The Impact of Energy Policies, Environmental Regulations, and Market Trends on the Power Sector

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Executive Summary

This report aims at analyzing the impact of energy policies, environmental regulations and market trends on the power sector. The analysis first focuses on the United States as a whole. It identifies key environmental policies that will shape the power sector such as the recent Mercury and Air Toxics Standard (MATS), Regional Haze programs and cooling intake structures regulations. It also unlocks the potential for energy efficiency on a statewide level and looks at the implementation of statewide carbon policies (fixed fees and cap and trade). Impacts are assessed on the short and long terms.

On the short term, potential impacts on the power sector are mainly the retirement of more than 59 GW of capacity by 2016, giving the opportunity to save 1.61-2.74% of 2011 total energy CO_2 emissions, but increasing power prices by $ 4-10 /MWh.

On the long term, potential impacts on the power sector are mainly dependent on the carbon policy adopted. A fee that starts at $ 10/metric ton of CO_2e and increases by 5% annually would decrease coal production by 413 and 676 TWh in 2025 and 2040 respectively, avoiding 18 and 32% of reference case electricity emissions. It would decrease 2025 and 2040 GDPs by 0.25 and 0.19% respectively. On the other hand, a 30$ fee growing 5% each year would require the increase in nuclear production by 24 and 825 TWh in 2025 and 2040 respectively, avoiding 55 and 88% of reference case electricity emissions. It would decrease 2025 and 2040 GDPs by 0.25 and 0.19% respectively. Cap & Trade scenarios follow similar trends, with a less harsh effect on fossil fuel decreases.
In addition, long-term effects of energy efficiency alone could save 27% of electricity generation and 19% of natural gas use up until 2030, reducing as much as 1000 million metric tons of CO_2 per year generating cumulative savings of $1.2 trillion.

The report then focuses on the specific climate action plan that the state of California has been implementing for decades, and assesses its current and future impacts. As far as the state's future energy mix is concerned, natural gas capacity will keep increasing, although some older plants will retire between 2011 and 2024 to satisfy once-through-cooling requirements. This will leave a capacity of over 12 000 MW to be replaced, and possibly cause shortages starting 2018. Natural gas generation will also increase due to the recent closing of the San Onofre plant, one of the state's two nuclear plants. The report highlights the main policies and strategies imposed by the California Assembly Bill 32, which aims at mitigating global warming. These include: Renewable Portfolio Standards (33% of electricity sales have to come from renewables by 2020), 3000 MW of installed solar capacity, various energy efficiency programs, the use of Combined Heat and Power (CHP) systems, Demand-Response programs, the regulation of the transportation industry, and the implementation of a cap and trade for greenhouse gases.

Modeling these policies allows to bring back greenhouse gases (GHG) to their 1990 levels as mandated by AB 32. This report estimates that 63% of GHG reduction will come from the various energy policies, 20% from the cap and trade, and 17% from offset programs outside the cap. The state's major pollution sources, the power and industrial sectors, will witness 32% and 14% of GHG reductions in 2020 respectively. The report anticipates various economic impacts from AB 32. While the total cost of carbon abatement is positive for some measure (Energy Efficiency for instance), renewable energies have a cost of abatement close to $ 100 /metric ton of CO_2e abated. In addition, AB 32 is expected to increase retail electricity prices by 1% to 6%, depending on whether the revenues from the carbon auctions are returned to utilities. Finally, although AB 32 is expected to decrease the Gross State Product by 0.2%, the California Air Resource Board predicts it will increase personal income by 0.1%.

Table of Contents

List of Tables

List of Figures

List of Acronyms

AEO: Annual Energy Outlook
CAA: Clean Air Act
CAIR: Clean Air Interstate Rule
CARB: California Air Resource Board
CEC: California Energy Commission
CHP: Combined Heat and Power
CSAPR: Cross State Air Pollution Rule
CSI: California Solar Initiative
DR: Demand Respond
EE: Energy Efficiency
EGU: Electricity Generating Units
EIA: Energy Information Administration
EPA: Environmental Protection Agency
GHG: Greenhouse Gases
LCFS: Low Carbon Fuel Standards
MATS: Mercury and Air Toxics Standards
Mmt CO_2e: Million metric tons of carbon dioxide equivalent
PM10: Coarse Particulate Matter
PM2.5: Fine Particulate Matter
VMT: Vehicle Miles Traveled

Introduction

The world is growing increasingly concerned about the issue of climate change and the various disturbances this phenomenon brings about. The most recent World Energy Outlook Special Report [1] highlights the importance of undertaking major steps to control global warming. The "4-for 2°C scenario" emphasizes the importance of four necessary and economically feasible actions in limiting the warming of the earth to 2°C by the year 2020. First and foremost, energy efficiency is expected to account for almost 50% of the emissions savings necessary to slow down warming. Second, limiting the use of inefficient coal power plants, either through retrofitting or retirement of capacity, is expected to account for around 20% of the reductions. Third, mitigating methane releases from upstream oil and gas (due in part to aging infrastructure that allows leakage) is expected to account for 18% of reductions. Fourth, the partial removal of fossil-fuel subsidies is expected to achieve the remainder of the reductions.
This is quite an ambitious scenario, which requires deep involvement of both developed and developing countries.

This global call for action puts the spotlight on the role that the United States, a country whose population consumes 25% of the world resources, has to play. This report examines the state of the power sector in the US, analyses current and future market trends within that sector, and assesses the short and long term impacts of various statewide environmental efforts and regulations. The analysis then focuses on the state of California's unique model and strict environmental regulation, and assesses the benefits and drawbacks of this model, and its applicability to the whole country.

The United States Model

Federal Environmental Policies in the Power Sector

Federal climate regulation has been stagnating for the past years, with various senate bills discussed but little action in the congress. Nevertheless, greenhouse gas (GHG) regulation is gradually taking shape under the existing Clean Air Act administrative authority. Indeed, since 2007, the Environmental Protection Agency (EPA) is obligated to limit GHGs to avoid "public endangerment". The standards for air pollution that have received the most attention due to their impacts on electric utilities are summarized below.

Cross State Air Pollution Rule (CSAPR) and Clean Air Interstate Rule (CAIR) [2]

The Clear Air Interstate Rule was established in 2005 to address indirect pollution in downwind states, but it was overturned in 2008. The alternative proposed by the EPA was a Cross State Air Pollution Rule (CSAPR), but in 2012, it was overturned as well, and on August of that year, the United States Court of Appeals for the District of Columbia Circuit announced its intent to vacate it. As a result, the regulation of SO_2 and NO_X emissions will continue to be administered under CAIR pending the promulgation of a valid replacement. CAIR covers fossil-fueled electric generating units of more than 25 MW nameplate capacity in 27 states and the District of Columbia CSAPR is similar to CAIR but the former is more limiting: For example, it has restrictions on state emissions trading, lower emission caps.

Mercury and Air Toxics Standards (MATS) [3]

As shown in figure 1, power plants are major emitters of harmful pollutants such as mercury, non-mercury metallic toxics, acid gases and organic air toxics. Today, approximately 40% of electric generating units (EGU) do not have appropriate control mechanisms for these pollutants. The MATS rule establishes power plant emissions standards for mercury, acid gases and non-mercury metallic toxic pollutants which, according to EPA, will prevent 90% of mercury coming from coal-fired power plants of being emitted to the air, reduce 88% of acid gas emissions from power plants and reduce 41% of sulfur oxide emissions. These numbers take into account the reduction caused by the retirement of some coal burning power plants from now until 2015.

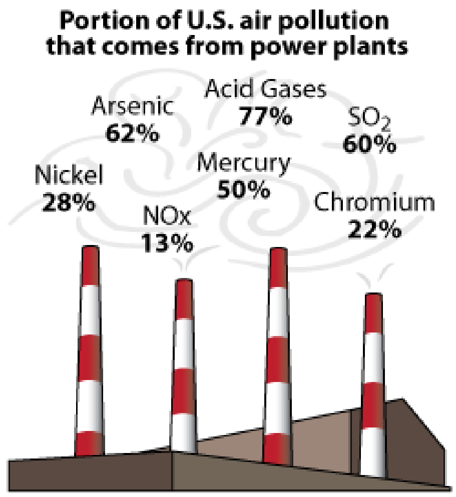

Figure 1: Portion of US Pollutants that come from power plants - Source EPA (2013)

The motivation behind MATS is to level the playing field between new plants and older plants that have no advanced control equipment installed. They are affective as of April 16, 2012 and the compliance period is 4 years.

MATS apply to EGUs that are larger than 25 MW and generate electricity for the national grid. About 1400 EGUs are affected by the rule out of which 1 100 are coal-fired power plants.

The major emission standards enforced under the MATS include numerical emissions limits for existing and new EGUs. Coal-fired units have to control mercury, particulate matter (PM), and hydrogen chloride (HCl), while oil-fired units have to control PM, HCl and hydrogen fluoride (HF).

The MATS requires semi-annual compliance reports and detailed records and documentation that the unit has undergone regular inspections and maintenance.

Maximum Achievable Control Technologies (MACT)

EGUs are required to reduce their emissions using maximum achievable control technologies (MACT) in order to reach the level of new cleaner power plants. A summary by the Bipartisan Policy Center [4] identifies the main technologies as follows:

For mercury: Activated carbon injection (ACI) coupled with particulate controls or wet scrubber coupled with selective catalytic reduction (SCR) or scrubber additives

For acid gases (which are controlled by a surrogate limit on HCl): Wet scrubbers, dry scrubbers coupled with particulate controls, or dry sorbent injection (DSI) coupled with particulate controls.

For metallic toxics (which are controlled by a surrogate limit on particulate matter (PM)): Upgrading of the existing electrostatic precipitators (ESP) or installing a baghouse (fabric filter), which has a higher efficiency.

For those power plants for which it is not economical to comply, the other alternatives are fuel switching or simply retiring.

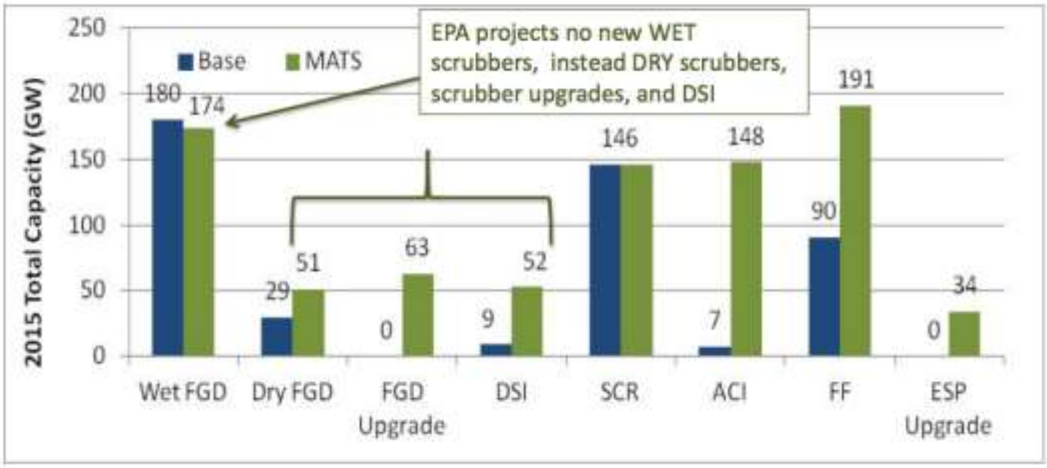

Figure 2: GW of retrofit projects - Source www.epa.gov, MATS section

(Base case includes existing regulations and Cross State Air Pollution Rule)

The EPA projected MATS compliance foresaw less than 2% retires out of the 310 GW of coal capacity, with 32%, 20% and less than 45% upgrades to meet mercury, HCl and PM limits respectively.
The EPA also projected a 3.1% average increase in electricity prices due to MATS.

GHG Regulation Using Best Available Control Technology (BACT) [5]

As of January 2011, GHG emissions from the largest stationary sources became covered by the Prevention of Significant Deterioration (PSD), and Title V Operating Permit programs, which are both required under the Clean Air Act. However, given that the thresholds they impose (100 and 250 tons per year) are not specifically designed to be applied to GHGs, the EPA's tailoring rule addresses that issue by setting a three steps approach to permitting GHG emissions under PSD and Title V. This rule insures that small sources are not unfairly penalized and sets CO_2e (CO_2 equivalent) limits.

BACTS for GHGs require new power plants that emit more than 100 000 tons of CO_2 per year and existing power plants that increase CO_2 emissions by more than 75 000 tons per year to undergo CAA permitting. The EPA guidance would prevent the construction of new coal plants if BACT requires the use of Carbon Capture and Storage (CSS).

New Source Performance Standards (NSPS) for CO_2

Under the Clean Air Act, the EPA is authorized to develop technical standards referred to as New Source Performance Standards (NSPS). They apply to new, modified and reconstructed affected facilities in specific source categories.

On March 27, 2012, the EPA introduced NSPS for GHG emissions from new fossil fuel-fired power plants. The standard to be met is 1000 lb CO_2/MWh, which is equivalent to the CO_2 emitted by a natural gas combined cycle unit. This standard indirectly requires the installation of Carbon Storage and Sequestration technologies. It is unclear when EPA will finalize the rule.

As for existing and modified coal plants, the EPA has indicated that it will propose NSPS in the future, which is already being legally challenged although the agency states that the standards will have no impacts on the electricity power sector. But this will also depend on the future prices of natural gas, and the fact that new coal plants might not be built for lack of ability to comply. [6]

What about energy efficiency instead? So far, EPA hasn't considered energy-efficiency measures to qualify as a compliance option for NSPS because this approach is "untested" for GHGs under NSPS. However, studies show that many states have already implemented efficiency policies and programs aimed at reducing CO_2 emissions from the power sector and that these could reduce administrative burdens, if properly credited. Another advantage of energy efficiency it that it faces less challenges from both coal advocates and environmentalists, because efficiency measures are already incorporated, under other sections of the CAA. Energy efficiency aims at improving power plant operations and reducing end-use energy consumption. This in turn leads to less burning of fossil fuels and thus less CO_2e emissions. [7]

PM 2.5 Standard [8]

PM2.5 (i.e. "fine particles", with diameters less than 2.5 μm) are currently limited to 15 $\mu g/m^3$ by the national ambient air quality primary standard. In June 2012, the EPA proposed to lower it within the range of 12 to 13 $\mu g/m^3$ and to establish a new secondary standard to preserve visibility. However, these standards are not expected to go below the levels required by CSAPR and MATS.

Cooling Water Intake Structures - Section 316 (b) **[9]**

On March 28, 2011, the EPA proposed requirements for cooling water intake structures for existing power plants that withdraw more than 2 million gallons of water per day (mgf) and use at least a quarter of it for cooling purposes.
Under 316 (b) of the Clean Water Act (CWA), the rules would be implemented through the National Pollutant Discharge Elimination System (NPDES) permits and

would set national requirements that reflect the best available technologies for minimizing negative environmental impact. These include impingement and entrainment of aquatic organisms. Impingement occurs when organisms are trapped against an intake structure's screens and are unable to escape. Entrainment, which has a very high mortality rate, occurs when the organisms pass through the screens and travel through the entire cooling system (pumps, discharge pipes…). Over the years, the EPA proposed a more flexible regulatory framework following public comments. Instead of mandating the use of cooling towers, which are extremely expensive, the EPA accepts other solutions to impingement such as installing screens that will return the fish to the water unharmed, or reducing the velocity of the entering water to 0.5 ft/s, which will prevent the aquatic life to get stuck.

