

Investigation, simulation and real options valuation of the GOPACS flexibility market

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Electricity, Congestion and Flexibility

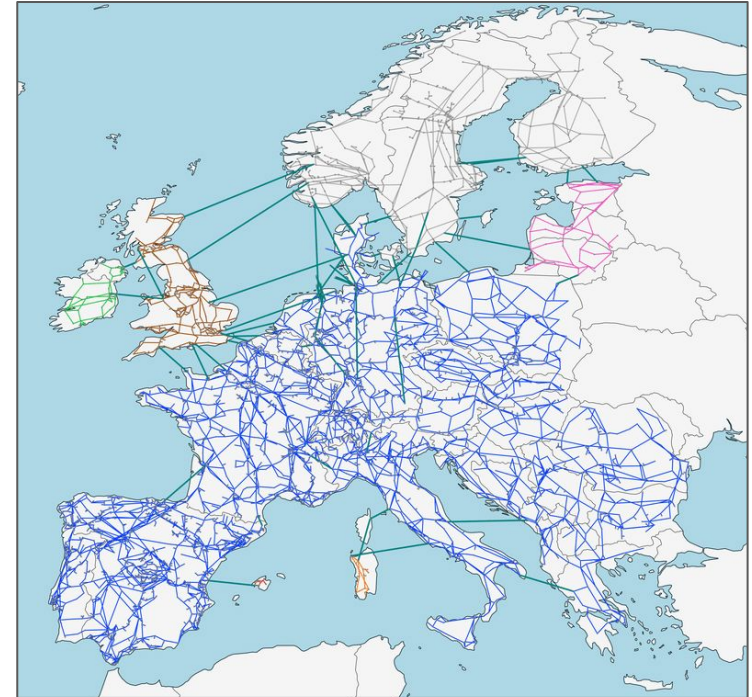
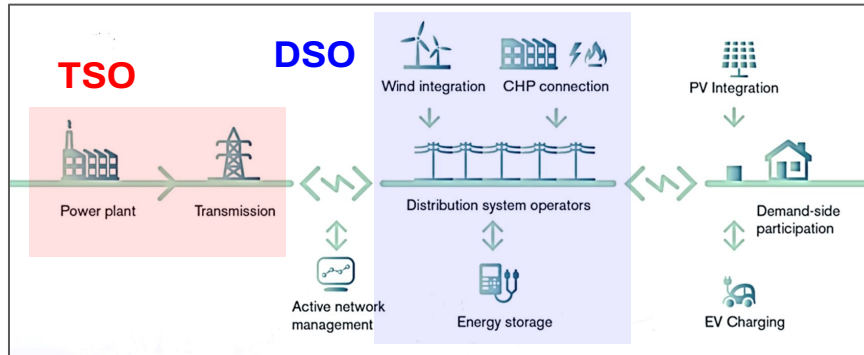
Electricity is a commodity, but different:

- non-storable
- special laws for transport

Increased congestion in European grid

→ Solution: **Flexibility markets**

Flexibility: “the ability to purposely deviate from a planned / normal generation or consumption pattern”¹⁶



GOPACS

RQ1: Who / What / When / Where / Why is GOPACS?

- dutch flexibility platform
- connects grid operators (DSO) with flexibility service providers (FSP)

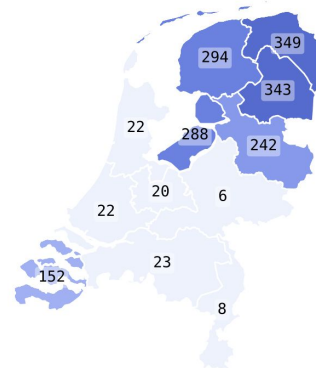
How it works:

1. DSO forecasts congestion
2. Market announcement on GOPACS
3. Sealed-bid pay-as-bid auction
4. order + counterorder + spread matched into an IDCONS
5. data is published

