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Global Warming: What Can California Do?

California has drawn much international attention with its efforts to reduce greenhouse gases and encourage clean electricity production. In addition to pre-existing regulations that require expanded energy efficiency programs and increased purchases of renewable energy, last year California passed Assembly Bill 32 which calls for an overall reduction in greenhouse gases to 1990 levels by 2020. This ambitious legislation caused many to speculate that California will lead the country and perhaps the world in reducing greenhouse gases (GhG).

IN THIS ISSUE

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In CSEM WP-166 Jim Bushnell (UC Energy Institute), Carla Peterman (UC Berkeley) and Catherine Wolfram (UC Berkeley) take a look at this policy potpourri. Their paper, "California's Greenhouse Gas Policies: Local Solutions to a Global Problem?" explores the intersection of two trends in environmental regulation that are coming into increasing conflict with each other. The trend toward more market-based regulations, which are more effective within a larger jurisdiction, is at odds with the trend of local jurisdictions (e.g., cities, states) implementing environmental regulations to combat global warming.

In this paper, the authors discuss three general categories of regulatory tools: regulatory standards, subsidies for clean technologies, and market-based regulations such as cap-and-trade. While market-based environmental regulations hold great promise relative to more traditional regulatory tools, limiting their application to local jurisdictions seriously undermines their effectiveness. The very flexibility that makes market based regulations attractive can make them liable to circumvention if only applied locally. The authors conclude that real reductions in carbon emissions seem most likely to be achieved by other, more interventionist, command-and-control policies, such as the renewable portfolio standard (RPS), which requires electric utilities to procure a certain fraction of their power from sources powered by renewable fuels. Thus, although subsidies can in many circumstances be the least efficient way of combating GhG, they may be the only tool that can achieve a meaningful impact on a local scale.

The standard criticism of the "traditional" regulatory tools, such as standards and subsidies, is that they involve a regulator dictating a solution to the regulated industries. To be successful, these approaches require that regulators pick the "right" technologies to require or subsidize. Although subsidies are often justified as giving a necessary "leg-up" to new technologies that will soon be competitive, such advances are not guaranteed. Politicians and regulators are in effect placing large bets that the promised economies of scale and learning will in fact materialize.

CONTINUED ON PAGE 5

The Economics of a Low Carbon Fuel Standard

California has positioned itself as an environmentally friendly state and is leading the charge to combat global warming. Earlier this year Governor Schwarzenegger committed California to pursuing a low carbon fuel standard for light-duty vehicles as one means to reduce greenhouse gases. While the passion to reduce greenhouse gases and clean up the environment is laudable, how we go about it needs to be carefully thought out.

Stephen Holland (University of North Carolina-Greensboro), Christopher Knittel (UC Davis) and Jonathan Hughes (UC Davis) put forth the first economic analysis of a low carbon fuel standard (LCFS) in their paper "Greenhouse Gas Reductions under Low Carbon Fuel Standards?" (CSEM WP 167). An LCFS regulates carbon emissions rates, not the absolute quantity of emissions, which gives fuel producers the flexibility to meet the standard through altering their production of fuels. Holland, Knittel and Hughes (HKH) analyze the efficiency and effectiveness of an LCFS.

HKH model the low carbon fuel standard to understand the incentives it creates and its impact on carbon emissions. To illustrate the theoretical impacts, they focus on two fuels with different costs and carbon emissions rates — a high carbon fuel, e.g., gasoline, and a lower-carbon fuel, e.g., ethanol. They find that the LCFS acts as a tax on any fuel with a carbon intensity above the standard and as a subsidy for any fuel with a carbon intensity below the standard. This contrasts with the ideal solution to reduce carbon emissions through a tax on all carbon-producing fuels proportionate to their carbon content.

The authors show that an LCFS causes production of high-carbon fuels to decrease but production of low-carbon fuels to increase. The net effect of this may be a decrease or, surprisingly, an increase in carbon emissions. Carbon emissions could increase under the LCFS if ramping up production of the low carbon fuel outweighs the reduction in carbon associated with decreasing production of the high carbon fuel. The more likely result, however, is a decrease in emissions through a relative increase in production of the low carbon fuel.

