CO_2 Quota Attribution Effects
On the European Electricity System

Smart Energy Systems International Conference 2020

AARHUS UNIVERSITY
DEPARTMENT OF ENGINEERING

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OCTOBER 2020

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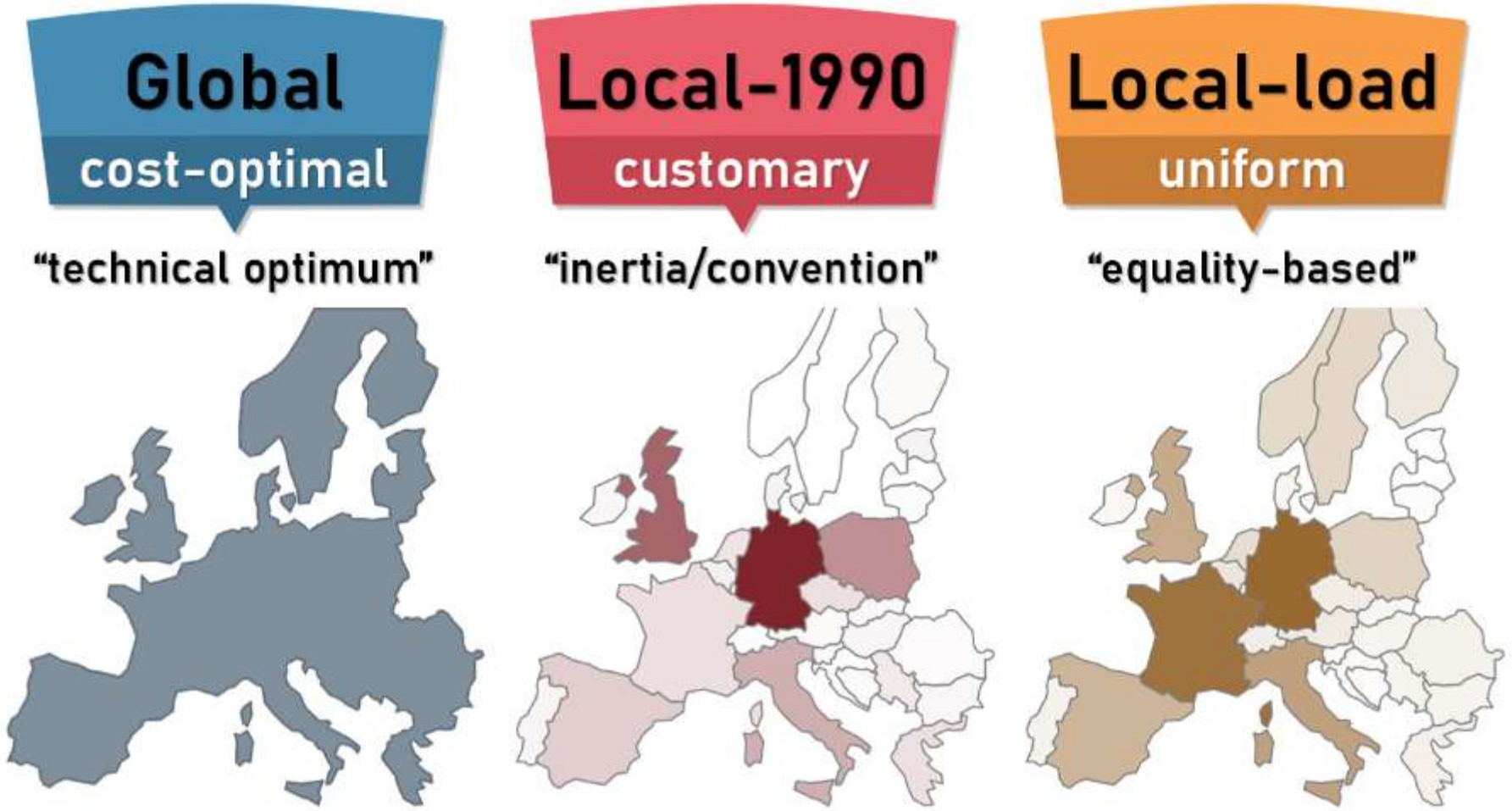
Motivation

