# Optimal pricing, subsidies, and solar panels: a two-sided market APPROACH

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#### **Overview**

We study the Transmission System Operator’s optimal transmission pricing problem in the presence of solar panel owners. The unique feature of such solar panel owners is that they might sell or buy, depending on the realization of the state (i.e. weather). We assume that the market is two-sided, where the grid is the (single-homing) platform, and the two types of end-users are generators and consumers, respectively. Solar panel owners are in one or the other side, depending (randomly) on weather. A certain degree of correlation of weather realization is assumed among solar panel owners. This is due to the fact that, if it is “sunny” for a given solar panel owner, it is likely “sunny” for some other (nearby) solar panel owners.

#### **Methods**

We consider an independent Transmission system operator (TSO), which is in charge of managing the transmission and distribution of electricity in a region. The TSO connects, through transmission lines, generators and consumers. In other words, the TSO acts as a monopoly platform that connects end-users of two types, i.e. generators (G) and consumers (C). Generators produce and sell electricity that consumers enjoy, but both types of “end-users” must use the platform (the grid) to trade.

A unit-measure, continuum of agents may choose to become generators (join side G), to become consumers (join side C), to become “both” producers and consumers of electricity, or not to join the platform (off-grid agents). The third type of end-users are usually called *prosumers*, which own a decentralized generation unit, typically a rooftop solar photovoltaic panel. *Prosumers* sell or buy electricity depending on the sun (randomly). We model this random process using a Bernoulli distribution (which takes value of 1 if it is sunny and value 0 if it is not sunny).

We study the incentives to join the platform market as a *prosumer* both in the absence and in the presence of environmental policies. We consider three different environmental policies, namely, a) production-based subsides (similar to the California Solar Initiative); b) upfront installation-based subsides (similar to the subsidies implemented in Germany); and c) Net Metering (which is a widespread used policy). For each of these cases we find the number of end-users that are willing to join the market as *prosumers*. Moreover, for each of these cases, we solve the TSO’s Ramsey pricing problem.

#### **Results**

We find that in the absence of environmental policies, end-users have no incentives to join the platform market (the grid) as *prosumers*. For each of the environmental policies considered, we find that end-users join the platform market as *prosumers* only if some conditions are satisfied. In particular, we observe some *prosumers* in the platform market if: a) the production-based subsidy is “sufficiently high”, b) in the presence of a “sufficiently large” upfront installation-based subsidy, c) if the region is “sufficiently sunny” in the presence of Net Metering.

However, when solving the TSO’s Ramsey pricing problem in the presence of environmental policies, we find that these policies increase the amount of fees paid by consumers that do not own solar panels.

#### **Conclusions**

We find that end-users with solar panels are present in equilibrium in the platform market only if some sort of subsidy (upfront, or based on production, or Net Metering) is granted to their owners. However, subsidies to solar panel owners necessarily increase the fees paid by end-users in the platform that do not own/cannot afford solar panels. The ultimate impact on market efficiency depends on the relative size of this cost imposed to non-solar-panel owners (the burden of the subsidies) and the impact of an increase in solar panel generation on the reduction in pollution (since an increase in solar generation potentially reduces generation from “traditional” and pollutant generation sources).

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