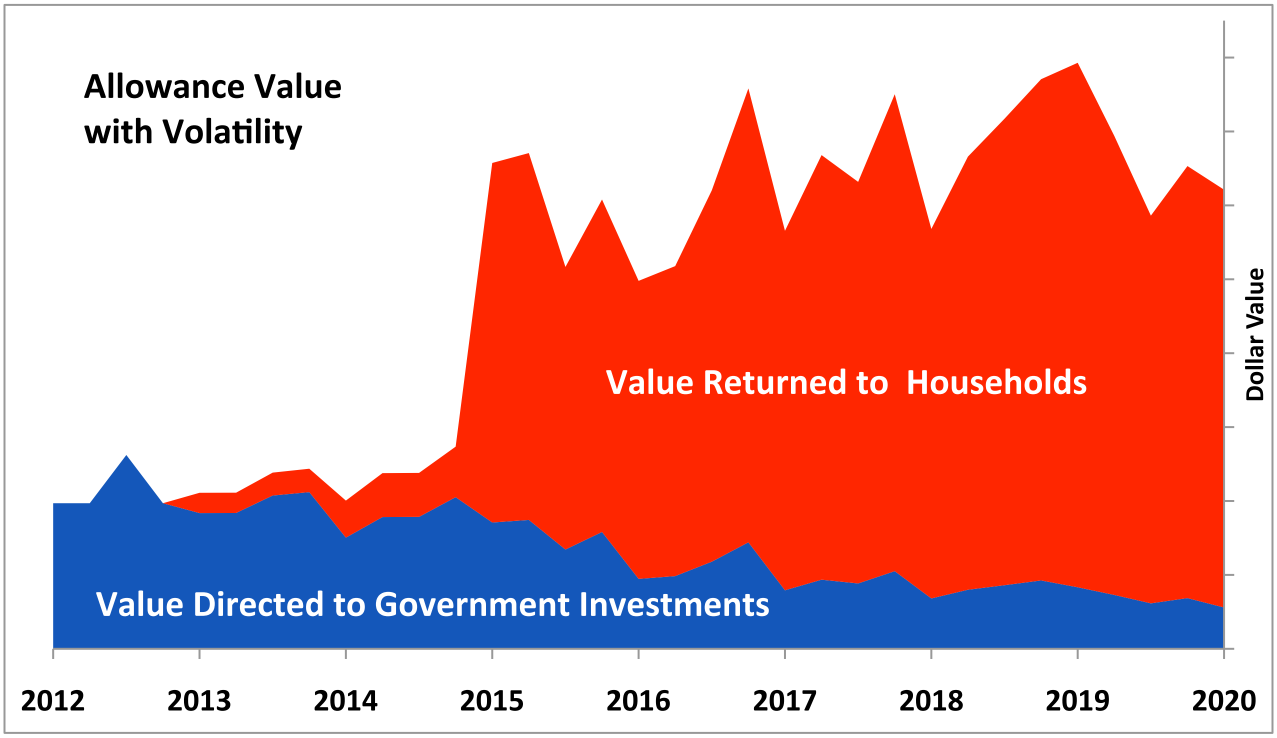

Figure 6-1: A hypothetical illustration of volatile allowance value which duplicates the trajectory for government investment as in Figure 2-2. The volatility in allowance price is reflected in the allowance value which funds government investments.

One way to address this uncertainty of allowance value is to simply not plan for the value allocated to each use but rather to employ a model similar to ACESA and plan for the number of allowances allocated to each use. In this relatively simple model every period in which allowances are distributed the total value of that distribution would be divided by some predetermined schedule of ratios. Figure 6-1 represents this model of dividing up allowance value, where, for the purpose of illustration, allowance value follows a predetermined split between uses which varies over time. Dividing total allowance value 3:1 is an extremely unlikely outcome with a predetermined schedule of distributing share of allowances to use.

This model ensures the fraction of allowance value going to each use at every allowance distribution, but it also passes along the volatility of allowance prices to each allowance use. While it may make little difference in returning revenue to households if in the next quarter allowance value is down 5 or 10 percent, it would seriously impact the effectiveness of some forms of government investment to receive a volatile source of funding. Some investments may be better suited to receiving fixed dollar amounts of funding, for example a FiT would likely benefit from the confidence based on the certainty of the number contracts to sign and support (Wang 2009). While other investments which accumulate funds may tolerate some volatility and potentially gain from expected upward price trends by receiving a fixed percentage of government investment. For the sake of clarity, consider this quality of a particular investment to be one aspect of its "character."

