Empirical Methods for the Analysis of the Energy Transition: Day 5

CEMFI Summer School

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Today's outline

1) Distributional issues of the energy transition
   - Background
   - Review of two papers
2) Case study: RTP impacts in Spain

The challenges of the energy transition

- Need to reduce Green House Gas emissions (GHGs).
- Electricity sector (≈35-40% of CO2emissions) has been most active and has the greatest potential in making the transition.
- Ambition to move towards carbon-free electricity by 2035.

- Limits to decarbonization:
  - Renewables' intermittency might lead to a potential mismatch between supply and demand, increasing need for flexibility.
  - Important challenge until better (cheap, scalable) storage solutions are found.
  - Extreme events with adverse outcomes for households also intensify impacts and limits to decarbonization.

The challenges of the energy transition

- The energy transition can have substantial impacts on households that can be highly heterogeneous.
- Net-metering of solar can leave poorer households stranded without policy action.
- Uneven impacts combined with climate change impacts:
  - Households most exposed to extreme events tend to have the lowest income (poor building construction and insulation, heat islands).
  - Also least able to adapt and upgrade with resilience equipment(solar + backup battery, solar + EV as battery)

Impacts depend on market design and competition

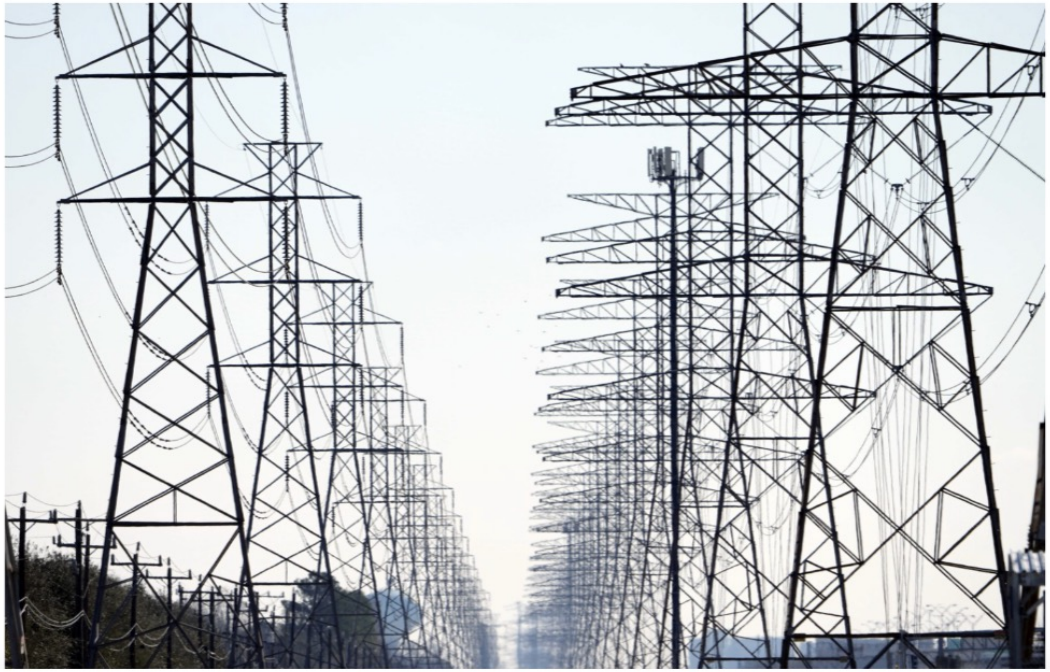
- Role of market design and competition is important:
  - What are the distributional implications of alternative market designs?
  - Are there provisions and safety nets in the face of more volatile prices?
  - Is there healthy competition that can mitigate some of these concerns?
  - How will retailers compete in the presence of these changes?
- Distributional impacts also crucial because they can impact the ability to complete the energy transition.

