Transition pathways for a low-carbon power system in Greece

Empowering consumers to produce and store clean energy at the local level

Vassilis Stavrakas, Serafeim Michas, Sotiris Papadelis, Alexandros Flamos

TRANSrisk
TRANSITION PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE POLICIES

Introduction

Strong incentives for the further deployment of small-scale PV in Greece are essential without continuing to rely on Feed-in-Tariffs (FiTs). Such incentives can be found in business models (BMs) that exploit the flexibility of demand without requiring significant changes in the current market design. So far, demand-flexibility is already available: **a.** as a way to increase self-consumption, and **b.** by applications that aim primarily to increase energy efficiency (e.g. smart thermostats).

However, recent studies on the French, German-Austrian and Nordic spot markets has shown that with demand-flexibility:

- Consumers enjoy significant consumption (and financial) savings, but
- For vertically integrated entities that combine both generation & retailing operations under one corporate roof, the financial results are fundamentally negative.

Context

RESEARCH QUESTION

How can Self-Consumption & Demand-Flexibility be brought into the Greek power market?

- Which policies can drive a **transition pathway** for the power system that is based on the **notion** of consumers **generating**, **storing** and **consuming** clean energy locally?
- How could potential **costs** and **benefits** be distributed to both the consumers and the power market actors?

Developing new BMs that incentivize all involved actors to incorporate demand-side flexibility into the markets that can valorize it:

- ❑ Change in distribution of electricity demand,
- ❑ Re-shaping the electricity system.

No significant changes are required in:

- the current regulatory framework,
- the current operation of the power market.

Incorporating Demand-Response into the retailing operations of the utilities

- ✓ Extra tool for the retailers' trades in the day-ahead, intra-day and real-time (where they exist) markets,
- ✓ Minimization of costs during short-term electricity procurement.

However…

Demand-Response (DR) by itself is unlikely to incentivize consumers to invest in new technological capabilities.

- ➢ The public is expected to adopt according to a value stemming from increased consumption of electricity generated onsite from renewable resources.
- ➢ When self-consumption is economically rational, consumers may invest in technologies that increase their demand flexibility to increase the proportion of the self-produced electricity they consume.

MOTIVATION

Increased adoption of building-scale technologies for electricity and heating/cooling using RES …

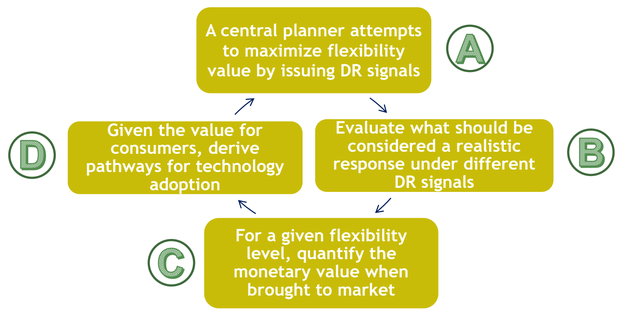
…requires that these technologies become competitive with fossil fuel alternatives.

Our study focuses on…

- ➢ …ways to couple small-scale PV with DR technologies
- ➢ …using this infrastructure to generate additional revenues for consumers…

Research Methods

We follow an iterative methodological approach



A We assumed a central planner that operates as retailer - The planner needs to solve a learning problem: to find the DR signals that maximize its benefit

Python Implementation

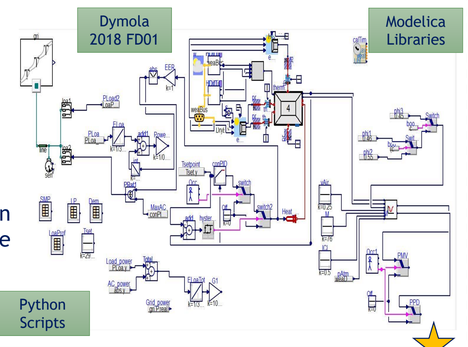
We employ Reinforcement Learning (RL) in order to "teach" the retailer the optimal policy to maximize its revenues.

