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California's Climate Policy – a Model?

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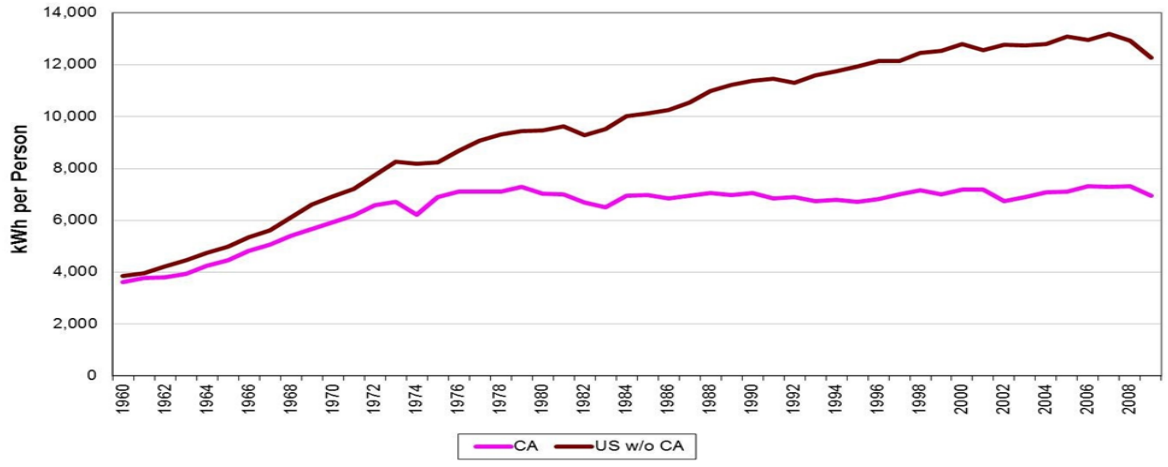
Executive summary

California's energy and climate policies deserve study for three new reasons. First, the impasse on climate legislation at the US federal level leaves climate action largely to individual states, of which California is the biggest. Second, California's politicians have taken climate policy further than those of any other US state, and won popular backing in the world's only direct referendum on greenhouse gas reduction in November 2010. Third, in the absence of any new legally-binding agreement in the United Nations climate negotiations, California, which on its own would be the world's eighth largest economy, is increasingly vaunting itself as a model of how a sub-national entity can take climate action irrespective of its national government's immobility on climate policy.

California is an interesting test bed for climate policy, because its economy is almost entirely the product of the fossil fuel age. Indeed, in contrast to earlier-settled US states further east, it barely existed before the railway came. The car, the highways and freeways – some of them with 12 lanes, along which Californians travel a collective 320 billion miles a year – then came quickly. However, despite the Achilles heel of its car culture, California's achievements in energy efficiency and clean energy are impressive by any standard, and particularly by any North American standard.

Figure 1: California v. US electricity consumption per capita



Source: Arthur Rosenfeld at http://coolwhiteplanet.org

Over the past 40 years, Californians have reduced their energy use per head by 20 per cent, while national energy consumption per capita in the rest of the USA has stayed largely above 1970 levels (see Figure 1). California is still not Denmark which, partly because it has a stable population, is unique in having prevented any growth in its overall energy consumption since the early 1970s. In contrast, both California's population and economy are growing. Because of this, the Golden state's total electricity consumption rose by 22 per cent from 1990 to 2009, yet per capita consumption fell by 6 per cent over the same period. [1] The rest of the US economy has also become less energy-intensive over time – it is a world-wide tendency – but not as dramatically as that of its largest state. California's energy productivity (the extra GDP produced with a given unit of energy) is now 68 per cent higher than for the rest of the USA, and the gap is widening; in 1990 the state was 63 per cent more energy productive than the rest of the country. Closely tracking this achievement in decoupling energy and economic growth has been California's relative de-carbonization. The average Californian's greenhouse gas emissions are half those of the average inhabitant of the other 49 states. Since 1990 California's gross state product has grown by 26 per cent, while its greenhouse gas emissions have fallen by 14 per cent.

These results show that California ought to be a demonstration lesson on clean energy and climate change policy to the rest of the USA, but it is very clearly not having that effect in most of the country, or at the federal level. In other aspects of life – culture (Hollywood) and technology (Silicon Valley) – California has been a pathfinder and trendsetter for the rest of America; that is certainly how Californians still see their role. But, in matters of energy, the rest of America is clearly not following.

Why has California gone down such a different path? This paper seeks to separate out the non-policy factors for the state's relatively sparing use of energy, such as its climate and demography, and to focus on the policies contributing to its considerable success in achieving energy efficiency, and solid achievement in building up renewables. A large part of this success in achieving efficiency is due to California's unique legal right to make its own rules to deal with air pollution, a right granted because of the state's unique problem with smog. It has used this right to pioneer a wide range of efficiency specifications for energy appliances, and to complement these with standards aimed at reducing the carbon intensity of fuels and energy

inputs, in a multi-pronged attack on emission levels. The paper also underscores the impact of energy efficiency programmes carried out by private utility company, but closely supervised by state regulators. Compared to all this regulation already in place, California's greenhouse gas cap and trade scheme, planned for 2012, will contribute relatively little to reducing emissions, at least in the short term.

California plans to generate a third of its electricity renewably by 2020, and has the natural resources and technology to meet that target. This paper cautions, however, that in the longer term California may not be as well placed to meet its drastic goal of reducing emissions over the next 40 years (to 80 per cent of 1990 levels by 2050), as one might imagine from its relative success in the past 40 years. This is because it appears to be neglecting the long term future of other necessary forms of low-carbon energy, such as electricity from nuclear power, or from natural gas with carbon sequestration.

California's climate policy is not a model that can be copied in its entirety; nowhere else has the same combination of wealth, natural resources, climate, technology, and legal room for manoeuvre. But for the rest of the USA, and also the world, California offers lessons about what can be achieved in energy efficiency through relentless pressure on mundane product standards, and clever regulation of utilities. For Californians, the challenge will be to keep their energy efficiency success going, while overcoming the power plant allergy that was one of the catalysts for that efficiency success in the first place.

1. Going it alone

Risking a broad generalization, it is fair to say that Americans have been quick to control air pollution where they have seen concrete evidence of damage – such as controlling the sulphur dioxide (SO_2) emissions from coal plants that caused acid rain – but slow to act where no local damage is evident. The USA, therefore, moved quickly to prevent acid rain stripping trees of leaves in the upper Mid West. It did this by inventing a system of capping and trading allowances, a mechanism that worked successfully for sulphur dioxide, but which would now be widely reviled in the USA if it should ever be applied to carbon dioxide. The SO_2 scheme worked well, for three reasons. First, the damage was clear: bare trees. Second, the solution was pretty painless: power plant operators could reduce SO_2 emissions by switching fuel (to low-sulphur coal or to natural gas) or by installing a known technology (flue gas scrubbers). Third, as a consequence of the fuel-switching possibility, no conservation or demand reduction was required. None of these factors holds with carbon dioxide cap and trade. Most Americans don't see a problem with greenhouse gases, whose impact is gradual and global, and rarely immediate and local. But they do see problems of expense in developing carbon-free energy, and of sacrifice in using less energy.

California, however, has had a special problem with air pollution – smog, formed by the interaction of car exhaust with sunlight – that has afflicted no other state to the same degree. Smog used to produce terrible air quality in southern California, such that on 'bad air days' schools would not allow children out during class breaks. It was to curb this smog that California began to regulate car exhaust emissions as long ago as 1959, and this fact won it the unique right among US states to design its own policies. Smog gave Californians the specific incentive, which other Americans lacked, to start down the road of curbing energy use, as a means of controlling air pollution. Moreover, Californians have acquired a confidence in their general ability to invent and innovate, first in defence and aerospace industries during the Cold War, and subsequently in Silicon Valley. Energy efficiency was also the only way to reconcile the state's strong economic growth with its residents' equally strong allergy to having any new power plant sited anywhere near them. This collective 'Nimbyism' has had the beneficial side-effect of focusing Californians on reducing energy demand instead of increasing supply, but, as stressed in the conclusion to this paper, it needs to be overcome in the longer term.

The different pathways down which Californians and other Americans have been travelling became evident in the elections of November 2010. Opposition to national controls on greenhouse gases helped Republicans to make gains almost everywhere outside California, while Californians themselves defeated a challenge to the state's impending cap and trade bill. Furthermore, they elected as governor the Democrat Jerry Brown, who in his first stint as governor in the 1970s had set California down the road to rejecting nuclear and fossil fuels in favour of energy efficiency and renewables.

