

A home powered by time: A decade of microgeneration and energy independency



Ana Silva

ana.ferreira.silva@tecnico.ulisboa.pt

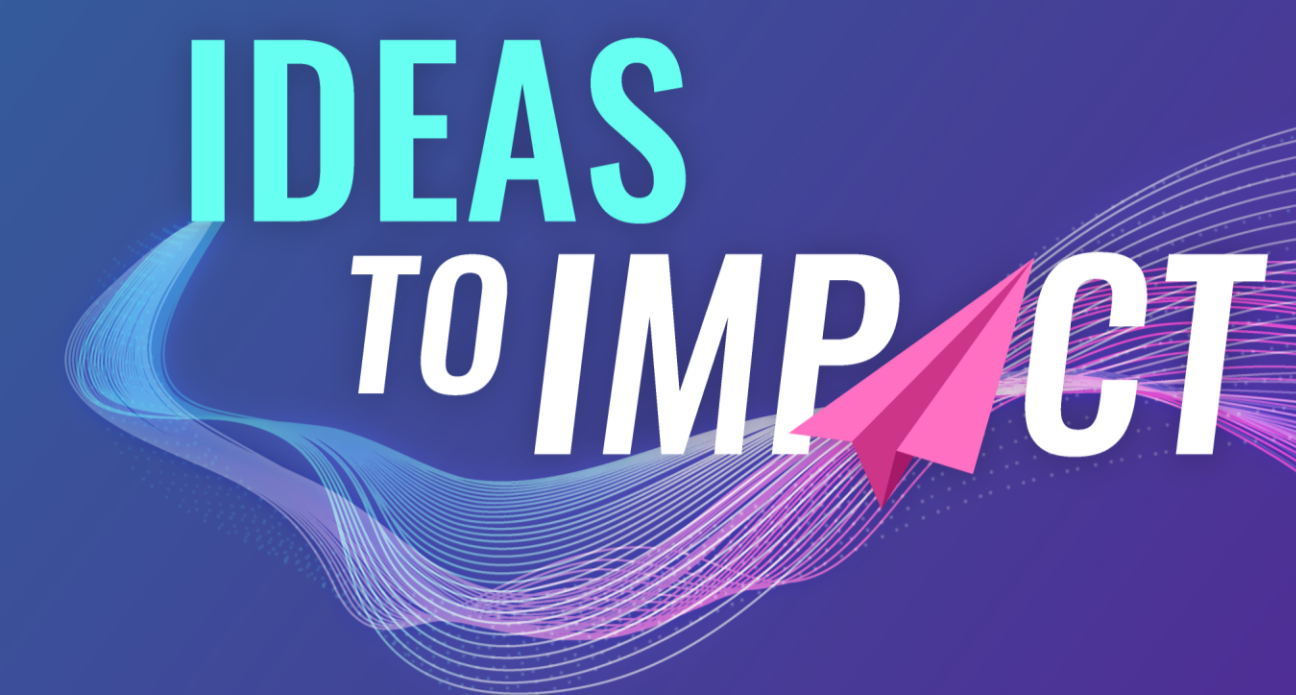
Wilamy Castro¹, Maria Paula Mendes², Pedro Lima Gaspar³, Christoph Reinhart⁴

1. IST, University of Lisbon, CERIS

2. IST, University of Lisbon, CERENA

3. Faculty of Architecture, University of Lisbon

4. Massachusetts Institute of Technology (MIT)



MIT Portugal
2024 Annual Conference

1. Introduction

Buildings account for 40% of energy consumption and 36% of greenhouse gas emissions in Europe. Reducing energy use in buildings is key to tackling climate change, but energy retrofitting often show a 30-40% gap between predicted and actual energy savings. In this sense, this study analysis energy consumption over a decade in a single-family house (Fig. 1) with integrated renewable energy systems, such as solar panels and battery storage. By analyzing real-world data, this project assesses the effectiveness of these technologies in reducing carbon emissions and improving energy efficiency.



Fig. 1. Location of the case study.

