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Case Studies

Final Conference
June 2nd, 2023

Sandrine Charousset (EDF)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 835896

Objectives of Case Studies

- ❑ Objective 1 : Show the adequacy and relevance of the Open ENTRANCE platform
  - → Run models with assumptions and data of the OpenEntrance Scenarios
  - → Link OpenEntrance models together
  - → Use OpenEntrance tools for exploiting results
  - → …
- ❑ Objective 2 : Show the ability of the OpenENTRANCE approach to answer specific questions related to the evolution of the energy system.
  - → Specific focus : effects of decentralisation, variability, need for flexibility, real market functioning, integration of energy sectors, behaviour of individuals and communities of actors.
- ❑ Objective 3 : Feed the OpenENTRANCE database
  - → Complementary Inputs
  - → Results of Models runs
  - → …
- ❑ Objective 4 : Increase knowledge in the energy transition field
  - → Barriers and determinants,
- ❑ Objective 5 : Enhance methodologies for performing case studies in the fields of OpenENTRANCE

Case Study 1

Demand response in household electricity usage

Ryan O’Reilly, Energy Institute Linz
Pedro Crespo del Granado, Mostafa Barani, NTNU
Nadia Oudjane, Sandrine Charousset, EDF

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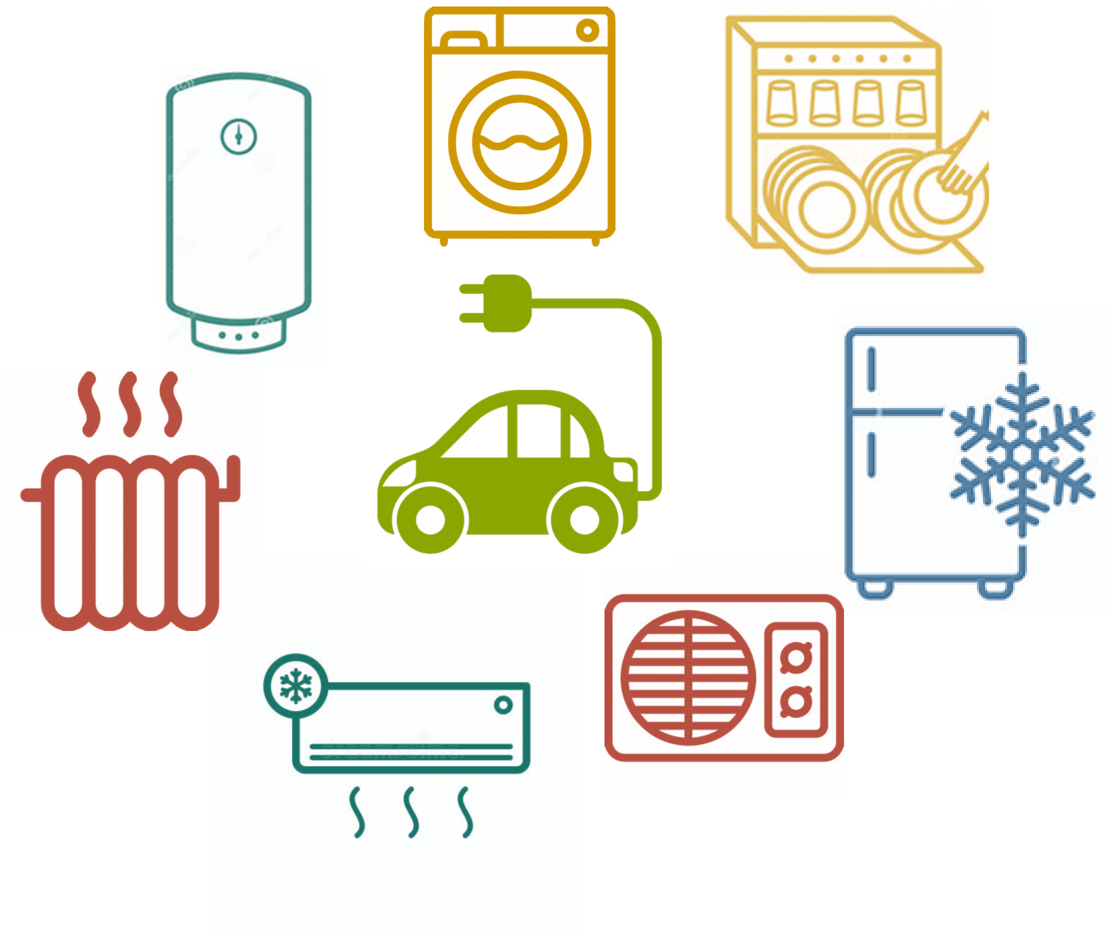
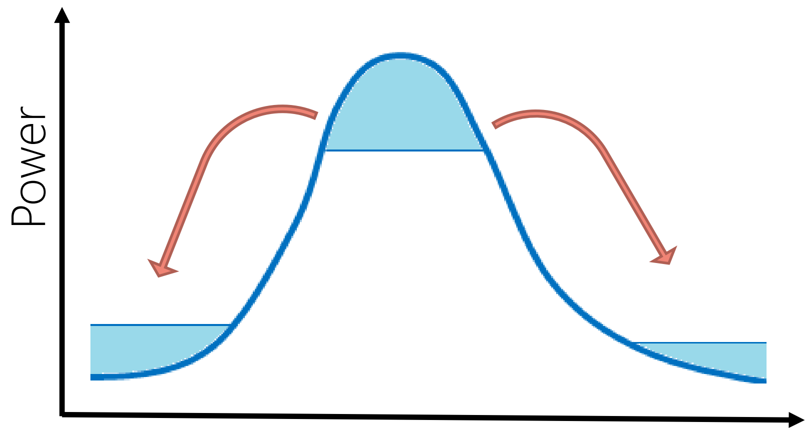
research and innovation programme under grant agreement No. 835896

Case Study 1: Demand response in household electricity usage



- What is the potential flexibility from demand response from household consumers taking into account the willingness of the population via a participation rate?
- Which impact on the integrated European electricity system operation and cost?
- Can it reduce investment needs?



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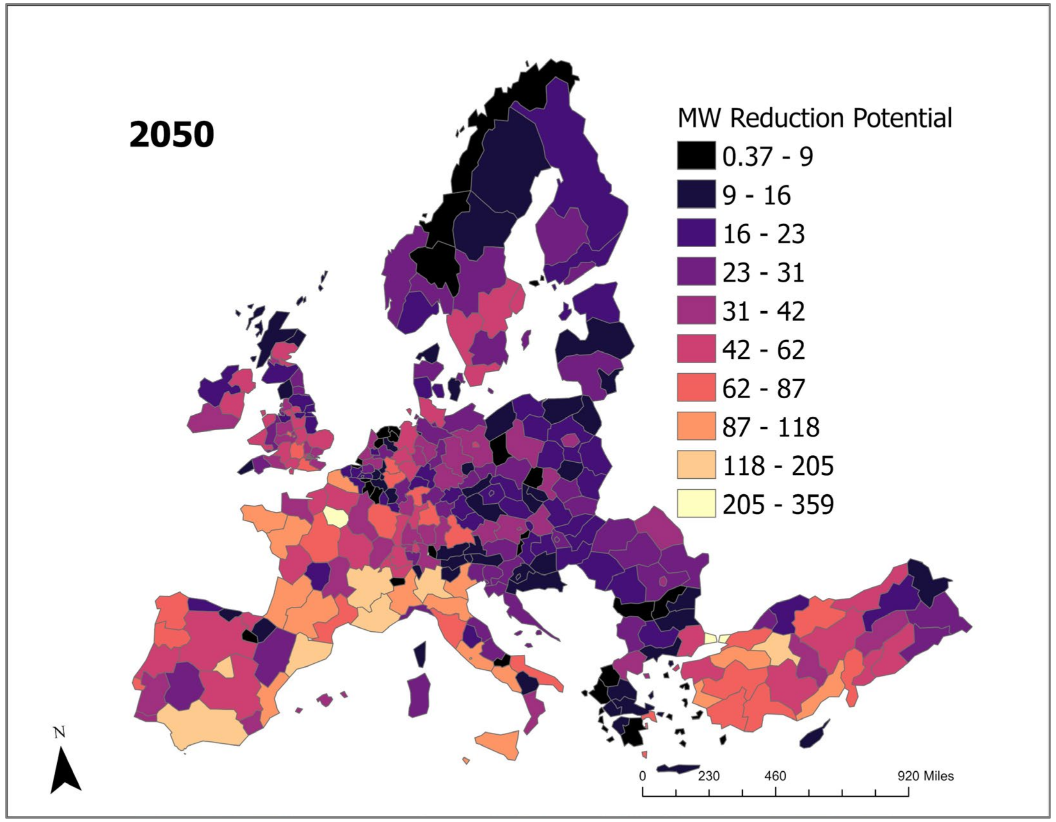
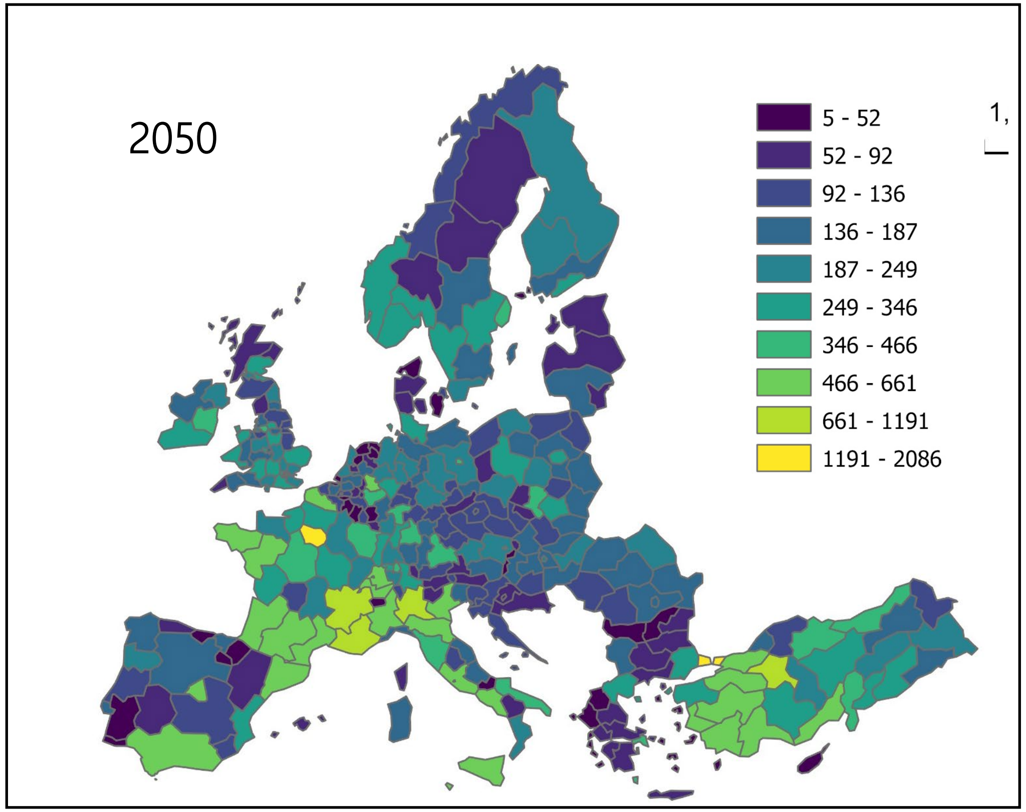
Case Study 1: Potentials of residential load control





