Modeling & Learning from the Design Recommendations for California's Greenhouse Gas Cap-and-Trade System

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ABSTRACT

Climate Change has become a Major issue beginning with our generation. Governments the world over are now recognizing that industry cannot continue to pollute in a business-as-usual manner. Emitting Greenhouse gases has a global impact, unlike pollutants that are released into soil or water. Global warming created by the Greenhouse effect, amongst other things is causing an increase in the ambient global temperature, causing glaciers to melt and global weather patterns to change. At the same time the world population is increasing, the standard of living for an increasing percentage of the population is improving, and with that the global energy usage is going up and up. Currently, a large portion of the global energy is derived from fossil fuels. Combusting fossil fuels are the primary source of Greenhouse gas emissions. The challenge for governments then is two-fold. One is how to cap and/or reduce the Greenhouse gases from industry, and second, how to achieve this first goal without being detrimental to the industry in a large way, or as some say with the least cost. In the USA, due to lack of a federal standard, several states have either banded together or gone it alone, in defining their own attempt to address the Greenhouse gas problem. The state of California is one such state that has put together a committee of experts, to advise the state on how best to design a system with the two afore-said challenges in mind. A model has been put together to model Option A, Program Design 1 of the California Cap-and-Trade system.

The goal of the model is to give the regulator an understanding of how by varying the main lever, which is the cap set, the regulator can influence the covered Electric entities in optimally meeting the cap, based on the headroom they have for abatement, and their actual ability to act and the degree to which they can act in abatement; and secondly how this main lever, can create a thriving market for trading allowances, by trying to have almost an equal number of players that want to buy the requisite number of allowances to meet the cap, or sell their excess allowances.

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Finally, stop my ten year old daughter, Analiese, from asking me if 'I am done yet?' and 'why is it taking so long?'.

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Chapter 1 : Introduction

"To live is to pollute " (Dales 1968). Men take from the environment, a wide variety of vegetable, mineral and animal materials; transform them into a very much wider variety of economic goods; consume these goods, a process during which these goods undergo physical or chemical transformations, and become, in effect, garbage; then discard this garbage into the environment, i.e. air, soil and water. In addition, unwanted materials, in solid, liquid or gaseous states, that are generated during the transformation phase, also called the production phase, are discarded into the environment. Hence pollution occurs at two points, at transformation and at consumption (Dales 1968).

The amount of pollution produced is dictated by the standard of living of the society. Higher the standard of living, the higher the consumption rate and larger the transformation processes, therefore proportionally increasing pollution. Since all societies, not just the US and the Western countries are interested in improving their standard of living, it is only correct to assume that the rate and level of pollution is only going to go up. On the other hand, the amount of pollution reduced depends on improvements in efficiencies of production, thereby reducing the amount of pollution produced per unit of good produced. The amount of waste recycling done by society, therefore proportionally decreasing pollution, and the natural processes occurring in nature, that "bio-degrade" the pollutants, garbage or waste (Dales 1968).

Pollution harm depends less on the pollutant itself, but more on the properties of the pollutant. If the pollutant can easily be re-cycled by man, the pollutant does not accumulate and its harmful effect minimized. If the pollutant is easily re-cycled by nature, the pollutants are less likely to accumulate, and its harmful effect is minimized. While pollution may be harmful, it also has a benefit; an economic benefit.
When a leather factory, discharges its effluents in a stream, it presumably is adopting the cheapest method of disposing off its unwanted wastes. This activity translates directly into dollars saved, and hence lower prices to its customers. However, losses or damages may be felt by those downstream; farmers, using the water for farming, or fisherman, using the stream for fishing. In other words, if the accumulation of pollutants is not large enough that it produces a benefit, without causing damages or losses that exceed the benefits, the pollutants are not a problem, and hence there is no pollution problem. Conversely if the harm done by disposing a particular waste in a particular way, outweighs the benefits associated with that practice, then a pollution problem occurs (Dales 1968).

Pollution control can be then surmised as that can be controlled at the production process, by increasing efficiencies, so as to reduce the amount of pollution produced, and, that which can be controlled, once produced, by natural or man-made recycling processes.
We assume the cost of recycling by nature is beneficial in most cases, but for our context we assume that it is free. Hence the real cost of pollution, to a producer is the sum of the

costs of pollution prevention and costs of pollution cleanup, which can be summed up as the following equation (Dales 1968).

Waste disposal Costs = Pollution Prevention Costs + Pollution Costs ... Equation 1

Pollution Costs, can be thought of as the aggregate of public expenditure, private expenditure and welfare damage to individuals, and can be written as the following equation (Dales 1968).

Pollution Costs = Public Expenditures to avoid Pollution Damage + Private Expenditures to avoid Pollution Damage + Welfare damage of Pollution ....Equation 2

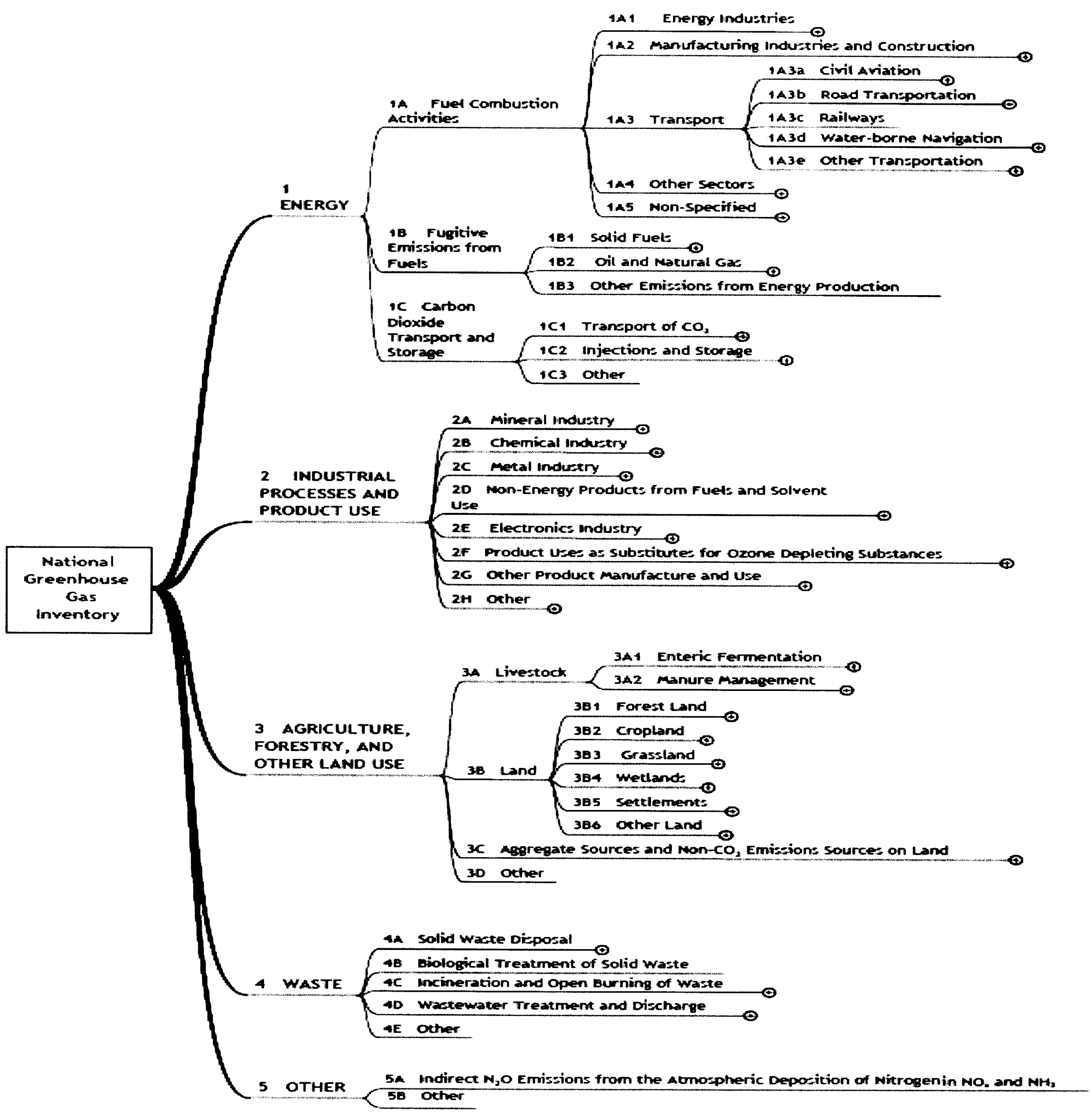

Figure 1 : Main Categories of emissions by sources and removal by sinks

To control pollution then would be to internalize the externality, i.e. the firm's actions that impose costs on others. Regulators rushed to enact legal rules that force the firm to bear the external cost to it; to internalize the externality. The net cost now equals the net cost to everyone, and the firm's action will be based on its net benefit.

The first such approach was of Direct Regulation. A government agency such as the EPA makes rules mandating use of particular solutions. For example, the EPA may make rules requiring steel mills to filter their smoke and build high smoke stacks. While this is an obvious solution it has serious problems. The first is that the EPA may not be interested in maximizing efficiency, since the EPA itself is controlled by politicians. The interests of the controlling politicians and the EPA may not be in alignment. The second issue is that even if the EPA wants to maximize efficiency, it does not know how to do it. Figuring out what pollution control measures are or are not worth taking, and how much steel ought to be produced after properly allowing for external costs of producing it are hard problems that the EPA is not equipped to handle (Friedman 2000). A third issue, offered by Gordon Tullock and Nobel Laureate James Buchanan, is that direct regulation takes away the property rights of those affected by pollution. This type of regulation represents an output restriction, i.e. the total amount of goods produced by a particular industry is reduced. If such an output restriction is mandated by government fiat, the price will rise as if the industry had formed a cartel. Essentially the result is an industry cartel managed and enforced by the policing power of the pollution control authority. Finally polluters can reap residual profits if the price increase exceeds the associated increase in cost incurred by pollution control capital expenditures (Yandle 1999).

A second type of regulatory approach was an indirect regulation. Instead of telling a firm specifically what to do, instead the regulator simply charges the firm for its pollution. This approach labeled "effluent fees", generally known as "Pigouvian taxes" has several advantages over direct regulation. To begin with, the regulator does not have to know anything about the costs of pollution control; he/she can safely leave that to the firm. If the firm can reduce its emissions at a cost less than the fee, it will do so, else pay the fee, giving the firm a choice. A second advantage is that this approach generates not only the right amount of pollution control but the right amount of product as well. Since the cost of the negative externality is embedded in the price of the product produced, how much of the product produced depends on how competitive this product is versus its competing product also sold at the true cost. Unfortunately, "effluent fees" do not solve all of the problems of controlling pollution. For one thing they do not solve the problem of making it in the political interest of the regulators to do the right thing. Fees could be set low to reward firms contributing to the political campaign, or set too high to punish firms contributing to the wrong candidate. Even if the regulators are trying to produce an efficient outcome, it may not be easy to measure the damage actually done by each additional pound of pollutant, and therefore the size of the penalty. However, while the political issues, as in the case of direct regulation still exists, they are reduced, since it is harder to provide special favors to your friends, when the decisions are made pollutant by pollutant, instead of firm by firm (Friedman 2000).

A third approach resorted to Tort law. Instead of having the regulators impose taxes, people are permitted to sue the firm for the damage its pollution is doing to themselves and their property. The firm now has the choice of eliminating the pollution, paying damages, or reducing the pollution and paying damages on what is left. There is a difference though. Effluent fees and fines go to the state, Tort damages go to the victim and his/her attorney.

The first two approaches are part of a command-and-control regulatory system.

A fourth approach was suggested by Ronald Coase. Coase debunked the then popular Pigouvian notion in three ways. First that existence of externalities does not necessarily lead to inefficient results. Second, Pigouvian taxes do not in general lead to an efficient result, and Third, and most important, the problem is not really externalities at all; it is transaction costs.

According to Coase, an external cost is not simply a cost produced by one person and borne by another. In almost all cases, the existence and size of external costs depend on decisions by both parties. If this is true then a legal rule that assigns blame to one of the parties gives the right result only if that party happens to be the one who can avoid the problem at the lower cost, or if the optimal solution requires precautions by both parties.

The next step in Coase's argument is that, as long as the parties can readily make and enforce contracts in their mutual interest, direct regulation nor a Piguovian tax is necessary in order to get an efficient outcome. This is because rights, pollution or otherwise, will be negotiated and move to those to whom they are of greatest value, giving an efficient outcome(Friedman 2000). (See Coase's thereom in Appendix)

But what happens if one party consists of a single or small number of entities and the othe party happens to be a large number of entities. In this case transaction costs are high. Hence when we observe externality problems (or other forms of market failure) in the real world, we should ask not merely where the problem comes from but what the transaction cost is that prevents it from being bargained out of existence.(Friedman 2000)

In effect Coase suggests a market solution, rather than a regulatory solution. The Cap-and-Trade system is one such system that internalizes the externalities, but at the lowest cost to the entities. The amount of pollution (stock) can be construed as a proxy for the cost of damage by the externality.

Chapter 2 : Background

Policy Instruments

Several types of policy instruments are available to address pollution control. Some of them are, the creation of well defined property rights, tradable permits, emission charges, user fees, subsidies, technology standards, emission standards, bans, quotas, provision of information, labeling, imposition of technology standards, and the provision of infrastructure or other public goods (Sterner 2003). The most important criterion for designing policy instruments is welfare maximization, while keeping in mind the serious economic consequences such as higher costs of production to a firm as well as increased energy prices to the consumer. Economics mixes with politics, and as a practical matter it is easier to focus on sub goals such as efficiency, incentive compatibility and equity. A mix and match of the above instruments could be tailored to a specific application creating a complex pollution control system. In the case of the Greenhouse gas containment, the two most commonly used systems of instruments are the command-and-control system, a system where a regulation is passed and enforced; and the Cap-and-Trade system, a market based emissions trading system.

Emissions Trading

There are three types of emissions trading. Credit based, Allowance based and a variant of credit-based called Averaging (Ellerman, Joskow et al. 2003). In a credit-based system, an entity creates credits by reducing its emissions more than the specified standard. These credits can be transferred to another entity, allowing that entity to have emissions above the standard. However, creating the credits and transferring them are decided by the regulator. Not so in the case of Allowance based trading. Tradable rights to emit (allowances) are created initially, and then distributed according to some scheme. There is no presumption that the entity will limit its emissions to the allowances that it receives. These allowances can be traded. The only restriction is that allowances covering the emissions must be surrendered at the end of every compliance period. The Averaging based system is similar to the credit based system, in the way credits are created. Except in the Averaging case, similar to the allowance based system, regulatory approval is not required to trade (Ellerman, Joskow et al. 2003).

Cap-and-Trade system

Allowance based emission programs are called Cap-and-Trade systems. Tradable allowances, representing the right to emit one metric ton of CO_2 equivalent, equal in total to the annual allowed emissions of the entities covered by the Cap-and-Trade system, are created. Allowances equal to, using some method as, average emissions over the last three to four years, are allocated for free to each entity on a pro-rated basis. A portion of the allowances approximately 3%-5% of the allocated allowances to each entity is withheld. These withheld allowances are then auctioned off annually, and can be traded between entities. At the end of the compliance period, each entity is required to surrender one tradable allowance for each ton of CO_2 equivalent emitted.

Banking

Allowances which are not used (surrendered) are allowed to be carried over to the next year, i.e. banked, for future use, either by the original entity or by another entity purchasing the tradable allowance. Banking is necessary. If investments in abatement costs result in reduced emissions, the entity will hold on to more of its allowances. However if these allowances expire at the end of the compliance period, the incentive to invest in abatement costs is reduced. All of the US emissions trading programs, except the RECLAIM program have included banking. These programs have shown that by including banking two positive results are achieved. The first, banking can lead to significant 'early action' when coupled with phased-in emission reduction requirements and second, that banking can dampen the volatility of allowance prices (Ellerman, Joskow et al. 2003).

Distribution

Allocations of allowances thus far have been allocated without charge to participants. What makes this allocation method attractive in positive political economy terms, i,e. the conveyance of scarcity rents to the private sector, makes allocation without charge problematic, in normative efficiency terms (Fullerton and Metcalf 2001). For example, in the case of SO2 allowance trading, costs of allowance trading would have dropped an additional 25% had allowances been auctioned off, rather than given away; since the revenues received could be used to finance reductions in pre-existing distortionary taxes (Goulder, Parry et al. 1996). Another issue is the post-trading equilibrium obtained in the presence of transaction costs, implying that aggregate abatement costs are sensitive to the initial permit allocation (Stavins and John 1994).

Safety Valve

Not all emission programs have worked out as well. For e.g. in the RECLAIM market the NOx allowances that traded in the range from $1000 to $3000, worked well until the electricity problem. The NOx allowances traded for as high as $80,000 before the system broke down (Jacoby and Ellerman 2004). The solution adopted by the state of California was to introduce a mitigation fee of $15,000 per ton instead of buying an allowance. The effect of the mitigation fee was to reduce the volatility of the allowance prices, and served as a safety valve. Safety valves are important to protect the system from major shocks.

One way to implement a safety valve would be to combine price and quantity policies. The quantity policy would establish binding emissions target, so long as the costs remain reasonable. The emissions target would be allowed to rise if prices became unreasonable, the price policy would kick in, with additional allowances being made available at a fixed trigger price.

Market Creation

In the Cap-and-Trade system, similar to the Averaging system, and unlike the Credit based system, the entity is no longer bound by the regulators abatement decision (Ellerman, Joskow et al. 2003). Instead the entity is in control of the abatement decision and it is free to decide how the abatement should be carried out, within the constraint of the cap. The entity, based on costs, could either decide to indulge in abatement itself, or trade away its abatement responsibility. Decentralizing the abatement decision and letting entities trade abatement responsibilities in this manner allows the emergence of a market for allowances. For entities facing relatively high abatement costs, a functioning market significantly reduces the cost of finding trading partners resulting in a more efficient solution (Ellerman, Joskow et al. 2003).

Abatement Technology

Porter hypothizes, also called 'Porter's Hypothesis' that strict environmental regulation triggers the discovery of cleaner technologies and environmental improvements, making production processes and products more efficient. Porter hypothizes that the cost savings that can be achieved are sufficiently large to cover both the innovation costs and the compliance costs (Roediger-Schluga 2004).

California Pollution Pie

The pollution pie below shows the contribution of carbon emissions by industrial sectors, using fossil fuel. Clearly Electricity and transportation are the two main sectors to be addressed.

