Challenges for Renewable Energy Investments

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The power sector's key role in decarbonizing our economies

Decarbonazing power is critical to addressing climate change

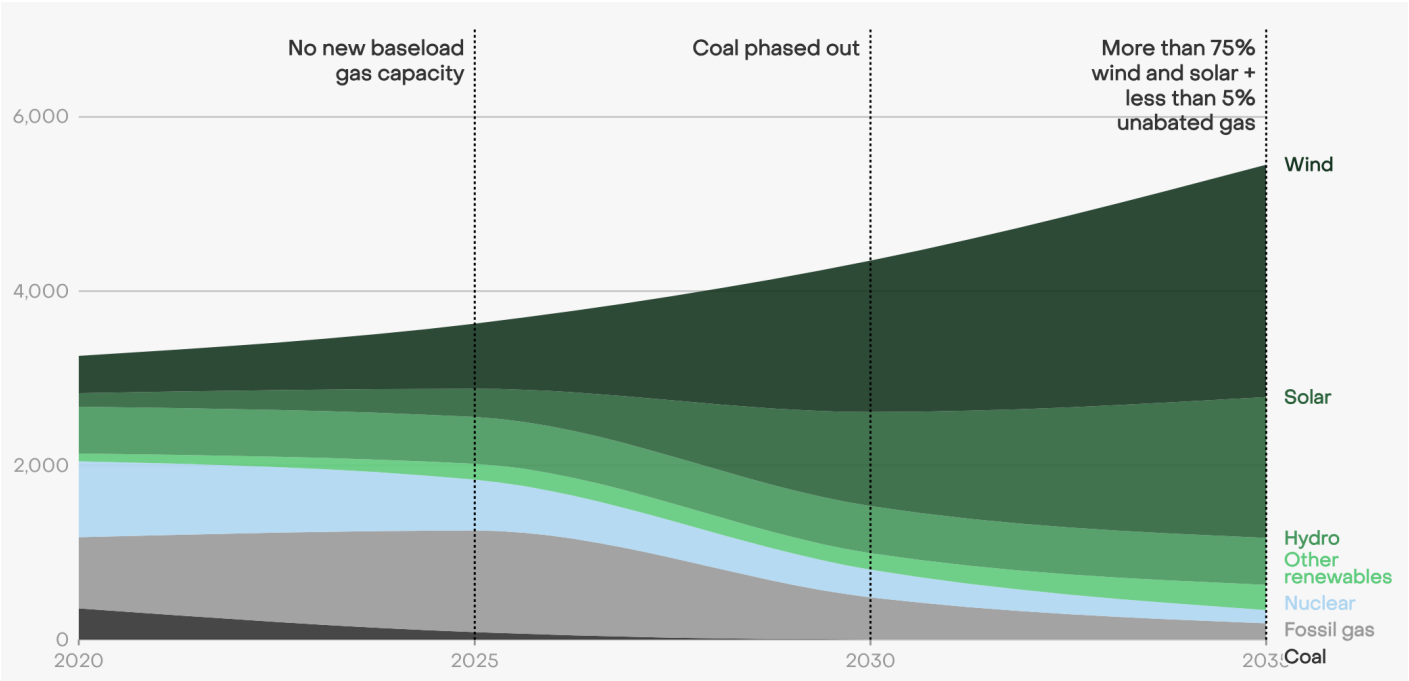

Figure: 1.5C pathways to clean power by 2035 in Europe

Decarbonazing power requires massively investing in renewables

Source: Ember

Challenges for renewable energy investments

1. Re-designing electricity market arrangements
2. Addressing intermittency: storage, demand response, integration
3. Promoting electrification
4. Reinforcing the transmission and distribution networks
5. Overcoming social opposition

Re-designing electricity markets

Re-designing electricity markets

"[Renewables' expansion] raises profound questions about whether the current market designs can be adapted to provide **good long-term price signals to support investment in an efficient portfolio** *of generating capacity and storage consistent with* **public policy goals**.*"*
(Joskow, 2019)