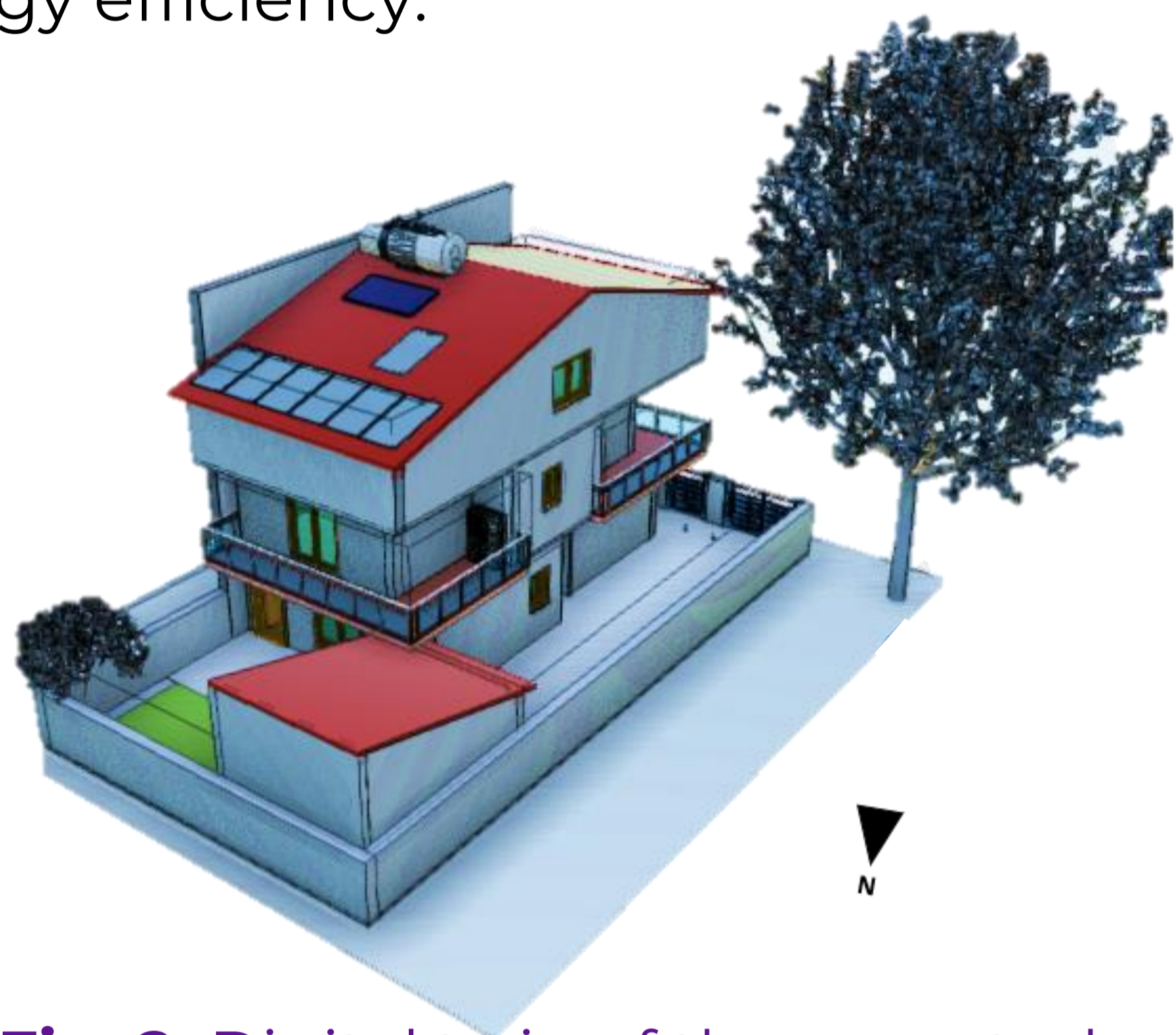


Fig. 2. Digital twin of the case study.

2. History of energy consumption and microgeneration

In the first years, the house presented water heating panels, with the electricity 100% supplied by an energy company, without air conditioning. After 3 years, four AC units were installed. After 6 years, 6 solar panels for electricity production were installed and after 9 years, to counter skyrocketing electricity prices, the owners decided to add five more solar panels to reach increased energy independence. Currently, the roof of the case study is covered with photovoltaic panels (Fig. 2), six with a power peak of 300W and five with a power peak of 380W.

3. Results

The incorporation of solar panels in 2020 and a battery in 2023 led to a noticeable reduction in energy costs, even as the homeowners stayed home during COVID lockdowns and continued remote work (Fig. 3). These renewable energy systems allowed them to generate their own electricity, lowering dependence on grid power and reducing bills. Traditional grid electricity, often sourced from fossil fuels, is subject to price fluctuations, contributing to CO₂ emissions tied to energy consumption. Despite rising temperatures in 2022 and 2023, the use of renewable technologies helped mitigate CO₂ emissions, demonstrating their potential in reducing reliance on fossil fuels and greenhouse gas emissions.

4. Conclusion

A ten-year analysis of energy consumption highlights the significant role of microgeneration in achieving sustainable residential living. The case study demonstrates the effectiveness of integrating photovoltaic solar panels and batteries, which optimized energy usage and reduced reliance on conventional grid power. Solar panels generated substantial savings during daylight hours, while batteries stored excess energy for later use, improving resilience to grid outages and price fluctuations. These findings underscore the importance of continued advancements in renewable energy technologies to enhance energy efficiency and sustainability one home at time.