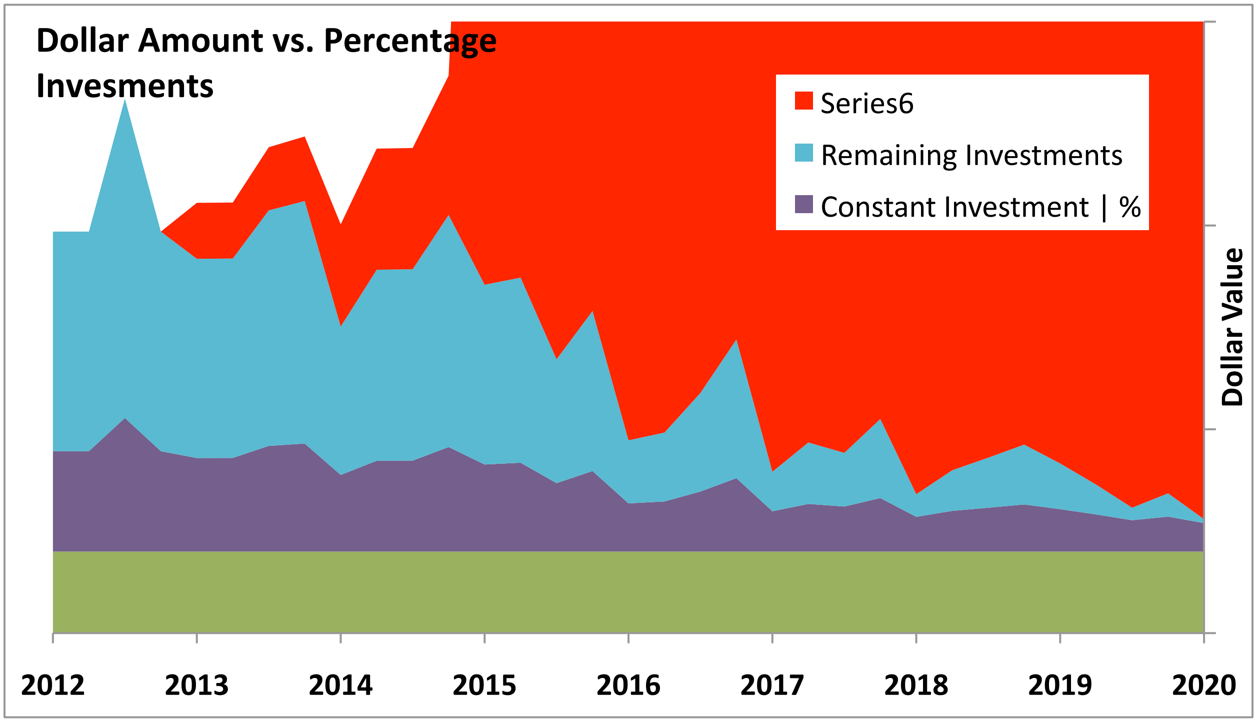

Figure 6-2: A hypothetical illustration of the difference between a constant investment based on dollar amount as compared to a constant investment based on percentage of total government investment. This figure is same as Figure 6-1 but with the scale zoomed in on the y-axis. Here government investments are broken into 3 subparts. The total value of government investment remains constant between this figure and the previous figure. Note that constant investment as a percentage of total government investment declines as the total government investment, which is a declining portion of total allowance value, declines over time as in figure 6-1.

6.2 Timing and Magnitude

The most effective timing of an investment is also an aspect of its character. For example land use planning will likely require a relatively small share of total government investment value and will be most effective if done early in the program and could be phased out in a short amount of time. This is part of the particular character of land use planning investments. Adding this aspect of character to the dollar vs. percentage aspect of investment character, which is conceptually represented in Figure 6-2, presents a situation where some investments may be better suited by declining over time whereas others potentially should increase, as illustrated in Figure 6-3. Additionally it may be preferable to ramp down some funding efforts over the life of the program whereas it may be preferable to ramp others up.

Operating under the assumption that investments are selected using some cost benefit analysis, it stands to reason selected investments are presumed to generate some level of benefit given some amount of investment. There is no reason to believe that this benefit should scale in an entirely linearly fashion with investment. It is also worth nothing that as the future is unknowable, and it is possible that your analysis was incorrect and in fact the costs were greater than the benefits even if an investment is funded as planned for its duration. However setting this aside as a reality of making a policy decision, if we assume that our analysis is correct at the time of the decision then we also know that at some point if investment falls far enough below what was anticipated in the justifying analysis we would expect that the costs would begin to outweigh the benefits. Consider this level of investment and above, where your policy is yielding as much or greater benefit as calculated to justify action, as a level of "adequate funding."

