cepe
Centre for Energy Policy and Economics
Swiss Federal Institutes of Technology

ETH zürich

Optimized market value of alpine solar photovoltaic installations

Jérôme Dujardin, Moritz Schillinger, Annelen Kahl, **Jonas Savelsberg**, Ingmar Schlecht, Rebecca Lordan-Perret

Introduction

Methodology

Results

Discussion

Electricity will be essential for decarbonization

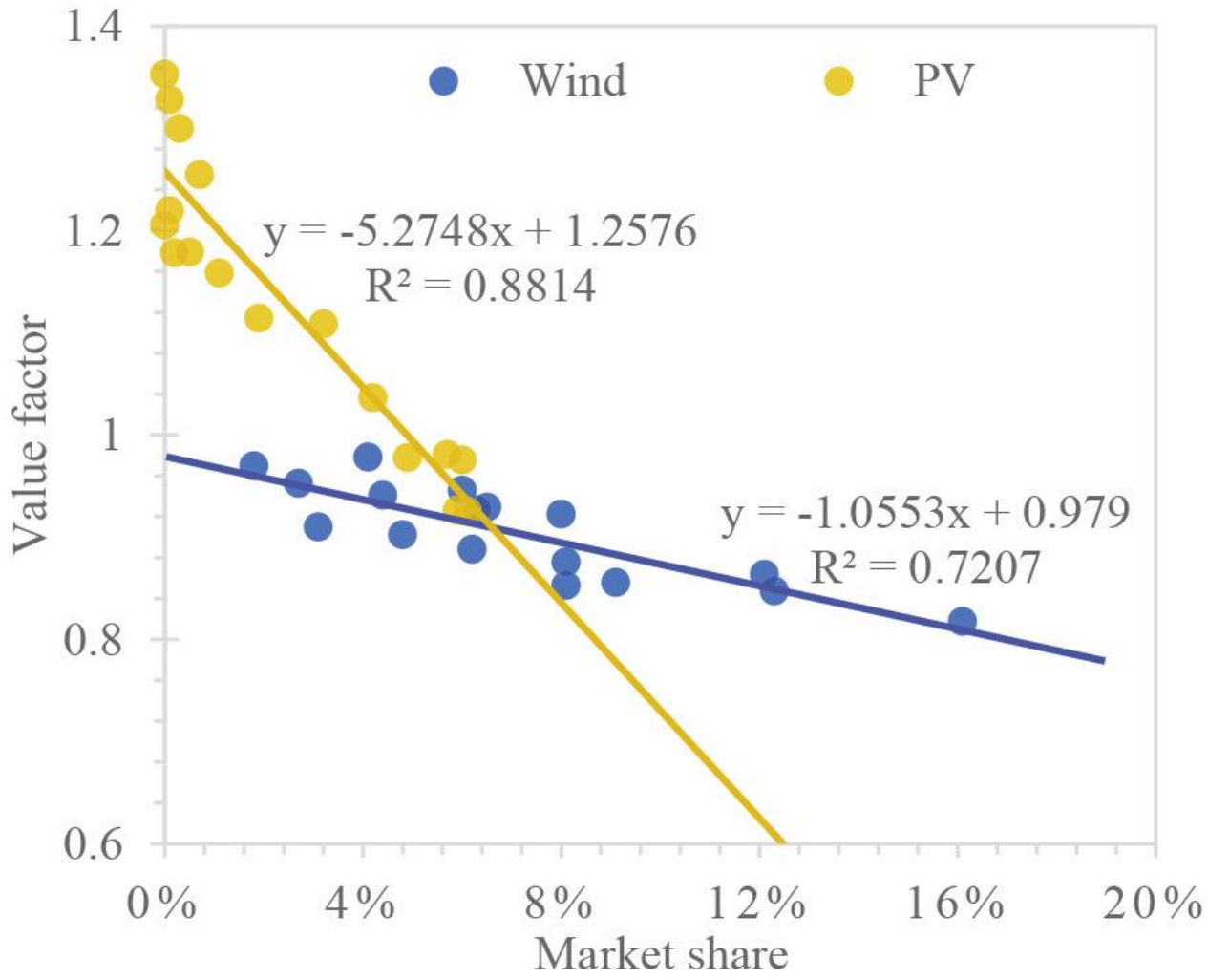
- Decarbonization following Paris agreement
- Electricity sector will play a leading role
  - expansion of renewable generation capacities
  - electrification of other sectors
- Solar PV expected to be one of the major drivers of the global expansion of renewable capacities
  - investment costs for solar PV panels have been falling rapidly and are expected to decrease further
  - solar power now cheaper than coal and gas in many countries

But the integration of high shares of renewable generation faces problems

- Temporally aligned generation results in a cannibalization of the market value of renewable generation

- At high levels of solar penetration, there is a mismatch between electricity demand and production, within the day and between seasons