Regional Haze Program **[10]**

The Regional Haze Program requires states to submit specific emissions control plans to the EPA for reducing haze and improving visibility. States are responsible for determining the Best Available Retrofit Technologies (BART) and presenting State Implementation Plans (SIPs).
On May 30, 2012, the EPA finalized a rule that allows states within the Cross-State Air Pollution Rule (CSAPR) to substitute their participation in the CSAPR for source-specific BARTs for sulfur dioxide and/or nitrogen dioxide emissions from power plants. This translates into the fact that CSAPR replaces regional Haze in Western States. [11]
EPA also finalized a limited disapproval of certain states implementation plans and is substituting them for stricter Federal Implementation Plans (FIP) that are often more costly. SIPs or FIPs can require coal power plants to install additional SO2 NOx and PM controls that would cost hundreds of millions of dollars.

Coal Combustion Residuals **[12]**

Coal Combustion Residuals (CCRs) are byproducts of burning pulverized coal for electricity generation. 40% of it is recycled (and used in concrete for example) but the rest is disposed in landfills or surface impoundments. There is a debate as to how CCRs should be regulated under the federal Resource Conservation and Recovery Act (RCRA). In 2010, EPA proposed federal regulations for the management of coal ash and considered two options: Listing CCRs under the hazardous regulatory program of RCRA, or under the non-hazardous category. Because of the multiple issues raised by both alternatives, the EPA is still reviewing comments and delayed its final ruling probably until 2014.

Energy Policies in the Power Sector

Energy Efficiency

Energy efficiency aims at reducing the amount of energy required to provide services to customers. Energy efficiency has multiple financial, environmental and technological benefits and is the key to a sustainable future. Energy efficiency programs have been in place for a long time in many areas across the United States and have experienced rapid growth over the past years, thanks to new energy savings standards established by state policies. Although there is a natural tendency towards increased efficiency (improved home appliances, stricter building standards etc.), there are still a lot of potential savings that can be achieved with respect to baseline energy consumption projections. This can be done through next generation programs that can not only achieve higher savings, but also target a wider customer base. These programs advocate the optimization of processes and systems rather than the implementation of multiple isolated measures. They also promote customer awareness and education.

This report considers the implementation of the most feasible next generation energy programs across the US and later summarizes the resulting energy and emissions savings that ensue, in addition to their impact on electricity prices. All the number and assumptions come from a 2013 study by the American Council for an Energy Efficient Economy (ACEEE). [13]

Baseline Energy Consumption

The following is a summary of the predictions that the EIA's Annual Energy Outlook 2013 anticipates in terms of future energy use. These numbers serve as a baseline for energy and emissions savings calculations in energy efficiency scenarios.

Residential Baseline Energy Consumption

Residential energy intensity, defined as annual energy use per household declines from 97.2 million Btu in 2011 to 75.5 million Btu in 2040, a 22% decrease.

Average electricity demand per household declines from 12.3 MWh in 2011 to 11.5 MWh in 2040, a 6% decrease.

Since the total number of households grows, the total delivered electricity consumption increases by 24%. But as far as the energy mix is concerned, residential use of natural gas and oil decreases by 12% and 25% respectively.

A breakdown of energy use reveals that in 2040, space cooling and "other uses" (mostly composed of new electrical devices) increase by over 40% and 50% respectively while equipment and appliances use less electricity. However, residential lighting sees the most decline in energy use over the years (even in "worst case" scenarios), mostly thanks to the Energy Independence and Security Act of 2007, which results in the certain replacement of incandescent bulbs with more efficient compact fluorescent lights (CFLs) and light-emitting diode (LED) lamps.

Commercial Baseline Energy Consumption
Commercial energy intensity delivered, defined as the ratio of energy consumption to floor space, declines by 10.8%, from 10.52 thousand Btu/ft^2 in 2011 to 9.38 thousand Btu/ft^2 in 2040, although floor space increases. With ongoing improvements in energy efficiency, the growth of energy consumption declines more rapidly than floor space increases, explaining the overall decrease in energy intensity.

Looking at end uses, although heating, cooling and ventilation needs decrease, there is a 33.9% increase in "other end uses" (for miscellaneous electric loads, such as video displays or medical devices) because these are often not subject to federal standards. Again, the lighting end use experiences the fastest decline in the share of purchased electricity, which decreases from 20.8% in 2011 to 15.1% in 2040. The energy intensity decrease is expected be maintained based on previsions in the Energy Policy act of 2005 and the Energy Independence and Security Act (EISA) of 2007.

Industrial Baseline Energy Consumption
Industrial energy intensity witnesses a continued decline from 2011 to 2040 in the Annual Energy Outlook 2013 Reference case, despite a 19% increase in industrial delivered energy consumption. This is due in part to a shift from activities such as petroleum refineries, iron, steel and cement production, towards less energy-intensive industries such as computers and plastics. Most of the industrial growth occurs prior to 2025, after which the annual rate of increase is about 0.3%. This is mirrored by an 18% increase in natural gas use up to 2025 followed by a smaller 6% increase from 2025 to 2040.

The industrial energy mix in the reference case sees an increase in the consumption of renewables, such as biomass, which becomes increasingly used with natural gas for Combined Heat and Power (CHP). Coal use drops by 1% while petroleum and liquid fuels increase by 6% by 2040.

Energy Efficiency Programs

Residential Programs
The residential programs aim at increasing the penetration rate across markets, getting people more involved, and finding new savings opportunities. Beyond

lighting, these programs will target other residential technologies or appliances. By 2030, the following technologies are assumed to be implemented: LED, ductless heat pumps, heat pump water heaters, high efficiency dryers and washers, advanced power strips and home energy displays and smart meters. In addition, new and existing home will be built/retrofitted while incorporating energy-saving technologies.

Commercial Programs

Similar to the residential sector, commercial buildings markets will continue to provide large savings in an array of domains, with next generation building programs yielding promising results for new and existing buildings. These focus on optimizing lighting design and using daylighting, control technologies (occupancy sensors and dimmers), along with LEDs to minimize energy use. Improvements on HVAC elements are also key, with the introduction of ground source heat pumps and radiant cooling and heating systems for example. However a successful energy efficiency strategy has to be one that integrates all approaches and encourages standardizing models and designs of high performance that can be applied across a greater number of buildings. It's all about expanding the market for retrofits, renovations and new constructions.

Industrial/Other Programs

Because the industrial sector accounts for almost a third of energy use, it is important to emphasize more on this domain and explore the currently emerging program trends, which can yield very high savings. The opportunities mostly lie in improvement and optimization of industrial processes beyond simple equipment replacement. The approaches under study take into consideration the unique size and needs of players in the industrial sector and tailors efficiency programs to their individual processes. In addition, they take into account the incorporation of energy efficient practices into the companies' culture. Moreover, they anticipate substantial savings from Combined Heat and Power (CHP) systems that have the potential to reduce the need for utility investments in generation and transmission.

The ACEEE also investigates savings in the agriculture sector, which has stagnated quite a bit in terms of energy efficiency. The programs under study involve educating farmers and increasing their awareness, in addition to assisting them in obtaining the necessary state or federal funding.

Carbon Fees/Cap and Trade Scenarios **[14]**

The 2013 Annual Energy Outlook Supplement examines several scenarios regarding carbon dioxide policies and assesses their impact on coal generation and emissions reductions. Although some of the more stringent scenarios are perhaps unlikely to happen, it is enlightening to see how sensitive coal production (and energy resources in general) is with respect to the different policies adopted. The following table summarizes the carbon dioxide policy cases considered by the EIA. The CO_2 fees start in 2014 and grow at a certain annual rate (5% or 7.5%) until 2040, where they range between 36 and 107 $/mtCO_2$. These fees are apply on the electricity sector, and can stand on their own or are coupled with deficit reduction (i.e. the revenues from the fees are not returned to customers/businesses) or rebates. The cap and trade scenarios on the other hand, aim at reducing 2012 emissions by 50% by the year 2040. One case includes offsets while the other doesn't. The option of an economy wide fee is also considered. Table 1 summarizes the different cases under analysis.

Table 1 List of Carbon Dioxide Policy Cases – Source: EIA Supplement 2013

	CO_2 Fees		Cap and Trade	Fee/Allowance Revenue Treatment			
Case Name	Start ($)	Real Rate of Increase	2040 Reduction from 2012	Deficit Reduction	Consumer Rebate	Corporate Rebate	Offsets
Reference	-	-	-	-	-	-	-
Electricity Sector Only Fee Cases							
$10 fee at 5%	$10	5.0%			X		No
$10 fee at 7.5%	$10	7.5%			X		No
$20 fee	$20	5.0%			X		No
$20 fee w/deficit reduction	$20	5.0%		X			No
$20 fee with business rebate	$20	5.0%				X	No
$30 fee	$30	5.0%			X		No
Electricity Sector Cap and Trade Cases							
Cap and Trade without Offsets	NA	NA	50%		X		No
Cap and Trade with Offsets	NA	NA	50%		X		Yes
Economy-Wide Fee Cases							
$20 fee economy-wide	$20	5.0%			X		No
$20 fee economy-wide w/deficit reduction	$20	5.0%		X			No

The advantage of a CO_2 fee is that it provides an incentive to invest in less pollutant energy sources such as natural gas, which has a lower carbon content than coal. The higher the fee and the faster it increases annually, the greater the emission reductions. When the fee applies to all the sectors in the economy, then the prices rise across all uses of fossil fuels, not just in the electricity sector. The EIA examined the results for 5 fee cases and 2 cap and trade cases (highlighted in red in table 1).

By 2014, the fees range from \$36 to \$107 per metric ton of CO_2. As for the cap and trade cases, one allows offsets while the other doesn't. The allowance prices are lower than the carbon fees and reach \$50 and \$55 respectively in 2040. Banking of allowances is not allowed and in one case only, offsets are to be used to cover up to 20% of emissions and they contribute to reducing the allowance price.

Market Trends [15]

This section looks at the different market trends of energy resources as detailed in the Annual Energy Outlook (2013) issued by the EIA. It helps understand the short and long-term changes in the power sector.

Energy and Electricity Consumption

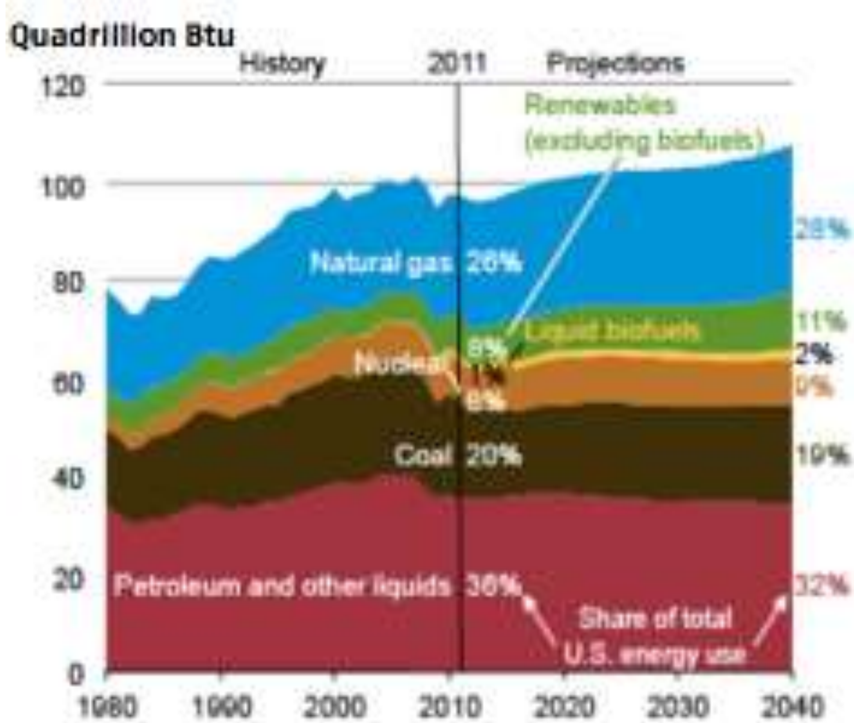

Figure 3: US Primary Energy Consumption by Source - Source: AEO 2013

Figure 3 displays the trends in primary energy in the US, both past and forecasted. There is an increase in primary energy of which the majority is natural gas as expected following the recent boom in natural gas production.

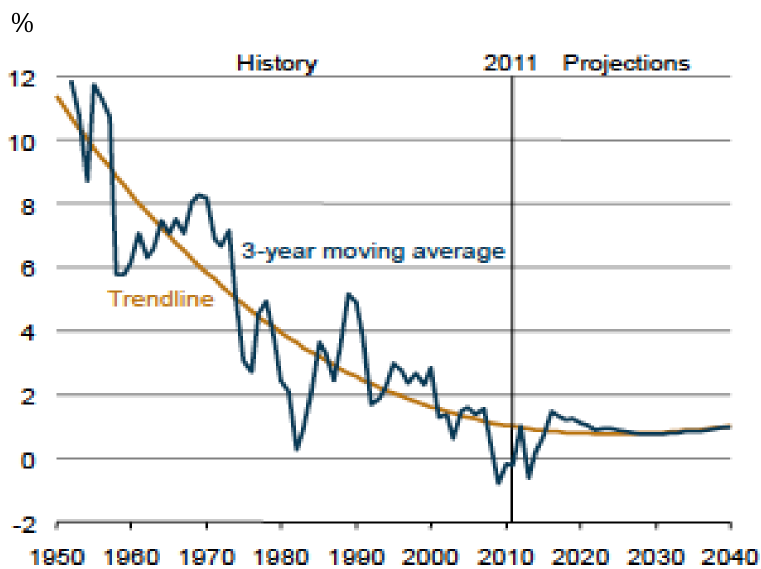

Figure 4: US Electricity Demand Growth, 3-year Moving Average - Source AEO (2013)

Figure 4 represents the electricity demand growth in percent, as a three year moving average. As can be seen, an increase in electricity use is expected, but the growth is slower as highlighted by the flatness of the curve.

Natural Gas

Taking a closer look at Natural Gas trends, figure 5 shows that the current increase in natural gas production is expected to continue until 2040, with shale gas supply increasing by almost 20 trillion cubic feet.

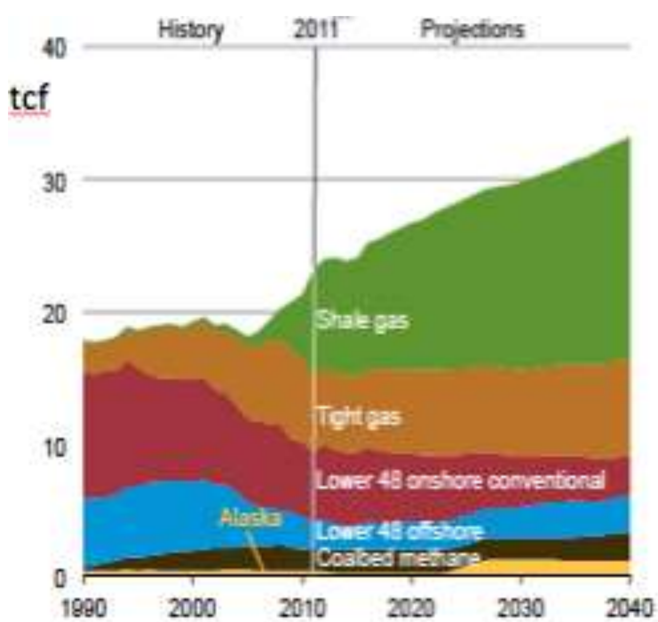

Figure 5: Natural Gas Production by Source, Historic and Projected – Source: AEO 2013

Since natural gas production and consumption depend on the resource's prices, it is important to estimate them on the long term. Figure 6 shows that after all-time lows in 2012, natural gas prices are going to inevitably increase. They reach $ 8/MMBtu in 2040 in the Reference case, but are sensitive to economic growth as well as the availability of oil and gas resources.