There are, of course, other reasons for US climate inaction, one of which is a natural reluctance to make the enormous changes required to use less energy in a vast country of temperature extremes, suburban sprawl, car dependence, and poor public transport. Conversely, west Europeans' somewhat greater interest in climate action may stem from the fact that changing energy systems or energy use is easier to contemplate in a continent with a milder climate, more compact communities, smaller houses, and good public transport. There is some evidence that the extent to which California shares a few of these 'European' features – a Mediterranean climate along coastal California and more people per household appliance relative to the US average – helps, together with other factors such as relatively lower carbon-intensive industry, to explain why Californians per capita emit fewer greenhouse gases than the average American. [2]

However, the major factor in California's energy and emission reduction success story has been the policies which the state of California has been plugging away at for decades. Indeed Californian policy predates federal policy. This fact has been key to the state's ability to steer its own course. It was in California that the first general standards on car emissions in the world were passed in 1959, the first specific standards on crankcase emissions in 1961, and the first controls on exhaust emissions in 1966. Recognizing that California had been first in the field, and that it needed specific legislation to fix a specific air pollution problem, the 1967 federal Air Quality Act gave California – and only California – the right to seek a waiver from the federal government in order to set its own environmental rules exceeding federal norms, provided that these rules were judged by the federal government to be just and reasonable. This California waiver right has been carried forward in all subsequent federal clean air acts and amendments.

(While California is the only state with the right to initiate its own environmental rules, other states are allowed to adopt the Californian model provided they do so in full; the aim of this proviso is to prevent more than two standards – the Californian one and the federal one – developing in one country.) This right, however, has not gone unchallenged in court. From time to time, opponents of California's environmental laws – such as car makers or oil refiners or the federal government under the presidency of George W. Bush – have challenged the state's laws on the ground that either they are pre-empted by federal legislation in the same area, or that they amount to an unconstitutional restraint on interstate commerce.

Such suits have not, or at least not yet, overturned any Californian laws, but they have sometimes resulted in considerable delay. In 2002 California approved, for the first time, car emission controls specifically relating to greenhouse gases (GHGs), as distinct from the standards on other pollutants and on fuel economy that already existed at a federal level. The Environmental Protection Agency, under President George W. Bush, refused to grant California its habitual waiver to go ahead on its own, and blocked the state's controls on GHG car emissions despite, or maybe because of, the fact that 14 other states indicated their desire to adopt the Californian standard. At the same time, the car manufacturers filed suits against California. They claimed that regulating GHGs was just another way of regulating fuel economy (which was partially true), on which federal norms already existed in the shape of the long standing Corporate Fuel Economy (Café) standards; these federal standards, they argued, ought to pre-empt any state rules. The impasse continued until 2009, when President Barack Obama brokered a three-way compromise in which the federal government introduced California-style GHG controls nationally, but on a slightly slower timetable which California agreed to, and the car manufacturers dropped their pre-emption suits.

Since 1967, California has received a waiver from the Environmental Protection Agency (EPA), either in whole or in part, on 53 occasions to pioneer innovations relating to emissions, including the first introduction of nitrogen oxide standards for cars and light trucks (1971), heavy duty diesel truck standards (1973), two-way catalytic converters (1975), unleaded gasoline (1976), low emission vehicles (1994 and 1998), zero emission vehicles (1990), and evaporative emissions standards and test procedures (1999). [3]

On occasion, California's regulatory ambition has overreached itself. In 1990 the California Air Resources Board (CARB) created a Zero Emissions Vehicle (ZEV) programme which required that car companies ensure that two per cent of their cars sold in 1998 would have zero emissions, rising to 10 per cent in 2003. This unusually tough combination of a performance standard of zero emissions with a minimum sales quota focused manufacturers' efforts on electric battery cars, the only potential technology around in 1990. However, this attempt to force the technology did not work as CARB had intended. A review by CARB in 2000 estimated that an electric car battery cost around $20,000, compared to the $1,350 originally forecast. The ZEV requirements were softened, and its timetable was extended.

All these regulations have, over the years, created growing markets for providers of green products and technologies. In turn, these providers have grown into a constituency with a vested interest in the continuance of clean energy and efficiency regulations. Proof of the power of this constituency came in November 2010 when it mobilized to defeat Proposition 23 – which would have suspended not only California's emissions trading plans, but also some key renewable and low carbon regulations. The campaign to defeat Proposition 23 portrayed its opponents as being dependent on 'big oil' money from Texas, a reference to the Valero and Tesoro corporations which have refineries in California but which are based in Texas. The supporters of Proposition 23 spent $10 million in total on their referendum motion. In reality, however, the 'big money' was on the other side, with $31 million put up by the Californian clean tech industry, environmental groups, and a few Hollywood greens. Proposition 23 lost by 61–39 per cent in the referendum vote.

2. Efficiency – 'first in the loading order'

The founding principle of California's energy and climate policy has been energy efficiency. This emphasis started in the 1970s when Jerry Brown was first governor and was looking for an argument against building new nuclear power plants to meet California's rising energy demand. The argument was supplied by a legendary figure in Californian energy policy, Art Rosenfeld, a University of California physicist and energy efficiency guru who, into his 80s, was a member of the California Energy Commission until 2010. Rosenfeld argued that energy demand could be met without any new nuclear plants, if California started to require manufacturers to make more energy-saving appliances, such as refrigerators. Therefore, since the late 1970s California has built no new nuclear power plants, and has been steadily regulating downwards the amount of energy going into buildings and appliances. The battle continues 30 years on. While most appliances use less power these days, the advent of huge plasma screens has reversed this trend in televisions. In 2009, therefore, the California Energy Commission (CEC) decided that new television sets with screens up to 58 inches wide sold in California would have to consume 33 per cent less electricity in 2011 and 49 per cent less in 2013. The Consumer Electronics Association has objected that California is trying to micro-manage the design of its products, but the CEC claims that Californians, who buy some four million television sets a year, will save over $8 billion in electricity costs over 10 years.

In order to enshrine efficiency as the top priority, the 2003 joint energy action plan of the CEC and the California Public Utilities Commission (CPUC) borrowed a phrase from the dispatchers of electricity to the grid. Energy efficiency was to be 'first in the loading order', followed by renewables, and only in third place relatively clean and efficient fossil fuel generation. The emphasis on efficiency appears to have paid off. Overall, in its 2007 Integrated Energy Report, the CEC claimed that energy efficiency measures had, in the 30 years since 1978, saved Californians $56 billion in electricity and gas costs, as well as averted the need for the state to build 15 large power plants during that time. The same report forecast a further $23 billion energy cost savings by 2013.

Much of this has been achieved through the direct regulation of products in Californian shops, homes, and factories. As with emissions standards, California has almost always acted in

advance of the federal government on efficiency. This drive for energy efficiency started with the creation of the California Energy Commission in 1974, with intellectual support from conservationists such as Art Rosenfeld, at the University of California at Berkeley. The Commission started with standards for buildings and new refrigerators/freezers in 1977–8. 'Over the next seven years, the CEC followed up with appliance efficiency standards for fluorescent lamp ballasts, various air conditions products, heat pumps, furnaces, boilers, wall heaters, showerheads and faucets'. [4] And to this day, California runs ahead of the Department of Energy in Washington in promulgating new efficiency standards.

However, California's lead over Washington in product efficiency regulation does not completely explain the big, and possibly widening, gap between California and the rest of the country in energy productivity and consumption per capita. After all, California may lead in product efficiency, but the federal government usually follows. The other part of the efficiency gulf between California and most other US states is accounted for by Californian regulators' success in involving the state's big utilities in getting their customers to use energy more efficiently.

The US utility scene is a patchwork. While it has some publicly-owned energy companies (mainly hydro in the West) serving defined areas, and also some competitive markets (such as the Mid Atlantic region or Texas), the privately-owned, but publicly regulated, energy local monopoly is very much an American speciality. (This is in contrast to Europe which has generally shifted from state ownership, with the public interest supposedly assured by the state owner, to competition – supposedly a self-regulating state of affairs.) California has three big privately-owned or investor-owned utilities – Pacific Gas and Electric, Southern California Edison, and San Diego Gas and Electric – which account for 80 per cent of the market, carved out along fairly firm territorial lines (see Figure 2). They are regulated by the California Public Utilities Commission (CPUC), which requires them to carry out efficiency services for their customers, as well as to generate more from renewables. The cost of these efficiency services is passed on to customers, but so are the efficiency savings that result in lower consumption and lower overall bills (see Table 1). Moreover, consumers might as well take advantage of the

efficiency programmes offered by their utility, because they are going to have to pay the cost anyway.