The authors simulate the likely effects of an LCFS and find that the carbon reductions can be surprisingly large. For example, an LCFS that reduces the carbon intensity by 10 percent could reduce emissions by 45 percent; these added carbon reductions occur because energy prices increase and discourage consumption. They also find, however, that the cost of achieving these reductions could be very high, ranging from $307 to $2,272 per ton. Since most damages are valued at less than $307 per ton, this implies that society could be better off without an LCFS, at least in the short run.

One important caveat to the calculations presented by HKH is that they do not incorporate incentives to innovate. HKH note that even an inefficient LCFS gives firms an incentive to find innovative ways to reduce their carbon emissions. However, an efficient policy would provide even better innovation incentives. Furthermore, absent additional market failures, the LCFS may provide too large of an incentive for innovation. For the LCFS to be the best way to correct inefficiencies in innovative technology, these inefficiencies must somehow be proportional to a fuel's carbon intensity.

Because an LCFS regulates emission rates, an LCFS constrains the amount of carbon produced divided by the amount of energy produced. While regulating rates, rather than levels, allows for flexibility in the presence of demand changes, an LCFS also allows firms to meet the standard by simply producing more energy from low carbon fuels, holding constant the amount of high carbon fuel production. In practice firms are likely to produce more low carbon fuel energy and less high carbon fuel energy, but it is "the ability" to meet the standard by simply producing more energy that creates inefficiencies. HKH explore several design options and show that one possibility, which defines the carbon intensity as the current amount of carbon produced divided by historical production levels, could efficiently reduce carbon emissions. This design, which is equivalent to carbon trading, would likely inspire spirited debate over each firm's historical production and may require additional mechanisms to allow carbon emissions to vary with the state of the economy.

HKH also analyze the economic impact of the LCFS on both the consumer and producer. Producers could be better off under an LCFS if the reduction in production of the high carbon fuel (and subsequent cost decreases) increases profits enough to offset their losses due to higher costs in the production of low-carbon fuel. Consumers could be better off if the lower prices on the low carbon fuel make up for the higher prices on the high carbon fuel. In practice, the authors estimate

CONTINUED ON PAGE 7

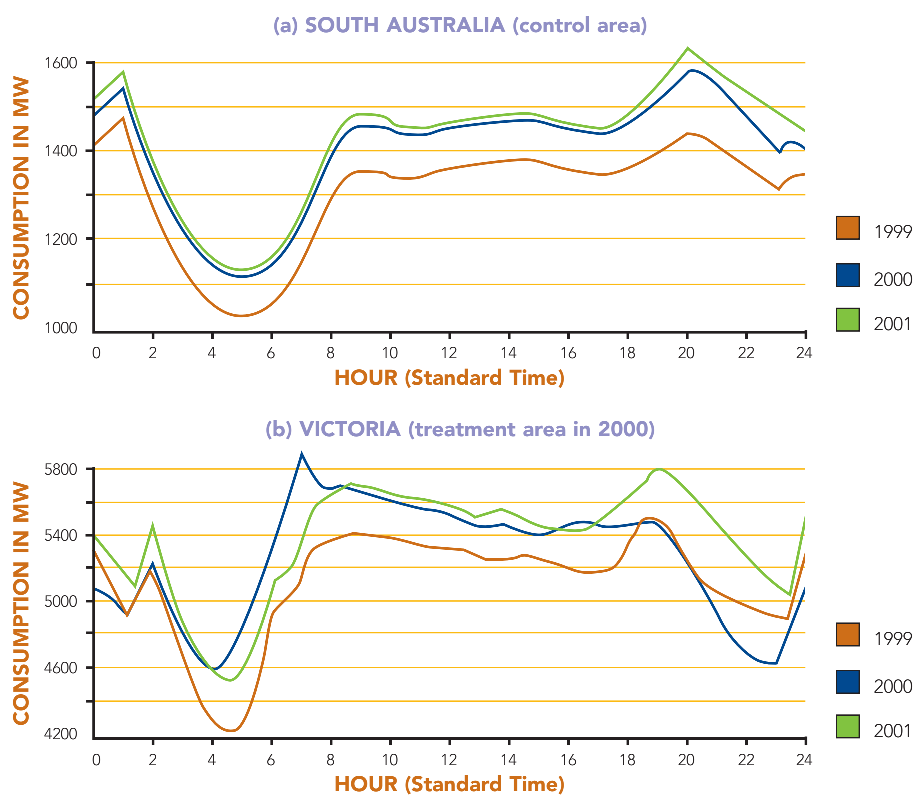
Does Daylight Saving Time Really Save Electricity?