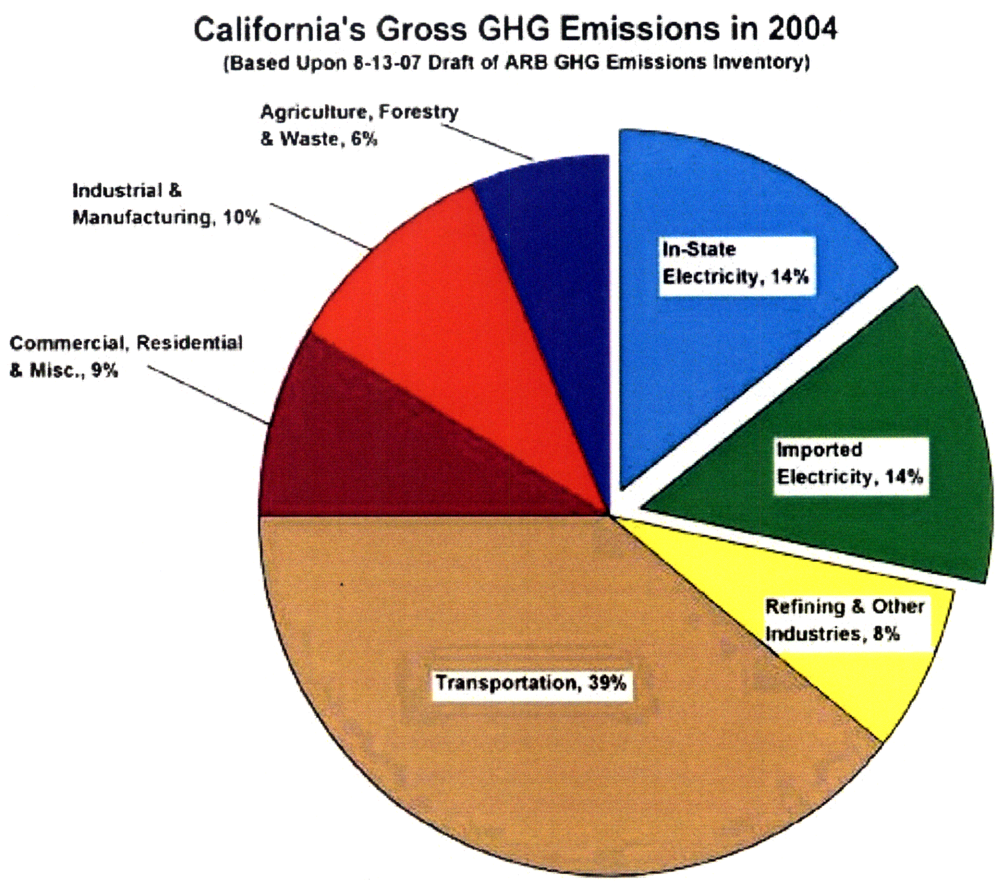

Figure 2 : California Greenhouse Gas pollution pie

Note : The following section is gleaned from the document "Recommendations for Designing a Greenhouse Gas Cap-and-Trade System for California" - Recommendations of the Market Advisory Committee to the California Air Resources Board – June 30, 2007.

Introduction

The California Global Warming Solutions Act of 2006 (Act) requires that the State of California dramatically reduce greenhouse gas emissions by year 2020. Specifically this forward looking statute charges the California Air Resources Board (CARB) with responsibility for overseeing the development and implementation of such a plan.
The Act recognizes that a market based system can be used in conjunction with regulatory and other strategies to meet an economy wide emissions reduction target.
In support of the Act, Governor Arnold Schwarzenegger directed the Secretary for Environmental protection to create a Market Advisory Committee (MAC) to advise CARB regarding the development of the greenhouse reduction plan for California. The Committee is composed of national and international experts who have backgrounds in economics, environmental policy, regulatory affairs and energy technologies.

Stringency of the Cap

The breadth of coverage and the quantity of emissions are closely related to each other. The narrow the coverage the fewer the entities covered and broader the coverage the larger the entities covered, which impact the setting of the cap in terms of quantity of emissions. The cap level is set above current emissions levels, allowing for emissions growth at first, but below 'business-as-usual'. The cap then is gradually declined, in frequent smaller step reductions, to return emissions to 1990 levels in year 2020. The benefit is that firms will be able phase in new emission reductions continuously and have a less impact on price volatility. The cap level is absolute, in the sense that it is not affected by change in GDP, shifts in production or control technology. As far as the impact of direct regulation, any gains made in reduction of emissions by entities outside the cap, can be used to increase the cap. Not so for covered entities.
Mandatory reporting to the California Climate Action Registry is expected from all covered entities.

Program Scope

A broad program scope yields additional opportunities for low-cost mitigation. It promotes greater market liquidity by increasing the number of entities involved in trading. It prevents any one entity or group of entities from hoarding and exercising market power. If covered entities cannot have their emissions monitored, reported and verified to a high degree of accuracy, then the breadth of the program should be limited, and not cover these entities with unreliable emission information. Similarly if transaction costs are particularly high for some entities, then these entities could be excluded from the program. Coverage can expand over time as these difficulties are overcome. An allowance for Greenhouse gas emissions is defined in terms of the mass of CO_2 equivalent, and is derived in two ways. Allowances defined in terms of actual emissions, and allowances defined in terms of a proxy for actual emissions. Under the second approach, the purchase or sale of a chemical or fuel, where the quantity of chemical or fuel bears a clear relationship to eventual GHG emissions, is used as a proxy for actual emissions. Which of the two method's to use, to define allowances, depends on the decisions concerning the 'point of regulation', i.e. which entities will be required to hold allowances authorizing their emissions or uses of fuels/chemicals, under the program. To pinpoint the 'point of regulation', the diverse emission sources (entities), of non-CO2 emissions, can be grouped into one of four categories.

1. Combustion emissions of CH4 and N2O
2. Industrial processes and product uses
3. Fugitive emissions of Methane, and
4. Biological processes

The MAC put forth four program designs, which define the scope and point of regulation of a Cap-and-Trade program, beginning with the least comprehensive to more comprehensive ones. The following figure (Fig 3.) facilitates the comparison between the four program designs.

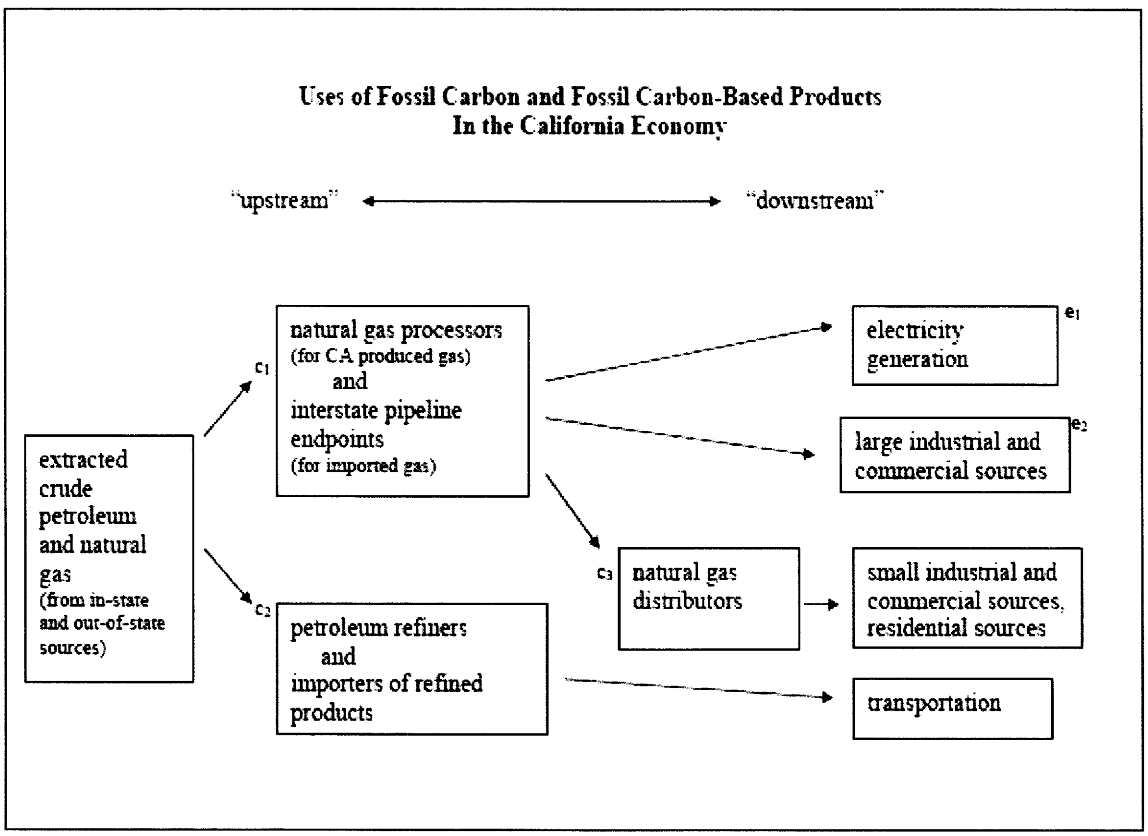

Figure 3 : Uses of Fossil Carbon and Fossil Carbon based products in the California economy

The above figure shows the two ways in which carbon enters the California economy, through production and through import, of two fossil fuels namely, crude petroleum and natural gas. (For simplicity coal is ignored here, and will be dealt with later)

Program 1 – Coverage of Medium and Large point sources of Emissions, and of Some Suppliers of High-GWP Gases; Coverage at point of Combustion:

- Scope: This program covers medium and large GHG emitting entities, for example, electric power plants or energy intensive industries, such as refining and cement production. It includes industrial process emissions (as opposed to combustion emissions) of CO2. It also includes N2O emissions from Nitric Acid production as well as the production or import of fluorinated gases.
- Points of regulation: Points e1 and e2 in Fig 3.
- Extent of coverage: Includes approximately 39% of California's GHG emissions and covers approximately 450 medium and large facilities.
- Administrative considerations: The administrative requirements are very similar to established programs such as the US acid rain program, the NOX program, the EU ETS and the Northeast RGGI program. This program requires very little new infrastructure to track CO2 emissions, since these are currently already being reported. The only additional infrastructure required will be that which is required to capture data on electricity imports and high GWP gases.
- Implementation: Program 1 could be implemented now. It is consistent with many of the current Cap-and-Trade systems. Data on hourly CO2 emissions from all power plants is currently available. Techniques for measuring and reporting the other covered entities are available.

Fig 4 below summarizes the emissions coverage and the number of entities that would need to be covered with the above four program designs.

Contributions of Different Programs to California Emissions Reductions

Program	Estimated Number of Points of Regulation[1]	Year 2004 Emissions under These Points of Regulation[2]		Percentage Contribution to AB32 Emissions Reduction Target if Cap Requires Reduction of[3] ...			
		tons	% of state total	10%	20%	30%	40%
1	450	192.6	39	13	27	40	54
2	480	355.9	72	25	50	74	99
3	490	408.8	83	29	57	86	114
4	150[4]	408.8	83	29	57	86	114

[1] The number of points of regulation listed is an estimate and excludes an indefinite number of small facilities responsible for emissions of high GWP gases. It also excludes the agents (LSEs and various electricity wholesalers) responsible for embodied emissions in imported electricity.

[2] Baseline 2004 emissions include CO2 embodied in imported electricity and exclude land use and forestry changes and international bunker fuels. Units are million metric tons of CO2 equivalent. The state total in 2004 was 494.3.

[3] Assuming 2020 business as usual emissions of 608.1 and 1990 emissions 29% below that level (implying a need to reduce emissions by 176.3 million tons). Also assumes proportional increases of emissions from all sources.

[4] An interstate or intrastate pipeline will often transport gas on behalf of several entities – businesses that take delivery of gas via the pipeline for purposes of direct consumption or subsequent sale in California. For Program 4, the estimated number of points of regulation includes approximately 100 business entities that take delivery and assume ownership of natural gas in connection with pipeline transport.

Additional Notes:
- These values are based on two sets of data received from the ARB: the revised 2004 inventory and a list of emissions of CO2 from sources over 10,000 tons in 2004.
- In every program, the cap-and-trade program is assumed to cover all process and high GWP emissions (4.2% of 2004 GHG emissions) and to cover CO2 emissions embodied in imported electricity (12.3% of 2004 GHG emissions).

Figure 4 : Summary of achievable emissions coverage with number of covered facilities

The columns on the right side represent the percentage contribution of emission reductions by the covered entities for a state mandated reduction percentage.
For example, if the state mandated reductions was set to 20% with Program 3 in place. Then the covered entities would provide 57% of the emission reduction, with the other 43% having to come from non-covered entities. Numerically, the BAU (Business As Usual) amount in year 2020 would be 600.8 MMT (Million Metric Tons). The 1990 levels are reported to be 426.6 MMT. Hence the required reduction is the difference of 174.2 MMT. The covered entities in Program 3 would provide a reduction of 99.3 MMT (57%), whereas the uncovered sources would have to provide a reduction of the balance 74.9 MMT (43%). But the baseline emissions outside the Cap-and-Trade are just 17% (100%-83%) or 102.1MMT. Dividing 74.9 MMT by 102.1 MMT implies that the

uncovered entities must undergo a 73% reduction in their GHG emissions. This is unrealistic and suggests that the Cap-and-Trade program must significantly increase the emission reductions to well over 20%.

The Market Advisory Committee fully agreed that the Cap-and-Trade system should work towards comprehensive coverage and focused on two ways to achieve this objective.
They created two options from the four program designs.
Option A, was to start with Program 1 immediately, then expand to Program 2 as data became available and administrative requirements were met. Subsequently the Cap-and-Trade program would evolve to Program 3, as data and administrative requirements of Program 3 were met.
Option B, entailed beginning Program 4 only after the data and administrative requirements pertinent to Program 4 were established. This would happen later than sooner.

Issues Specific to the Electricity sector

The Electricity sector accounts for approximately 22% (2006) of California's Greenhouse emissions, half of which is from electricity imported from outside the state.
For the Cap-and-Trade system to be effective, it has to address the serious problem of potential emissions 'leakage' associated with electricity imports. To prevent this potential emissions 'leakage', imported electricity must be brought within the sphere of the Cap-and-Trade system. If not, the bias will be towards less of in-state generation and more of imports to circumvent the additional cost of in-state Cap-and-Trade system compliance. Clearly this would contradict the spirit and letter of the Global Warming Solutions Act as well as the guiding principles enunciated by the MAC committee. (The Global Warming Solutions Act, aims to reduce emissions associated with the state's consumption, and not just generation of electricity.) Several methods can be employed in the design of the Cap-and-Trade system to control potential emissions leakage.
The Market Advisory Committee has highlighted two methods. The first is a 'load-based' approach, in which the obligation for compliance rests with the LSE. A LSE (see appendix) is not only an investor owned utility that the PUC regulates, but also includes municipal utilities, co-ops, and other entities that serve customer electricity load. The second method is the 'first-seller' approach, in which the obligation for compliance is on the first seller of power in the California electricity markets.
The points of regulation differ for the two methods. In the load-based approach the LSE is the point of regulation. The LSE is responsible for accounting for emissions for electricity consumed in the state that is made available from both imported electricity and in-state generation. In the first-seller approach the owner/operator of the California power plant or the importing contractual party, is the point of regulation. The importing contractual party could be any wholesale power marketer and need not be a LSE.
Calculation of the Greenhouse gas emissions, for either of the above approaches, can be done in two ways. Actual monitoring of generator emissions, OR, calculations based on fuel content. Since actual monitoring of generator emissions of imported electricity is extremely difficult due to a variety of reasons, it is a non-starter, despite the fact that almost all of California's in-state electricity generators have a continuous (hourly)

monitoring process already installed and which reports that data to the California Energy Commission. However if the Western Electricity Coordinating Council (WECC) which coordinates power dispatch over the western electricity grid and encompasses eleven entire western states and portions of three others along with British Columbia and Alberta, Canada; were to agree on the electricity portion of California's Cap-and-Trade program a simple generator-based monitoring approach could be used without concern for leakage. But there is no such agreement in place.

Hence both the load-based and first-seller approaches would need to approximate emissions for imported electricity. Imported power is assigned an emission intensity based on California's Climate Action Registry's Power/Utility Reporting Protocol. The Carbon intensity of in-state electric generation in California for 2004 was 700lbs of CO2 per Mega Watt hour (MWh). Using the California's Emissions Inventory and electricity consumption data from the California Energy Commission to account for imported power brings the average emissions intensity of electricity consumed in the state to 930lbs per MWh. Across the US, the average emission intensity of electric generation is 1,176lbs per MWh. The above protocol identifies the power plant and the associated emissions for about 56% of imported power, (Alvarado and Griffin 2007…To be added) with some default intensity to be applied to the remaining 44%.

Using the calculations based on fuel content, i.e. the Carbon intensity method, the first-seller approach would impose compliance obligation on contractors bringing power into the state, as identified by E-tags. The load based approach places an additional step, i.e. making the approximation between the first seller and the LSE that has the compliance obligation. This is because a LSE could buy from several different sources. Not only is tracking this difficult, due to various intensity values being assigned to various sellers in various sub regions, but it could lead to imprecision too. Besides it could also lead to the financial contract path to be imprecise. An imprecise method raises issues of transparency, and whether reductions under a load based approach can be adequately measured compared to an emissions and generator based cap. With the new 2008 regulation called the California Independent System Operator (ISO) Market Redesign and Technology Upgrade (MRTU) that amongst other things, allows for the establishment of a day-ahead market, which is likely to attract approximately 10-20% of all power on the grid, it would make the load-based system a nightmare.

Under Program designs 1, 2 and 3 (Option A), both approaches, first seller and load based apply directly. Under Program 4 (Option B) these approaches apply only as they pertain to out-of-state sources of power sector emissions.

Contract Shuffling and Legal Challenges represent two other challenges that affect the ability to control leakage. The compliance obligation of California's Cap-and-Trade system could induce out-of-state power wholesalers to shift the assignment of existing sources so that sources with comparatively lower emissions are assigned to the California load, and those with higher emissions are routed to meet demand elsewhere. This shuffling of contracts could reduce the emissions attributed to California's imports, even though no actual reduction in emissions has taken place. The legal challenge is due to the principal issue of whether the regulations treat in-state and out-of-state electricity in a similar way. The rub is whether California's treatment of imported electricity is consistent with the Interstate Commerce Clause, which prohibits discrimination in trade.

Summary Table Comparing First-Seller and Load-Based Approaches	
Environmental Integrity	
Ability to Control Emissions Leakage	Similar under both approaches
Ability to Track Responsibility for In-State Emissions	First-seller approach has an advantage. Identification of in-state source of emissions more difficult under load-based approach.
Implications for Consumer Prices	Similar in most cases. However, price impact is muted if allowances are allocated for free to LSEs and regulatory agencies do not permit LSEs to pass the opportunity cost of allowances through to customers.
Cost-Effectiveness	
Ease of Administration	First-seller approach has an advantage, in part because of the potential for more accurate monitoring. The load-based approach entails additional administrative requirements, such as the need to track in-state sources by time of day.
Ability to Promote Low-Cost Emissions Reduction Strategies	Some on Committee feel this is similar under both approaches. Other Committee members assert that the load-based approach may have an advantage on the basis that the obligation to hold allowances will produce stronger direct incentives for LSEs to pursue low-cost emission reduction strategies.
Ability to Serve as a Model for Other Cap-and-Trade Programs	First-seller approach may have advantage. It would probably allow for an easier transition to a federal cap-and-trade program, in particular, since a federal program would likely be generator-based.

Figure 5 : Advantages and DisAdvantages of First-Seller and Load-Based Approaches

The Market Advisory Committee has also recommended that the following three issues should be paid attention to.

The first is that the Cap-and-Trade system, as applied to the Electricity sector has to demonstrate that it is actually achieving the stated emission reductions. The key areas of concern here are, ensuring the data quality of out-of-state generators serving California load, attributing emissions from both in- and out-of-state generators to specific LSE's, and managing the degree to which contract shuffling reduces actual emissions reductions under the program.

Related to the first, the second issue relates to ensuring that the provisions designed to discourage contract shuffling or to track emissions from imports do not interfere with current trading of short-run and real-time electricity markets.

The third issue regards multi-jurisdictional utilities and independent power producers; they have to be treated equitably.

Electricity pricing to consumers is based on average cost of servicing customers. LSE's including investor-owned utilities and municipal utilities operate under this type of cost-recovery rule. Electric prices are not impacted whether a first-seller or load-based approach is chosen, but on whether permits are given away for free or charged for, and to whom they are offered. If LSE's are the points of regulation and are required to hold allowances, then LSE's will pass on the cost of Allowances to the consumers. If in-state generators and electricity importers are the points of regulation, then they pass on the cost of Allowances to the LSE's, who in turn pass it on to the consumers.