Reduction = Delay potentials

2022: 7 GW

2050: 12 GW

Increase = Anticipation potentials

2022: 51 GW

2050: 67 GW

With 2022 participation rates

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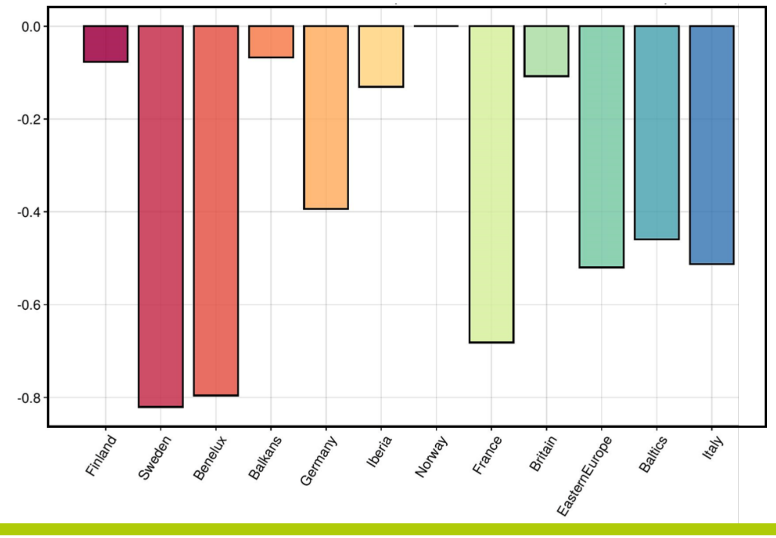
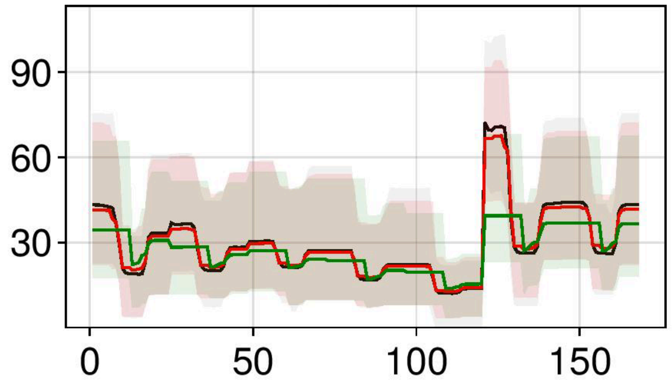
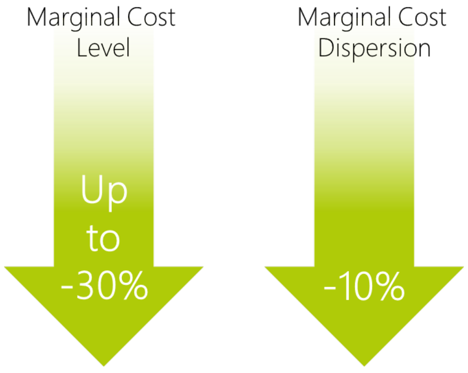
Household demand response reduces the operation costs by ~1% (2.5% with 100% participation) *(average on 40 climatic scenarios, 2050)*

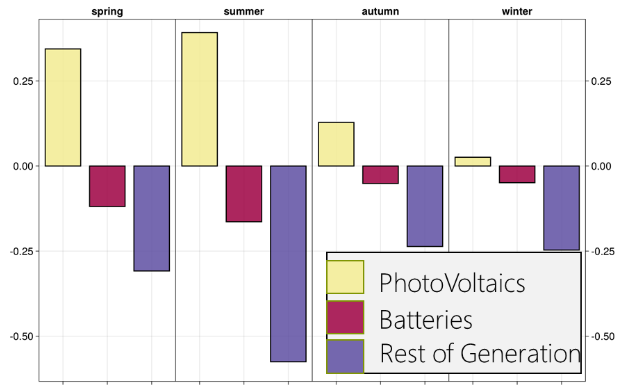


Household demand response reduces Marginal Costs Peaks and dispersion

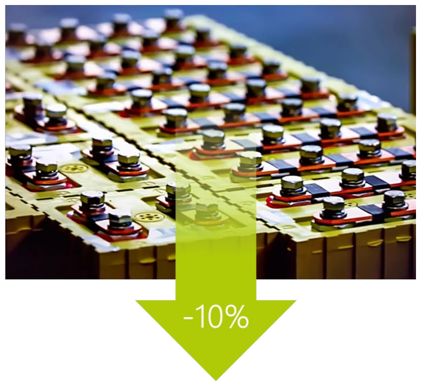




Household demand response reduces PhotoVoltaic generation curtailment



Household demand response reduces the need for battery storage and traditional power generation



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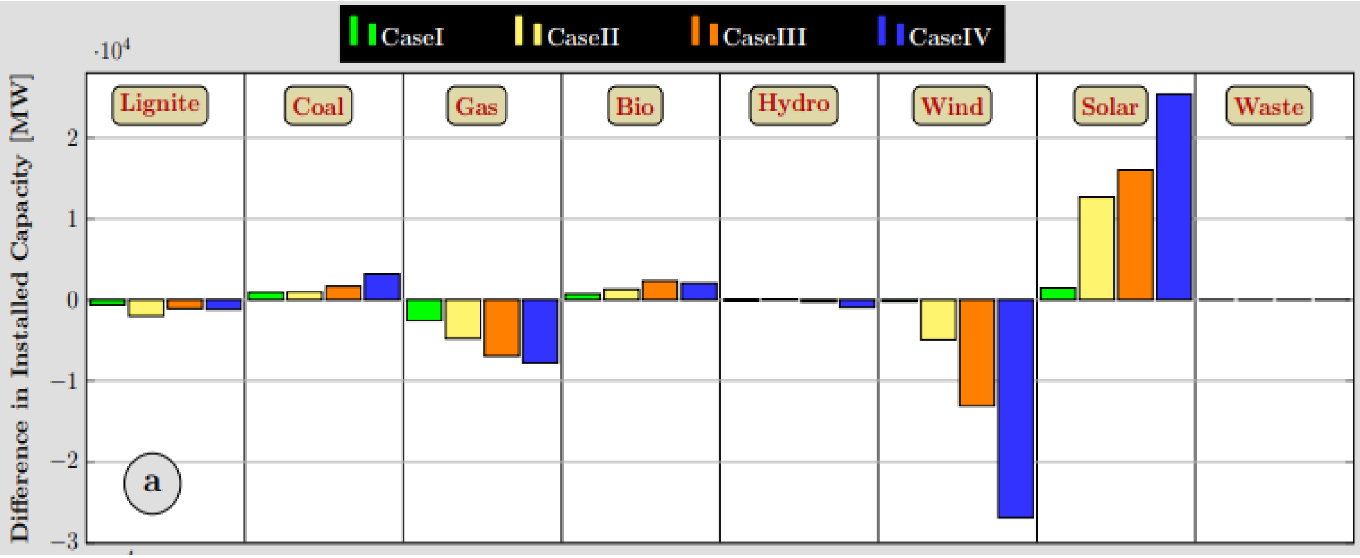
Case Study 1: Demand response in household electricity usage

Improvement in total system cost for various cases with DLC with respect to the Base Case.

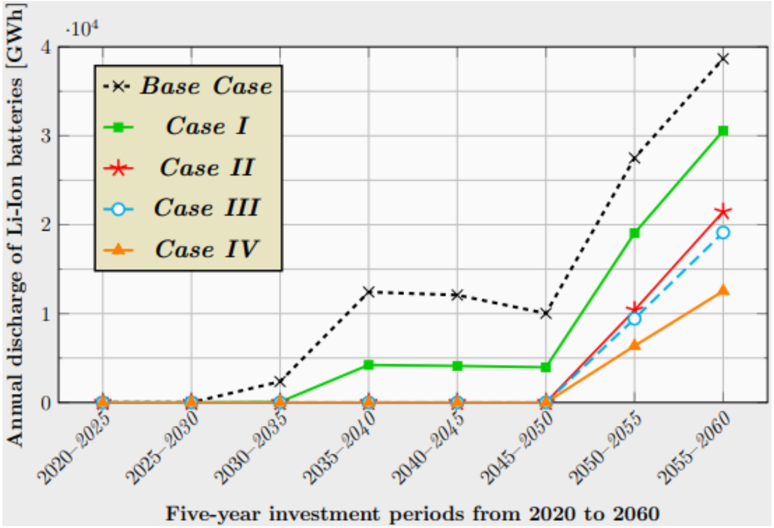
Total cost [€]	Improve percentage			
Base Case	Case I	Case II	Case III	Case IV
2.2×10^{12}	0.27%	0.58%	0.84%	0.99%

Lowest integration of DLC programs (Case I) — Highest integration of DLC programs (Case IV)

Changes in installed capacities of various generation resources in the 7th investment period (2050–2055)



Annual expected generation of Li-Ion batteries.