Why are we asked to "spring forward" even earlier and "fall back" even later these days? The answer, unfortunately, lies in an outdated study that claims these inconveniences will save energy and reduce pollution. Today, heightened concerns regarding energy prices and pollution are driving renewed interest in implementing and extending daylight saving time (DST) in many countries. The unifying assumption is that by moving clocks forward one hour in the spring and back one hour in the fall, we will consume less energy and therefore save money and reduce pollution.

But do we? That is the question Ryan Kellogg and Hendrik Wolff ask in their paper, "Does Extending Daylight Saving Time Save Energy? Evidence from an Australian Experiment" (CSEM WP 163). Kellogg and Wolff looked at the research supporting the claim of energy savings and found that the most widely cited savings estimate of one percent is based on a U.S. study done in 1975. Since our electricity consumption habits have changed significantly since then, e.g., greater use of air conditioning, it is likely those results are no longer applicable. More recent studies such as the 2001 California Energy Commission study, use simulation models. The weakness with the simulation studies is they use data from consumers on the current DST schedule to simulate what those consumers would do if DST were extended. Such an approach is not likely to capture the behavioral responses to a change in DST timing, such as getting up earlier or later.

Kellogg and Wolff were fortunate enough to find data from a "natural" DST experiment in Australia to measure the impact on electricity consumption from extending DST. In 2000 two out of three adjacent Australian states began DST two months earlier than usual to facilitate hosting of the 2000 Olympics. Kellogg and Wolff compare electricity consumption in Victoria, the state that did accelerate DST, with that in South Australia, the state that did not change its DST schedule. Because the Olympics can directly affect electricity demand, they did not look at the state of New South Wales, which hosted the Olympics, and they excluded the two-week Olympic period from the data to further remove confounding effects. They also looked at electricity consumption in 1999 and 2001 in these states for a further comparison.

FIGURE 1: AVERAGE HALF HOUR ELECTRICITY DEMAND IN SOUTH AUSTRALIA AND VICTORIA DURING THE TREATMENT DATES



Using detailed electricity consumption and price data from Australia's National Electricity Market Management Company Limited, Kellogg and Wolff examined the effect of the extension of DST on electricity use and prices. Figure 1 displays the average half-hourly electricity demand in Megawatts (MW) in South Australia (SA) and Victoria for 1999, 2000 and 2001. SA's - the control state's - demand is consistent over the three years with an increase in consumption between 5:00 and 10:00, a peak load between 18:00 and 21:00, and then a decrease until about 4:00 on the following morning. SA's electricity use appears to be unaffected by the DST extension in 2000. Victoria, on the other hand, demonstrates a very different electricity consumption pattern in 2000 when it extended DST than what it experienced in 1999 and 2001 when it did not. In 2000, there is a higher morning peak and a reduced evening peak. This behavior is consistent with the expected effects of DST's one-hour time shift: less lighting and heating are required in the evening and more in the morning. Extending DST can only conserve energy if the morning increase in consumption is outweighed by the evening decrease. Just looking at the figure can't tell us the net

CONTINUED ON PAGE 6

Indisputably, Energy Efficiency Does Pay

Energy efficiency programs are the slam-dunk answer to lowering our electricity consumption, say the majority of experts. However, an influential paper that received the International Association for Energy Economists' Best Paper Award in 2004 calls those assertions into question. The authors, Loughan and Kulick ("LK"), sought "to test whether DSM [demand-side management] expenditures during the 1990s succeeded in increasing the energy efficiency of the US economy." Although the authors found that the programs increased energy efficiency, they concluded that "DSM (has) had a much smaller effect on retail electricity sales than estimates reported by utilities themselves." LK found that the utilities have been overstating the electricity savings and underestimating the costs of their DSM or energy efficiency programs. Were this to be true, the expenditures of billions of dollars on energy efficiency programs might not be the most cost effective use of resources to reduce electricity consumption.

