UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

CEENRG Cambridge Centre for Environment, Energy and Natural Resource Governance

Planning for low financial risk and stable electricity prices

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CEEPR – EPRG International Energy Policy Conference

- Goals of the structure and regulation of the electricity industry: short-term operation efficiency, long-term investment efficiency and (importantly) decarbonization through electrification
- Energy only markets can theoretically deliver all these objectives: requires full transmission of undistorted short-term signals to investors & users, complete markets and pricing of GHG externality
- In practice, these conditions are not met:
  - Energy markets are far from complete
  - Short term price signals are distorted by interventions, particularly when prices are "too high"
- Likely explanation: energy only markets would result in too much volatility: 1) beyond the forecasting and risk management capabilities of individual agents; 2) creating substantial systemic effects: hysteresis, inefficient destruction/creation of capital, etc.
  - Parallel to financial sector regulation: private contracting could in principle be designed to deliver efficient dynamic stochastic equilibrium, but the conditions for this are not realistic

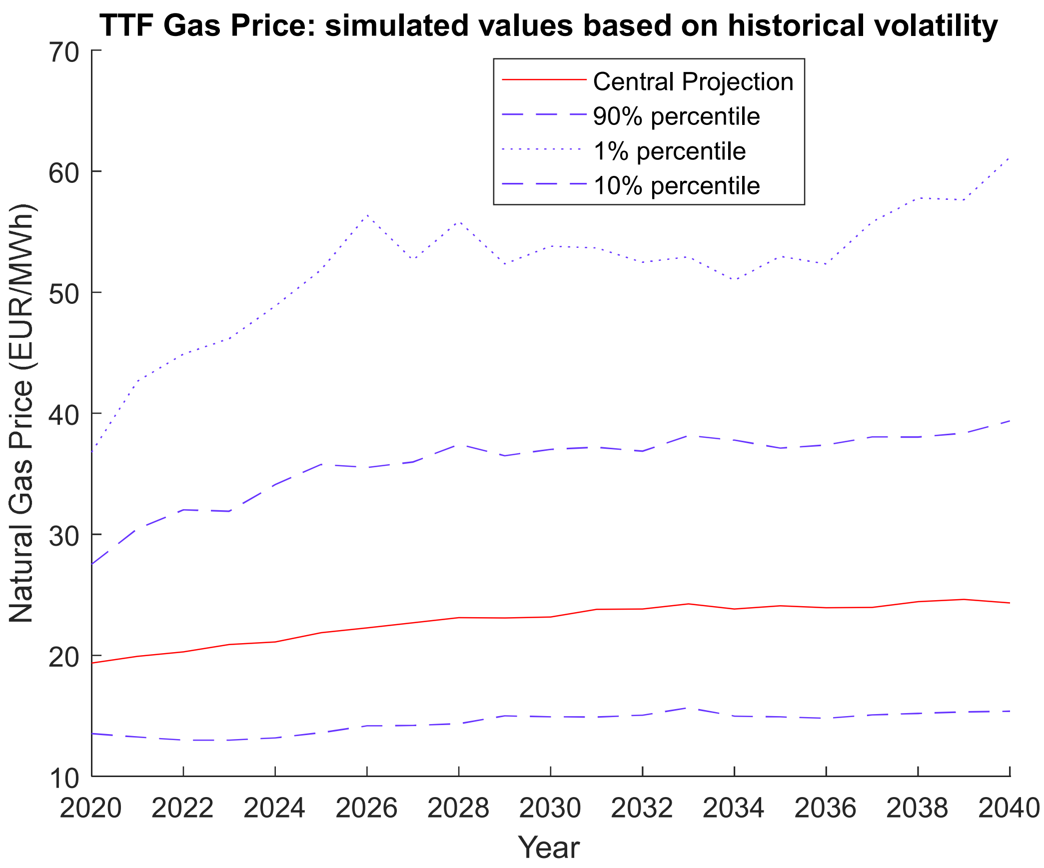
- Return of planning: hybrid models with capacity targets (Roques & Finon, 2017)(Joskow, 2021)
- Focus is on providing long term certainty to generation investments: planning for low financial risks
  - Lower risk premium in generation investments
- All good for decarbonizing generation but: it is enough to deliver electrification?
  - Electrification requires price of electricity attractive relative to other energy forms
  - Volatile relative prices make it difficult for adopters to invest in electrification
  - Increases risk premium in adoption investments (transport, heat pumps, industrial heat, etc.)
  - Remember: electricity is a very close substitute of other energy forms, energy service is not particularly distinct…but price stability could become distinguishing feature that accelerates adoption
- Existing approaches to hybrid models pay insufficient attention to ensuring stable electricity costs to final users: for example, (Corneli, 2020) does not mention it (but would probably result from centralized procurement of capacity through swaps)