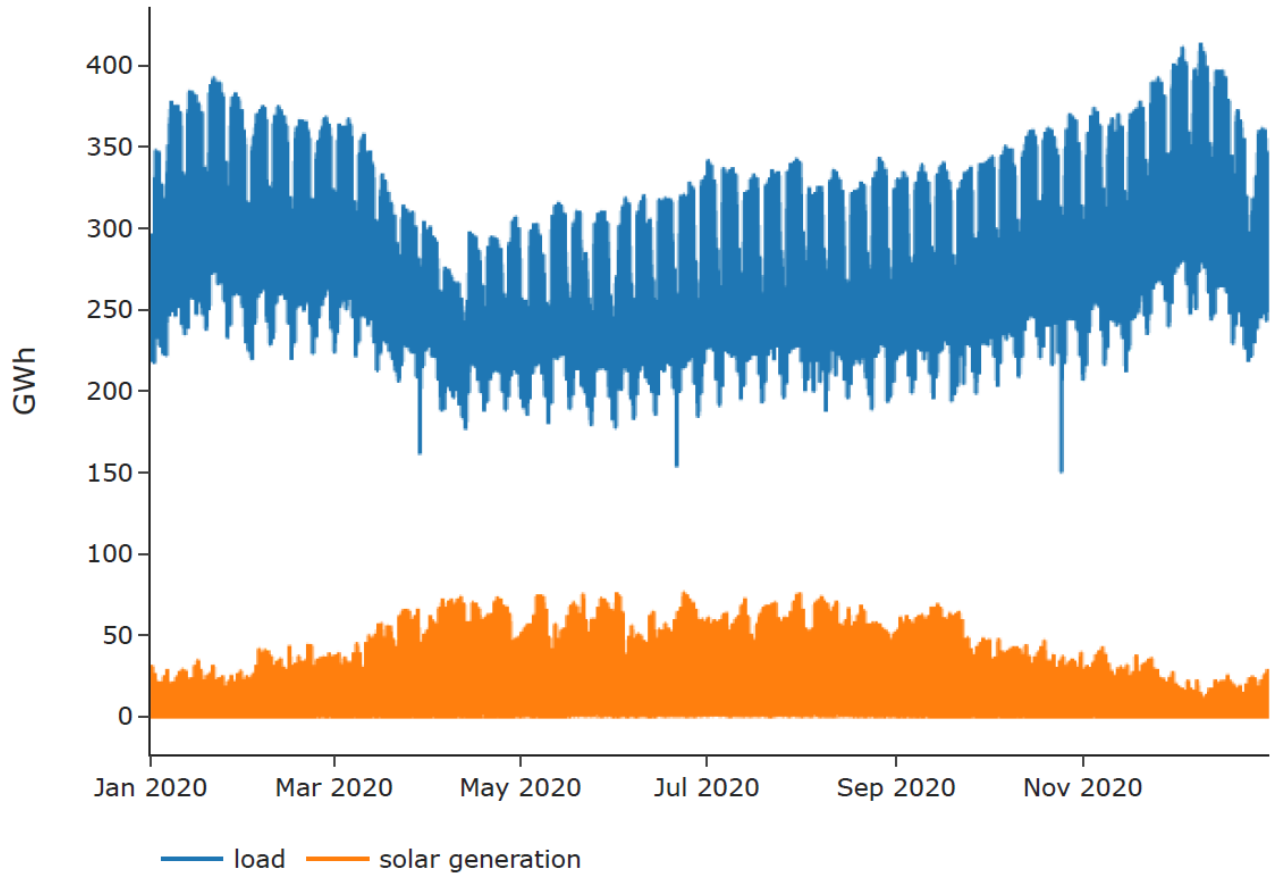
Cannibalization effect



The market value of wind power and solar power in Germany 2001-15, expressed as market value over average power price (Hirth & Radebach 2016).

There is a mismatch between solar generation and electricity demand

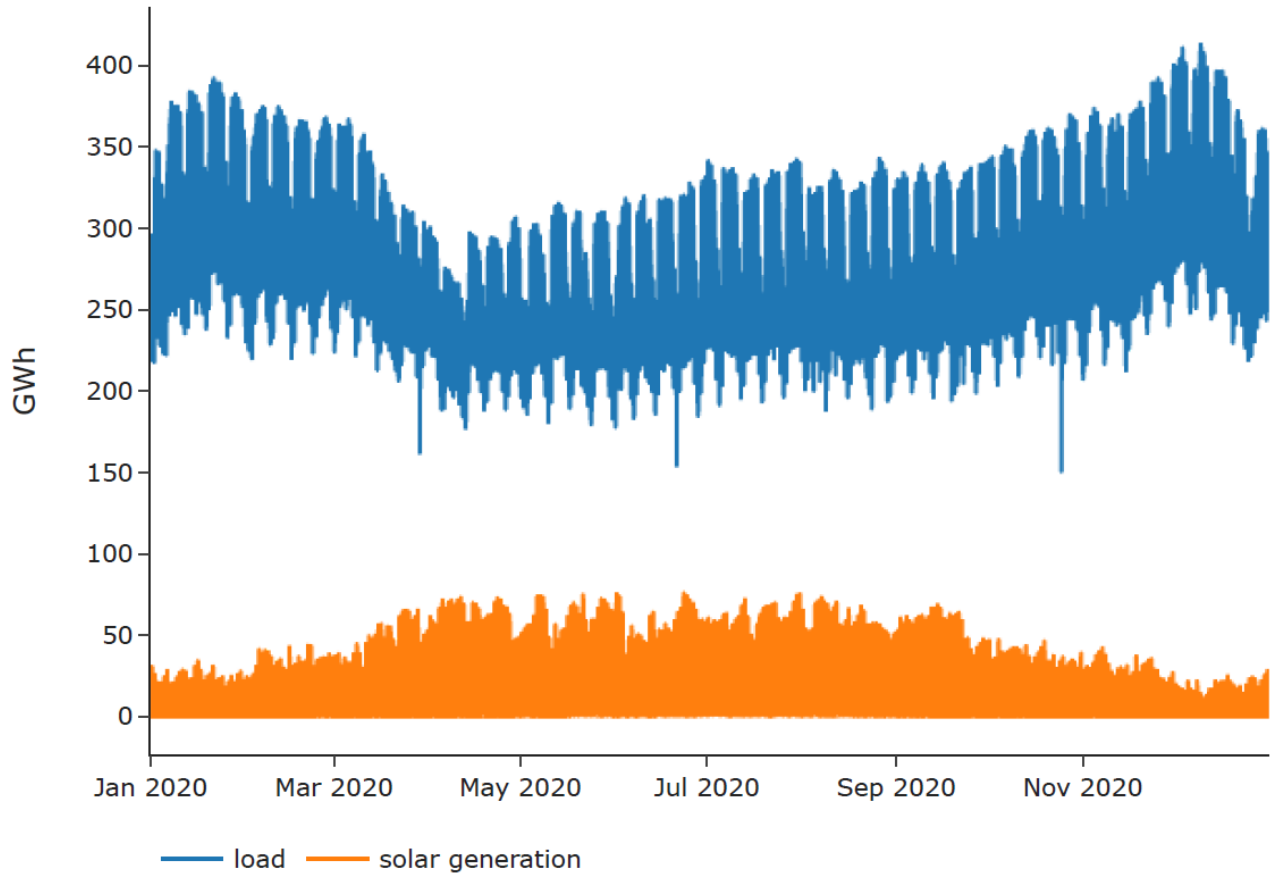
- Seasonal mismatches between high demand in the colder and darker winter months and high solar generation in summer
- Seasonal storage options, grid expansions or additional wind power capacity



There is a mismatch between solar generation and electricity demand

- Seasonal mismatches between high demand in the colder and darker winter months and high solar generation in summer
- Seasonal storage options, grid expansions or additional wind power capacity

- **Or placing solar PV in locations that have a different seasonal profile with a much higher level of winter production**



What we find

- Placement in mountainous regions increases market value due to increased winter production across all scenarios.
- This means less capacity is needed to reach same output.
- Most locations with high increases are in an alpine environment.

