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Toward Net Zero in the midst of the Energy and Climate Crises: the Response of Residential Photovoltaic Systems

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This paper aims to provide insights on potential strategies for a sustainable energy transition amidst market fluctuations. We analyze the impact of PV adoption on electricity consumption during a volatile price time span, leveraging high-frequency consumption data of over 10,000 households in Northern Italy during the period of the 2022 energy crisis. Our findings reveal that PV adoption reduces electricity consumption responsiveness during extreme price and temperature events, enhancing energy security and affordability. Also, PV uptake effectively reduces greenhouse gas emissions deriving from electricity consumption in the residential sector. Based on estimated demand, we measure changes in consumer surplus loss, highlighting substantial benefits from PV adoption: the change in the annual consumer welfare due to the 2022 price increase is around minus 300 euros for the median consumer with no PV and minus 133 euros when PV is adopted by a comparable median household.

This study exploits high-frequency data of households residing in the municipality of Brescia between 2021-2022 to infer the impact of PV adoption and the influence of temperatures on grid electricity consumption, as well as to detect potential differences in price elasticity among different consumption groups and seasons. We find that adopting PV systems significantly reduces grid consumption: by 75% on average and by as much as 100% during sunny hours and warmer seasons. Exploiting the exogenous Russia-Ukraine price shock, we find that households who adopt solar PV are more likely to better manage increased temperatures at higher electricity price levels and price fluctuations. Furthermore, we find that "small" consumers can cope worse with high temperatures and are more sensitive to electricity-prices compared to "medium" and "large" consumers, highlighting electricity as a relevant source of inequality.