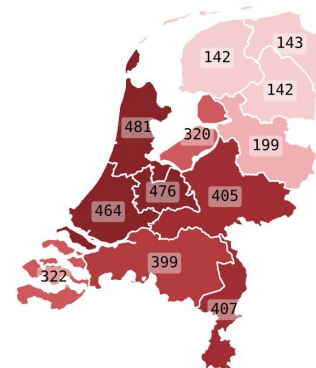
Request for buy orders in Groningen; Friesland; Drenthe; on all voltage levels																							
Request for sell orders in Noord-Oost-Polder; Overijssel; Gelderland; Utrecht; Noord-Holland; Zuid-Holland; Zeeland; Brabant;																							
Hide problem volume																							
Date 09/02/2022																							
Hours 16				17				18				19				20				21			
Quarter	00	15	30	45	00	15	30	45	00	15	30	45	00	15	30	45	00	15	30	45	00	15	30
MW	174	174	174	174	657	657	657	657	585	585	585	585	652	652	652	652	689	689	689	689	980	980	980
Extra information/message:																							
Type: TRANSPORTPROBLEM Gridoperator: TenneT Compliance is Voluntary State: Closed Bids most likely used if posted between 09/02/2022 03:23, Created: 09/02/2022 03:23																							

GOPACS Data

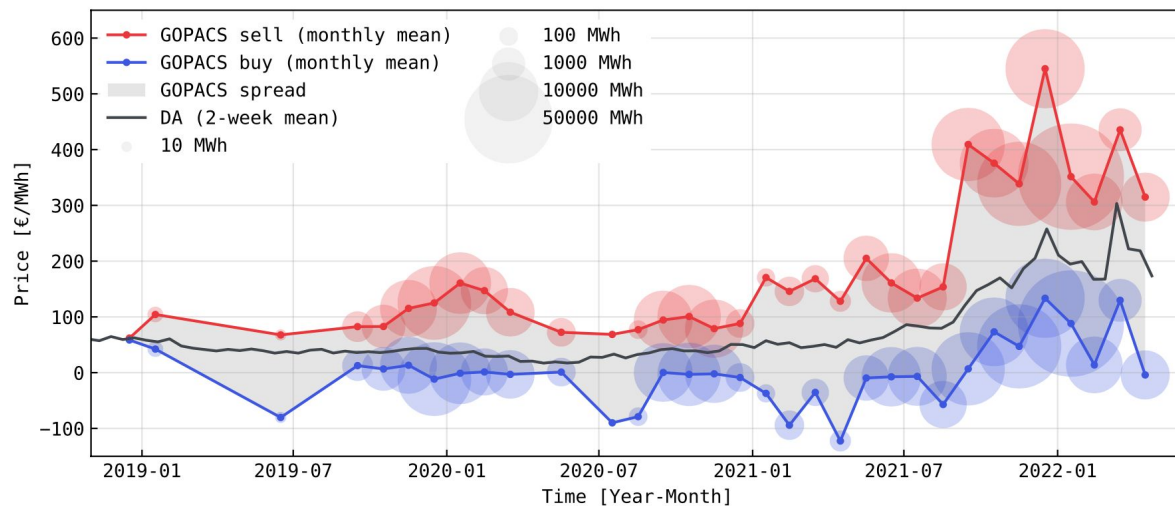
- 4 data sources
- time + price + volume data



(A) Appearance as buy location (i.e. where DSO is looking for buyers of electricity)



(B) Appearance as sell location (i.e. where DSO is looking for sellers of electricity)



FA Valuation

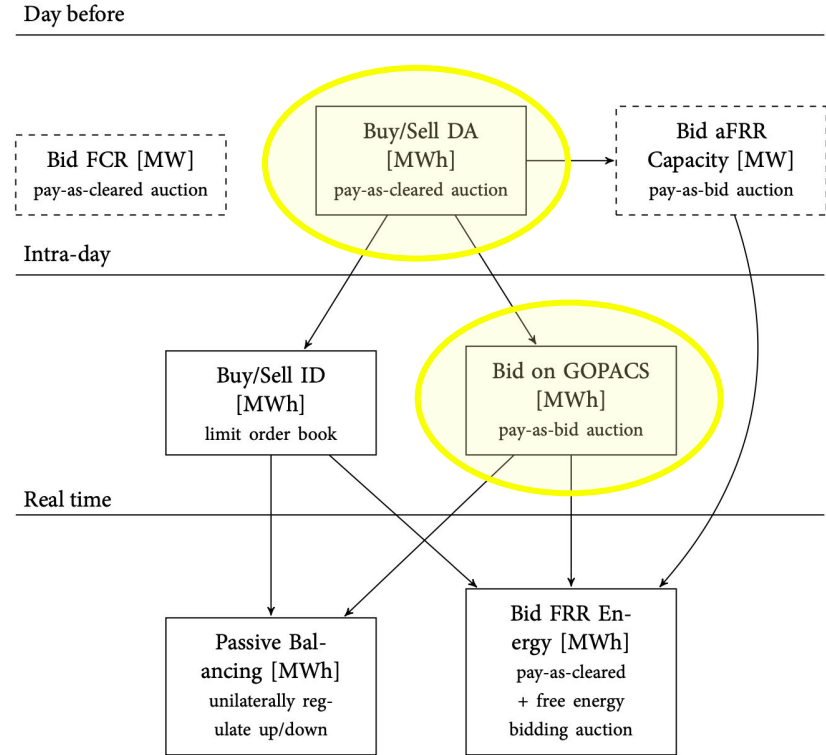
RQ2: What is the value of a flexible asset that is participating in GOPACS?