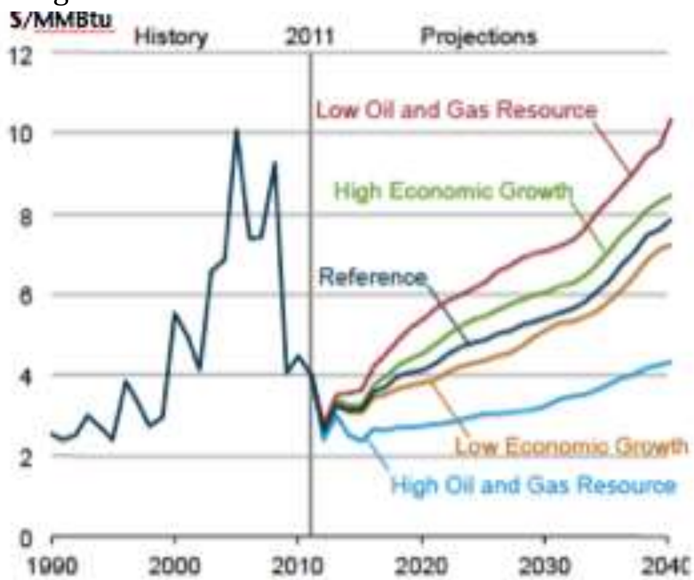

Figure 6: Natural Gas Average Spot Prices - Source AEO (2013)

Coal and Nuclear Generation

Although it is clear that natural gas will be the preferred fossil fuel resource for the country in the future, it is important to look at the forecasted trends of other resources that are more polluting, like coal, ore more risky, like nuclear.

Figure 7 shows coal prices, which in turn would influence coal growth or decline. The graph shows that prices will increase across all the US, although not uniformly, after lows in 2011-2014 (due to various constraints such as competition with natural gas).

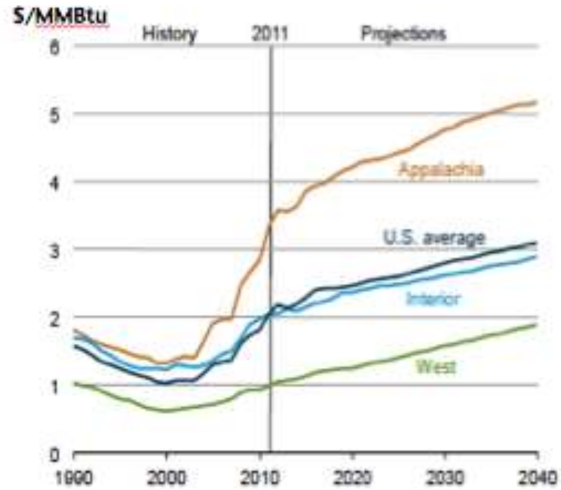

Figure 7: Coal Prices Projections by Region – Source: AEO 2013

Finally, figure 8 clearly shows that nuclear capacity will slightly increase by 2025, regardless of the state of the economy and will only increase thereafter in the case of high economic growth.

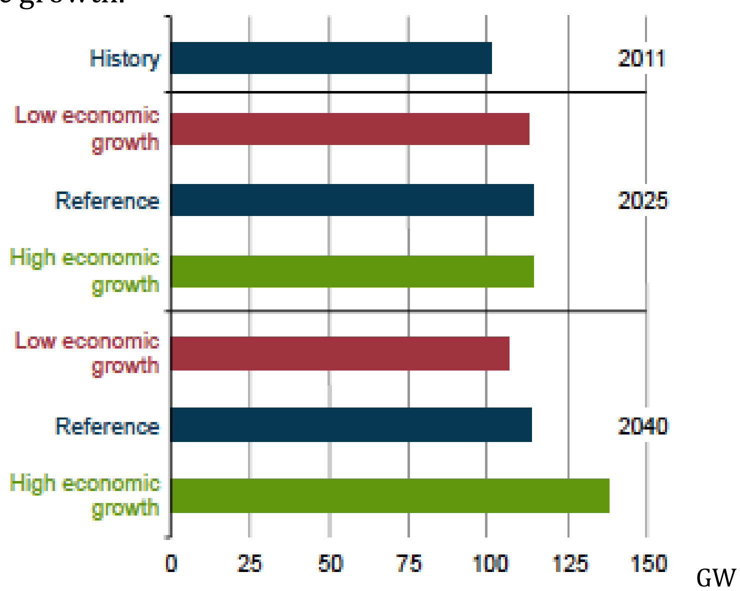

Figure 8: Nuclear Capacity Projections for 2025 and 2040 – Source AEO (2013)

Short-Term Trends (2013-2016)

The major drivers of short-term trends in the power sector are mainly market trends, EPA environmental Policies, and the natural state of coal power plants in the country. The following section analyses the combined effects of these drivers.

Coal Decommissioning

Between 2013 and 2020, utilities will retire an unprecedented number of coal power plants. The decrease of natural gas prices with respect to coal prices, coupled with the possibility of more stringent federal regulations on pollutant limits are both drivers to shut down the oldest, least efficient power plants. But many retirements are being announced even before the compliance deadline, which highlights the sole impact of market changes.

In the EIA's Annual Energy Outlook 2013 [15], coal production is expected to decrease until 2016 and increase up to 0.6% per year until 2040. In addition, in 2012, the EIA anticipated a retirement of 27 GW up until 2017. However, around the same time, the National Electric Reliability Council (NERC) announced the scheduled closure of over 40 GW of capacity over the next 5 years [16].

A study conducted by the Brattle Group [17] predicts even more retirements that what is currently scheduled. It considers two different policy scenarios: The Lenient and Strict scenarios where in the first case, more plants are expected to undergo retrofits and in the second case, more plants will be forced to close doors. Table 2 groups the characteristics of both scenarios.

Table 2: The Brattle Group Lenient and Strict Policy Scenarios

Lenient	Strict
Applies to units > 25 MW	Applies to units > 25 MW
SNCR (Selective Non Catalytic Reduction) and ACI (Activated Carbon Injection) on all units	SCR (Selective Catalytic Reduction) on all units
DSI (Dry Sorbent Injection) and baghouse filters on units in WECC and on units < 200 MW in other regions	DSI (Dry Sorbent Injection) and baghouse filters on units in WECC and on units < 200 MW in other regions
Wet FGD (Flue Gas Desulfurization) on units ≥ 200 MW outside WECC	Wet FGD (Flue Gas Desulfurization) on units ≥ 200 MW outside WECC

Under the Lenient Policy case, 59 GW of capacity are expected to retire until 2016. 226 GW will be retrofitted and 49 GW will be replaced. Under the Strict Policy case, 77 GW of capacity are expected to retire until 2016. 212 GW will be retrofitted and 57 GW will be replaced

However, the Union of Concerned Scientists (UCS) goes even further as to how much coal could be effectively retired. The "Ripe for Retirement" report [18] states that an additional of 59 GW can be retired, on top of the announced NERC closures, amounting to a total of 100 GW to be shut down in the next 4-5 years. This capacity is deemed ripe for retirement even before EPA policies interfere, meaning that operating the corresponding coal power plants is currently not economically viable against other fossil-fired sources such as Natural Gas Combined Cycle (NGCC). This is mainly due to the old age of these plants and their inefficiency compared to newer technologies.

Figure 9 summarizes the different retirements that are expected to occur on the short-term (i.e. from 2012 to 2016 approximately).

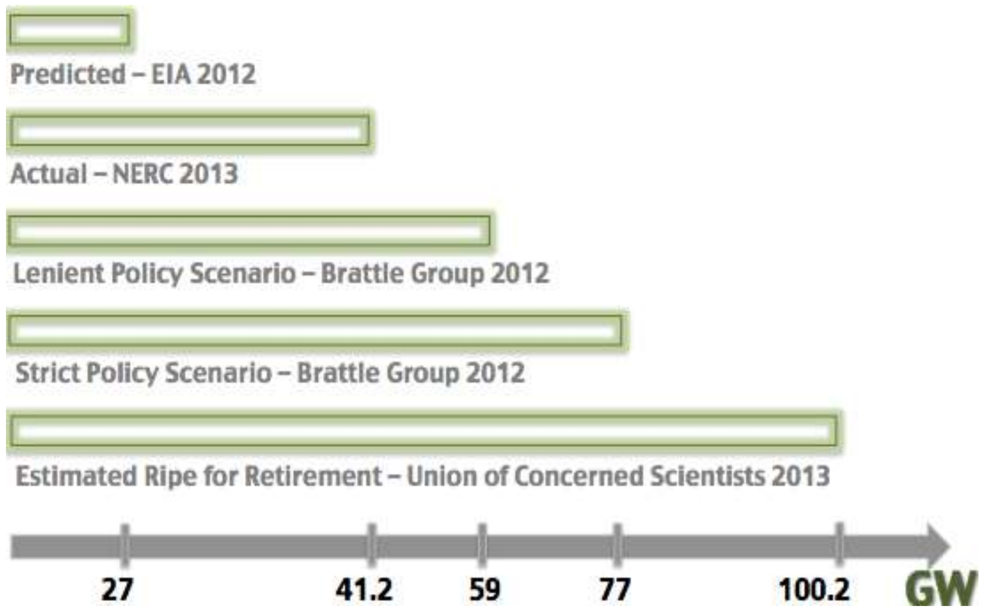

Figure 9: Different Scenarios of Retirements (GW) for Different Cases

Emissions Avoided

As the multiple retirement scenarios show, different assumptions lead to different outlooks, which in turn, lead to different environmental impacts. For example, the announced retirements would avoid between 88 and 150 million tons of CO_2 emitted annually while the UCS's rather idealistic analysis would avoid an additional 157 to 260 million tons of CO_2 annually [18]. These numbers are hard to predict because they also depend on the energy resource that is going to be used to replace the omitted coal.

Economic Impacts

As far as economic impacts are concerned, there is little information as to how severe they will be. The Brattle Group [17] anticipates a 4 to 10 $/MWh increase in power prices due to the short-term disturbances that the power sector will experience in the next few years, but doesn't foresees major disruptions or shortages. This is mainly because of the slow ongoing economic growth and the fact that the country has the extra capacity to make up for the retired coal generation.

Long-Term Trends (2016-2040)

The major drivers of long-term trends in the power sector are mainly energy mix trends, carbon policies (fees or cap and trade options), and energy efficiency across various sectors. The following section analyses the potential combined effects of these drivers for selected years or periods.

Potential Coal Retirements

Figure 10 shows the expected coal capacity retirements, up until 2025. As discussed in the previous section, short-term disturbances accelerate retirements, but on the long-term, both agencies predict little or no further retirements (except for those plants that have reached their end of life). [15],[16].

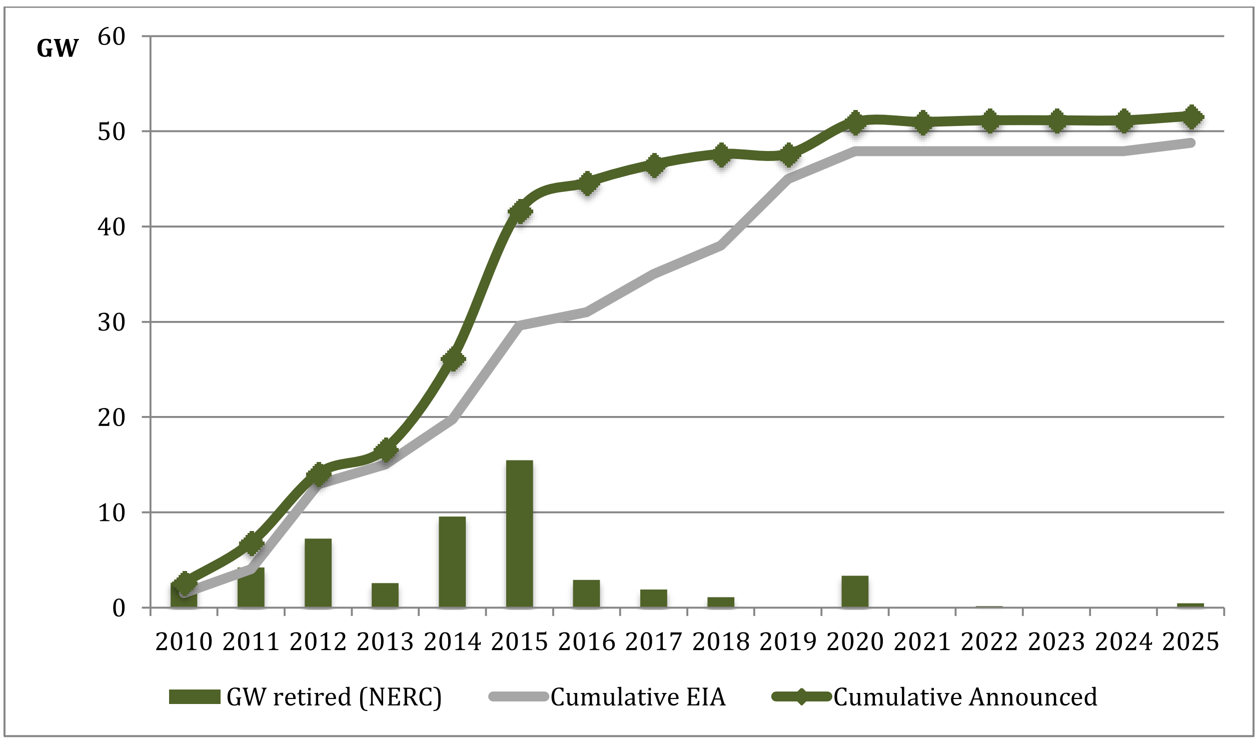

Figure 10: Coal Capacity Retirements Projections - Adapted from EIA and NERC (2012)

Potential Changes in the Electricity/Energy Mix

The 2013 Annual Energy Outlook Reference Case [15] indicates a steady reliance on oil, a 27% increase in natural gas, a 7% increase in coal, almost no change in nuclear and a 26% increase in Renewable and other sources between 2025 and 2040. However, this mix might considerably change due to both carbon policies and long-term energy efficiency measures.

Carbon Policies

In its supplemental study [14], the EIA considers different carbon policies as discussed in this report. If implemented, these policies will considerably impact the country's energy mix. Since the fees raise the cost of using fossil fuels, the energy mix changes, with coal generation dropping substantially, especially when the fee is high. Even the less stringent policy (10$ fee with a 5% annual increase) causes over a third of the coal capacity to retire by 2040. Stricter cases go up to 75% of retirements.

The natural gas generation future is more nuanced. When the CO_2 fee is first imposed (in 2014), power plants retire rather than retrofit a large number of power plants, which sharply increases the generation of natural gas. Over time however, as the fees increase, non-polluting energy resources become more attractive, such as nuclear and renewables. By 2040, as more of these new plants are brought online, the contribution of natural gas-fired plants falls towards or even below reference case levels. It is important to note that in the later years, a portion of the natural gas generation is accompanied by carbon capture and sequestration methods.

Similar to natural gas, renewables grow in the early years in response to carbon fees. However they become increasingly attractive as the fees increase and by 2040, they are expected to account for 25% to 31% of the energy mix (as opposed to 17% in the 2040 reference case). A breakdown of renewable sources reveals that for less expensive fees, it is advantageous to rely on co-firing of coal and biomass but for higher fees, it is wind and solar who both increase more substantially.

Nuclear energy generation is expected to increase slightly by 2025 (up to 12%). But by 2040, generation grows from 20% to 105% more than the reference case, depending on the CO_2 fee. This rate of nuclear expansion is extremely high and very challenging to achieve, as it exceeds the historical peaks of the 1970s and the 1990s. As seen in the market trends section of this report, it is unlikely that the nuclear sector will experience this much growth.