Table 1: Higher electricity prices but lower bills.

	California	US (inc. Calif.)
Prices in cents per KWh (2009)	13.65	9.98
Consumption per capita in KWh (2009)	6,961	11,646

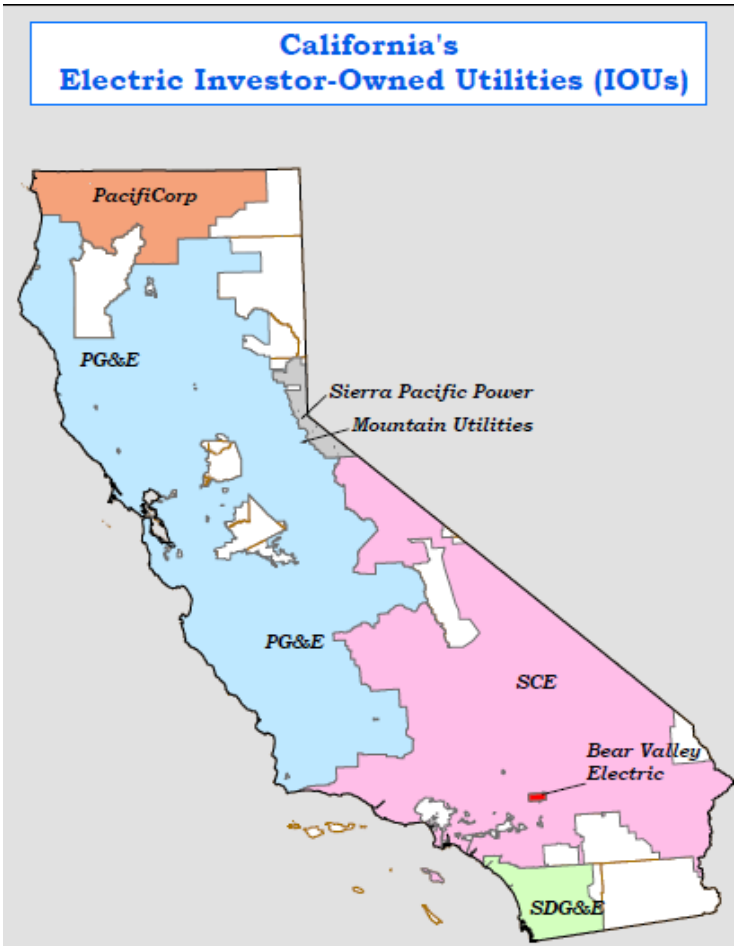
Source: California Energy Commission

Long ago, the CPUC acted to weaken the link between electricity sales and profits. In the early 1970s the electricity tariff was changed from what was called a 'declining' block rate (under which the more electricity you used, the less you paid for it) to a 'inclining' or rising block rate (under which the tariff per KWh rose with consumption). However, the crucial move came in the late 1970s, when the CPUC started to allow utilities to recoup the cost of energy efficiency programmes from their ratepayers, and guaranteed utilities a certain level of profitability even if energy efficiency programmes reduced their sales. This de-coupling of profits from revenue sales succeeded in the first essential step of making the utilities indifferent to the level of sales. But as Steve Weissman of the University of California at Berkeley observed, this was not enough – 'the utilities needed rewards, otherwise they would tend to over-invest in order to enlarge their rate base and gain extra revenue'. [5] So people like Ralph Cavanagh, a leading light in the National Resources Defense Council, campaigned for utilities to be positively rewarded for their energy efficiency efforts. As Cavanagh put it in a recent article [6]: 'it's good not to lose money when you help your customers save energy and reduce pollution, but it's better for both shareholders and society if management is rewarded when it succeeds'. Nowadays regulators in California attempt to reward utilities for 'real' energy saving achievement. This involves splitting energy savings, so that the utility gets some of the money saved by its customers as a result of energy efficiency programmes run by the utilities.

Duane Larson, a senior executive in charge of efficiency at Pacific Gas and Electric, explains how it works. PG&E has the largest energy efficiency programme of any utility in the USA. This will cost $1.3 billion between 2010 and 2012 with the aim, Mr Larson says, of saving 3,110 GW hours of electricity and of avoiding the cost of adding two 350 MW gas turbine power plants to

the grid. The CPUC delegates to PG&E the responsibility for running energy efficiency in its territory of northern California, and allows the utility to recoup the cost of its programme by putting a 'public purpose' levy on ratepayers' bills. PG&E spends the money not only on educating consumers about efficiency and offering them energy audits – as utilities do in the UK for example – but it is also much more closely involved than most European utilities in subsidizing the cost of energy efficient appliances. 'The way we do this depends on the product', says Mr Larson. 'For instance, buyers of efficient new washing machines get a combined rebate of $125 from us at PG&E, and from the local water district, towards the cost of their purchase. In the case of compact fluorescent light bulbs, we incentivize the manufacturers directly. We pay the makers a certain amount on proof that the light bulbs have been sold in PG&E territory'. [7]

Figure 2: California's principal utilities



Source: California Energy Commission

Like Caesar's Gaul, California is basically divided into three – Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E) have 80 per cent of the power market. They are privately-owned regulated monopolies, in their designated areas. They are able to pursue, with their captive customers, long term relationships that, when properly regulated, result in considerable energy and financial savings. The one big addition to this trio is the Los Angeles Department of Water and Power, the largest municipally owned utility in the USA. Partly because it is publicly-owned and therefore more lightly regulated, it has a poorer performance on energy efficiency.

It is, of course, California's acceptance that its utilities operate with plenty of regulation, but without competition, in their own set 'territory' that makes possible the long-term planning and relationships between utility and customers which are often needed to get energy savings. This is why it is hard to conceive of transplanting this part of the Californian model to a country such as the UK, where politicians and regulators have lauded the high rate of 'churn' – customers switching suppliers – as a virility symbol showing the degree of competition within the UK market.

There is, however, a drawback. This is the cost of assessing how to split rewards from energy savings between utility and customer. The issue is how much of the saving really resulted from the utility's efficiency programme, and how much would have happened anyway. Weissman of UC Berkeley, himself a former CPUC administrative judge, gives an example: 'Take the new energy-saving bulbs given away or subsidized by the energy companies. You should really estimate how many of these bulbs would have been bought anyway by customers, and also where they put the bulbs. For instance if I put a new energy-saving bulb in my garage, I might only turn it on once a week'. Like any exercise in the counter-factual, argument and ambiguity abound. Assessing rewards or penalties for energy saving is costly. No less than 8 per cent of the $2 billion cost of California's 2006–8 energy efficiency programme, or $160 m, was set aside for evaluating what part of the energy savings could be attributed to the utility's efficiency programme (for which the utility should be rewarded) and what part was due to behavioural change by the consumer unrelated to the utility and its programme. Evaluation costs eventually came in at less than 8 per cent, but still provided a lot of employment for consultants and lawyers.

Michael Peevey, president of the CPUC, admits it is a headache for his Commission still to be arguing in 2010 about the correct attribution of efficiency improvement and reward in 2006–8. However, he believes that 'in the process of rewarding utilities for energy efficiency, we want them not only to be indifferent to sales, but to have financial incentives to do more. There is much more to be done here. A lot of low-hanging fruit has been picked, but we are only one third of where we need to go'.[8]

Results so far are promising. The three big Californian investor-owned utilities reported that their 2009 energy efficiency produced a saving of 10 per cent on 2006–8 levels, or a reduction of 1.5 million tonnes in carbon dioxide. [9] California is now only one of 35 states with some form of energy efficiency programme funded by ratepayers. But it is the heavyweight. For instance, from the total of $3.1 billion spent on these energy efficiency programmes across the USA in 2008, California accounted for a third.

However, in addition to the private sector investor-owned utilities, California has several municipally-owned utilities, of which one, the Los Angeles Department of Water and Power, is the biggest in the USA. They have proved much less effective in saving their customers' energy. They are barely regulated, because being publicly owned they are considered to be inherently acting in the public interest. In theory, the California Energy Commission regulates these publicly-owned utilities, or POUs, but the CEC has only the power of suggestion, in contrast to the CPUC which has the power of compulsion over the private sector utilities. Lara Ettenson, a utility specialist with the Natural Resources Defense Council (NRDC), says that the poorer efficiency record of the POUs is not only because they tend to be run by politicians focused less on long term energy savings than on their next election (see Table 2). 'Despite legislation stating that they must put efficiency first and set targets for energy savings, the publicly-owned utilities still calculate their revenue on how many KW hours they sell. So efficiency, selling less, is a loser for them. They don't need to be profitable, because they have no shareholders, but nor should they lose money', she says. [10]

Table 2: How private and public utilities compare on energy efficiency spending

Utility	Efficiency spending (% of total revenues 2006–8)
Los Angeles Dept of Water and Power (public)	0.78
Pacific Gas & Electric (private)	2.43
Southern California Edison (private)	2.36
San Diego Gas & Electric (private)	2.50

Source: Natural Resources Defense Council.

