

Influence of distribution tariff structures and peer effects on the adoption of distributed energy resources: an agent-based modeling approach Jorge A. Moncada, Zhenmin Tao, Pieter Valkering, Frank Meinke-Hubeny, Erik Delarue IAEE June 9th 2021





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Outline

- Introduction
- Research question
- Research approach
- Results
- Conclusions
- Future work

Introduction

Consumer-centric energy systems

- Advances in electricity generation and storage technology, as well as Information and Communication (ICT) have led to a rapid increase of prosumers
- The emergence of prosumers raises a series of challenges that cut across technical, social, and institutional dimensions (e.g., the utility death spiral)
- The emergence of prosumers calls for an assessment of distribution tariffs that takes into account consumers behavioral factors



Research question

- Research question:
 - What is the influence of both peer effects and distribution tariff structures on the adoption of integrated photovoltaic and battery energy storage systems as well as on the utility death spiral?
- Contribution
 - A novel modeling framework that:
 - Incorporates the effect of social and attitudinal components into residential consumers' DERs adoption decision-making
 - Considers the interplay between DERs adoption and the evolution of the distribution tariff



Theories & Methods

- Theories
 - Theory of planned behavior
 - Diffusion of innovations theory
- Methods
 - Agent-based modeling.
 - Overview, Design concepts, and Details (ODD) protocol
 - Pattern Oriented Modeling (POM)

Theory of planned behavior*



Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179–211

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Diffusion of innovations theory*



Source: Evered Rogers Orlasion of Innovations model

Rogers, E. M. *Diffusion of Innovations* 5th Edition (Simon and Schuster, 2003).

ABM positioning







Input data

- Number of households = 50
- PV cost projections based on TIMES.
- Probability that a household owns the property = 80%.
- Households average annual electricity consumption:
 - High income = 3900 kWh
 - Medium income = 3500 kWh
 - Low income = 1200 kWh

Adopter	Adoption threshold	weight payback utility
	[-]	[-]
Innovator	0.4	U(0.9, 1)
Early adopters	0.5	U(0.8, 0.9)
Early majority	0.6	U(0.6, 0.7)
Late majority	0.7	U(0.6, 0.7)
Laggards	0.8	U(0.6, 0.7)

Results

PV installed capacity



- Distribution tariff structures influences DERs adoption
- DERs adoption occurs faster in the absence of peer effects

Peer effect

Case 1: economic factors + peer effects Case 2: economic factors

Results

Evolution of distribution tariff



• Distribution tariff structures influences the evolution of distribution tariff

Peer effect

Case 1: economic factors + peer effects Case 2: economic factors

In the long term, peer effects have no a significant influence on the distribution tariff

Conclusions

- An agent-based model was developed to understand how peer effects and distribution tariff structures influence households' DERs adoption
- The creation of channels of communication enhancing the influence of peer effects on the adoption process may significantly accelerate DERs adoption in the short-term
- Distribution tariff structures can influence DERs adoption patterns and the utility death spiral

Future work

- A further step in this research would be the incorporation of elements of risk and loss aversion in investment decision making
- To develop a full picture of the distribution tariff spiral, additional studies are needed that take into account the feedback loop describing a shift in wholesale electricity prices driven by high PV penetration



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