Electricity Generation	**2011**	**Reference**		**\$10 @ 5%/year Electricity**		**\$10 @ 7.5%/year Electricity**		**\$20 @ 5%/year Electricity**		**\$20 @ 5%/year Economy**		**\$30 @ 5%/year Electricity**	
(Billion kWh)		2025	2040	2025	2040	2025	2040	2025	2040	2025	2040	2025	2040
Oil	28	18	18	-1	-1	-3	-5	-4	-6	-4	-6	-5	-6
Natural Gas	1000	1233	1563	122	-53	282	83	358	-14	349	-13	478	-222

Coal	1730	1715	1827	-413	-676	-752	-1425	-944	-1670	-946	-1635	-1296	-1761
Nuclear	790	912	911	0	180	2	520	23	853	24	825	112	957
Renewable /Other	544	716	900	149	355	286	501	298	464	298	435	322	620
Total	4092	4594	5219	-143	-195	-185	-326	-269	-373	-279	-394	-389	-412

Table 4 summarizes the changes in electricity generation from different sources under different CO_2 policies scenarios.

Table 3: Change in Energy Generation from Reference Case under Different Policy Scenarios Adapted from AEO Supplement (2013)

Table 3 (Cont'd)

Electricity Generation	**Cap & Trade w/o Offsets Electricity**		**Cap & Trade w/ Offsets Electricity**	
(Billion KWh)	**2025**	**2040**	**2025**	**2040**
Oil	-2	-4	-2	-3
Natural Gas	288	145	218	144
Coal	-607	-1225	-427	-1013
Nuclear	3	392	0	257
Renewable /Other	192	406	117	357
Total	-126	-286	-94	-258

Energy Efficiency

The energy mix is also affected by energy efficiency. If the energy efficiency programs analyzed in the ACEEE study [13] were to be implemented, then the potential energy savings could be achieved across various sectors, reducing the need for electricity and natural gas mostly. The following results are for the year 2030.

Residential Energy Savings

The following table is a summary of the savings that could be achieved in the residential sector according to this study.

Table 4: Residential Energy Savings for Different Energy Efficiency Measures - Adapted from ACEEE Study (2013)

	Electricity (TWh)	**Natural Gas (Tbtu)**
	Reference Case: Energy Delivered in 2030	
	1626	5550

	Savings from High Efficiency Programs	
Lighting	44	-
New Construction	5	16
Plug Loads and Electronics	46	-
Low-Income Weatherization	24	68
Home Energy Retrofits	118	279
Appliances	30	39
Mechanical Systems	66	446
Behavior-Based Programs	39	48
Manufactured Housing	32	29
Multi-Family Housing	12	73
Total Savings	**417**	**997**
Savings as a % of Reference	**26%**	**18%**

As can be seen, the resulting savings would amount to a reduction of more than a quarter of the TWh electricity delivered, and a little less than a third of natural gas delivered.

Commercial Energy Savings

The ACEEE study estimates the following achievable savings within the commercial sector with respect to the reference case forecasted by the Annual Energy Outlook 2013.

Table 5: Commercial Energy Savings for Different Energy Efficiency Measures - Adapted from ACEEE Study (2013)

	Electricity (TWh)	Natural Gas (Tbtu)
	Reference Case: Energy Delivered in 2030	
	1607	3600
	Savings from High Efficiency Programs	
Lighting	68	-
Building Operations	50	83
Small Business Direct Install	12	-
Major Retrofit and Renovation	116	259
HVAC	53	176
New Construction	42	94
Combined Heat & Power (CHP)	9	-
Miscellaneous Energy Use	176	68
Commercial Behavior	40	90

Total Savings	**565**	**770**
Savings as a % of Reference	**35%**	**21%**

As can be seen, the resulting savings would amount to a reduction of 35% of the TWh electricity delivered, and a little over 20% of natural gas.

Industrial and Other Programs Energy Savings

The results are summarized in table 6 below.

Table 6: Industrial/Other Energy Savings for Different Energy Efficiency Measures - Adapted from ACEEE Study (2013)

	Electricity (TWh)	Natural Gas (Tbtu)
	Reference Case: Energy Delivered in 2030	
	1009	1590
	Savings from High Efficiency Programs	
Industrial Programs	68	107
Agriculture	6	12
Combined Heat & Power CHP	35	-
Total Savings	**109**	**119**
Savings as a % of Reference	**11%**	**7%**

As can be seen, little can be achieved in these domains between 2013 and 2030, with potential savings of around 10% for electricity and natural gas delivered.

Total Energy Savings

Combining the results of the study's findings and adding distribution efficiency into the potential areas of improvements, the total energy savings forecasted for 2030 are 1162 TWh of delivered electricity and 1887 TBtu of natural gas. The savings with respect to the reference forecast amount to 27% and 19% of electricity and natural gas consumption respectively.

Table 7: Total Energy Savings for Different Energy Efficiency Measures - Adapted from ACEEE Study (2013)

	Electricity (TWh)	Natural Gas (TBtu)
Reference Case Delivered Energy in 2030	**4242**	**10030**
Residential Programs	419	997

Commercial Programs	565	770
Industrial Programs	109	119
Distribution System Efficiency	70	
Total Energy Efficiency Savings	**1162**	**1887**
Savings as a % of Reference Forecast	**27%**	**19%**

Emissions Avoided

This section attempts to estimate the potential carbon emissions reductions due to the implementation of long-term policies (carbon fees/cap and trade and nationwide energy efficiency programs).

Carbon Policies

The electricity sector is strongly affected by CO_2 fees and between 2014 and 2016, emissions decline rapidly while power companies alter their investments and electricity consumers react to higher prices by cutting their demand. This leads to an increase in natural gas use. Emissions reductions continue after that, but at a slower pace. By 2040, the majority of programs reach more than a 50% decrease compared to the reference case. The impact of fees on the electricity sector is obviously a decrease in emissions that reach a 32% decrease in the least strict scenario ($10 fee) to an 88% decrease in the stricter scenario ($30 fee). This decrease is linearly mirrored in the reduction in total energy related reductions. One surprising result is that the $20 fee that covers the whole economy results in only slightly lower total emissions than the $20 fee applied only to the electricity sector. The relatively small emissions reductions seen in this case are mainly due to the fact that the reference case already incorporates strict fuel economy and tailpipe emissions standards from the transportation sector. As a result, the inherent reductions in the reference case lead to a limited incremental effect of the CO_2 fee, because any increase in gasoline costs would be mitigated by the high fuel economy of the vehicle fleet already in place. [15].

Table 8 a: Emissions Reductions for Different Policy Cases - Adapted from AEO Supplement (2013)

	2011	**Reference**		**$10 @ 5%/year Electricity**		**$10 @ 7.5%/year Electricity**		**$20 @ 5%/year Electricity**		**$20 @ 5%/year Economy**		**$30 @ 5%/year Electricity**	
Emissions (Mm t CO2e)		**2025**	**2040**	**2025**	**2040**	**2025**	**2040**	**2025**	**2040**	**2025**	**2040**	**2025**	**2040**
Net Electricity Sector	2166	2141	2308	1750	1566	1450	799	1276	516	1283	585	959	276

% Change from Reference	**-**	**-**	**-**	**-18%**	**-32%**	**-32%**	**-65%**	**-40%**	**-78%**	**-40%**	**-75%**	**-55%**	**-88%**
Emissions cap	na	na	na	na	na	na	na	na	na	na	na	na	na
Total Energy Sector	5471	5481	5680	5066	4923	4764	4173	4580	3893	4524	3814	4246	3659
% Change from Reference	**-**	**-**	**-**	**-8%**	**-13%**	**-13%**	**-27%**	**-16%**	**-31%**	**-17%**	**-33%**	**-23%**	**-36%**

Table8: (Cont'd)

	Cap & Trade w/o Offsets Electricity		Cap & Trade w/ Offsets Electricity	
	2025	**2040**	**2025**	**2040**
Net Electricity sector Emissions	1602	1032	1600	1028
% Change from Reference	**-25%**	**-55%**	**-25%**	**-55%**
Emissions cap	1598	1030	1598	1030
Total energy-related CO2 emissions	4926	4417	5091	4635
% Change from Reference	**-10%**	**-22%**	**-7%**	**-18%**

Table 8 b: Percent GHG Reduction from 1990 levels in 2025

Year	**1990**	**2025**							
	Ref.	**Ref.**	**$10 @ 5%/year Electricity**	**$10 @ 7.5%/year Electricity**	**$20 @ 5%/year Electricity**	**$20 @ 5%/year Economy**	**$30 @ 5%/year Electricity**	**Cap & Trade w/o Offsets Electricity**	**Cap & Trade w/ Offsets Electricity**
GHG Emissions	5389	5481	5066	4764	4580	4524	4246	4926	5091
% Change	**-**	**-**	**-6.0%**	**-11.6%**	**-15.0%**	**-16.0%**	**-21.2%**	**-8.6%**	**-5.5%**

Looking at how much reduction could be achieved with respect to 1990 levels of GHG emissions (the California reference target year), the AEO Supplement reveals that by these levels would be exceeded by 2025, if any carbon policy is adopted.

Energy Efficiency

The ACEEE study doesn't offer a complete breakdown of emissions savings, as they are hard to capture. It estimates that as much as 1 gigaton of greenhouse gases could be reduced each year.

Economic Impact

Carbon Policies

Electricity and Fuel Prices

Upon the imposition of CO_2 fees/allowances, there is an obvious increase in the average electricity prices delivered to all consumers. But the variations depend not only on the value of the fees and their respective growth, but they also depend on the uses of the revenues that come from these measures. The range of increase in prices across all cases is found to be from 12% to 34% in 2025 and from 14% to 28% in 2040.

The CO_2 fees also raise the cost of using fossil fuel resources for electricity generation. Coal experiences the harshest increase with respect to the reference case (where coal prices increase only mildly between 2025 and 2040). The cost of natural gas generation, which is already expected to increase in later years, becomes higher too, with prices ranging from $9.94 to $13.31 per MMBtu in 2040 (instead of $8.51 in the reference case).

Gross Domestic Product

Because consumer electricity prices increase, economic growth, measured in terms of the Gross Domestic Product (GDP) tends to slow down in all the different policy cases under study. Upon the imposition of the fees, there is a shock in the economy leading to a sustained reduction in GDP. The EIA finds that the worst year is 2020 (with a range of reduction that goes from 0.3% to 1.2%). By 2025, the decreases are still felt but by 2040, the difference with the reference case is reduced (except for the cap and trade cases and the 10$ at 7.5% case). One noticeable fact is that the biggest impact on GDP is felt when the carbon fee applies to the whole economy, not just the electricity sector, with decreases of 0.66% and 0.54% in 2025 and 2040 respectively.

Table 9 summarizes the economic impacts for selected carbon policies.

Table 9: Economic Impacts of Carbon Policies – Adapted from AEO Supplement (2013)

$10 @ 5%/year (Electricity)		$30 @ 5%/year (Electricity)		$20 @ 5%/year (Economy)		Cap & Trade w/ Offsets (Electricity)	
2025	2040	2025	2040	2025	2040	2025	2040
Change in Electricity Prices from Forecasted Reference Case							
12%	14%	34%	28%	23%	26%	8%	20%
Change in GDP from Forecasted Reference Case							
-0.25%	-0.19%	-0.64%	-0.17%	-0.66%	-0.54%	-0.19%	-0.40%

Energy Efficiency

Economic impacts of energy efficiency programs are hard to capture. However the ACEEE estimates savings worth $ 1.2 trillion until 2030.

The California Model

The Electric Power Sector

California's in state electricity generation amounts to around 200 000 GWh annually and is transported over 32 000 miles of transmission lines. About 70% of the electricity is produced locally whereas the rest is imported from the Pacific Northwest and the Southwest. Currently, California's mission is to guarantee electricity supplies to customers while drastically reducing greenhouse gas emissions. The state's electricity loading order to meet demand lists energy efficiency and demand response first, then renewable energy, then efficient natural gas. [19]

Below are the most recent (2010) characteristics of the electricity sector in California, compiled by the EIA.

Table 10: California Electricity Sector Summary - Adapted from EIA (2011)

	Value	Rank
Primary Energy Source		**Gas**
Net Summer Capacity (MW)	**67,328**	**2**
Net Generation (MWh)	**204,125,596**	**4**
Emissions (thousand metric tons)		
Sulfur Dioxide	3	47
Nitrogen Oxide	80	9
Carbon Dioxide	55,406	16
Sulfur Dioxide (lbs/MWh)	<0.5	49
Nitrogen Oxide (lbs/MWh)	0.9	41
Carbon Dioxide (lbs/MWh)	598	46
Total Retail Sales (MWh)	**258,525,414**	**2**
Direct Use (MWh)	**10,073,764**	**3**
Average Retail Price (cents/kWh)	**13.01**	**11**

Electricity Supply

Electricity Mix [19], [20]

Figures 11 and 12 provide a breakdown of electricity-generating sources in

California. The first diagram shows the state's electricity mix. Natural gas represents more than half of the generation resource (53%) followed by renewables (29%) and nuclear (16%). A breakdown of renewable sources shows that the majority (57%) comes from hydro, followed by geothermal (22%) then wind (10%) and solar (6%). Therefore, California's energy mix is relatively "clean", since it heavily relies on the least polluting energy resources.

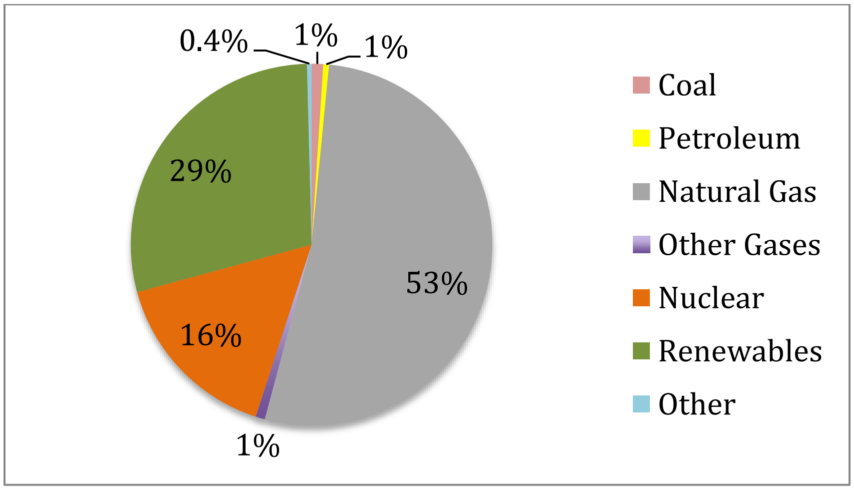

Figure 11: California Electricity Generation by Source – Adapted from EIA (2010)

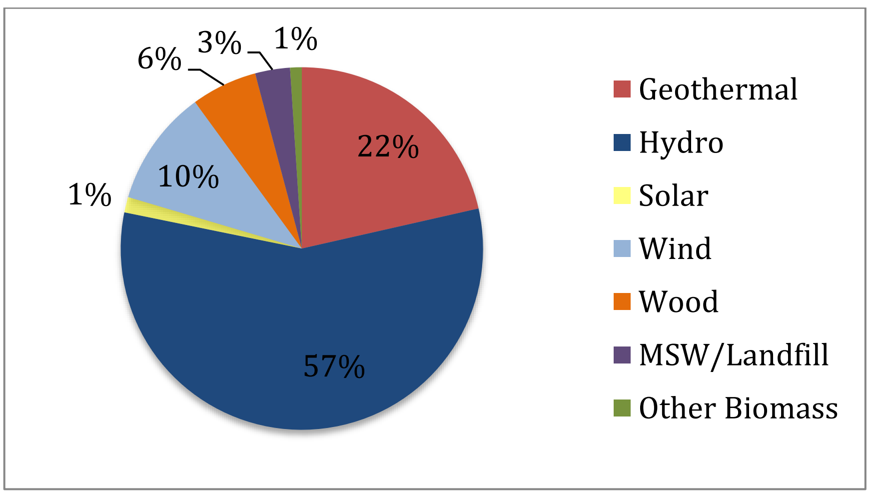

Figure 12: California Renewable Electricity Generation by Source – Adapted from EIA (2010)

Electric Capacity [21]

Table 11 is a compilation of the installed capacity of California by fuel type, in megawatts (MW).