- What type of stability? As (Battle, Schittekatte & Knittel, 2022), we should distinguish:
  - Short-term volatility: episodes of very high prices at hourly, daily or weekly frequency, driven by reliability issues, weather patterns, etc.
  - Long-term volatility: protracted periods of high prices, lasting several months or years.
    1) Affecting monthly, quarterly, annual average price of (wholesale) electricity prices
    2) Driven by three factors:
       1) Cyclical variability in demand
       2) Cyclical variability in fossil fuel prices
       3) Variations in weather patterns from one year to another: i.e. rainy years, windy years, etc.
- Arguably, adopters of electrification investments and regulators should be more worried about long-term volatility: fully fledged variable time of use rates are not common, whereas sustained periods of high wholesale prices must at some point be passed through to users
  - Useful lifetime for EVs, heat pumps and several industrial electrification technologies are within cyclical durations (5 to 7 years), cannot rely on long term trends to average out cycles

- European Union as an example in what follows:
  - EU has, at least formally, a strong normative framework. Member States must publish National Energy and Climate Plans (NCEPs), which are explicitly designed to provide investment certainty
    - National Energy and Climate Plans are very detailed: include indicative forecasts for demand, generation mix, interconnections, etc. Also, they are full-energy system plans: include electricity jointly with other energy flows
  - Regulation on the governance of the energy union and climate action (EU) 2018/1999: recital (34): *"Integrated national energy and climate plans should be stable to ensure the transparency and predictability of national policies and measures in order to ensure investment certainty."*
  - EU is close to the levels of renewable penetration that are likely to drive significant changes in price volatility and financial risks. Current target is 32% RES energy by 2030 but legal acts are being approved to raise this target (probably 45% in next iteration)
  - EU runs a (comparatively) wide CO2 cap and trade system (ETS), interactions between planning and markets are a relevant issue

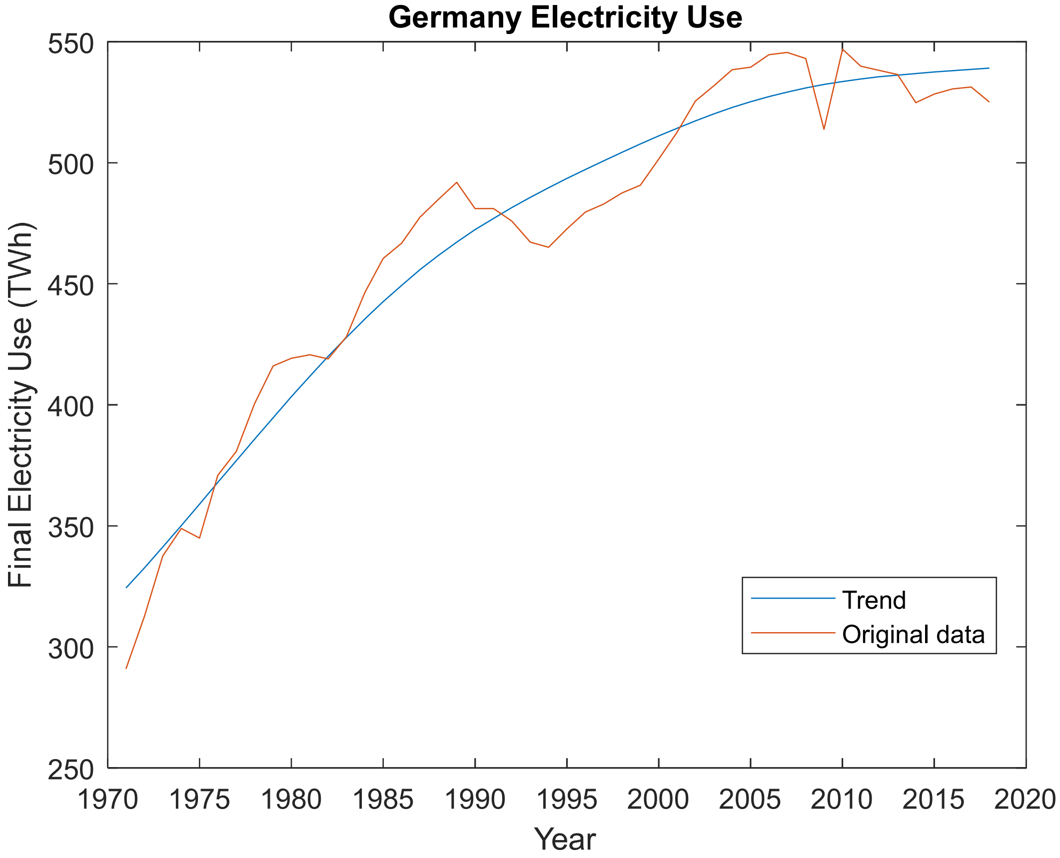
- Methodology:
  - Derive econometric estimates of the cyclical volatility of fuel prices and demand at annual frequency
  - Re-sample weather years from historical observed data
  - Superimpose over the central projections of EU Energy Plans: 1) cyclical noise for fuel prices; 2) cyclical noise for demand; 2) full weather years (hourly capacity factors, inflows into hydro, etc.)
  - Throughout, it is assumed that EU capacity plans are delivered on time
  - In other words, methodology assumes the National Energy & Climate Plan does indeed predict the future central trends in demand, external prices and capacity, but also that cyclical/weather noise will create fluctuations around this trend (with their pattern matching historical experience)
  - Modelling answers the question: what is the range of cyclical variation to be expected for the capacity mix planned in the National Plans?
  - Simulate optimal cost dispatch for r=600 repetitions of every year from 2020 to 2040, where every repetition corresponds to a different combination of fuel prices, demand and weather
  - Using a variation of MIT's Gen X open source: dispatch is replicated for the 8760 hours of every year/repetition
  - Derive distribution of annual prices, revenues depending on different designs, etc.