In the broad area of energy efficiency there is one area – demand side management – in which California seems not much further advanced than anywhere else. In its December 2010 report on 'the Smart Grid Roadmap and Architecture', the state's Independent System Operator said that

by 2020 California would have a smart grid with smart meters in houses and smart sub-stations in communities, be able to use storage technology, to track output from distributed generation (like roof-top solar photovoltaics), and to manage demand for electricity so that the peaks in demand could be shifted and, by being shifted, lowered. Such demand management does not necessarily save electricity. It might merely spread electricity consumption more smoothly in time. However, that smoothing can enable a utility to delay or, even better, to avoid altogether building an extra power plant that would only be used at peak demand times, and therefore be cost-ineffective. But the technical tools for such demand management are not yet all in place. Californian utilities are still installing smart meters, and report some resistance by their residential customers to these machines. Smart metering is essential for the introduction of 'time of use' or 'critical peak' pricing, which is in turn needed for demand side management. Businesses are being asked, ahead of householders, to switch to 'time of use' tariffs, under which charges vary according to the time rather than the volume of consumption. Most business customers are now on this system, but only in 2012 will such 'time of use' tariffs become standard for business.

3. Emissions – the other angles of attack

California first focused on efficiency – the desire to use less energy to run appliances, to light and heat buildings, and to propel cars – as the way to control energy-related emissions. But, in recent years, as the state's attention has shifted from merely the saving of energy, to the saving of energy plus the reduction of greenhouse gases, the state energy authorities have taken to bolstering efficiency with supply and demand measures.

What makes California particularly interesting is the way in which it has systematically tackled energy efficiency and energy emissions from every angle. In the case of electric power, it has:

- **a**) an emission performance standard to produce relatively clean electricity, and a renewable portfolio standard for 33 per cent of electricity to be renewably generated by 2020,
- **b**) efficiency standards to minimize the use of this relatively clean electricity in buildings and appliances, and
- **c**) demand-reducing incentives that regulators provide to utilities and utilities provide to customers.

The problem is that **a** + **b**, by themselves, can just result in electricity – even if clean and even if efficiently used – being consumed in ever greater overall quantity, unless you also have **c**.

California takes the same three-pronged approach to transport emissions with:

- **a**) a low carbon fuel standard imposed on fuel suppliers,
- **b**) an efficiency standard on appliances (in this case cars), and
- **c**) an attempt to control overall vehicle miles travelled through better land use planning to reduce the amount of driving people do between where they live, work, and shop.

Again, you can have both relatively clean fuel and efficient cars, but unless you reduce people's need to use their cars, overall car emissions can still increase. In a sense, California's demand-reducing measures are designed to prevent any 'rebound effect' from its energy efficiency policies.

Regulating the rate. The supply measures are designed to reduce the carbon-intensity of California's energy sources. The state is a large importer of energy. It imports more than a

quarter of its electricity, nearly 90 per cent of its natural gas, and almost two-thirds of its oil. It particularly wants to avoid being dependent on gasoline from Alberta's tar sands or on electricity from Rocky Mountain coal. So, in addition to a Renewable Portfolio Standard (discussed in section 4), the state has imposed two upstream measures on its energy sources. One is the 2006 legislation (passed as SB 1368) which set an Emissions Performance Standard for new baseload electricity plants serving California, either based in the state or distributing power imported into the state. The standard is set at 1,100 lbs of carbon dioxide per megawatt hour (MWh) of electricity, which is roughly what an efficient combined cycle gas turbine produces. Effectively, this precludes from California's market any coal-generated electricity without carbon sequestration. The European Union has no legal equivalent of this carbon-intensity standard for electricity. But the policy of some EU member states, such as the UK, of 'no new coal without carbon capture and storage' amounts to more or less the same. Moreover, the European Commission is understood to be studying the possibility of applying a California-style emissions standard for electricity generators across the EU.

The other measure is more controversial – the state's Low Carbon Fuel Standard (LCFS). This standard was set under an executive order of the then Governor, Arnold Schwarzenegger, in 2007 that became operational in 2010. It requires that fuel sold by 'fuel providers' (meaning refiners, importers, blenders) must, on average, meet a threshold of greenhouse gas emissions (set in grams of carbon dioxide equivalent per unit of fuel) which gets steadily lower year by year, so that in 2020 fuel emissions must be 10 per cent lower than in 2010. The threshold applies to an average of fuels sold, therefore giving the supplier the flexibility to balance dirty fuel with clean fuel, to blend ethanol into gasoline, to develop clean hydrogen to offset above-threshold fuel, or – because under the LCFS cap there is even a mini-trading scheme – to buy credits from clean fuel suppliers, such as an electricity generator selling electrons to power an electric car. The emissions are measured on a 'full cycle' basis. They include not only what comes out of the car exhaust, but also all the upstream emissions from extraction, production, and transport of fuel. Inclusion of full cycle emissions was designed to meet the objection that the LCFS could be counter-productive if it encouraged the use of, say, Mid West biofuels with high fuel cycle emissions in their production. [11]

The state authorities believe that reducing the carbon intensity of fuel in this way is a vital complement to California's vehicle emissions standards which, on their own, would still allow total GHG emissions to rise if the number of cars rises and the number of miles driven rises. A principal rationale for the LCFS is that other ways of trying to tackle the carbon problem in fuel would not produce a high enough carbon price to change the fuel mix. 'The probable impact of a cap and trade system on gasoline prices would be to add 20–40 cents per gallon, and this would not be enough to drive investment in alternative fuels', says Anthony Eggert, one of the five-person California Energy Commission. [12] From European experience, one could argue that even a price impact much higher than 20–40 cents might have no effect. Despite very high taxes on carbon-based petrol which have produced higher fuel economy, Europe has seen the need to follow California with a similar de-carbonizing fuel standard.

Eggert predicts that the LCFS 'will create a market for 4 billion gallons a year of low carbon fuel by 2020, will provide certainty to the fuel market and is also technology-neutral' as between biofuels, hydrogen, and other alternatives. He describes the car makers as big fans of the standard because of the incentive it gives for production of advanced fuels. However, the standard is controversial among fuel providers themselves. The National Petrochemical and Refiners Association has challenged it in a federal court, arguing that it violates the constitution's interstate commerce clause because it discriminates against Mid West ethanol that has to be trucked into California. (Even without emissions arising from its transport, Mid West corn-based ethanol's GHG emissions are reckoned to be close to those of easy-to-extract Middle East oil, because of the fertilizer and tillage that have gone into its cultivation.) The state of California's counter to this is that the LCFS is based on protecting the environment, not on commerce, and that as it is imposed on all fuel distributed in California, it is not discriminatory.