Table 11: In-state Electric Capacity (MW) - Adapted from the California Energy Commission (2012)

	2005	2006	2007	2008	2009	2010	2011	2012
Coal	576	576	576	576	558	563	563	426

Biomass	1,104	1,108	1,099	1,125	1,112	1,123	1,164	1,180
Geothermal	2,626	2,644	2,644	2,601	2,651	2,651	2,651	2,651
Nuclear	4,456	4,456	4,456	4,456	4,456	4,577	4,577	4,577
Natural Gas	37,750	39,907	40,364	41,229	43,897	45,035	44,424	45,183
Large Hydro	12,127	12,218	11,969	12,250	12,250	12,281	12,321	12,321
Small Hydro	1,579	1,577	1,580	1,573	1,582	1,567	1,567	1,567
Solar	380	403	403	406	419	516	622	855
Wind	2,064	2,064	2,064	2,064	2,184	3,019	3,992	4,967
Other	591	582	598	598	597	574	526	376
Total	63,253	65,534	65,753	66,879	69,705	71,907	72,407	74,103

A stacked area chart of this data allows discerning the relative trends of each energy source in addition to their relative magnitude. Globally, there is an increase in total capacity installed (34% over the past 12 years according to the California Energy Commission). While hydro, nuclear, geothermal, coal and biomass stay relatively constant, there is a sustained increase in natural gas and renewables.

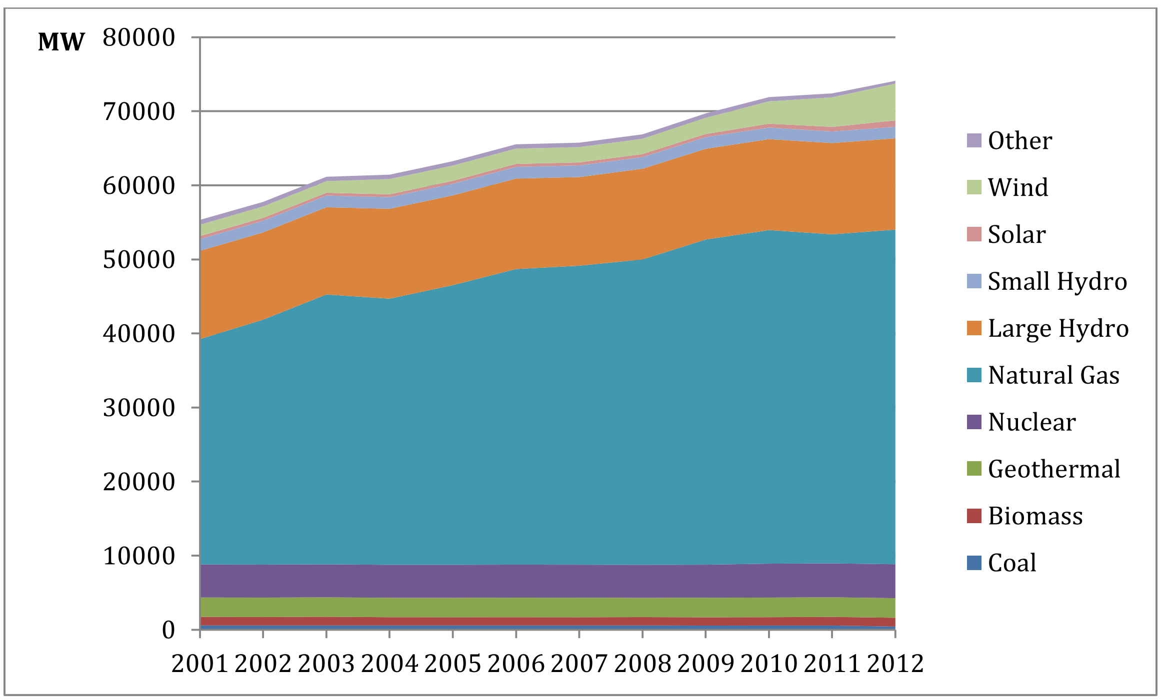

Figure 13: In State Capacity by Source – Adapted from the California Energy Commission (2012)

Important aspects to notice are:

- Natural gas has been increasing consistently over the past 12 years, especially due to the recent shale gas revolution.

- Wind power tends to stagnate for some years and increase substantially for others. This is due to the uncertainty of the renewable electricity Production Tax Credit (PTC) that is sporadically renewed right before it expires every year or couple of years. For example, the most recent PTC expired in 2012 and its fate was unknown, which might have explained the increased installed capacity between 2011 and 2012. As of January 2013, the PTC has been extended.
- Solar energy witnessed an increase in capacity over the last 6 years (note that this figure only shows large scale solar and doesn't include generators of less than 1 MW). This is due to the technological improvements in the solar sector coupled with various incentives and rebates that are available statewide.

One important factor that is causing changes in the current capacity is the recent (2010) policy that requires coastal power plants (including the state's two nuclear plants) to phase out the use of once through cooling systems. Once Through Cooling (OTC) is the use of coastal or estuarine water to cool a plant's turbines. The water is then returned at higher temperatures, which harms marine life.
The California State Water Resources Control Board (SWRCB) adopted this policy to effectively satisfy the Clean Air Act's section 316 (b) on cooling water intake structures, which requires that the Best Available Control Technologies (BACT) be implemented; these include the (expensive) installation of cooling towers or other adequate infrastructures. The compliance period depend on the nature of the each power plant and the area it serves. Studies by the California ISO [22] expect retirements of 12 079 MW to occur, which are expected to be replaced by 12 000 MW of CC and CT plants. However shortages may occur starting 2018 because of OTC.

Electricity Demand

Every year, each household in California consumes 7000 KWh of electricity on average and spends 1000 $ on electricity expenditures as opposed to 11000 KWh and 1300 $ respectively in the US. California ranks 47th in terms of energy intensity: The total energy consumed per capita in 2011 amounted to 209 million Btu (as a reference, Wyoming ranks 1st with 975 million Btu/capita in 2011). [23]

The residential consumption is broken down by end use as shown in figure 14: The major advantage of California is that the mild climate allows for less energy use for space heating and cooling.

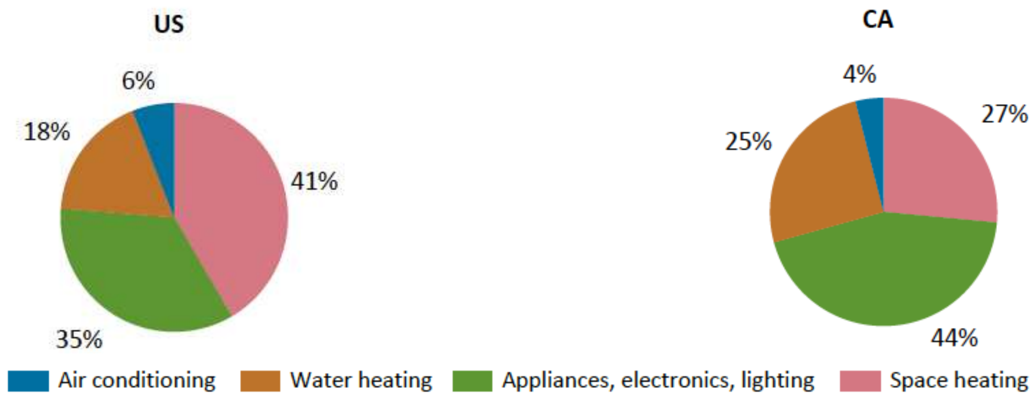

Figure 14: Household Consumption by End Use (US and California) – Source: EIA (2009)

As far as total electricity demand (GWh/year) is concerned, figure 15 shows a decrease in nuclear and coal generation and an increase in natural gas and renewables generation.

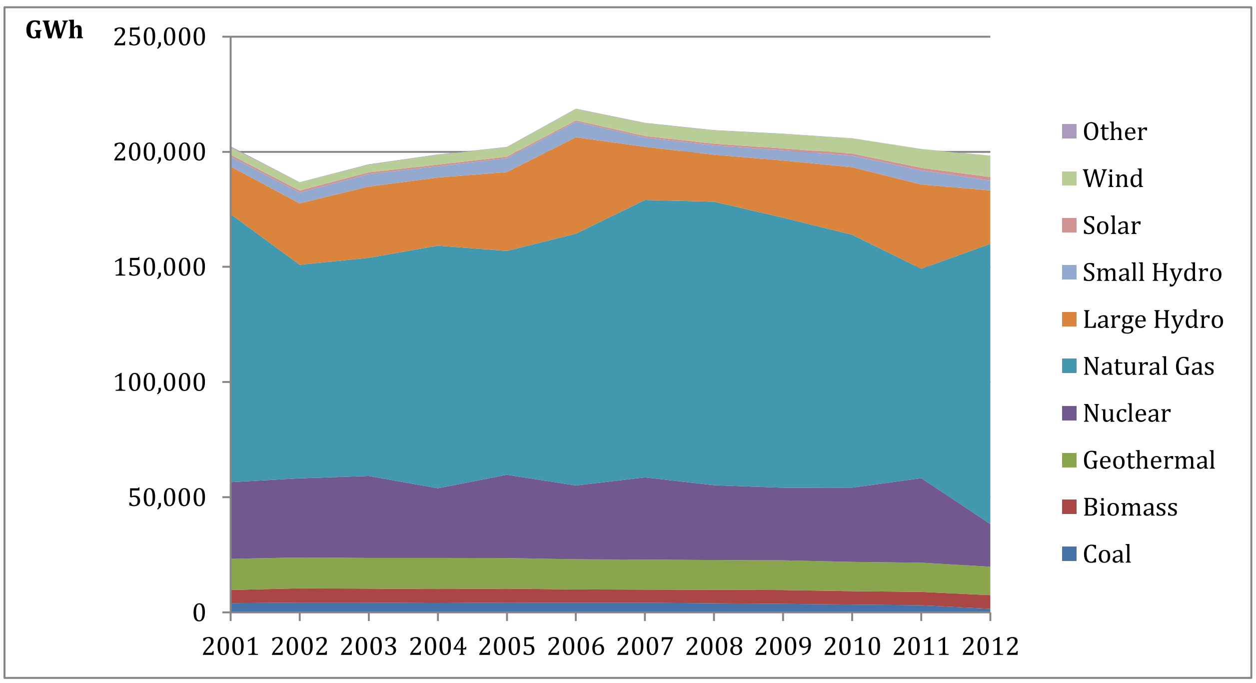

Figure 15: In State Electric Generation by Source - Adapted from the California Energy Commission (2012)

Important aspects to notice are:

- Total demand stays almost flat, despite the state's demographic growth This is probably due to the proliferation of "behind the meter" rooftop solar PVs in addition to the statewide energy efficient efforts.

- A decrease in nuclear generation might be due to the shut down of the San Onofre nuclear power plant, which is mirrored by an increased natural gas generation to compensate for the retired capacity.

Power Prices

The state of California is known for its high electricity and energy prices. This section summarizes the current market and retail electricity prices.

Market Prices

From January to June 2013, the average market price for California was 42.43 $/MWh, a 59% increase from that same period in 2012 [24]. On the larger scale, average on-peak day-ahead electricity prices rose across the whole country and the EIA attributes this increase to the rise in the prices of natural gas in 2013 compared to their 10-year lows of April 2012. The Pacific Northwest was particularly affected by natural gas prices, and California in particular was additionally handicapped by the ongoing outage of the San Onofre Nuclear Generating Station (SONGS). This resulted in unequal power prices between the north and south parts of the state.

Retail Prices

The following diagram gives a breakdown of electricity retail prices across various sectors, showing state and country averages. As can be seen, 2012 prices are consistently higher for California, except for the electricity related to the transportation sector [19].

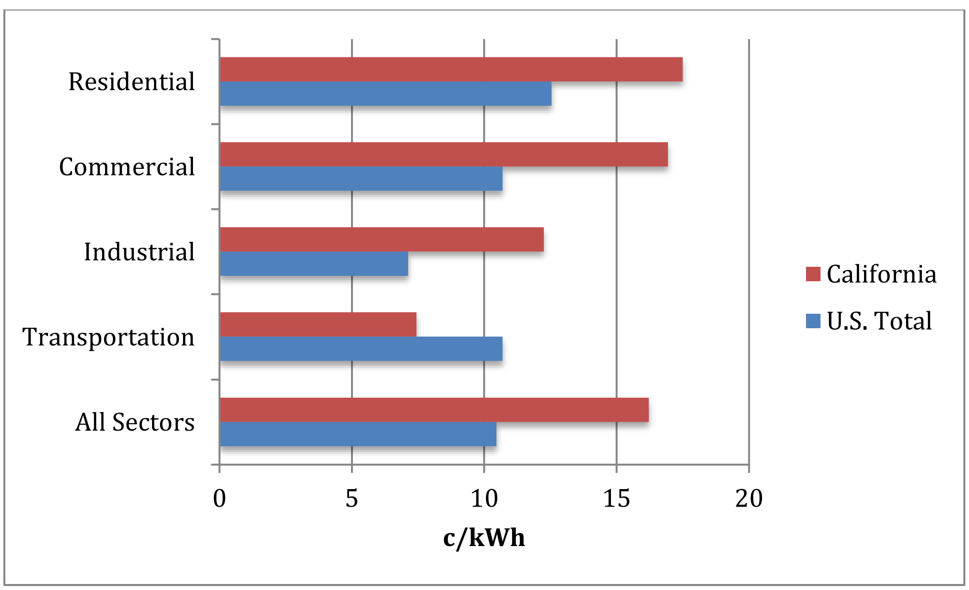

Figure 16: Average Retail Prices of Electricity to Customers by End Use Sector – Adapted from EIA (2013)

Energy Policies

The Agency: The California Energy Commission

The California Energy Commission is the state's main energy policy and planning agency. Its primary goals are to forecast energy needs, to promote energy efficiency and efficiency standards, to support research and technology advancements, to develop renewable energy resources for all sectors and to set state responses to energy emergencies (such as cases of high temperatures and reduced hydroelectric production).

The Warren-Alquist Act of 1974 led to the creation of the California Energy Commission, and conferred upon its commissioners the authority to handle the state's energy policy and planning. By law, the commission is required to present a biannual Integrated Energy Policy Report (IEPR) analyzing trends and issues related to electricity, natural gas, transportation, renewables, and energy efficiency.

Energy Policies on Supply

Renewable Energy Policies and Program

As revealed through its energy mix, California strongly supports renewable energy. Californians have been taking advantage of the solar resource for water heating since and throughout the 20th century, especially with the oils crisis of the 1970s. Just before the turn of the 21th century, the deregulation of electric utilities was accompanied by a sustained statewide bipartisan effort to increase total renewable electricity production. Important drivers include the state's Renewable Portfolio Standards (RPS) and the Energy Commission's Renewable Energy Programs that provide market-based incentives for utilities powered by renewable energy, and rebates for the installation of wind and solar capacity. One important example is the Go Solar California initiative.

Renewables Portfolio Standard (RPS) [25]

In 2002, California put in place its Renewables Portfolio Standard (RPS) program, with the goal of increasing the percentage of renewable energy in the state's electricity mix to 20% by 2017. The goal was officially modified in 2008 to 33% by 2020, under an executive order signed by Governor Schwarzenegger. This order directed the California Air Resources Board to enact regulations to reach that goal, under California's Assembly Bill 32 (AB 32: See Cap and Trade section). In 2011, Governor Brown codified the new RPS by signing a Senate bill that applies the RPS to all electricity retailers including POUs, IOUs, electricity service providers and community choice aggregators. By the end of 2013, all of these entities will have adopted the 25% goal by the end of 2016 and the 33% goal by the end of 2020.