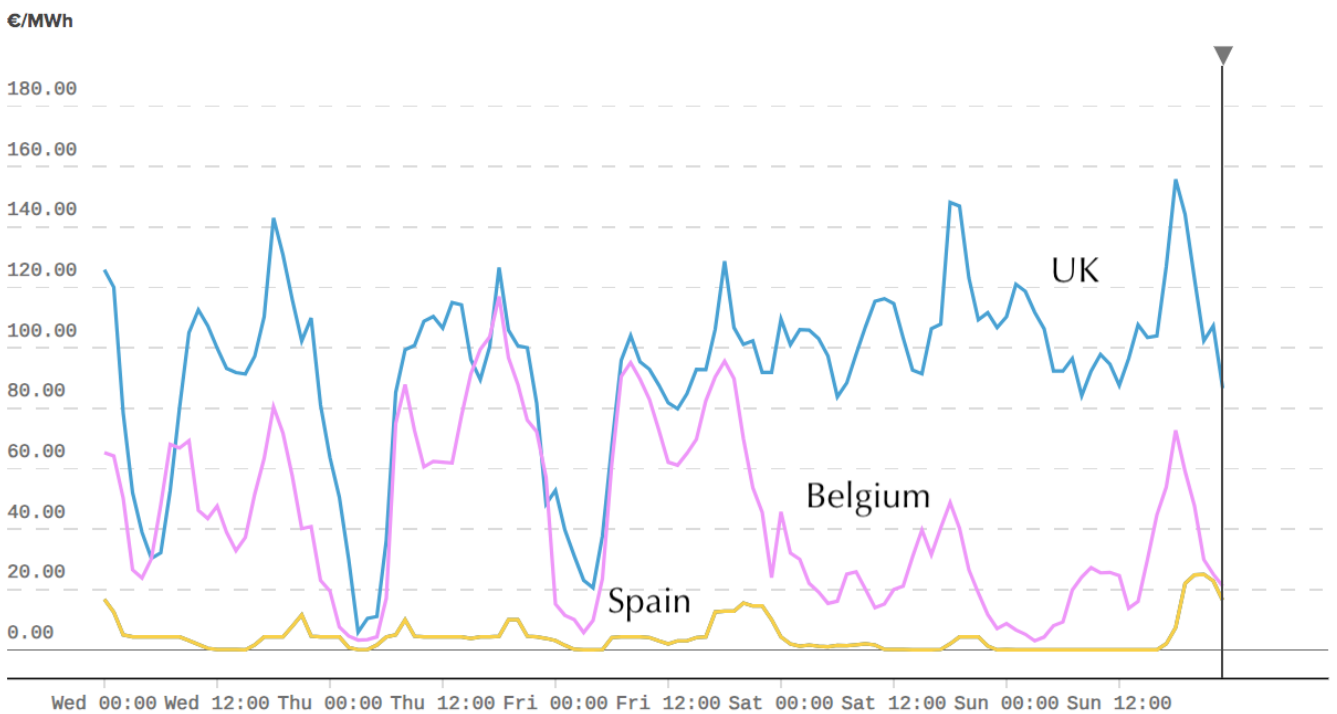

Figure: Last week's electricity prices in the EU: Spain, Belgium and the UK

Reforming European electricity markets

European Commission's proposal:

"[The Proposal] will optimize the electricity market design by complementing the short-term markets with a **greater role for longer-term instruments**, *allowing consumers to benefit from more fixed priced contracts, and facilitating investments in clean technologies."*

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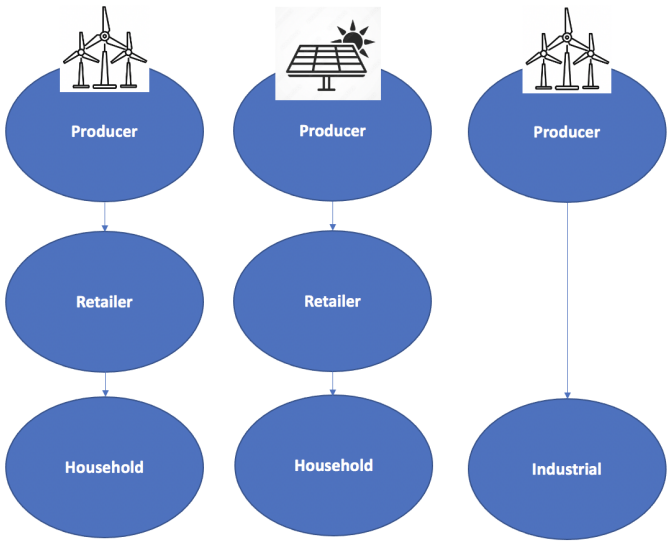
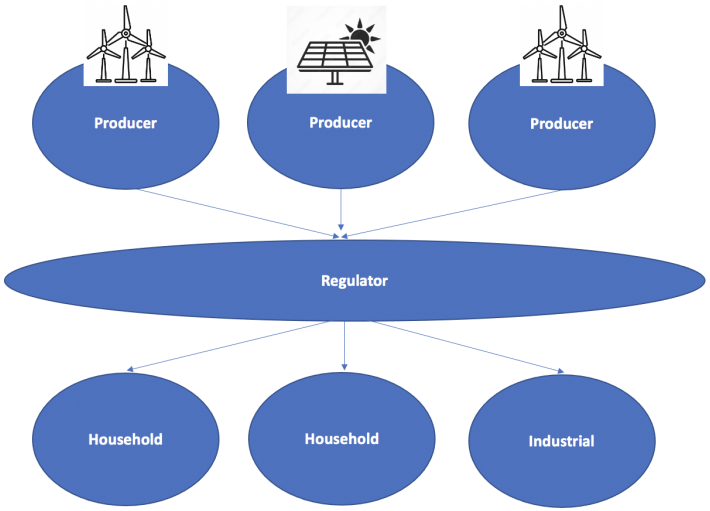


(a) Bilateral contracting (PPAs)



(b) Auctions (CfDs)

Long-term contracting in electricity markets

Policy concerns:

- *"A barrier to the growth of this market is the* **credit risk that a consumer will not always be able to buy** *the electricity over the whole period."*
- *"Member States should be free to* **decide which instruments they use** *to achieve their decarbonisation objectives."*

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Research and policy questions:

- How does counterparty risk affect contracting? Who should the counterparty be? Are public guarantees useful?

  (Ryan, 2023)
- How should long-run contracts be designed and allocated? How should contract prices be passed-on to final consumers?

  (Fabra and Montero, EJ 2023; Fabra, EneEco 2023; Newbery, 2021)

Who should the counterparty of the long-run contracts be?

