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Future development of the European solar market towards decentralized renewable energy generation and storage: A cross-country comparative analysis

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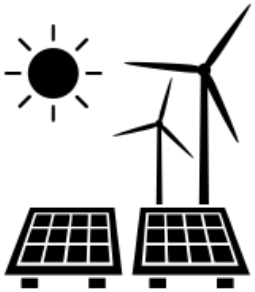
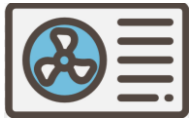
Europe's vision for a socially fair energy transition towards 2050…



100% RES System using **Storage** & **Demand-Response** technologies

System Change →

Decentralized community projects & innovative **business models**



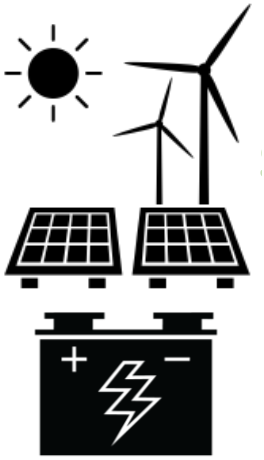
Diffusion of **technological breakthroughs** at the residential sector

Potential also lies in **energy efficiency** & tackling **energy poverty**

Smart-Grid paradigm

Digitalization can make this transition more **efficient** & **democratic**

Business Models (BMs) to explore benefits of self-consumption in the power market



Our study focuses on:

- ➔ ..on ways to couple **small-scale PV** with **storage** technologies
- ➔ using this infrastructure to generate **additional revenues** for consumers…

Decentralized community projects & innovative **business models**

Revenue opportunity
Less reliance on subsidies

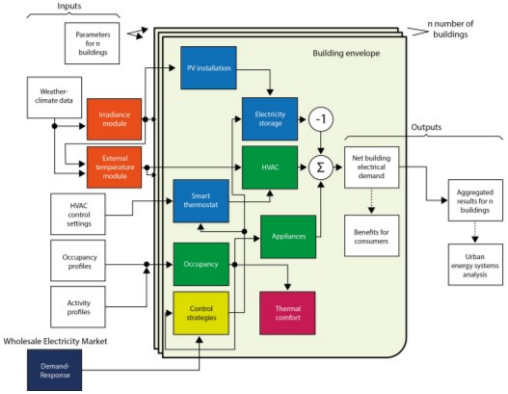
Such sources of revenue can **counterbalance** the phasing out of **FiTs** around Europe, so that **incentives** for PV adoption remain strong

A Transdisciplinary Modeling Framework (1/4)

TEEM
High-resolution Energy System Simulation Models

Modeling **suite** to perform **quick simulations** as part of an iterative **participatory** process aiming to provide answers to **"what if"** scenarios

- **DREEM**
  Dynamic High-Resolution Demand-Side Management Model



ATOM
Agent-based Technology Adoption Model

A Transdisciplinary Modeling Framework (2/4)

Business Model

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

DREEM

Dynamic High-Resolution Demand-Side Management Model

Benefits of **PV self-consumption** with **storage** at the **residential** sector

ATOM

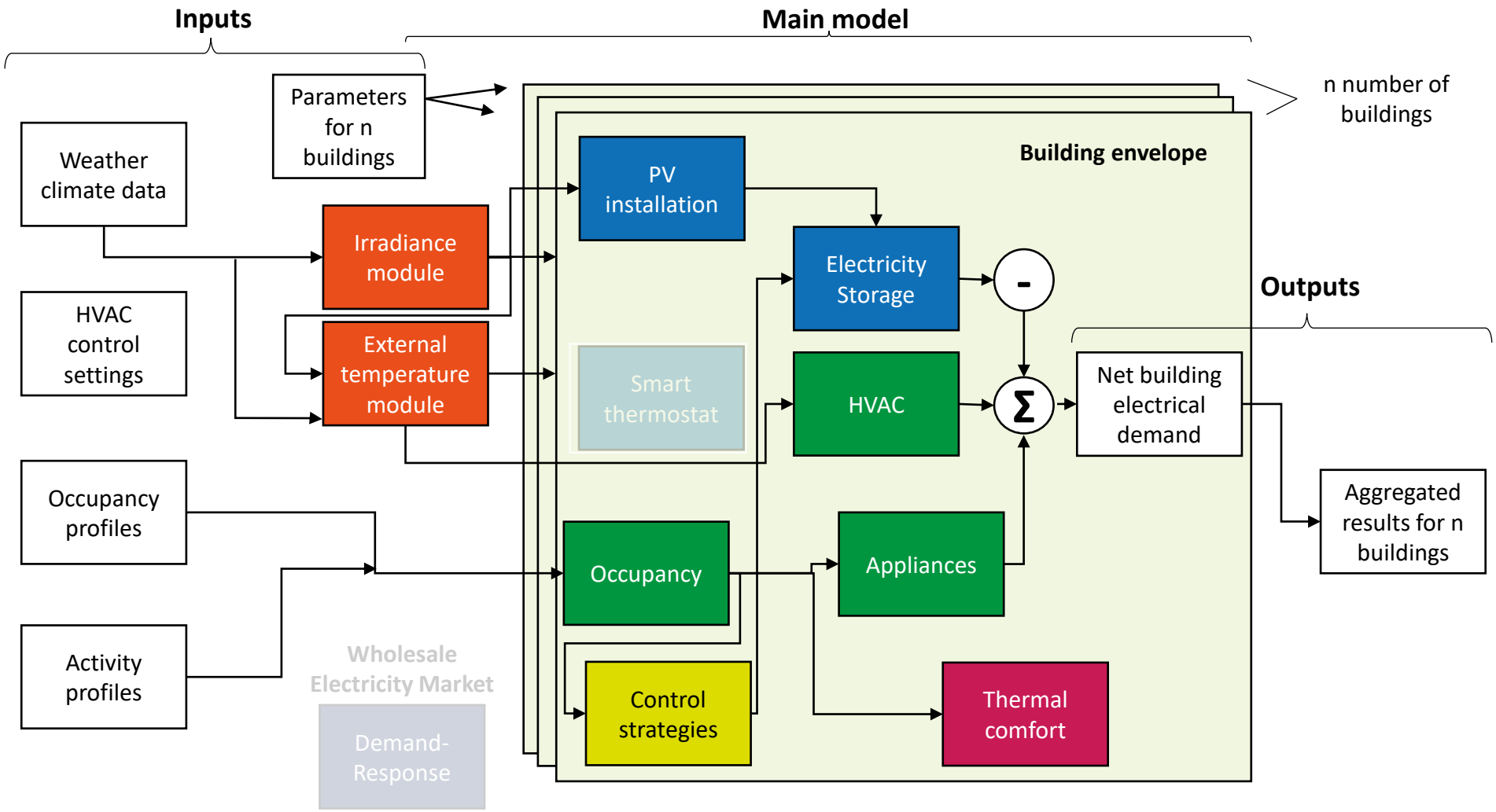
Agent-based Technology Adoption Model

Simulation

Forward-looking projections

New small-scale PV capacity addition

A Transdisciplinary Modeling Framework (3/4)



A Transdisciplinary Modeling Framework (4/4)

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Agent-based Technology Adoption Model

Agent-related parameters

Calibration based on historical market data

ELSEVIER
Applied Energy
Volume 255, 1 December 2019, 113795

An agent-based model to simulate technology adoption quantifying behavioural uncertainty of consumers

Vassilis Stavrakas, Sotiris Papadelis, Alexandros Flamos

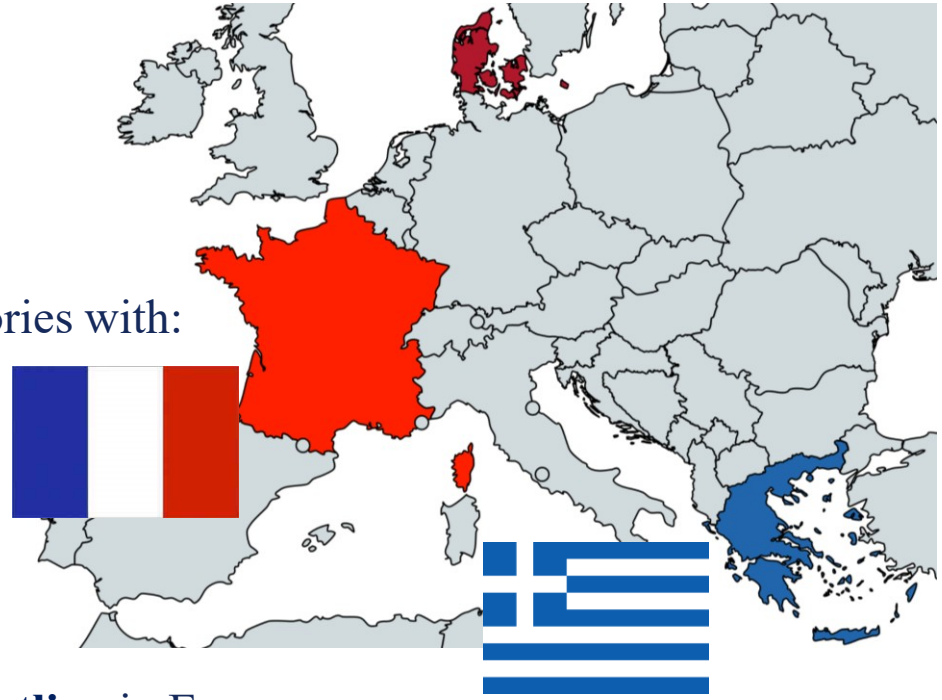
Show more

https://doi.org/10.1016/j.apenergy.2019.113795

Case Studies – Geographical context

Denmark

Nordic country in **Northern Europe** with relatively low solar energy availability (i.e., 1000 kWh/m^2)