- Most agree that our electricity system should be decarbonised
- The countries have very different systems
- Need for self-sufficiency

Motivation


Is it time to rethink collaboration?
CO_2
Emission attribution
Generation autonomy
Grid extension

Considered emission attribution schemes



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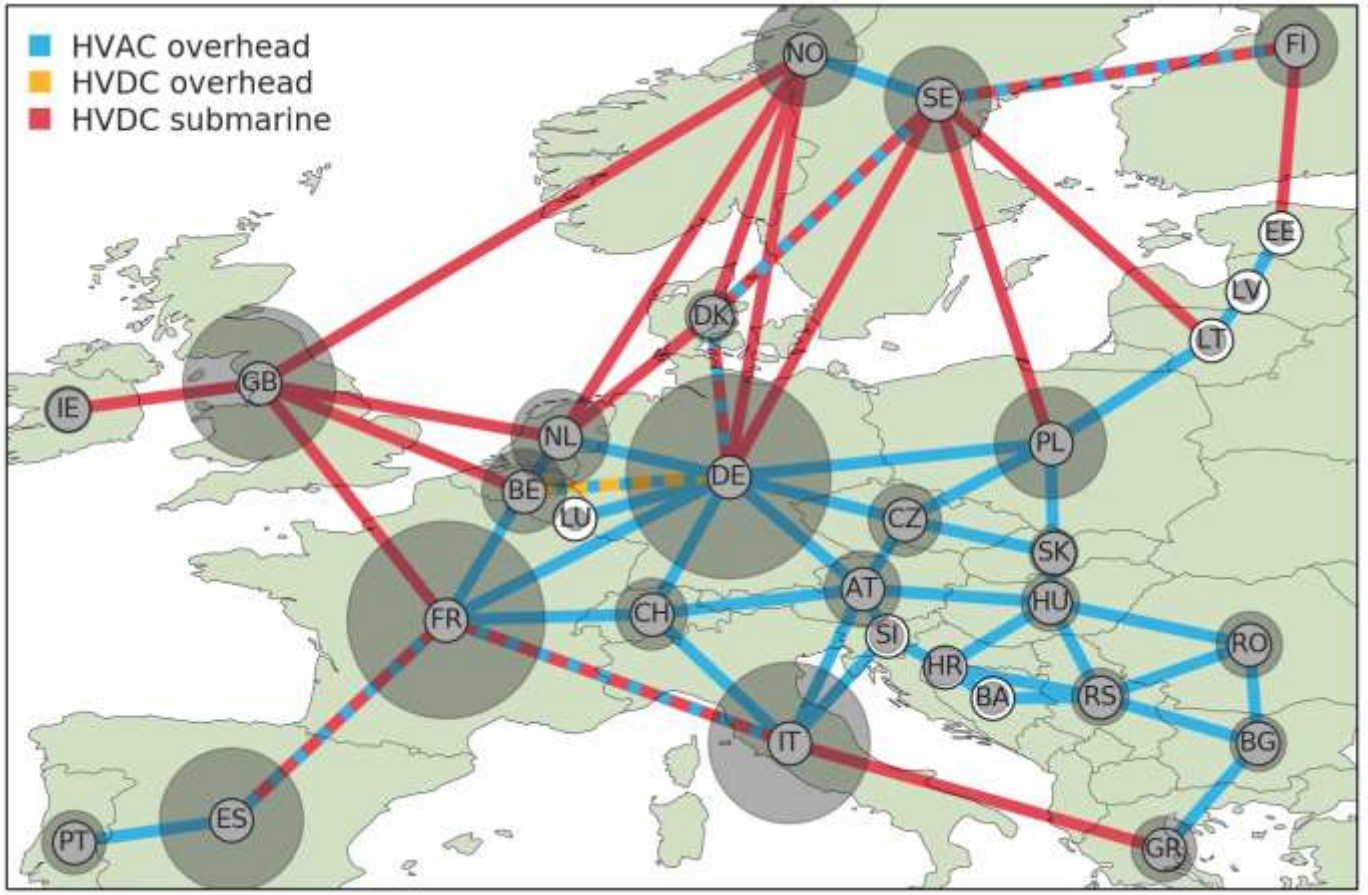
Modelling framework