1) Fuel price volatility is systematically underestimated

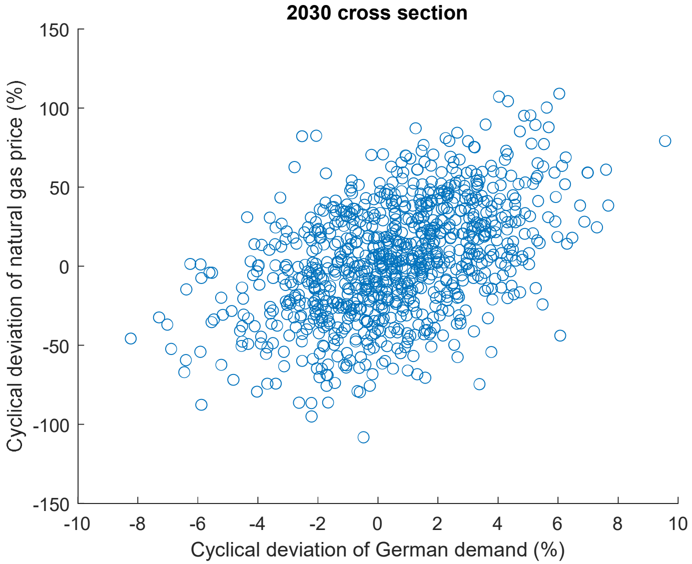


- Planners should be prepared for wide and protracted fluctuations in fuel prices
- Natural gas prices prices at 46 EUR/MWh (as in 2021) or above are indeed extreme (but not impossible, even with simple models, see graph)
- But annual averages of natural gas prices above 30 EUR/MWh (around 11 USD/MMBtu) are to be expected more than once every ten years according to the path assumed in the EU plans for commodity prices

2) Cannot ignore demand variability: it is very large at cyclical frequency



- Cyclical variation of demand is large: shocks to demand of 10% over 1-3 years are not infrequent
- Deviations from trend are persistent and moderately positively correlated with fuel prices (at least in Europe historically)



3) On energy only markets, financial viability of VRE would essentially depend on credibly setting a consistently high CO2 price