As long as investments have adequate funding, the character of an investment is likely of equal importance as the magnitude of funding supporting that investment. Improperly matching funding streams to investment character would be expected to dramatically reduce the calculated effectiveness, or benefit against cost, of these measures. The greater the deviations from the expected total allowance value directed to government investment the harder it will be to match funding streams with appropriate investment character. For instance waiting to remove major market barriers until the later years of the program would yield much smaller benefits than removing those barriers early in the program. Setting aside funding in late value streams to remove barriers from would make those investments much less effective than appropriately matching a funding stream with the character of market barrier reduction investments.

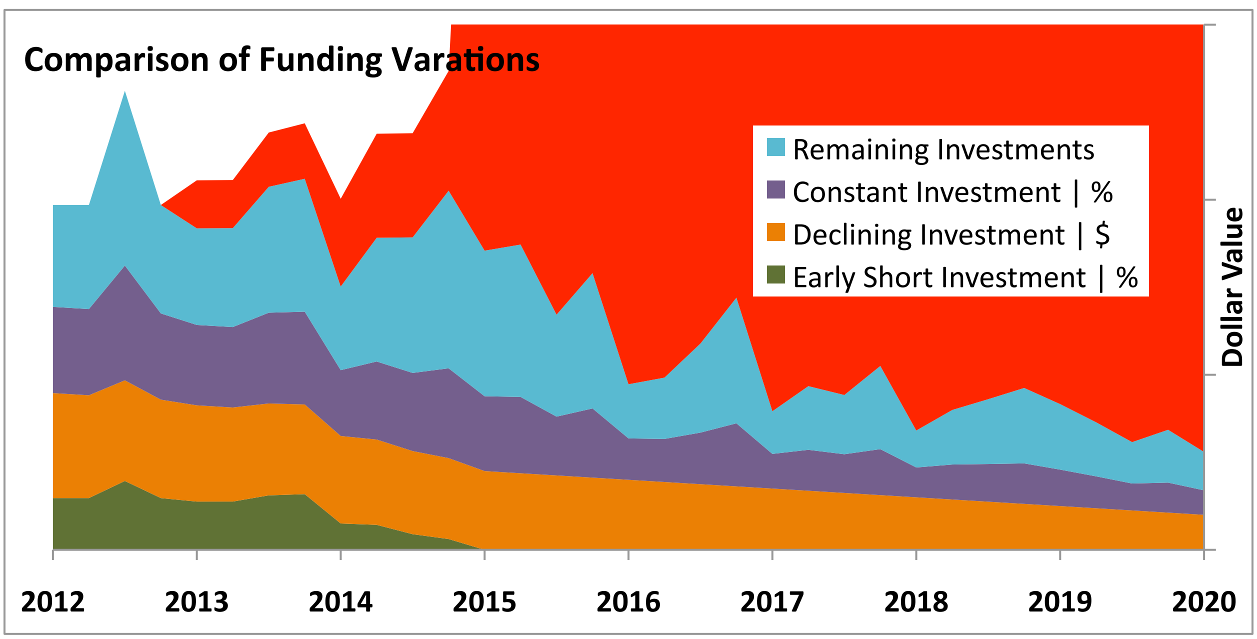

Figure 6-3: A hypothetical illustration of both timing and percentage versus dollar amount characteristics of investments. Both the constant investment as a percentage of total government investment and the declining constant dollar value investment decrease over time. As in figure 6-2, here total government investment declines as a share of total allowance value over time, so percentages of total government investment would decline as well.

What is likely a preferable solution to the ACESA model where the distribution of allowances, not value, are predetermined, is to use a model which assumes some lower bound of allowance value over the life of the program. This lower bound could be based on some set of rigorous modeling predictions about market activity, or through some other means. By determining some lower bound for total value flowing to government investment, investments can be planned with a greater degree of certainty and their exposure to fluctuations in allowance price can be limited. A model in this vein can parcel the majority of the volatility off to the allowance value directed to households, and provide more predictable streams of funding to be matched with appropriate investment character. The greater certainty there is around the quantity of allowance value, the less the distinction between dollar and percentage investments matters.

