The Takeaway

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California's Solar Rooftop Experience

A Report Card

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Before embracing solar rooftops as a model for the United States, let's look at California's experience. Our report card looks not only at the costs and benefits to the solar adopters, but also to the investor-owned electric utilities, to the government, and especially to the environment from lower carbon emissions. What glistens is not gold.

Since 2000 in California, electricity generation from solar rooftops has grown at an annual rate of 32%. By 2017, it accounted for 12.5% of residential electricity production.[1] Policy makers can point to that growth with self-congratulation for having adopted generous tax credits both at the federal and state level. Without tax credits, most residential users would have found it too expensive to adopt solar. Even though the cost of solar panels has fallen steeply over the last decade,[2] without tax credits the electricity savings from rooftop solar would never come close to paying for itself.

WHAT'S THE TAKEAWAY?

A+ Widespread Adoption of Rooftop Solar

D High Cost per Carbon Tons Abated

D An Unintended Tax on the Poor

F Cheaper Ways to do the Same Thing

Using information from a paper by University of California Berkeley economist Severin Borenstein[3] and industry sources, we calculated how much a typical high consumption residence in 2010 would spend on a rooftop solar system based on the fixed cost of the equipment, tax credits, and monthly solar savings. Without tax credits, that residence would have to pay $73,680 for the installation, and over the subsequent 25-year life of the solar panels would save only $44,050 on its electricity bills, leaving a net cost of $29,630. Policy makers understood the power of tax credits to fundamentally change that calculus. With the federal solar tax credit of 30% plus a California tax credit worth about two-thirds as much,[4] that same hypothetical residence (shown in Table 1) would discover with the combined tax credits of $36,830, that its out of pocket cost would be reduced from a negative $29,630 to a positive $7,200! However, before we heap too much praise on this policy maybe we should grade it by the economists' metric of costs and benefits to all of the parties involved.

AN EXPENSIVE WAY TO ABATE CO_2

Looking beyond the small benefit to the solar adopter, we must recognize that government revenues decreased by the amount of the tax credits ($36,830). These reduced tax revenues in turn have an opportunity cost because they crowd out other useful public expenditures. Less obvious are the costs solar adopters impose on electricity providers. In California, residential customers only pay for the electricity delivered to them, so electricity cost savings to solar adopters are a *lost* revenue to the electric utilities. Obviously, electric utilities will not have to purchase the electricity from the wholesale grid that solar displaced, but that is only about a quarter of the lost revenue. The local distribution network must still be maintained so when solar households wish to turn on appliances at night or on cloudy days, the network will be there to provide service.

The problem is further compounded by the fact that California regulators impose increasing block tariffs, meaning that the biggest users pay marginal prices almost four times the price paid by the lowest users. High consumption users (paying the highest marginal prices) are the ones most incentivized to adopt solar. By adopting solar, they can move out of the high price blocks into the low price blocks that typically lower income, lower consumption users pay. So, for the electricity providers, the increasing block tariffs exacerbate their losses. Our hypothetical solar adopter reduced electricity purchases by 60% annually. Even after subtracting the cost for the power displaced by the solar generation, the electric utility still faced a revenue shortfall of $35,700 (see Table 1). Paradoxically, as we shall see later, those costs were passed along to the less affluent, non-solar adopters.

What are the environmental benefits in terms of reduced carbon dioxide (CO_2) emissions to the atmosphere? For our hypothetical solar adopter, the annual reduction in kWh generated was 8,340 kWh which translates into 2.77 tons less carbon annually than if a combined cycle natural gas plant had produced the electricity.[5] Over the 25-year life of the rooftop solar system, that amounts to 69.4 tons less CO_2. Putting a price on a ton of CO_2 has led to a vast economic literature with no consensus. One widely cited paper reports a central value for the social cost of carbon of $21/ton.[6] The Energy Information Agency (EIA) places it at $37/ton of CO_2. To be conservative, we used the higher EIA estimate, resulting in a $2,570 benefit to the environment. As shown in Table 1, summing the costs and benefits to consumers, electric utilities, government, and the environment results in a net loss of $62,580. To pass a cost/benefit test, the environmental cost of a ton of CO_2 would have to be almost twenty-four times larger. In sum, solar rooftops are a very costly method to achieve modest environmental benefits.