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Case Study 2

Behavior of Community of Actors

Theresia Perger, Sebastian Zwickl-Bernard, Hans Auer,
TU Wien

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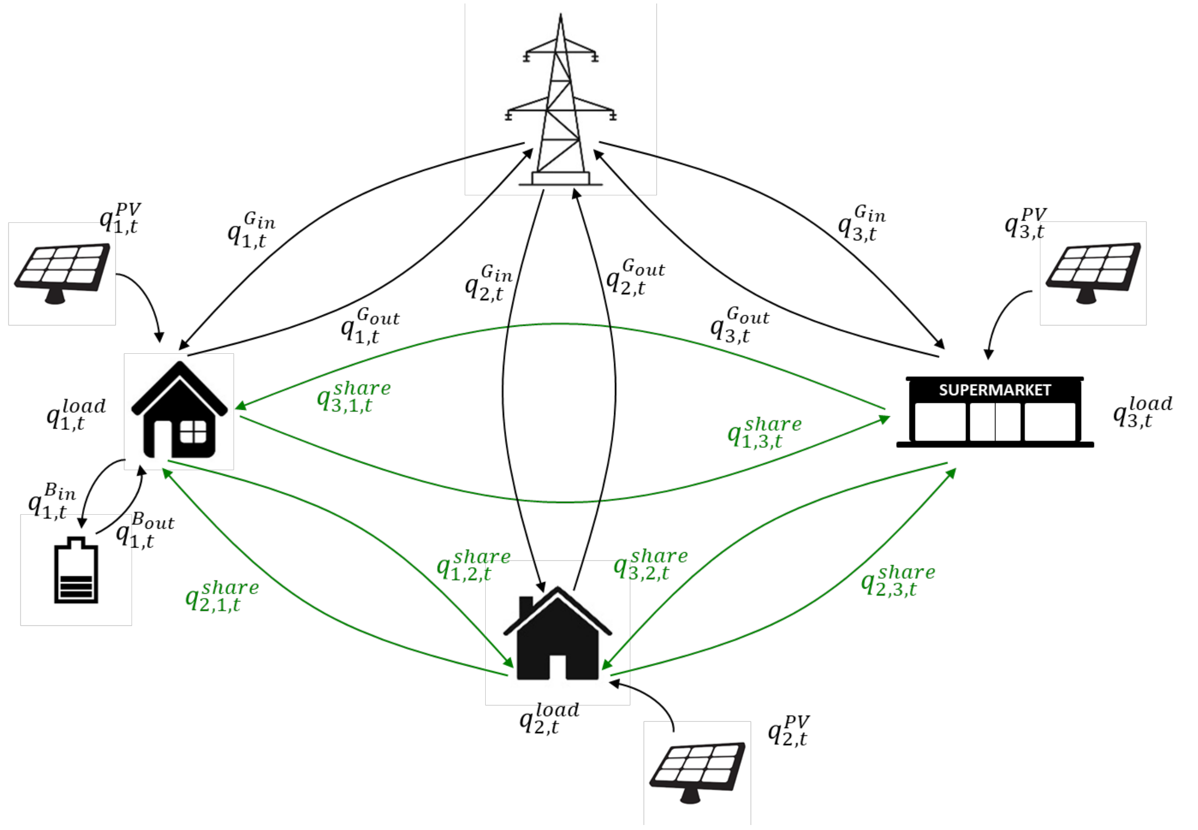
research and innovation programme under grant agreement No. 835896

Case Study 2: Behavior of Community of Actors

- Communities of actors are energy communities:
  - Voluntary participation and consideration of individual willingness-to-pay
  - Low entry barriers:
    - No closed systems;
    - All members are connected to the distribution network
  - Trading and sharing of locally generated energy within a certain framework: E.g., with a local electricity/energy market, here as <u>Peer-to-Peer Trading</u>
  - Dynamic phase-in and phase-out of members

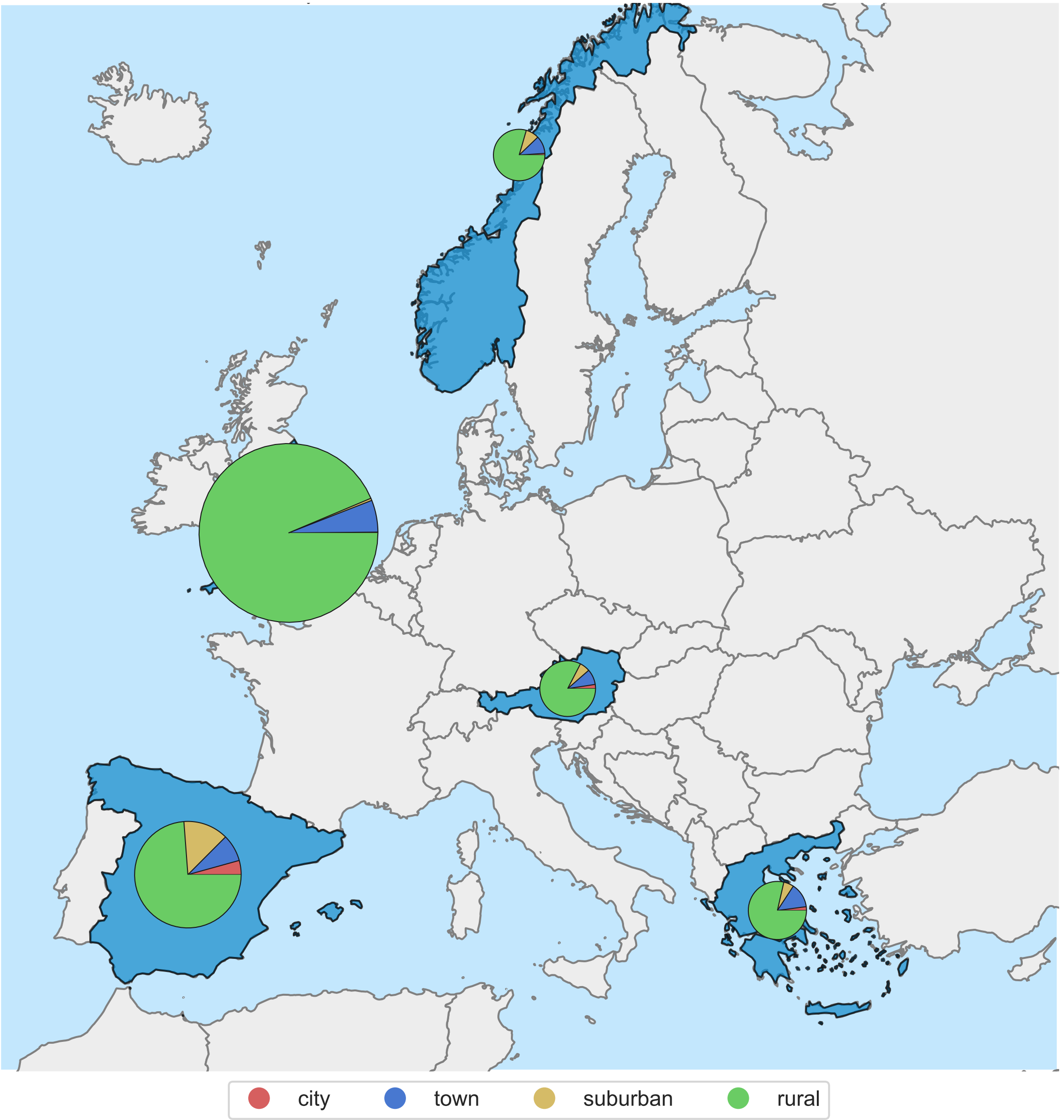
PEER-TO-PEER TRADING MODEL
FRESH:COM



Case Study 2: Behavior of Community of Actors

Potential of energy communities in five reference countries by settlement patterns

	city	town	suburban	rural
Austria	4353	16 123	10 734	148 107
Greece	4087	26 719	11 006	153 294
Norway	1587	17 062	12 753	121 641
Spain	28 170	53 865	89 516	483 401
UK (England)	2779	106 715	7490	1 728 185



Case Study 2: Behavior of Community of Actors

- Upscaling the potential of energy communities for different European countries based on building stock, PV potential, electricity consumption
- Reference countries:
  - Austria, Greece, Spain, Norway, England
- Quantitative upscaling of the local energy community potential is conducted for Europe as a whole

UPSCALING THE POTENTIAL OF ENERGY COMMUNITIES

In theory, up to 11.5 million residential energy communities could be implemented in Europe, with the potential for self-consumption of PV generation in communities to increase by up to 70%.

	city	town	suburban	rural
Europe total	221,266	998,730	655,381	9,800,271

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Case Study 3

Need for Flexibility – storage

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Ingeborg Graabak, Dimitri Pinel, Ove Wolfgang, SINTEF
Sebastian Zwickl-Bernard, TU Wien