Allowance Distribution

The method of initial allowance distribution, impact's the prices but does not impact the environmental outcome. The MAC recommends that the allowances be distributed in a manner consistent with fundamental objectives of cost-effectiveness, fairness and simplicity. In other words auction off the Allowances. However, the Committee feels that several factors weigh in favor of starting with distribution of some allowances for free and eventually transitioning to a full auction. The key advantages of auctioning over allocation are that firstly, auctioning more effectively avoids windfall profits and perverse incentives. Secondly auction revenues can be used more directly and more transparently to advance program goals. Thirdly auctioning treats new entrants and existing emitters on a level playing field, and finally, auctioning avoids the challenges of designing a fair free distribution. However, there is no experience to draw from, since none of the previous emissions trading programs have used auction a 100%. Engaging in auctions impact the cash flow of regulated entities, and this could be challenging especially at the beginning of the program. Required upfront payments for allowances, may contribute to the alteration of an entities capital structure, reducing capital efficiency for the entity. The idea of auctioning seems to have come from the practice of auctioning Treasuries, radio spectrum, etc.

An entities investment in early action needs to be recognized rather than penalized. If allowances are given away for free, then early action would entail receipt of fewer allowances than business-as-usual. Acting after the fact would free up more allowances to sell, and hence a windfall for a non-early actor. Hence most entities would wait till the last minute, at the point that they find out that they are roped into the Cap-and-Trade system, to make any investments in emission reductions. To encourage early action the MAC recommends granting the entities offset allowances for reductions made in periods prior to their inclusion in the Cap-and-Trade system, and employ direct financial incentives with tighter regulatory policies outside the Cap-and-Trade system. However granting offsets raises the issue of 'additionality' hence the MAC recommends employing direct financial incentives.

Encouraging emissions reductions amongst entities not covered by the Cap-and-Trade program, offsets (see Appendix) broaden the reach of the program and helps promote the goal of overall emission reductions at the lowest cost. Offset's are subject to the scrutiny of the principle of additionality (see Appendix) and exclusive ownership. California needs to develop and implement a credible offset program that establishes accurate and rigorous baselines in addition to adopting strong monitoring and verification requirements, for both in-state and out-of-state generated offsets. Since there is an inherent risk to an offset project, i.e. the small probability of not generating actual reductions, the offsets need to be backed by guarantees if they are to be reversed. In the absence of such a guarantee, the MAC recommends an application of an appropriate discount factor for use of offset credits, and a quantity limit to the number of offsets that should be absorbed

Uncertainties about cost and timing in the adoption of new, low-carbon technologies create the potential for high or volatile allowance prices under the Cap-and-Trade program. High prices can cause economic hardship, while price volatility creates uncertainty for investments in emission reductions and reduces market confidence. One way of fixing the high and volatile prices, is by allowing for intertemporal trading of Allowances. Borrowing and Banking are the two main forms of intertemporal Allowance trading. Since Borrowing creates the risk that borrowed allowances may not be recouped, Borrowing is not recommended. Banking allows entities to over-comply in the early phase, thereby improving environmental performance earlier, and allowing the allowances to be saved for surrender in future compliance periods. Hence unlimited banking is supported.

The length of the compliance period can neither be too short or too long. The length of the compliance period affects intertemporal flexibility. A short compliance period, say one year, would not let the covered entities to smooth emission fluctuations due to changes in a number of variables, e.g. weather, market conditions, etc. A long compliance period would not provide regular assurance that emission targets are being met, since the true-ups (see Appendix) would be spread apart too far. The MAC has recommended a compliance period of approximately three years in length, to balance the goals of flexibility and environmental integrity. This means that at the end of every three years, compliance would be assessed, by comparing emissions against Allowances held.

The recommended emissions reporting period is at the end of every quarter for large sources and at least annually for the remaining entities.

The Safety Valve mechanism is not recommended, since the MAC has determined that the various difficulties and challenges posed by a safety valve outweigh the potential attractions. Having the safety valve firstly compromises one of the major attractions of the Cap-and-Trade program which is the certainty that total emissions are always going to be kept within the cap, and secondly causes linkage problems with other Cap-and-Trade programs. While a safety valve establishes a ceiling on the Allowance price, having a floor for the Allowance price has been recommended. The price floor would be enforced by purchasing allowances and removing them from circulation, whenever the floor price was reached. Another way of enforcing the floor price would be to institute a reservation (or floor) price in any auction for emission allowances. Since the price floor, contrary to the safety valve, would enhance environmental integrity and also signal to investors that emission prices would never fall below a certain level, protecting their return on investments in low carbon technology, the price floor has been recommended.

Another cost-containment mechanism that has been mentioned is the circuit-breaker.

The circuit breaker delays or cancels a scheduled deadline in the emissions cap. The circuit breaker may reduce the Allowance price, but provides neither price nor quantity certainty for covered entities, and does not ensure environmental integrity.

Penalties for non-compliance, may take the form of the NOx program, where a shortfall of an Allowance requires making up with an Allowance to cover the shortfall plus two additional Allowances as penalty. Hence the non-compliant entity has to come up with three Allowances for each Allowance worth of non-compliance. Other systems like the SO2 and the EU ETS apply financial penalties rather than in-kind penalties. Civil and Criminal penalties are also recommended to ward of continuous non-compliance.

Chapter 3 : Methods

This chapter captures the key points and parameters set by CARB in the design of the California Cap-and-Trade system.

Between the two options, Option A or Option B, it is practical to start with Option A rather than Option B. Option B although an excellent and the best choice, requires a new and sophisticated infrastructure to be put in place, before emission caps can be applied, monitored and reported. This new and sophisticated infrastructure will require new technologies and billions of dollars in cost. Option A, which consists of three program designs, allows the state to begin right away with Program Design 1. Implementation of Program Design 1 requires existing infrastructure and resources, without having to indulge in new monitoring and reporting technologies or related costs. Another benefit is that in parallel, infrastructure can be put into place to transition to Program Design 2 and then Program Design 3, while at the same time leveraging the additional learnings as the program progresses.

450 entities are covered by Option A, Program Design 1. They account for 39% or 192.6 MMT (Million Metric Tonnes) of CO2 equivalent GHGE. These 450 entities individually generate more than 10,000 MT's (Metric Tonnes) of CO2 equivalent GHGE's per year. The 450 entities covered by Program 1 include the electricity sector (in-state and imported generation) and other industrial sources. Looking through California's Environmental Database, we have identified 278 such Electric entities (See Appendix for the plants, fuel source type, owners, MW installed etc.) that generate in excess of 10,000 MT of GHGE individually, and cumulatively generate approximately 98MMT of GHGE. We assume that the remaining 172 (450-278) entities are the industrial sources that generate the balance 94 (192-98) MMT of GHGE.

The compliance period is set equal to three years. We make the assumption, that since the recommendations are made in July of 2007, and that it takes a little bit of time to decide and implement a policy, and since that no policy is implemented as of May 2008 that the policy will first see implementation in 2009. Working back from year 2020, which is our target for 1990 levels of compliance, we conclude there will be four compliance periods, as shown in the table below, which also fits in with our earlier assumption of the policy being implemented from 2009. See table below.

Compliance Period	Years included		
1	2009	2010	2011
2	2012	2013	2014
3	2015	2016	2017
4	2018	2019	2020

Table 1 : Compliance Periods for Option A of California's Cap-and-Trade System

The estimated Business-As-Usual (BAU) GHGE emissions for year 2020 is 601 MMT, and the actual emissions for year 1990 is 427 MMT.

Using emissions data from the CARB site, and assuming the above compliance periods, and using the strategy of stabilizing the emissions during the first compliance period, called the 'hold' strategy and then actively reduce the emissions over period 2, 3 and 4, we calculate the emissions cap and per period required reductions, as shown in the following table. For more details see the Appendix.

Compliance Period	1	2	3	4
Total estimated BAU GHGe	1576	1644	1712	1780
Total estimated Cap GHGe	1553.25	1492.48	1401.33	1310.18
Per Period reductions	22.65	128.72	159.10	159.10

Table 2 : Total Greenhouse gas reductions under our assumed compliance trajectory

Since we are focused on the Electric sector and the abatements by this sector, and given that from above, that the amount of emissions by the electric sector and the industrial sources are close enough, 98MMT and 94MMT, we make the assumption that the 278 electric entities will provide half, 20% of the 39%, of the required per-period reductions, for Option A , Program Design 1.

The 450 entities, that produce 39% (192.6MMT) of the total GHGE, will be responsible for providing the 22.65MMT of reductions, to stay on the above compliance trajectory. In other words the cap is set to 11.76% (22.65/192.6) for these entities of which the 278 electric entities would be responsible for a reduction of 11.61 (22.65*20/39) MMT or 6.02%.

Abatement curves and their variation across power plants are key to the success of the Cap-and-Trade system. No reliable data is available regarding abatement curves, and at this time we will have to model this parameter. Abatement curves vary considerably between entities, because of the type of technology, the utilization model, the age of equipment etc. Even if two plants are similar in technology and size, other attributes such as man-power, financial situation, company strategy, etc, cause differences in the abatement curves of similar plants. Some plants may achieve abatement earlier while others later and in a different compliance period. Due to insufficient data we will model this parameter.

Allowance distribution is to be a mixture of giving some away for free and auctioning the rest. What percentage should be given away for free? do entities get free allowances pari-passu? and the amount to be auctioned off has not been clearly specified. Insufficient data exists regarding the above hybrid mix of allowance distribution and this needs to be modeled.

Unlimited banking of allowances is recommended. There is insufficient data on the impact of unlimited banking to the Cap-and-Trade system. Borrowing on the other hand is not recommended. If an entity under performs with respect to its emission obligations, and cannot come up with the requisite allowances to cover the gap at true-up time, then penalties will apply. The penalty recommended is three allowances for every allowance exceeding the cap.

A safety valve is not recommended but instead enforcement of a price floor is recommended. The reservation or floor price would be the price of the allowance at the auction.

Finally, the California Cap-and-Trade system is designed to address the following two issues: Environmental Integrity and Cost-Effective emission reductions.

I have modeled a Cap-and-Trade system using as much data that is available from the state of California. The goal of the model is to understand the degree of control that a regulator can have in achieving the twin goals of Environmental Integrity and cost-effective emission reductions based on the recommendations of the MAC to CARB.

Description of the Model:

Data from the CARB site identified 900+ electric supply companies for California, with data on their MW installed capacity.

The first step is to identify how much Green House Gases (GHG) are emitted by these entities. We know that this number should be roughly 28%, the amount attributed to the Electricity sector, of the total GHG emitted by the state of California (See Figure 2)

We calculate the MWh per year by multiplying the installed capacity in MW * 24 hours * 360 days per year. The assumption here is that the equivalent of five days a year is scheduled for maintenance. The average carbon intensity of electric consumed in California is 930lbs/MWh of CO2 GHGE equivalence. (Page 41, Recommendations of GHG C&T sys for Cali). Multiplying the total MWh/year * 930lbs/MWh * lb_to_MT scaler; gives the total amount of average GHG emissions emitted per year by each electric entity in Metric Tonnes (MT). After calculating this value for each entity, and since our interest is in Option A, Program Design 1, which covers GHG producing entities that generate GHG over 10,000 Metric Tonnes, we filter out the entities on this criteria and are left with 278 Electric entities, that generate approximately about 98 MMT of GHG's.

Since these GHGE numbers are for year 2004. I then calculated a scale factor to scale the year 2004 numbers to years 2009, 2010 and 2011. I did this by dividing the GHGE's for these years by the GHGE for year 2004. For example the estimated GHGE for year 2009 is 518MMT, whereas the GHGE for year 2004 is 480MMT. Hence my scale factor for year 2009 is 1.079167, which is the result of 518 divided by 480.

I then used the scale factors to calculate the GHG emissions for each of the 278 entries for the years in compliance period 1. Now I can apply the 'hold' strategy to these entities with these calculated numbers. As discussed before, with the "hold' strategy the 278 electric entities would be responsible for a reduction of 11.61 (22.65*20/39) MMT or 6.02% of abatement.

I then defined a headroom parameter, which specifies the minimum and maximum value across all entities. The headroom is a projected value, defined as the amount of abatement possible by an entity. The assumption is that across the industry (i.e. all electric entities), it is possible for any entity to achieve a maximum amount of abatement, given infinite time and costs, and that no entity will not be able to make a certain minimum amount of abatement. These two values are captured as maximum and minimum headroom parameters, and can be varied. For example, based on the experience with the industry it may vary widely initially, say 20% to 50%, and as abatements are made, in the later years/compliance periods, this could vary from 2% to 10%. The regulator would program this variable based on their current findings in the industry. The model assumes that the headroom is normally distributed, and the headroom is then calculated for each entity.

Since there are three years within the compliance period, the model assumes that the abatement method, discovered or invented, can happen in any one of the three years and that once the abatement method is installed it will continue to provide abatement in the subsequent years. The model assumes that an entity will have made at least one abatement discovery or application during the compliance period. No entity will have made zero abatement. The model also assumes that no more than one abatement discovery or invention is made in the same compliance period.

Actual abatement done is computed by assuming a normal distribution, which can be any amount from zero to the headroom being the upper limit. An entity may not be able to find an abatement solution, even though it thinks it could, or the solution may just not be ready, or installing the solution may take more time and effort than originally planned. Or, it just maybe that the solution is currently too expensive, and a cheaper way out would be buy allowances in the open market. Hence it is reasonable to allow an entity to make no actual abatements. While it is possible for entities to have made significant breakthrough's and exceed their initial expectation of the size of the abatement possible. i.e. exceed their headroom projections, the model does not allow for this and clamps the maximum possible actual abatement to the headroom level. The actual abatement for each of the years is calculated, and then summed up to provide a cumulative value at the end of the compliance period. Similar companies that have their abatements applied in different years may have differing cumulative abatements.

The Regulator provides the cap for the compliance period as a control parameter. The model uses this parameter and calculates the cap on the business as usual values for the compliance period, per entity. The model then compares the cumulative abatement against the cap. If the cumulative abatement is lower than the desired abatement (the cap) then the entity has a shortfall in its abatement obligations and has to go to the open market to buy allowances. This means the entity is forced to take part in the 'trade' part of the Cap-and-Trade system. The model then calculates the number of entities that are forced into the trading system. The entities that made abatements exceeding the cap, have excess allowances. These entities may choose to trade, or they may choose to bank their excess allowances. Since California allows for unlimited banking there is no limit to how many allowances may be banked.

The model provides feedback on the percentage abatement below cap, the number of entities that would be forced into the trading system, the number of entities that may bank their excess allowances and how many allowances in penalties the state of California would gain. In essence by setting the cap, and having an understanding of the headroom that the entities have, and estimating the entities ability to make abatement changes to realize actual GHGE reductions, the regulator can move the industry to an optimal point where the difference between cap and actual abatement is optimal and the number of entities forced into trading hovers around 50% (This is so that there is no buyers market or sellers market induced).

A breakdown of the 278 Electric Entities reveals the following table. There are 67 entities that spew out less than 50,000 Metric Tonnes of GHG emissions, and 28 that spew out between 1 Million to 3 Million Metric Tonnes.

Bin limits 2004 GHGE (MMT)		# Entities
	0	0
	50,000	67
	100,000	66
	150,000	64
	200,000	7
	250,000	11
	300,000	9
	350,000	5
	400,000	2
	450,000	3
	500,000	2
	550,000	3
	600,000	1
	1,000,000	5
	3,000,000	28
	6,000,000	5
Total		278

Table 3 : Distribution of CA Electric Entities by GHG emissions (2004)

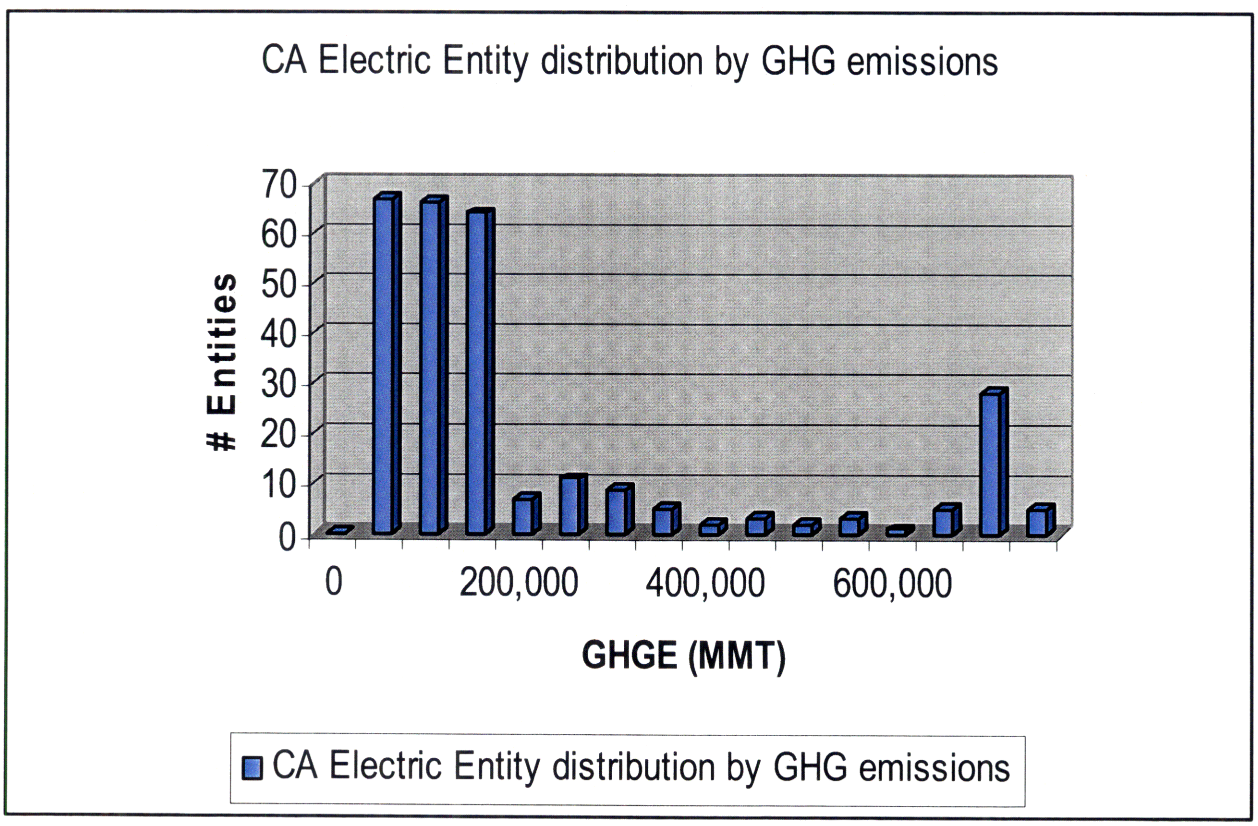

Fig 6 : Distribution of California's Electric Entities by GHGE produced for year 2004

Chapter 4: Results, Analysis and Conclusions

I have modeled various scenarios, to understand how this model can be used to discover the optimal cap for a given set of data that can be got from the Electric Entities.
An electric entity would have a fair idea of the maximum possible abatement it can make. If this data was gathered from every entity, some would be capable of more abatement than others. Hence we would have the largest maximum value and the smallest maximum value. We call this maximum headroom and minimum headroom in our model.
For a given amount of headroom, the entity could provide data as to how much % abatement they would be able to achieve within the compliance period, and possibly in which year within the compliance period.
Keeping the headroom values static and running the model a 1000 times over in which we vary the cap in steps of 0.5%, from 0% to 10%, we get the following results that are graphed.
We graph the difference between the cap and the actual abatement versus the % cap set. The optimal point is when the cap is set between 7% and 7.5%. We also graph the number of entities forced to trade in the trading scheme based on the % cap set. The optimal point occurs when the cap is set between 5% and 6%.
The regulator could then give weightage to either the environmental integrity at which the abatement is almost equal to the cap, as in somewhere in the 7% range, or give weightage to cost effective emission reductions, or an optimal point in between.
However we know that to follow our "hold" strategy we need to have an abatement of 6.02%, and the regulator, in this scenario, has the flexibility to pick this cap % number.