The basic calculations reported in Table 1 make no allowance for discounting—in effect assuming that a dollar's worth of savings 25 years from now are equivalent to a dollar savings today. Table 1 also shows the same calculations assuming a 4% discount rate and constant 2010 dollars to account for inflation.[7] Discounting makes the value of future savings from reduced electricity bills even smaller, thus making the decision to switch to solar even less attractive. In essence, the policy conclusion is the same. Rooftop solar tax incentives are an extremely inefficient way to reduce carbon emissions.

AN UNINTENDED TAX ON THE POOR

Let's go back to the cost borne by the electric utilities. Who pays for this? The stockholders in the electric utilities or the rate payers served by the electric utilities? Because the electric utilities are publicly regulated and investors are guaranteed a fair return on their capital, they pass these costs along to consumers. The costs cannot be avoided because the distribution system must still be maintained for solar customers who will continue to use the grid intermittently. Frank Wolak, an economics professor at Stanford, has found that over the period 2003 to 2016, average electricity distribution charges doubled. Of this approximate 4 cents per kWh increase, he calculates that two-thirds is attributable to the distributed solar customers' reduced consumption.[8] Obviously, policy makers did not contemplate this unintended effect.

CHEAPER WAYS TO DO SAME THING

While policy makers were well intentioned, their zeal for picking winners and losers has led to a very costly program with relatively small environmental benefits. Rooftop solar is only one example. Others include tax credits for electric vehicles, ethanol mandates for

Table 1: Costs and Benefits for a Hypothetical High Consumption Solar Adopter in California

	Solar Adopter	Electricity Provider	Government	Environ-ment	Net Benefit (over 25 years)
No Discounting					
No Tax Credit	–$29,630	–$35,700	$0	+$2,750	–$62,580
With Tax Credit	+$7,200	–$35,700	–$36,830	+$2,750	–$62,580
4% Discounting					
No Tax Credit	–$45,030	–$23,210	$0	+$1,670	–$66,570
With Tax Credit	–$8,200	–$23,210	–$36,830	+$1,670	–$66,570

gasoline, CAFÉ limits on auto efficiency, and the list goes on. With such a dismal track record, Congress should get out of the business of picking future technologies to reduce carbon. However, that does not mean that policy makers should do nothing about the climate change problem. The problem is real, and barring some major technological advance, not likely to go away.

The most *cost effective* method of dealing with our CO_2 problem is to put a bounty on it in the form of a carbon tax and let the market find the cheapest ways to reduce carbon. The beauty of a carbon tax is that by increasing the price of fossil fuel energy, it will unleash innovations by both producers and consumers to find cost-effective means of reducing emissions. A carbon tax will allow the market to sort through new technologies in a cost-effective way. By anointing certain technologies as winners, like rooftop solar, we crowd out other alternatives.[9]

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Notes:

[1] California Energy Commission (2018). https://www.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf

[2] Roberts, D. (2016). The falling costs of US solar power, in 7 charts. *Vox*. Retrieved from https://www.vox.com/2016/8/24/12620920/us-solar-power-costs-falling

[3] Borenstein, S. (2017). Private net benefits of residential solar PV: The role of electricity tariffs, tax incentives, and rebates. *Journal of the Association of Environmental & Resource Economists*, *4*(S1), S85–S122.

[4] In 2010, the California solar tax credit was under $.50 per watt of capacity.

[5] Coal is not used in California for non-commercial electricity production. See https://www.energy.ca.gov/almanac/electricity_data/electricity_generation.html.

[6] Greenstone, M., Kopits, E., & Wolverton, A. (2013). Developing a social cost of carbon for US regulatory analysis: A methodology and interpretation. *Review of Environmental Economics and Policy, 7*(1), 23-46. doi: 10.1093/reep/res015.

[7] A 4% real discount rate is widely applied in cost-benefit analysis as shown in Borenstein (2017).

[8] Wolak, F. (2018, Sept). The Evidence from California on the economic impact of inefficient distribution network pricing. NBER Working Paper No. 25087. doi: 10.3386/w25087.

[9] For more information on a carbon tax, see James M. Griffin's book, *A Smart Energy Policy: An Economist Rx for Balancing Cheap, Clean, and Secure Energy.*

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