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COMILLAS UNIVERSIDAD PONTIFICIA ICAI ICADE CIHS

GUSTO
TU WIEN TECHNISCHE UNIVERSITÄT WIEN

EMPS-W
SINTEF

This project has received funding from the European Union's Horizon 2020
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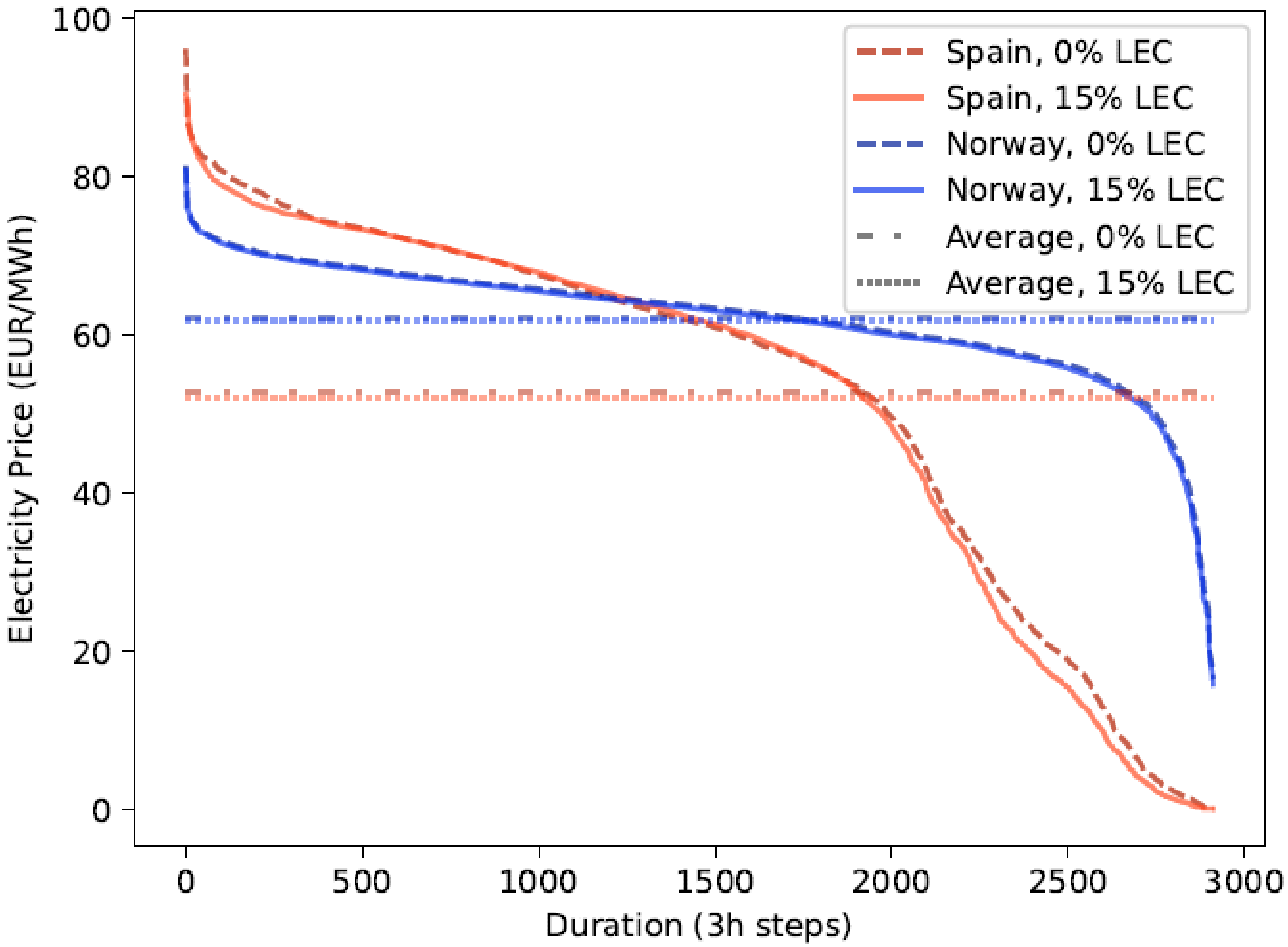
Scope of the study and approach followed

- Analysis of the impact on the system operation, the transmission network development, the level of use of the several flexibility sources, and wholesale electricity prices of local energy communities (LECs). LECs are deemed not to include additional EVs managed by them
  - To what extent the flexibility provided by LECs would be a substitute for that to be provided by centralized storage (batteries, or pumped hydro) and the grid
- Introduction of LECs is only considered within the Spanish and the Norwegian systems, which are represented with a higher level of detail (several areas per country and more detailed modelling of storage management)
  - The rest of the European system is only represented at an aggregate level (single node per country and more simplified management of storage)
- Simplification: Only the development of transmission grid is affected by an increase in the penetration of LECs
- TechnoFriendly Scenario considered: high environmental awareness, bottom-up societal revolution, and top-down technology revolution
- Static planning: 1 year (2030 horizon) with hourly resolution

Results

- The changes induced by LECs in the net demand largely depend on the features of the system where they are deployed. Both within Spain and Norway, the net demand decreases as a result of the deployment of LECs, due to the deployment of some distributed generation within them (notably solar PV in Spain)
    - Despite limited switching from direct electric heating systems to heat pumps in Norway, and the fact that heat pumps electrify the heat supply in Spain
- In countries with large decentralized RES generation potential, LECs cause a decrease in prices in low-price periods, as well as a less significant decrease in prices in the highest-price periods ➔ increase in price spread. Average prices decrease as well
- The use of storage technologies increases both in Spain and Norway with the deployment of LECs to exploit the larger spread of prices across time created by LECs
    - In Spain, medium-to-long-term flexibility ones, while, in Norway, those providing short-term one
- RES energy curtailments and spillages increase with LECs
- Use of the transmission grid increases in systems with uneven deployment of DERs within LECs across the system and decreases in those others featuring an even deployment. Grid investments tend to increase

Results: impact of LECs on the price duration curve and average ones



Case Study 4

Need of flexibility – Sector Coupling and Integration

Philipp Haertel, Felix Frischmuth, Fraunhofer IEE
Nadia Oudjane, Sandrine Charousset, EDF

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 835896

Case study investigates low and high realisations of crucial system development determinants based on Techno-Friendly storyline

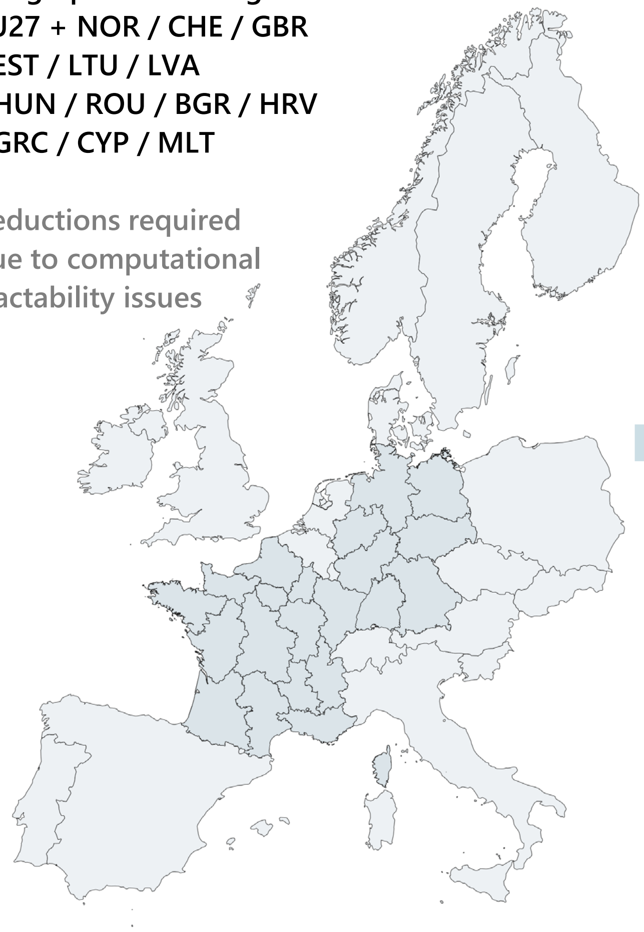
Storyline „Techno-Friendly" + SCOPE SD (IEE) ↔ Plan4EU (EDF)

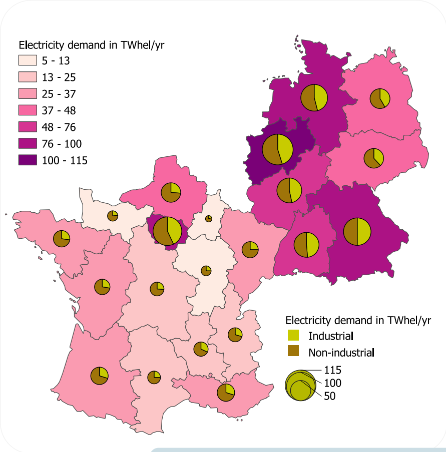
System development determinants	Sensitivities (low and high)	
Cross-border electricity exchange (XB) capacity	**Low cross-border exchange capacity expansion (XB↓)** **Europe 118.5 GW** (w/o internal) DEU 101.1 GW (internal only) FRA 110.2 GW (internal only)	**High cross-border exchange capacity expansion (XB↑)** **Europe 229.9 GW** (w/o internal) DEU 108.2 GW (internal only) FRA 133.3 GW (internal only)
×		
Share of electric vehicles (EV) with a flexible charging policy	**Low electric vehicle charging flexibility (EV↓)** **10%** of all electric vehicles (BEV, PHEV, REEV) allowed to charge in a system-friendly manner	**High electric vehicle charging flexibility (EV↑)** **90%** of all electric vehicles (BEV, PHEV, REEV) allowed to charge in a system-friendly manner
×		
Import price for hydrogen (H_2) from global markets (PtX global ATLAS)	**Low hydrogen import price (H_2↓)** **45.1 EUR/MWh$_{th}$** (~1.5 EUR/kg LHV)	**High hydrogen import price (H_2↑)** **85.0 EUR/MWh$_{th}$** (~2.82 EUR/kg LHV)