France

Western & **Central Europe** - Territories with:

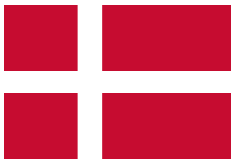
- **Diversely** climate zones,
- Solar energy availability:
  1,000 kWh/m^2 (**North**)
  1,700 kWh/m^2 (**South**)

Greece

Southern Europe - **Largest coastline** in Europe - electricity **interconnection** remains a **continuous** challenge

Diverse geographical landscape & high solar irradiation levels

Case Studies – Policy background

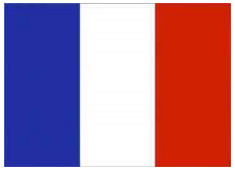


2030 short-term target: 50% RES production (**700 MWp** of PV power installed)

2050 long-term target: 100% RES system (**1,500 MWp** of PV power installed)

PV regulatory framework (**at present**):

- Net-metering scheme
- Efforts to support self-consumption



2030 short-term target: 33 GWp of PV power installed

PV installations

- **1st Model:** FiTs **without** the possibility of self-consumption
- **2nd Model:** Self-consumption **with** investment grant & **fixed** FiTs for excess electricity fed into the grid

2030 short-term target: 6,900 MWp of PV power installed

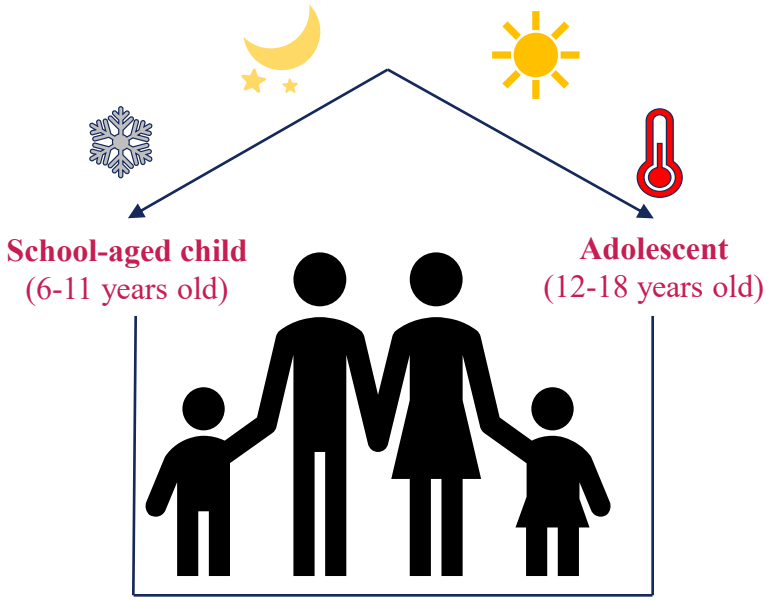
PV regulatory framework (**at present**):

- Net-metering scheme
- Efforts to support self-consumption

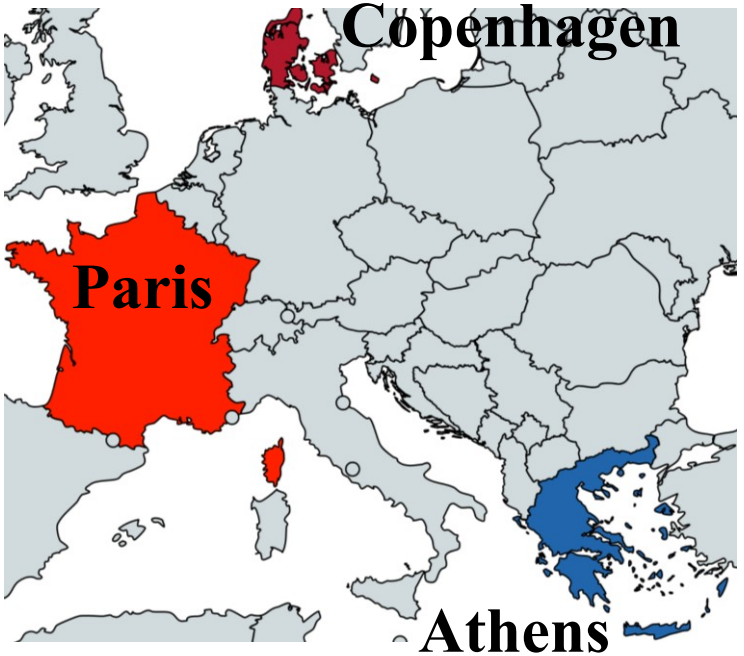
Case Studies – Scenario analysis (1/4)

I. Business-As-Usual ("SC1")

Weather Data



Nuclear (conjugal) family:
2 working parents & **2 children**



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Case Studies – Scenario analysis (2/4)

I. Business-As-Usual ("SC1")

Building Typologies

TABULA webtool

Single Family House
2007 -2010
Reference Floor Area: 145 m²

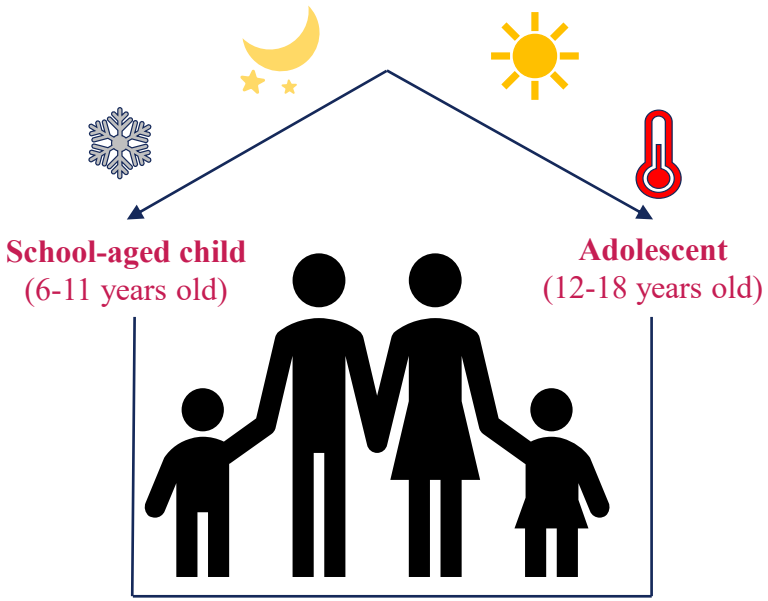
Single Family House
2006 -2012
Reference Floor Area: 105 m²

Single Family House
2001 -2010
Reference Floor Area: 115 m²

Case Studies – Scenario analysis (3/4)

II. Flexibility through provision of services to the grid ("SC2")

Policy scheme:
- 25% subsidy of storage



Nuclear (conjugal) family:
2 working parents & 2 children

Initial investment cost
800 €/kWh

Nominal power
1 kWp

Expected lifetime
3,000 equivalent full cycles

Case Studies – Scenario analysis (4/4)

II. Flexibility through provision of services to the grid ("SC2")

Storage dispatch model

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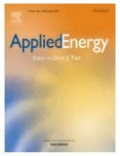
Applied Energy