Ryan (2023): Holding Up Green Energy: Counterparty Risk in the Indian Solar Market

Counterparty risk increases contract prices, which sharply reduces investment, because demand for green energy is elastic

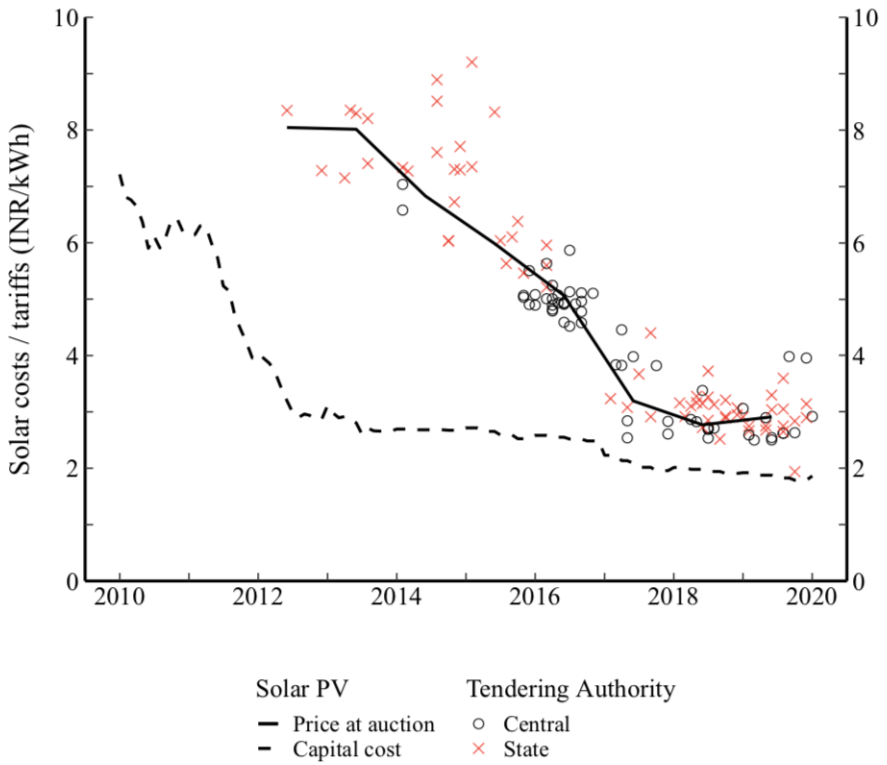

Figure: Solar auction clearing prices by intermediation; Indian solar auctions

Who should the counterparty of the long-run contracts be?

The supply curves for higher-risk counterparties shift sharply inwards relative to what would be offered to the central government

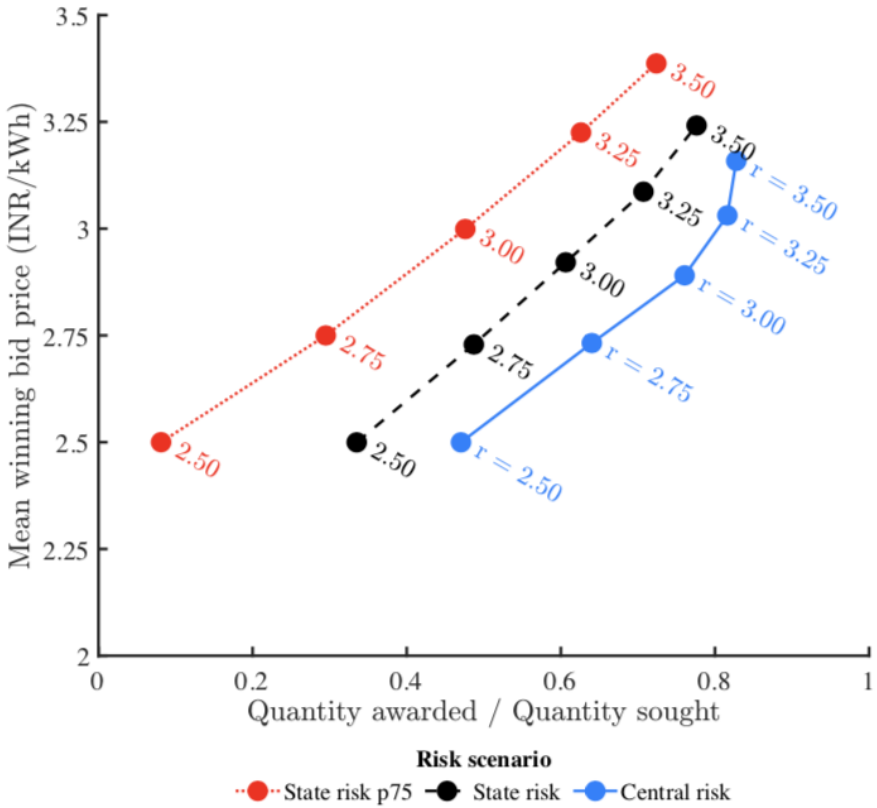

Figure: Counterfactual procurement by risk under uniform ceiling prices

Auction and contract design raise exciting questions

1. **Auction design**:
   - Which auction format?
   - Should reserve prices be kept secret?
   - How much to auction off? How often?
   - **Are technology-neutral auctions optimal?**

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   - **Are technology-neutral auctions optimal?**
2. **Contract design:**
   - Should contracts be at fixed prices or contain some exposure to market prices?
   - Should contracts contain a price floor?
   - Should investors be paid four output or for capacity?
   - Should they be paid for actual output or for a fixed output?

Are technology-neutral auctions optimal?