Three researchers with a unique combination of talents and history in energy efficiency research decided to dig deeper into Loughan and Kulick's methodology for assessing the effectiveness of energy efficiency programs. Maximilian Auffhammer (University of California, Berkeley), Carl Blumstein (University of California Energy Institute) and Meredith Fowlie (University of Michigan) dissected the methodology and re-ran the analysis in their paper "Demand-Side Management and Energy Efficiency Revisited" (CSEM WP 165R). Using the original data and econometric models graciously provided by the authors of the original study, Auffhammer, Blumstein and Fowlie (ABF) find that the utility-reported savings and costs of their energy efficiency programs cannot be dismissed. The electricity savings and costs that ABF calculated were consistent with the utility-reported figures.

In the past, studies demonstrating the cost effectiveness of DSM programs have relied heavily on cost and savings estimates that the utilities are required to report annually to the Energy Information Administration (EIA). Each year utilities are not only required to report their annual DSM expenditures and electricity sales, but also to estimate the annual electricity savings. LK use these data from 324 utilities over the period 1989-1999 to estimate several models of DSM electricity savings.

In digging into the analysis, the first problem Auffhammer, Blumstein and Fowlie encounter in LK's methodology is the use of an *unweighted* average percent change in electricity consumption due to energy efficiency expenditures rather than the weighted average percent change. Using the unweighted average underestimates the aggregate percent of savings and overestimates the costs; it treats the costs and savings reported by large and small utilities as if they are of equal weight when they should not be if one is interested in the impact of these programs on the energy efficiency of the overall economy. Smaller utilities with smaller electricity sales tend to spend relatively less on DSM programs and report lower percentage savings and should not be given equal weight with large utilities. A closer look at the data reveals that these unusually small savings (relative to expenditures) are typically associated with the first year of reporting by utilities overseeing relatively small DSM programs. To get an accurate measure of the percent change in electricity consumption due to expenditures on energy efficiency, the expenditures and savings should be weighted by each utility's share of aggregate electricity sales. Table 1 (on page 7) compares the results when calculating the weighted and the unweighted average. The unweighted average consistently underestimates the savings and overestimates the costs of energy efficiency programs.

The second criticism ABF had of the paper was its interpretation of the costs and savings estimates. In reporting their results, LK did not take into account the uncertainty surrounding their estimates. To estimate energy savings from DSM programs, we need to know how the level of electricity consumption we observe after implementing a DSM program differs from what electricity consumption would have been had there been no DSM program. Since we cannot observe the latter, it is necessary to build an econometric model to estimate what the electricity consumption would have been. LK create such a model to estimate the costs and savings of energy efficiency programs. Based on their estimates, LK concluded that the true average electricity savings attributable to DSM are less than the 1.8% reported by the utilities. Similarly they found that the true average DSM costs are higher than the average costs reported by the utilities ($0.02-$0.03/kWh). Auffhammer, Blumstein and Fowlie use the same data and the same econometric models as those used by LK but conclude that the utility-reported costs and savings cannot be rejected statistically. The difference between these two analyses is in the interpretation of the test statistics. LK base their conclusion on the estimates without fully including the range of uncertainty around those estimate. Confidence intervals, which account for the inherent uncertainty in any estimated value, give a range of possible values for an estimate. ABF include confidence