Introduction

Methodology

Results

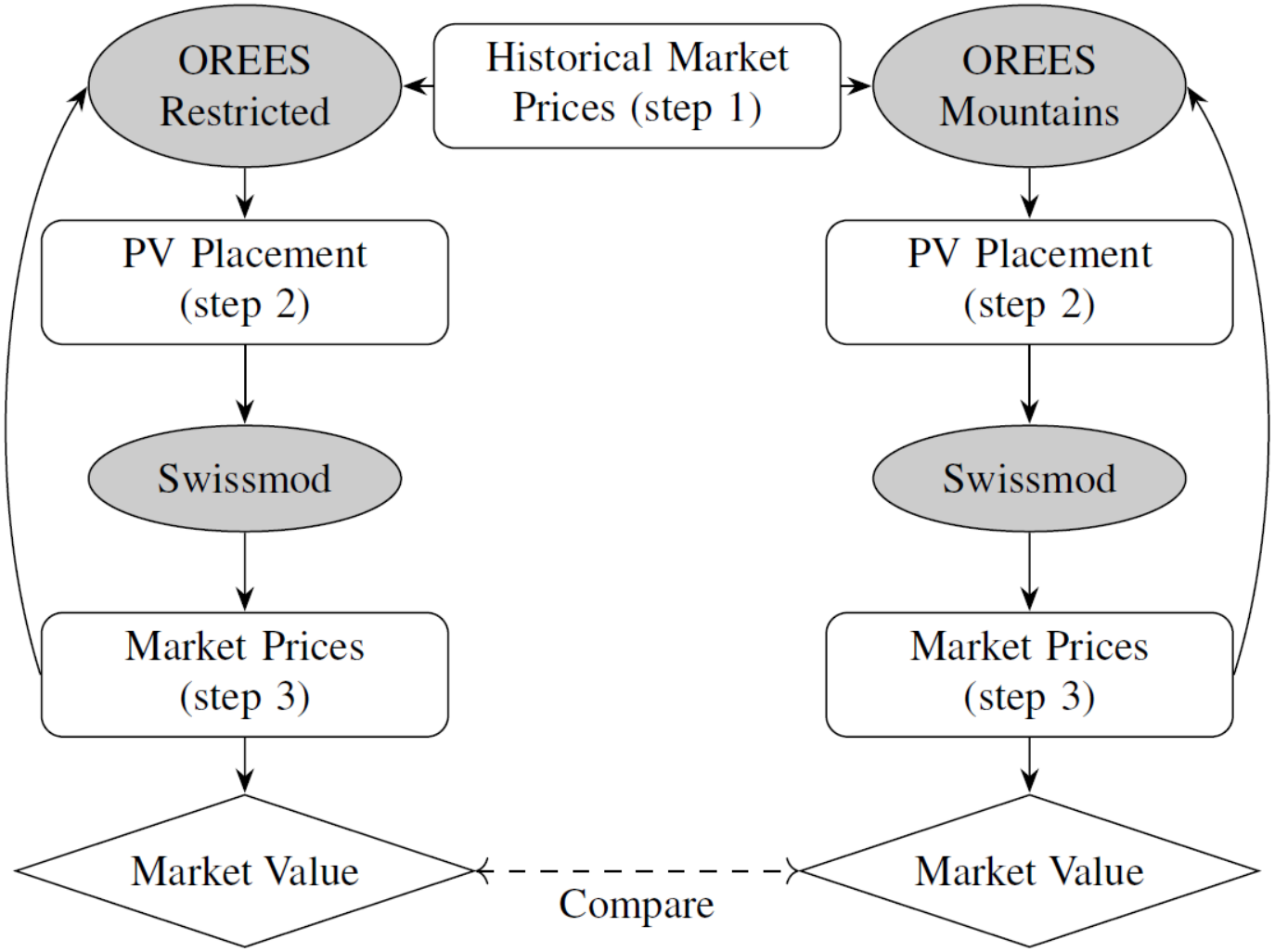
Discussion

Market value approach

- The Market Value and Cost of Solar Photovoltaic Electricity Production (Borenstein 2008, Hirth 2015) and combined analysis of wind and solar (Joskow 2011, Hirth 2013)

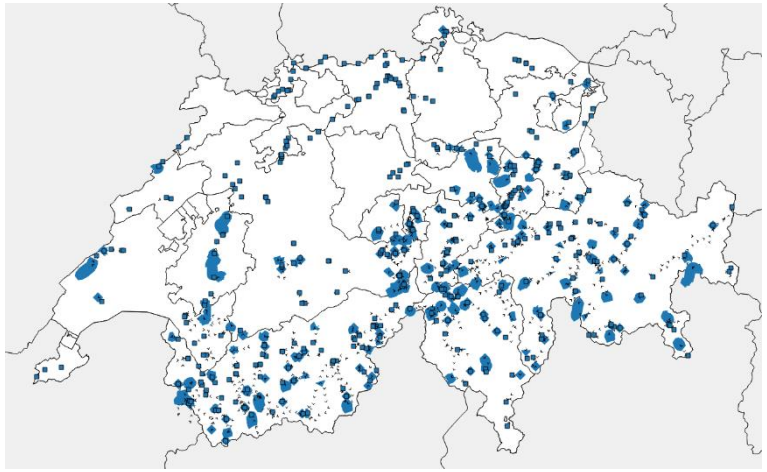
- Technical potential of mountain solar installations (Dujardin and Kahl 2018, Dujardin, Kahl and Lehning 2021)

