



# Structural properties in the diffusion of the solar photovoltaic in Italy: individual people/householder vs firms

Franco Flandoli<sup>1</sup> · Marta Leocata<sup>2</sup>  · Giulia Livieri<sup>3</sup> · Silvia Morlacchi<sup>4</sup> · Fausto Corvino<sup>5,6</sup> · Alberto Pirni<sup>7</sup>

Received: 26 February 2024 / Accepted: 4 July 2025

© The Author(s), under exclusive licence to Associazione per la Matematica Applicata alle Scienze Economiche e Sociali (AMASES) 2025

## Abstract

This paper develops two mathematical models to understand subjects' behavior in response to the urgency of a change and inputs from governments e.g., (subsidies) in the context of the diffusion of the solar photovoltaic in Italy. The first model is a Markov model of interacting particle systems. The second one, instead, is a Mean-Field Game model. In both cases, we derive the scaling limit deterministic dynamics, and we compare the latter to the Italian solar photovoltaic data. We identify periods where the first model describes the behavior of domestic data well and a period where the second model captures a particular feature of data corresponding to companies. The comprehensive analysis, integrated with a philosophical inquiry focusing on the conceptual vocabulary and correlative implications, leads to the formulation of hypotheses about the efficacy of different forms of governmental subsidies.

**Keywords** Green Energy Transition · Solar Photovoltaic · Individual based modeling · Procrastination · Markov model · Mean-Field Games

**Mathematics Subject Classification** 60K35 · 91A16 · 60J27

## 1 Introduction

Green Energy Transition (GET, henceforth) has, in general, many facets. One is the problem of understanding subjects' reactions to the urgency of a change and inputs from governments (e.g., subsidies). The latter is a fascinating question at the intersection of several cultural fields. This paper investigates this interrogative through the lens of mathematicians and philosophers by examining a specific case study, namely the diffusion of solar photovoltaic panels in Italy, to identify concrete issues and have some data comparing our proposed models; Section A in Appendix gives a short description of the development of solar photovoltaic in Italy. More precisely, in the

---

Extended author information available on the last page of the article