- PyPSA* model of the electricity system
- One node per country
- Cross-border transmission lines
- Brownfield approach



* https://github.com/PyPSA

Methodology

Objective function:

$$\min \left(\sum_{n} \underset{costs}{generation} + \underset{costs}{storage} + \underset{costs}{transmission} + \sum_{n,t} \underset{costs}{variable} \right)$$

Subject to several constraints, including:

$$generation + balance = demand \quad \leftrightarrow \quad \lambda_{n,t} \qquad \forall\, n, t$$

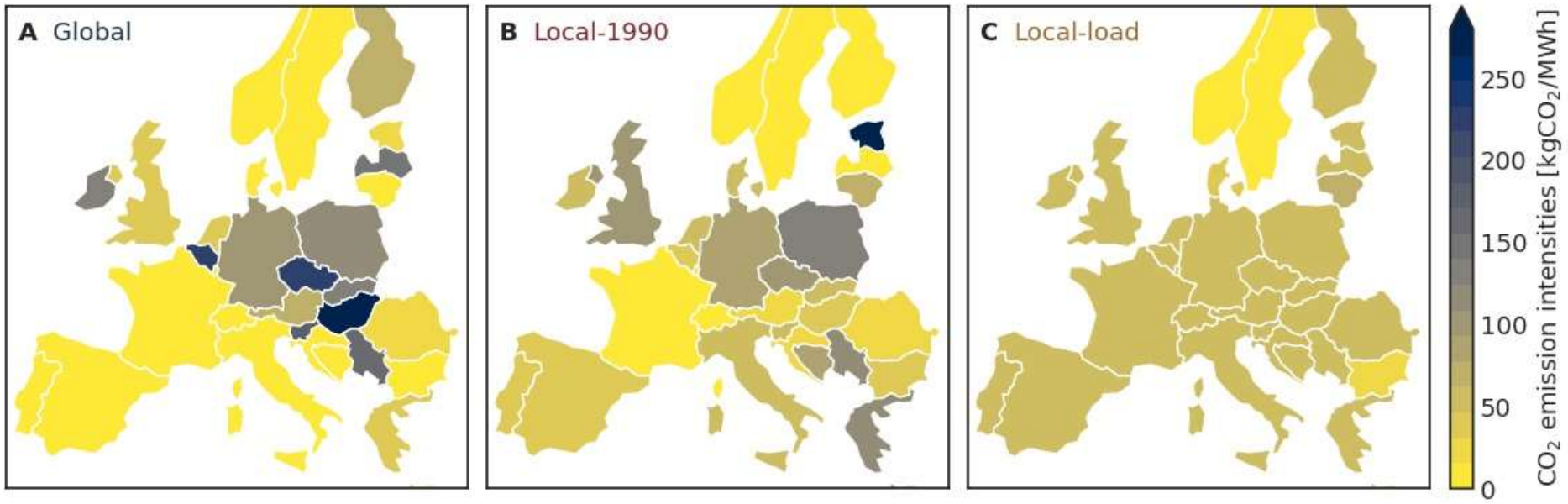
$$\sum emissions \leq CAP_{CO2} \quad \leftrightarrow \quad \mu_{CO2}$$

Main assumptions: perfect foresight, perfect competition, long-term market equilibrium.