Volume 182, 15 November 2016, Pages 58-67



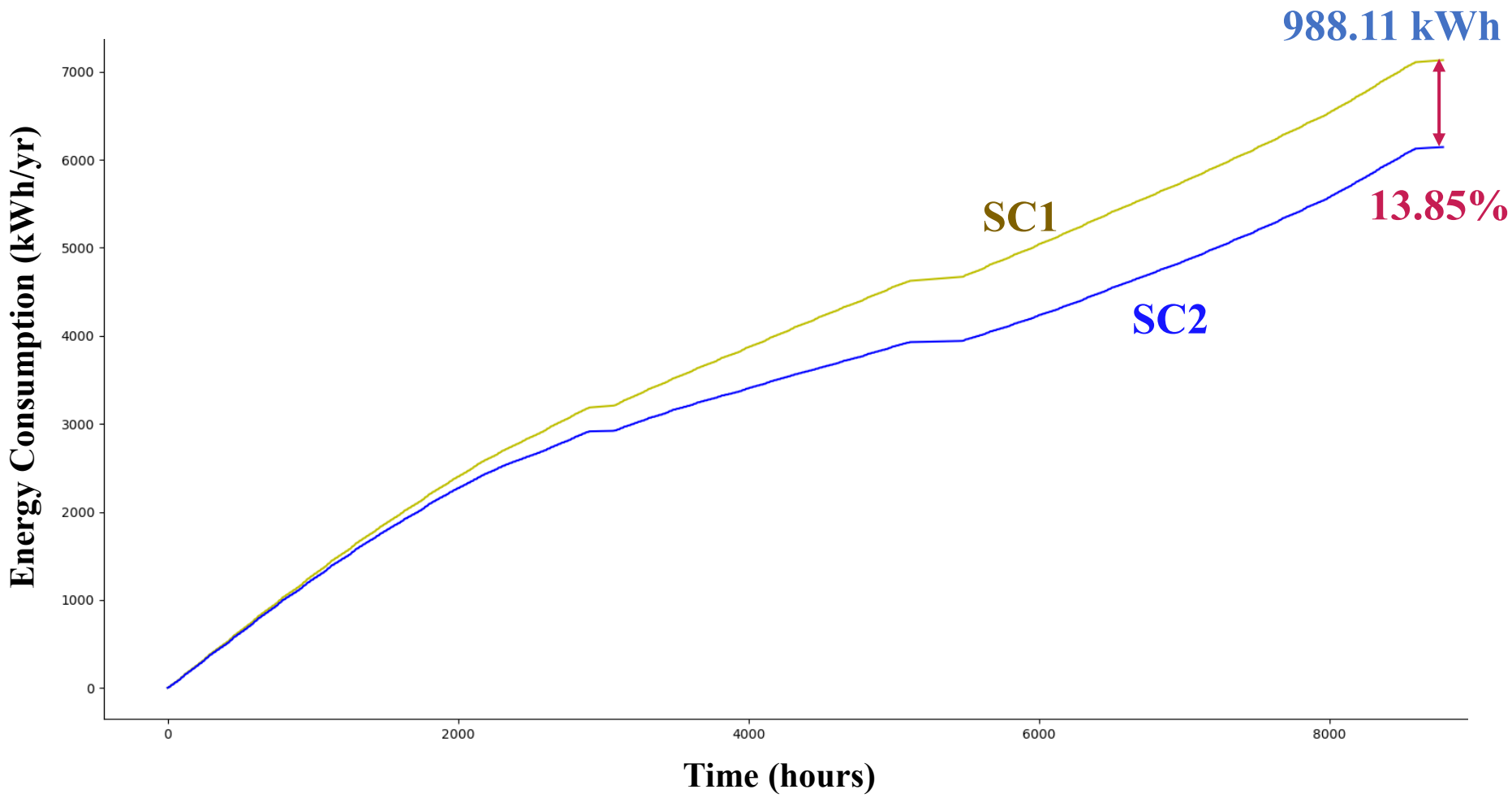
Quantifying self-consumption linked to solar home battery systems: Statistical analysis and economic assessment ☆

Sylvain Quoilin [a], Konstantinos Kavvadias [a], Arnaud Mercier [b], Irene Pappone [b], Andreas Zucker [a]

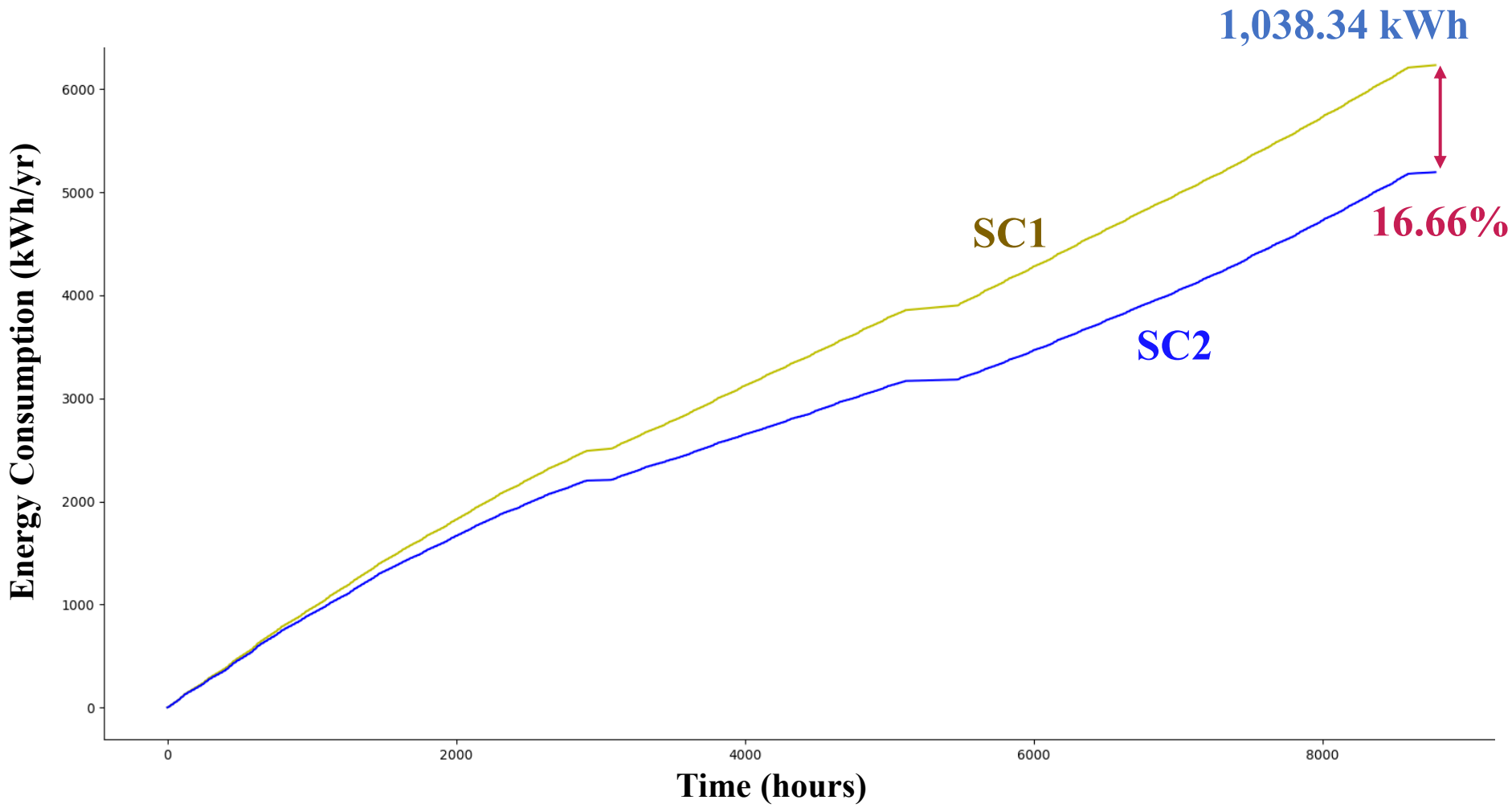
Optimization algorithm:
Storage capacity **dispatched** in an optimum way to **maximize** self-consumption

Sizing of **1-to-1** for storage capacity to PV peak power

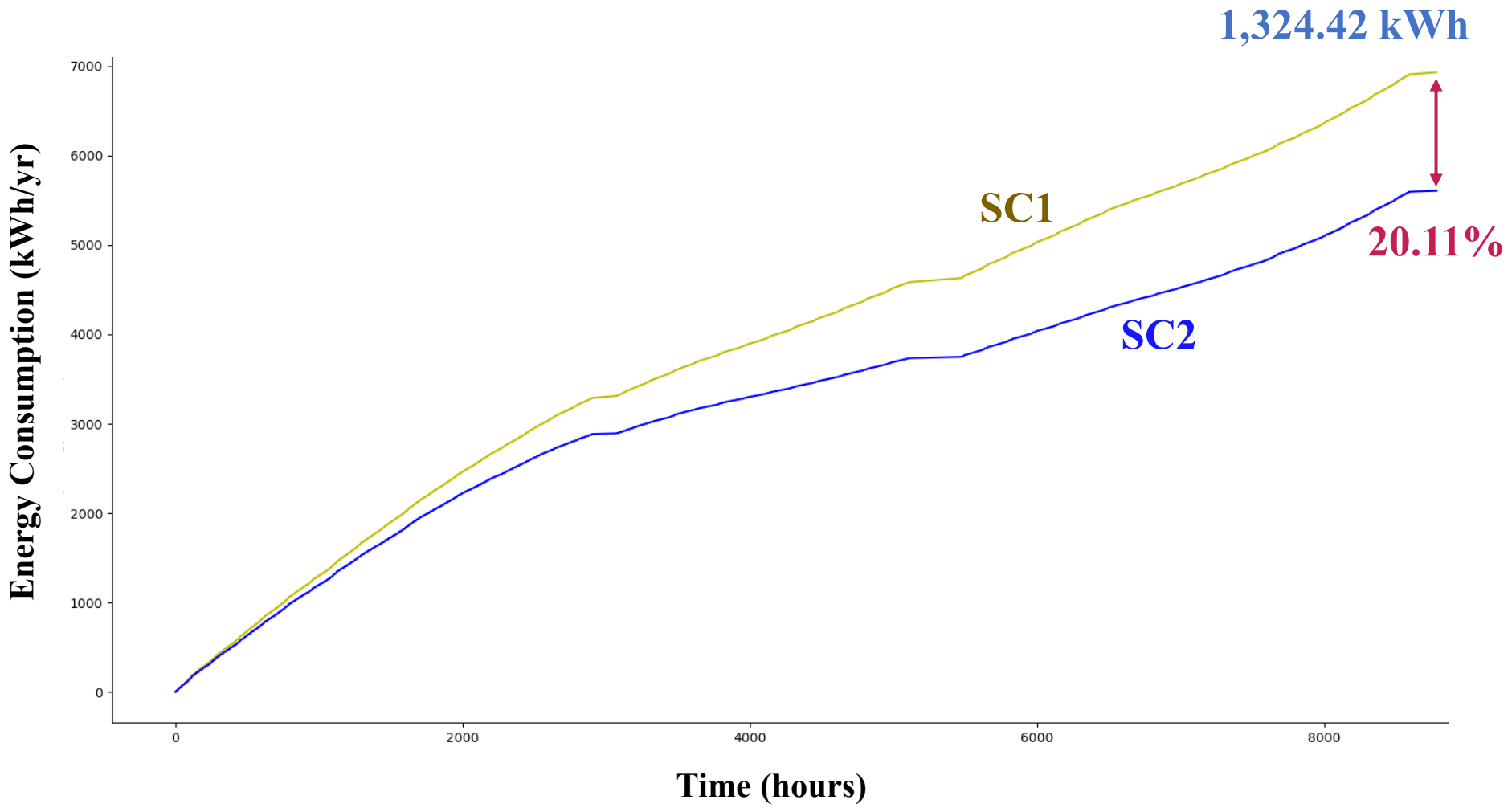
Results – Benefits of PV self-consumption with storage for consumers in Denmark