Fabra and Montero (EJ, 2023): Technology-neutral *vs.* technology-specific procurement

The choice of technology-neutral versus technology-specific auctions faces regulators with a **rent-efficiency trade-off**

1. A technology-neutral approach is good for **cost efficiency**
2. A technology-specific approach is good for **reducing rents**

The **optimal mechanism** involves departures from technology-neutral auctions

A Technology-Neutral Auction

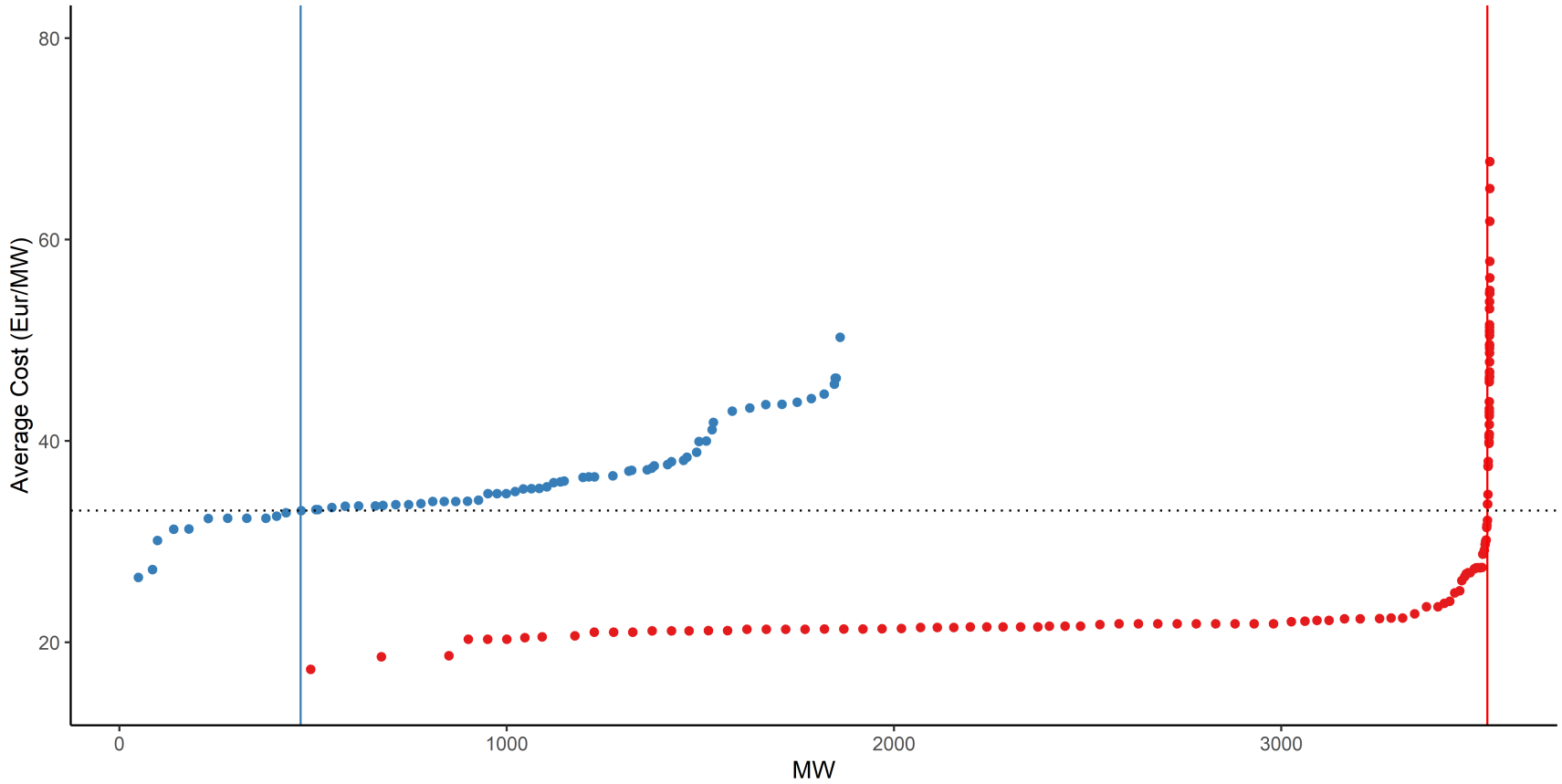


Figure: Supply curve for renewable projects under technology-neutrality in the Spanish electricity market