B We developed a **D**emand-**RE**spons**E** **M**odel (DREEM) coupling dynamic simulation between:

- Building envelope properties
- Indoor environment,
- HVAC control systems,
- Thermal comfort,
- Renewable self-consumption,
- Incoming DR signals based on the Hourly Electricity Price (HEP)

Dymola 2018 FD01

Modelica Libraries



Python Scripts

Novelty

- Combining electricity storage with smart thermostat capabilities (so far only used for increasing energy efficiency in buildings),
- Controllers/control algorithms to comply with the DR signals.

C The central planner receives the results of its DR signals

according to the degree of compliance..

..allocates the benefits to the consumers

D We developed an **A**gent-based **T**echnology ad**O**ption **M**odel (ATOM) to create scenarios for small-scale PV adoption in Greece under:

- a proposed self-consumption support scheme (i.e. 25% subsidy of residential electricity storage) - **Pathway 1**
- a proposed DR support policy (i.e. 25% subsidy of electricity storage & allowing Demand-Response to the market) - **Pathway 2**

APPLICATION

Increasing the **value** of **flexibility** through provision of **services to the grid**

BAU Scenario
Maintaining thermal comfort

Pathway 1
PV self-consumption with storage

Pathway 2
Demand Response through the retailing operations

PV, Storage, Smart-grid devices with Automation Control Systems

DREEM Dynamic Demand-Response Simulation Model

Exploring DR events preserving energy services & thermal comfort of consumers

Evaluation of **provision** of **services** to the grid

Simulation

Forward-looking projections

ATOM Agent-based Technology Adoption Model

Simulating the dynamics of small-scale PV adoption among consumers

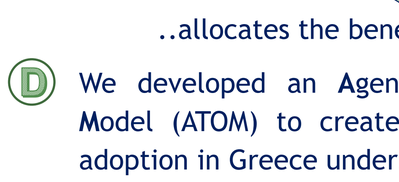
Revenue opportunity
Less reliance on subsidies

For simplicity we assume that all consumers that decide to adopt become then clients of the central planner

New small-scale PV capacity addition

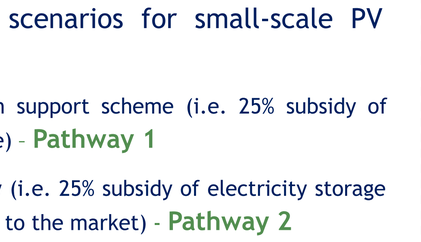
Results

BAU SCENARIO



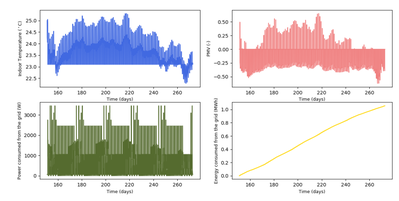
Period 2 (December – March)	
Electricity from Grid	1.60 MWh
Competitive Charges	€150.67
Thermal comfort	Acceptable levels

Period 1 (June – September)	
Electricity from Grid	1.30 MWh
Competitive Charges	€123.97
Thermal comfort	Acceptable levels



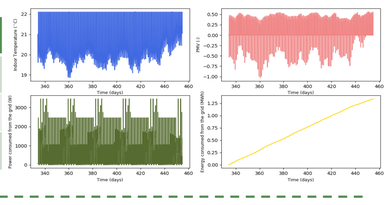
Results (continued)

PATHWAY 1



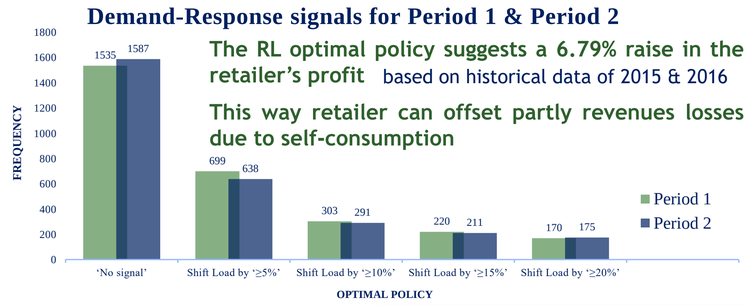
Period 2 (December – March)	
Electricity from Grid	1.34 MWh **(-17%)**
Competitive Charges	€137.38 **(-9%)**
Thermal comfort	Acceptable levels