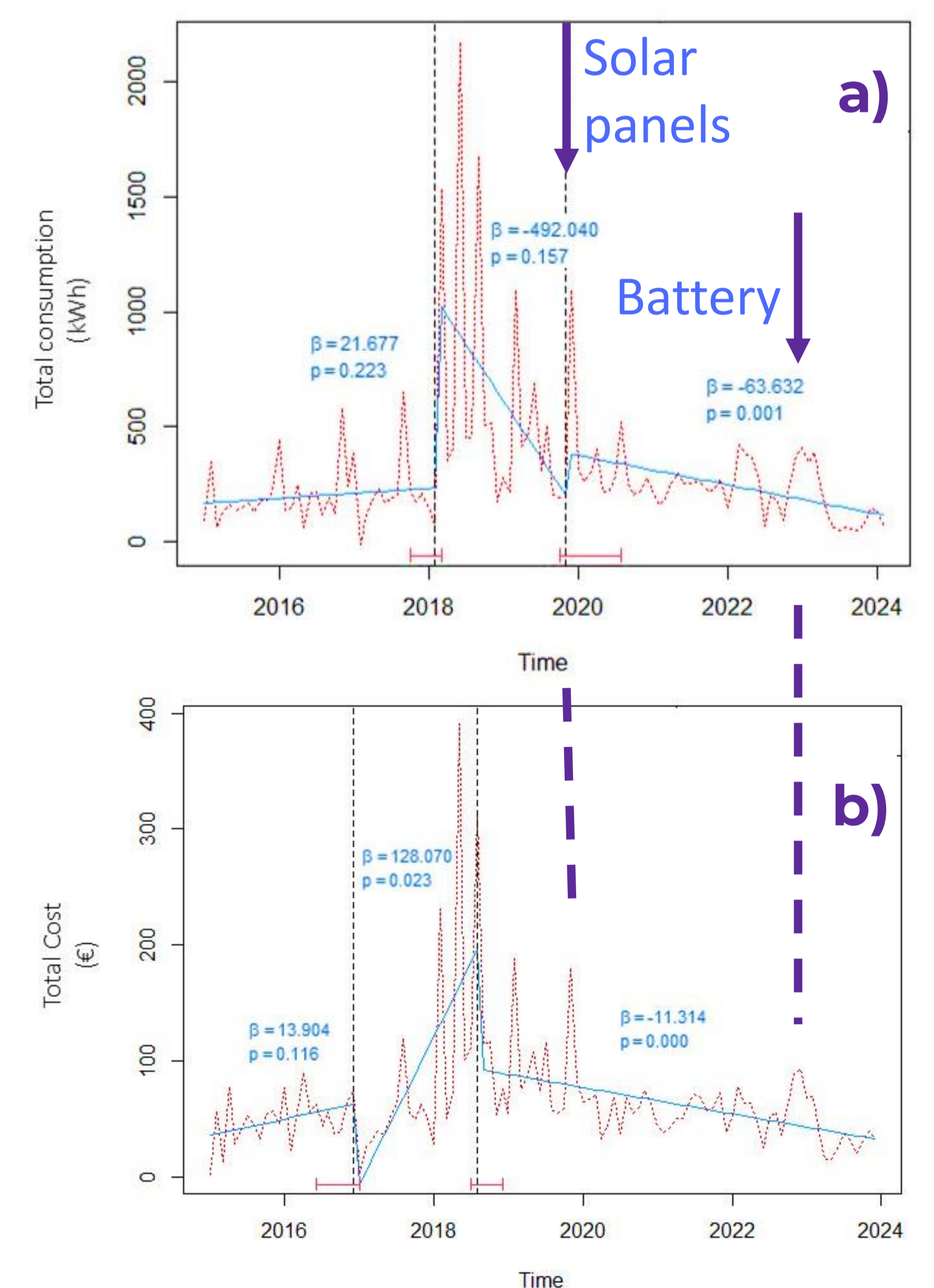
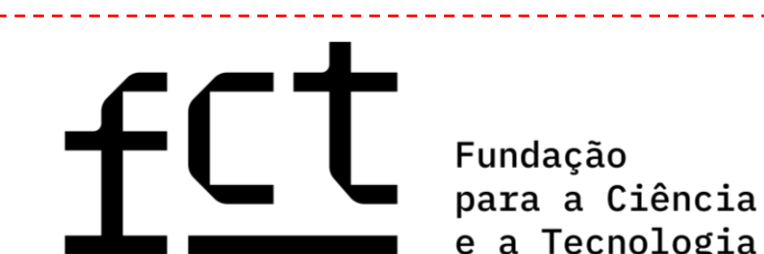


Fig. 3. Time series of the energy consumed (a) and the costs of energy (b) over the years.

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