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Estimating unmetered photovoltaic power consumption using causal models

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Energy accounting encompasses the compilation of coherent statistics on energy related issues in countries, including the production and consumption of electricity. A complete picture of demand and supply of electricity must include data on electricity production outside the energy industries, such as electricity produced by domestic photovoltaic (PV) installations. These PV installations are rarely metered by distribution net operators, hence, their production remains invisible to statistical agencies responsible for the energy accounts. Consequently, the renewable electricity production is di-cult to estimate while monitoring it is crucially important for climate policy evaluation. In the Netherlands the country studied in this article an incomplete register of PV installations is available. Such registers can be used to estimate power produced by PV installations using a modelling approach relating installed capacity to produced electricity. In the present article we propose inferring solar power production from causal relations between solar irradiance and consumption of grid power. Since the production of solar power by domestic PV installations results in a reduced consumption of electricity from the high-voltage grid the combination of time series of electricity exchange on the high-power grid and series of solar irradiance contain a hidden signal of unmetered solar power produced by domestic PV installations. In this paper a causal model for these time series to estimate unmetered solar power production is developed on a daly frequency. Final analysis is based on ARIMAX models. Our estimates are compared with the offical statistics on produced solar power published by Statisitcs Nehterlands. These estimates are based on an incomplete register of PV installations and assumptions about their average capacity. We conclude that our model estimates are in line with these official statistics. While official statistics are at annual level, our modelling approach produced daily estimates. In contrast with the regular official statistics, no administrative or survey data on PV installations in the country was required. Hence, the proposed model can be applied easily, quickly and widely, and could be particularly useful in countries where no good estimates of unmetered PV electricity are available yet.