Lowering the level. The ultimate target, of course, is to go beyond reducing the relative rate of emissions from energy use to reducing the absolute level of emissions from energy. The previous sections described some of the measures to curb overall demand in electricity, mainly through rewards to utilities and their customers for using less power. Even more ambitious – and possibly delusional – are the demand-side measures being attempted to reverse the sprawling, car-centric nature of the state's twentieth century development, for the good reason that transport is the

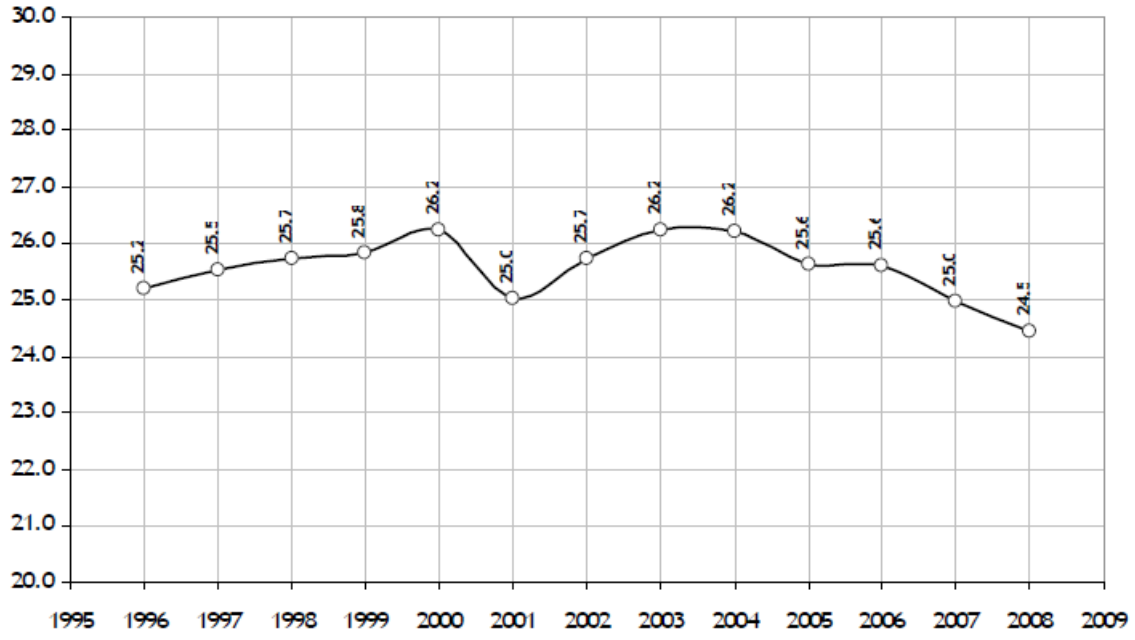
biggest single source (40 per cent) of the state's GHG emissions. The centrepiece of this effort is the 'anti-sprawl' bill (Senate Bill 375 or SB 375) of 2008. This sets regional greenhouse gas limits on the state's 18 main metropolitan areas, which the Air Resources Board proposes should be in the range of 7–8 per cent reductions by 2020, and of 13–16 per cent by 2035. It then requires regional planning authorities to come up with plans and changes in land use to deliver the emission reductions.

The inspiration for SB 375 was the regional 'Blueprint' plan developed in 2005 by the Sacramento Area Council of Governments (SACOG), grouped around the state capital of Sacramento. This involved doing what Eggert called 'a projection of an unplanned future based on an unplanned past', seeing that this would result in nightmare congestion and soaring oil consumption, and planning a different pathway that would use less land and save on fuel. SACOG is now in the process of developing its Metropolitan Transport Plan 2035 (MTP2035). The aim is to gradually reduce the distance people have to travel between where they live, where they work, and where they shop, as Matt Carpenter and Raef Porter of SACOG explain it. [13] SACOG's MTP2035 is a plan that depends on incentives and options rather than compulsion. Local communities cannot be compelled to conform to MTP2035 guidelines. But they will get easier access to state and federal funding, and quicker planning approval, for housing and commercial projects that conform to MTP2035 guidelines. Likewise, people cannot be ordered to live next to shops, but, says Raef Porter, 'they can be given a palette of choices that would allow them to switch to more walkable communities if they want to'. Cities in the SACOG area are 'now planning for higher density, more mixes of housing and retail, and thinking about different types of housing and different types of retail'. The location of jobs is obviously harder than housing or shops to predict or influence.

There are some modest early results. The key metric of success in this endeavour to hold back California's sprawl is vehicle miles travelled (VMT), which equates very closely to vehicle emissions. Figure 3 tracks the recent pattern of daily VMT per capita in the Sacramento area (SACOG), which is of course influenced by the economy and oil prices. Thus there was a steady rise in 1996–2000, a slump with the bursting of the dotcom bubble that affected California considerably, a recovery in 2003 that tailed off as fuel prices rose, the economy slackened, and

unemployment increased. Recent housing starts in the SACOG area also show a hopeful pattern, in terms of potential GHG emissions; relatively more multi-family units and smaller houses are being built, and though house prices have fallen everywhere, the drop in value has been less in city centres with shops in walking range. So far, efforts to encourage public transport have been disappointing. Mass transit ridership has increased, but as admitted in the MTP2035 plan, 'transit to date has increasingly served those who do not have the choice to drive, despite the focus on luring drivers out of their autos'. Unlike King Canute, state planners believe, or claim to believe, that they can reverse the tide. But, despite some influence of the economy on VMT, the principal way in which it can be reduced lies in land use changes, and reversing California's suburban, even exurban, sprawl may take decades. In the near term, the level of motor miles will still go on rising. The average annual growth in VMT in the SACOG region between 1995 and 2005 was 2.5 per cent. For the future, implementation of MTP2035 should, it is hoped, reduce this annual growth of VMT to 1.4 per cent. This would be below the estimated rate of population growth of 2 per cent a year, and therefore continue the trend shown in the chart below of a slight downward trend in average daily driving. But there would still be an overall increase.

Figure 3: Daily vehicle miles travelled per capita in the six-county Sacramento region



Source: SACOG, March 2010. Based on "California Public Road Data" reports by the California Department of Transportation, and household population estimates from the California Department of Finance.

Until the absolute level of motor miles in their state – currently around 320 billion a year – starts to come down, Californians will have done nothing to contradict Canute. Therefore, the state will have to continue its push toward zero emission cars. In terms of alternative fuel vehicles, California is clearly out ahead of other states. While Californians in 2008 accounted for 9 per cent of total new vehicle sales in the USA, they bought 24 per cent of alternative fuel vehicles sold across the USA in that year, according to Next10's Green Innovation Index. But non-gasoline cars are still a tiny fraction of California's overall car fleet.

4. Renewables

If any state can generate a large portion of its electricity renewably, it ought to be California. The state is blessed with plenty of hydro, geothermal, wind, and of course solar resources. Recently, however, it has let the ambition of its targets run ahead of reality, or at least plausibility. In 2002 California set a renewable portfolio standard (RPS) of 20 per cent (for the renewable share of electricity) to be achieved by 2017. In 2006 achievement of this 20 per cent target was accelerated to 2010, and in 2008 a target for a 33 per cent renewable share of electricity was set for 2020. With renewables now accounting for around 17 per cent, the 20 per cent RPS will probably be met around 2012–13. However, raising the renewable share in electricity from one fifth to one third in just 10 years will be a stretch. The California Public Utilities Commission estimated in 2009 that while four major new transmission lines would be needed at a cost of $4 billion to achieve the 20 per cent target, a further seven additional lines at a cost of $12 billion would be needed to deliver the 33 per cent RPS. As mentioned earlier with the impractical Zero Emission Vehicle timetable, California occasionally over-reaches itself.

But progress has been made in extending the grid, especially in southern California. The permitting procedure is almost finished for the Sunrise line to transport 1,000 MW of wind and solar power from the Imperial Valley to San Diego. Permitting is complete and construction has started on the connection across the Tehachapi mountain pass that will link some 4,500 MW of new wind capacity to the grid; during the summer the hot air rising off the Mojave Desert draws a steady stream of colder, denser air in off the Pacific and across the Tehachapi. A joint 2010 report by California's Independent System Operator (of the high voltage grid) and by GE Energy predicts that, if California continues its progress towards its 20 per cent target for renewables and hits it by 2012, the state's renewable resource mix in 2012 will be as shown in Table 3 (which includes 2006 for comparison).

Table 3: Growth in renewables (figures given in MW)

	Solar	Wind	Geothermal	Biomass/gas	Small hydro
2006	420	2,648	1,101	701	614
2012	2,246	6,688	2,341	701	614

Source: Integration of Renewable Resources, report by California Independent System Operator & GE Consulting, August 2010.