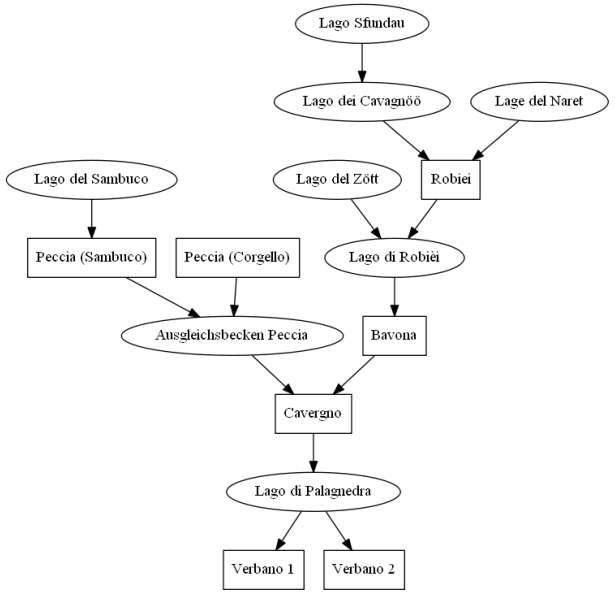
Model framework

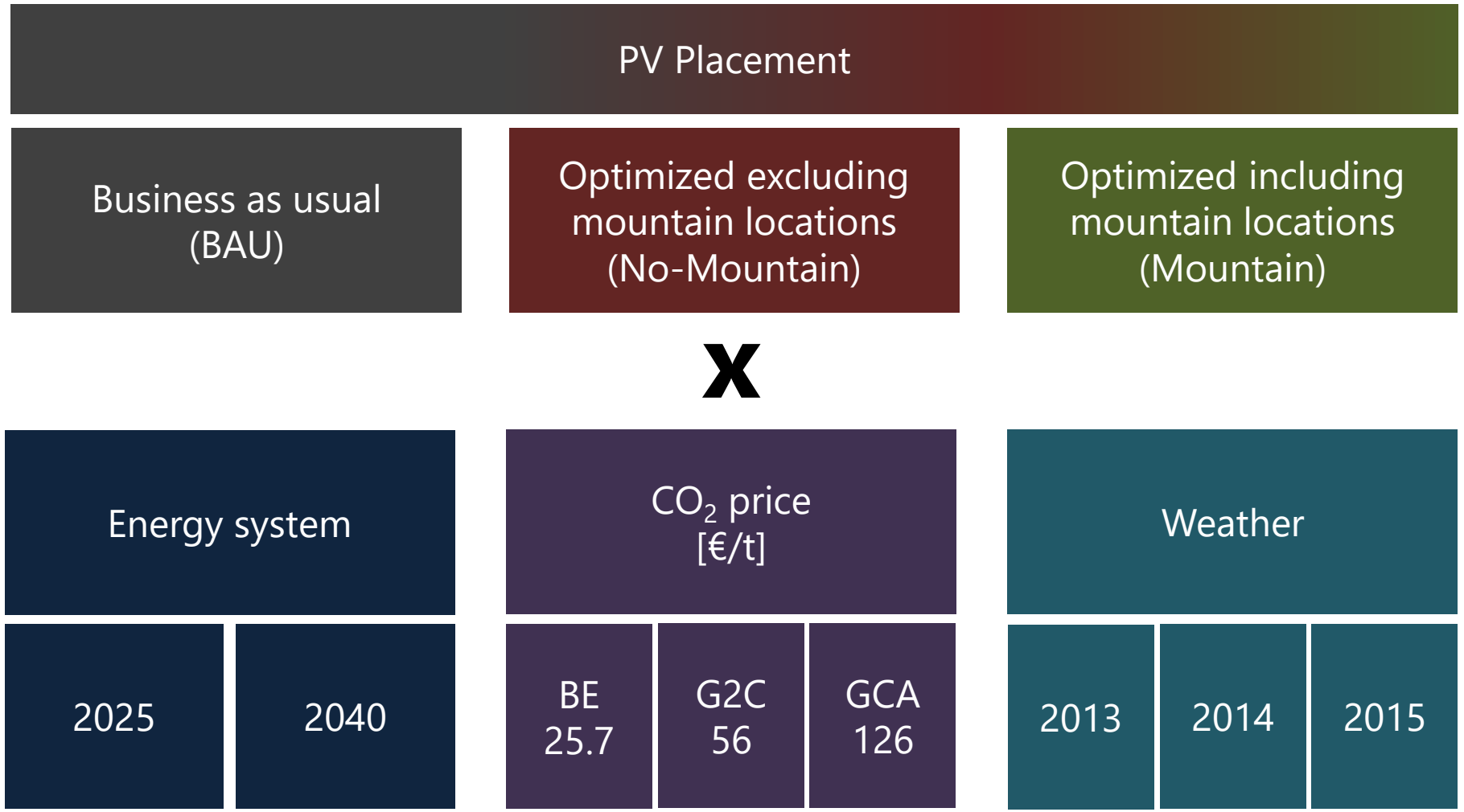


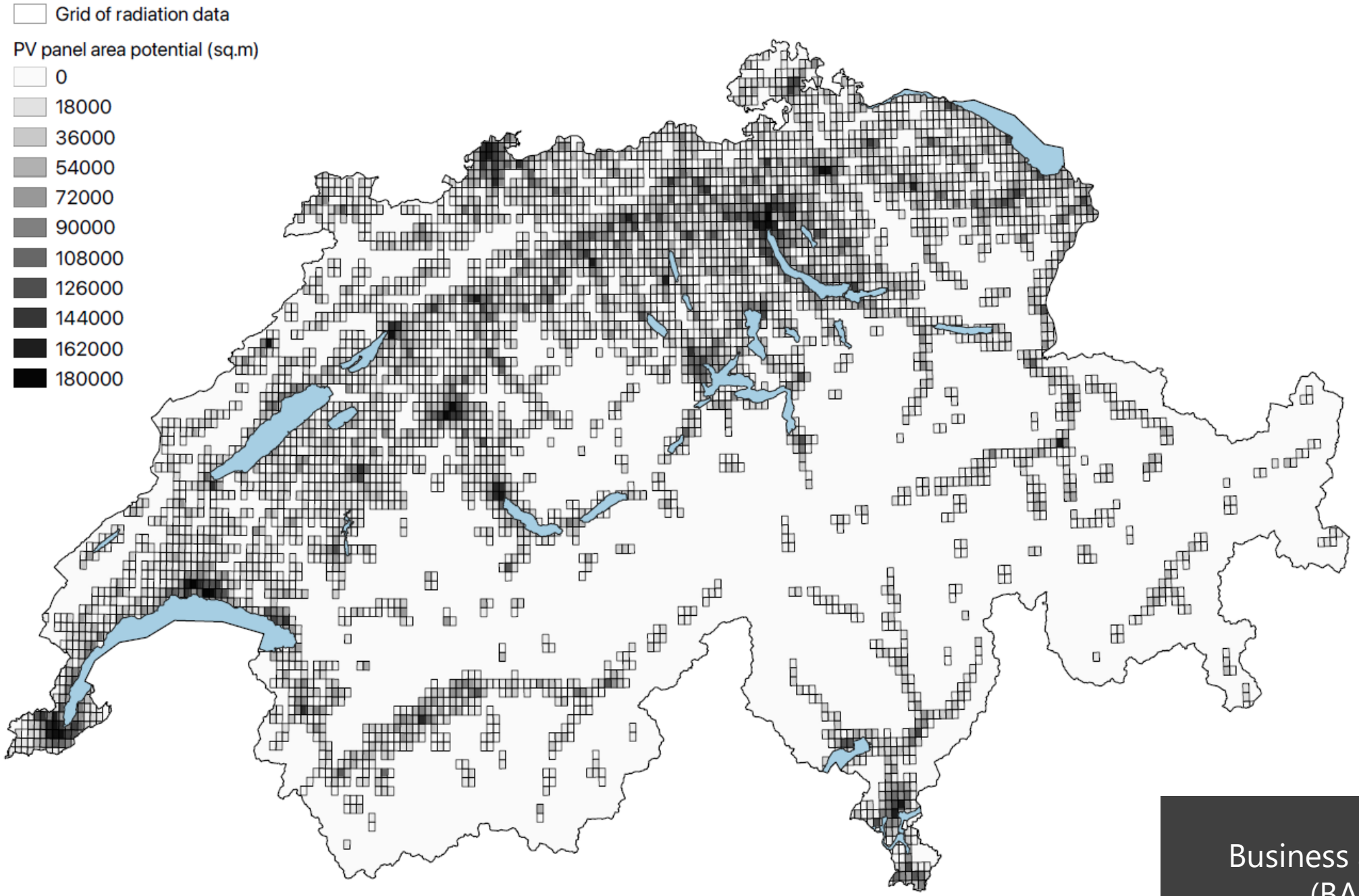
Model Framework

- Swissmod is a classical electricity market dispatch model
- Cost-minimization approach
- The model is deterministic, assumes a perfect competitive market with perfect foresight and considers a whole year
- Detailed hydro and renewable generation structures in Switzerland
- Aggregated generation structures for 19 European countries (neighbors and neighbors of neighbors)