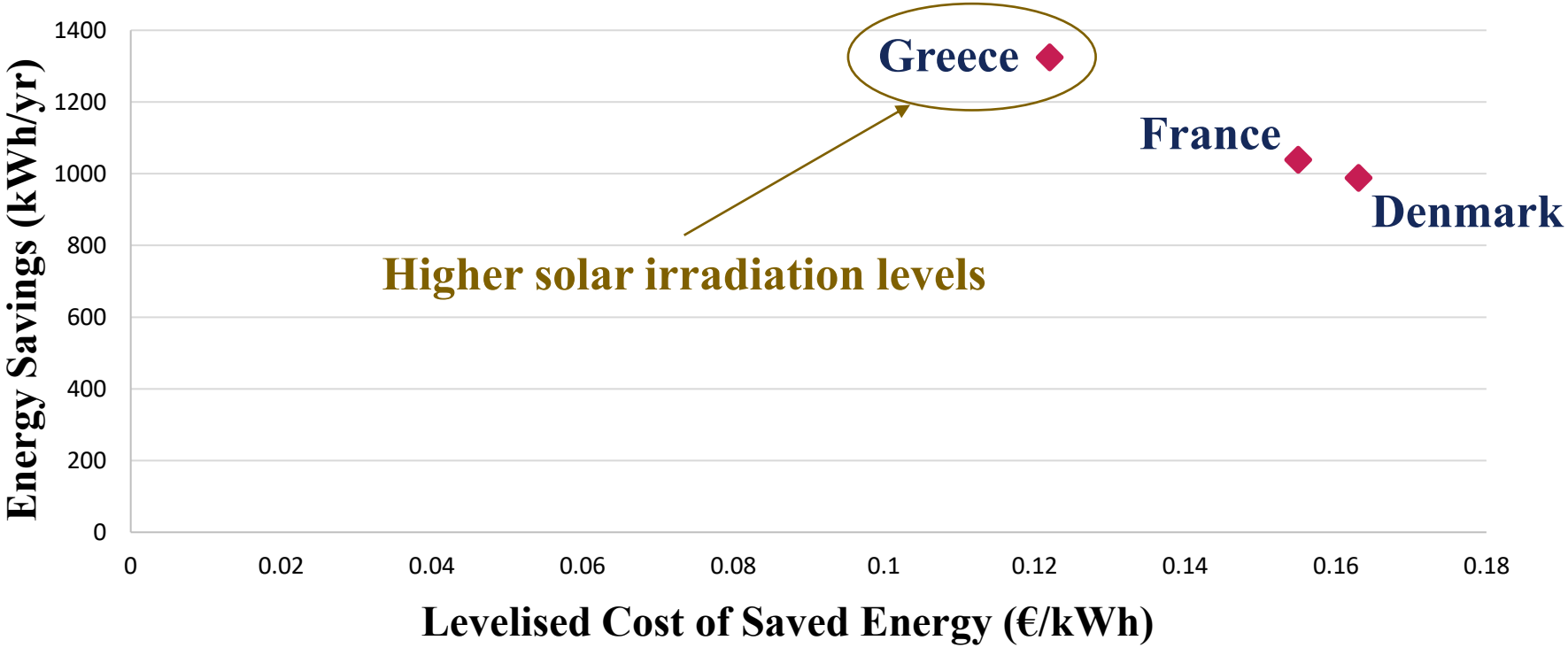
Results – Benefits of PV self-consumption with storage for consumers in France



Results – Benefits of PV self-consumption with storage for consumers in Greece



Results – Comparative analysis



Indicative PV & storage Cost Data, as obtained from the **scientific literature** & **technical reports**

Energy Savings as derived from the DREEM **model**

Dynamic High-Resolution Demand-Side Management Model

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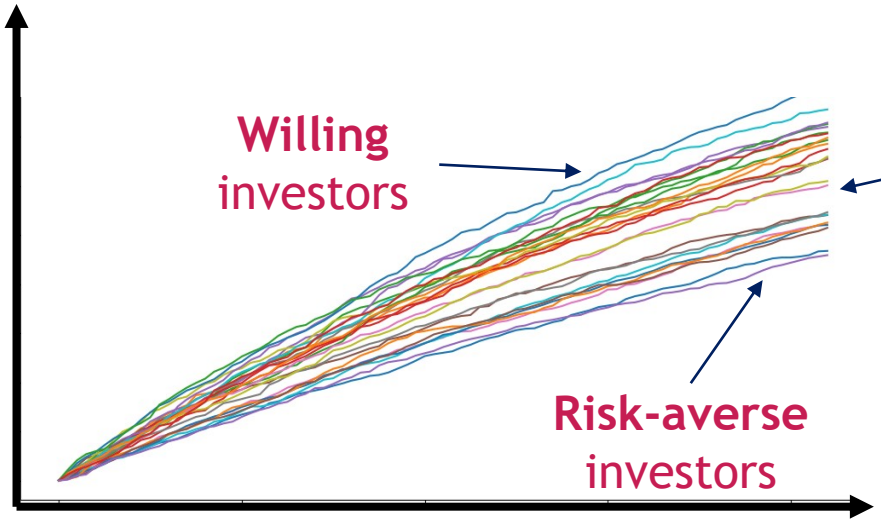
Results – Further adoption of small-scale PV towards 2030



25 adoption scenarios

25 different **realistic behavioral** profiles of consumers

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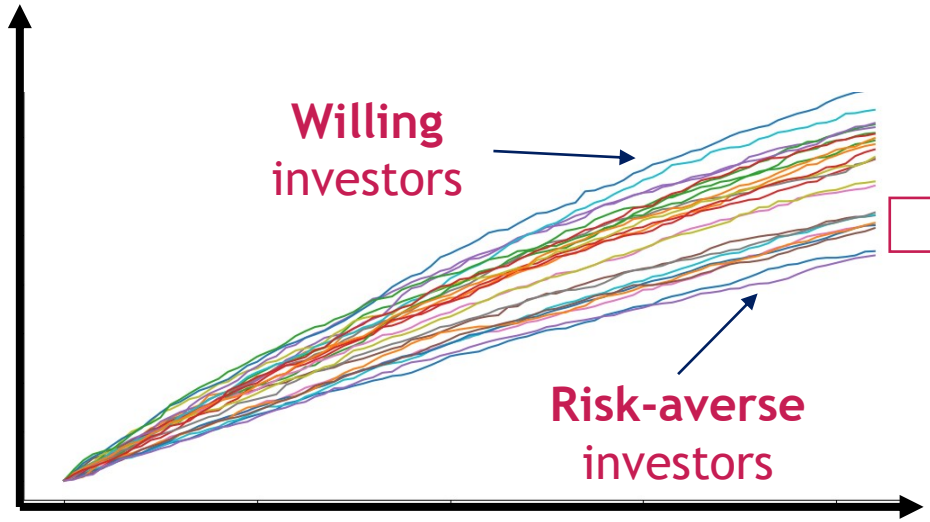
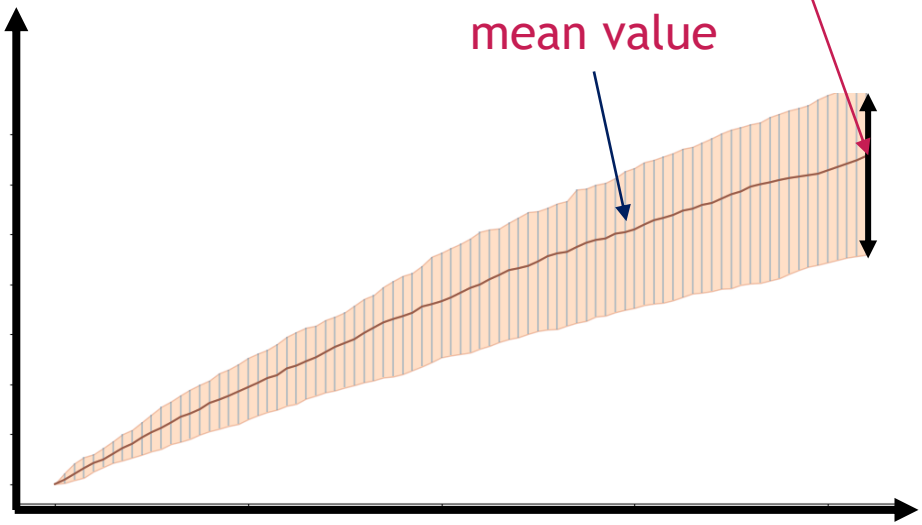
Agent-based Technology Adoption Model