Technology-Specific Auctions

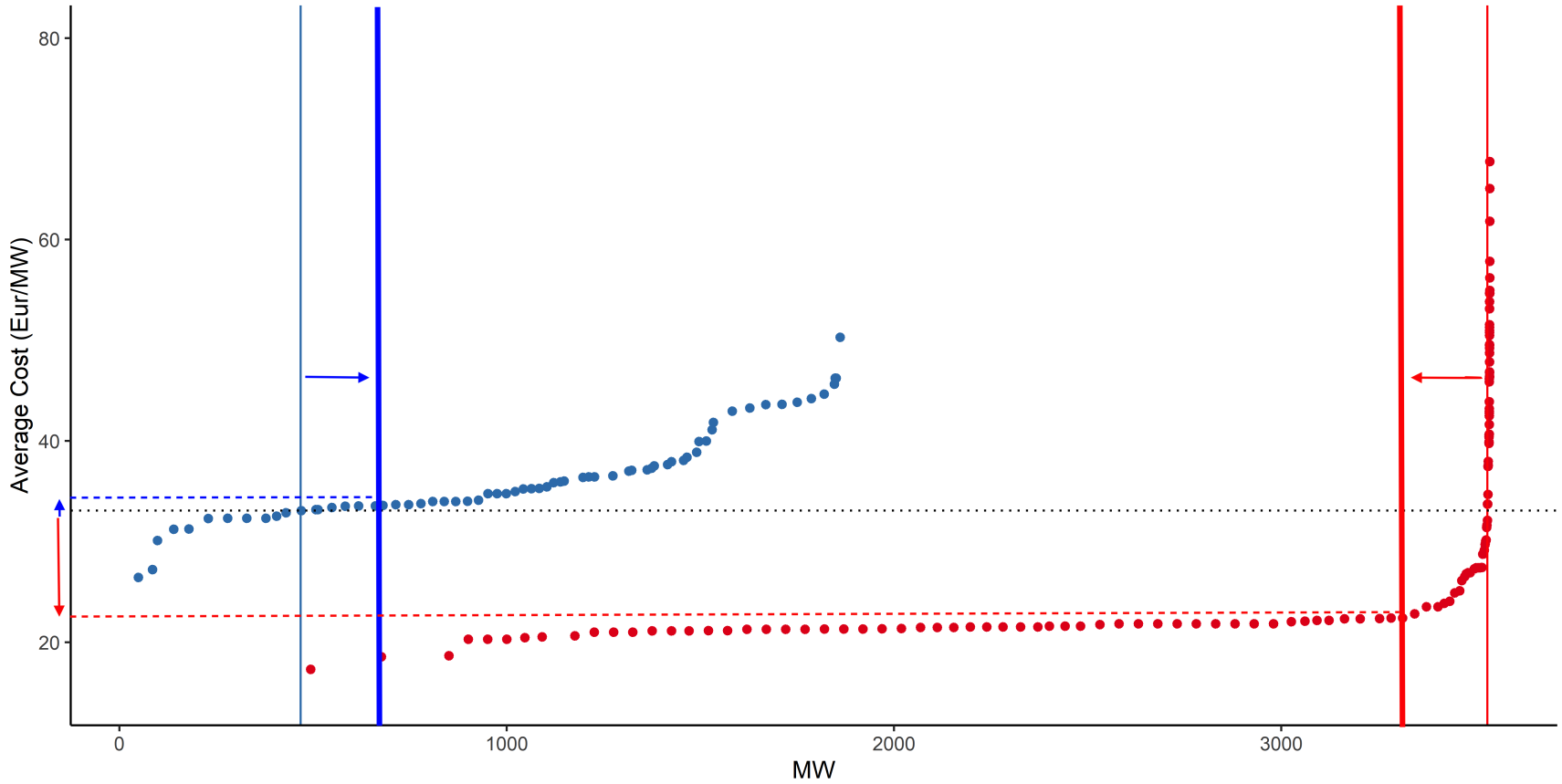


Figure: Supply curve for renewable projects under technology-specific auctions in the Spanish electricity market

Addressing renewables intermittency:

energy storage, demand response, and market integration

Energy storage, demand response, market integration

- With fossil fuels, supply can follow demand
- But renewables are intermittent and often non-dispatchable

$\rightarrow$ Storage, demand response, and market integration become critical:

- By increasing supply/reducing demand when renewables are scarce
- By reducing generation costs and emissions
- By strengthening security of supply
- By mitigating market power

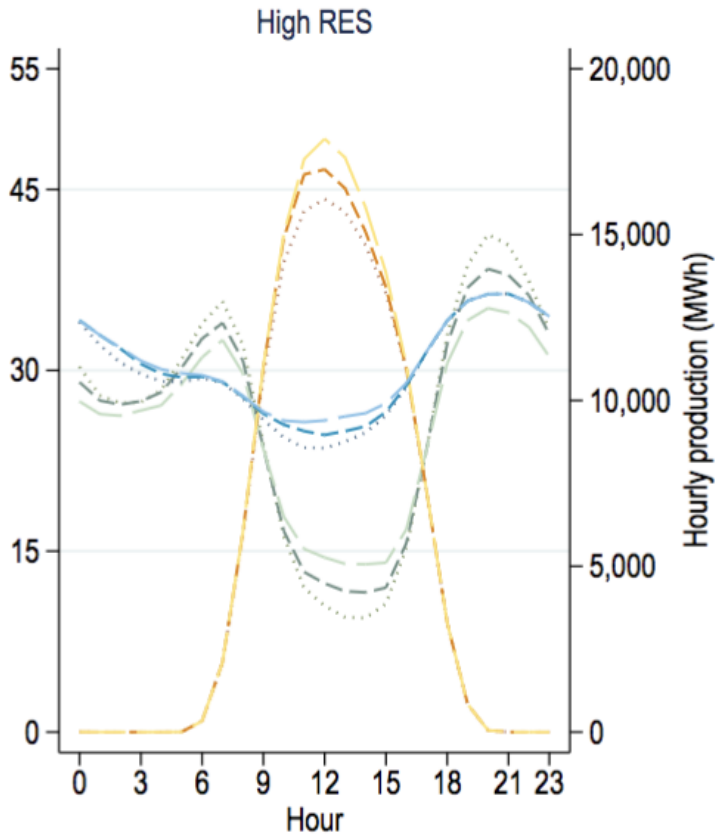
Energy storage, demand response, market integration

Research and policy questions:

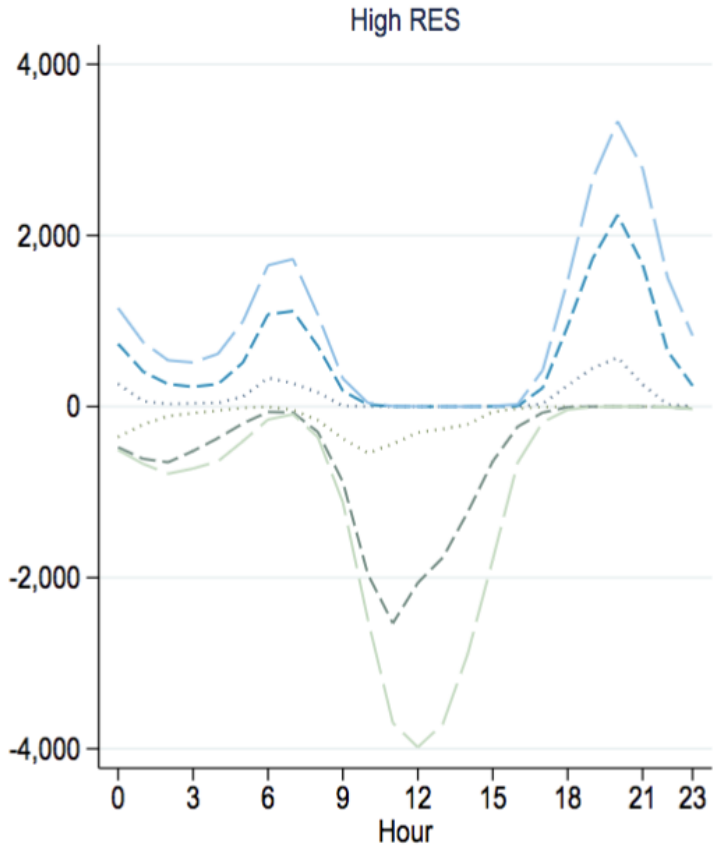
- Efficient incentives to invest in and operate storage facilities?
  (Andres-Cerezo and Fabra, RJE 2023)
- Are storage and renewables complements or substitutes?
  (Andres-Cerezo and Fabra, mimeo 2023; Butters, Dorsey, and Gowrisankaran, 2023)
- Is demand elastic enough to counteract renewables intermittency?
  (Fabra et al., AER P&P 2021; Allcott, REE 2011)
- Enhancing demand response through information? Automation?
  (Jessoe and Rapson, AER 20014; Bollinger and Hartmann, MS 2020)
- Effects of market integration?
  (Gonsales et al, Etca 2023; Yang, JEMM 2022; Ryan, AEJ:M 2021; Cicala, AER 2022)

Does storage promote renewable investments?

Andrés-Cerezo and Fabra (2023): Renewables and storage: friends of foes?



(a) Prices and renewable production



(b) Storage

Figure: Renewable production, prices and storage decisions across the day

Does storage promote renewable investments?

Renewables and storage: friends or foes?

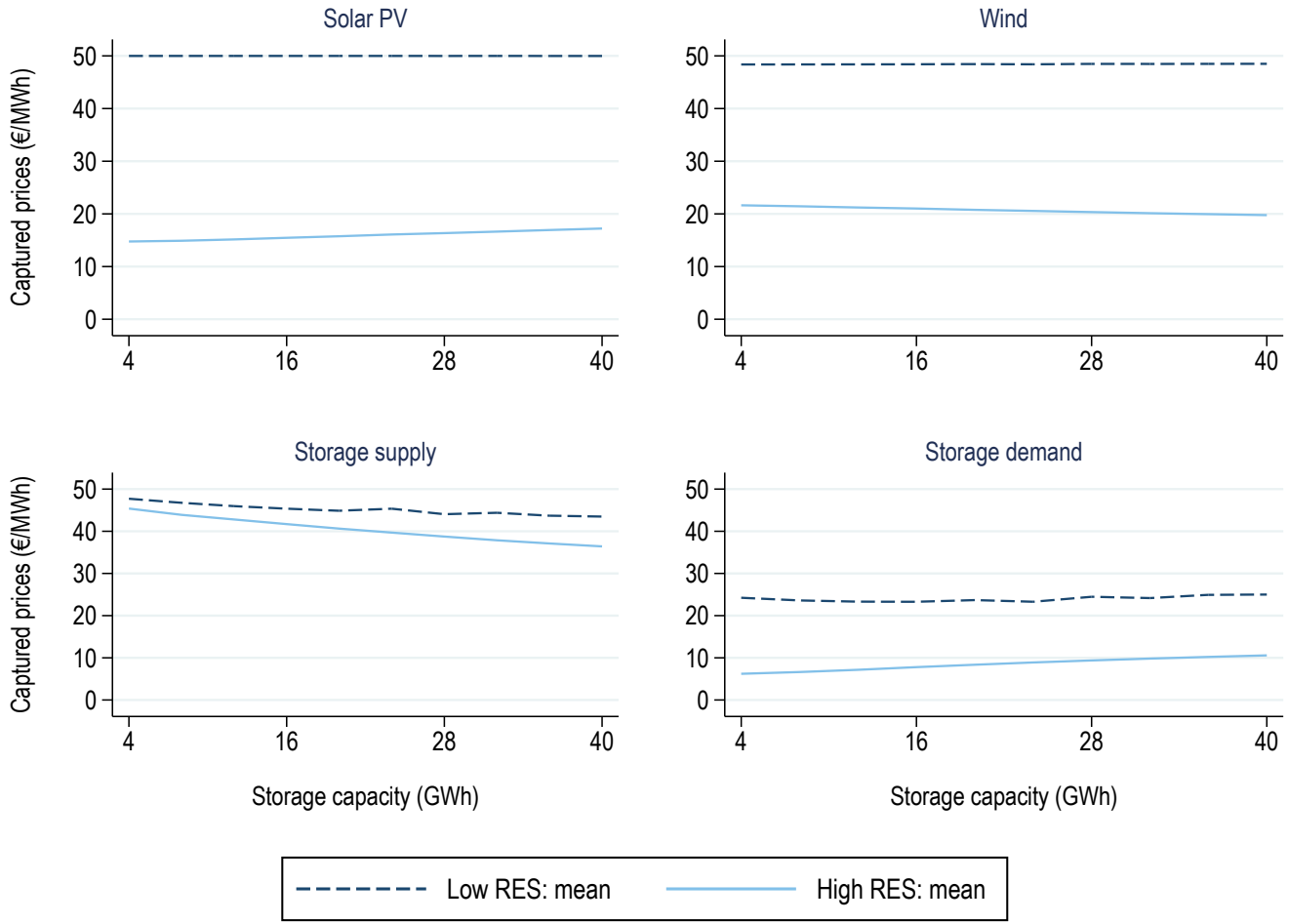


Figure: Price impacts of increasing renewables and storage

Promoting electrification: the role of electricity prices

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- Boosting demand would increase renewables profitability through price effects and reduction in curtailment
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Research and policy questions:

- What are the price-depressing effects of renewables?