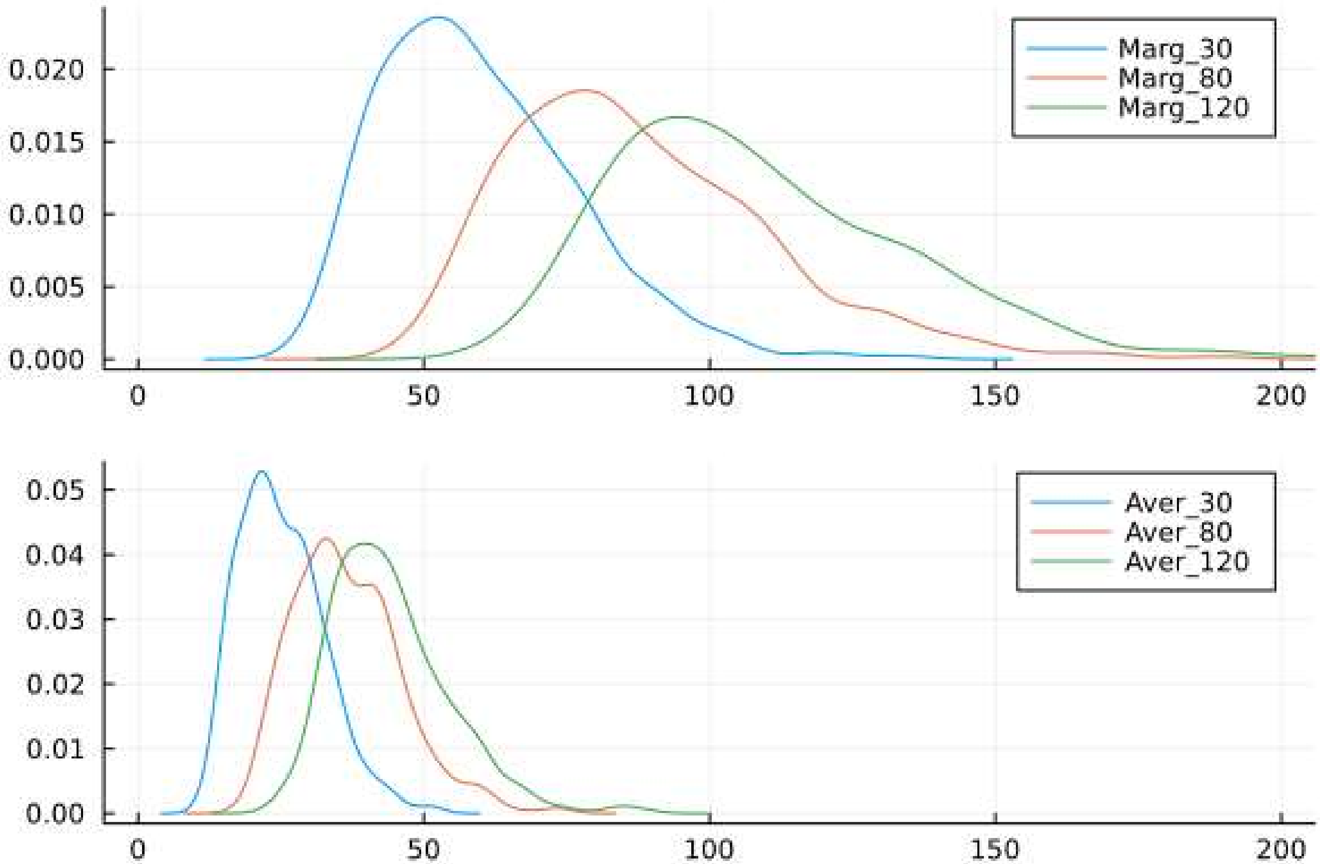
Result echoes Pollitt & Chyong (2019) and Green & Lautier (2015), but dynamical modelling here highlights how economic value depends crucially on the credibility of the capacity mix planning and the credibility of CO2 pricing