Results – Further adoption of small-scale PV towards 2030

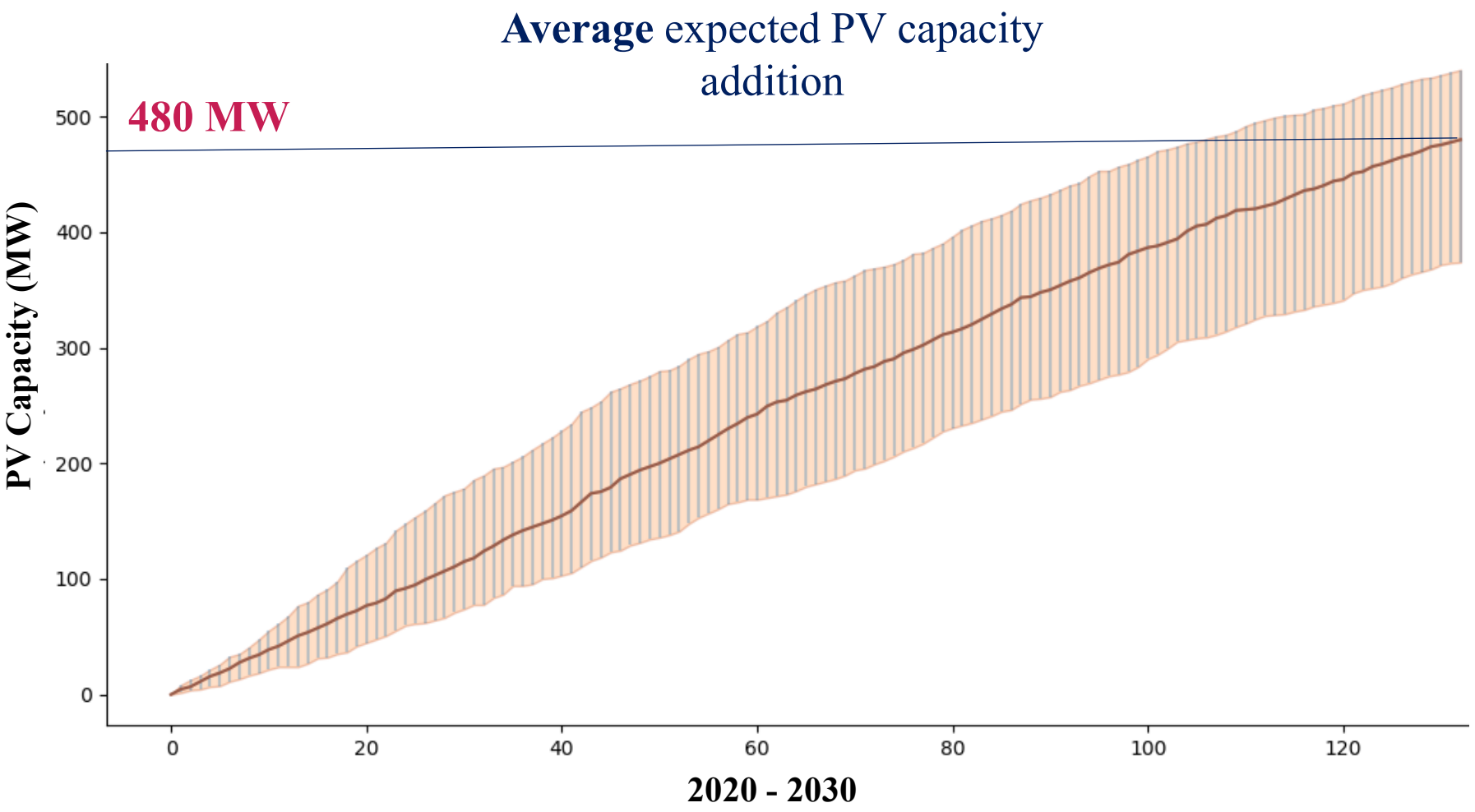


Quantifying adoption uncertainty = Variance of outcomes

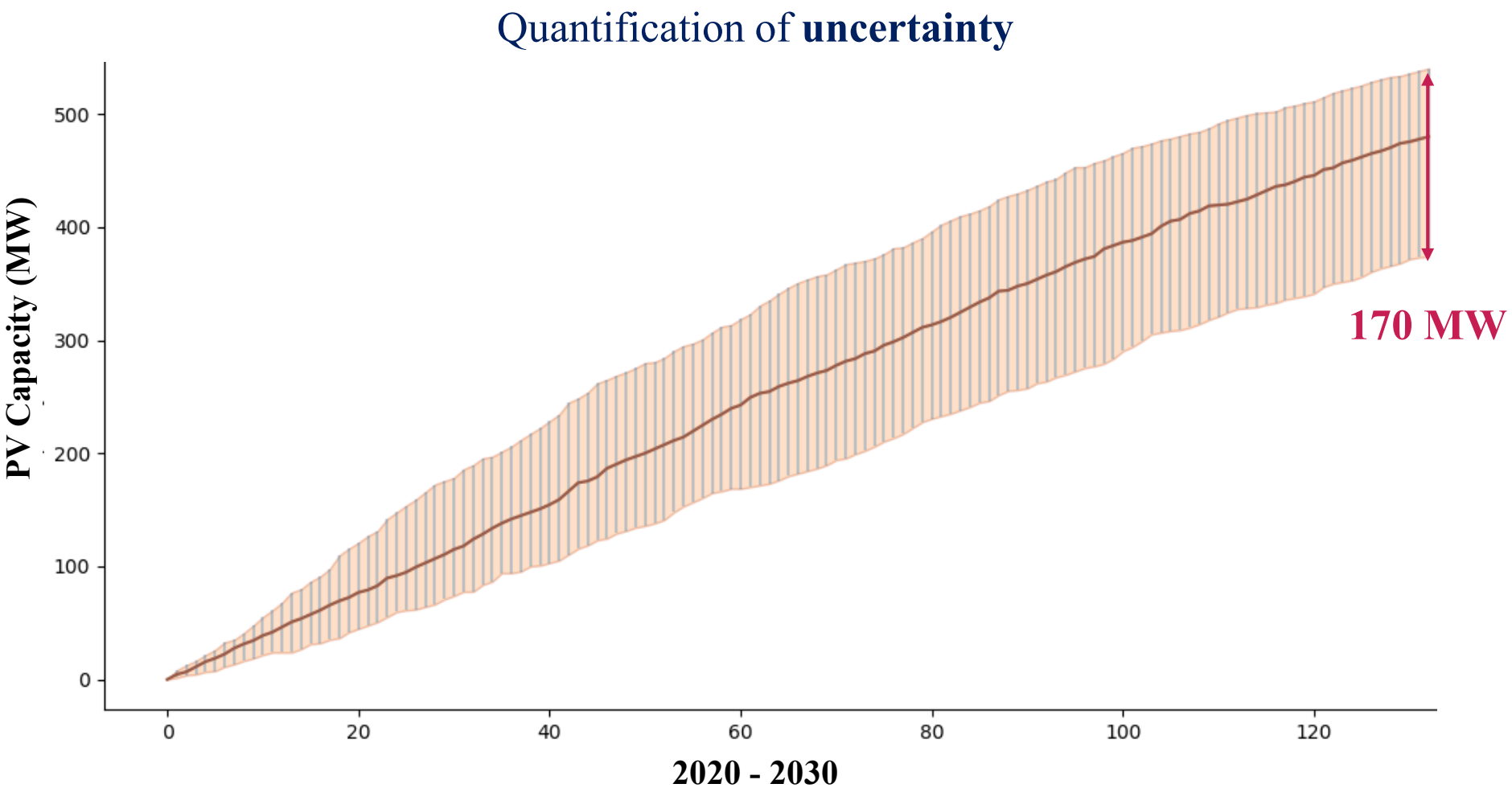


ATOM
Agent-based Technology Adoption Model

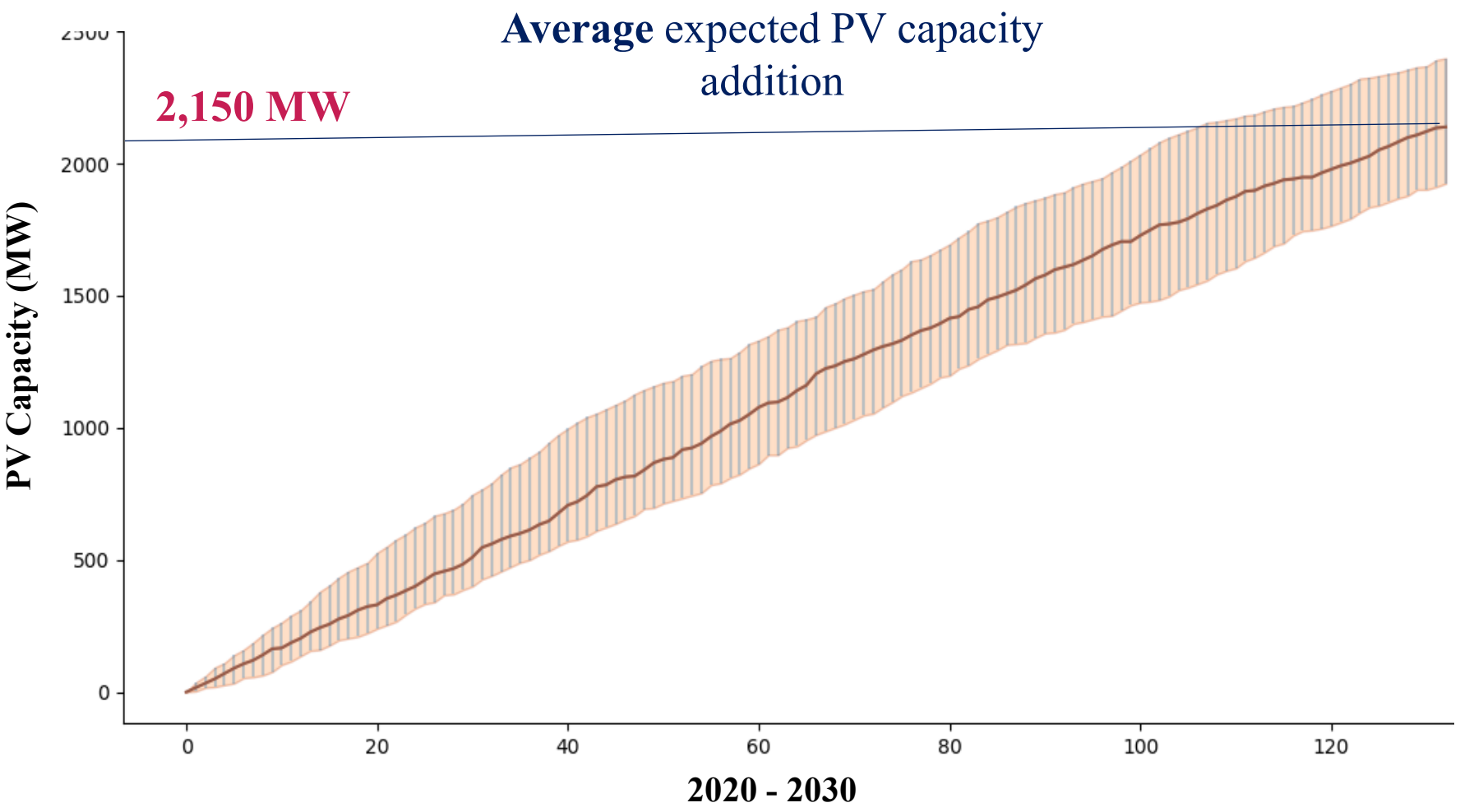
Results – Further adoption of small-scale PV in Denmark towards 2030



