Cost-effectiveness of policies supporting solar panels in Indiana

Juan P Sesmero[1], Jinho Jung[2], and Wallace Tyner[3]

[1] Assistant Professor, Department of Agricultural Economics, Purdue University, IN 47907-2056, USA,

jsesmero@purdue.edu

[2] PhD student, Department of Agricultural Economics, Purdue University, IN 47907-2056, USA,

jung104@purdue.edu

[3] James and Lois Ackerman Professor, Department of Agricultural Economics, Purdue University, IN 47907-2056,

USA, wtyner@purdue.edu

Selected Paper prepared for presentation at the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Joint Annual Meeting, San Francisco, CA, July 26-28

Summary
We adopt a real options approach to quantify transfers to households that are sufficient to induce adoption of solar panels. These transfers are then combined with the panels' production capacity to obtain a measure of cost-effectiveness of alternative policies that are either in effect, or currently being considered by State governments. Alternative policies are then ranked based on their cost-effectiveness. Generally we find that a combination of net metering and peak-pricing is more cost-effective than the federal tax credit and the solar loan interest tax deduction.

Background and Contribution
Solar energy is generally regarded as an attractive source of electricity due to its renewable nature and the fact that it results in lower carbon emissions than electricity generated from fossil fuels. Electricity from fossil fuels is poorly priced because negative externalities associated with emissions of greenhouse gases are typically not included in its cost. This makes solar energy less competitive against fossil-based electricity than it would be were the external damages of fossil energy internalized in its price. Consequently governments have tried to align private and social incentives by implementing policies reducing the cost of solar energy. While the economics of solar panels have been examined before, a calculation of the cost of solar panel that would trigger adoption given the stochastic evolution of electricity prices has not been by conducted. Calculation of such price is necessary to compute the economic cost for the government (and/or society) to induce adoption. This is the objective of our study.

Previous studies (Borenstein, 2007; Makhyoun, 2012; Pickrell et al., 2013) have analyzed the economics of solar panels from a net present value point of view. Most studies present a levelized cost of electricity (LCOE) of the solar photovoltaics (PV) system. In general results show that the economic viability of solar panels has significantly has significantly improved in the last few years. Jung and Tyner (2014) find that solar energy has about a 50-50 chance of being economically profitable when uncertainty in electricity price and solar systems is factored in. However this is the result of policies that are currently in place. They also find that without net-metering (a policy that allows users to sell excess electricity back to the grid), a relatively larger system is less attractive than the smaller one even though the larger system generates more electricity. They generally conclude that policies can have a significant impact on economic viability of solar systems. Without current policies, which include federal tax credit, solar loan interest tax deduction, and net metering, solar energy would be far from economically attractive (NPV would be negative even under high electricity prices). On the other hand, if additional policies are added to the existing ones, such as depreciation and carbon tax, the likelihood of solar being economical increases to around 90% or more.

Unfortunately none of these studies explicitly quantified the electricity price that would trigger adoption of solar energy by a risk-neutral investor under uncertainty. This "trigger price" is important because it provides a lower bound for adoption as risk-averse consumers will require a premium above that price given the risk associated with an irreversible investment. In turn this calculation of the trigger price allows explicit quantification of the cost-effectiveness of policies supporting solar-fueled electricity. The present study uses a real options approach to quantify the trigger price. The cost-effectiveness of different policies is then assessed including policies that are currently in place but, more importantly, policies that are currently being considered by policy makers. Three policies already in place are considered: the Federal Tax Credit, interest deductibility for investment loan, and net metering. Finally, we also examine the impact of peak-pricing by which the electricity price is higher in times of the day when consumption increases (typically around noon). This instrument has been implemented in California and is currently being given consideration in Indiana.

In the real options approach it is recognized that an investment in solar energy can be in one of two states. One is an inactive stage where the investor has the option to adopt a solar panel but has not yet. The other one is an active state where the investor has already adopted the panel and can opt to continue operating it or not. In this approach a Bellman equation and Ito's lemma are combined to derive two conditions. One describing the point where the investor in an active state is indifferent between scrapping the panel or not (the exit condition), and the other describing the point where an inactive investor is indifferent between investing or not. These conditions are then combined with two smooth-pasting conditions governing the transition between the two states. This composes a system of four equations in four unknowns: an entry trigger price, an exit trigger price, and two constants of integration.

We calibrate our model for a representative solar panel investor in Indiana. Technical and cost information on the solar panel is obtained from NHR, Inc., a local retailer of solar PV panel in Indiana. NHR, Inc. provides two capacities of solar PV systems, 5.88 kW and 7.84 kW and we focus our attention on the larger panel for which the impact of policies is more apparent. A Shapiro-Wilk test based on historical data of electricity price from 1960 to 2012 (EIA) resulted in failure to reject normality of the change of electricity price. Statistical estimation suggests the best approximation to the dynamic evolution of electricity price change is captured by a Geometric Brownian Motion described as $EP_k = EP_{k-1} \times (1 + EGR) + Normal(mean, st.dev)$, where EP_k is the residential electricity price in year k, EP_{k-1} is the residential electricity price in year $k-1$, EGR is the growth rate of the residential electricity price, and the last term captures the random component of this price.

Our results show that the combination of net metering and peak-pricing is sufficient for adoption of solar panels in Indiana. The combination of federal tax credit and interest deduction (as currently implemented) is not. Implementation of all instruments makes adoption of solar panel a very attractive investment. Results also reveal that financing and federal tax credits are more cost-effective than net metering for the small solar panel while the latter is the most cost-effective instrument for adoption of the larger solar panel. Moreover, while peak-pricing is the least cost-effective instrument, it does greatly improve the cost-effectiveness of net metering. In fact, under peak-pricing, net metering is the most cost-effective policy for panels of all sizes.

References

Borenstein, S., 2007. Electricity Rate Structures and the Economics of Solar PV: Could Mandatory Time-of-Use Rates Undermine California's Solar Photovoltaic Subsidies? Center for the Study of Energy Markets, University of California Energy Institute, UC Berkeley.

Jung, J., & Tyner, W. E. (2014). Economic and policy analysis for solar PV systems in Indiana. Energy Policy, 74, 123-133.

Makyoun, M., Crowley, R., Quinlan, P., 2012. Levelized Cost of Solar Photovoltaics in North Carolina. NC Sustainable Energy Association.

Pickrell, K., DeBenedictis, A., Mahone, A., Price, S., 2013. Cost-Effectiveness of Rooftop Photovoltaic Systems for Consideration in California's Building Energy Efficiency Standards. California Energy Commission. Publication Number: CEC-400-2013-005-D.