CONTINUED ON PAGE 7

GLOBAL WARMING

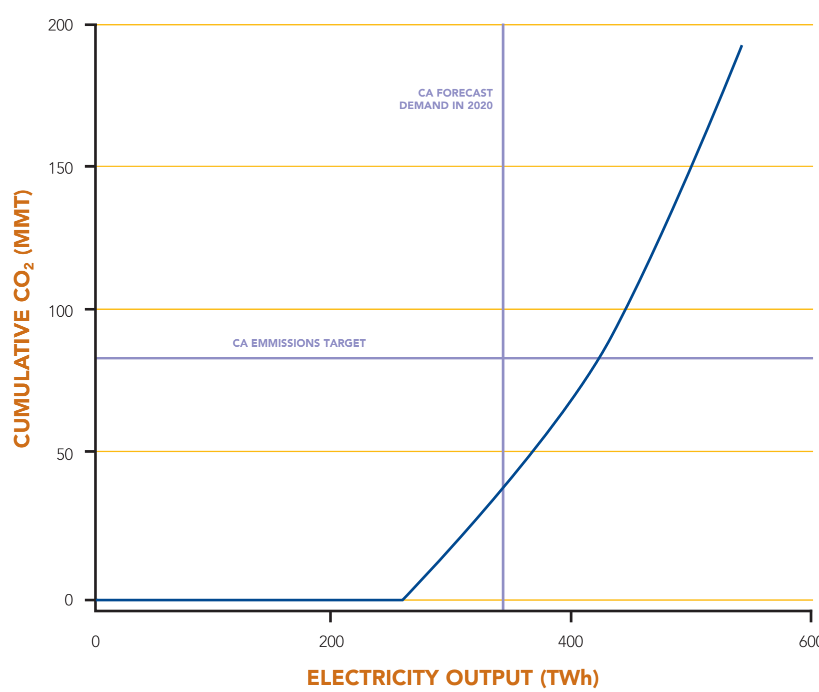
CONTINUED FROM FRONT PAGE

California has implemented two such programs - the California Solar Initiative and the renewable portfolio standard (RPS) - that take contrasting approaches. The CSI targets a specific technology, photovoltaic solar panels, while the RPS does not. It simply requires that utilities purchase a fraction of their power from a variety of renewable sources. The RPS therefore contains market-like features in the sense that different renewable technologies can compete against each other. It does, however, exclude other low-carbon options such as energy efficiency, nuclear power and carbon sequestration. Many believe that these options will be necessary to achieve long-term goals for GhG reductions.

Market-based regulations can provide more flexibility for compliance, and thereby achieve environmental targets with greater efficiency and at lower cost. They can also create stronger incentives for compliance and for innovation. Rather than dictating the specific technology or fuel choice to be used to reduce emissions, these regulations use price signals to provide incentives to firms to reduce emissions in the most cost-effective way possible. Market-based regulations can include taxes on carbon emissions or programs through which the government limits carbon emissions by issuing permits that can be traded among polluters' cap-and-trade policies. These policies do not require a perfectly-informed regulator to come up with the optimal carbon-reducing strategy. In theory individual firms will choose the least-cost method to reduce their emissions because they have an incentive to do so. Regulators still play a central role in a market-based system but their role is more constrained than under the other regulatory approaches.

However, although market-based regulations have many appealing attributes, they are problematic when their application is limited to a local level. Much of the problem with cap-and-trade stems from the ability of firms to source their production outside of the reach of the local regulation. In many cases this may involve the physical relocation of the economic activity (e.g., a power plant). This outward migration of production to unregulated areas is known as leakage. Because California imports so much electricity, and because leakage is a serious concern, strong consideration is being given to a proposal to regulate the buyers of electricity rather than the producers. If California regulators can penalize the purchase of high-carbon electricity, demand for such power should dry up and emissions decline.

FIGURE 1: IMPORTING CLEAN POWER
(All WECC sources eligible for import into California)



Unfortunately, regulating buyers doesn't solve the fundamental problem that California is only one state in an integrated western electricity market. Regulations on buyers can be circumvented by reshuffling purchases between regulated and unregulated customers. Californians may end up buying the "clean" power formerly consumed in Nevada, while Nevada imports more of the "dirty" power formerly consumed by Californians. On paper, California looks cleaner, but there is no real change in the atmosphere.

In CSEM WP-166, the authors demonstrate that reshuffling is a real risk for California's cap-and-trade proposals. There are abundant "clean" resources already in existence throughout the west. California could meet its GhG targets merely by changing the sources of its power imports. As Figure 1 illustrates, California could cover its forecast 2020 power needs from clean plants that already exist in the west. To combat this reshuffling problem, additional non-market regulations will likely be necessary. Yet these regulations also undermine the strengths of a market-based approach.