Results – Further adoption of small-scale PV in Denmark towards 2030



Results – Further adoption of small-scale PV in France towards 2030



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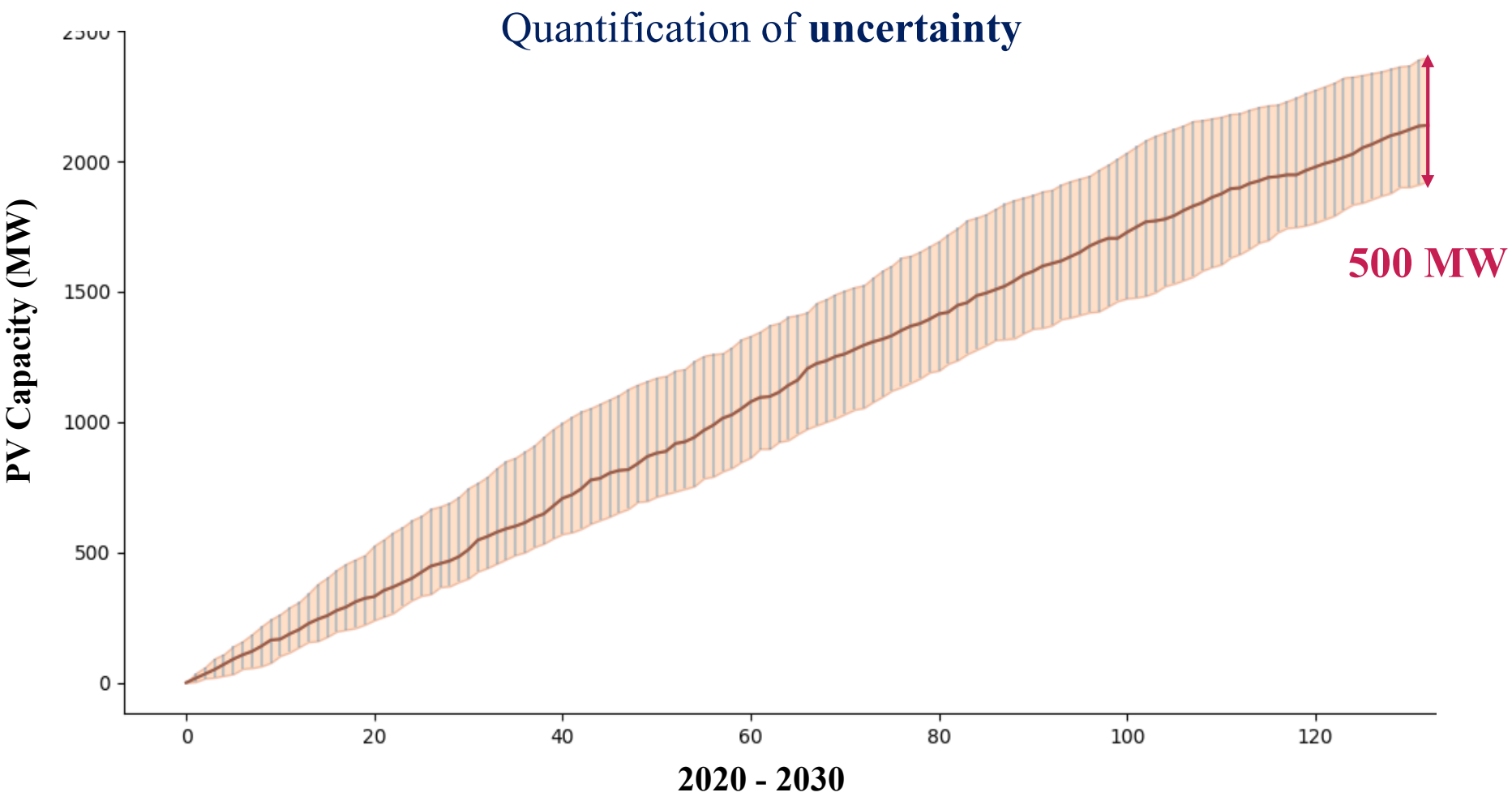
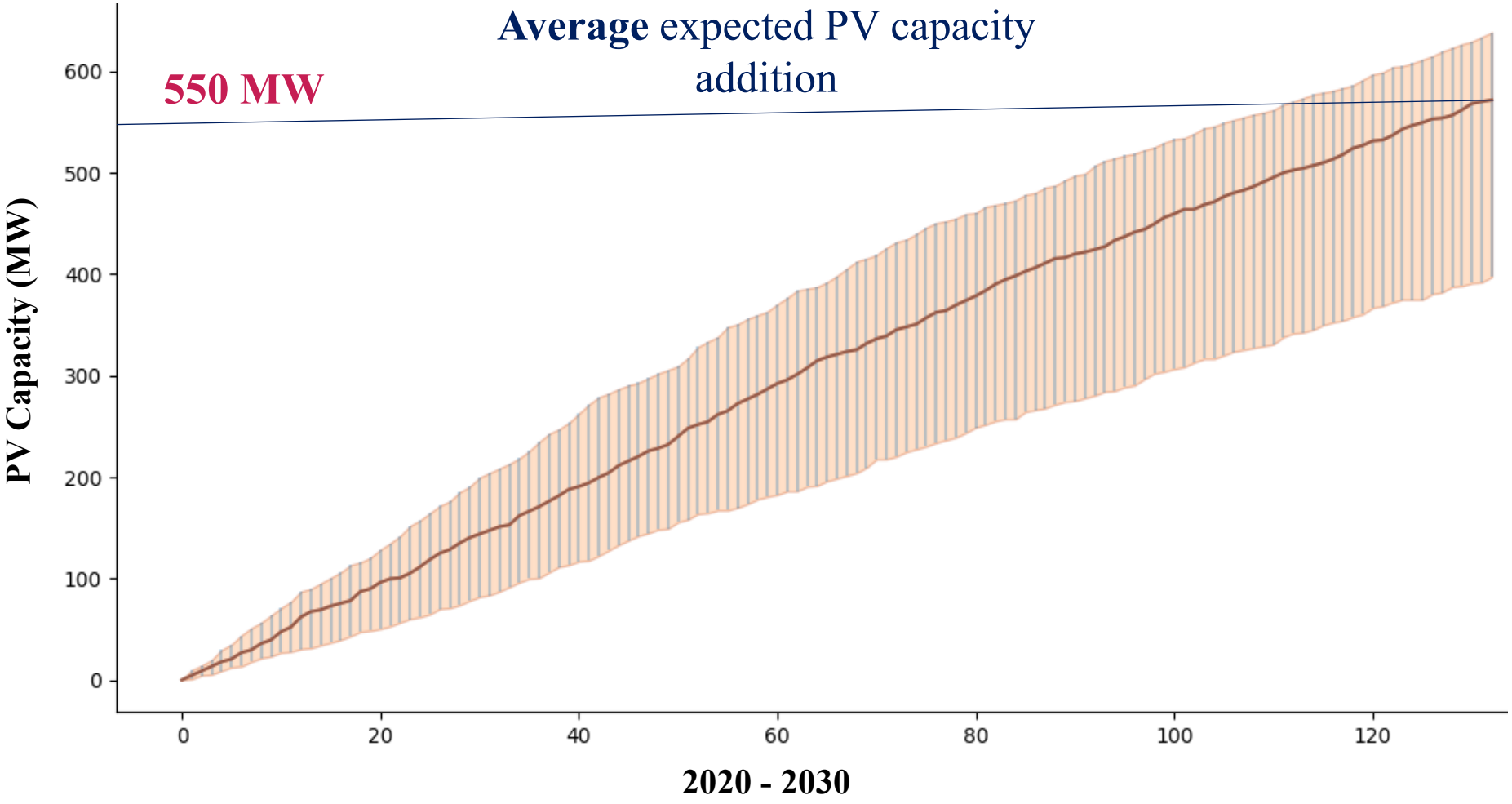
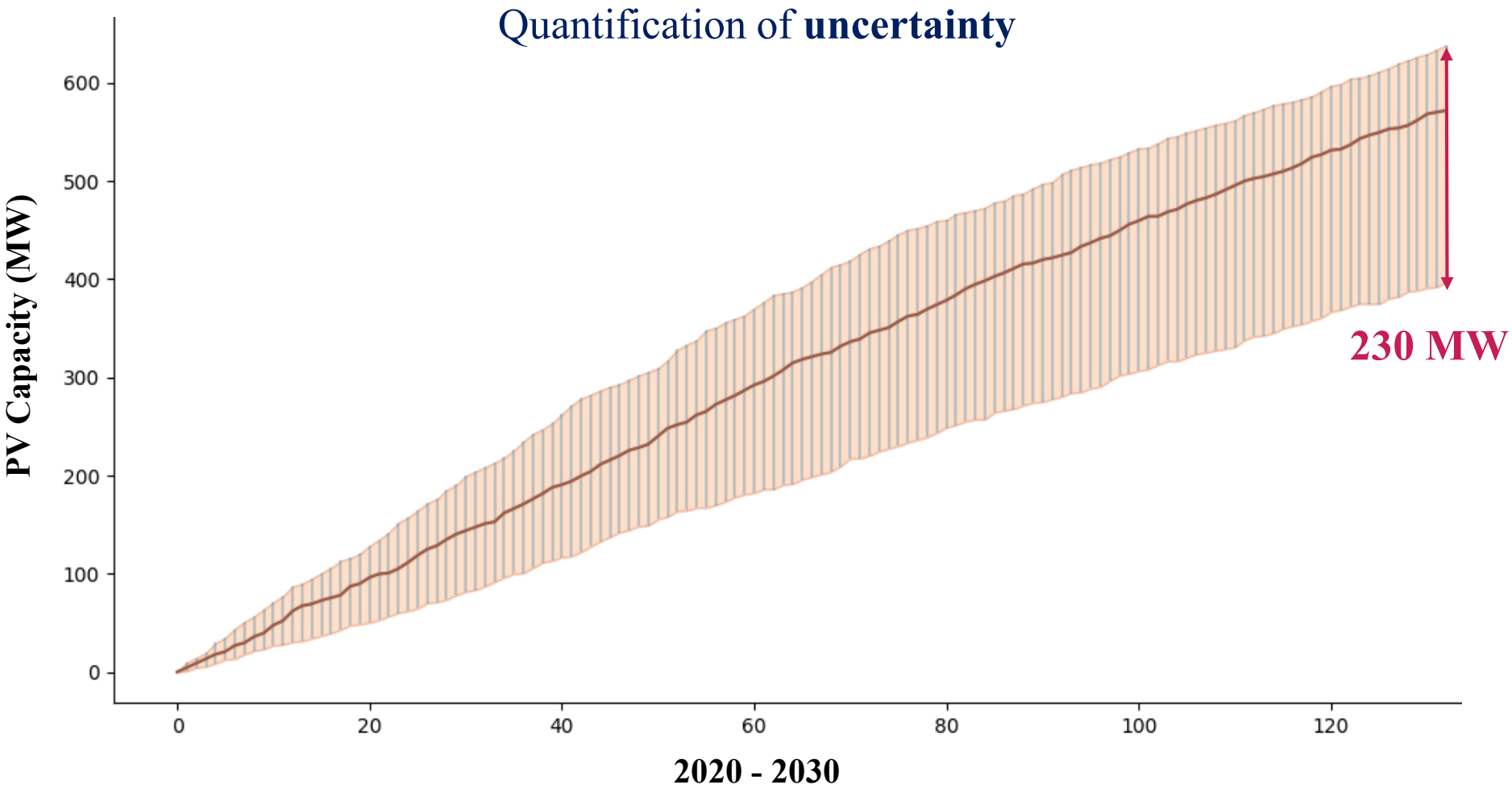
Results – Further adoption of small-scale PV in France towards 2030