Equity impacts recently on the news

After Days Of Mass Outages, Some Texas Residents Now Face Huge Electricity Bills

February 21, 2021 · 12:01 PM ET

REBECCA HERSHER



Equity impacts can be devastating

WINTER STORM 2021

At least 111 people died in Texas during winter storm, most from hypothermia

> The newly revised number is nearly twice the 57 that state health officials estimated last week and will likely continue to grow.

BY **SHAWN MULCAHY** MARCH 25, 2021 4 PM CENTRAL

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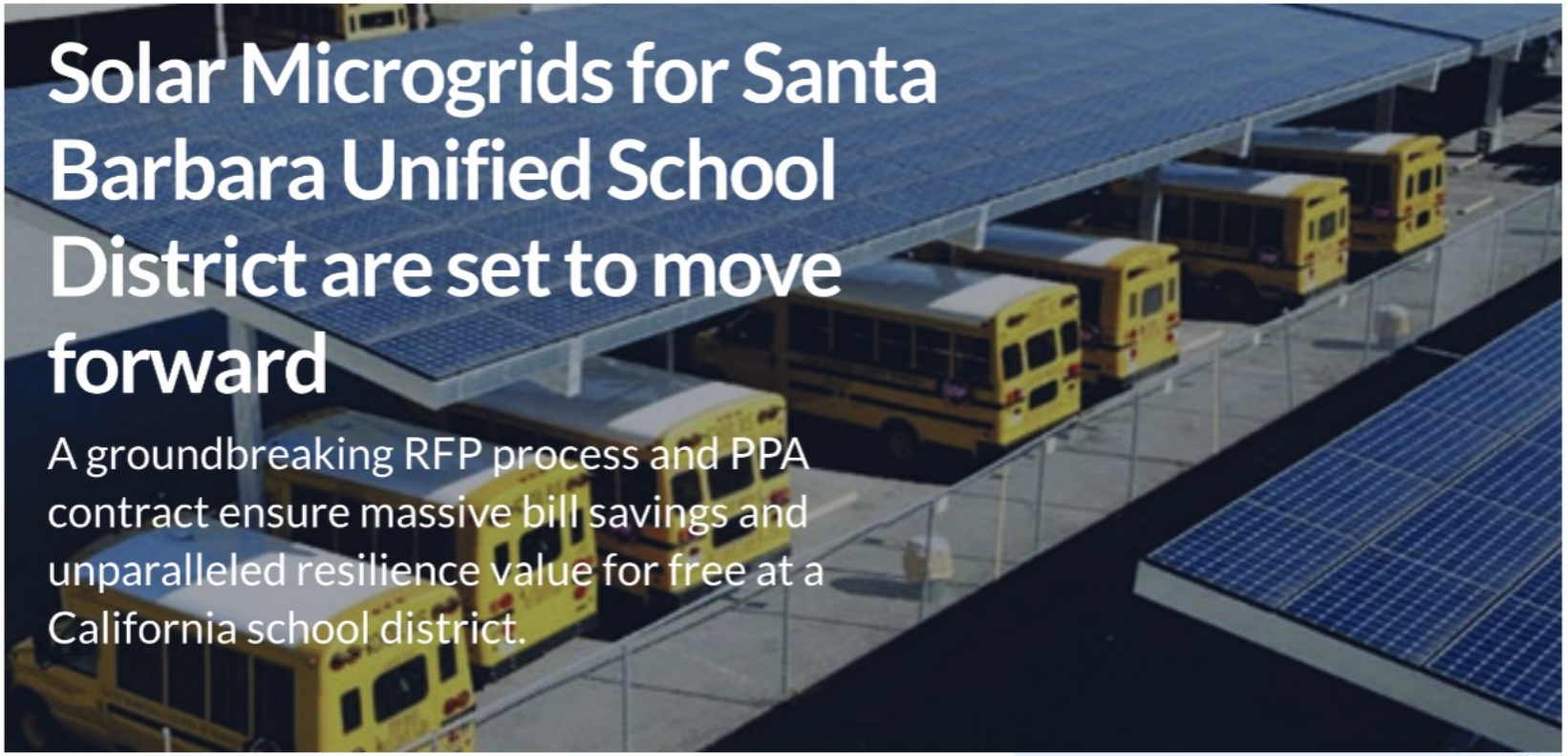
Resilience preparedness will not start where most needed