Cap in % for Compliance Period 1	Diff (Cap-Actual) abatement in MMT	# Entities forced to take part in trade
0.0%	-21.38	0
0.5%	-19.80	21
1.0%	-18.19	34
1.5%	-16.58	45
2.0%	-14.97	63
2.5%	-13.36	70
3.0%	-11.74	80
3.5%	-10.13	93
4.0%	-8.52	103
4.5%	-6.91	116
5.0%	-5.30	125
5.5%	-3.69	132
6.0%	-2.07	142
6.5%	-0.46	151
7.0%	1.15	172
7.5%	2.76	178
8.0%	4.37	183
8.5%	5.98	187
9.0%	7.60	191
9.5%	9.21	197
10.0%	10.82	204

Table 4: Variations in Abatement Shortfall and # Entities trading for step changes in cap %

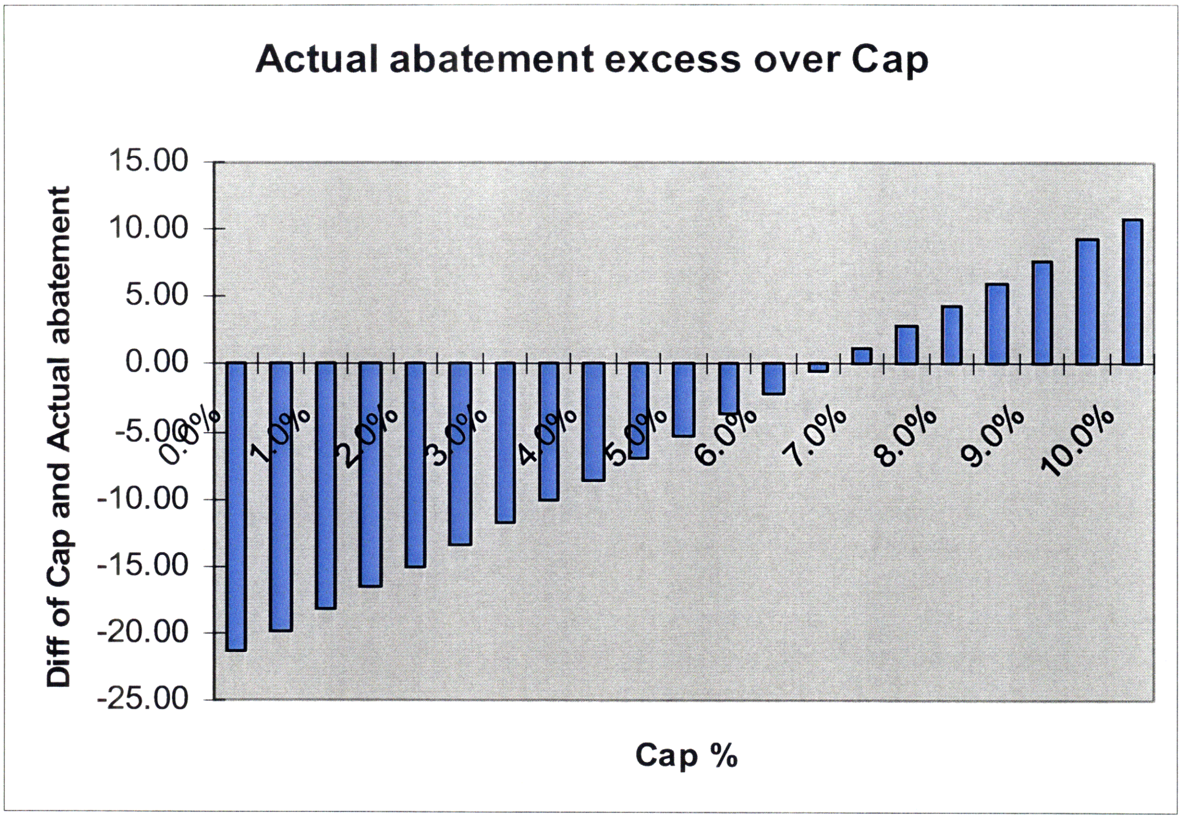

Figure 6 : Variations in Abatement Shortfall for step changes of 0.5% in cap %'s

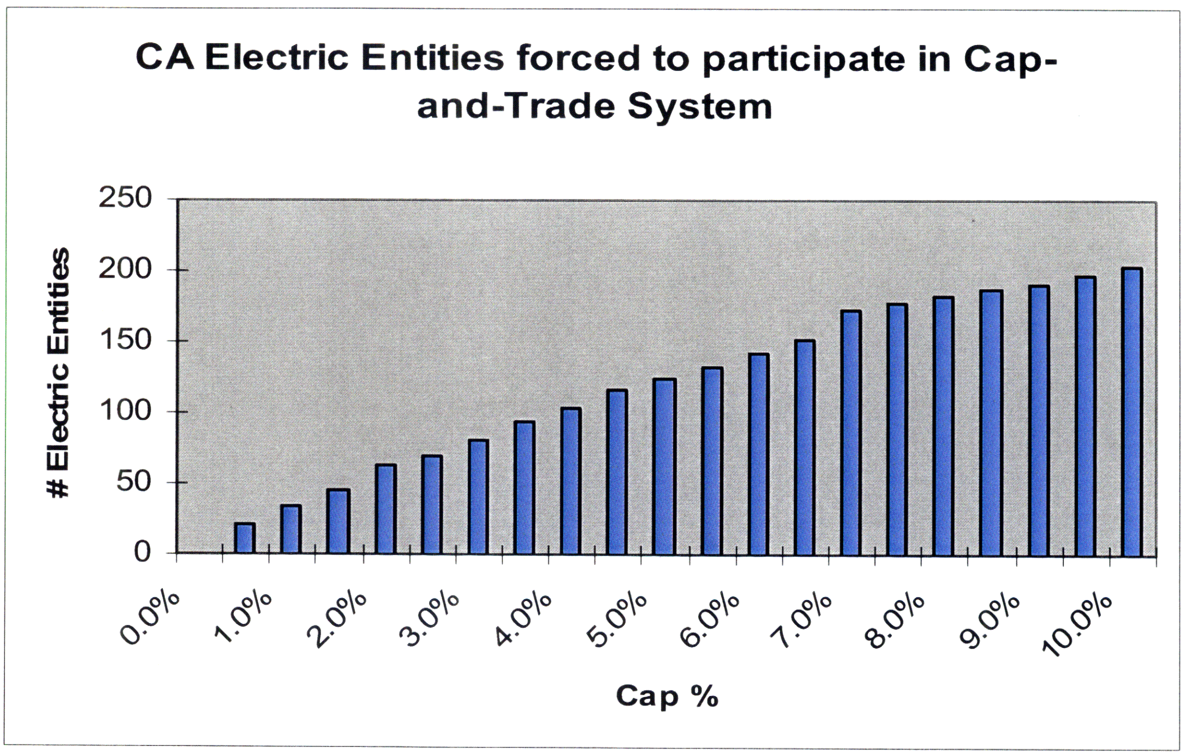

Figure 7 : Variations in # Electric entities trading, for step changes of 0.5% in cap %'s

Another scenario to consider would be to use the model in determining how the variation in actual abatement capability could affect meeting the cap, and impact the number of entities drawn into the trading scheme, given that the Headroom data is known and is static. I have modeled this scenario at 5%, 6% and 7% cap, to show and discuss the differences. Since our interest hangs around 6.02%, I picked a percentage point on either side.

At 5% Cap :

From the following graph that given a static headroom (kept same as the above case), and allowing for a random distribution of Entities ability to make changes within random years of the compliance period shows that if the cap is set at 5% then more often than not the industry (comprising of the 278 entities) would come up with excess abatements with the most likely excessive abatement of about 4 MMT. At the same time there would most likely be 134 entities that would come up short in meeting their cap, leaving 144 entities that would meet the cap, or almost an equal number of buyers and sellers.

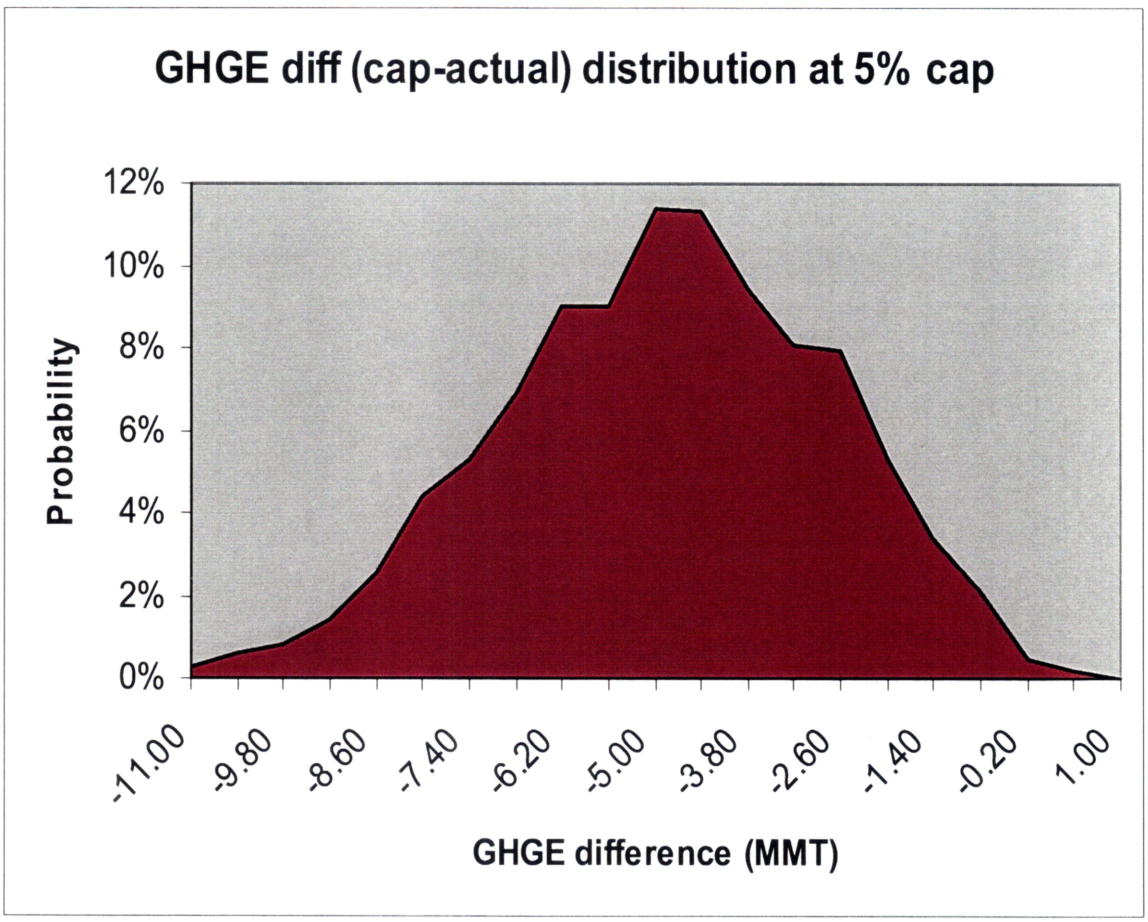

Figure 8 : Distribution of the difference, of GHGE, between Cap (5%) and Actual Abatement in MMT

The negative numbers mean that the actual abatement is larger than the Cap value.

GHGE difference (Cap – Actual Abatement) At 5% Cap

GHGE difference (Cap – Actual Abatement) At 5% Cap	Probability
-11.00	0.30%
-10.40	0.60%
-9.80	0.80%
-9.20	1.40%
-8.60	2.60%
-8.00	4.40%
-7.40	5.30%
-6.80	6.90%
-6.20	9.00%
-5.60	9.00%
-5.00	11.40%
-4.40	11.30%
-3.80	9.40%
-3.20	8.10%
-2.60	7.90%
-2.00	5.30%
-1.40	3.40%
-0.80	2.10%
-0.20	0.50%
0.40	0.20%
1.00	0.00%

Table 5 : GHGE difference (Cap - Actual Abatement) in MMT's at 5% Cap

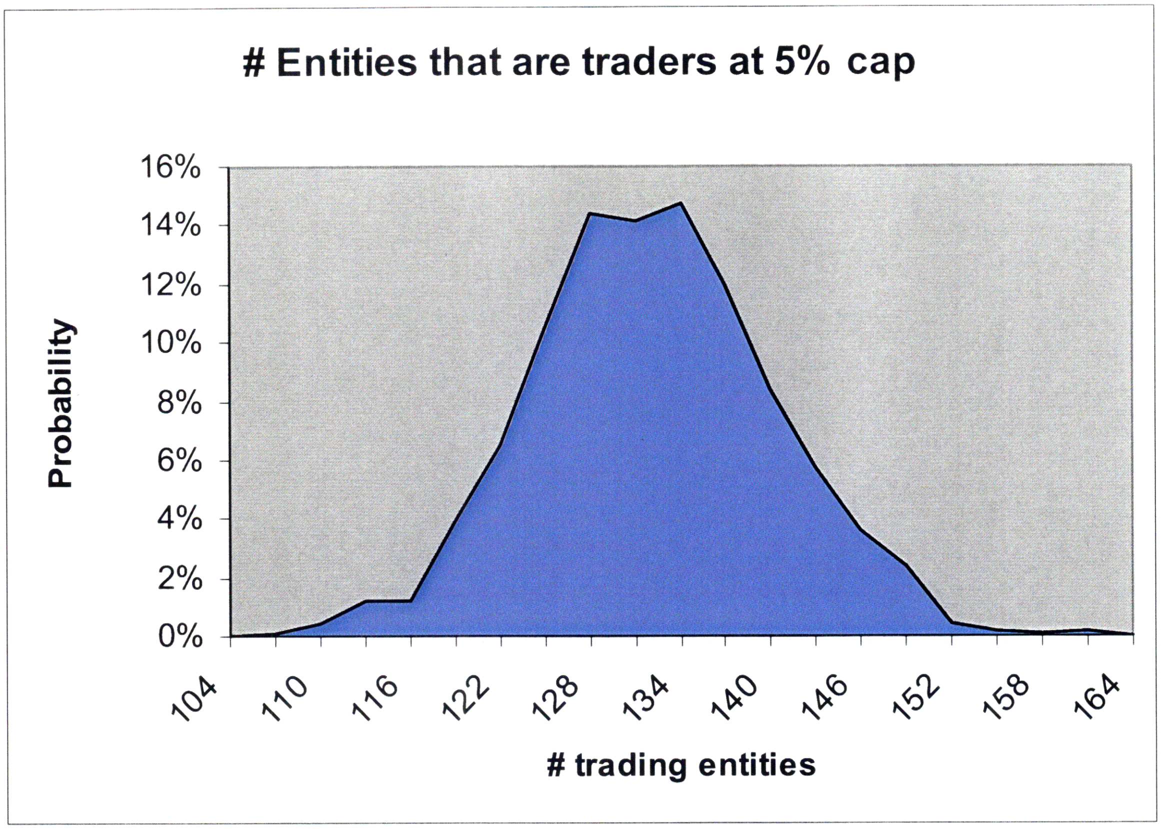

Figure 9 : # Electric entities forced to trade at a 5% Cap level

# Electric entities forced to trade at 5% cap level	Probability
104	0.00%
107	0.10%
110	0.40%
113	1.20%
116	1.20%
119	3.90%
122	6.50%
125	10.50%
128	14.40%
131	14.10%
134	14.70%
137	12.00%
140	8.40%
143	5.70%
146	3.60%
149	2.40%
152	0.40%
155	0.20%
158	0.10%
161	0.20%
164	0.00%

Table 6 : # Electric entities forced to trade at the 5% Cap level

At 6% Cap :

If the cap is set at 6% then more often than not the industry (comprising of the 278 entities) would come up with an excess of 1.25 MMT of abatement. At the same time there would most likely be 154 entities that would come up short in meeting their cap, leaving 122 entities that would meet or exceed the cap. Hence the trading market would be a good thriving market. There are fewer sellers than buyers, and it may seem that sellers could manipulate price to their advantage, but sellers have more to sell. Hence this is a pretty much balanced scenario.

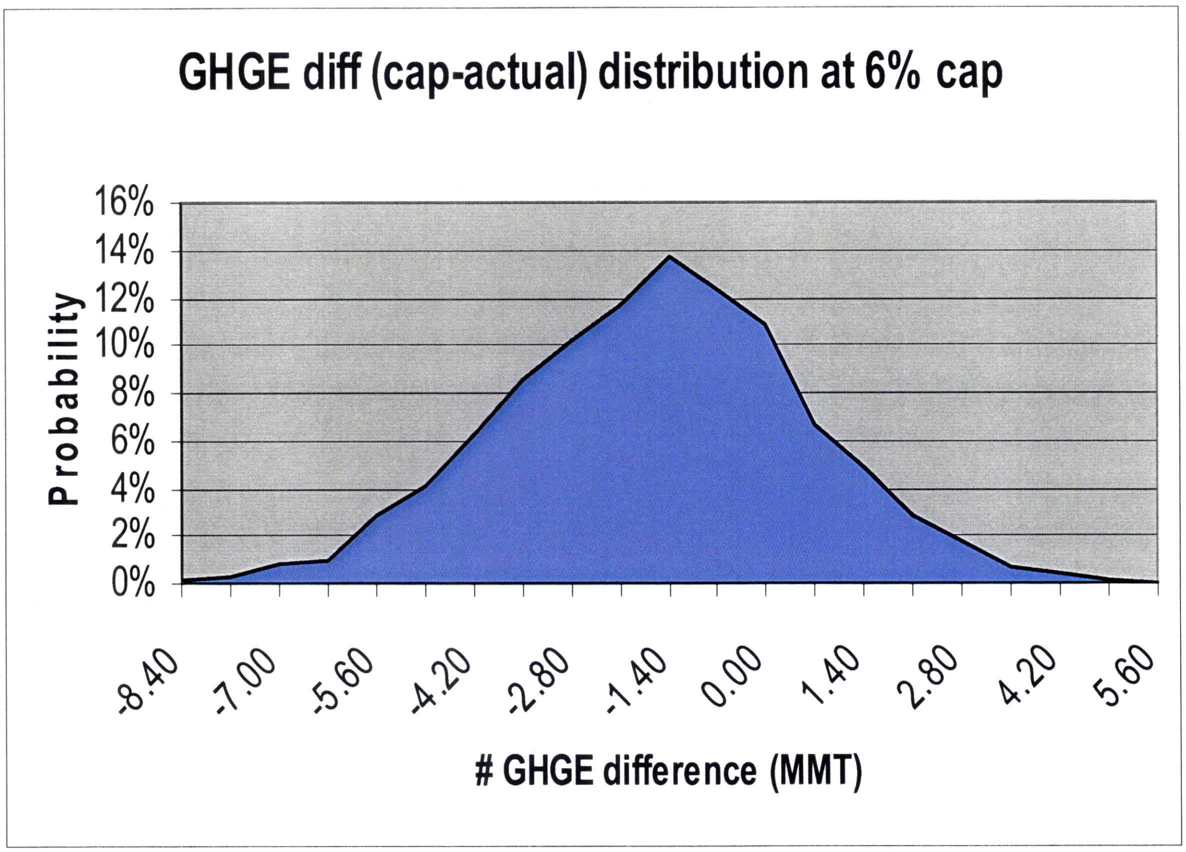

Figure 10 : Distribution of the difference, of GHGE, between Cap (6%) and Actual Abatement