Go Solar California [26]

The Go Solar California campaign is a joint effort of the California Energy Commission and the California Public Utilities Commissions. The goal is to create 3000 MW of solar energy systems on homes and businesses by the end of 2016, and install 585 million therms of solar hot water systems by the end of 2017, replacing those who work on gas.

The following table summarizes the three programs that form Go Solar California: The California Solar Initiative, The New Solar Homes Partnership and the various programs of Publicly Owned Utilities (POU).

Table 12: Summary of California Solar Programs - Adapted from the Go Solar California website (2013)

Authority	**California Public Utilities Commission**	**California Energy Commission**	**Publicly Owned Utilities**	**Total**
Name	California Solar Initiative	New Solar Homes Partnership	*	Go Solar California
Budget Until 2017 (million USD)	2167	400	784	3351
Solar Goals (MW)	1940	360	700	3000
Scope	All within IOU areas except new homes	New homes within IOU areas	All within POU areas	All California

* Various programs with various names

The California Solar Initiative (CSI) is a renewable energy program that aims at adding 1940 MW of solar-produced capacity from its launching in 2007 until 2016. The total budget allocated for that initiative is $2.17 billion and goes toward providing incentives on solar PV systems to customers of California's 3 IOUs, under the authority of the CPUC.

The New Solar Homes Partnership (NSHP) program provides financial incentives and support for the construction of new energy efficient solar homes. The incentives go to builders, developers and homeowners associated with the state's IOUs. The program seeks to install 360 MW of capacity with a $400 million budget.

To cover customers from the Publicly Owned Utilities, various smaller programs are put in place since 2007, with the goal of spending $784 million to install 700 MW of solar capacity on new and existing structures.

Energy Policies on Demand: Demand Side Management

Energy Efficiency [27]

Energy Efficiency Programs vary across regions and utilities. Many financial incentives (local rebates, tax incentives, loans…) exist at the state level and at the utility level. In addition, many policies and programs target energy savings in various sectors. This section details the most important ones.

Appliance Efficiency Program

The Appliance Efficiency program requires manufacturers to ensure that their appliances are in compliance with the state and federal laws for energy and water efficiency. They also need to certify and demonstrate the appliances' performance and make the data available to the Commission and to the public.

The California Energy Commission has an Appliances Database containing listings for all the currently certified appliances that meet state efficiency standards, or federal efficiency standards if present.

In addition, rebates and incentives were made available to encourage people to buy the most energy efficient appliances. As a result, only the most efficient appliances, such as those who have the Energy Star label, are authorized in California, yielding important energy and emissions savings.

2013 Building Energy Efficiency Standards

California's Building energy Efficiency Standards apply to new construction, additions and alterations to residential and nonresidential buildings. They are continuously updated every three years approximately.

For residential standards, some measures are prescriptive (such as high performance windows or natural night ventilation alternatives) while some others are mandatory (such as duct sealing and hot water pipe insulation). As for nonresidential standards, the concerned areas are envelope, lighting, mechanical systems, electrical distribution systems, and process loads (commercial supermarket refrigerators, computer data centers etc.).

Energy Efficiency in California's Existing Buildings

In addition to energy standards for new constructions, the state of California developed a comprehensive program to achieve greater energy efficiency in existing buildings. This program is embodied by the Assembly Bill 758, which requires the California Energy Commission and the California Public Utilities Commission to work hand in hand in a three-phased approach. Phase 1 (2010-2012) coincides with the implementation of the American Recovery and Reinvestment Act of 2009 (ARRA) which was designed to help the country bounce back from the recession and contains an energy efficiency section. Efforts were supported through upgrade programs, workforce training and outreach efforts and campaigns. Phase 1 also includes the adoption of a comprehensive roadmap containing all energy efficiency approaches. Phase 2 focuses on promoting and implementing that roadmap and actually achieve energy efficiency goals. Phase 3 focuses on making some approaches mandatory, in order for them to become common practice.

Demand Response

Demand Response (DR) is a resource that allows big electric customers to reduce their electricity usage in a given period (usually during hot weather when the grid is under stress) in response to a financial incentive. Since the peak electricity demand price is high ($/MW of peak load), DR allows businesses enrolled to save money. DR programs are currently available through California's Investor Owned Utilities (IOUs): PG&E, SCE and SDG&E and apply mostly to large customers who have the tools to measure hourly energy usage. [28]

Residential and smaller customer will eventually be able to participate once advanced metering procedures are implemented.

Emissions Policies

The Agency: The California Air Resources Board

The California Air Resources Board (CARB or ARB) is a regulatory agency created in 1967 and is a department within the California Environmental Protection Agency. The CARB is responsible for attaining and maintaining healthy air quality standards. California is the only state to be allowed to have such a regulatory agency, because it preceded the passage of the federal Clean Air Act. Some states may follow the CARB standards but are not allowed to set their own.

The CARB is responsible for monitoring the regulatory activity of the state's 35 air districts (each of which has rules). It can also issue executive orders and carry out formal test procedures for measurement of physical parameters related to air pollution.

The following sections analyze standards and rules for both greenhouse gases and other criteria pollutants.

Greenhouse Gas Rules: The Global Warming Solutions Act of 2006 [29]

Background

The Global Warming Solutions Act, or Assembly Bill (AB) 32 is a California state law that passed in 2007 and that addressed global warming due to the excess of greenhouse gas (GHG) emissions. The goal set by this law is to bring back GHG emissions to their 1990 levels through various regulations and market mechanisms. A cap-and-trade program for CO_2 is intended to address 19% of this target while the rest is to be achieved through direct regulation and other non-fiscal policy measures. The GHGs defined by this bill are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFC) and perfluorocarbons (PFC).

Implementation

The strategies adopted by AB 32 are:

- A cap-and-trade program, which is expected to cover 85% of all emissions statewide.
- Generating 33% of electricity (in terms of sales) from renewable sources by 2020.
- Reducing the use of refrigerants that have high global warming potentials (GWP). Examples include HFC-134 leakages from HVAC systems.
- Reducing fuel, water and nitrogen based fertilizers in the agriculture industry.
- Achieving considerable GHG emissions reductions in he transportation industry (through environmentally friendly vehicles).
- Auditing and regulating emissions from large industrial sources such as cement plants.
- Encouraging reforestation and natural carbon sequestration through voluntary programs.
- Reducing methane emissions from landfill through technologies such as anaerobic lagoons and on-site methane burning to generate electricity.

The Cap and Trade [30]

Background

By directly regulating over 360 businesses and 600 facilities across California by 2015, the cap-and-trade is expected to reduce 19% of GHG emissions by 18 to 27 Mmt CO_2e (million metric tonnes of CO_2 equivalent) by 2020. There are three initial commitment periods:

2013-2014: Covers emissions from electricity and large industrial sources (> 25 000 mt CO2e, excluding fugitive GHGs), which corresponds to 37% of California's economy.

The cap level starts at 163 Mm t CO_2e in 2013 and will be reduced 2% in 2014.

2015-2017: In order to cover fuel emissions from transportation, industrial facilities, residential and commercial buildings, the coverage expands to fuel

distributors. This corresponds to 85% of the economy.
The cap expands to 395Mm t CO_2e and will be reduced 6% by 2017.

2018-2020: The cap level will be reduced 15% by 2020 (Around 335 Mm t CO_2e).

Any entity inside the cap has to hold a California carbon allowance (CCA) for every metric ton of CO_2e it emits. Initial allocation of CCAs involves giving free allowances to electricity utilities and trade-vulnerable industries equivalent to 90% of their 2008 emissions in 2013, declining thereafter. These utilities must put their free allowances for sale at an auction, while benefiting ratepayers (i.e. the money they make has to be re-injected in some way as to benefit customers). Independent power producers (IPPs) and all other emitters do not receive any free allocations and must buy all of their allowances during the auction.

Some mechanisms are set to prevent prices of CAAs from fluctuating: In case they exceed a ceiling (starting at \$ 40/mtCO_2e), the price containment reserve is set to be at 1% (2013-2014), then 4% (2015-2017), then 7% (2018-2020) of allowances set aside as reserve. The auction reserve prices are not allowed to fall below an initial floor of \$ 10/mtCO_2e.

The Auctions [31], [32], [33]
The first auction took place in November 2012, the second in February 2012 and the third in May 2013. The next one is scheduled on August 16, 2013. Table 13 summarizes the results of the previous auctions.

Table 13: Summary of Previous Auctions - Adapted from CARB (2013)

	Auction 1 November 2012	Auction 2 February 2013	Auction 3 May 2013
2013 Allowances sold	23.1 million	12.9 million	14.5 million
Ratio of bids to CCAs	1.06	2.49	1.78
Settlement price	$10.09	$13.62	$14.00
CCAs sold to emitters	97%	88%	90.20%
Average bid price	$13.75	$14.68	$16.67
2015 Allowances sold	5.6 million		
Ratio of bids to CCAs	0.14		
Settlement price	$10.00		
CCAs sold to emitters	91%		

Average bid price	$11.07		

2016 Allowances sold		4.4 million	7.5 million
Ratio of bids to CCAs		0.46	0.79
Settlement price		$10.71 (minimum)	$10.71
CCAs sold to emitters		100%	86.50%
Average bid price		$12.40	$12.19

The Offsets

A carbon offset is a contract to reduce GHG emissions by a specified amount, within a specified time, and to a specified degree of certainty, from a GHG source that is not already legally bound to make such reductions.

Emissions offset = Baseline emissions – Project emissions. The baseline emissions are virtual (counterfactual), as they represent what would be replaced by the project. Therefore, there are inherent uncertainties as to the exact amount of reduction achieved through the offset protocol. This calls for independent verification, since both parties may have an interest in exaggerating the reduction. The key criteria for carbon offset integrity are that the offsets have to be real, voluntary, additional (i.e. the reductions wouldn't have occurred anyways), measurable, verifiable, permanent (i.e. the GHGs will be removed for a minimum of 100 years) and enforceable.

The California Carbon Offsets (CCOs) for entities under the cap is 8% of covered emissions. Initial protocols are for livestock, forestry and ozone-depleting substance destruction. Additional protocols on agriculture and fugitive methane emissions are currently in progress. California allows for out-of-state offsets from the US, Canada and Mexico.

The carbon offset transaction is a elaborate process. Both parties must agree on the unit price ($/ton-CO2e), the expected number of offsets (ton-GHG expressed as ton-CO2e), the terms of the offset purchase agreement, the schedule (up-front versus on-delivery payments), the vintages of the emissions (which year's emissions are offset) and the penalties/rewards in case of variation in performance.

The following diagram is a simplified model of a cap and trade with offsets. Assuming for simplicity purposes that the cap is set at 100 mt-CO_2e, then the entities covered by the cap can either abate their CO_2 emissions and trade their allowances in return for money, or they can buy offsets from various programs outside the cap. Note that the actual emissions will be 105 mt in this case due to the use of outside offsets.

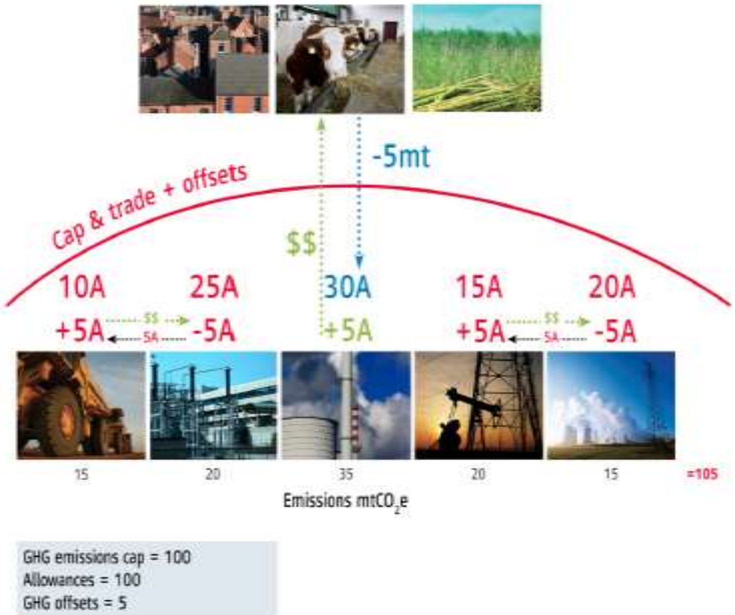

Figure 17: A Cap and Trade Model with Offsets (Source: Camco 2009)

The following figure is a theoretical representation of the cap and trade mechanism along with the trends that each element (emissions, offsets, allowances) is expected to follow as years go by. As can be seen, as the cap tightens, there is a gradual decrease in allowances allocated and a higher reliance on purchased offsets, to reach emissions that are equivalent to those of the base year.

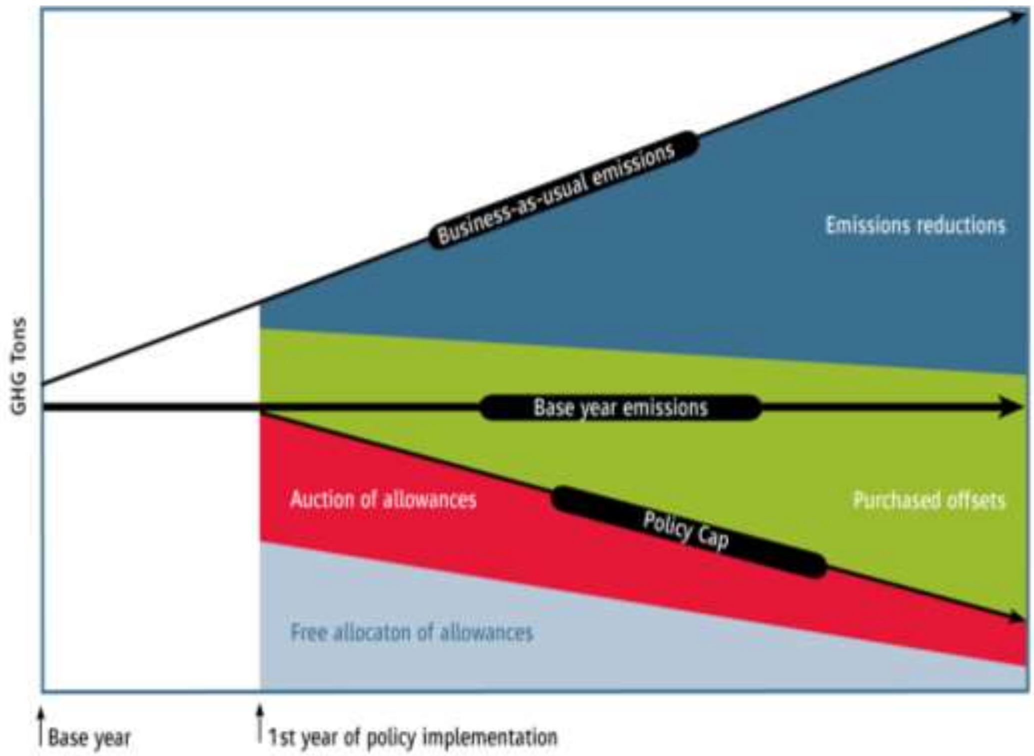

Figure 18: A Simplified Diagram of a Cap and Trade Model - Source Camco

Other Emissions: California's Ambient Air Quality Standards [34]

The CARB is responsible for upholding strict air quality standards in California, and making sure their limits are not exceeded. The criteria pollutants are: Ozone (O_3), coarse and fine particulate matter (PM_{10} and $PM_{2.5}$ respectively), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2), Lead (Pb), Visibility Reducing Particles, Sulfates, Hydrogen Sulfide, and Vinyl Chloride. All of the California limits imposed on the first seven pollutants are stricter than the equivalent federal limits, while the last four pollutants do not even have set national standards.

