Optimal capacity, production and prices in competitive electricity markets when
the effective use of PV varies over the hours of the day

Irena Milstein and Asher Tishler

Abstract
This study develops a two-stage model to determine capacity, production and prices in
competitive electricity market in which firms can employ natural gas and/or photovoltaic cells
(PV) generation technologies. Electricity production by a given capacity of PV varies over the
day as a function of the rate of radiation of the sun; it is low in the early morning and late
afternoon, and highest around noon. Only gas technology is employed during the night-hours,
while both PV and gas technologies can be employed during the day-hours. We show that the PV
technology is employed at full effective capacity during the early morning and late afternoon
hours, and at less than full effective capacity during mid-day. Gas technology produces electricity
during the night and, occasionally, during the day hours. Using gas technology during the day
hours inhibits large price spikes and substantially reduces PV capacity. Applying our model to a
reasonable projection of Israel's electricity market in 2030, we show that the profits of the natural
gas-using firms are, generally, positive, while the profits by the PV-using firms are likely to be
negative when the capacity cost of the PV technology is at its 2019 level. An increase in the
number of PV-using firms to 40 or more in 2030, a likely event, will result in considerable losses
to these firms. This outcome suggests that a serious 'missing money' problem may arise in
markets with substantial PV capacity, requiring the intervention by the regulator in the market
and/or an innovative market design.