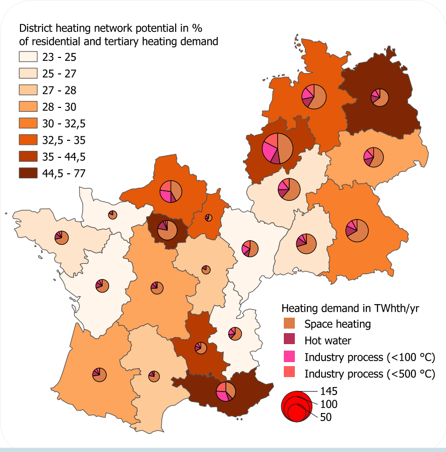
Geographical scope and regional data preparation

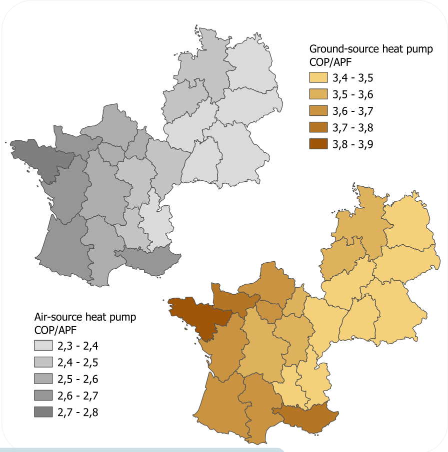
Geographical coverage
EU27 + NOR / CHE / GBR
- EST / LTU / LVA
- HUN / ROU / BGR / HRV
- GRC / CYP / MLT

Reductions required due to computational tractability issues

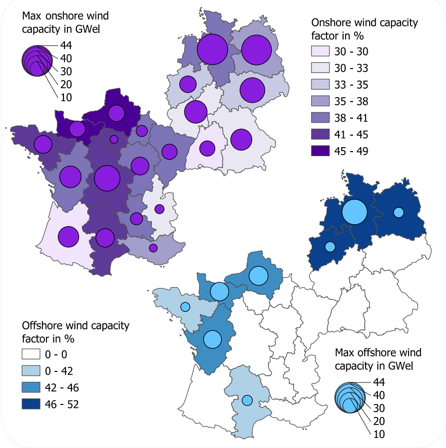


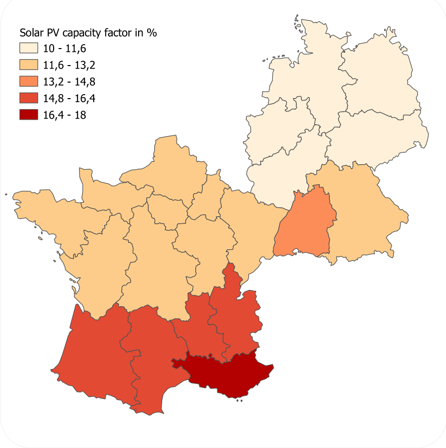


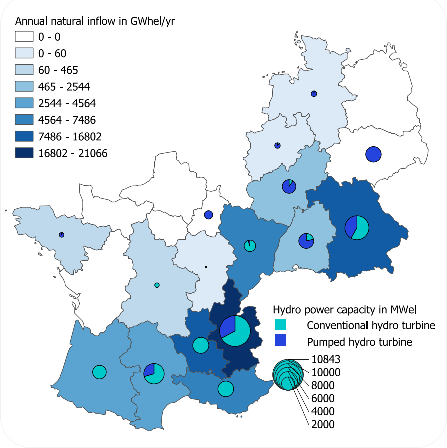




Meteorological year 2012 with highest "Dunkelflaute" index (TYNDP 2022)







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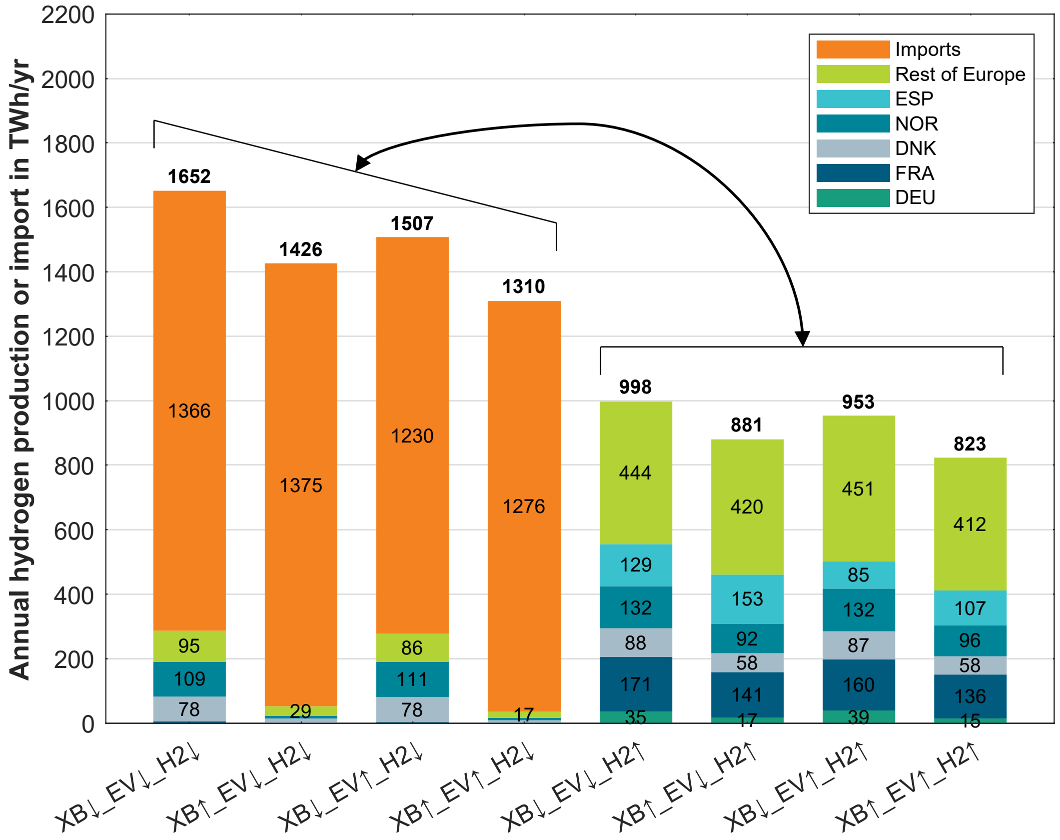
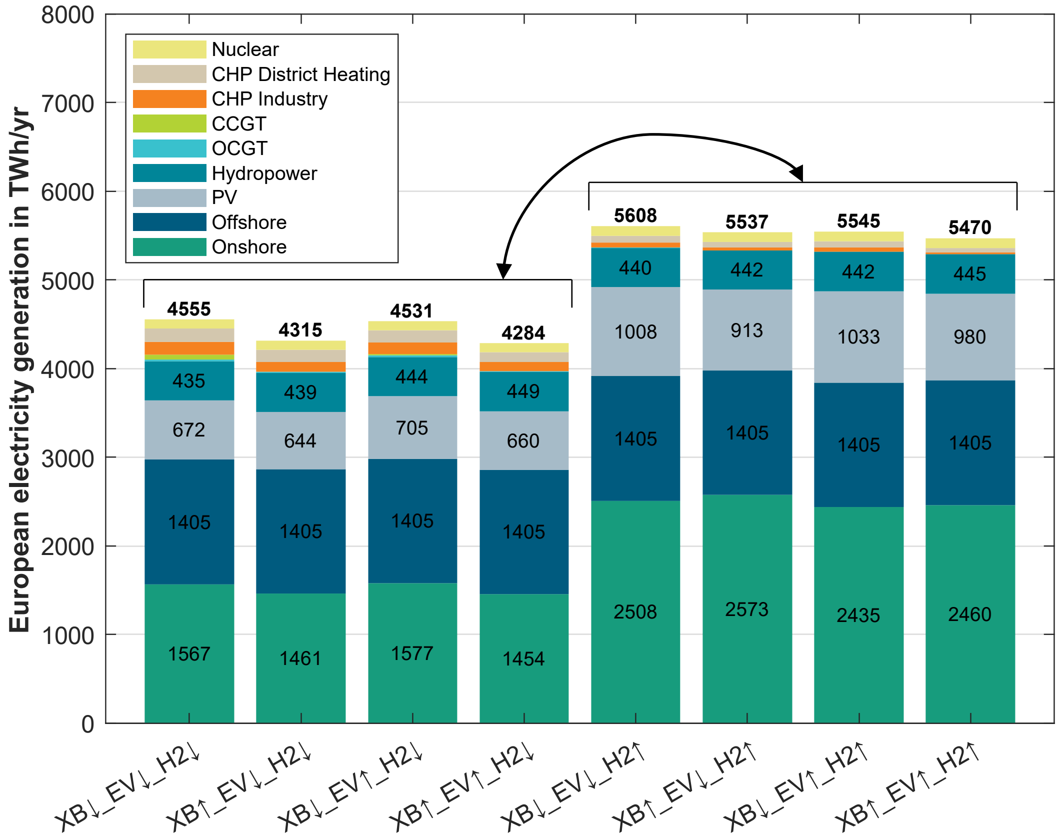
Hydrogen imports show strongest influence on integrated energy system development and hydrogen demands