Many IO-related questions

- Huge need to think about several topics concerning the energy transition that seem highly suited for IO economists and that touch distributional issues:
  - Market design with renewables and climate policy.
  - Non-linear and dynamic pricing during energy transition.
  - Stranded assets and design of tariffs for fixed costs.
  - Competition with dynamic prices and heterogeneous consumers.
  - Solar panel and battery adoption.
  - Transportation electrification.
  - Heterogeneous impacts of reliability and resilience…

Many IO tools and data

Tools to examine distributional impacts:

- models of pricing and regulation.
- Structural dynamic models.
- Demand models with rich unobserved heterogeneity.
- Equilibrium models of supply and demand with discrete choice adoption or continuous investments.
- Mathematical programming tools to solve for equilibrium.
- Plenty of high frequency data can be used to study these questions and build accurate models

Many challenges

There is large value in trying to think about how economics can contribute to reducing the costs of large impacts:

- Some of the future impacts will be necessarily not well identified.
- Need to build general equilibrium models of the energy transition with heterogeneous agents and calibrated responses.
- Need to use counterfactuals much more out of sample than we currently do.
- Prioritize realism over methodological choices.
- Large value to partnering with electrical engineers and climates scientists to understand the pressure of extreme temperatures or deployment of solar/EVs at a local level.

Mix of approaches: examples

- Comparisons of impacts with micro data and aggregate income/demographic data (Borenstein, 2012; Leslie et al, 2021; Wang et al, 2021).
- Quantification of impacts via detailed data (e.g., US energy tax, Davis & Borenstein (2016)).
- Counterfactual equilibrium model of demand and supply (Wolak, 2016 (water); Feger et al., 2021).

Feger, Pavanini, Radulescu (2021)

Slides

Leslie, Pourkhanali, Roger (2021)

Slides

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We have already seen distributional impacts in our case studies

- **[Day 2]** The Efficiency and Sectoral Distributional Implications of Large-Scale Renewable Policies, JAERE, 2019.
- **[Day1]** Measuring the Impact of Wind Power in the Spanish Electricity Market, w/ Claire Petersen and Lola Segura.
- **[Today]** The Distributional Impacts of Real-Time Pricing, w/ Jingyuan Wang, Natalia Fabra, and Michael Cahana.

Paper #1: Industrial vs. residential sectors

- **Question**: Examine current practice of charging renewable costs mostly to residential sector.
- **Data**: California market data to calibrate a stylized model of an electricity market with 3 types of end users (I, C, R).
- **Methods**: Ramsey pricing theory with externalities, computational tools for quant assessment.
- **Finding**: Charging residential HH cannot be justified by Ramsey pricing unless industrial sector leaks.

Paper #2: Producers vs. consumers sectors

- **Question**: Examine the welfare implications of wind subsidies at the margin (vs. lump sum).
- **Data**: 10-year time series from the Spanish electricity market.
- **Methods**: Reduced form analysis of the quantile impact of wind generation, event study to examine regulation change.
- **Finding**: Moving from PTC to ITC had large distributional implications, making consumers worse off.

Paper #3: High- vs. low-income consumers

- **Question**: : Examine heterogeneous impacts from defaulting residential consumers into dynamic real-time pricing (RTP).
- **Data**: Detailed smart meter data from millions of households in Spain.
- **Methods**: : k-means clustering based on smart meter data combined with distributional aggregate moments of income distribution.
- **Finding**: Move towards RTP was mildly progressive, caveats on likely different impacts going forward.

Wang, Reguant, Fabra, and Cahana (2021)

Slides

Thank you!

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