One challenge is to maintain this rate of increase in order, first, to hit the old target of 20 per cent renewable share in total electricity production (see Table 4 for 2008 figures), and then to chase the new one of 33 per cent. The other big challenge is how to deal with the variability that all this wind and solar power brings (see Figure 5). California is lucky in that, as a general rule, its winds blow mainly at night, balancing solar power during the day. So while solar power may be more valuable in today's electricity market because it coincides with peak daytime demand, the increase in wind power at night could be useful in tomorrow's world of electric cars that need to recharge their batteries at night. But forecasting wind is still an imperfect science, admits Mark Rothleder, director of market analysis and development at the California Independent System Operators (Caiso). 'Even forecasts of wind production only 1–2 hours out can still leave us with a 10–20 per cent error rate. A 400–500 MW production error like this creates a significant burden on the grid dispatchers who have to do some fast ramping up'. [14]

Table 4: Renewables' share in the electricity mix

	Share of electricity generation (2008)
Natural gas	46.8
Nuclear power	14.9
Large hydropower	9.6
Coal	15.5
Renewables (for 2009 details see Table 5)	13.5

Source: California Energy Commission

Table 5. Energy sources in the renewable mix

	In-state generation (GW hours 2009)	% of in-state power 2009
Biomass	5,685	2.8
Geothermal	12,907	6.3
Small hydro	4,181	2.0
Solar	846	0.4
Wind	4,949	2.4
Total renewables	28,567	13.9

Source: California Energy Commission

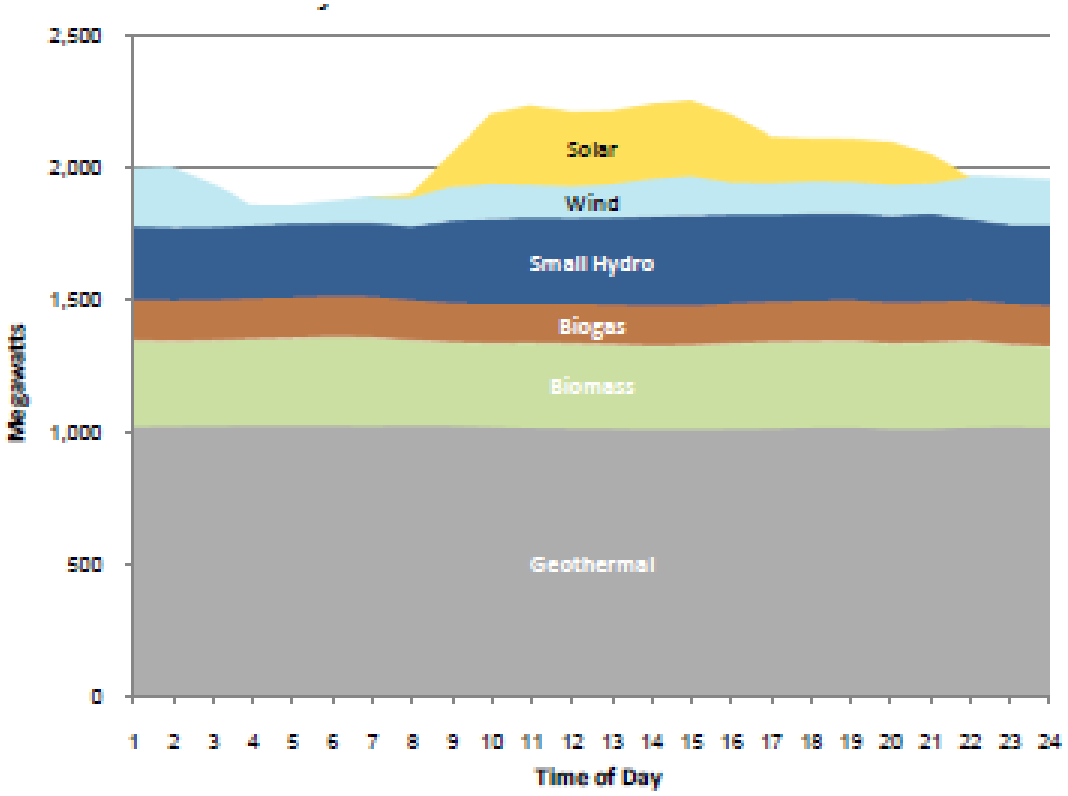
It is also an increasing challenge to forecast solar power, especially with the increase of photovoltaic power that switches off suddenly when a cloud comes across the sun, and then switches on just as suddenly when the cloud passes. (Solar thermal power is less prone to this,

because there is a certain amount of inertial heat in the system and because some solar thermal units use natural gas anyway to augment their heat.) 'Scattered cloud cover is very unpredictable, but we will have to get into the business of cloud-tracking', says Mr Rothleder. Micro-solar projects – such as former Governor Arnold Schwarzenegger's Million Solar Roofs initiative – add further variability. The running total, kept by the CPUC, listed 73,139 projects, amounting to 733 MW installed, on 1 December 2010.

All this variability requires more back-up. A new problem that has emerged for California's grid planners has resulted from the concern of the state's environmental officials for coastal marine life. About one third of California's installed general capacity is now subject to a forthcoming ban on the use of sea and river water being passed through electricity generating plant to cool them down. This so-called 'once-through' water cooling method throws heated water back into the ocean or rivers and is destructive of aquatic life. Subject to this cooling ban will be 8,000 MW of gas-fired generators which have provided back-up to variable renewable power. 'If these get replaced by CCGT (combined cycle gas turbine) plants, that will be fine because these plants can provide flexible back-up to renewables. But we will have a problem if this 8,000 MW is replaced only by renewables. Because in this case, we will be increasing the need for flexibility with the new renewables, but at the same time reducing, with the new renewables replacing old gas generators, the capacity for flexible back-up', says Mr Rothleder.

In the view of Bryan Hannegan, a vice president of the Electric Power Research Institute (EPRI) based in Palo Alto, California will have to combine extra back-up supply with more interconnections with other states to spread the impact of wind surges in a larger balancing area, with a breakthrough in electricity storage, and with demand management measures, such as night-time charging of electric cars or even dimming the lights when supply dips. 'I do not see how you can absorb 33 per cent of renewables without dealing with demand side management', he says. [15]

Figure 4: Example of hourly breakdown of renewable output (for 17 November 2010)



Source: Daily Renewable Watch, California Energy Commission.

5. Cap and Trade

Impressive though all California's clean energy and efficiency regulations are, the one thing they don't do – cannot do – is to attempt to deliver a specific volume of emission reduction. This was left to the then Governor Schwarzenegger's 2005 executive order, which set the target of returning the state by 2020 to its 1990 emission levels, and by 2050 to a level 80 per cent below 1990. Once such a cap was set, trading emissions allowances under the cap became logical and desirable as a cost-effective way of ensuring the cap is met. So in 2006 California legislators passed the California Global Warming Solutions Act (better known as Assembly Bill 32 or AB 32). This enshrined the emissions cap into state law, and under this authority the state Air Resources Board (CARB) has worked out a detailed scoping plan of the means – including a cap and trade system – by which the necessary annual reduction of around 174 million tonnes of carbon dioxide equivalent in GHGs will be achieved by 2020.

Cap and trade has stirred, at the federal level, such furore among opponents, and fervour among proponents, that one might easily imagine that California is depending on its state cap and trade for a large part of this 174 million tonne annual reduction. Not so. The rough estimates are that putting a price on carbon through cap and trade will produce somewhere between 18 million and 27 million tonnes of emissions reduction by 2020. [16] This contribution from cap and trade to overall emission reduction is far smaller than the contribution of more than 50 per cent that the Europeans are hoping to get from their emission trading scheme. Why? Partly because California has, relatively speaking, a stronger set of regulations to achieve reductions than Europe has. And partly because the California cap and trade is planned to get off to a softer start in 2012, at least compared to the reformed and tougher system the Europeans are putting in place in 2013 (though not to the one Europe started with in 2005).

The **main proposed features** of California's scheme are:

- A phased-in cap. This starts in January 2012 for electric utilities and industrial facilities producing 25,000 tonnes of carbon dioxide equivalent, accounting for some 37 per cent of total state GHG emissions. The cap for the first year of operation, 2012, will be at the

expected level of emissions in 2012, with reduction beginning thereafter. Coverage will spread across the economy to 85 per cent of state emissions in 2015 when all fuel distributors are brought in.

- Allocation. As in Europe, in order to promote initial support for the scheme, most allowances will be distributed free at the start, especially for companies claiming to be at risk of losing market share to rivals outside the carbon trading scheme. To give liquidity to the market, financial institutions will be permitted to hold and trade allowances, up to some as yet unspecified limit to prevent market manipulation. Auctioning will only be phased in gradually, with a special regime for utilities. They will be obliged to sell all their free allowances into the market and to hand the proceeds of these sales to their ratepaying customers, in order to prevent them reaping windfall profits and to keep retail power prices down.

- Banking of allowances. Learning the lesson from Europe's ETS (in which the price crashed partly because allowances could not be carried over or 'banked' from the first to the second phase), CARB is proposing to allow unlimited carry-over of allowances. This is designed to reward early emission reducers (by giving them confidence in keeping the fruits of their early labour) and is expected to give a modest upward boost to the price of allowances in the early years of cap and trade, and possibly a corresponding downward price pressure later as early achievers cash in.

- Offsets of up to 8 per cent of an emitter's obligation. In contrast to the Kyoto provisions adopted by the EU which did not allow for offsets in forestry and agriculture, California will allow offsets to be earned in forestry and agriculture in the rest of the USA, possibly Canada and Mexico, and perhaps eventually developing countries.