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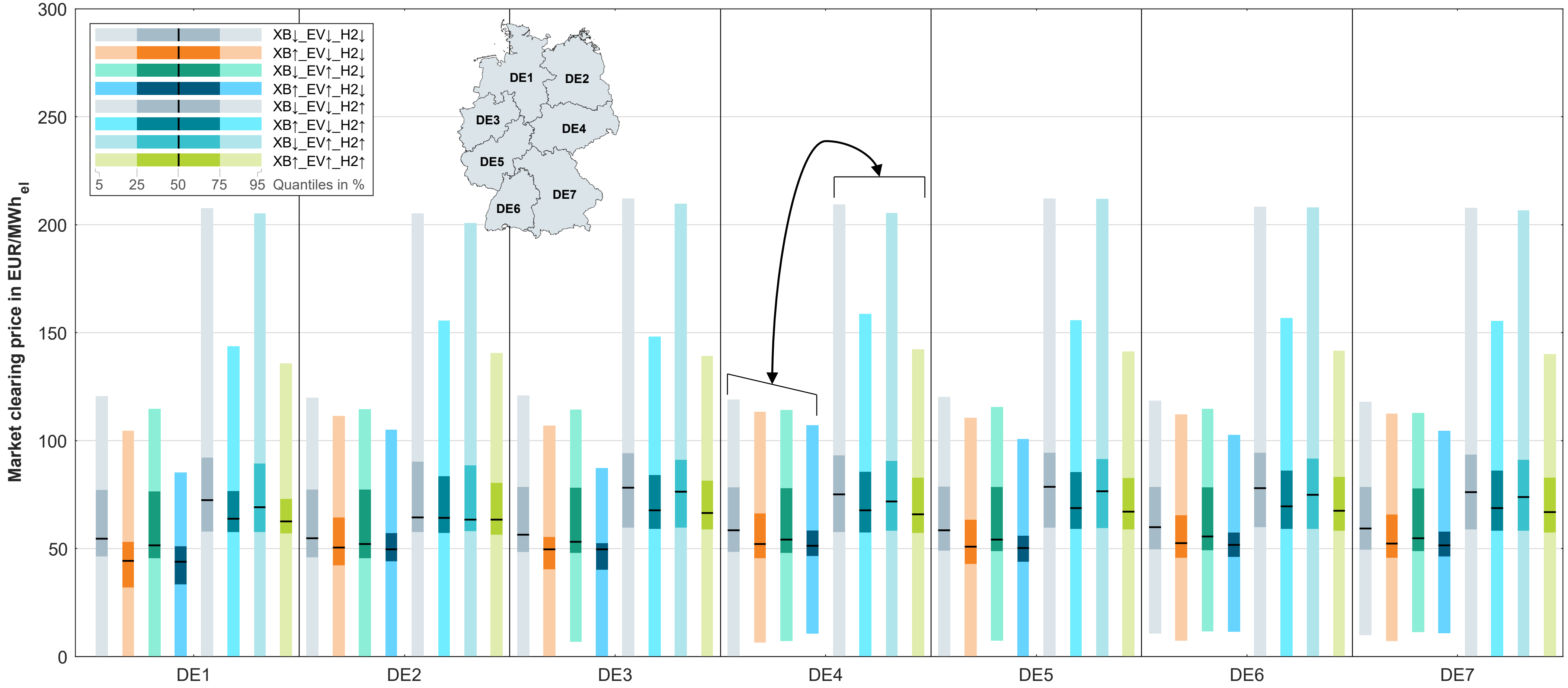
Price of hydrogen supply – import vs. domestic production – has large impacts on the clearing prices in low-carbon power markets



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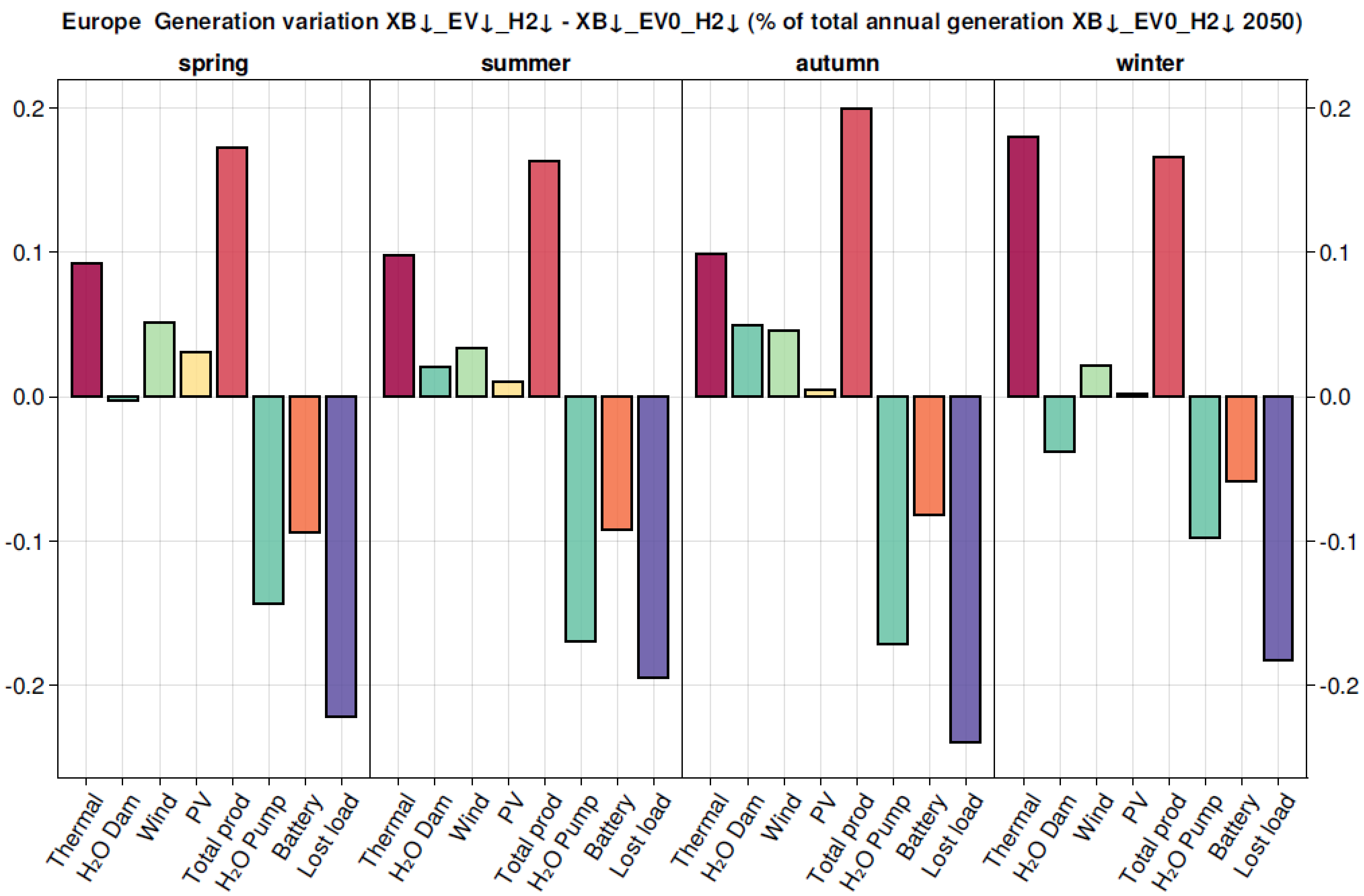
Europe Generation variation XB↓_EV↓_H2↓ - XB↓_EV0_H2↓ (% of total annual generation XB↓_EV0_H2↓ 2050)
spring
summer
autumn
winter
0.2
0.1
0.0
-0.1
-0.2
Thermal
H₂O Dam
Wind
PV
Total prod
H₂O Pump
Battery
Lost load

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Case Study 5

Impact of decentralization of investment decisions in power systems

Nadia Oudjane, Sandrine Charousset, Sebastien Lepaul, EDF

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 835896

Case Study 5: Impact of decentralization of investment decisions in power systems

- How to coordinate European decisions with Member States decisions to reach a European *Decarbonization Target* in 2050 ?

- Decarbonization Target : a minimum share of the available energy produced by decarbonized assets

From centralized to decentralized decisions schemes

CC: Centralized decisions & Centralized target ❯ **CD: Centralized decisions & Decentralized targets** ❯ **DD: Decentralized decisions & Decentralized targets**

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Insights for relevant coordinated decentralization schemes

CC: Centralized decisions & Centralized target

- ☺ Investments decided while exploiting exchanges between countries
- ☺ Exploits different renewable potentials between countries

CD: Centralized decisions & Decentralized targets

- ☺ Investments decided while exploiting exchanges between countries
- ☹ Same share of decarbonized sources per country

DD: Decentralized decisions & Decentralized targets

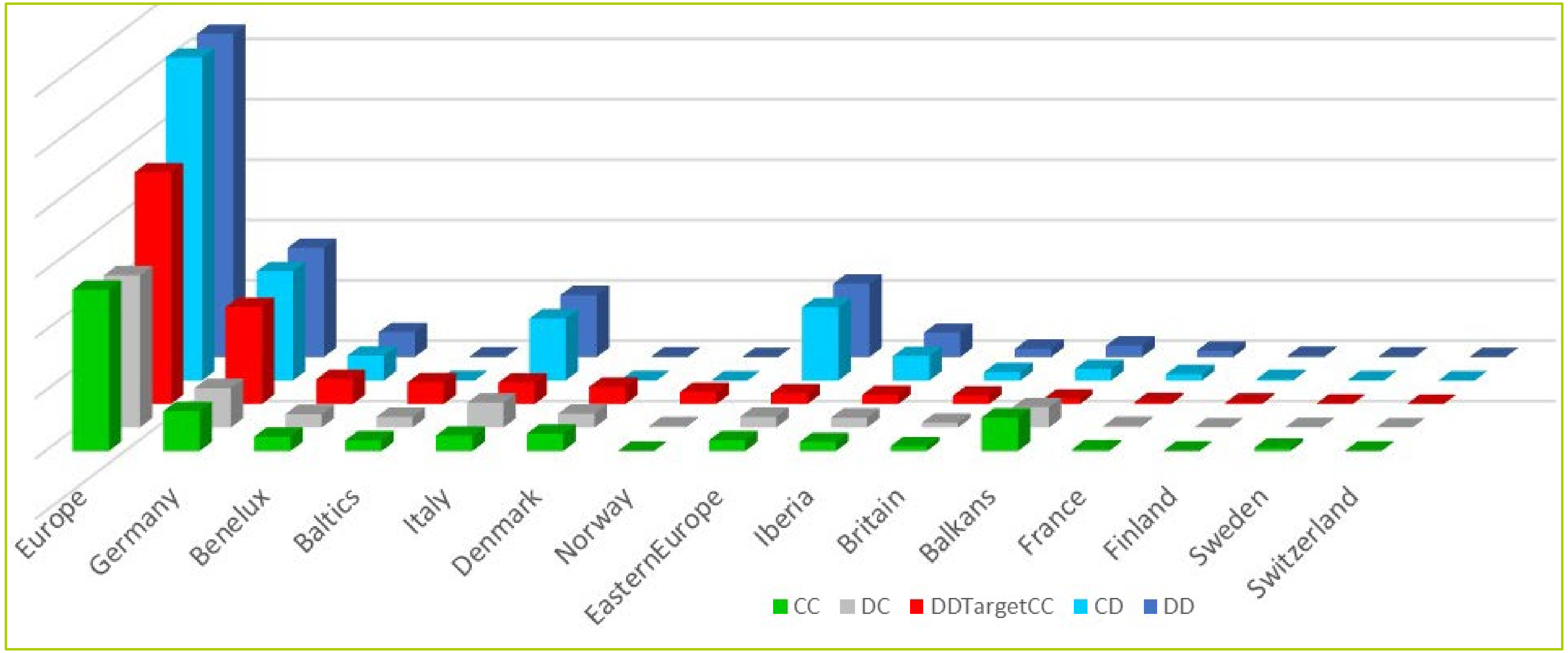
- ☹ Investment decisions assume self sufficient countries
- ☹ Same share of decarbonized sources per country