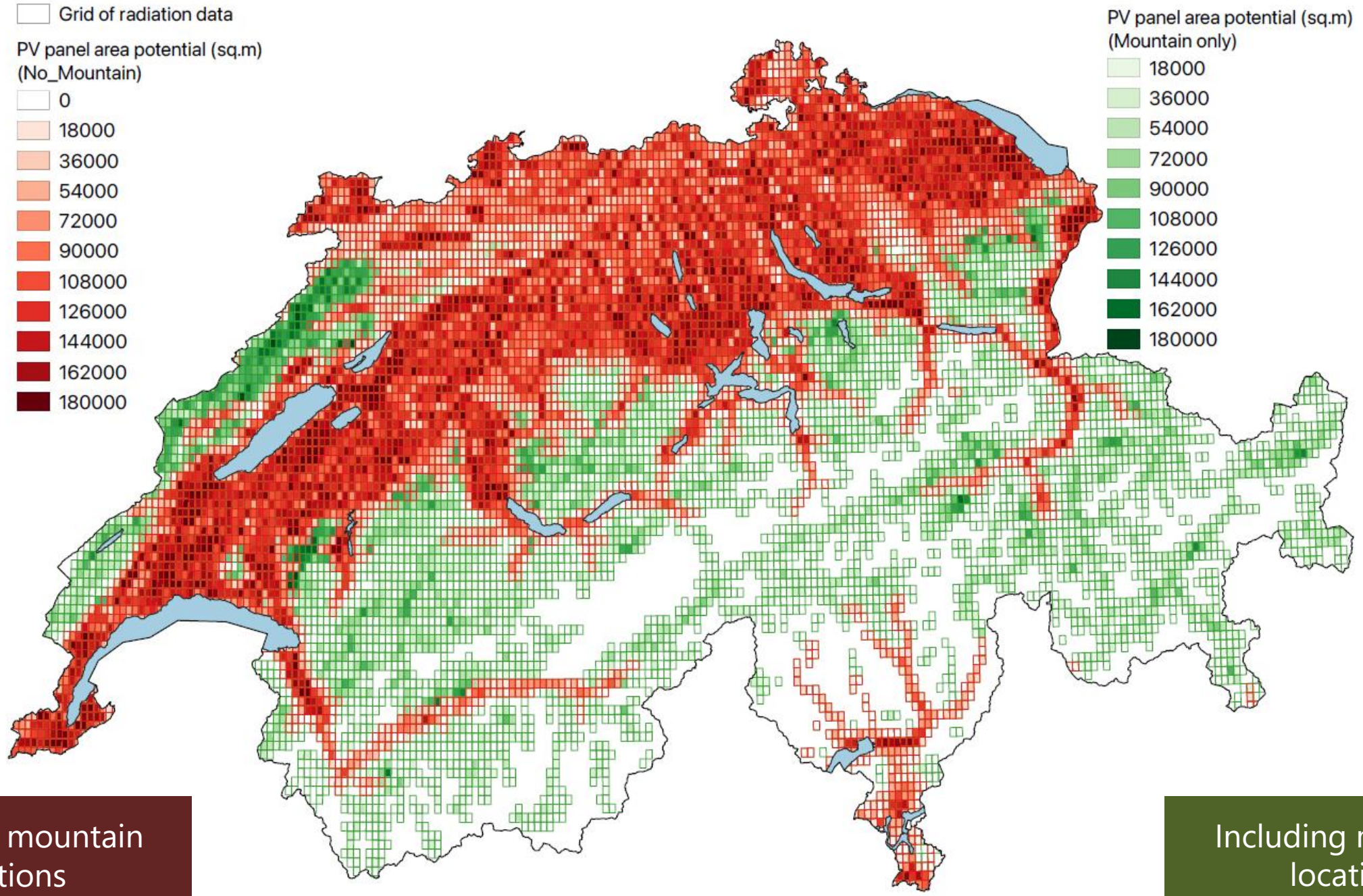





PV Placement
Business as usual (BAU)
Optimized excluding mountain locations (No-Mountain)
Optimized including mountain locations (Mountain)
X
Energy system
2025
2040
CO_2 price [€/t]
BE 25.7
G2C 56
GCA 126
Weather
2013
2014
2015



Business as usual (BAU)



Excluding mountain locations (No-Mountain)

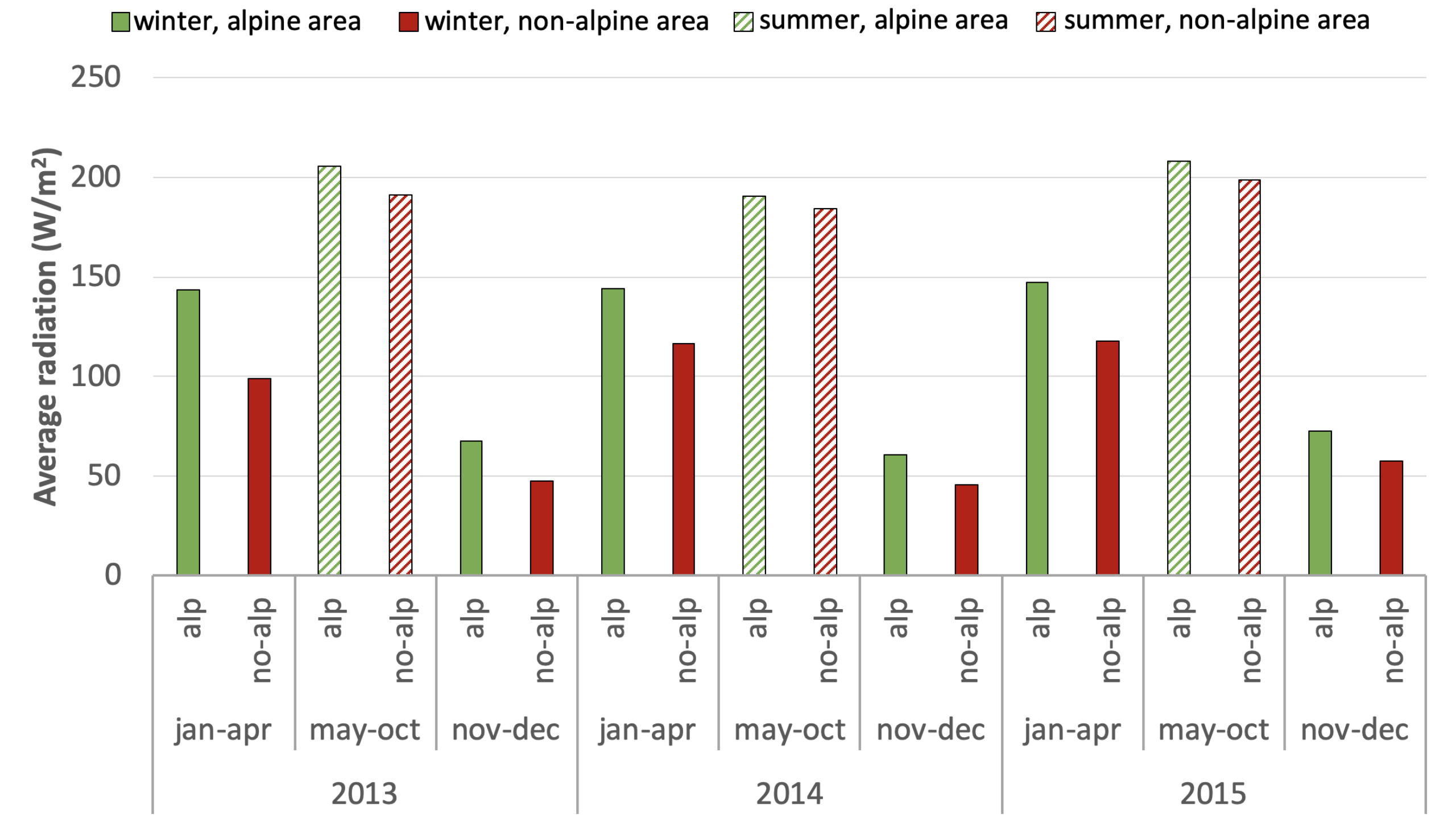
Including mountain locations (Mountain)