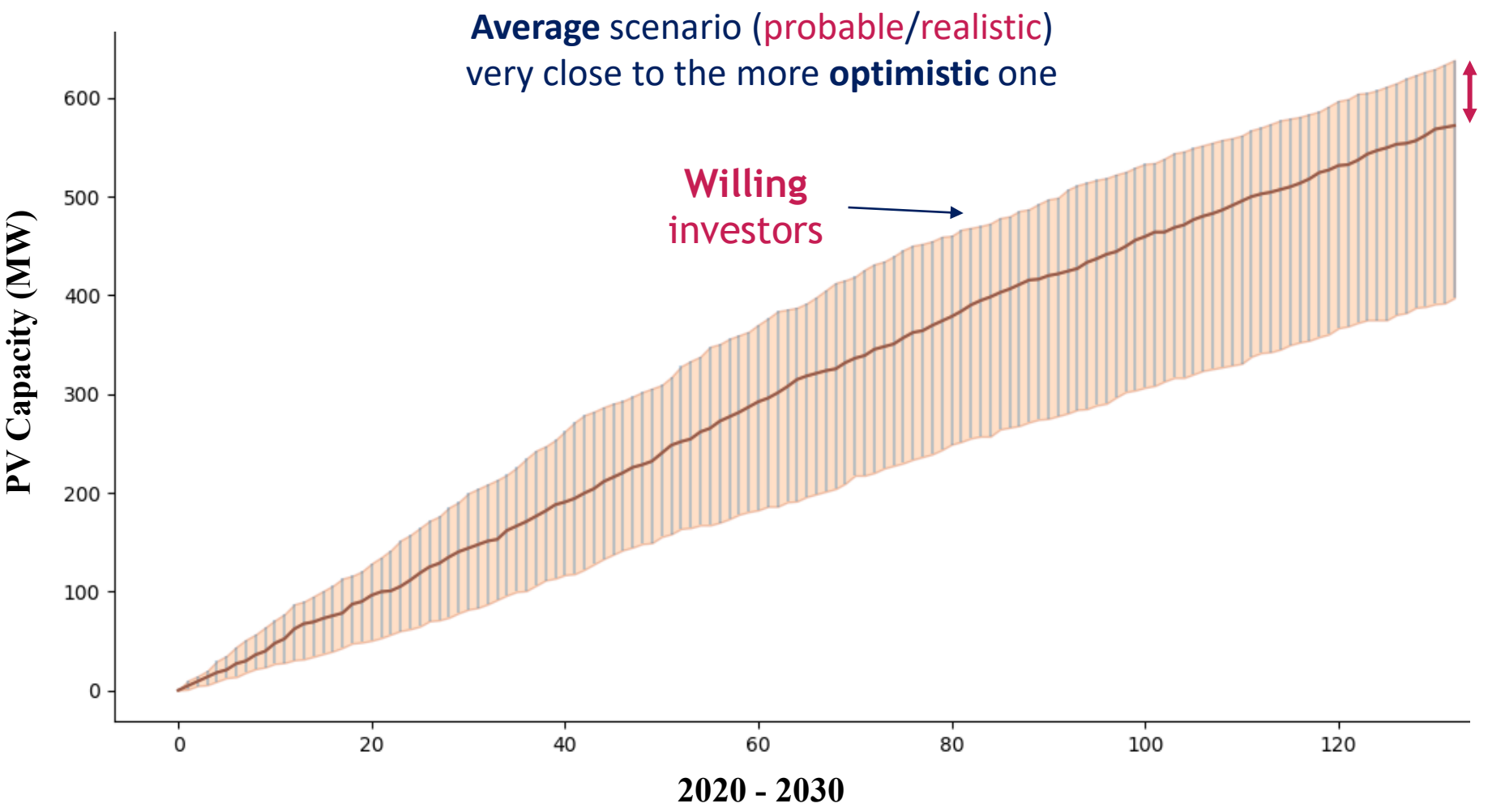
Results – Further adoption of small-scale PV in Greece towards 2030