A coordinated decentralization scheme

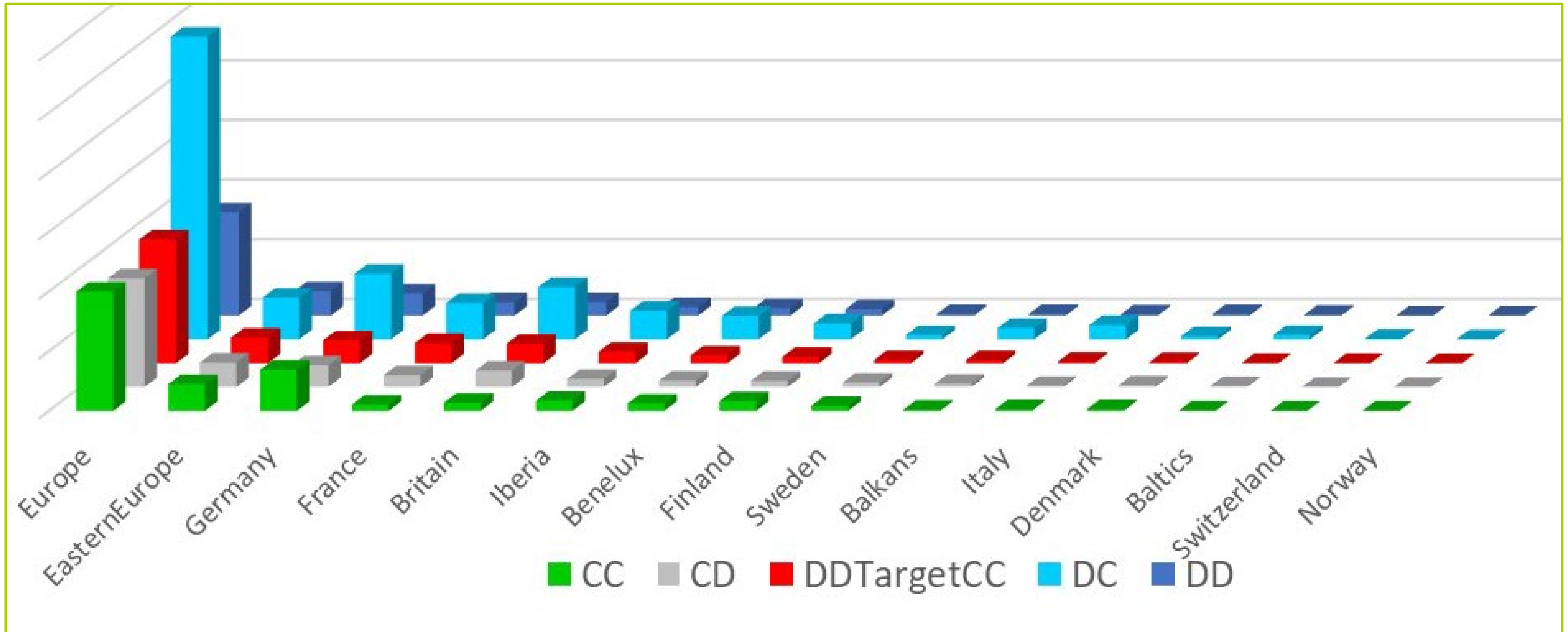
DDtargetCC: fully Decentralized & coordinated country-specific targets

- ☹ Investment decisions assume self sufficient countries
- ☺ Coordinated Decarbonized share target in each country (from CC simulation)

Investment Costs



Operation Costs

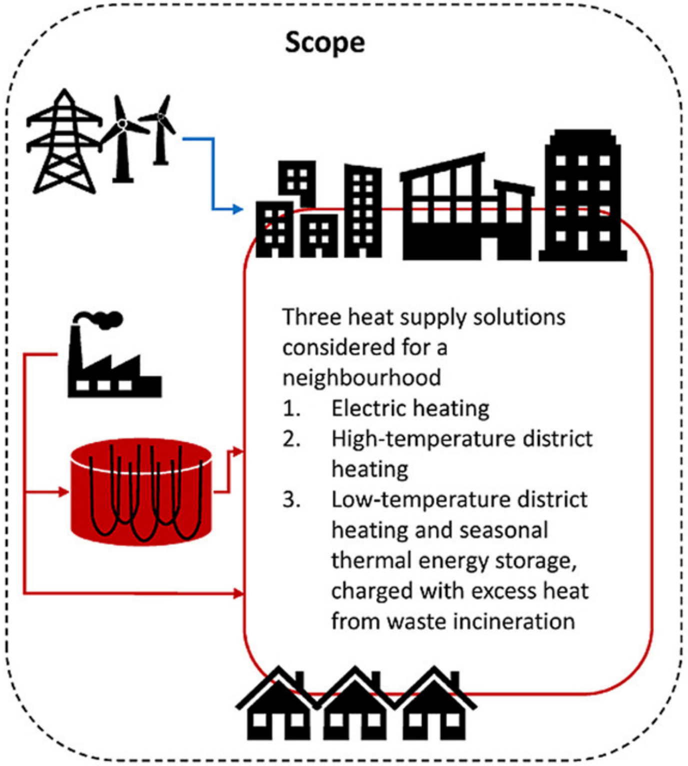


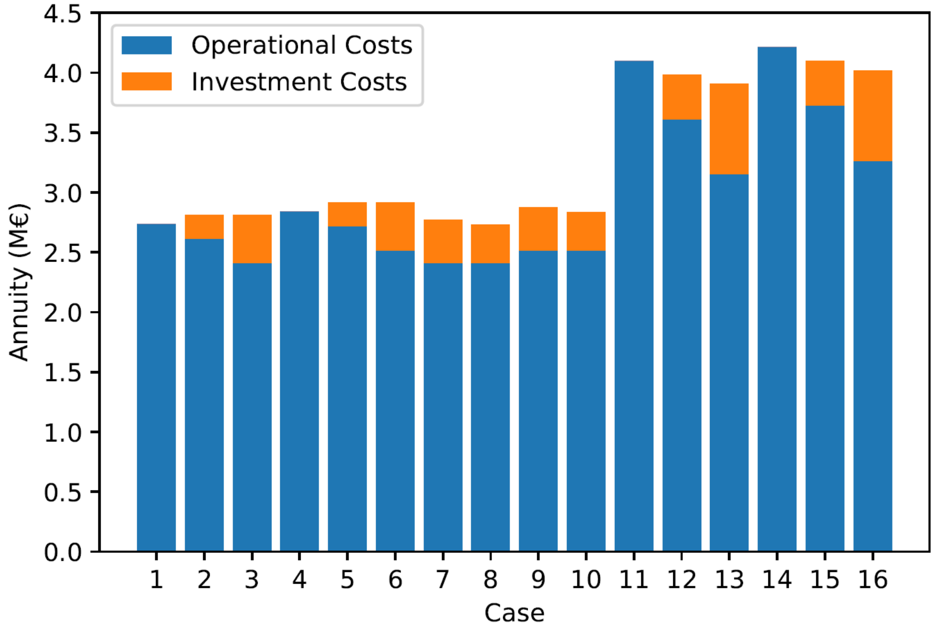
Case Study 6

Dimitri Pinel, Hanne Kauko, Ove Wolfgang, Ingeborg Graabak, SINTEF

Case study 6 Innovative technologies – seasonal storage of heat – Furuset, Oslo, Norway

- How can seasonal storage of waste heat in a local energy system contribute to: a reduction of peak demands? A reduction or delay in distribution grid capacity investments?