Emissions Trends in California

Sources of Emissions [19]

The California state total energy consumption reflects the heavy reliance on natural gas in the electricity sector and also highlights the significant consumption of motor gasoline in the transportation sector (around 1700 trillion Btu in 2011), to accommodate for the state's 41.6 million vehicles. The detailed consumption is shown in the figure below, which helps in identifying the major pollution and emissions sources.

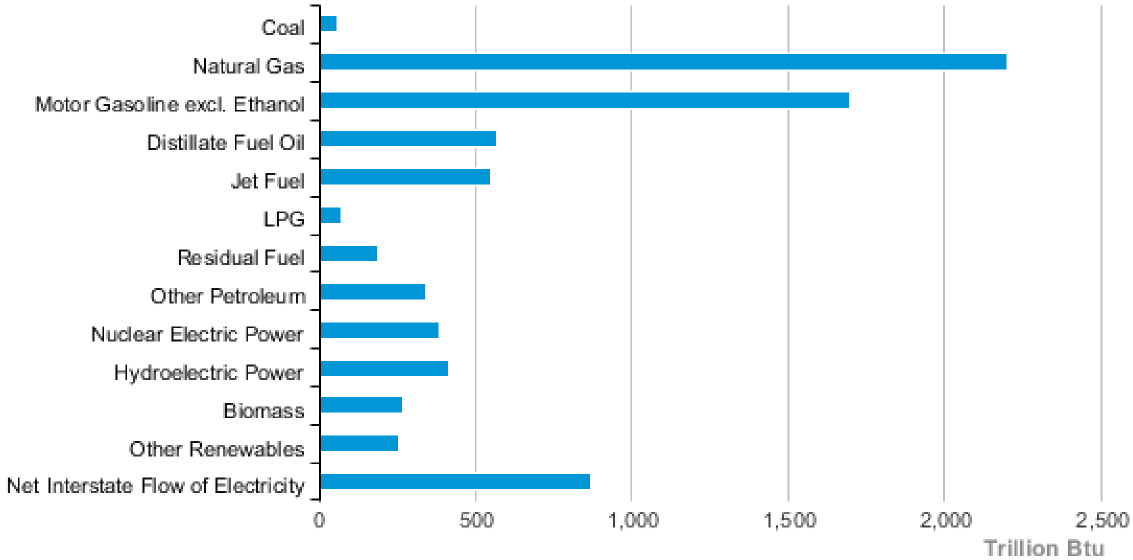

Figure 19: California Energy Consumption Estimates (2011) - Source: EIA (2012)

Figure 20 shows the breakdown of emissions by fossil fuel in 2010: As can be seen, the majority comes from oil (65%), followed by natural gas (33%) then coal (2%). This shows how polluting petroleum products are. It also shows that the state is keeping the most polluting source (coal) at a minimum.

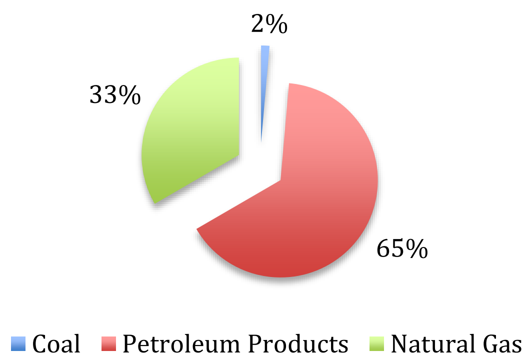

Figure 20: Emissions by Fuel Type (2010) - Adapted from EIA (2012)

CO_2 Trends [35]

The following graph illustrates the CO2 emissions trends from fossil fuel combustion in California, from 1980 to 2010, coupled with the most recent available trends in the state's Gross Domestic Product (GDP) [36], which is an indicator of economic health. CO_2 emissions from the burning of fossil fuels have been increasing as a whole for the past two decades. As of 2007, the state witnessed a sustained decrease, due in part to the economic recession, which is also consistent with a drop of GDP. However, as GDP picks up again, emissions are still tipping down, which might be due in part to environmental policies such as the early onset AB 32 (although there might be a lag between GDP and emissions trends).

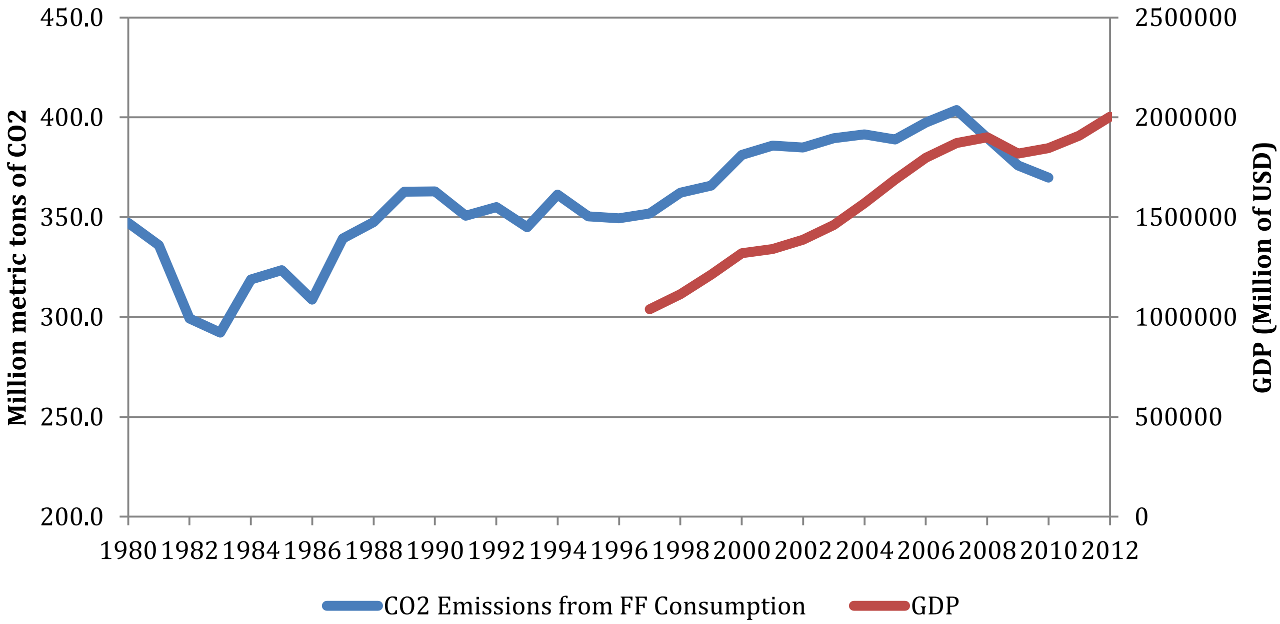

Figure 21: CO2 Emissions from Fossil Fuel Consumption in California and GDP
Adapted from EIA and Bureau of Economic Analysis (2012)

Criteria Pollutants Emissions Trends [35]

Figure 12 illustrates the trends of the major criteria pollutants in California (NOx, SOx, PM_{10} and $PM_{2.5}$) over the past 30 years. The initial (1975-1985)) decrease in SOx, NOx and to a lesser extent; $PM_{2.5}$ is a reaction to the Clean Air Act (CAA) of 1970 and its first amendment in 1977. A second pronounced decrease in 1990 is the reflection of the CAA's last amendment that occurred that year. After that date, all pollutants except NOx have remained at constant levels. The constant NOx decrease can be attributed to energy efficiency and to continuous technological progress on vehicles, such as the invention of the three-way catalytic converter.

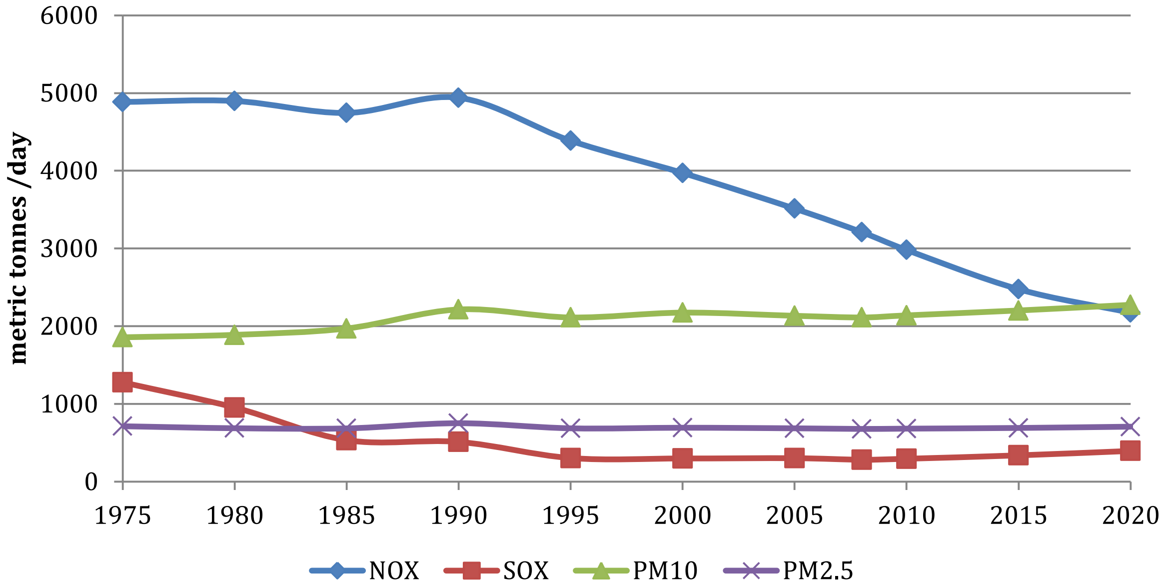

Figure 22: Criteria Pollutants Trends in California 1975-2020 - Adapted from CARB (2013)

The Impacts of California's Climate Action [37]

Modeling And Assumptions

The California Air Resource Board published a Scoping Plan in 2008 that outlines the steps that need to be taken to reach California's 2020 environmental goals. This plan is required to be updated every 5 years and a new update is scheduled for late September 2013. The version that this report is based on has been updated with better economic estimates in 2010.

Several Scenarios are analyzed in the scoping plan but the most reliable case has the following characteristics: Cap and Trade with Offsets, Low Carbon Fuel Standards (LCFS), Pavley II, Vehicle Miles Traveled reduction, Energy Efficiency (EE), 33% RPS and Combined Heat and Power (CHP).

Low-Carbon Fuel Standards (LCFS): To achieve 10% reduction of the carbon intensity of fuels by 2020, the ethanol share of passenger vehicles is increased to around 18% for light vehicles, and the biodiesel share of freight ground transportation is increased to 15%. Although biofuel prices are decreasing, and might compete or be lower than crude oil prices by 2020, the analysis assumes that gasoline remains cheaper.

Pavley II Vehicle Standards: Starting 2017, the marginal vehicle efficiency for passenger cars and light trucks is incrementally increased to reach a vehicle fleet of 42.5 mpg by 2020. This case implies increased expenditures for more efficient vehicles on the one hand, and fuel savings on the other hand.

Vehicle Miles Traveled (VMT) Reduction Measure: The Scoping Plan Model assumes a reduction of 4% in Vehicle-Miles Traveled per year in California. This is consistent with the implementation of a 2008 state law (SB 375) to reduce GHG emissions from vehicles through communities planning.

Energy Efficiency: Residential and commercial standards and programs are assumed to reduce electricity demand by 24200 GWh and natural gas sales by 800 million therms by2020.

33% Renewable Portfolio Standards: To achieve a 33% sales share of renewable electricity by 2020, the Scoping Plan relies on resource mix projections by the CPUC but doesn't account the cost for new added transmission. It includes all major programs and incentives related to renewables (like the California Solar Initiative).

Combined Heat and Power (CHP): The CHP measure sets a target of 4 000 MW of installed CHP capacity by 2020, which is expected to displace 30000 GWh of electricity demand. The heat generated is assumed to serve heating loads (existing and new).

Emissions Reductions

From 2012 to 2020, the cumulative difference between the business as usual reference case and the AB 32 case is around 500 million metric tons of CO_2e.

The Scoping Plan divides emission reductions drivers into three categories: Emissions Reductions from Complementary Policies (LCFS, Pavley II, VMT reduction, EE, RPS and CHP), emissions reductions as a direct result from Cap and Trade, and Emissions Reductions from Offsets. The model predicts the following breakdown each driver in terms of its abatement role. As can be seen the major source of reductions will come from complementary policies (63%).

Table 14: Percentage of Abatement from Different Policies - Adapted from CARB Scoping Plan (2010)

From Complementary Policies	63%
From Covered Sources due to Cap and Trade	20%
From Offsets	17%

Assuming allowance price to be 25$/metric ton of CO_2e by 2020, the Scoping Plan model the following predictions for total abatement under the AB 32 program.

Table 15: Cumulative Abatement Achieved under AB 32 - Adapted from CARB Scoping Plan (2010)

Allowance price in 2020	25$
Cumulative Abatement (2012-2020) Mmt CO2e	
From Complementary Policies	319.2
From Covered Sources due to Cap and Trade	103.8
From Offsets	86.8

Comparing year 2020 under AB32 to the "business as usual" scenario, a total of 15% GHG reduction is expected to occur as seen in table 16.

Table 16: Scoping Plan Predicted Emissions by Sector - Adapted from CARB Scoping Plan (2010)

2020 California GHG Production (Million metric tons CO_2e)	Reference	AB 32	% Change from Reference Case
Residential	29.7	27	-9%
Commercial	12.1	11.3	-7%
Industrial	102.8	87.9	-14%
Energy Intensive Industry	49.2	46.9	-5%
Other Industry	53.6	41	-24%
Mining	12.2	11.5	-6%
Agriculture	31	30.8	-1%
Transportation	227.8	200.1	-12%
Passenger	168.8	146.1	-13%
Freight	58.9	54	-8%
Power Sector	100	67.6	-32%
Domestic Power Sector	39.1	33.9	-13%
Electricity Imports	60.8	33.7	-45%
Waste and Other	12.4	12.4	0%
Total	528	448.5	-15%

As can be seen emission reductions from the power sector are substantial (32%) while the passenger transportation sector and the industrial sector both show potential for abatement.

Economic Impacts

Impact on the Electricity Sector

Cost of Implementation

The following graph taken from an E3 study [38] highlights some major costs incurred upon implementation of the state's main environmental measures. Note that EE is Energy Efficiency, CHP is Combined Heat and Power, and CSI is the California Solar Initiative.

As can be seen, energy efficiency saves money ($32/ton of CO_2e abated), and the majority of renewables are costly (up to $900/ton of CO_2e) to abate emissions. These costs are the total abatement cost which are calculated by subtracting the customer costs from the utility costs.