Participation with FA:

- produce more
- consume less
- consume more
- produce less

Focus on **consume less**:

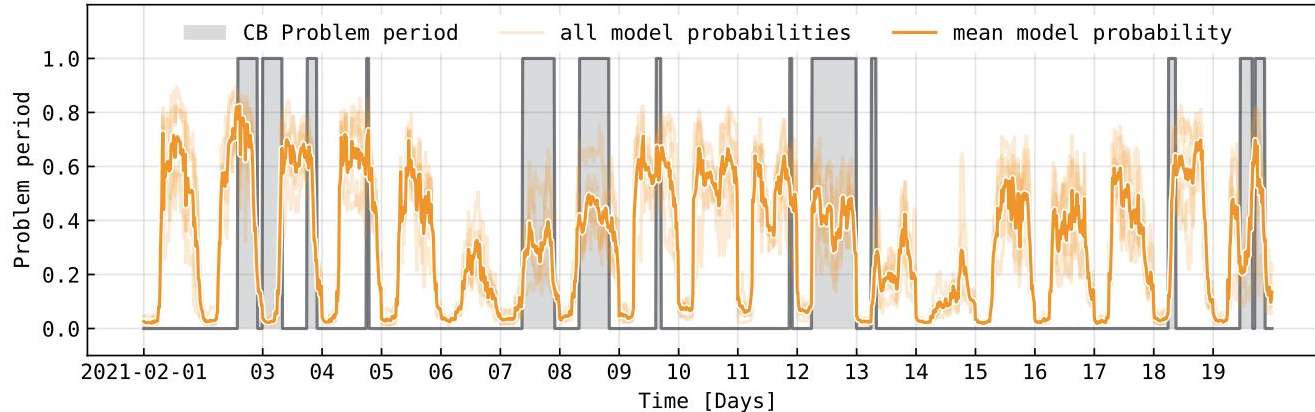
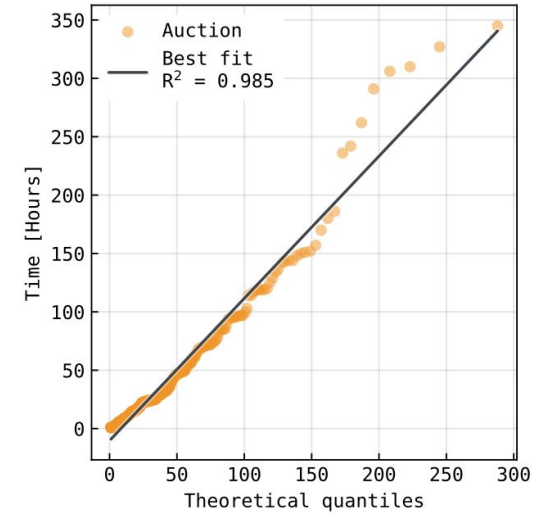
- consume electricity all the time, produce good/service → buy electricity contracts on DA
- **flexibility**: can stop consumption → sell contracts on GOPACS
- only do so when financially sensible
- how much value can be extracted from GOPACS?