1 - PV, Elec
2 - PV, HTDH
3 - PV, LTDH & STES
4 - ~~PV~~, Elec
5 - ~~PV~~, HTDH
6 - ~~PV~~, LTDH+STES
7 - PV, LTDH & STES (-20%)
8 - PV, LTDH & STES (-40%)
9 - ~~PV~~, LTDH & STES (-20%)
10 - ~~PV~~, LTDH & STES (-40%)
11 - PV, Elec, $2 \cdot P^{el}$
12 - PV, HTDH, $2 \cdot P^{el}$
13 - PV, LTDH & STES, $2 \cdot P^{el}$
14 - ~~PV~~, Elec, $2 \cdot P^{el}$
15 - ~~PV~~, HTDH, $2 \cdot P^{el}$
16 - ~~PV~~, LTDH & STES, $2 \cdot P^{el}$

Case study 6 Innovative technologies – seasonal storage of heat – Furuset, Oslo, Norway

- Main takeaways:
- Surplus heat from waste incineration is a widely available heat source for seasonal thermal energy storage
- Seasonal storage reduces the demand for peak heating in the winter, thus the emissions and costs related to production of district heating
- District heating alone can be enough to alleviate constraint on the local electricity grid
- Seasonal heat storage of heat is a relatively cheap way to hedge against high electricity prices

Case Study 7

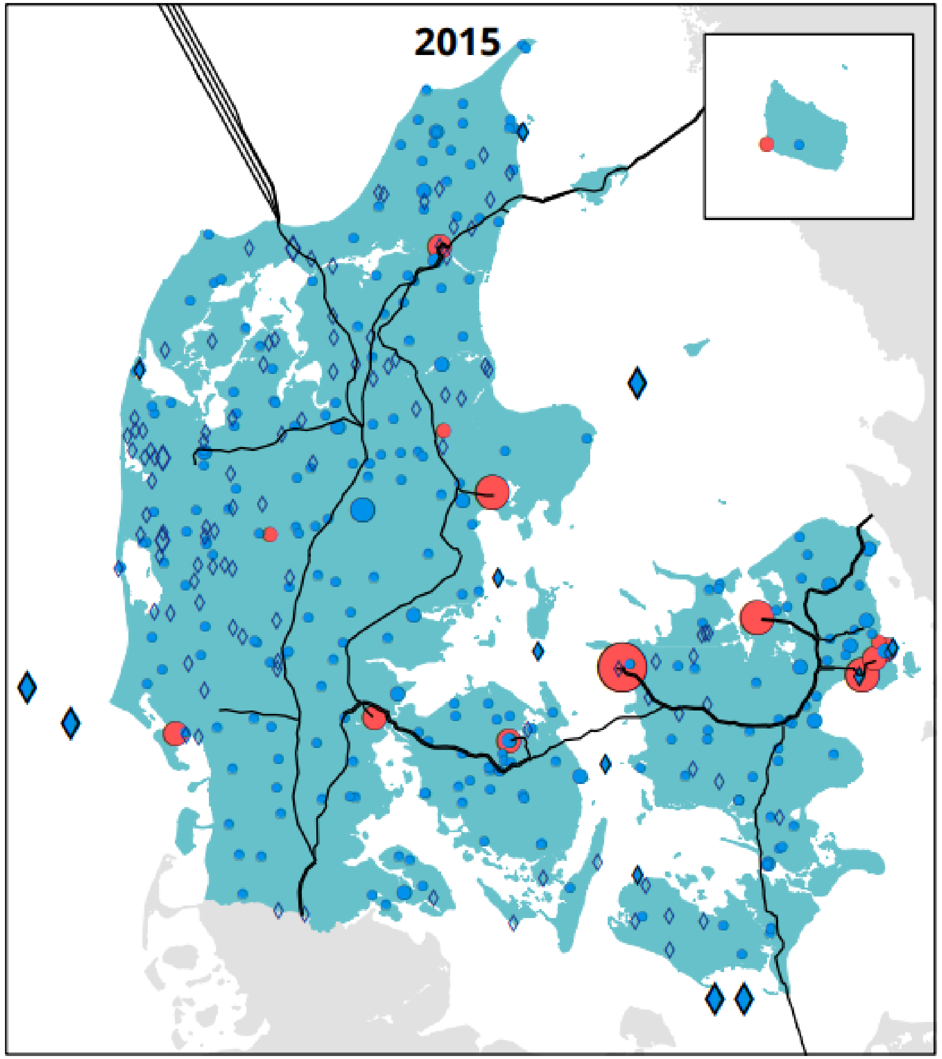
Power-to-heat demand flexibility in the Danish electricity system of 2050

Amos Schledorn, Dominik F. Dominkovic, DTU
Sandrine Charousset, EDF

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 835896

Case study 7 (DTU, EDF)

Power-to-heat demand flexibility in the Danish electricity system of 2050



Danish Power infrastructure in 2015, Danish energy angency

Case study scope:

- CS7 developed a novel methodology for integrating realistic demand response models in large-scale energy system models …
- … and applied it to quantifying the role of heat storage and power-to-heat demand response in the Danish electricity system of 2050.

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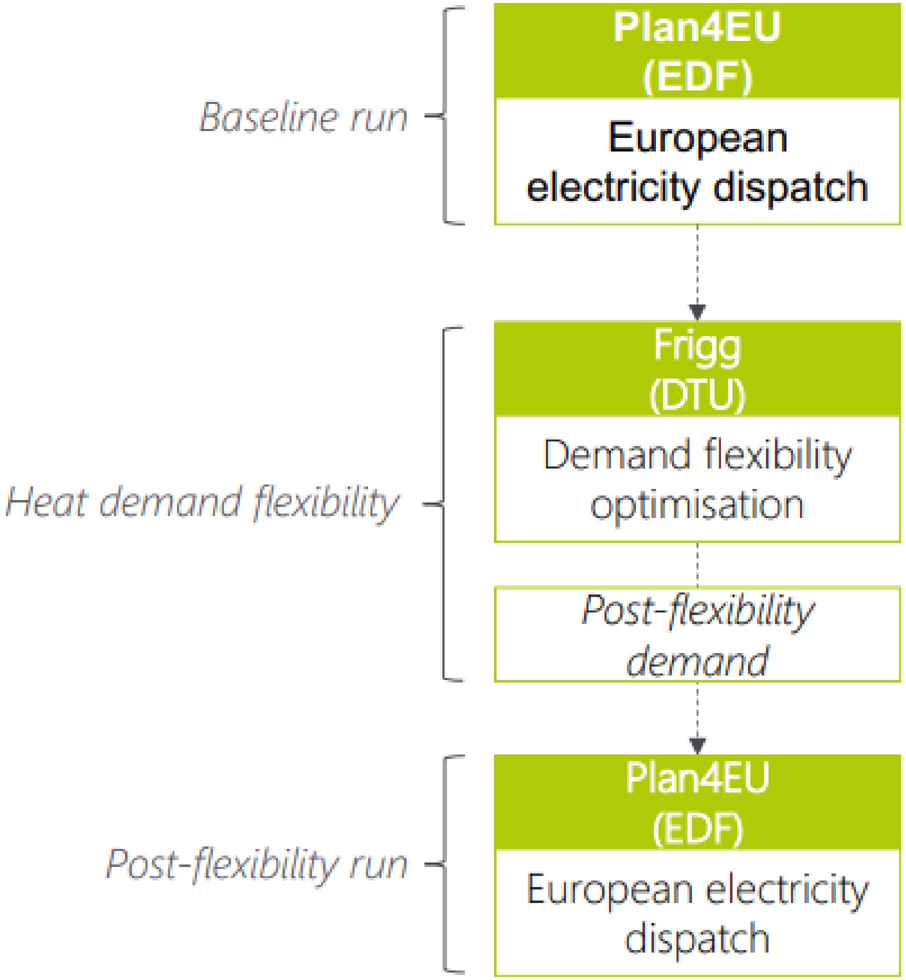
Case study 7 (DTU, EDF)

Power-to-heat demand flexibility in the Danish electricity system of 2050



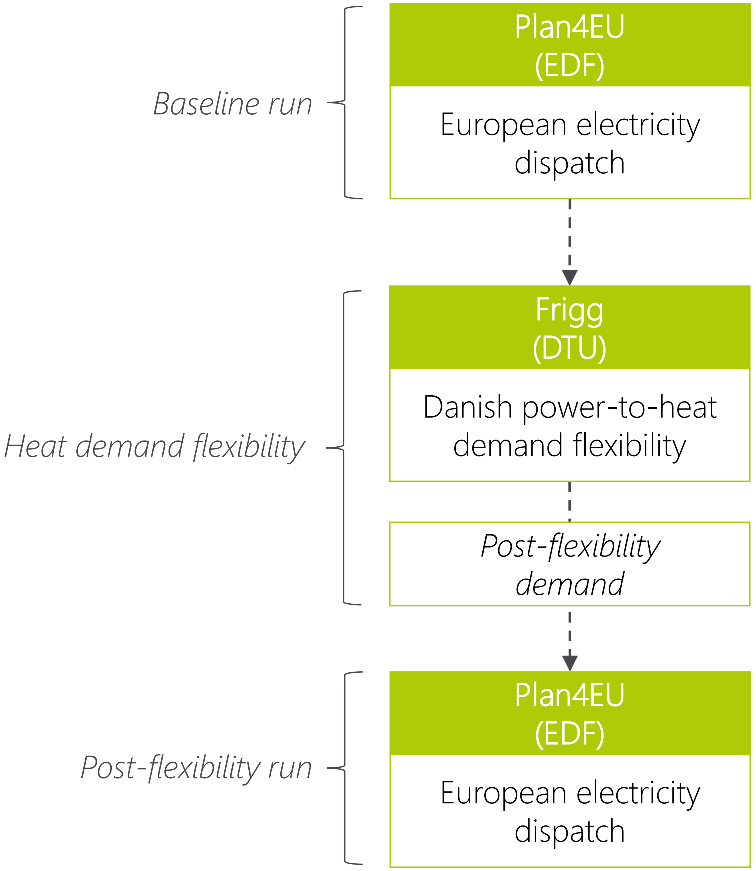
1. Plan4EU computes computes **baseline electricity dispatch** for Europe.

2. Frigg approximates a dispatch and a heat demand response model **for Denmark** and finds **the least-cost post-flexibility demand trajectory**.

3. Plan4EU calculates computes **post-flexibility electricity dispatch** under modified demand.

Case study 7 (DTU, EDF)

Power-to-heat demand flexibility in the Danish electricity system of 2050



Results:

- Power-to-heat demand flexibility significantly improves system operation.
- Heat storage is more significant than demand response.
- Danish electricity cost are reduced noticeably (-1.3 EUR/MWh in OPEX through heat storage).

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Thank you.

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