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DAYLIGHT SAVING TIME

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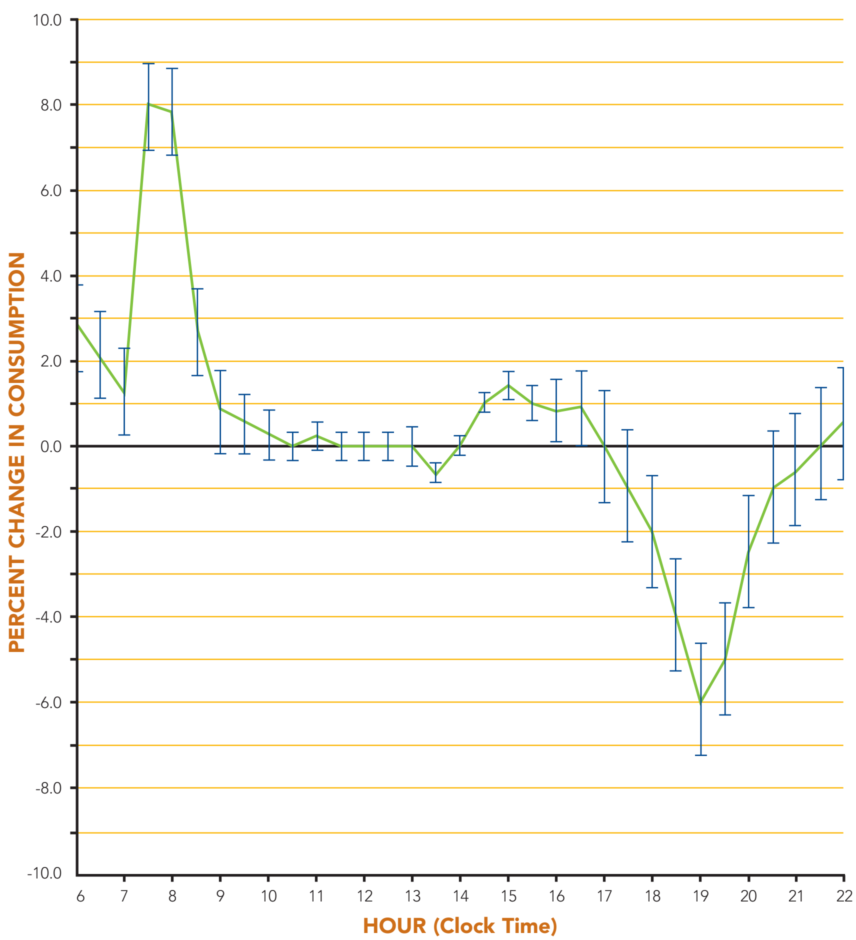
FIGURE 2: HALF HOURLY EFFECTS OF EXTENDING DST ON ELECTRICITY USE



95% confidence intervals are indicated, with standard errors clustered by day.

result, so the authors built an econometric model to take into account the effects of economic conditions, weather, school vacations and other factors that change over time as they measure the net impact of extending DST.

Figure 2 shows the half hourly effects of extending DST and is consistent with what we saw earlier – a transfer of consumption from the evening to the morning. To assess whether the evening decrease in demand outweighs the morning increase, the authors add up all the half-hourly changes in demand. They find that the estimate of the change over the entire period is a 0.11 percent increase in demand. More interestingly though, they find that when looking just at the impact in September, which is equivalent to March in the U.S., overall electricity consumption *increases* by 0.34 percent. These results suggest that extending DST in North America not only will fail to save energy but could lead to an *increase* in energy consumption.

Kellogg and Wolff wanted to understand why their results differed so dramatically from those derived from the CEC's simulation of the impact of extending DST in California. To help answer that question, they ran the simulation model with the Australian data to see whether the California simulation model would have accurately predicted what actually happened in Victoria. In fact, the Australian simulation results were inconsistent with what actually happened in Australia. The Australian simulations produced results similar to those for California and predicted an energy savings of about 0.42%. The simulation failed to predict the morning increase in demand and overstated the evening decrease. The likely breakdown in the simulation model is its assumption that people will behave during a dark spring morning under extended DST in the same way that they behave on a dark winter morning under the current DST scheme. If people awaken earlier in the spring than they do in the winter, the simulation will be inaccurate.

