Challenges for Renewable Energy Investments

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The power sector’s key role in decarbonizing our economies

Decarbonizing power is critical to addressing climate change

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

Decarbonizing 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
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."
Long-term contracting in electricity markets

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- "Member States should be free to decide which instruments they use to achieve their decarbonisation objectives."

**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?

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?*

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 for output or capacity?
- Should they be paid for actual output or for a fixed output?
Auction and contract design raise exciting questions

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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

→ 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?

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

(a) Prices and renewable production
(b) Storage
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
Promoting electrification: the role of electricity prices

- Boosting demand would increase renewables profitability through price effects and reduction in curtailment
- For consumers to be willing to invest in electrification, electricity prices need to go down
Promoting electrification: the role of electricity prices

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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
Reinforcing networks, and allocating fixed costs

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

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)
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What is the value of market integration?


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

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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)
Overcoming social opposition to renewables expansion

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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
Thank You!

Questions? Comments?

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

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