A model like this might assume some schedule of ratios beforehand based on the lower bound of allowance value. Fitting with EAAC's recommendation this ratio would likely represent more than a quarter of the total allowance value if there is a strong degree of confidence that allowance value will exceed the lower bound for the duration of the policy. At times when the total allowance value trajectory appears to be such that if government investments continued along their predetermined ratios they would represent substantially less than a quarter of total value then more value might be directed to government investments. This model would be somewhat more complicated than the ACESA model, and require some explicit expectations about what the price trajectory may look like when establishing the lower bound for government investment. However this model does carry a significant advantage of lessening the importance of investment character, making it a simpler task to estimate the efficacy of potential measures on account of more predictable funding.

7 Conclusions

While there are a number of ways to potentially use allowance value generated by the expected cap and trade system in AB 32, there are four key factors which make a strong case that some portion of allowance value should be directed toward government investments rather than other possible uses of allowance value. These four key factors, motivated by the criteria set out in the Adopted Scoping Plan, are the existence of negative non-greenhouse gas externalities, a requirement for fairness and considerations of equity in implementing the bill, a need to ensure public goods are funded at a socially optimum level and the expected cost savings of addressing market barriers.

Government investments, which represent a subset of all forms of allowance value use, can be separated into two distinct categories of types of investments, those which are oriented toward driving mitigation and those which are oriented toward managing impacts. Investments focused on managing the adverse impacts of undertaking mitigation of climate change and investments focused on managing the consequences of climate change make up the two primary types in the latter category. The former category can be thought of as space formed by two continuums, one spanning the range of abatement today to abatement tomorrow and the other ranging from targeting equity to targeting market efficiency, which represents all types of mitigation investments. Given the justifications for government investment as well as specific considerations for the state, the types of investment which should be prioritized are those which cover the breadth of the equity-market efficiency spectrum and those which minimize the adverse impacts of the policy and climate change. The first set of priorities should be balancing government investments such that rationales for investment justifications are fulfilled while also addressing particularly difficult areas of abatement and early investments with lasting effects. To the extent this set of priorities can be funded with less than the total value set aside, additional state R&D and deployment should be funded. It is likely worthwhile to create a single entity to handle decisions around how much value is directed to which government investment.

A potentially useful tool for comparing different investments in an effort prioritize specific programs, projects and measures is an aggregate net social benefit metric which would expand traditional cost effectiveness to include ancillary benefits and the cost of overcoming market barriers. An initial attempt at formulating such a measure divides aggregate social benefit into five components: health benefits, green job creation benefits, ecological benefits, social and community benefits, and market barrier benefits. An examination of attempts to broadly quantify these benefits suggests that the calculation of aggregate benefit from these components will primarily be driven by the value of removing market barriers and the value of lessening existing health damages caused by co-pollutants from the combustion of fossil fuels.

In designing a system to set aside roughly one quarter of total allowance value for government investment will require acting on some expectations about total market value which will either arise from market design or modeled assumptions. Finally, it is important to recognize the different characters of potential investments. That is to say, the effectiveness of investments will vary depending on their optimal timing during the program, declining or increasing support over time and tolerance to volatility in funding streams. Investments of different character should be tied to appropriate funding streams to be effective.

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Appendix A

A summary of EAAC recommendations:

- Devote allowance value to purposes related to three central efforts: preventing adverse impacts on certain individuals, communities—both of which may face regressive impacts from pricing GHGs (Boyce and Riddle 2009)— and businesses; financing public expenditure and investment; and returning value to citizens as dividends or tax reductions.
- Direct sufficient value to low-income (150% above the poverty line) households to protect them from disproportionate economic impacts by using financial transfers rather than subsidizing energy prices.
- Do not mute or muddle the signal in energy prices by conferring additional allowance value to electricity consumers or subsidizing energy prices.
- Except where necessary to prevent leakage, do not use allowance value to support industry profits.
- Devote a "significant share of allowance value" to public financing and encouraging private investments. There are three main justifications for this: market barriers and external benefits will prevent some cost effective measures from being adopted; environmental remediation, job training, improved infrastructure and adaptation are all public goods; and some local and state level entities have beneficial plans which may lack sufficient funding.
- Return a "significant fraction" of allowance value to households either through lump-sum rebates or cuts to or avoided increases in individuals' state taxes.
- Utilize an expanded measure of cost effectiveness to select amongst alternative investments funded though allowance value. This cost effectiveness measure should account for overcoming market barriers and environmental co-benefits as well as fairness, accountability and transparency. Establishing an independent Investment Advisory Board will help in screening potential investments. Approximately half of the EAAC members also recommended establishing a Community Benefits Fund (CBF) as a vehicle to targets investments in disadvantaged communities.[8]
- Set aside a fraction of allowance value for a contingency fund which would be dedicated to environmental remediation for any communities with increased exposure to co-pollutants from fossil-fuels as a result of implementing AB 32. In so far as adverse impacts and unintended consequences are avoided, the value in this fund could be redirected to other uses.
- The total allowance value spanning from 2012-2020 should be roughly apportioned in the following manner:
    - A small portion of allowance value should be earmarked for contingencies, leakage, environmental remediation and avoiding impacts to low-income households. If revenue is recycled by offsetting taxes, low-income households will still need support to avoid