In addition to energy savings, two other benefits have been put forth as reasons to extend DST: a reduction in electricity prices and in the likelihood of blackouts. The authors could not confirm these benefits and instead show that the Australian DST extension caused sharp peak loads and prices in the morning. The 2000 morning peak demand, in fact, was higher than the evening peak in 2001, and its sharp increase and decrease around 7:00am and 8:00 am are steeper than those for any peak period found elsewhere in their data set. These results do not suggest that electricity demand under DST will be flatter and result in lower prices and greater reliability.

In their study of Australia Kellogg and Wolff find that extending DST does not decrease electricity consumption but in fact leads to an increase in demand. The lessons from Australia may carry over to the U.S. and to California since Victoria's latitude and climate are similar to those of Central California, and in particular, the extension of DST into March in the U.S. is directly analogous to extending DST to September in Australia. These results suggest that instead of saving energy, an earlier start to DST may increase our electricity consumption.

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ENERGY EFFICIENCY

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intervals in their analyses and find that the utilities reported costs and savings are valid and lie within the confidence intervals of the estimates reported by LK.

Contrary to LK's conclusion that the effects of DSM are "small relative to what the utilities themselves report," ABF found that the utility-reported savings and costs are accurate, and hence, that DSM programs are cost-effective. Since California is half way through its commitment to allocate $2 billion on energy efficiency programs for the period 2006-2008, understanding the cost effectiveness of such programs is critical to their design and implementation.

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TABLE 1
SUMMARIZING UTILITY REPORTED DATA

Sample	N	Unweighted Average Electricity Savings (%)	Sales Weighted Average Electricity Savings (%)	Unweighted Average Costs ($/kWh)	Expenditure Weighted Average Costs ($/kWh)
Full	3597	1.45%	1.46%	1.72	0.024
Model 1	1815	1.51%	1.82%	1.69	0.026
Model 2	1815	1.51%	1.82%	1.69	0.026
Model 3	2373	1.53%	1.86%	1.75	0.023
Model 4	774	1.99%	2.58%	1.09	0.024
Model 5	998	2.13%	2.79%	0.84	0.021

Source: EIA Form 861, 1989:1999.

LOW CARBON FUEL

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that in most realistic cases the producers and consumers will each bear some of the costs of an LCFS.

Adoption of any policy requires careful comparison of the costs and benefits of the policy along with the consideration of other policy options and any potentially unintended consequences. This paper lays out a framework for analyzing low carbon fuel standards. Explicit comparisons of an LCFS with other carbon-reducing policies, such as a cap-and-trade program, depend on the details of the LCFS and the other program. However, given all the potential problems and excessive costs of an energy-based LCFS identified here, the authors conclude it is unlikely that an LCFS would be the preferred policy unless the range of alternative options is extremely limited.

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GLOBAL WARMING

CONTINUED FROM PAGE 5

Indeed, California will almost certainly pursue aggressive traditional regulations in the electricity sector regardless of the existence and shape of a cap-and-trade program. This reduces the downside to cap-and-trade – firms will be less able to leak or reshuffle due to the other regulations – but it also decreases the upside. Since other regulations, RPS in particular, will reduce GHG substantially, there is less room under which a cap-and-trade program could work.

The outlook for cap-and-trade brightens considerably if the geographic scope of its reach is broadened. BPW examine a program extended to additional western states: Arizona, New Mexico, Oregon, and Washington. Recent initiatives by western Governors have expanded this group to include Utah and British Columbia. The authors find the risks of leakage and/or reshuffling greatly reduced, although still serious.

Thus, a market-based system designed at a regional level would stand a greater chance of succeeding. However the current agreements are simply goals, with California the only state to adopt binding legislation. California is therefore designing its regulations under the assumption that it will be going it alone. The analysis in this paper suggests that California may be better off focusing on traditional regulations until regional or national cap-and-trade proposals become less of a vision and more of a reality.

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