Introduction

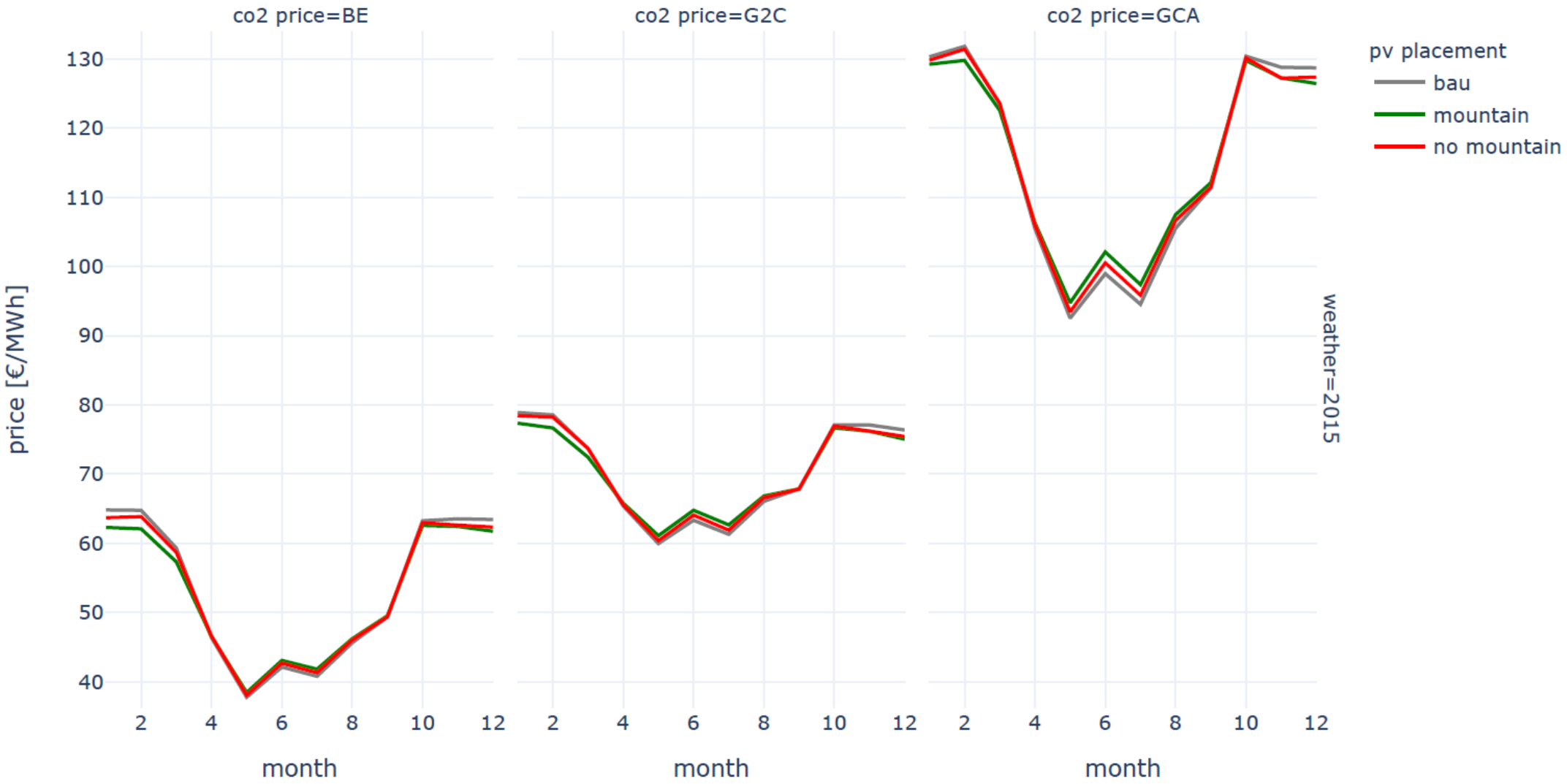
Methodology

Results

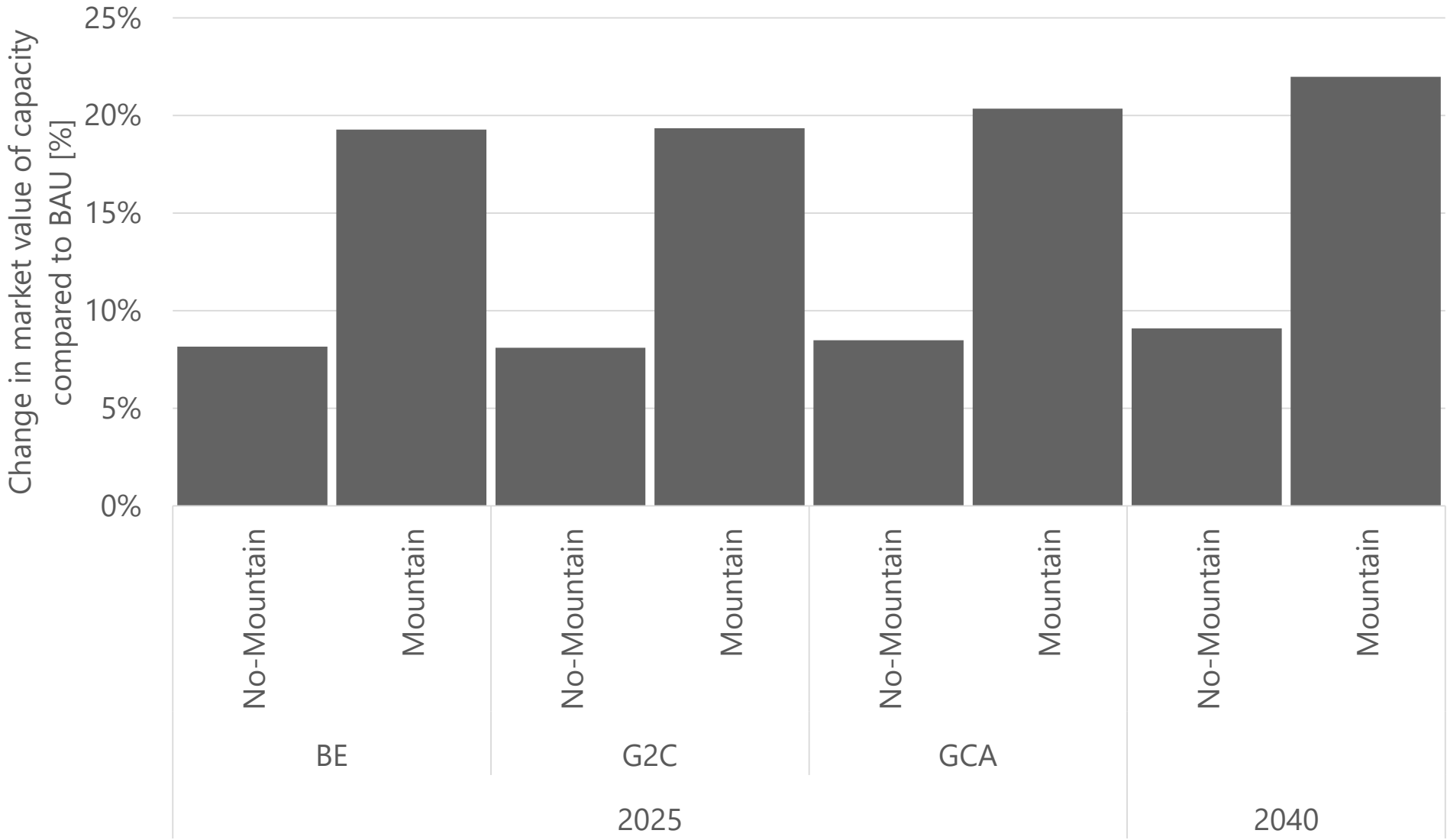
Discussion


winter, alpine area
winter, non-alpine area
summer, alpine area
summer, non-alpine area