GHGE difference (Cap – Actual Abatement)

At 6% Cap	Probability
-8.40	0.10%
-7.70	0.30%
-7.00	0.80%
-6.30	0.90%
-5.60	2.80%
-4.90	4.10%
-4.20	6.20%
-3.50	8.50%
-2.80	10.20%
-2.10	11.70%
-1.40	13.70%
-0.70	12.30%
0.00	10.90%
0.70	6.70%
1.40	4.90%
2.10	2.90%
2.80	1.70%
3.50	0.70%
4.20	0.40%
4.90	0.10%
5.60	0.00%

Table 7 : GHGE difference (Cap - Actual Abatement) in MMT's at 6% Cap

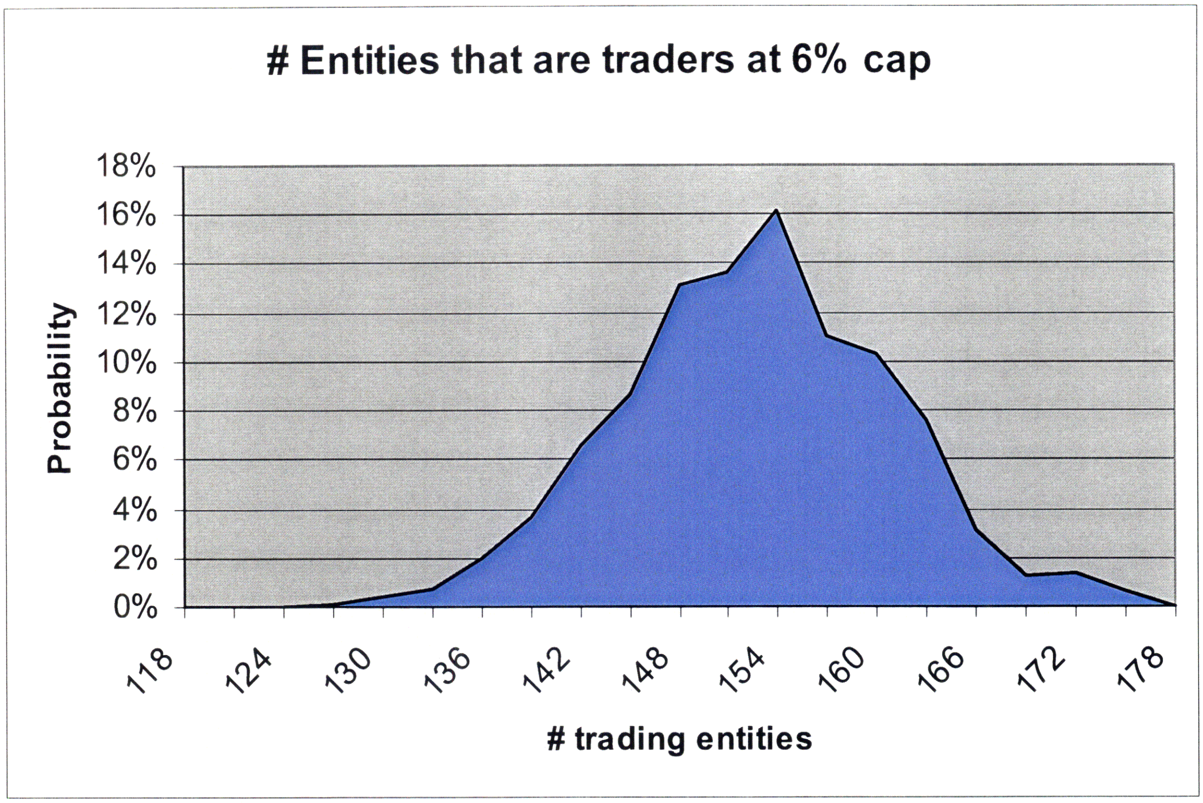

Figure 11 : # Electric entities forced to trade at 6% Cap level

# Electric entities forced to trade at 6% cap level	Probability
118	0.00%
121	0.00%
124	0.00%
127	0.10%
130	0.40%
133	0.70%
136	2.00%
139	3.60%
142	6.60%
145	8.60%
148	13.10%
151	13.60%
154	16.10%
157	11.00%
160	10.30%
163	7.60%
166	3.10%
169	1.20%
172	1.40%
175	0.60%
178	0.00%

Table 8 : # Electric entities forced to trade at the 6% Cap level

At 7% Cap :

From the following graph that given a static headroom (kept same as the above case), and allowing for a random distribution of Entities ability to make changes within random years of the compliance period shows that if the cap is set at 7% then more often than not the industry (comprising of the 278 entities) would come up short with the most likely shortfall of about 1.5 MMT. At the same time there would most likely be 172 entities that would come up short in meeting their cap, leaving 106 entities that would meet the cap. Hence the trading market would be skewed in favor of the sellers, and become even more skewed if some of the sellers decided to bank their excess allowances. With penalties three times the price of an allowance, another premium would be added to the market price of the allowance in favor of the sellers.

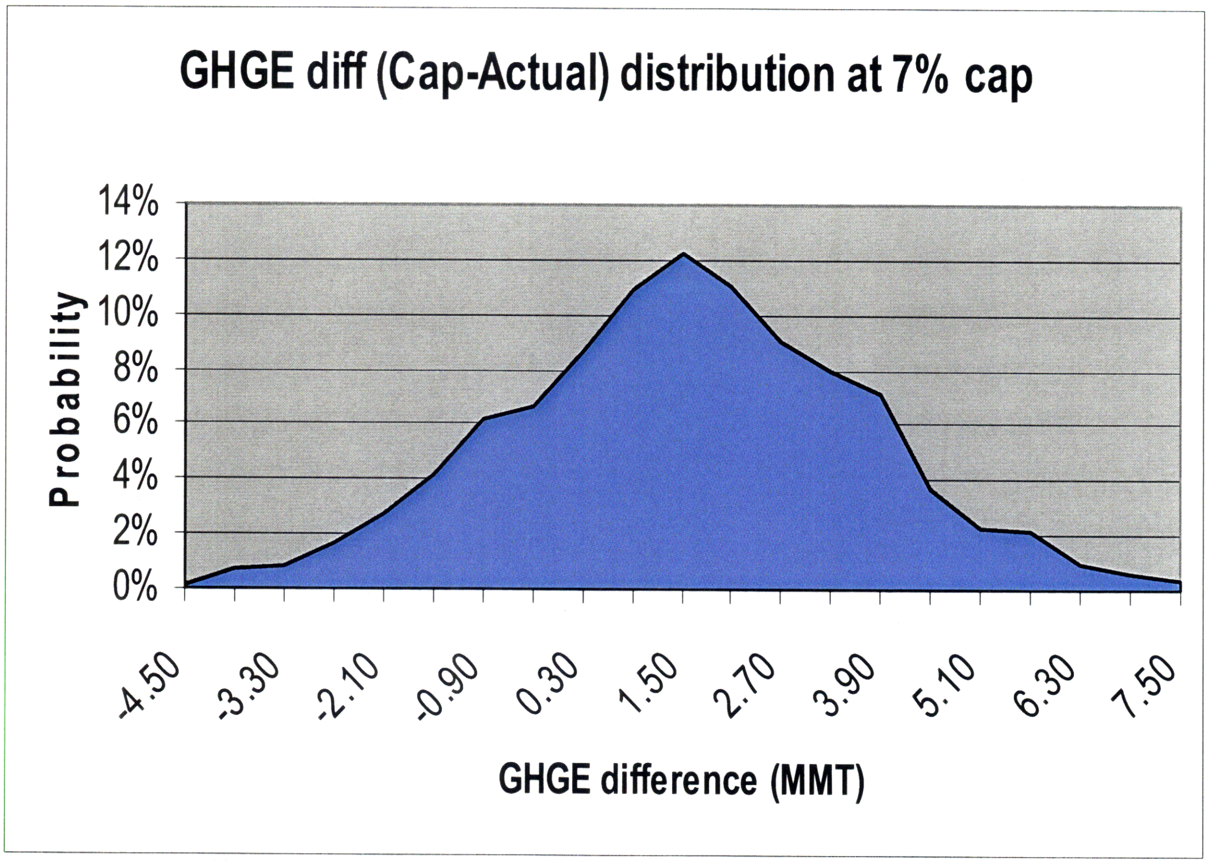

Figure 12 : Distribution of the difference, of GHGE, between Cap (7%) and Actual Abatement

GHGE difference (Cap – Actual Abatement) At 7% Cap	Probability
-4.50	0.10%
-3.90	0.70%
-3.30	0.80%
-2.70	1.70%
-2.10	2.70%
-1.50	4.10%
-0.90	6.20%
-0.30	6.70%
0.30	8.70%
0.90	10.90%
1.50	12.20%
2.10	11.00%
2.70	9.00%
3.30	8.00%
3.90	7.10%
4.50	3.70%
5.10	2.30%
5.70	2.10%
6.30	1.00%
6.90	0.60%
7.50	0.30%

Table 9 : GHGE difference (Cap - Actual Abatement) in MMT's at 7% Cap

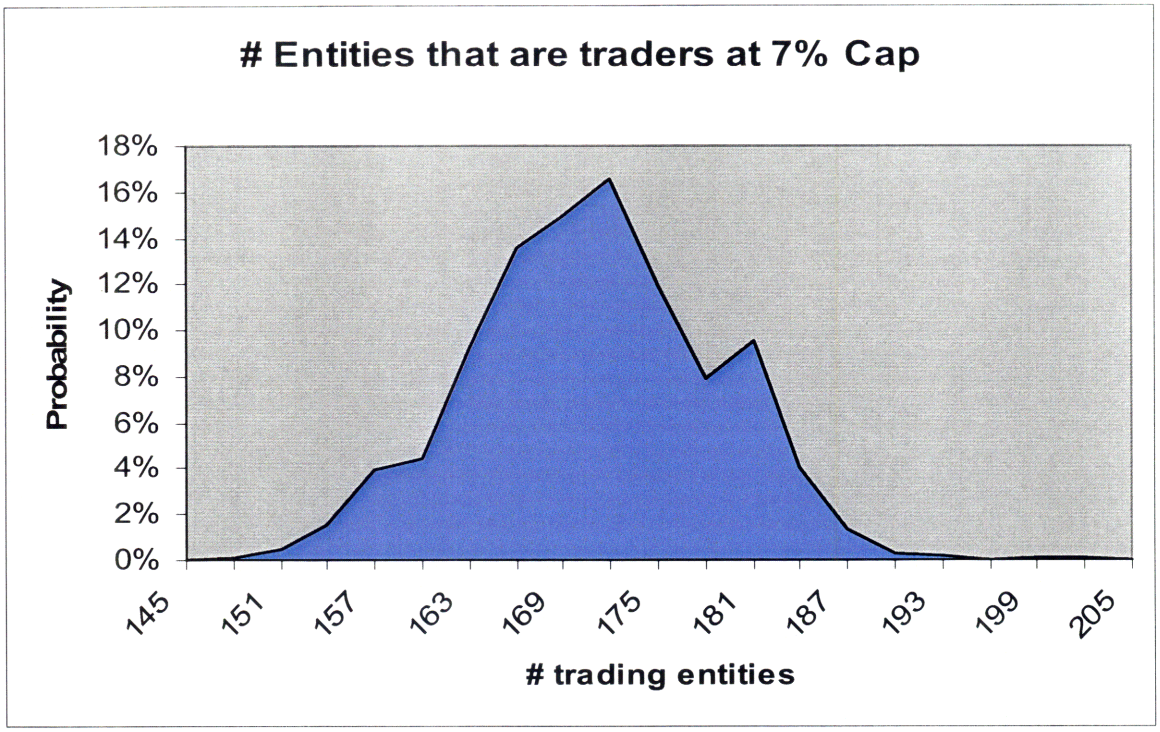

Figure 13 : Distribution of the difference, of GHGE, between Cap (7%) and Actual Abatement

# Electric entities forced to trade at 7% cap level	Probability
145	0.00%
148	0.10%
151	0.50%
154	1.50%
157	3.90%
160	4.40%
163	9.20%
166	13.60%
169	14.90%
172	16.60%
175	11.90%
178	7.90%
181	9.50%
184	4.00%
187	1.30%
190	0.30%
193	0.20%
196	0.00%
199	0.10%
202	0.10%
205	0.00%

Table 10 : # Electric entities forced to trade at the 7% Cap level

From the Cap set at the three different Cap levels and fixing the headroom, and examining how entities would be able to achieve the desired abatement, it becomes clear that the 5% cap makes it a buyers market, since there are fewer buyers and there is an excess of abated allowances. On the other hand setting the cap at 7%, reverses the above scenario. In this case there is a shortage of allowances, and there are many more buyers, making it a sellers market. The happy medium seems to be when the cap is set to 6%, where there is slight excess of abated allowance, but also a larger number of buyers.
In conclusion the model can be used to simulate the kind and amount of control a regulator has, in regulating the market in terms of both cap and trade, to offer the optimum environmental benefit and abatement at least cost.

Chapter 5 : Recommendations

The first issue with the current form of the Cap-and-Trade system is that the government has put itself in the midst of a market. This is not the ordinary case of the government auctioning off a public resource, as in treasury bills or a radio frequency spectrum and walking away. Tied to the hip, after the auction is done or the give-away completed, is the matter of meeting an obligation.
Second, the revenues collected by the government from the auction are to be deployed by the government for investment in clean and other low-carbon technologies. This money could be collected via a carbon tax, so why need the Cap-and-Trade system? besides does the government really knew how to invest in new cool technologies? This is similar to the direct regulation issue, where the government tells an entity the technology or process to use.
Third, a long Compliance period length is chosen so as to enhance the trading volume.
Fourth, long compliance periods tend to make the caps feel like they occur in large steps, and can have a major impact on an entity's cash flow. Since the cap sizes between compliance periods have a larger swing, so will the buying and selling quantities, causing volatility in prices close to the finish line.
Fifth, having the safety valve firstly compromises one of the major attractions of the Cap-and-Trade program which is the certainty that total emissions are always going to be kept within the cap, and also causing linkage problems with other Cap-and-Trade programs
Sixth, Offsets are not used to their full extent, and the government is the major source of pollution rights. Offsets are allowed to be non-technology based.
Seventh, Investors need to feel confident that their returns are protected and not wiped out. This is done with government intervention during price spikes or high price volatility.
Eighth, government determines whether to charge or not charge the entity for the allowance. This price cannot be known, ahead of time or calculated; hence the electric prices could be very volatile.

My recommendations to fix the gaps in the Cap-and-Trade System

To fix the above issues, I am proposing a Modified Cap-and-Trade system (MCAT).
This system does not drive fear driven entities to push for banking. Banking if done will be done by the government, and banking means a better environmental outcome, that can be used by all entities. The system does not require the government to step in with a Safety valve. This method is more of a continuous method that places less stress on a company's cash flow, by reducing the cash spike associated with buying Allowances all at once.

1. No Banking by entities, but banking by issuer
2. No Safety Valve
3. Method impacts not only prices but the environmental outcome

The Government

The government does not auction Allowances neither does it give away 'gratis' Allowances. Instead the government gives call option's to covered entities, to buy emission Allowances from the government at a Strike price that is particular to the entity that is given the call option.

Cost of Call option

For now let's assume that the government gives away the call option for free to the entity.

Life of Tradable Allowance

The emission Allowances purchased by the firm are good for a 'life-period'. A 'life-period' is a period of time that is specified on the emission Allowances, and indicates the period during which this Allowance can be used or traded. Once the 'life-period' is up, the emission Allowance 'expires'. The emission Allowances purchased by the firm, to be used/traded in the current life-period can only be purchased within the previous life-period. This is an important restriction. For e.g. using one month as the life-period, tradable emissions Allowances valid for the month of May, can only be purchased in the month of April. At the end of May these tradable Allowances expire.

Expiration of Tradable Allowance

Expiration means that the tradable Allowances are returned to the issuer at a highly discounted price or for free. Expiration also means that the firm that paid for the tradable emission Allowance has lost money from its purchase, and can only salvage the discounted amount as set by the issuer. For the issuer or regulator in the current case it means that the regulator has banked the emissions that were not emitted (or used). The regulator or issuer is free to set the salvage price to none, some, or the issuance price.

Compliance Window

The compliance window is set to the life-period of the tradable Allowance.

Call option availability and exercise

The call option is made available once beginning each life-period, and is exercisable at any time during the life-period, but can be exercised only once during the period. The call option expires at the end of the life-period. A new call option is made available in the next period, but now the strike price is a recalculated new Strike price.

Number of Tradable Allowances that can be purchased by the call option

The number of tradable emission Allowances that can be bought by a firm using the call option is dependent on the number of firms in the mix for the life-period concerned and the cap for that period. The issuer or regulator adds the requests for tradable emission Allowances and allocates them pro-rata relative to the cap for that period, to each requesting firm. Firms have to be careful in the amount of requested tradable allowances. If they ask for too few, and are allocated the few or fewer, means they have to go and buy additional Allowances from the market. If on the other hand the firms ask for too many or more than they can use, and are allocated that many, then they are up against the life-

period clock. They will have to either sell these allowances before the life-period is reached or may have to forfeit the extra allowances, claiming the set salvage value.
For the firms with excess Allowances, as they approach the end marker on the life-period, the losses loom large and larger, due to potential forfeit. For firms with fewer Allowances than necessary, as they approach the end marker of the life-period, the potential penalties loom larger and larger. Hence the motivation to trade for either side is large. The value of the trade, on the average, could be in the band, between the Strike price of the seller but less than the penalty for the buyer. However this is not always the case. A nervous seller may rush to sell and may accept an amount larger than salvage but below issuance price.

Strike Price for Tradable Allowances

The Strike price of the Allowance, for a specific entity is based on its emissions intensity, i.e. CO2 lbs per MWh. Because the Strike price is based on the emission rate, the problem of rewarding or penalizing an early actor goes away. It is to the benefit of the entity to get the dual benefit of lower Strike price and fewer required Allowances, reducing its overall compliance costs, due to its investment in emission reductions.

Finally, the Cap and Trade system is a new idea that is being tested in the wider market. More work needs to be done in building sophisticated models, that take into account real world data. Marginal costs to entities and the trading band needs to be studied and modeled. The impact of new discoveries and technology needs to be considered. The variation in marginal costs amongst entities needs to be considered. There is plenty of future work to be done!

Appendix

A.1 Additional Program Designs

Program 2 – Program 1 plus upstream coverage of CO2 emissions from Transportation:

- Scope: Includes Program 1 entities Plus CO2 emissions from the combustion of gasoline and diesel in the transportation sector.
- Points of regulation: Points e1 and e2 as in Program 1, Plus point c2 in Fig 3.
- Extent of coverage: The inclusion of CO2 emissions from gasoline and diesel use expands the coverage from 39% as in Program 1 to 72% of California Greenhouse gas emissions.
- Administrative considerations: Program 2 adds an administrative infrastructure cost. Program 2 requires California to create a system to monitor the amount of carbon sold by refiners and importers in the form of gasoline and diesel fuel. There are approximately, only 30 such entities in the state.
- Implementation: Program 2 augments Program 1 by including the road transportation sector. The transportation sector is not currently part of any Cap-and-Trade system, and additional work is required to identify specific points of regulation, develop measurement and reporting protocols and sort out the regulatory roles and responsibilities of industry and government officials. The benefit of adding the transport sector is that it increases the scope, lower cost s and offers greater market liquidity.