Near-future scenarios

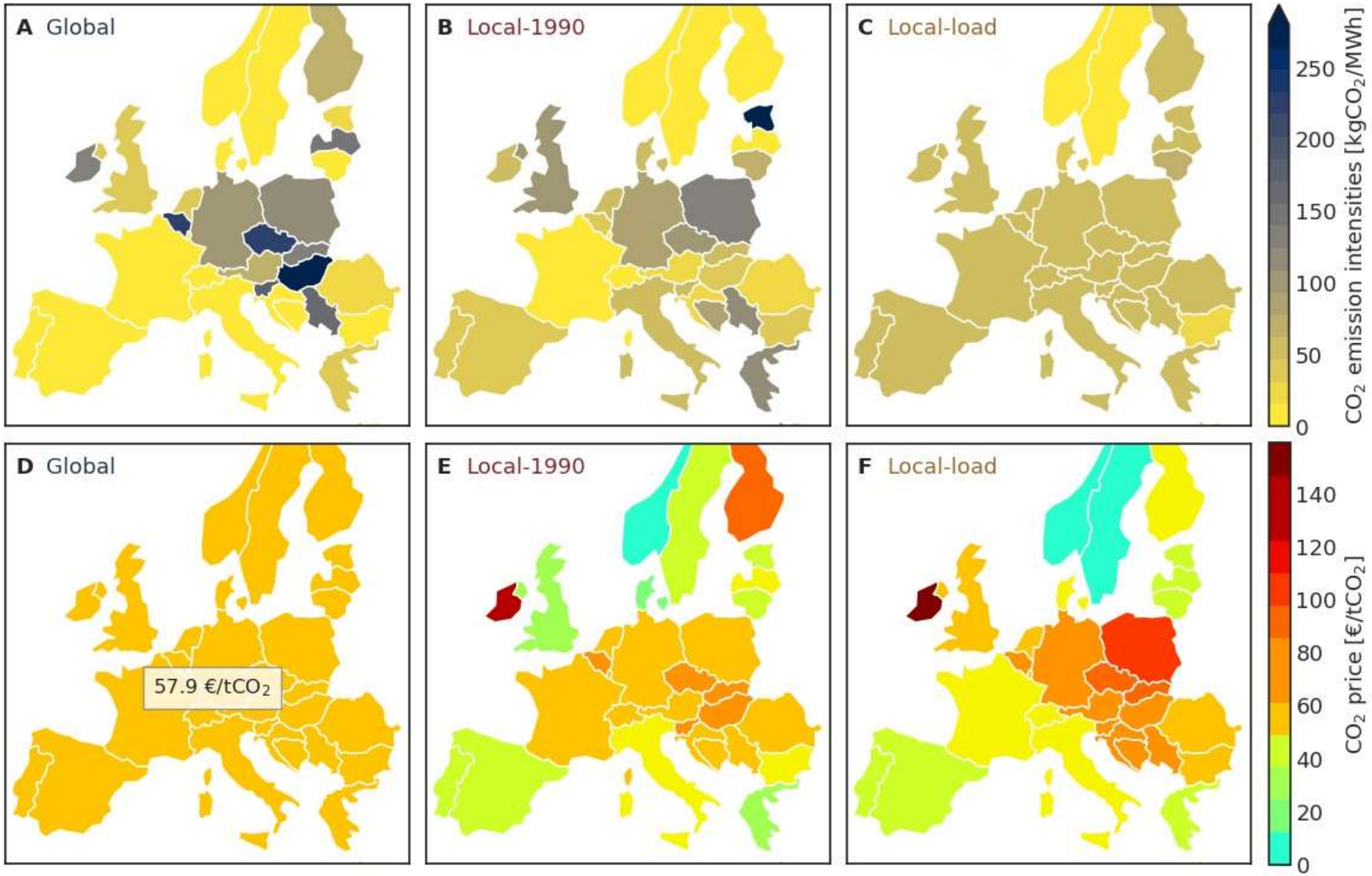
- 15% of 1990 electricity generation related emissions
- Planned cross-border transmission capacities
- All countries are highly self-sufficient
- Comparing different emission attribution schemes

Emission attributions



2030 transmission expansion projection. On average, fully self-sufficient countries.