Average radiation (W/m²)
250
200
150
100
50
0
alp
no-alp
jan-apr
may-oct
nov-dec
2013
2014
2015

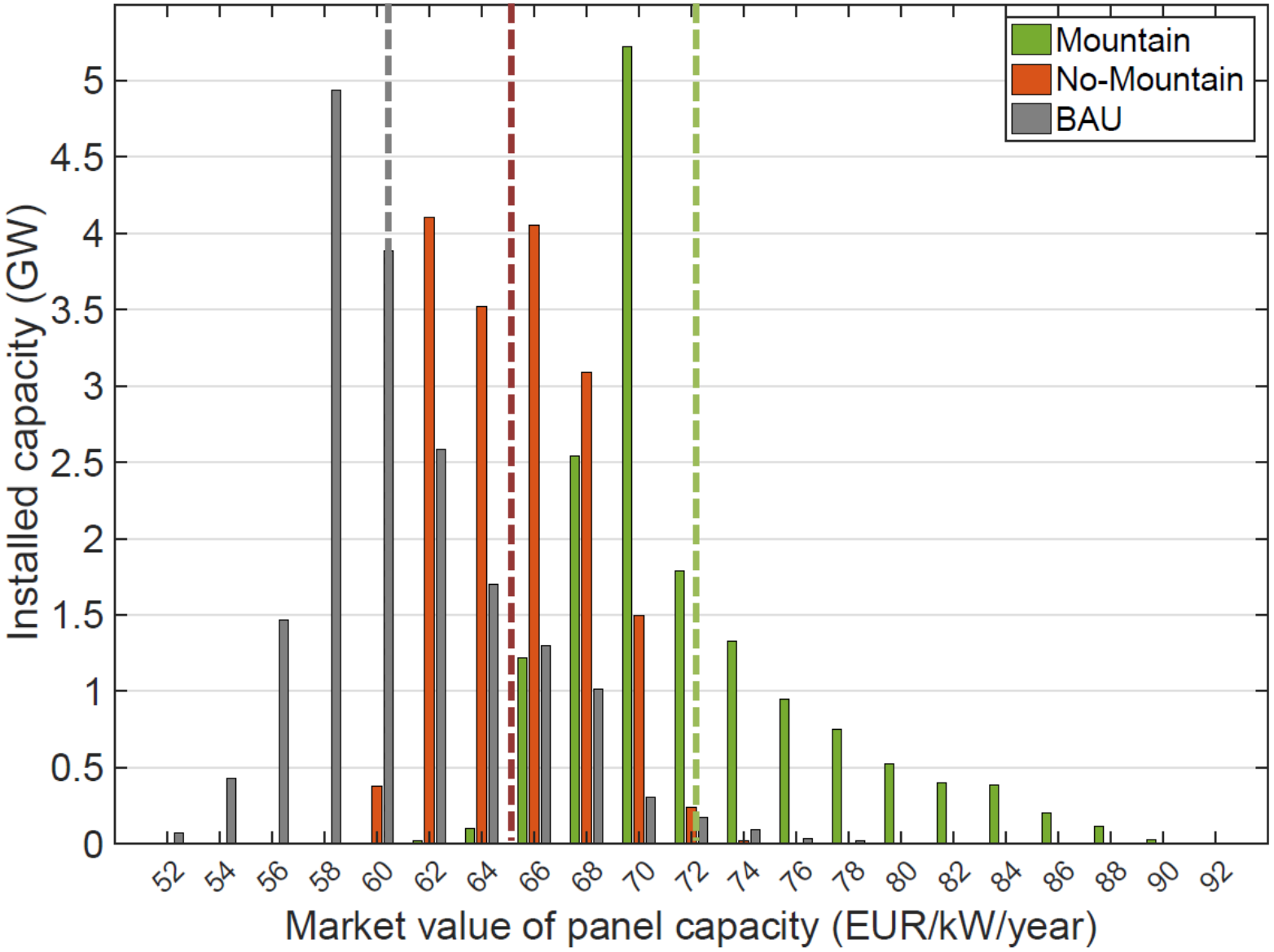
Electricity prices decrease in winter and increase in summer