Program 3 – Program 2 plus upstream coverage of Fossil fuel combustion by other sectors:

- Scope: Includes Program 1 and Program 2 entities Plus upstream coverage of CO_2 emissions from fossil fuel combustion at residential and small industrial/commercial facilities.
- Points of regulation: Points e1 and e2 as in Program 1, Point c2 as in Program 2 Plus point c3 in Fig 3.
- Extent of coverage: Residential use of fossil fuels accounts for 6% of California's GHG emissions. Small industrial/commercial facilities account for 5% of California's GHG emissions. Program 3 expands the coverage from 72% to 83%.
- Administrative considerations: Program 3 adds an administrative infrastructure cost. In addition to the Program 2 administrative requirements, Program 3 requires a new monitoring and reporting system to include local and natural gas distribution companies. There are 10 such entities in the state.
- Implementation: Program 3 broadens the scope of Program 2 by adding in the fuel consumption/emissions of residential and industrial/commercial facilities. Additional work is required to ensure that fuel used by these sectors is accurately measured and reported. Points of regulation, protocols for measuring and reporting fuel carbon content, avoidance of double counting and selection of responsible individuals at natural gas companies is required. The agency or agencies in charge of this part of the program needs to be setup or identified.

Program 4 – Upstream coverage of CO_2 from fossil fuel combustion and downstream coverage of large sources of non-CO_2 gases and some suppliers of high-GWP gases:

- Scope: Includes Program 1,2 and 3 entities Plus ALL CO_2 emissions from the combustion of fossil fuels. It also includes industrial process emissions, high GWP gases and electricity imports.
- Points of regulation: Natural gas delivery point c1 and gasoline and diesel supply point c2 for CO_2 emissions from in-state combustion. Industrial process sources, supply of high GWP gases and electricity imports for other emissions.
- Extent of coverage: Similar to Program 3, program 4 would cover 83% of California's GHG emissions.
- Administrative considerations: Program 4 adds the most administrative infrastructure costs. Similar to Program 3, Program 4 requires the development of a monitoring and reporting system to track all fossil fuels produced in or imported into California. This includes all natural gas processing plants, the state's seven interstate natural gas pipelines, and pipelines from Mexico. As with Program 3, Program 4 too has no precedent for using this approach in a Cap-and-Trade system run by a single agency.
- Implementation: Program 4 achieves the same coverage as Program 3 but by moving the point of regulation upstream and thus having to cover fewer entities.

A.2 Large and Medium Electric Suppliers in California

PLANTNAME	TECHNOLOGY	OWNER	GENERAL FUEL	YEAR ONLINE	SERVICE AREA	ONLINE MW	MegaWatts (MW) PER YEAR	GHGE PER YEAR Metric Tonnes (MT)
ALAMEDA	COMBUSTION TURBINE	NORTHERN CALIFORNIA POWER AGENCY/CSC	OIL/GAS	1986	ALAMEDA	49.20	255052.80	107592
OAKLAND	COMBUSTION TURBINE	LS POWER	OIL/GAS	1978	PG&E	165.00	855360.00	360826
PE - BERKELEY INC.	COMBINED CYCLE	US TRUST OF NEW YORK	OIL/GAS	1987	PG&E	28.50	147744.00	62324
WADHAM	DIRECT COMBUSTION	WADHAM ENERGY LP	BIOMASS	1990	PG&E	29.07	150698.88	63571
WILBUR WEST POWER PLANT	STEAM	GWF POWER SYSTEMS	COAL	1990	PG&E	22.80	118195.20	49860
WILBUR EAST POWER PLANT	STEAM	GWF POWER SYSTEMS	COAL	1990	PG&E	22.80	118195.20	49860
US STEEL POSCO INDUSTRIES	STEAM	GWF POWER SYSTEMS	COAL	1989	PG&E	22.80	118195.20	49860
GWF POWER SYSTEMS L.P.	STEAM	GWF POWER SYSTEMS	COAL	1990	PG&E	22.80	118195.20	49860
GWF POWER PLANT NICHOLAS ROAD	STEAM	GWF POWER SYSTEMS	COAL	1990	PG&E	22.80	118195.20	49860
CONTRA COSTA	STEAM, SYNCHRONOUS CONDENSOR	MIRANT CORP.	OIL/GAS	1964	PG&E	674.00	3494016.00	1473919
PITTSBURG	STEAM TURBINE	MIRANT CORP.	OIL/GAS	1954	PG&E	1311.00	6796224.00	2866925
C & H SUGAR	STEAM TURBINE, WASTE HEAT	C&H SUGAR COMPANY, INC.	OIL/GAS	1957	PG&E	9.50	49248.00	20775
MARTINEZ REFINING CO.	STEAM, COMBUSTION TURBINE	MARTINEZ REFINING CO.	OIL/GAS	1995	PG&E	80.00	414720.00	174946
LOS MEDANOS ENERGY CENTER	COMBUSTION TURBINE, STEAM	CALPINE	OIL/GAS	2001	PG&E	543.00	2814912.00	1187445

MOBILE GT	GAS COMBUSTION TURBINE	PACIFIC GAS AND ELECTRIC COMPANY	OIL/GAS	1983	PG&E	41.90	217209.60	91628
FOSTER-WHEELER MARTINEZ COGEN L.P.	GAS TURBINE	FOSTER WHEELER POWER SYSTEMS, INC.	OIL/GAS	1987	PG&E	113.50	588384.00	248204
TOSCO SFAR CARBON		TOSCO CORP	OIL/GAS	1984	PG&E	27.38	141937.92	59875
SAN FRANCISCO REFINERY			OIL/GAS	1987	PG&E	49.90	258681.60	109122
RIVERVIEW ENERGY CENTER	COMBUSTION TURBINE	CALPINE	OIL/GAS	2003	PG&E	48.10	249350.40	105186
CROCKETT COGEN	COMBINED CYCLE	CROCKETT COGENERATION	OIL/GAS	1995	PG&E	240.00	1244160.00	524838
CALPINE PITTSBURG	GAS TURBINE	CALPINE	OIL/GAS	1966	PG&E	74.00	383616.00	161825
DELTA ENERGY CENTER	COMBUSTION TURBINE, STEAM	DELTA ENERGY CENTER, LLC	OIL/GAS	2002	PG&E	948.50	4917024.00	2074202
WELLHEAD POWER PANOCHE, LLC	COMBUSTION TURBINE, INTERNAL COMBUSTION	WELLHEAD POWER PANOCHE, LLC	OIL/GAS	2001	PG&E	50.85	263606.40	111200
KINGS RIVER CONSERVATI ON DISTRICT PEAKER	COMBUSTION TURBINE	KINGS RIVER CONSERVATION DISTRICT	OIL/GAS	2005	PG&E	96.00	497664.00	209935
FRESNO COGEN	COMBINED CYCLE	FRESNO COGENERATION PARTNERS	OIL/GAS	1989	PG&E	25.00	129600.00	54671
COALINGA	GAS TURBINE/HEAT RECOVERY STEAM GENERATR	CHEVRON U.S.A.	OIL/GAS	1986	PG&E	20.70	107308.80	45267
AL RESOURCES	GAS TURBINE/HEAT RECOVERY STEAM GENERATR	AERA ENERGY LLC	OIL/GAS	1988	PG&E	8.50	44064.00	18588
COALINGA COGEN CO.	GAS TURBINE	COALINGA COGENERATION	OIL/GAS	1991	PG&E	52.90	274233.60	115683
SANGER POWER & FEED		DYNAMIS INC.	OIL/GAS	1991	PG&E	39.80	206323.20	87036

FRESNO COGEN PARTNERS LP PKR	COMBUSTION TURBINE	FRESNO COGENERATION PARTNERS	OIL/GAS	2001	PG&E	21.90	113529.60	47891
CALPEAK POWER PANOCHE, LLC	COMBUSTION TURBINE	CALPEAK	OIL/GAS	2002	PG&E	60.00	311040.00	131209
WELLHEAD POWER GATES, LLC		WELLHEAD POWER GATES, LLC	OIL/GAS	2001	PG&E	46.50	241056.00	101687
PE - KES KINGSBURG LLC		PE MANAGEMENT-KINGSBURG, LLC	OIL/GAS	1990	PG&E	34.50	178848.00	75445
MENDOTA BIOMASS POWER LTD	STEAM	AES CORP.	BIOMASS	1989	PG&E	33.00	171072.00	72165
RIO BRAVO FRESNO	DIRECT COMBUSTION	RIO BRAVO FRESNO	BIOMASS	1988	PG&E	28.00	145152.00	61231
HUMBOLDT BAY	COMBUSTION TURBINE, STEAM TURBINE	PACIFIC GAS AND ELECTRIC COMPANY	OIL/GAS	1956	PG&E	137.00	710208.00	299595
PACIFIC LUMBER CO.	DIRECT COMBUSTION	PACIFIC LUMBER CO.	BIOMASS	1989	PG&E	32.50	168480.00	71072
FAIRHAVEN POWER CO.	DIRECT COMBUSTION	EEL RIVER SAWMILLS INC.	BIOMASS	1986	PG&E	21.00	108864.00	45923
BRAWLEY	COMBUSTION TURBINE	IMPERIAL IRRIGATION DISTRICT	OIL/GAS	1986	IID	20.00	103680.00	43736
EL CENTRO	STEAM TURBINE, COMBINED CYCLE	IMPERIAL IRRIGATION DISTRICT	OIL/GAS	1952	IID	80.00	414720.00	174946
ROCKWOOD	COMBUSTION TURBINE	IMPERIAL IRRIGATION DISTRICT	OIL/GAS	1979	IID	46.00	238464.00	100594
MESQUITE RESOURCE RECOVERY PROJECT	STEAM TURBINE, GRATE	NEW CHARLESTON POWER 1 LP	BIOMASS	1988	IID	17.89	92741.76	39122
MT. POSO COGENERATI ON	STEAM TURBINE, COAL GASSIFICATION	MT POSO COGENERATION CO.	COAL	1988	PG&E	63.64	329909.76	139169
RIO BRAVO JASMIN	STEAM TURBINE, COAL GASSIFICATION	RIO BRAVO JASMIN	COAL	1989	PG&E	33.00	171072.00	72165

RIO BRAVO POSO	STEAM TURBINE, COAL GASSIFICATION	RIO BRAVO POSO	COAL	1989	PG&E	33.00	171072.00	72165
CHALK CLIFF COGEN	GAS TURBINE	EL PASO MERCHANT ENERGY	OIL/GAS	1990	PG&E	47.00	243648.00	102781
MIDWAY-SUNSET COGEN	COMBUSTION TURBINE	MIDWAY-SUNSET COGENERATION CO	OIL/GAS	1989	PG&E	234.00	1213056.00	511717
KERN RIVER COGEN	COMBUSTION TURBINE	KERN RIVER COGEN	OIL/GAS	1985	PG&E	300.00	1555200.00	656047
LA PALOMA GENERATING PROJECT	COMBINED CYCLE	LA PALOMA GENERATING COMPANY	OIL/GAS	2003	PG&E	1035.69	5369016.96	2264871
SOUTH BELRIDGE COGEN	COMBUSTION TURBINE	AERA ENERGY LLC	OIL/GAS	1985	PG&E	69.00	357696.00	150891
SUNRISE POWER PROJECT	COMBUSTION TURBINE, STEAM	EDISON MISSION ENERGY	OIL/GAS	2001	PG&E	612.66	3176029.44	1339779
ELK HILLS	COMBUSTION TURBINE, STEAM	ELK HILLS POWER	OIL/GAS	2003	PG&E	549.00	2846016.00	1200566
PASTORIA ENERGY FACILITY	COMBUSTION TURBINE, STEAM	CALPINE	OIL/GAS	2005	PG&E	727.00	3768768.00	1589821
DOME PROJECT	GAS TURBINE	NUEVO ENERGY CO	OIL/GAS	1988	PG&E	6.60	34214.40	14433
ARCO - FEE "C"	GAS TURBINE	ARCO	OIL/GAS	1987	PG&E	7.45	38620.80	16292
ARCO - FEE "A"	GAS TURBINE	ARCO	OIL/GAS	1986	PG&E	7.93	41083.20	17331
LOST HILLS		KERN COUNTY	OIL/GAS	1985	PG&E	10.97	56863.30	23987
TEXACO - MCKITTRICK	GAS TURBINE	TEXACO	OIL/GAS	1994	PG&E	10.97	56863.30	23987
NORTH MIDWAY	GAS TURBINE	TEXACO	OIL/GAS	1987	PG&E	10.97	56868.48	23989
BORON	GAS TURBINE	U.S. BORAX AND CHEMICAL CO	OIL/GAS	1984	SCE	45.00	233280.00	98407
SYCAMORE COGEN	GAS TURBNE	SYCAMORE COGENERATION CO	OIL/GAS	1988	PG&E	300.00	1555200.00	656047
BERRY COGEN - MIDWAY SUNSET	COMBUSTION TURBINE	BERRY PETROLEUM	OIL/GAS	1986	PG&E	38.00	196992.00	83099
OCCIDENTAL OF ELK HILLS INC.		CCIDENTAL OF ELK HILLS, INC.	OIL/GAS	1994	PG&E	10.00	51840.00	21868

MIDSET COGEN	COMBUSTION TURBINE	MID-SET COGENERATION	OIL/GAS	1989	PG&E	52.90	274233.60	115683
BADGER CREEK LTD.	GAS TURBINE	EL PASO MERCHANT ENERGY	OIL/GAS	1991	PG&E	55.30	286675.20	120931
CHEVRON CYMRIC	GAS TURBINE	CHEVRON U.S.A.	OIL/GAS	1982	PG&E	26.30	136339.20	57513
CHEVRON - TAFT	GAS TURBINE	CHEVRON U.S.A.	OIL/GAS	1982	PG&E	12.50	64800.00	27335
DAI/OILDALE COGEN	COMBUSTION TURBINE	DIAMOND ENERGY INC.	OIL/GAS	1989	PG&E	36.80	190771.20	80475
DOUBLE "C" LTD.	GAS TURBINE	EL PASO MERCHANT ENERGY	OIL/GAS	1988	PG&E	53.60	277862.40	117214
FRITO-LAY	COMBUSTION TURBINE	FRITO-LAY INC	OIL/GAS	1986	PG&E	6.90	35769.60	15089
HIGH SIERRA LTD.	COMBUSTION TURBINE	EL PASO MERCHANT ENERGY	OIL/GAS	1989	PG&E	60.30	312595.20	131865
KERN FRONT LTD.	COMBUSTION TURBINE	EL PASO MERCHANT ENERGY	OIL/GAS	1989	PG&E	60.00	311040.00	131209
LIVE OAK COGEN	COMBUSTION TURBINE	EL PASO MERCHANT ENERGY	OIL/GAS	1991	PG&E	55.30	286675.20	120931
MCKITTRICK COGEN	COMBUSTION TURBINE	EL PASO MERCHANT ENERGY	OIL/GAS	1991	PG&E	57.90	300153.60	126617
MIDSUN		MIDSUN PARTNERS	OIL/GAS	1989	PG&E	26.00	134784.00	56857
MOJAVE COGEN	COMBUSTION TURBINE	MOJAVE COGENERATION CO	OIL/GAS	1990	SCE	55.00	285120.00	120275
BERRY PETROLEUM CO.	COMBUSTION TURBINE		OIL/GAS	1986	PG&E	17.00	88128.00	37176
OILDALE COGEN	GAS TURBINE	OILDALE ENERGY LLC	OIL/GAS	1984	PG&E	40.00	207360.00	87473
BEAR MOUNTAIN LTD.	GAS TURBINE	EL PASO MERCHANT ENERGY	OIL/GAS	1995	PG&E	55.30	286675.20	120931
SEKR COGEN		TEXACO	OIL/GAS	1989	PG&E	34.47	178682.11	75375
DELANO ENERGY CO. INC.	STEAM	DELANO ENERGY	BIOMASS	1990	SCE	49.90	258681.60	109122
HANFORD	STEAM	HANFORD LP	COAL	1990	PG&E	29.40	152409.60	64293
HANFORD ENERGY PARK PEAKER	COMBUSTION TURBINE	KINGS COUNTY WM AUTHORITY	OIL/GAS	2001	PG&E	100.00	518400.00	218682
GWF HENRIETTA	COMBUSTION TURBINE	GWF ENERGY, LLC	OIL/GAS	2002	PG&E	96.57	500618.88	211182

DINUBA ENERGY INC.	STEAM	YANKE ENERGY	BIOMASS	2001	PG&E	12.00	62208.00	26242
SPI-SUSANVILLE	DIRECT COMBUSTION	SIERRA PACIFIC INDUSTRIES, INC.	BIOMASS	1985	LASSEN MUD	14.34	74338.56	31359
HI POWER CO.	STEAM	CMS	BIOMASS	1989	LASSEN MUD	36.80	190771.20	80475
MT. LASSEN POWER	DIRECT COMBUSTION	COVANTA	BIOMASS	1985	LASSEN MUD	13.30	68947.20	29085
INTERMOUNTAIN 1 & 2	COAL GASSIFICATION	LOS ANGELES DEPT. OF WATER & POWER	COAL	1987	SCE	1640.00	8501760.00	3586390
PEBBLY BEACH	INTERNAL COMBUSTION		OIL/GAS	1966	SCE	9.40	48729.60	20556
LONG BEACH	COMBUSTION TURBINE, STEAM TURBINE	LONG BEACH GENERATION LLC	OIL/GAS	1976	SCE	577.00	2991168.00	1261797
HARBOR	COMBINED CYCLE, GAS TURBINE	LOS ANGELES DEPT. OF WATER & POWER	OIL/GAS	1949	SCE	472.00	2446848.00	1032181
REDONDO BEACH GENERATING STAT	STEAM	AES CORP.	OIL/GAS	1954	SCE	1333.98	6915352.32	2917178
HARBOR COGEN	COMBUSTION TURBINE, STEAM	HARBOR COGENERATION CO	OIL/GAS	1988	LADWP	106.51	552147.84	232919
AES PLACERITA	COMBINED CYCLE	AES PLACERITA	OIL/GAS	1988	SCE	122.41	634573.44	267689
OLIVE	STEAM TURBINE, GAS TURBINE	BURBANK WATER AND POWER	OIL/GAS	1959	BURBANK	152.50	790560.00	333491
CITY OF VERNON COMBINED CYCLE (MALBURG)	COMBUSTION TURBINE, STEAM	CITY OF VERNON	OIL/GAS	2005	VERNON	134.00	694656.00	293034
HAYNES	STEAM TURBINE, NATURAL GAS	LOS ANGELES DEPT. OF WATER & POWER	OIL/GAS	1962	SCE	1570.00	8138880.00	3433312
GRAYSON	STEAM & COMBUSTION TURBINE, COMB. CYCLE	CITY OF GLENDALE	OIL/GAS	1953	GLENDALE	272.50	1412640.00	595909