Period 1 (June – September)	
Electricity from Grid	1.04 MWh **(-20%)**
Competitive Charges	€106.62 **(-14%)**
Thermal comfort	Acceptable levels



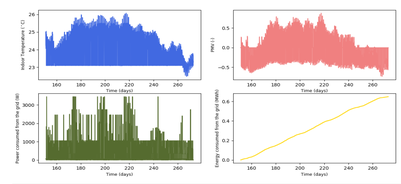
PATHWAY 2

Demand-Response signals for Period 1 & Period 2



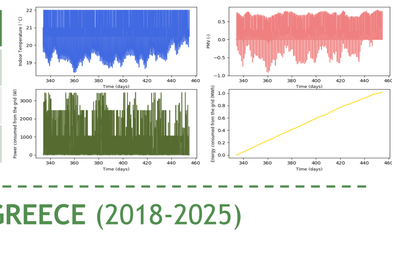
The RL optimal policy suggests a 6.79% raise in the retailer's profit based on historical data of 2015 & 2016

This way retailer can offset partly revenues losses due to self-consumption



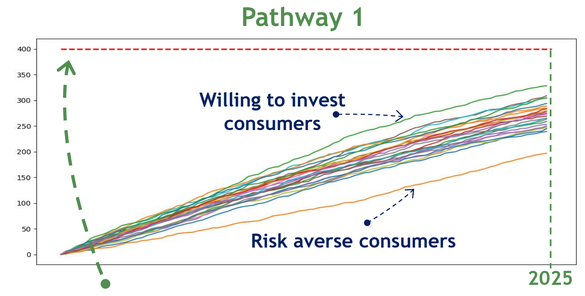
Period 2 (December – March)	
Electricity from Grid	1.00 MWh **(-35%)**
Competitive Charges	€103.34 **(-30%)**
Thermal comfort	Acceptable levels

Period 1 (June – September)	
Electricity from Grid	0.70 MWh **(-45%)**
Competitive Charges	€66.64 **(-42%)**
Thermal comfort	Acceptable levels



NEW PV CAPACITY ADDITION IN GREECE (2018-2025)

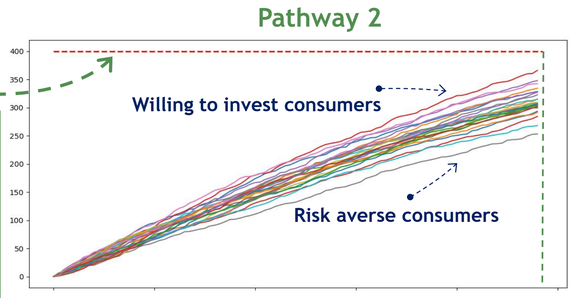
Pathway 1



400 MW - PV capacity addition that FiTs achieved from 2010 until 2013

Pathway 2 is more effective than **Pathway 1** in terms of new PV capacity addition

Pathway 2



Pathway 2 is equally effective as the new **Net-Metering** scheme in Greece (in effect as mid of 2015)

Conclusions & Policy Implications

- **The flexibility to increase self-consumption can be brought to the market without a need: a.** for significant changes in the current market design, and **b.** for consumers to sacrifice thermal comfort and energy services,
- **Bringing flexibility to the market increases the value of the technologies that enable this flexibility:** This increased value can counterbalance the phase out of FiTs and provide new incentives for PV investment in Greece,
- **New and more sustainable BMs will arise for the utility:** Promotion of energy saving technologies will reduce the costs of penalties (i.e. non-compliance with the recently introduced Energy Efficiency Obligation schemes - EEOs),
- **A synergistic co-operation between the power provider and the prosumer can lead to significant cost reductions and energy savings:** A fair allocation of benefits can provide incentives to both so that to coordinate,
- **Although the shift to DR seems logical: a.** it is not inevitable in terms of consumer behavior, and **b.**it is game-changing, as the implementation of new BMs in the electricity market captures new value on the supply side by coupling it to the demand side.

TEES lab
University of Piraeus Research Center

Contact name
Email: aflamos@unipi.gr
Phone: +30 210 414 2460
https://teeslab.unipi.gr
www.transrisk-project.eu

The TRANSrisk project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 642260.