Results – Further adoption of small-scale PV in Greece towards 2030



Results – Further adoption of small-scale PV in Greece towards 2030



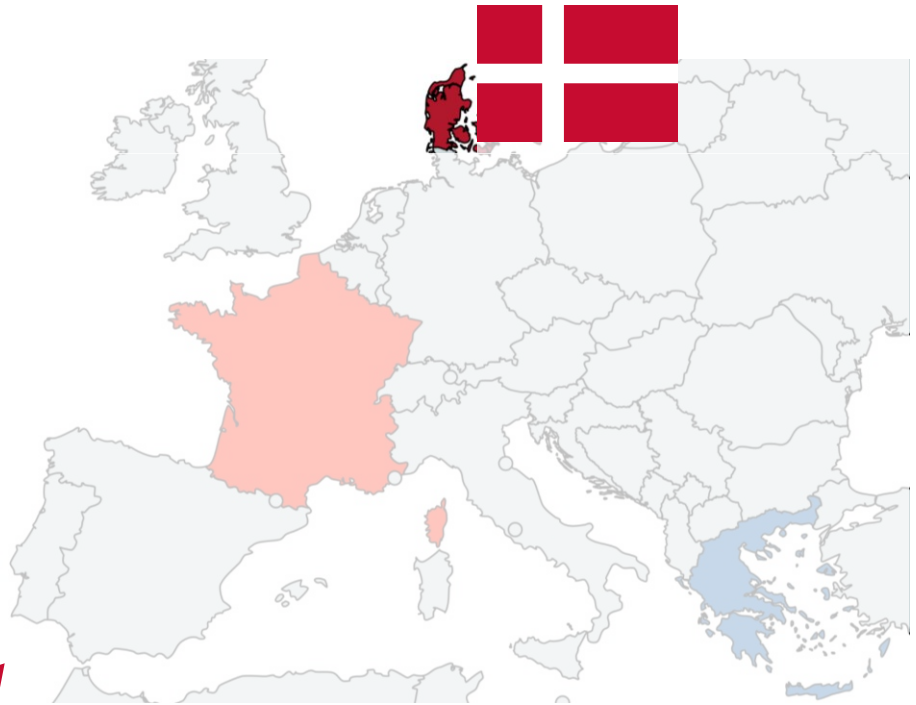
Conclusions & Implications for policy

Denmark

Results are very **encouraging**, demonstrating the country's **high** potential for a **switch** to a more **decentralized** electricity system

Public support of PV self-consumption with storage through an initial subsidy (25%) will lead to **economic** viability towards the **National targets** of **2030**

A **low** storage **subsidy** (e.g., 25%) is enough for consumers to **perceive** the **profitability** of their investment



A **switch** to individual **PV self-consumption** with **storage** seems **reasonable** and **viable**

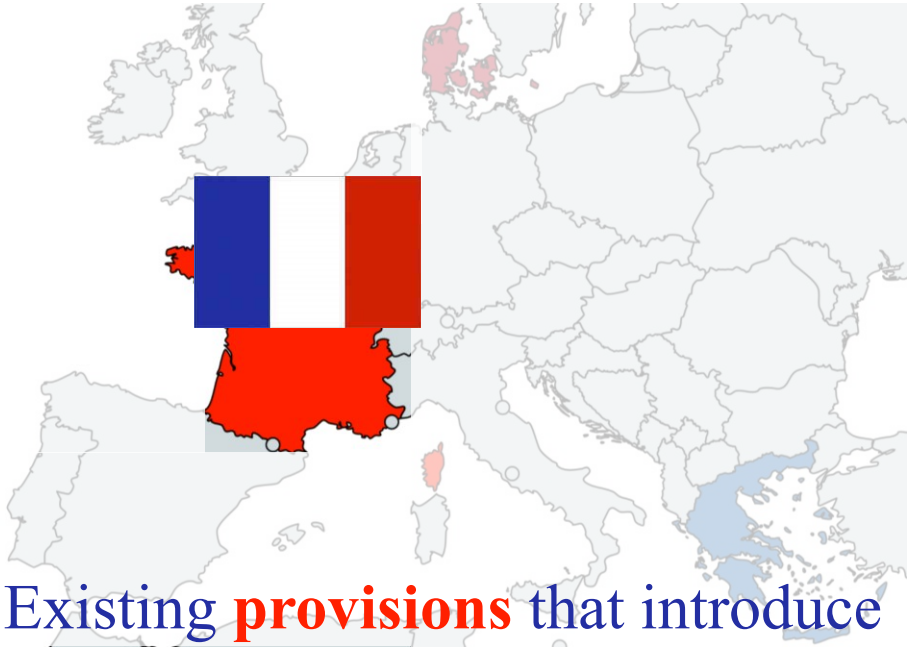
Conclusions & Implications for policy

France

France could be one of the **front liners** towards a European **decentralised** electricity system

Public support of PV self-consumption with storage through an initial subsidy (25%) will lead to **economic** viability towards the **National targets** of **2030**

A **low** storage **subsidy** (e.g., 25%) is enough for consumers to **perceive** the **profitability** of their investment



Existing **provisions** that introduce **PV storage** systems & **individual** self-consumption could become economically **viable**

Conclusions & Implications for policy

Greece

2030 National targets of small-scale PV are estimated at **620 MW** → the success of a self-consumption scheme seems **probable**

A **low** storage subsidy (e.g., 25%) may **not** be **enough** to **boost** the further diffusion of small-scale PV

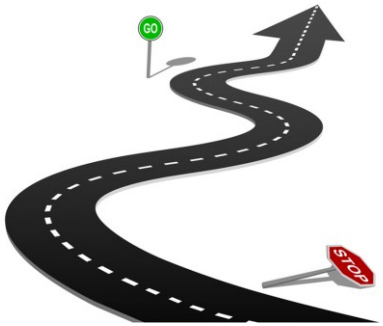
Higher levels of subsidization seem rather **infeasible** owing to implications of the economic **recession** of the past decade

National policy planning should focus on new & sustainable **business models** that will prove the economic **viability** of PV self-consumption with storage

Further Research: Need for Adaptive Policy Pathways … (1/3)

So …

… What should we do ???



Especially striving towards **National** RES **Targets** of **2030** & **2050**

Further Research: Need for Adaptive Policy Pathways … (2/3)

Considering uncertainty…

AIM
Adaptive Policymaking Model

Need for Adaptive Policy Pathways…

…incorporating multiple stakeholders' **perspectives** into modelling scenarios

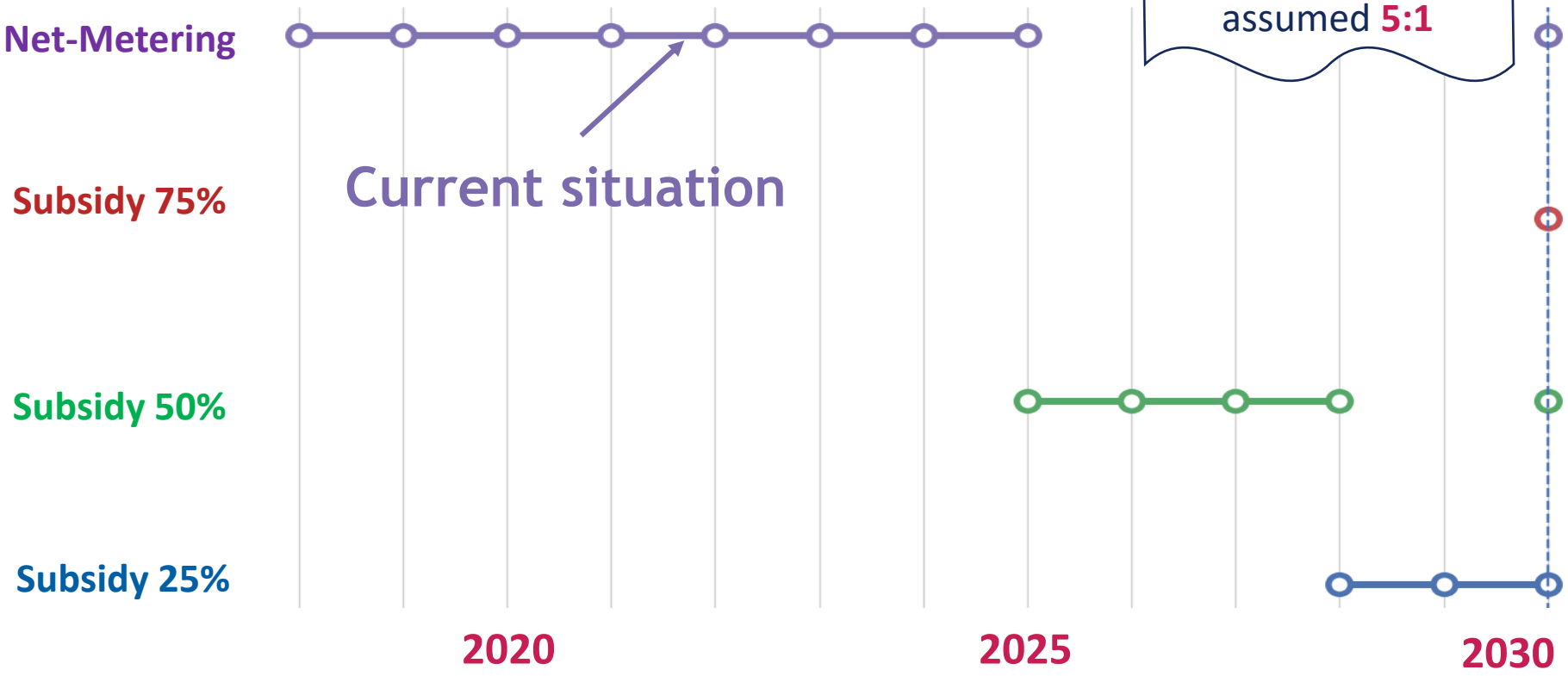
…visualizing **policy adaptation maps**, showing **alternative** pathways leading to **desired** policy **outcomes**

Further Research: Need for Adaptive Policy Pathways … (3/3)

Indicative example…

… towards **National** PV targets of **2030**

The **ratio** between large- and small-scale installations is assumed **5:1**



For more information…

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