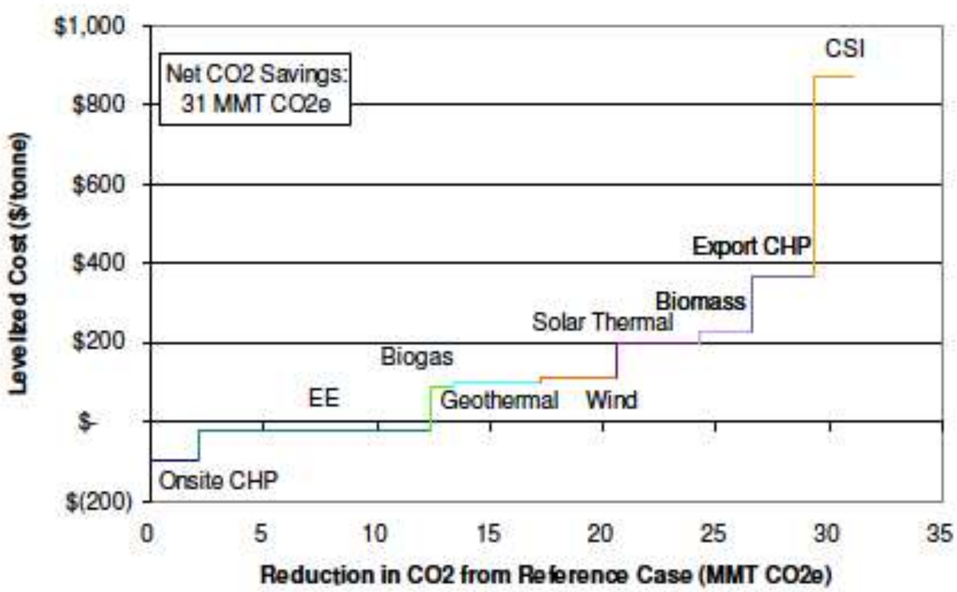

Figure 23: Total Cost GHG Abatement Supply Curve - Source: E3 Study (2010)

Electricity Bills/Prices

Thanks to its mild climate and by decades of energy efficiency and sustainable practices, California offers the lower monthly electricity bill to its customers than other states as seen in figure 24. This is the case even if the average rate per kWh is amongst the highest in the country.

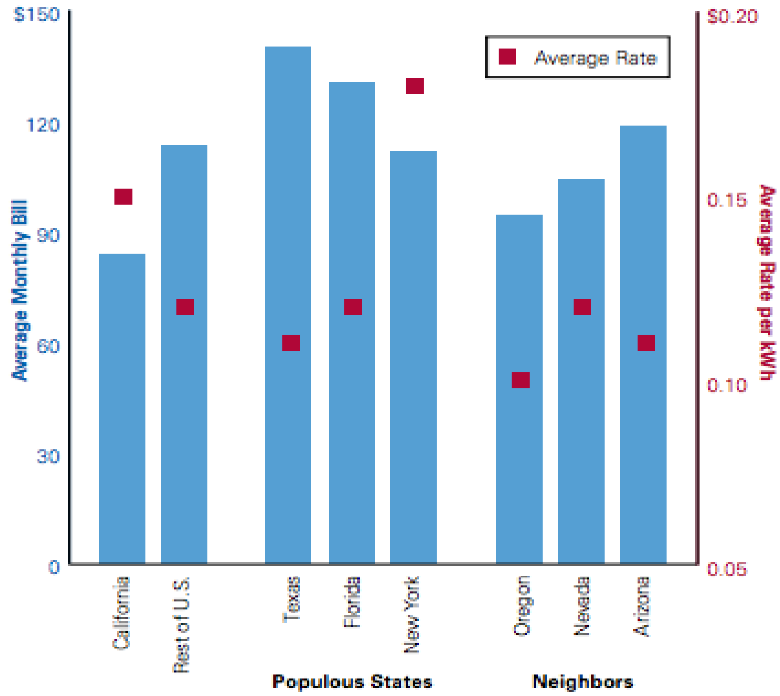

Figure 24: Average Monthly Residential Electricity Bill and Rate per kWh - From EIA (2011)

The future of these prices depends on where the benefits/costs of the implemented climate policies go. For example, E3 modeled three different options for the Cap and Trade revenues. If nothing is returned to the customers then electricity raises will considerably increase across utilities' customers (from 4% to 11%). On the other hand, if the revenues are all returned based on historic emissions of the retail provider, then rates will not increase as much and might decrease in one case. The results are graphed in figure 25.

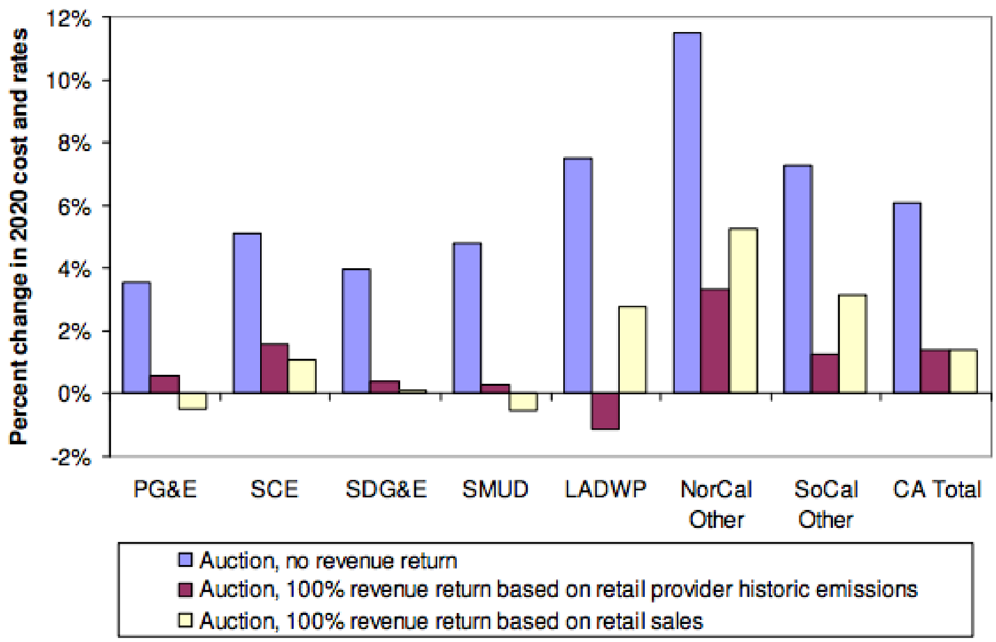

Figure 25: Change in Electricity Costs & Rates Across California Utilities under 3 Cap and Trade Scenarios
Source: E3 Study (2010)

Impact on the State Economy

The CARB Scoping Plan foresees the following changes in 2020 due to the completion of the first phase of AB32: A slight decrease in the state's gross economic product and a slight rise in total and per capita personal income, due to energy savings incurred by customers.

Table 17: 2020 Economic Indicators and Change from Reference- Adapted from CARB Scoping Plan (2010)

	Reference	AB 32	% Change
Gross State Product ($ Billions)	2502	2497	-0.2%
Personal Income ($ Billions)	2027	2029	0.1%
Income Per Capita ($ Thousands)	46.06	46.09	0.1%

As for fuel prices, they are expected to increase across almost all sectors, with big increases in industrial coal prices and increases in natural gas prices around 13%.

Table 18: 2020 Fuel Prices Variations From Reference Case – Adapted from CARB Scoping Plan (2010)

Sector	% Change in Fuel Price from Reference Case

Residential	
Electric	0%
Gas	13%
Oil	9%
LPG	4%
Commercial	
Electric	1%
Gas	14%
Oil	10%
LPG	4%
Industrial	
Electric	1%
Gas	12%
Oil	7%
Coal	89%
LPG	5%
Transportation	
Light Gasoline	6%
Light Diesel	4%

The Applicability of the California Model to the Whole US

Potentials

The US could successfully adopt the California Model in a variety of domains. Energy efficiency programs for appliances and new buildings could be standardized with respect to the California norms. Similarly car manufacturers are adapting their fleet to the California standards, given that it controls 11% of the US new car sales.

Limitations

The proliferation of behind-the-meter renewables that would accompany a statewide Renewable Portfolio Standards would require a decoupling all of the utilities' revenues from their energy sales, in order to compensate for their losses and keep the prices of electricity as low as possible. Adopting California's rate "tier-ing" structure would encourage energy efficiency and renewables, while a fixed compensation to the utilities would avoid the excessive rise of prices. Given that in some states, the prices of electricity are negatively or neutrally correlated with consumption, restructuring the rates is not an easy feat.

In addition, applying a statewide cap and trade could dissuade energy intensive industries to stay in the country and would only shift emissions abroad, while losing

domestic revenues.
Finally, applying the California strict National Ambient Air Quality standards for criteria air pollutants would involve major costs at the power plant/industries level and possible jobs and revenues losses.

Conclusion

The US power sector is going to experience a few disruptions on the short term until the end of the 2010s. The closing of coal power plants due to inefficient production, EPA standards and the natural gas boom is inevitable and although the grid is capable of making up for the majority of the lost capacity, the magnitude of the retirements could increase beyond what is expected, putting stress on the state transmission and distribution systems. However, it is also an opportunity for the new construction of renewable electricity plants in addition to more efficient combined cycle natural gas plants.
On the long term, "business as usual" (increased fossil fuel use) will resume if no further federal environmental policies are implemented. Statewide aggressive energy efficiency programs coupled with carbon policies such as fees or cap and trade would however change up the energy mix and achieve considerable energy and emissions savings, below 1990s levels by 2025.

The California Model represents somewhat of an advanced prototype in terms of environmental efforts. These efforts are believed to have paid off by limiting total and individual energy consumption. On the long term, the AB 32 emissions reductions goal will likely be achieved, and a tightening of the GHG limits or renewable energy minimum could be expected.

There is no doubt that the unique characteristics of the state of California facilitated the state's energy conservation success. Were the same policies applied nationwide, the country would have to face numerous challenges in terms of reducing per capita consumption, installing and linking renewable resources, and closing down fossil fuel power plants and energy-intensive industries.

REFERENCES

[1] International Energy Agency, (2012). *World Energy Outlook*. Retrieved from website: www.iea.org

[2] Environmental Protection Agency, (2012). *Fact Sheet: The Cross-State Air Pollution Rule: Reducing the Interstate Transport of Fine Particulate Matter and Ozone.* Retrieved from website: http://www.epa.gov/airtransport/CSAPR/pdfs/CSAPRFactsheet.pdf

[3] Environmental Protection Agency, (2012). *Fact Sheet: Mercury and Air Toxics Standards for Power Plants*. Retrieved from website: http://www.epa.gov/mats/pdfs/20130328fs.pdf

[4] Macedonia, J. Bipartisan Policy Center, (2012). *Summary of Power Sector Regulations: Air Toxic Standards*. Retrieved from website: www.bipartisanpolicy.org

[5] Mangino, J. Operating Permits Group, Office of Air Quality and Standards. (2010). *Prevention Of Significant Deterioration And Title V Greenhouse Gas Tailoring Rule*

[6] http://www.epa.gov/compliance/monitoring/programs/caa/newsource.html

[7] http://nicholasinstitute.duke.edu/articles/epa-urged-qualify-efficiency-existing-utility-nsps-compliance-option#.UjoebmQlU0N

[8] http://www.epa.gov/pm/actions.html

[9] Environmental Protection Agency, (2012). *Fact Sheet: Notice of Data Availability Related to Impingement Mortality Control Requirements for Proposed Regulations for Cooling Water Intake Structures.* Retrieved from website: http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/upload/Notice-of-Data-Availability-Factsheet.pdf

[10] Environmental Protection Agency, (2012). *Fact Sheet: Regional Haze: Final Alternative to Source-Specific Best Available Retrofit Technology Determinations, Limited State Implementation Plan Disapprovals, and Federal Implementation Plans.* Retrieved from website: http://www.epa.gov/airquality/visibility/pdfs/20120530fs.pdf

[11] Dumoulin-Smith, J. UBS Utilities. (2013). *Understanding the Next Round of Air Regs.*

[12] http://www.epa.gov/epawaste/nonhaz/industrial/special/fossil/ccr-rule/index.htm

[13] York, D., Molina, M., Neubauer, M., & Nowak, S. American Council for an Energy-Efficient Economy, (2013). *Frontiers of energy efficiency: Next generation programs reach high efficiency savings* (Report No U131)

[14] US Energy Information Administration, (2013). *Further Sensitivity Analysis Of Hypothetical Policies To Limit Energy-Related Carbon Dioxide Emissions* (Supplement to the Annual Energy Outlook 2013)

[15] US Energy Information Administration, (2013). *Annual Energy Outlook*

[16] Saha, A. MJ Bradley & Associates LLC, (2013). *Review of Coal Retirements*

[17] Celebi, M., Graves, F., & Russell, C. The Brattle Group, (2012). *Potential Coal Plants Retirements: 2012 Update*

[18] Cleetus, R., Clemmer, S., Davis, E., Deyette, J., Downing, J., & Frenkel, S. Union of Concerned Scientists, (2012). *Ripe for retirement: The Case For Closing America's Costliest Power Plants*. Retrieved from website: www.ucsusa.org/ripeforretirement

[19] Energy Information Administration, *California Energy Profile*, Retrieved from website: http://www.eia.gov/state/?sid=CA

[20] Energy Information Administration, *State Renewable Electricity Profile* (2010)

[21] California Energy Commission, California Energy Consumption Database (2012) Retrieved from website: http://ecdms.energy.ca.gov/

[22] Meeusen, K. California ISO, (2012). *Flexible Capacity Procurement - Phase 1: Risk Of Retirement*

[23] Energy Information Administration, (2009). *Household Energy Use In California: A Closer Look At Residential Energy Consumption*. Retrieved from website: www.eia.gov/consumption/residential/

[24] Energy Information Administration: *Wholesale Electricity Prices Rose Across the United State* (2013) Retrieved from website:
http://www.eia.gov/todayinenergy/detail.cfm?id=12211

[25] California Public Utility Commission (2013) *California Renewable Portfolio Standards.* Retrieved from website:
http://www.cpuc.ca.gov/PUC/energy/Renewables/index.htm

[26] Go Solar California Retrieved from website:
http://www.gosolarcalifornia.ca.gov/about/index.php

[27] California Energy Commission *Energy Efficiency Programs in California*. Retrieved from website: http://www.energy.ca.gov/efficiency/

[28] Pacific Gas & Electric, Demand Response Program for Businesses. Retrieved from website:
http://www.pge.com/en/mybusiness/save/energymanagement/index.page

[29] California Air Resource Board. *Assembly Bill 32 Global Warming Solutions Act.* Retrieved from website: http://www.arb.ca.gov/cc/ab32/ab32.htm

[30] California Code of Regulations, Subchapter 10 Climate Change (2013), *Article 5: California Cap On Greenhouse Gas Emissions And Market-Based Compliance Mechanisms To Allow For The Use Of Compliance Instruments Issued By Linked Jurisdictions* Sections 95800 to 96023, Title 17

[31] California Air Resources Board (2013) *Quarterly Auction 1, November 2012 Summary Results Report.* Retrieved from website:
http://www.arb.ca.gov/cc/capandtrade/auction/november_2012/updated_nov_results.pdf

[32] California Air Resources Board (2013) *Quarterly Auction 2, February 2013 Summary Results Report.* Retrieved from website:
http://www.arb.ca.gov/cc/capandtrade/auction/february_2013/updated_feb_results.pdf

[33] California Air Resources Board (2013) *Quarterly Auction 1, May 2013 Summary Results Report.* Retrieved from website:
http://www.arb.ca.gov/cc/capandtrade/auction/may-

2013/updated_may_results.pdf
[34] California Air Resource Board *Criteria Air Pollutants Monitoring*. Retrieved from website: http://www.arb.ca.gov/aaqm/criteria.htm

[35] California Air Resource Board *California Greenhouse Gas Inventory Data* and *California Emissions Trends (1980-2010)*. Retrieved from website: http://www.arb.ca.gov/cc/inventory/data/data.htm

[36] Bureau of Economic Analysis (2013) *California GDP Data Table.* Retrieved from website: http://www.bea.gov/regional/index.htm

[37] California Environmental Protection Agency, Air Resources Board. (2010). *Updated Economic Analysis Of California's Climate Change Scoping Plan*

[38] Energy and Environmental Economics Inc., (2010). *Greenhouse Gas Modeling of California's Electricity Sector to 2020: Updated Results of the GHG Calculator Version 3b update.*