Europe: Value of VRE investments if National Plans Fully Executed

			Median NPV of 20 years Net Energy			Median Economic Value		
Technology	Country	2020 Capex	20 EUR/ton in 2020 50 Eur/ton in 2040	Flat 80 Eur/ton	80 EUR/ton in 2020 200 Eur/ton in 2040	20 EUR/ton in 2020 50 Eur/ton in 2040	Flat 80 Eur/ton	80 EUR/ton in 2020 200 Eur/ton in 2040
On Wind	Germany	1800	1240	1910	2300	-560	110	500
On Wind	France	1800	400	3200	470	-1400	200	-1330
On Wind	Italy	1800	1450	1110	2710	-350	310	910
On Wind	Spain	1800	1120	430	1880	-680	-1370	80
Off Wind	Germany	3000	2070	760	3870	-930	-2240	870
Off Wind	France	3000	700	220	840	-2300	-580	-2160
PV	Germany	800	720	2190	1320	-80	390	520
PV	France	800	210	1650	230	-590	850	-570
PV	Italy	800	1100	1630	2020	300	-170	1220
PV	Spain	800	630	940	1040	-170	140	240

4) High CO2 prices mean probability of long periods of high marginal prices are very large (unsustainable?)

Germany 2030: distribution of annual Marginal Cost and Average Cost (EUR/MWh)



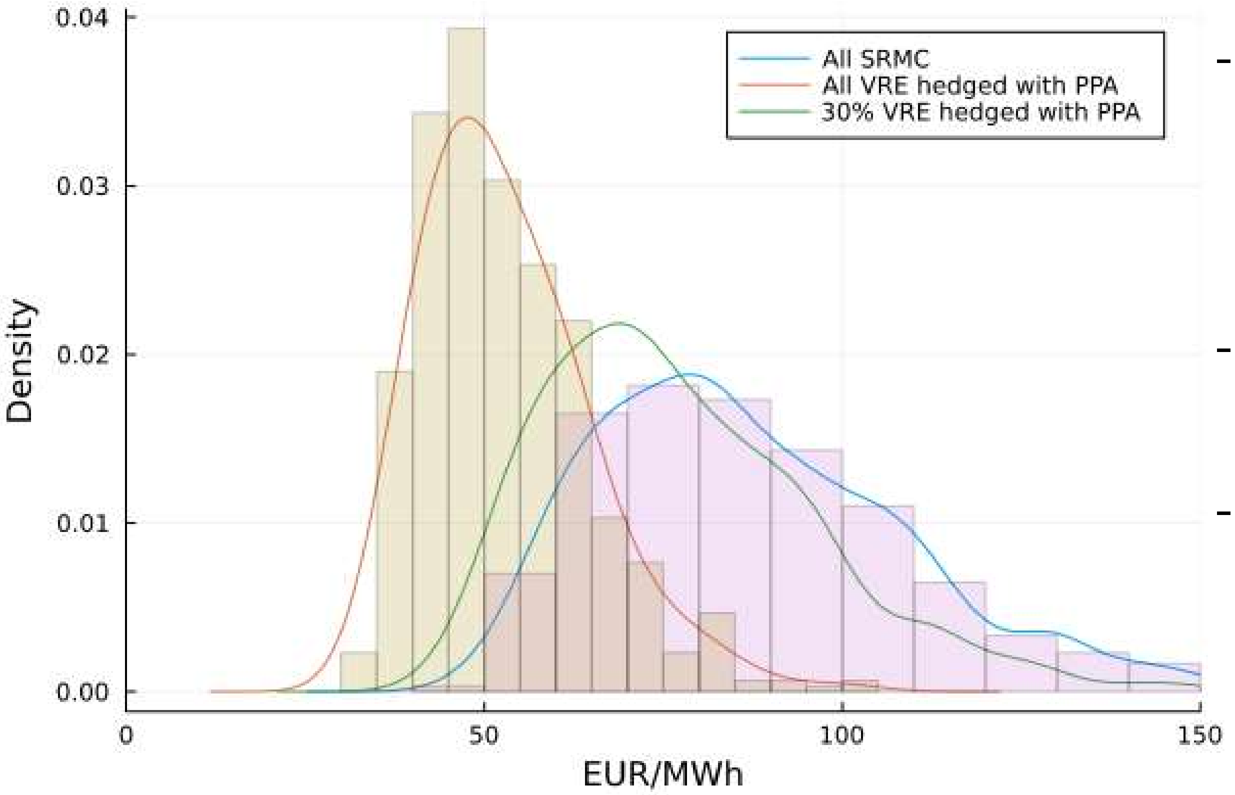
Marg = Short run marginal cost
Aver = Short run average cost
Numbers after each series name = price of CO2 per ton

- Interaction of fuel prices and CO2 prices is key
- Higher CO2 prices imply size of fuel price shock required to create high SRMC is lower
- Also, high CO2 price concentrates dispatch on CCGT, lower diversification of fuel price mix
- Germany 2030 according to National Energy and Climate Plan:

CO2 Price (EUR/ton)	Prob. Price > 100	Prob. Price > 150
30	3%	0
80	26%	2%
120	56%	7%

5) For PPAs to have a significant effect on final volatility, the share of hedged VRE capacity must be large

Germany 2030: final user cost distribution
(Flat 80 EUR/ton CO2 ETS price)



- High VRE + high share of PPA fixed pricing delivers the required stability of electricity cost for final users
- Reinforcing effect: high share of hedged VRE production makes intervention in short-run dispatch less likely and high CO2 prices more credible
- Can these high levels of hedging be achieved with decentralized contracting?
- If done centrally with auctions for long term contracts, probably better to buy capacity or “average” MWh, rather than metered MWh (Newbery, 2021)(Corneli, 2020) . Otherwise distortions in short run dispatch

6) Centralized and decentralized contracting could be mutually incompatible, with realistic entry dynamics

Technology	Country	2020 Capex	PPA strike price premium over median price required for financial viability: 20 EUR/ton in 2020 50 Eur/ton in 2040	Flat 80 Eur/ton	80 EUR/ton in 2020 200 Eur/ton in 2040
On Wind	Germany		45%	-6%	-22%
On Wind	France		350%	319%	283%
On Wind	Italy		24%	-18%	-34%
On Wind	Spain		61%	10%	-4%
Off Wind	Germany		45%	-6%	-22%
Off Wind	France		329%	295%	257%
PV	Germany		11%	-28%	-39%
PV	France		281%	264%	248%
PV	Italy		-	-52%	-60%
PV	Spain		27%	-15%	-23%

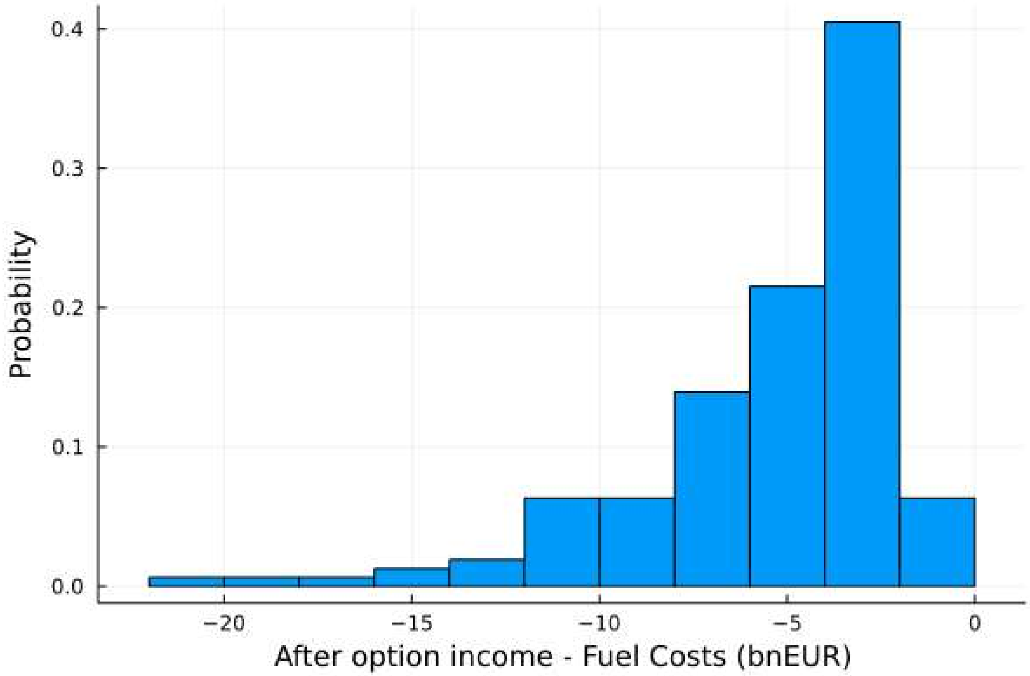
Figures highlighted in green show situations where PPA buyers could sign a strike price below the expected market value of future energy in the contract, while sellers could still get a 5% WACC from this strike. Potential for mutually beneficial contract exists. The remaining figures are white when buyers would have to pay a risk premium below 35% and orange when the required premium would exceed that threshold.