[8] The establishment of a Community Benefits Fund is proposed by AB 1405 to the California state legislature. AB 1405 would require 30% of revenues to go into the fund.

adverse impacts. EAAC finds that these purposes should require a small share of total allowance value.

- The remaining allowance value, which is expected to represent the bulk of total value, should be split with roughly 75% returning to households and 25% going towards financing investments and other public expenditures. The ratios between these two should likely change over time, with investments receiving a larger share of total value in early years when allowance value is expected to be low (Economic and Allocation Advisory Committee 2010, 65-70).

Appendix B

List of market barriers taken from the ETAAC report on opportunities, barriers and policy solutions: (Economic and Technology Advancement Advisory Committee 2009)

Cost and Market Barriers			
Barrier	Frequency	Severity	
External Benefits	High	High, in some cases considered medium	GHG-reducing technology external benefits that are not available to the owners of the technologies, as well as other environmental benefits and employment & other spill-over economic benefits are examples.
Up-Front Capital Costs	High	High	Up-front capital costs are higher for the production and purchase of many zero and Low-carbon technologies. While capital costs are often repaid over time, lack of access to capital and short term planning by industries, small businesses, and households can compound this barrier. Capital-intensive demonstrations may be particularly challenging.
Demonstration Costs & Risks	High/Medium	High/Medium	Technologies in the development & demonstration phase may have higher capital cost, higher labor/operating cost, increased downtime & lower reliability, lack of standardization, and/or lack of engineering, procurement and construction capacity. Private investments in reducing these costs & risks through demonstration projects may be dis-incentivized by benefits that can be shared by competitors.
Market Demand	Medium/High	Medium/High	Customers may be risk/change-averse; “chicken and egg” dilemma of Low demand for emerging technologies prior to full commercialization may inhibit production at scale necessary to achieve full commercialization.
Misplaced Incentives	Medium	Medium (in some cases considered Low or High)	Misplaced incentives occur when the buyer/owner is not the consumer/user (e.g., landlords and tenants in the rental market and speculative construction in the buildings industry) – also known as the principal-agent problem.

Information Barriers			
Barrier	Frequency	Severity	
Incomplete and Imperfect Information	High/ Medium	Medium/High	Lack of information about technology performance (especially trusted information), increased decision-making complexities, and cost of gathering and processing information about new technologies are potential barriers. This barrier may be compounded to the extent that shared benefits of customer education are a disincentive for private investments.
Lack of Specialized Knowledge	Medium/High	In some cases considered Low, Medium, and High	Inadequate workforce training/expertise, cost of developing a knowledge base for available workforce, and inadequate reference knowledge for decision makers are examples.
Government Barriers			
Barrier	Frequency	Severity	
Unfavorable Standards	Medium	Medium (in some cases considered High)	Standards that "grandfather" existing infrastructure and facilities; programs that operate in "silos" rather than integrating relevant concerns such as air quality, climate change, and energy security; and rules granting access to water rights and other resources on a "first come first served" basis can create barriers. These barriers can be legislative or regulatory.
Uncertain Standards	Medium	Medium	Examples of uncertainty about future regulations of greenhouse gases including emission levels, potential GHG emission subsidies through free GHG allowances allocations, and ownership/liability of underground sequestered carbon.
Unfavorable Fiscal Policy	Medium	Medium (in some cases considered Low)	Fiscal policies that slow the pace of capital stock turnover; state and local variability in fiscal policies such as tax incentives and property tax policies; distortionary tax subsidies that favor conventional energy sources and high levels of energy consumption are potential barriers.
Uncertain Fiscal Policy	Medium (In Some Cases Considered High)	Medium (in some cases considered High)	Short-duration tax & fiscal policies (such as production tax credits); uncertainty over future costs for GHG emissions; market-development oriented incentive programs with uncertain lifespan & funding levels are examples.
Unfavorable Approval Processes	Medium	High (in some cases considered Medium)	Approval processes may favor incumbents if agencies lack familiarity & established processes for new technologies such as off-shore renewable energy development. Permitting/approval procedures serving valuable public purposes that apply to new but not existing facilities & infrastructure may favor incumbents that are grandfathered, especially when approval processes are not coordinated.