SCATTERGOOD	STEAM TURBINE, NATURAL GAS	LOS ANGELES DEPT. OF WATER & POWER	OIL/GAS	1958	LADWP	803.00	4162752.00	1756019
ALAMITOS GENERATING STATION	STEAM	AES CORP./WILLIAMS	OIL/GAS	1956	SCE	2010.38	10421809.92	4396346
B. BRAUN MEDICAL INC.	GAS TURBINE, COMBINED CYCLE	B. BRAUN MEDICAL INC.	OIL/GAS	1995	SCE	6.10	31622.40	13340
VALLEY	STEAM TURBINE, NATURAL GAS	LOS ANGELES DEPT. OF WATER & POWER	OIL/GAS	1954	LADWP	517.00	2680128.00	1130588
BROADWAY	STEAM TURBINE	CITY OF PASADENA	OIL/GAS	1965	SCE	162.00	839808.00	354265
VERNON		CITY OF VERNON	OIL/GAS	1933	VERNON	41.80	216691.20	91409
GLENARM	COMBUSTION TURBINE	CITY OF PASADENA	OIL/GAS	1976	PASADENA	133.85	693878.40	292706
COLDGEN - SUNLAW COGEN #1	COMBUSTION TURBINE/TOPPIN G CYCLE	SUNLAW ENERGY CORP/COGEN PARTNERSHIP	OIL/GAS	1984	VERNON	56.00	290304.00	122462
SMURFIT POMONA MILL	GAS TURBINE	.SMURFIT NEWPRINT CORP.	OIL/GAS	1985	SCE	16.30	84499.20	35645
JEFFERSON SMURFIT CORP.	COMBUSTION TURBINE/TOPPIN G CYCLE	JEFFERSON SMURFIT COPP.	OIL/GAS	1985	LADWP	40.00	207360.00	87473
SAN GABRIEL COGEN	COMBINED CYCLE/TOPPING CYCLE	TRACTEBEL ELECTRICITY & GAS	OIL/GAS	1985	SCE	36.00	186624.00	78726
PITCHESS COGEN	COMBINED CYCLE	LOS ANGELES COUNTY SHERRIF'S DEPARTMENT	OIL/GAS	1988	SCE	31.93	165525.12	69825
DIESELS			OIL/GAS		VERNON	26.00	134784.00	56857
TORRANCE REFINERY	GAS TURBINE, STEAM TURBINE	MOBIL OIL COMPANY	OIL/GAS	1987	SCE	222.70	1154476.80	487006
ARCO PETROLEUM PRODUCTS CO.	STEAM TURBINE	ACRO PETROLEUM PRODUCTS	OIL/GAS	1985	SCE	8.00	41472.00	17495

WATSON COGEN	GAS TURBINE, STEAM TURBINE	WATSON COGENERATION	OIL/GAS	1986	SCE	398.00	2063232.00	870356
LAKE	RECLAIMED WATER	BURBANK WATER AND POWER	OIL/GAS	2002	BURBANK	47.00	243648.00	102781
CARSON COGEN CO.	GAS TURBINE, STEAM TURBINE	CARSON COGENERATION COMPANY	OIL/GAS	1989	SCE	56.06	290615.04	122593
MAGNOLIA	STEAM TURBINE, COMBINED CYCLE	BURBANK WATER AND POWER	OIL/GAS	2004	BURBANK	328.00	1700352.00	717278
PLACERITA UNIT II	I.C. TOPPING CYCLE	ARCO	OIL/GAS	1985	SCE	21.76	112803.84	47585
N.P. COGEN INC.	COMBINED CYCLE/TOPPING CYCLE	GE CONTRACTURAL SERVICES	OIL/GAS	1982	SCE	24.70	128044.80	54015
EL SEGUNDO	STEAM TURBINE	NRG/DYNEGY POWER	OIL/GAS	1964	SCE	1020.00	5287680.00	2230560
COLDGEN - SUNLAW COGEN #2	COMBUSTION TURBINE/TOPPIN G CYCLE	SUNLAW ENERGY CORP/COGEN PARTNERSHIP	OIL/GAS	1986	VERNON	56.00	290304.00	122462
NORWALK ENERGY	GAS TURBINE	WHEELABRATOR NORKWALK EGY CO	OIL/GAS	1987	SCE	30.75	159408.00	67245
LOS ANGELES REFINERY	GAS TURBINE	TOSCO CORP	OIL/GAS	1987	LADWP	68.50	355104.00	149797
UCLA COGEN	GAS TURBINE	UCLA	OIL/GAS	1990	LADWP	43.00	222912.00	94033
UCLA COGEN		UCLA	OIL/GAS	1994	LADWP	43.00	222912.00	94033
LINDE WILMINGTON	COMBINED CYCLE	PRAXAIR INCORPORATED	OIL/GAS	1989	LADWP	28.00	145152.00	61231
TEXACO LOS ANGELES REFINERY	GAS TURBINE	EQUILON ENTERPRISES LLC, LA REFINING	OIL/GAS	1983	SCE	60.00	311040.00	131209
THUMS GENERATION FACILITY		THUMS LONG BEACH COMPANY	OIL/GAS	2002	SCE	47.00	243648.00	102781
WILMINGTON	STEAM TURBINE	AIR PRODUCTS & CHEMICALS, INC.	OIL/GAS	1996	SCE	31.90	165369.60	69760

CIVIC CENTER COGEN	GAS TURBINE, STEAM TURBINE	COUNTY OF LOS ANGELES	OIL/GAS	1989	LADWP	34.50	178848.00	75445
PLACERITA UNIT I	I.C. TOPPING CYCLE	ARCO	OIL/GAS	1985	SCE	21.76	112803.84	47585
TOTAL ENERGY FACILITY	GAS TURBINE COMBINED CYCLE	L.A. COUNTY SANITATION DISTRICTS	DIGESTER GAS	1995	SCE	25.00	129600.00	54671
COMMERCE REFUSE TO ENERGY	STEAM TURBINE	LA COUNTY SANITATION DISTRICTS	MSW	1986	SCE	10.50	54432.00	22962
SOUTHEAST RESOURCE RECOVERY	MUNICIPAL SOLID WASTE	SERRF JOINT POWERS AUTHORITY	MSW	1988	LADWP	34.60	179366.40	75664
MM LOPEZ ENERGY LLC	RECIPROCATING ENGINE	MINNESOTA METHANE LOPEZ ENERGY LLC	MSW	1999	SCE	6.60	34214.40	14433
MADERA POWER LLC	STEAM	MADERA POWER LLC	BIOMASS	2001	PG&E	25.00	129600.00	54671
SAN JOAQUIN POWER CO.			OIL/GAS	1991	MEID	10.75	55728.00	23508
CALPINE KING CITY COGEN	COMBUSTION TURBINE, STEAM	CALPINE /KING CITY COGENERATION LLC	OIL/GAS	1989	PG&E	133.30	691027.20	291504
MOSS LANDING	COMBUSTION TURBINE, STEAM	LS POWER	OIL/GAS	2002	PG&E	2530.03	13115675.52	5532728
SALINAS RIVER COGEN	GAS TURBINE	SALINAS RIVER COGEN CO.	OIL/GAS	1991	PG&E	49.60	257126.40	108466
SARGENT CANYON COGEN	GAS TURBINE	SARGENT CANYON COGEN	OIL/GAS	1991	PG&E	38.00	196992.00	83099
CALPINE KING ENERGY CENTER	COMBUSTION TURBINE	CALPINE	OIL/GAS	2002	PG&E	44.60	231206.40	97532
MONTEREY POWER CO.	STEAM	SUNNYSIDE COGENERATION INC.	OIL/GAS	1990	PG&E	7.90	40953.60	17276
SOLEDAD ENERGY	DIRECT COMBUSTION	YANKE ENERGY	BIOMASS	1990	PG&E	15.00	77760.00	32802
HUNTINGTON BEACH	STEAM	AES CORP.	OIL/GAS	1958	SCE	904.03	4686491.52	1976954
ANAHEIM GAS TURBINE	COMBUSTION TURBINE	CITY OF ANAHEIM	OIL/GAS	1990	ANAHEIM	46.00	238464.00	100594
AMERICAN MCGAW #2	GAS-TURBINE	AMERICAN MC GAW	OIL/GAS	1995	SCE	6.10	31622.40	13340
AMERICAN MCGAW	STEAM TURBINE & GAS TURBINE	AMERICAN MC GAW	OIL/GAS	1981	SCE	8.60	44582.40	18807

PLANT NO. 2	DIGESTER GAS/OTHER	ORANGE COUNTY SANITIATION DISTRICT	DIGESTER GAS	1993	SCE	18.00	93312.00	39363
KINGS BEACH	INTERNAL COMBUSTION	SIERRA PACIFIC POWER COMPANY	OIL/GAS	1969	SPP	16.20	83980.80	35427
ROSEVILLE	COMBUSTION TURBINE	NORTHERN CALIFORNIA POWER AGENCY/CSC	OIL/GAS	1986	PG&E	53.75	278640.00	117542
SPI- LINCOLN	DIRECT COMBUSTION	SIERRA PACIFIC INDUSTRIES, INC.	BIOMASS	1997	PG&E	13.00	67392.00	28429
RIO BRAVO ROCKLIN	DIRECT COMBUSTION	RIO BRAVO ROCKLIN	BIOMASS	1989	PG&E	28.00	145152.00	61231
SPI- QUINCY	DIRECT COMBUSTION	SIERRA PACIFIC INDUSTRIES, INC.	BIOMASS	1986	PG&E	27.50	142560.00	60138
COLLINS PINE CO. PROJECT	STEAM	COLLINS PINE CO.	BIOMASS	1984	PG&E	13.80	71539.20	30178
SPRINGS GENERATION PROJECT	GAS TURBINE	CITY OF RIVERSIDE	OIL/GAS	2002	RIVERSIDE	40.00	207360.00	87473
COACHELLA	COMBUSTION TURBINE, NATURAL GAS	IMPERIAL IRRIGATION DISTRICT	OIL/GAS	1973	IID	80.00	414720.00	174946
BLYTHE ENERGY POWER PLANT PROJECT		CAITHNESS ENERGY	OIL/GAS	2003	SCE	520.00	2695680.00	1137148
CLEARWATE R COGENERATI ON PROJECT	COMBINED CYCLE, STEAM TURBINE	CITY OF COLTON	OIL/GAS	2005	CCDW	49.00	254016.00	107154
CORONA COGEN	COMBUSTION TURBINE	CORONA ENERGY PARTNERS	OIL/GAS	1988	CCDW	50.05	259459.20	109451
RIVERSIDE ENERGY RESOURCE CENTER, UNIT 1&2 - CITY OF RIVERSIDE	SIMPLE CYCLE, COMBUSTION TURBINE	CITY OF RIVERSIDE	OIL/GAS	2006	RIVERSIDE	96.00	497664.00	209935
WILDFLOWE R - INDIGO	GREEN FIELD	INTERGEN	OIL/GAS	2001	SCE	135.00	699840.00	295221
MECCA PLANT	DIRECT COMBUSTION	COLMAC ENERGY	BIOMASS	1991	IID	49.90	258681.60	109122

CARSON COGEN	COMBUSTION TURBINE WITH WASTE HEAT	CENTRAL VALLEY FINANCING AUTHORITY	OIL/GAS	1995	SMUD	97.00	502848.00	212122
PROCTER & GAMBLE - SMUD	COMBUSTION TURBINE WITH WASTE HEAT	SACRAMENTO MUNCIPAL UTILITY DISTRICT	OIL/GAS	1997	SMUD	193.40	1002585.60	422932
MCCLELLAN	COMBUSTION TURBINE, NATURAL GAS	SACRAMENTO MUNCIPAL UTILITY DISTRICT	OIL/GAS	1986	SMUD	49.00	254016.00	107154
SPAC	COMBUSTION TURBINE WITH WASTE HEAT	SACRAMENTO MUNCIPAL UTILITY DISTRICT	OIL/GAS	1998	SMUD	146.00	756864.00	319276
UC DAVIS MEDICAL CENTER	GAS TURBINE	UNIVERSITY OF CALIFORNIA SACRAMENTO	OIL/GAS	1982	SMUD	30.00	155520.00	65605
SMUD CONSUMNES RIVER PHASE 1	STEAM	SACRAMENTO MUNCIPAL UTILITY DISTRICT	OIL/GAS	2006	SMUD	500.00	2592000.00	1093412
CENTURY	COMBUSTION TURBINE	COLTON POWER, LP	OIL/GAS	2001	COLTON	43.00	222912.00	94033
ARGUS COGEN PLANT	COAL-FIRED TOPPING CYCLE, COAL GASSIFICATION	US TRUST CO. OF CALIF	COAL	1978	SCE	55.00	285120.00	120275
TXI RIVERSIDE CEMENT POWER HOUSE	COAL FIRED BOTTOMING CYCLE, COAL GASSIFICATION	TXI RIVERSIDE CEMENT	COAL	1979	SCE	17.00	88128.00	37176
MOUNTAINVIEW POWER PROJECT	COMBUSTION TURBINE, STEAM	MOUNTAINVIEW POWER COMPANY, LLC	OIL/GAS	2005	SCE	1050.00	5443200.00	2296164
ETIWANDA	STEAM TURBINE, GAS TURBINE	RELIANT ENERGY	OIL/GAS	1963	SCE	1019.00	5282496.00	2228373
COOLWATER	STEAM, COMBUSTION TURBINE	RELIANT ENERGY	OIL/GAS	1961	SCE	635.70	3295468.80	1390164
HIGH DESERT POWER PLANT PROJECT	COMBUSTION TURBINE, STEAM	HIGH DESERT POWER, LLC	OIL/GAS	2003	SCE	854.90	4431801.60	1869515
DREWS	COMBUSTION TURBINE	COLTON POWER, LP	OIL/GAS	2001	COLTON	41.40	214617.60	90534

MOUNTAINVIEW POWER CO. - SAN BERNARDINO	STREAM TURBINE	THERMO ECOTEK	OIL/GAS	1957	SCE	126.00	653184.00	275540
RIVERSIDE CANAL POWER	STEAM TURBINE	RIVERSIDE CANAL POWER	OIL/GAS	1952	SCE	160.00	829440.00	349892
INDECK ONTARIO	GAS TURBINE	INDECK CAPITAL, INC.	OIL/GAS	1984	SCE	12.00	62208.00	26242
LOMA LINDA UNIVERSITY	GAS TURBINE, STEAM TURBINE, INTERNAL COM	LOMA LINDA UNIVERSITY	OIL/GAS	1990	SCE	13.40	69465.60	29303
ONTARIO MILL	GAS TURBINE	INLAND CONTAINER CORPORATION	OIL/GAS	1985	SCE	34.00	176256.00	74352
WESTEND	COMBUSTION TURBINE/TOPPING CYCLE	NORTH AMERICAN CHEMICAL CO.	OIL/GAS	1979	SCE	15.00	77760.00	32802
CHINO NUG	COMBINED CYCLE/TOPPING CYCLE	ENERGY INITIATIVES, INC.	OIL/GAS	1988	SCE	27.60	143078.40	60356
AGUA MANSA POWER PLANT	SIMPLE CYCLE	CITY OF COLTON	OIL/GAS	2003	SCE	49.00	254016.00	107154
NORTH ISLAND	GAS TURBINE	CABRILLO POWER II LLC (NRC WEST COAST INC.)	OIL/GAS	1972	SDG&E	34.00	176256.00	74352
NTC/MCRD ENERGY FACILITY	COMBINED CYCLE	APPLIED ENERGY. INC.	OIL/GAS	1989	SDG&E	23.00	119232.00	50297
NORTH ISLANDCOGENERATION	GAS TURBINE	APPLIED ENERGY, INC.	OIL/GAS	1989	SDG&E	34.50	178848.00	75445
MIRAMAR	COMBUSTION TURBINE	CABRILLO POWER I, LLC	OIL/GAS	1972	SDG&E	36.00	186624.00	78726
KEARNY	COMBUSTION TURBINE	NRG/DYNEGY POWER	OIL/GAS	1969	SDG&E	136.00	705024.00	297408
SOUTH BAY	STEAM, COMBUSTION TURBINE	DUKE ENERGY	OIL/GAS	1960	SDG&E	707.60	3668198.40	1547396
ENCINA	STEAM	CABRILLPOWER I, LLC (NRG WEST COAST INC)	OIL/GAS	1954	SDG&E	946.00	4904064.00	2068735

GOODRICH COGENERATI ON PLANT	INTERNAL COMBUSTION	GOODRICH AEORSTRUCTURE S GROUP	OIL/GAS	2002	SDG&E	9.48	49144.32	20731
NAVAL STATION	GAS TURBINE, STEAM TURBINE	DYNERGY POWER AND NRG ENERGY, INC.	OIL/GAS	1989	SDG&E	49.90	258681.60	109122
NAVAL STATION	COMBUSTION TURBINE WITH WASTE HEAT	DYNERGY POWER AND NRG ENERGY, INC.	OIL/GAS	1976	SDG&E	26.00	134784.00	56857
EL CAJON	COMBUSTION TURBINE	CABRILLO POWER II, LLC	OIL/GAS	1968	SDG&E	15.00	77760.00	32802
DIVISION	GAS TURBINE	NRG/DYNEGY POWER	OIL/GAS	1990	SDG&E	13.00	67392.00	28429
MMC CHULA VISTA		MMC ENERGY, INC.	OIL/GAS	2001	SDG&E	44.00	228096.00	96220
CALPEAK BORDER, LLC PHASE I	SIMPLE CYCLE	CALPEAK	OIL/GAS	2001	SDG&E	49.50	256608.00	108248
GOAL LINE L.P.	COMBUSTION TURBINE	GOAL LINE LP	OIL/GAS	1994	SDG&E	50.30	260755.20	109997
PALOMAR ESCONDIDO	COMBUSTION TURBINE	SDG&E	OIL/GAS	2006	SDG&E	546.00	2830464.00	1194005
MMC ESCONDIDO	SIMPLE CYCLE	MMC ENERGY, INC.	OIL/GAS	2001	SDG&E	49.50	256608.00	108248
WILDFLOWE R -LARKSPUR	GREEN FIELD	INTERGEN	OIL/GAS	2001	SDG&E	90.00	466560.00	196814
CP - KELCO	COMBUSTION TURBINE	KELCO- DIVISION OF MERCK & CO.,INC	OIL/GAS	1983	SDG&E	25.00	129600.00	54671
SOLAR TURBINES INC.	GAS TURBINE	SOLAR TURBINE INC.	OIL/GAS	1995	SDG&E	8.90	46137.60	19463
CHULA VISTA COGEN	COMBINED CYCLE	ROHR INCORPORATED	OIL/GAS	1993	SDG&E	9.00	46656.00	19681
SAN DIEGO STATE UNIVERSITY	GAS TURBINE	SAN DIEGO STATE UNIVERSITY	OIL/GAS	1985	SDG&E	14.77	76562.50	32297
PACIFIC BELL		PACIFIC BELL	OIL/GAS		SDG&E	6.42	33281.28	14039
CALPEAK POWER EL CAJON, LLC		CALPEAK	OIL/GAS	2002	SDG&E	48.68	252357.12	106455

NTC CENTRAL	COMBUSTION TURBINE WITH WASTE HEAT	SDG&E	OIL/GAS	1968	SDG&E	16.00	82944.00	34989
GAS UTILIZATION FACILITY	INTERNAL COMBUSTION	CITY OF SAN DIEGO	DIGESTER GAS	1985	SDG&E	6.80	35251.20	14870
POTRERO	STEAM, COMBUSTION TURBINE	MIRANT CORP.	OIL/GAS	1965	PG&E	362.00	1876608.00	791630
HUNTERS POINT	COMBUSTION TURBINE, STEAM	PACIFIC GAS AND ELECTRIC COMPANY	OIL/GAS	1948	PG&E	215.00	1114560.00	470167
SAN JOAQUIN COGEN	COMBUSTION TURBINE	EL PASO MERCHANT ENERGY	OIL/GAS	1990	PG&E	48.00	248832.00	104968
GWF TRACY PEAKER	COMBUSTION TURBINE	GWF ENERGY LLC	OIL/GAS	2003	PG&E	188.00	974592.00	411123
GIANERA	COMBUSTION TURBINE	SILICON VALLEY POWER/CITY OF SANTA CLARA	OIL/GAS	1986	SILICON VALLEY POWER	49.50	256608.00	108248
STOCKTON SIERRA 1			OIL/GAS	0	PG&E	22.00	114048.00	48110
NCPA STIG	COMBUSTION TURBINE	NORTHERN CALIFORNIA POWER AGENCY	OIL/GAS	1996	PG&E	50.00	259200.00	109341
LODI	COMBUSTION TURBINE	NORTHERN CALIFORNIA POWER AGENCY/CSC	OIL/GAS	1986	PG&E	25.30	131155.20	55327
RIPON MILL	GAS TURBINE	RIPON COGEN INC	OIL/GAS	1988	MID/PG&E EXPANSIO N	49.50	256608.00	108248
STOCKTON COGEN 1	COAL FIRED, COAL GASSIFICATION	AIR PRODUCTS & CHEMICALS, INC.	OIL/GAS	1988	PG&E	49.90	258681.60	109122
BYRON POWER CO.	GAS TURBINE	RIDGEWOOD BYRON LP	OIL/GAS	1990	PG&E	6.50	33696.00	14214
MID RIPON	GREEN FIELD	MODESTO IRRIGATION DISTRICT	OIL/GAS	2006	MID/PG&E EXPANSIO N	95.00	492480.00	207748
TRACY BIOMASS PLANT	DIRECT COMBUSTION	GWF POWER SYSTEMS	BIOMASS	1990	PG&E	20.30	105235.20	44393
MORRO BAY	STEAM TURBINE	L.S. POWER	OIL/GAS	1955	PG&E	1021.00	5292864.00	2232747
UNITED COGEN INC.	GAS TURBINE, STEAM TURBINE	UNITED COGEN	OIL/GAS	1987	PG&E	31.00	160704.00	67792