- For sufficiently high (and long term credible) CO2 prices, private contracting of PPAs has economic value and would in fact drive capacity beyond what is on the National Energy Plans
- Early buyer's curse. Private buyers could obtain better terms signing a PPA basket skewed towards later (and cheaper) vintages of VRE, rather than the centralized cumulative basket
- With immediate entry, capacity would adjust to the private contracting level (the plan would be irrelevant). But access to network and other factors make entry slow: economic premium for early entrants and early buyers, who derive economic rents in transitory period
- Distribution of these rents is not politically or economically neutral

7) Other possibilities, transition policies and planning design

- Stabilization through Asian option style instruments (Battle, Schittekatte & Knittel, 2022) can be useful, but has different properties to PPAs. If strike is set below fuel costs, large losses (hence credit risk) can accumulate if all users are hedged (see graph). Not clear whether private sector could sustain generalized hedging. Trade off between competition and solvency (also existing in the financial sector).

Germany 2030: generator losses (annual) with Asian option at strike=100 and all demand hedged



- Transition policies could modulate legacy costs to partially replicate Asian style options if private sector cannot take on these risk

- Some planning design implications:

1) Include long term volatility explicitly in the choice of indicative capacity mix. Plans that only work for the central scenario are no good

2) Announce offsetting policies and their triggers in advance

3) Ensure that hedges are simultaneous with user cost fluctuations (basis risk can be significant)

Summing up

- Seems obvious these days, but the only thing that can be safely assumed is that there will be big fluctuations even in the smoothest transitions
- Tension between high CO2 prices and “safety margin” to absorb fuel price or demand shocks… tentation of price intervention will be high (irresistible?)
- Long term contracting can help improve the political economy of high CO2 prices but significant shares of PPA coverage are required
- For sufficiently high and credible CO2 prices, the issue is no longer whether VRE will be built, but rather how fast it can connect. Economic rents (whose distribution will be polemic) and distortions if centralized contracting allowed in parallel to private contracting
- Planning only for stable fuel prices and smooth demand is unlikely to result in low risk premia or stable prices
- Best to plan with explicit recognition of volatility, designing policy to reduce ex ante and also preannouncing actions to be taken if extremes occur

Thank you

Chyong, C. K., Pollitt, M., & Cruise, R. (2019). *Can wholesale electricity prices support "subsidy-free" generation investment in Europe?* http://www.jstor.org/stable/resrep30343

Green, R., & Vasilakos, N. (2011). The Long-Term Impact of Wind Power on Electricity Prices and Generating Power. https://doi.org/10.2139/ssrn.1851311

Batlle, C., Schittekatte,T. & Knittel, C. (2022a) Power price crisis in the EU: Unveiling current policy responses and proposing a balanced regulatory remedy. MITEI Working Paper

Batlle, C., Schittekatte,T. & Knittel, C. (2022b) Desperate times call for desperate measures. MITEI Working Paper

Blyth, W., Bunn, D., Chronopoulos, M., & Munoz, J. (2016). Systematic analysis of the evolution of electricity and carbon markets under deep decarbonization [Article]. *Journal of Energy Markets*, *9*(3), 59-94. https://doi.org/10.21314/JEM.2016.150

Mays, J. & Jenkins, J. (2022). Electricity Markets under Deep Decarbonization. USAEE Working Paper No. 22-550, Available at SSRN: https://ssrn.com/abstract=4087528

Simshauser, P. (2021). Vertical integration, peaking plant commitments and the role of credit quality in energy-only markets. *Energy Economics*, *104*, 105612. https://doi.org/https://doi.org/10.1016/j.eneco.2021.105612

Tietjen, O., Pahle, M., & Fuss, S. (2016). Investment risks in power generation: A comparison of fossil fuel and renewable energy dominated markets [Article]. *Energy Economics*, *58*, 174-185. https://doi.org/10.1016/j.eneco.2016.07.005

Muñoz, J. I., & Bunn, D. W. (2013). Investment risk and return under renewable decarbonization of a power market. *Climate Policy*, *13*(sup01), 87-105. https://doi.org/10.1080/14693062.2012.750473

Newbery, D., (2021) Designing an incentive-compatible efficient Renewable Electricity Support Scheme. Cambridge Working Papers in Economics 2128, Faculty of Economics, University of Cambridge.