Uncertain Approval Processes	Medium	Medium/High	Uncertain timing and outcome of approval processes may be a potential barrier.
Industry Structure & Infrastructure Barriers			
Barrier	Frequency	Severity	
Existing Infrastructure "Lock-in"	Medium/High (Even Split)	Medium/High (even split)	Existing large investments such as long-term power and transportation fuels production and distribution infrastructure can "lock-in" existing technologies.
Lack of Needed Infrastructure for New Technology	High/Medium	High	Renewable electricity transmission capacity, alternative transportation energy supply distribution, and other infrastructure needs are examples. Lack of manufacturing facilities and distribution/supply channels and other supply chain shortfalls can also be a barrier.
Incumbent Industry Market Dominance	High , In Some Cases Considered Low And Medium	Mostly High, in some cases considered Low	Natural monopolies or large incumbents with market power may disenable technological innovation to prevent disruption of existing profitable markets & investments.
Industry Segmentation or Fragmentation	Medium	Medium/Low	Industry segmentation can inhibit change. For instance, manufacturing a single long-haul truck is often split among independent engine, chassis, and body manufacturers segments, with a variety of manufacturers within each segment. Small business owners may be harder to reach with information about new energy efficiency technologies, especially as their needs often vary based on business type.
Intellectual Property	Medium	Low/Medium	High transaction costs for patent filing and enforcement, conflicting views of a patent's value, and techniques such as patent warehousing, suppression, and blocking can create barriers.

Appendix C

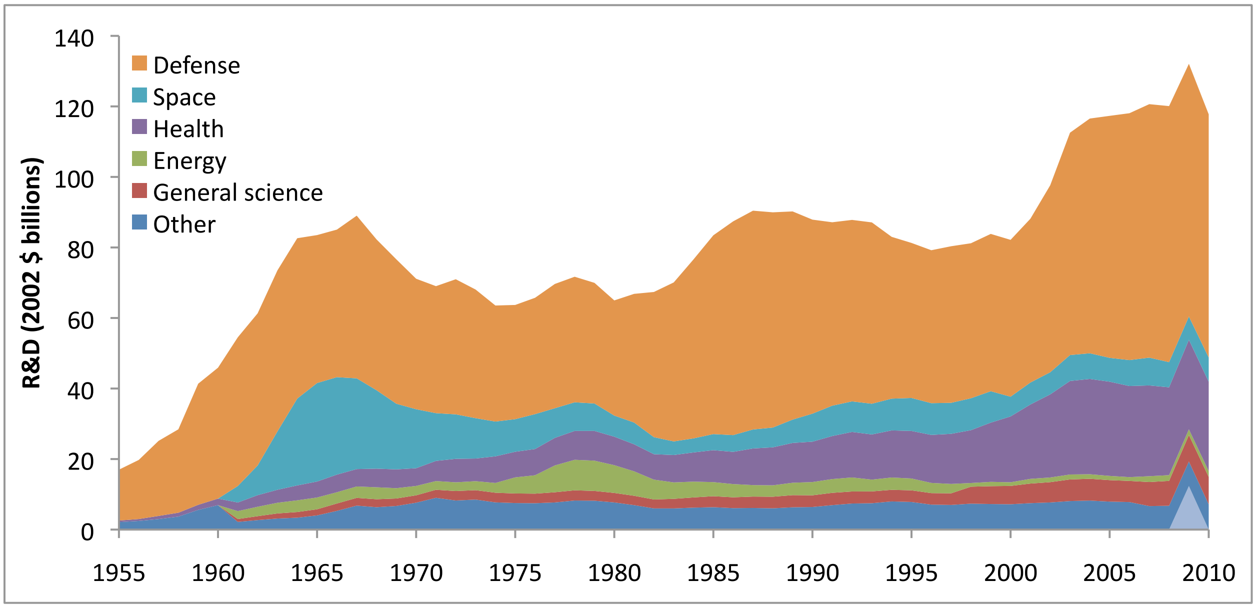

Figure 7-1: An updated version of a figure from the Nemet and Kammen paper (2007) including funding through estimated for 2010. Note the American Recovery and Reinvestment Act funds in 2009. Updated data from (Bennof 2010).