  (Fabra and Llobet, EJ 2023; Acemoglu et al, EneJ 2017)
- How does this depend on the design of their support schemes? And on the ownership structure?

  (Fabra and Imelda, AEJ:EP 2023; Fabra and Llobet, mimeo 2023)
- What are the effects of carbon pricing in electricity markets?

  (Fabra and Reguant, AER 2013; Borenstein and Kellogg, 2023; Liski and Vehviläinen, JAERE 2020; Elliot 2023)

Reinforcing networks, and allocating fixed network costs

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- Existing networks were not built to accommodate renewables
  - Renewable are often far from consumption $\rightarrow$ reinforce transmission
  - Some consumers have become producers $\rightarrow$ reinforce distribution
- Network costs are often recovered through volumetric charges
  - Self-consumption does not contribute to network costs

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Research and policy questions:

- What is the value of transmission lines?

  (Gonzales, Ito, and Reguant, Etca 2023)
- How to define efficient and equitable electricity tariffs?

  (Cahana, Fabra, Reguant, Wang, 2023)
- And for rooftop solar?

  (De Groote and Verboven, AER 2019; Feger, Pavanini, and Radulescu, RES 2022)

What is the value of market integration?

Gonzales, Ito, and Reguant (Etca, 2023): The Investment Effects of Market Integration: Evidence from Renewable Energy Expansion in Chile

Market integration generates gains from trade and further cost reductions as it promotes investments in solar energy