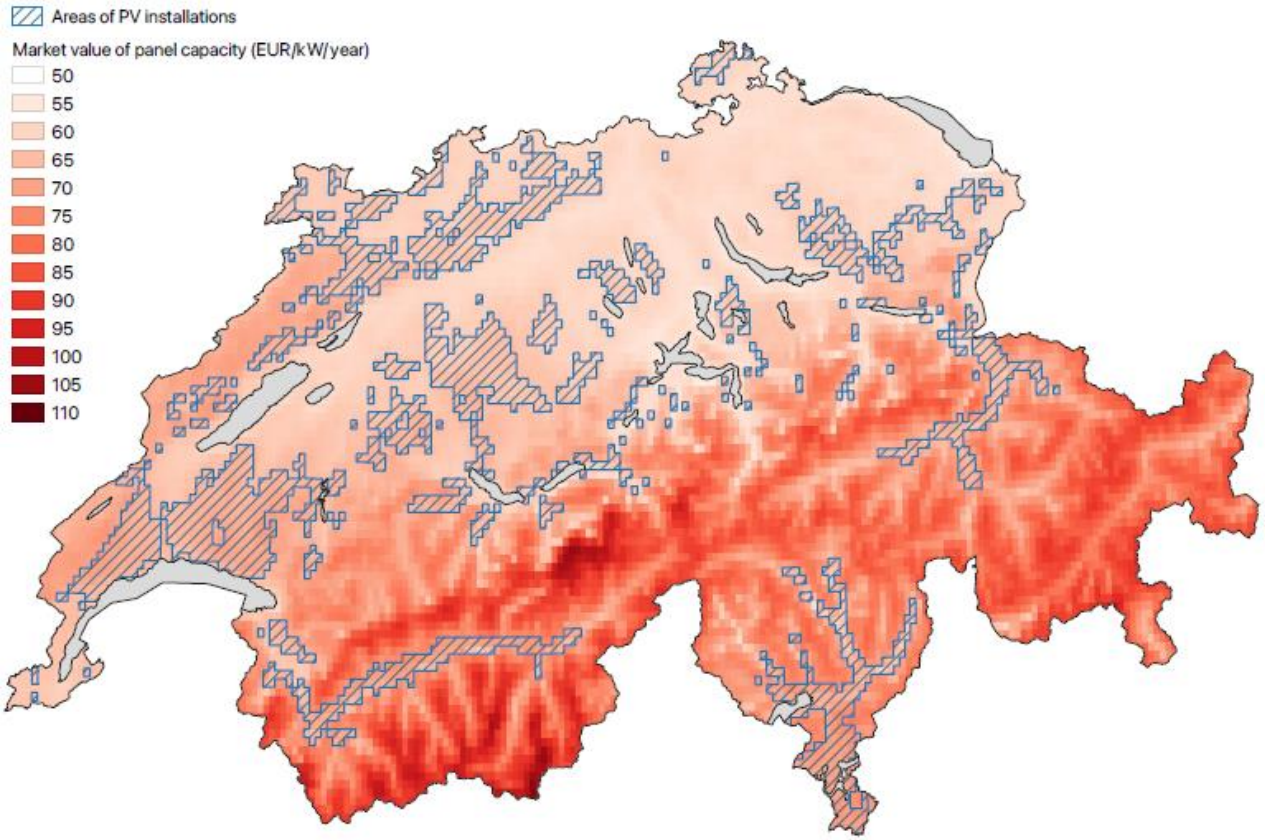
Mountain scenario increases market value



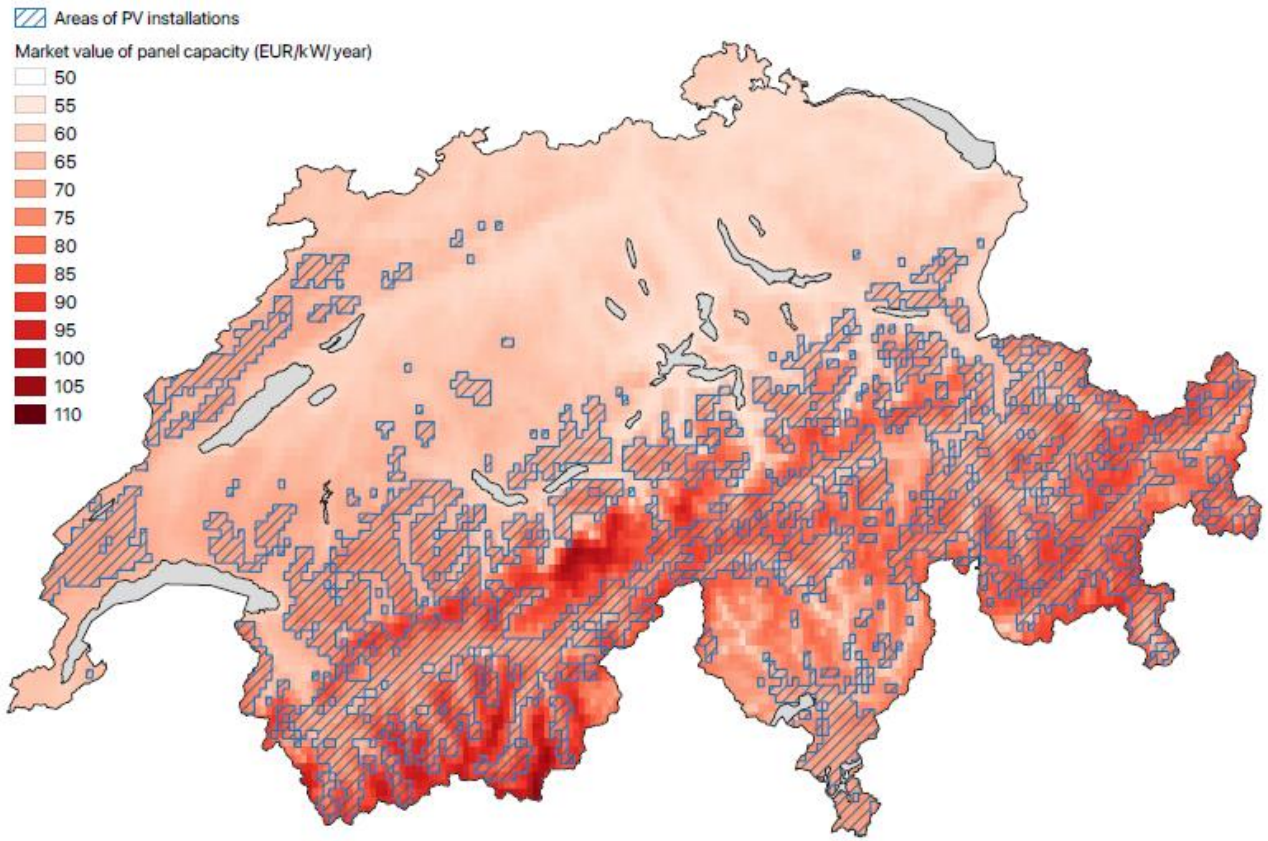
Distribution of market value is strongly shifted



Alpine capacities are fully used



2015 No-Mountain



2015 Mountain

Introduction

Methodology

Results

Discussion

Discussion

- We explored the effect of increased winter production on the market value of PV panels under different scenarios.
- Placement in mountainous regions increases market value due to increased winter production across all scenarios.
- Most locations with high increases are in an alpine environment.
- Cost-benefit assessment difficult to calculate due to high heterogeneity of investment costs.

Centre for Energy Policy and Economics
Swiss Federal Institutes of Technology

ETH zürich

Jonas Savelsberg

jsavelsberg@ethz.ch

https://sites.google.com/view/jonassavelsberg/