- A reserve of allowances. Emitters can buy extra allowances from this reserve if the carbon price starts getting high. At the same time, there will be a floor price, starting at $10 per tonne, below which allowances will not be sold. So there will be a sort of price collar (floor and ceiling) on GHG allowances.

The state authorities evidently see every political reason for, and no economic obstacle to, a slow phase-in of cap and trade in California. The CARB gauges that the allowance price will be in the $15–30 range in 2020, but it would neither surprise nor dismay anyone, if it were lower. Californian economists generally see no great tension between their incipient cap and trade system and their set of clean energy and efficiency regulations. 'From a strictly economic viewpoint direct regulations can be inefficient if you have abatement costs that are higher in some sectors than in others, whereas it would be better to have a lower abatement cost everywhere achieved by cap and trade. Probably Californian regulations will force higher emissions reductions, and therefore higher costs, than cap and trade', says Professor Lawrence Goulder of Stanford University. But he says the dual system provides certainty. 'Having cap and trade and the regulations is like wearing a belt and suspenders, if one doesn't do the work, the other will'. [17] This relaxed view about the compatibility of regulatory and market mechanism is in contrast to Europe, where a number of economists expressed concern that the EU's renewable standard, in particular, would seriously weaken the price of carbon on Europe's Emissions Trading System. The reason for the different attitude is that the EU and California expect different things from their cap and trade systems in the short term. Europe had hoped, at least until the recession, that the ETS would do the heavy lifting, with a carbon price high enough to start generators switching out of coal into gas, and the like. By contrast, Californian officials and economists generally see their regulations, with a longer history and wider scope than those in Europe, producing more of the emission reductions, with cap and trade providing, in the words of Michael Hanemann and Chris Busch, 'a broad carbon pricing overlay to sweep up the last increment of economy-wide reduction needed'. [18]

Western Climate Initiative – dealing with leakage by linkage.

California has another reason for a soft start to its cap and trade system – to entice others into the system. Ideally, it would like a common system with all 49 other states. But in the absence of a national scheme, California is counting on a regional cap and trade scheme called the Western Climate Initiative (WCI) to increase opportunities for emission reduction in more carbon-intensive states, to reduce the risk of Californian companies losing market share/jobs to rivals without carbon constraints, and to increase liquidity and reduce volatility in GHG trading.

Ideally, for California the WCI would include all other states that are members of US western grid interconnection. However, some states, like Colorado or Nevada, never joined in the first place. Of the six other US states that joined California in forming the WCI, most have got cold feet. Arizona, Montana, Oregon, Washington, and Utah made clear some time ago that they would not take any practical steps to capping and trading in WCI. Until very recently New Mexico was on course to join California in a WCI scheme as early as 2012. But the Democrat governor responsible for steering that course, Bill Richardson who was energy secretary in the Clinton administration, had to retire at the November 2010 election because of term limits, and has been succeeded by a Republican who, when she takes office in early 2011, has vowed to try to repeal the state's cap and trade preparations. On the other hand, three out of the four Canadian provincial partners in the WCI – British Columbia, Ontario, and Quebec – have declared themselves ready to participate in a WCI scheme in 2012, though each still needs to take further measures to make that a reality. (The fourth Canadian WCI partner, Manitoba, is much smaller than the other three, and its non-participation would be of less consequence).

'We could, if necessary, go ahead with cap and trade by ourselves. But enlarging the programme with the WCI will undoubtedly help', says Michael Gibbs, assistant secretary for climate change at the California Environmental Protection Agency. [19] He says California and at least its three Canadian partners have agreed on most, but not all, aspects of a common cap and trade system. 'We have a common level of ambition. Each partner has adopted a specific target, which does not have to be numerically identical but of similar stringency. We have also agreed on the scope of the programme and how it would phase in, with the first phase in 2012 covering electricity generators and large industrial facilities, and then a second phase in 2015 bringing in all transport fuels. The penalty for non-compliance has also been agreed. Any entity failing to comply would have to surrender three allowances for every one allowance it has failed to produce'. It is no surprise, given California's relative weight in WCI, that these features of the WCI architecture reflect those in its own state plan. Still undecided in autumn 2010, according to Gibbs, were issues about putting some allowances in a reserve that could be drawn on in the event of high prices.

6. Is California special?

In the grand scale of climate change, California's intensive energy efficiency and clean energy serves as a demonstration project for the rest of the USA and the world. California only accounts for around two per cent of world emissions. As Severin Borenstein, a leading economist at UC Berkeley, stresses, California's cap and trade market 'is not going to change the greenhouse gas footprint of the USA, in part because of leakage' of market share, jobs, and emissions to other US states.

So the key question is: can California's policies be replicated elsewhere in the USA and the world, or is it special?

In terms of reducing energy intensity, California starts with a few advantages that are unrelated to the policies we have been discussing. Two Stanford University economists, James Sweeney and Anant Sudarshan, set out to 'deconstruct the Rosenfeld curve', in other words to examine what other factors might be responsible for California's divergence from the national energy efficiency trend, in addition to the policies and regulations espoused by Art Rosenfeld. They concluded that only about a quarter of the state's emissions reduction could firmly be attributed to 'policy'. [20] Among non-policy advantages for California is its climate, which is mild except in the mountains and in the southern and south-eastern parts of the state. Another is demography. California has slightly more people per household than the US national average, which because of economies of scale reduces per capita energy consumption. California and the USA as a whole happen to have exactly the same percentage of 3–4 person households, but California has a smaller percentage of one person and two person households, and a larger share of households with five or more family members than the nation. This is partly because California has big immigrant communities. This in turn may account for the fact that, though the state is a rich one, there are apparently slightly more Californians without a separate freezer and without a washing machine than the national average. The state has relatively more light industry than many other states. As Sweeney and Sudarshan point out, Californian factories get a higher portion (35 per cent) of their electricity from on-site generation than the national average (15 per cent), and this power is not counted in the state's electricity statistics, which therefore understates somewhat

California's electricity consumption. This on-site power production is largely the result of the state's 'Self-Generation Incentive Program' that gives companies upfront money to install generating equipment. The aim is to reduce peak load on the main grid, and possibly save building new power plants. But this saving may be offset by inefficiencies in piecemeal generation.

The contribution to energy saving of California's high electricity rates is a grey area. These high rates, which are partly the result of state policy favouring more expensive renewables over coal, may have driven some energy-intensive industry or land-extensive commerce elsewhere, thereby inclining the state towards lighter industry and energy saving. Rosenfeld himself attributes California's energy savings: one third to high power costs, one third to factors like demography and climate, and one third to the policies that he has helped create. Other US states often contend policies that work in California work there for special reasons, and wouldn't work or couldn't work as well for them, or would hit them harder. 'There is some truth in this', admits Michael Peevey, chairman of the CPUC, adding that 'if California still had rubber, steel, auto manufacturing, chemical plants, [a policy like cap and trade] would have more impact on us'.

This makes the California Air Resources Board's estimate of minimal negative economic impact from cap and trade quite plausible, given the state's economic structure and given that cap and trade may add little to the many energy efficiency regulations California has long had in place. The CARB predicts that capping emissions will only reduce the growth of gross state product from an annual average of 2.4 per cent over the 2007–20 period under business-as-usual conditions, to 2.3 per cent. At least one economist, David Roland-Holst of UC Berkeley, regards even this as too pessimistic, because it does not factor in the dynamic effect of California's proven track record in 'innovation to reduce energy intensity'.

This track record of innovation is fostered by the combination of excellent universities and an entrepreneurial base and culture that produced the phenomenon of Silicon Valley in the IT world. Since California tops the list of US states in the overall number of patents filed, it is not surprising that the state also files the most patents in clean energy, mostly in batteries, fuel cells, solar, and wind energy. [21] Innovation attracts the venture capitalists if they think there is a

market, which in California is promoted by state policies. In a 2010 report looking at the effect of state policy on funding, the Cleantech Group surveyed four areas across the USA – renewable energy, energy efficiency, cleaner vehicles, and low carbon fuels. It showed that, from 2006 to 2010, Californian companies accounted for most of the venture capital in the USA going into these sectors, both in number of deals and in total dollars (though in the Cleantech survey, Texas did not do badly, despite its low ranking in state policies on clean energy). The report concluded that it was no accident that these four sectors were the focus of California's AB 32 legislation. [22] Energy generation attracts the most money – 42 per cent of all venture capital money in 2009 according to Next10 with efficiency and transport getting 18 per cent each. But the share of money going to energy efficiency is growing faster than funding for other sectors.