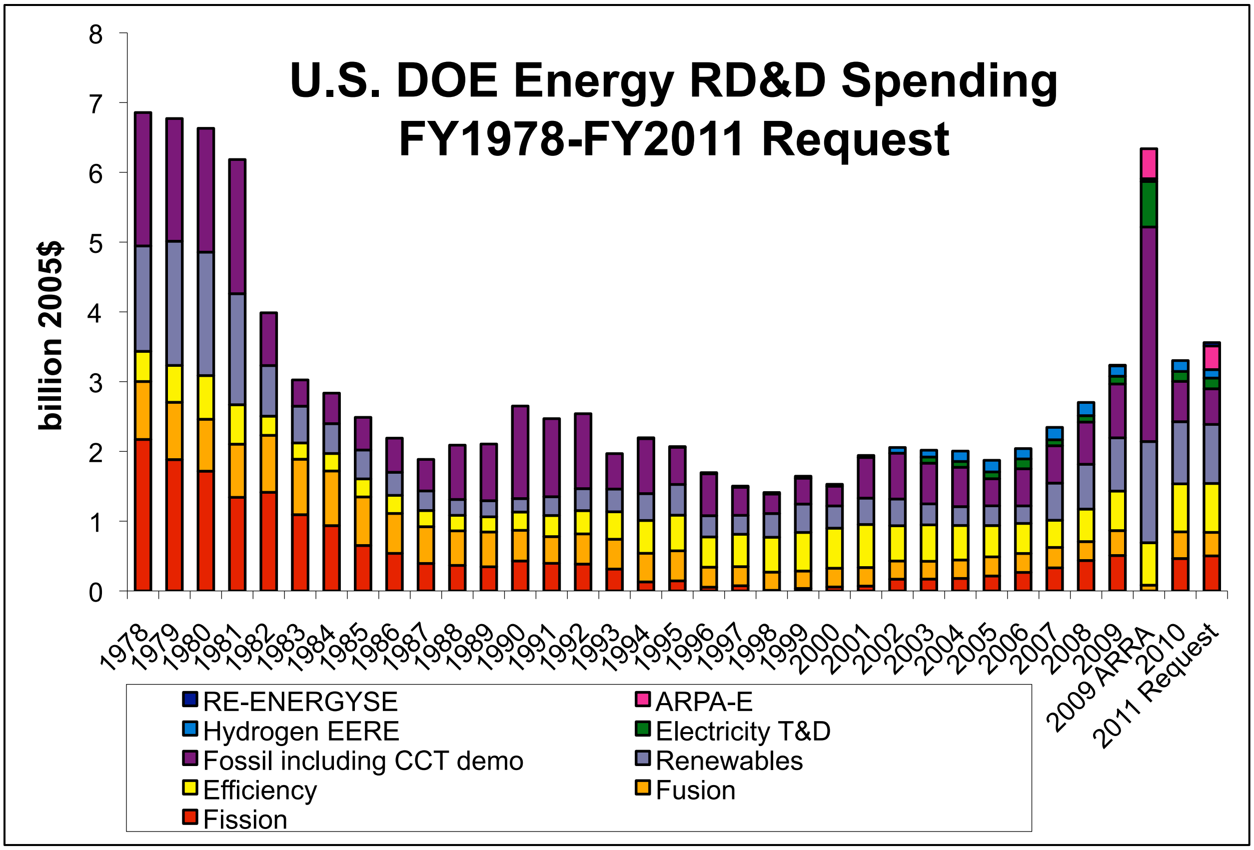

Figure 7-2*:Gallagher, K.S. and L.D. Anadon, "DOE Budget Authority for Energy Research, Development, and Demonstration Database," Energy Technology Innovation Policy, John F. Kennedy School of Government, Harvard University, March 22, 2010.*

Program:	California Solar Initiative R&D	Sponsor:	CPUC	Overview:
Funding source:	Electric utility ratepayers	Geographic limits:	California	Overview The PUC will initiate a program to promote photovoltaic distributed generation. The intended outcomes are to: -Move the market from the current retail solar price of $9/watt or about 30 cents/kWh to levels that are comparable to the retail price of electricity. -Install increasing volumes of solar DG that build from the current range of 160 MW per year to 350 MW or more per year. The current (first) solicitation offers up to $15 million for the integration of photovoltaics into the utility grid.
Sectors supported:	Photovoltaic distributed generation	Funding:	$50 million over 10 years	
Activities supported:	Mostly demonstration projects; also R&D and deployment incentives	Grant amount:	$0.2 to $3 million	
Program:	**Innovative Clean Air Technologies (ICAT) Grant Program**	**Sponsor:**	**CARB**	**Overview:**
Funding source:	Research Division of CARB	Geographic limits:	Supported technologies must be useful in California	ICAT co-funds practical demonstrations of innovative technologies that can reduce air pollution, including GHGs. Its purpose is to advance such technologies toward commercial application in California, thereby reducing emissions and helping the state's economy. ICAT seeks technologies that are not yet marketed but are substantially ready for practical demonstrations of their utility to potential users. It focuses on co-funding such demonstrations. It does not support research, R&D that is not intrinsic to performing a particular demonstration, or marketing activities.
Sectors supported:	New technologies for reducing criteria, toxic, or global-warming emissions	Funding:	Up to $1 million per year	
Activities supported:	Demonstrations	Grant amount:	$200,000 average	