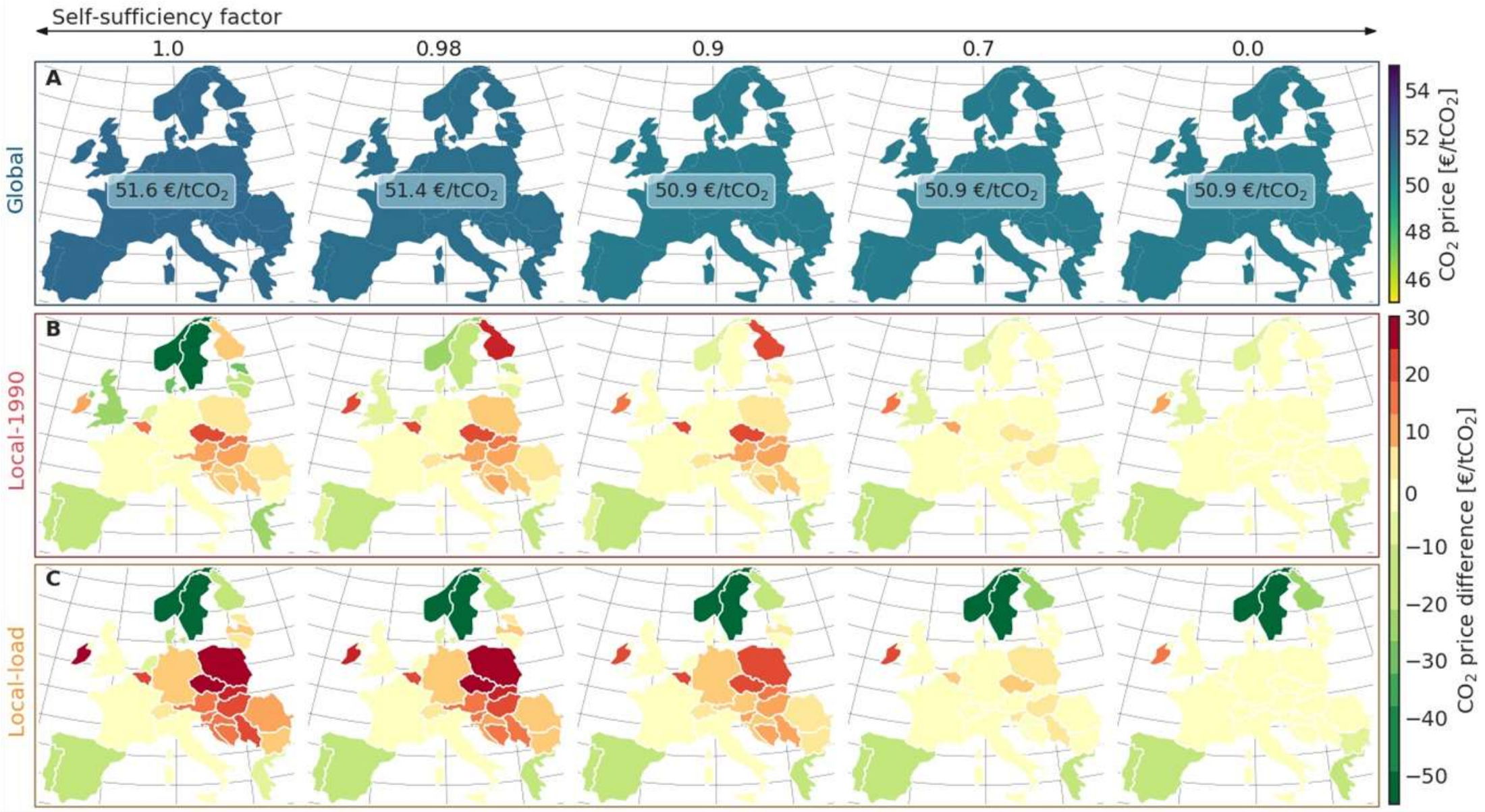
Required emission prices



Full collaboration

- 15% of electricity generation related emissions
- ~~No cross-border grid extension~~ → **Cross-border grid extension**
- ~~All countries are highly self-sufficient~~ → **Relax self-sufficiency requirement**
- Comparing different emission attribution schemes

Emission prices



Conclusions

- We analysed the effects of collaboration by
  - country specific emission allowance distributions
  - cross border transmission extension
  - self-sufficiency requirement relaxation

- We found that stronger collaboration leads to
  - lower total system cost
  - more similar CO_2 emission prices
  - stronger dependence on others in terms of security of supply

- A middle way is possible: 70-90% self-sufficiency leads to most benefits

Outlook

- Investigate what causes high CO_2 prices in the individual countries

- Include a cross-sector coupling
  - Broader coverage
  - Synergies
  - Different transition speeds in different countries and sectors

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