More surprising than all this, however, is the way that California's green economy (meaning jobs in clean technology products and services) now extends well beyond Silicon Valley's venture capitalists and universities, and into manufacturing. Total manufacturing employment in the state fell by 9 per cent over the 1995–2008 period to just over two million jobs. [23] This was broadly in line with the national trend, though rising California electricity prices may have played a small part in the reduction of jobs in lower value manufacturing. Over the same period, however, jobs in manufacturing green products and technologies rose by 19 per cent to over 33,000. These green jobs are also more evenly distributed around the state than traditional manufacturing. California's green economy still consists predominantly of white-collar jobs in hi-tech, environmental services, economics, and consulting. Nonetheless, at a time of general US concern about the outsourcing of manufacturing jobs to places like China, it is interesting that in California, manufacturing should account for 21 per cent of green employment, but only 11 per cent of total jobs in the state economy as a whole. Overall, then, what is emerging in California is a broad-based coalition of people with a vested interest in the continuance of the state's energy and climate policies. Thus do policies create markets, and markets create constituencies. This is important. To gain political traction in the USA, even more than in Europe, at the present time, pro-climate arguments have to be couched in terms of green jobs or energy security as much as stabilizing the climate.

Conclusion

Partly because of this growing green constituency, and partly because of this acquired self-image of green leadership, California will probably continue on its clean energy course regardless of what happens in Washington. Like many other entities – the European Union, for example – California aspires to reduce its GHG emissions by 80 per cent by mid century. Is it better placed to achieve this than others? Probably, but not certainly. The reason for doubt is that California's energy/climate policy is lopsided. It has recorded great success in energy efficiency and solid achievement in renewables – which have been the main themes of this paper. But the state authorities appear to have given relatively little consideration to how to maintain the state's other source of low-carbon electricity – from nuclear power – or to develop new ones – such as capturing and storing the carbon emissions from a relatively clean fossil fuel like natural gas.

Meeting the 80 per cent target will involve de-carbonizing all of California's power supply (and most of its transport system). Renewables cannot provide 100 per cent of power demand, even if the size of that 100 per cent is kept as small as possible by further necessary improvements in energy efficiency. California still has two nuclear plants operating. They provide around 15 per cent of the state's total electricity, but their contribution to the state's low-carbon electricity is around twice that share. A 1976 law bans any new nuclear plants being approved while the question of final disposal of nuclear waste remains unsettled (as it is in virtually all countries). A more relevant hazard is the state's seismic geology. This makes some places in the state unsuitable for nuclear reactors, but not everywhere is risky. The seismic problem may also restrict the potential for underground storage of carbon dioxide, but it would not totally prevent such storage either within the state or in neighbouring states.

The challenge for Californians will be to keep their energy efficiency success going, while at the same time overcoming the power plant allergy which was one of the catalysts for that success in the first place. An early test will come with the need to replace older power stations that will no longer be able to use ocean and river water for 'once-through' cooling (see section 4).

Bryan Hannegan is a vice president of the Electric Power Research Institute and a member of the California Council on Science and Technology team currently looking at how California can de-carbonize its power and transport sectors in order to meet its 2050 emission reduction target. He says: 'We have got to have an energy efficiency increase of 60–80 per cent more than today. Otherwise, the growth in GDP and population would force on us a rate of technological change that would be mind-boggling'. His recipe for electricity generation in 2050 is a third renewables, a third nuclear, and a third fossil fuels (probably natural gas) with carbon sequestration. Whatever its precise components, carbon-free electricity is the key to reducing transport emissions, the biggest source of the state's GHGs, via electric cars. It is also important politically. Nothing would trigger a backlash in Californian opinion against climate change policies quicker than constraints on personal mobility.

Nonetheless, the California demonstration project has plenty to teach the rest of the USA about clean and efficient energy production and use. California's successful regulation of utilities can be replicated in many other parts of the USA, where public regulation of privately-owned territorial monopolies has long been the norm and could be exercised more forcefully in the public interest of a cleaner climate.

For Europe, California has lessons about what can be achieved by regulators. This paper has stressed how Californian regulators have created a framework for utilities to save energy for their customers. This depends on a stable long-term relationship between utility and customer that cannot be guaranteed in a competitive market, such as the UK has been and the European Union has tried to become. Nevertheless, it is not impossible that California-style energy saving programmes could be introduced in Europe. The Californian stress on, and success with, energy regulation deserves Europe's attention at a time of European nervousness concerning the inefficacy of the ETS. Possibly, too, the EU could benefit from applying a bit of flexible federalism, as practised between California and Washington, to the differing climate policy priorities inside the EU between east and west Europe.

Generally speaking, the new EU member states from central and east Europe worry more about reliable energy than clean energy, in contrast to the northern tier of older member states in west

Europe. [24] EU treaties do allow member states to exceed minimum EU-wide environmental rules, provided (as in the USA) these higher standards do not become a restraint on cross-border trade; this possibility to exceed EU environmental norms was insisted upon by Sweden and Finland when they joined the EU. There is no case for markedly different standards on products circulating within the EU, partly because nowhere in Europe has the equivalent of Los Angeles smog to warrant being an exception. Indeed it has probably been a strength of energy efficiency in the EU that standards have been set uniformly, with the more efficiency-minded member states of west Europe dominating the standard-setting process. But there is nothing to stop west European states from imposing a California-style emissions performance standard on their electricity generators. The UK government policy of no-new-coal-without-CCS is the equivalent of such a standard, though, in contrast to California's standard, it does not cover imports – it does not need to because the UK's electricity imports are carbon-free nuclear power from France. It could be controversial if west European states were to apply emissions performance standards to, say, the coal-generated electricity that several of them import from the Czech Republic.

For other governments of states and regions around the world, California would like to be an object lesson in how a subnational entity can take climate action irrespective of its national government's immobility on climate policy. In November 2010, under Arnold Schwarzenegger, as one of his last acts as governor, California created a grouping called the R20 (Regions of Climate Action) with a few other state and local governments from other countries. The R20 is a conscious echo of the C-40 – a group of climate-conscious big cities around the world, founded by Mayor Michael Bloomberg of New York. The idea is to compensate for the basic impasse between national governments in the 'top down' United Nations process, with a 'bottom up' approach in which subnational regions and states would take cooperative climate action. As Mary Nichols, chairman of the California Air Resources Board, put it, California hopes to 'infect' other parts of the world with the climate action bug, and persuade them that deadlock at the national level need not preclude regions across the globe from cooperating in measures on the ground. It is unclear how many important regions will be enticed into R20 by California, or what their actions will amount to. For instance, no Chinese province has signed up to R20. At Schwarzenegger's third and final Governor's Global Climate Summit in November 2010 that launched R20, Chinese central government officials made clear Beijing's caution about letting

Chinese provinces become swayed by California's free-wheeling approach. In particular Beijing was wary about handing its provinces the power to decide on the import of clean energy technology. At the same time, however, Schwarzenegger did sign up a memorandum of understanding with the governors of Brazil's Acre province and of Mexico's Chiapas province to tackle deforestation, with the ultimate goal of letting Californian companies use credits from forest projects in those provinces to offset their liabilities in California's cap and trade scheme. California may end up working on climate issues as closely with foreign counterparts as with its fellow US states.

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[1] This and other figures in this paragraph are taken from Next10's California Green Innovation Index 2010, page 18, prepared by Collaborative Economics, www.next10.org.

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[5] Author interview November 2010.

[6] *Reinventing Competitive Procurement of Electricity Resources*, Ralph Cavanagh, ElectricityPolicy.com, 2010. Available at: www.electricitypolicy.com/cavanagh-10-2-10-correct.pdf

[7] Author interview, November 2010.

[8] Author interview October 2010.

[9] Estimate by Cavanagh, see above.

[10] Author interview November 2010.

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[11] Author interview October 2010.

[12] Author interview October 2010.

[13] Author interview November 2010.

[14] Author interview October 2010.

[15] Author interview November 2010.

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[17] Author interview November 2010.

[18] Same as 3.

[19] Author interview October 2010.

[20] Same as 2.

[21] Green Innovation Index, Next 10, www.next10.org.

[22] *California in Perspective: A Review of State Energy Policies and their Impact on High Growth Cleantech Markets*, David Chen and others, Cleantech Group LLC. Available at: http://cleantech.com/research/upload/California-in-Perspective-A-Review-of-State-Energy-Policies.pdf

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