Program:	Public Interest Energy Research Program	Sponsor:	CEC	Overview
Funding source:	Investor-owned utility ratepayers	Geographic limits:	US	PIER supports energy RD&D projects that will bring environmentally safe, affordable and reliable energy services and products to the marketplace. The PIER Program partners with other RD&D organizations that include individuals, businesses, utilities, and public or private research institutions. PIER supports these RD&D program areas, some with contracts and others with direct grants: · Buildings End-Use Energy Efficiency · Climate Change Program · Energy Innovations Small Grant Program · Energy-Related Environmental Research · Energy Systems Integration · Environmentally-Preferred Advanced Generation · Industrial/Agricultural/Water End-Use Energy Efficiency · Natural Gas Research · Renewable Energy Technologies · Transportation Research Technologies supported by PIER address the following goals: · Reduce the cost (and increase the value) of electricity · Increase the reliability of the electric system · Reduce the environmental impacts of electricity generation, distribution and use · Enhance California's economy · Advance science and technology not provided by competitive and regulated markets In 2009, CEC offered up to $21 million (of the annual $62.5 million) of PIER funds as co-funding to awardees of federal funding under the American Recovery and Reinvestment Act.
Sectors supported:	All sectors	Funding:	$80 million per year	
Activities supported:	RD&D	Grant amount:	Varies by program area	
Program:	**Technology Advancement**	**Sponsor:**	**South Coast Air**	**Overview**

	Program		**Quality Management District (CSAQMD)**	
Funding source:	Vehicle registration fees, regulatory violation settlements, State Federal grants	Geographic limits:	South Coast Air Basin (the greater Los Angeles area)	The Technology Advancement Program expedites the development, demonstration and commercialization of cleaner technologies and clean-burning fuels. It uses cooperative partnerships with private industry, academic and research institutions, technology developers, and government agencies to cosponsor projects intended to demonstrate the successful use of clean fuels and technologies that lower or eliminate emissions. The supported technologies are chosen to provide emission reductions in the AQMD in the context of the AQMD's emission-reduction strategies. Typically, the public-private partnership enables the AQMD to leverage its public funds with an average of $3 from outside sources for every dollar contributed by the AQMD. Awards are made to both proposals made in response to RFPs with specific objectives and to unsolicited proposals for new technologies.
Sectors supported:	Transportation	Funding:	$9 to $15 million per year	
Activities supported:	R&D, demonstration projects and incentives	Grant amount:	Ranges from $6,000 to $3 million	
Program:	**Alternative and Renewable Fuel and Vehicle Technology Program (AB 118)**	**Sponsor:**	**California Energy Commission**	**Overview**
Funding source:	Vehicle registration fees	Geographic limits:		Assembly Bill 118 (Núñez, 2007) created the Alternative and Renewable Fuel and Vehicle Technology Program. The statute authorizes the California Energy Commission to spend up to approximately $120 million per year over seven years to "develop and deploy innovative technologies that transform
Sectors supported:	Economic sectors affected: Transportation, energy production	Funding in millions:	Electric Drive - $46 Hydrogen Fueling Stations - $40 Biodiesel - $6	

Sectors supported:	Economic sectors affected: Transportation, energy production	Funding in millions:	Ethanol - $12 Natural Gas - $43 Propane $2 Market & Program Development - $27	California's fuel and vehicle types to help attain the state's climate change policies." The statute, amended by Assembly Bill 109 (Núñez, 2008), directs the Energy Commission to create an advisory committee to help develop and adopt an Investment Plan to determine priorities and opportunities for the program, and describe how funding will complement existing public and private investments, including existing state and federal programs. The Energy Commission will use the Investment Plan as a guide for awarding funds. The statute calls for the Investment Plan to be updated annually.
Activities supported:	Functions supported: TBD			

Table 7-Set of state funded R&D programs taken from the 2008 ETAAC report (2008).