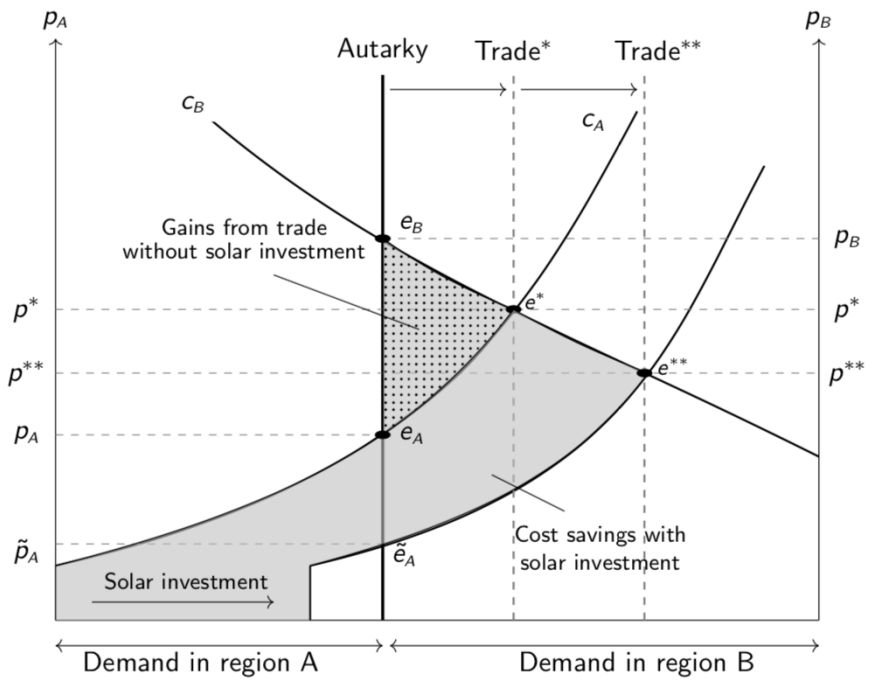

Figure: Impacts of Market Integration with and without Investment Effects

The importance of market integration

Market integration contributes to price convergence

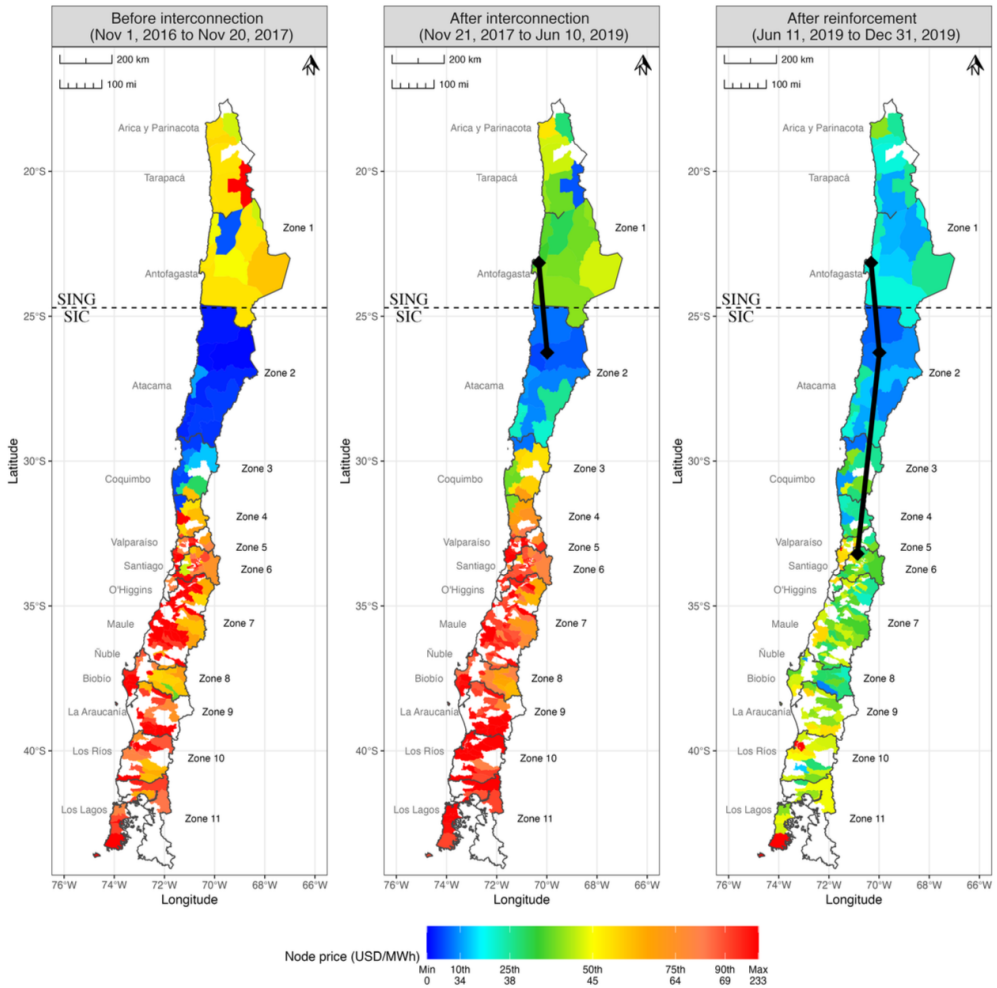

Figure: Market Integration and Spatial Variation in Electricity Prices

Market integration promotes investments in renewables

Market integration increased solar generation by around 180%, even before the interconnection was completed

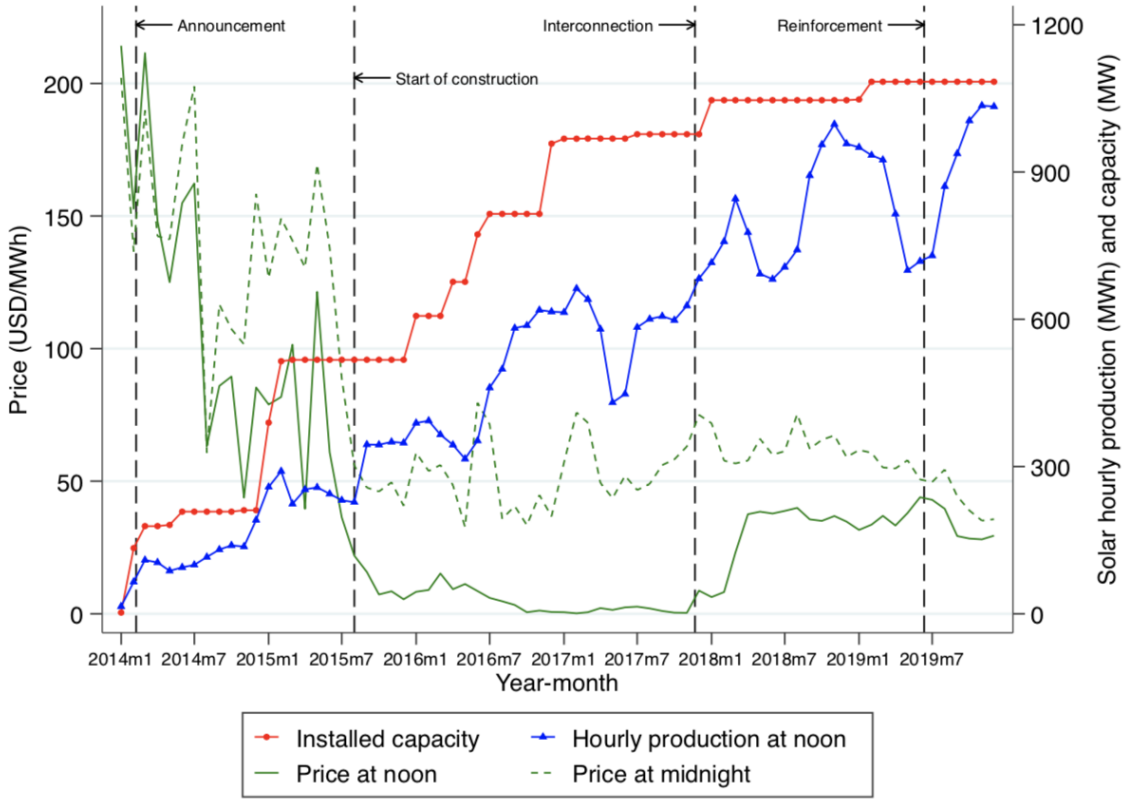

Figure: Impacts of Market Integration on Solar Expansion

Overcoming local opposition to renewables expansion

Overcoming social opposition to renewables expansion

- Renewables create global environmental and socio-economic benefits (employment, industry,...) (Curtis et al., 2023; Popp et al, 2021)
- But some of the municipalities where investments occur oppose the investments (NIMBYism)

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Research and policy questions:

- Do local citizens support renewable investments?

  (Germeshausen, Heim and Wagner, 2023; Jarvis, 2021)
- What are the perceived local costs?

  (Gibbons, JEEM 2015; Haan and Simmler, JPubE 2018)
- What are the local socio-economic benefits?

  (Fabra, Gutierrez, Lacuesta, Ramos, 2023)

Conclusions

- Massive investments in renewables, storage and networks are required to decarbonize the power sector
- Multiple challenges for expanding renewables:
  - Market design issues
  - Competition issues
  - Socio-economic issues

These issues bring exciting research opportunities that should prove useful for policy-making

Our research can greatly contribute to the achievement of environmental goals efficiently and equitably

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Thank You!

Questions? Comments?

More info at nfabra.uc3m.es and energyecolab.uc3m.es

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