GAVIOTA	COMBUSTION TURBINE	POINT ARGUELLO PIPELINE COMPANY	OIL/GAS	1987	SCE	17.50	90720.00	38269
ELLWOOD	COMBUSTION TURBINE	RELIANT ENERGY ELLWOOD	OIL/GAS	1974	SCE	52.00	269568.00	113715
SANTA YNEZ	COMBUSTION TURBINE/TOPPIN G CYCLE	EXXON COMPANY, U.S.A.	OIL/GAS	1983	SCE	49.30	255571.20	107810
SANTA BARBARA COTTAGE HOSPITAL			OIL/GAS	1985	SCE	6.40	33177.60	13996
O'BRIEN ENERGY SYSTEMS - SANTA MARIA			OIL/GAS	1986	PG&E	43.00	222912.00	94033
SANTA MARIA COGEN	GAS TURBINE	SANTA MARIA COGEN	OIL/GAS	1989	PG&E	9.50	49248.00	20775
AGNEWS		CALPINE	OIL/GAS	1991	PG&E	36.10	187142.40	78944
CALPINE GILROY COGEN	COMBUSTION TURBINE, STEAM	CALPINE GILROY COGEN, LP	OIL/GAS	1987	PG&E	105.00	544320.00	229616
DONALD VON RAESFELD COMBINED CYCLE	COMBUSTION TURBINE, STEAM	SILICON VALLEY POWER	OIL/GAS	2005	SILICON VALLEY POWER	147.00	762048.00	321463
LOS ESTEROS CRITICAL ENERGY CENTER	COMBUSTION TURBINE	CALPINE	OIL/GAS	2003	PG&E	194.80	1009843.20	425993
CALPINE GILROY PEAKER	COMBUSTION TURBINE	CALPINE	OIL/GAS	2002	PG&E	144.20	747532.80	315340
METCALF ENERGY CENTER	COMBUSTION TURBINE, STEAM	CALPINE/BECHTE L	OIL/GAS	2005	PG&E	617.00	3198528.00	1349270
CARDINAL COGEN	GAS TURBINE, STEAM TUBINE	STANFORD UNIVERSITY	OIL/GAS	1988	PG&E	57.30	297043.20	125305
WATSONVILL E COGEN	STEAM TURBINE, GAS TURBINE	CALPINE	OIL/GAS	1901	PG&E	31.00	160704.00	67792
REDDING POWER	STEAM TURBINE & COMBUSTION TURBINES	CITY OF REDDING	OIL/GAS	1995	REDDING	97.20	503884.80	212559
LASSEN ENERGY	GAS TURBINE	WHEELABRATOR LASSEN	OIL/GAS	1983	PG&E	38.80	201139.20	84849

CITY OF REDDING		CITY OF REDDING	OIL/GAS	1989	REDDING	28.00	145152.00	61231
WHEELABRA TOR SHASTA	DIRECT COMBUSTION	WHEELABRATOR SHASTA ENERGY COMPANY	BIOMASS	1987	PG&E	55.00	285120.00	120275
BURNEY MOUNTAIN POWER	DIRECT COMBUSTION	COVANTA	BIOMASS	1985	PG&E	11.00	57024.00	24055
BURNEY FOREST PRODUCTS	STEAM	CONNECTIV	BIOMASS	1989	PG&E	35.70	185068.80	78070
SPI- BURNEY	DIRECT COMBUSTION	SIERRA PACIFIC INDUSTRIES, INC.	BIOMASS	1986	PG&E	11.00	57024.00	24055
SPI-LOYALTON	DIRECT COMBUSTION	SIERRA PACIFIC INDUSTRIES, INC.	BIOMASS	1989	SPP	11.00	57024.00	24055
CREED ENERGY CENTER	COMBUSTION TURBINE	CREED ENERGY CENTER LLC (CALPINE)	OIL/GAS	2003	PG&E	47.80	247795.20	104530
WOLFSKILL ENERGY CENTER	COMBUSTION TURBINE	WOLFSKILL ENERGY CENTER, LLC (CALPINE)	OIL/GAS	2003	PG&E	46.90	243129.60	102562
CALPEAK POWER VACA DIXON, LLC		CALPEAK	OIL/GAS	2002	PG&E	49.95	258940.80	109232
GOOSE HAVEN ENERGY CENTER	COMBUSTION TURBINE	GOOSE HAVEN ENERGY CENTER LLC (CALPINE)	OIL/GAS	2003	PG&E	46.70	242092.80	102125
LAMBIE ENERGY CENTER	COMBUSTION TURBINE	LAMBIE ENERGY CENTER LLC (CALPINE)	OIL/GAS	2003	PG&E	47.70	247276.80	104311
VALERO UNIT 1 & 2	COMBUSTION TURBINE, BROWN FIELD	VALERO REFINING CO.	OIL/GAS	2002	PG&E	51.00	264384.00	111528
MID WOODLAND I & II	COMBUSTION TURBINE WITH WASTE HEAT, CC	MODESTO IRRIGATION DISTRICT	OIL/GAS	1993	MID	129.40	670809.60	282975
MCCLURE	COMBUSTION TURBINE	MODESTO IRRIGATION DISTRICT	OIL/GAS	1980	MID	112.00	580608.00	244924
ALMOND	COMBINED CYCLE	TURLOCK IRRIGATION DISTRICT	OIL/GAS	1982	TID	51.50	266976.00	112621

WALNUT	GAS-FUELED TURBINE	TURLOCK IRRIGATION DISTRICT	OIL/GAS	1986	TID	48.50	251424.00	106061
HERSHEY CHOCOLATE	INTERNAL COMBUSTION		OIL/GAS	1989	MID/PG&E EXPANSIO N	6.20	32140.80	13558
WALNUT ENERGY CENTER	GREEN FIELD	TURLOCK IRRIGATION DISTRICT	OIL/GAS	2006	TID	250.00	1296000.00	546706
STANISLAUS RESOURCE RECOVERY FACILITY	STEAM TURBINE	COVANTA STANISLAUS, INC.	MSW	1998	PG&E	22.50	116640.00	49204
SUTTER POWER PROJECT	COMBUSTION TURBINE, STEAM	CALPINE	OIL/GAS	2001	PG&E	561.00	2908224.00	1226808
YUBA CITY ENERGY CENTER	COMBUSTION TURBINE	YUBA CITY ENERGY CENTER, LLC	OIL/GAS	2002	PG&E	46.00	238464.00	100594
FEATHER RIVER ENERGY CENTER	SIMPLE CYCLE	FEATHER RIVER ENERGY CENTER	OIL/GAS	2002	PG&E	46.30	240019.20	101250
GREENLEAF UNIT ONE	COMBUSTION TURBINE, STEAM	CALPINE	OIL/GAS	1989	PG&E	63.75	330480.00	139410
YUBA CITY COGEN	GAS TURBINE	YUBA CITY COGEN PARTNERS LP	OIL/GAS	1990	PG&E	49.00	254016.00	107154
GREENLEAF UNIT TWO	COMBUSTION TURBINE	CALPINE	OIL/GAS	1989	PG&E	63.75	330480.00	139410
SIERRA POWER CORP.	STEAM	SIERRA POWER CORP.	BIOMASS	1985	SCE	7.00	36288.00	15308
PACIFIC ULTRAPOWE R CHINESE STATION	DIRECT COMBUSTION	ULTRAPOWER	BIOMASS	1985	PG&E	27.50	142560.00	60138
ORMOND BEACH	STEAM TURBINE	RELIANT ENERGY	OIL/GAS	1971	SCE	1516.27	7860343.68	3315814
MANDALAY	STEAM, COMBUSTION TURBINE	RELIANT ENERGY	OIL/GAS	1959	SCE	560.29	2904543.36	1225255
OXNARD I & II	GAS TURBINE	PROCTER & GAMBLE	OIL/GAS	1989	SCE	69.78	361739.52	152597
HUENEME PAPER MILL	GAS TURBINE	WILLIAMETTE INDUSTRIES INC	OIL/GAS	1986	SCE	25.00	129600.00	54671
ROCKWELL INTL.	MISCELLANEOUS/ BOTTOMING CYCLE	ROCKWELL INTERNATIONAL	OIL/GAS	1993	SCE	28.00	145152.00	61231
CAMARILLO NUG	COMBINED CYCLE/TOPPING CYCLE	ENERGY INITIATIVES, INC.	OIL/GAS	1988	SCE	28.04	145359.36	61319

SITHE ENERGIES	COMBINED CYCLE/TOPPING CYCLE	SITHE ENERGIES, INC.	OIL/GAS	1990	SCE	48.50	251424.00	106061
WOODLAND BIOMASS POWER LTD	DIRECT COMBUSTION	XCEL ENERGY	BIOMASS	1989	PG&E	28.00	145152.00	61231
TOTAL						44,848	232,493,69 1	98,075,349

A.3 Cap Trajectory for GHG emissions to 2020

Modeling the Reductions

From data obtained at California's CARB website, http://www.arb.ca.gov/cc/ccei/inventory/tables/rpt_inventory_ipcc_sum_2007-11-19.pdf the following table shows the actual net emissions, by year, for the state of California.

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
427	410	412	409	422	411	409	428	444	451	452	469	464	463	480

Table 11 : California's Net Greenhouse gas emissions from year 1990 to 2004 in MMT

Estimated BAU emissions for year 2020 from the California report is 600.8 MMT Assuming a straight line increase, from 2004 through 2020, the average rate of increase in Greenhouse gas emissions is approximately 7.55MMT/year. The estimated values are shown in the table below.

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	
427	410	412	409	422	411	409	428	444	451	452	469	464	463	480	
2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
488	495	503	510	518	525	533	540	548	556	563	571	578	586	593	601

Table 12 : Projected BAU Greenhouse gas emissions from year 2004 to 2020 in MMT

Since Option A, consists of implementation of Program Design 1, followed by implementation of Program Design 2 and then followed by Program Design 3, we assume that Program Design 1 is implemented in the first Compliance Period, followed by Program Design 2 in the second and third Compliance periods, followed by Program Design 3 in the fourth Compliance period.

We suggest that compliance trajectory is as follows. During Compliance period 1, we put a stop to the growth of Greenhouse gas emissions. During Compliance periods 2, 3 and 4, we drive down (negative growth) Greenhouse gas emissions.

Hence we assume that for Compliance period 1, that the Greenhouse Cap will be maintained constant at 2009 levels. For Compliance periods 2, 3 and 4, the average Cap decline will be set to 10.13 MMT/year, so that year 2020 Greenhouse gas emission levels are the same as 1990 Greenhouse gas emission levels. See table and chart.

2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
480	488	495	503	510	518	518	518	508	497	487	477	467	457	447	437	427

Table 13 : Projected Greenhouse Gas Cap levels from year 2009 to 2020 in MMT

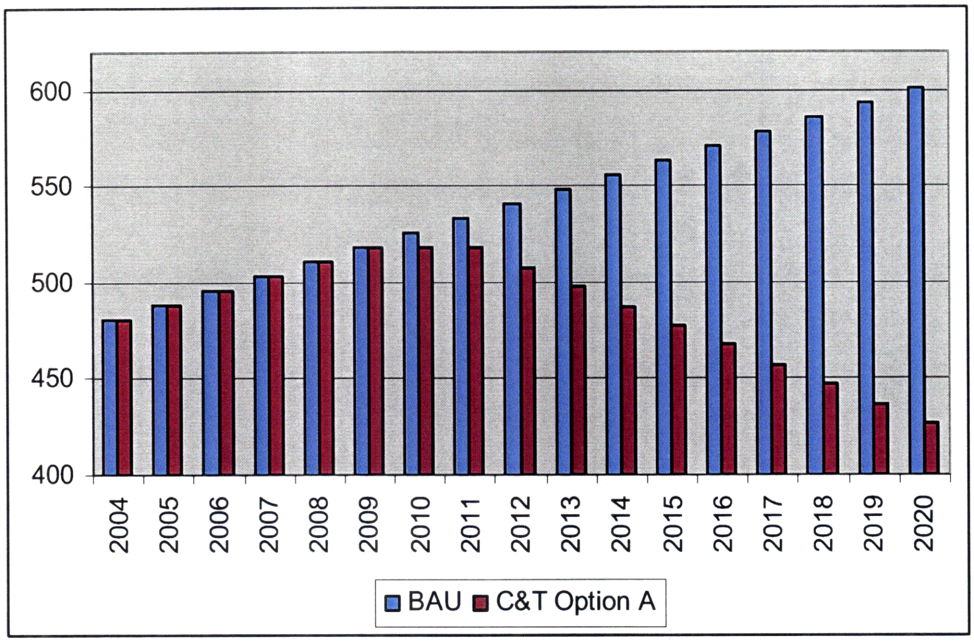

Figure 14 : Chart showing Option A Greenhouse gas emission levels for Business as Usual and Cap

We now calculate the per period reductions across the board for the state of California, under our assumption that Greenhouse gas is contained and not allowed to grow in Compliance period 1 and then aggressively reduced in the remaining Compliance periods. See following table.

Compliance Period	1	2	3	4
Total estimated BAU GHGe	1576	1644	1712	1780
Total estimated Cap GHGe	1553.25	1492.48	1401.33	1310.18
Per Period reductions	22.65	128.72	159.10	159.10

Table 14 : Total Greenhouse gas reductions under our assumed compliance trajectory

We assume that the percentage contributions of each of the Greenhouse gas contributing sectors does not vary and stays constant within the compliance period.

A.4 Definitions

Additionality
Emission reductions achieved through a given project over and above those that would have occurred in the absence of the project under the business-as-usual scenario.

Carbon Credits
One carbon credit (CC) gives the owner the right to emit one ton of carbon dioxide. Carbon credits are a new financial instrument representing certified reductions in the emission of greenhouse gases in the atmosphere. Carbon Credits are the "currency" of recently formed climate exchanges. Carbon credit is one particular form of ERC. When a firm buys carbon credits, to cover its excess emissions, the carbon credit is deemed a carbon offset.

Clean Technology
Technologies that are driven by market factors, appeal to investors, and 'clean' by definition.

Coase's theorem
If transaction costs are zero, if, in other words, any agreement that is in the mutual benefit of the parties concerned gets made, then any initial definition of property rights leads to an efficient outcome.

Emission Reduction Credits
An Emission Reduction Credit (ERC) is a credit granted, upon request by an emission source, who voluntarily reduces emissions beyond required levels of control. An ERC represents the legal ability to emit regulated pollutants in an amount equal to the quantity specified when the ERC was granted. ERCs may be sold, leased, banked for future use, or traded in accordance with applicable regulations established by SWCAA. ERCs are intended to provide an incentive for reducing emissions below required levels, and to establish a framework to promote a market based approach to air pollution control.

Green Technology
Environmental-type issues—the 'end of the smokestack tech' technologies that tend to be driven by regulations.

LSE
Load Serving Entities are California companies that purchase electricity in the wholesale power market and deliver it to California customers.

MWh
Mega Watt hour, is an energy measure, and is the generation of 1000,000 Watts for one hour.

NERC E-tags
North American Electric Reliability Council E-tags are used to track the transmission of electricity so that sources of grid congestion may be more easily identified and mitigated. Along with other information, the E-tag identifies the source and destination control region and thus could be used to assign average emissions intensity to electricity transmitted into California as part of a specific transaction.

Offset
An offset is a credit for emissions reductions achieved by an entity in a sector that is not covered by a given Cap-and-Trade system.

Offset Projects
Offset Projects are registered and certified projects, that reduce greenhouse (GHG) gases using existing technologies in order to promote sustainable farming while simultaneously creating tradable Carbon Credits. An Offset Provider is an owner of an offset project or projects that registers those offsets directly on the exchange, and sells offsets on its own behalf. An Offset Aggregator is an entity that serves as the administrative representative, on behalf of offset project owners, of multiple offset-generating projects.

Ownership
Ownership constitutes of
1. The set of rights to use property in certain ways and a set of negative rights that prevents its use in other ways,
2. The right to prevent others from exercising those rights, or to set the terms on which others may exercise them, and
3. The right to sell your property rights

Pecuniary Externality
A pecuniary externality is a special type of externality that imposes no net cost, since the effects on other people cancel out. Unlike other externalities the actor's private net costs are equal to total net costs, just as if there would be no externality at all. A pecuniary externality does not lead to inefficiency.

Renewable Energy Credit
One Renewable Energy Credit or "REC" represents one megawatt hour (MWh) of renewable energy that is physically metered and verified from the generator, or the renewable energy project.. The green-power (electricity) is sold into the local electric grid where the renewable energy project is located. The REC's are sold separately as a commodity into the marketplace. In a REC deal, the power from the new renewable energy facility is not physically delivered to the customer, but the environmental benefits created by the facility are attributed to that customer, directly offsetting the environmental impact of the customer's conventional energy use.

True-Up

The submission, at the end of each compliance period by entities, of sufficient allowances to validate the actual emissions during the compliance period, is called a true-up.

Waste

Waste is something without value that no one will either pay for, or accept as a gift.

Weather derivatives

Weather insurance/derivatives are perceived to be evolving products with the highest degree of commercial promise for application in the renewable energy sector. In general, weather derivatives cover low-risk, high-probability events. Weather insurance, on the other hand, typically covers high-risk, low-probability events, as defined in a highly tailored, or customized, policy. For example, a company might use a weather derivative to hedge against a winter that forecasters think will be 5° F warmer than the historical average (a low-risk, high-probability event). In this case, the company knows its revenues would be affected by that kind of weather. But the same company would most likely purchase an insurance policy for protection against damages caused by a flood or hurricane (high-risk, low-probability events).

Welfare damage

Welfare Damage is measured as the monetary equivalent, of the reduction in welfare, resulting from pollution damage that is NOT prevented. For e.g. a native of Los Angeles, born and raised there, may move out of LA, to avoid breathing the smog, and breathe the same fresh/quality of air of his/her younger days, elsewhere. This may result in a lower salary, at this new place.

A.5 Acronyms

CARB	California Air Resources Board
CAT	Climate Action Team
CCAR	California Climate Action Registry
CEC	California Energy commission
CPUC	California Public Utilities Company
ERC	Emissions Reduction Credit
GHGe	Green House Gas emissions
GWP	Global Warming Potential
MAC	Market Advisory Committee
MWh	Mega Watt Hour
NERC	North American Electric Reliability Council
PUC	Public Utility Commission
REC	Renewable Energy Credit
WECC	Western Electricity Coordinating Council

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