GOPACS Model

- GOPACS data hard to predict
- LightGBM regression + classification not promising

→ opted for a **stochastic** approach



GOPACS Model

Arrival-departure process:

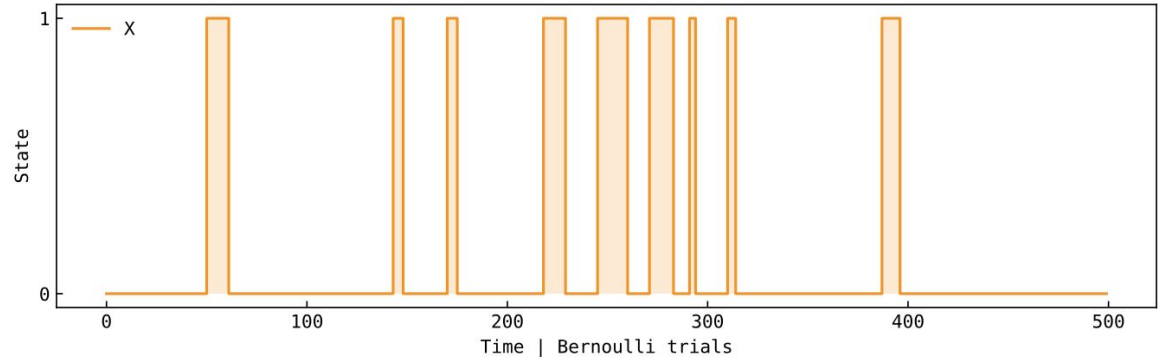
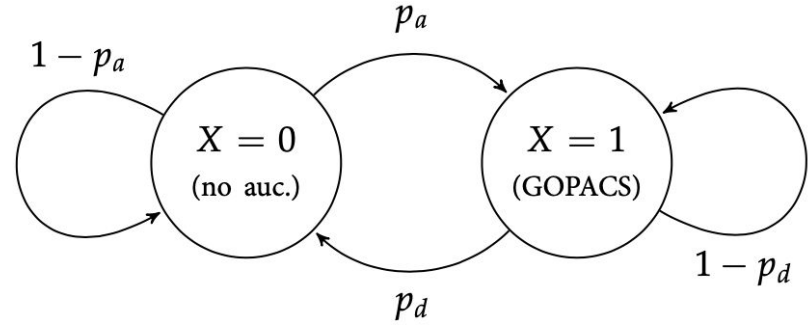
- 2 Bernoulli processes
- represented by Markov Chain

$$\alpha \sim \mathcal{B}(p_a) \quad \beta \sim \mathcal{B}(p_d)$$
$$\mathcal{B}(p) = \begin{cases} 1 & \text{with probability } p \\ 0 & \text{else} \end{cases}$$

Combined into **stochastic finite-difference equation**

$$\Delta X = (1 - X)\alpha - X\beta$$

$$X_{t+1} = X_t + \Delta X$$



GOPACS Model

Model price as deviation from
Day-Ahead (DA) prices

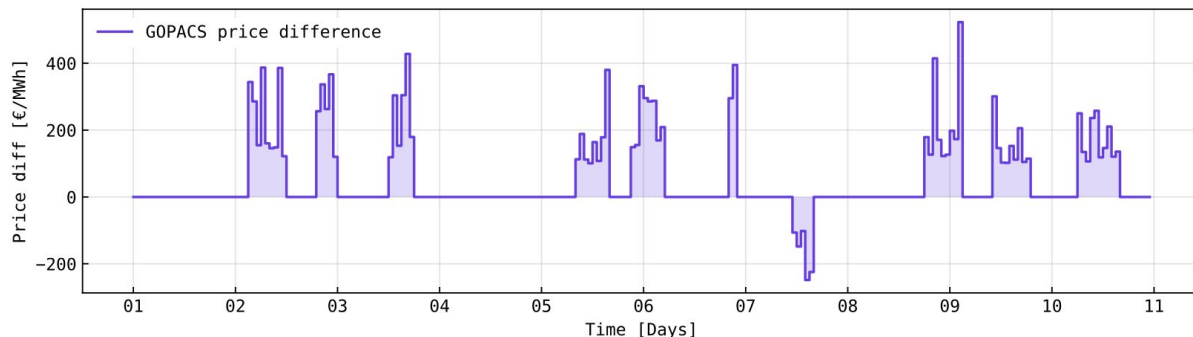
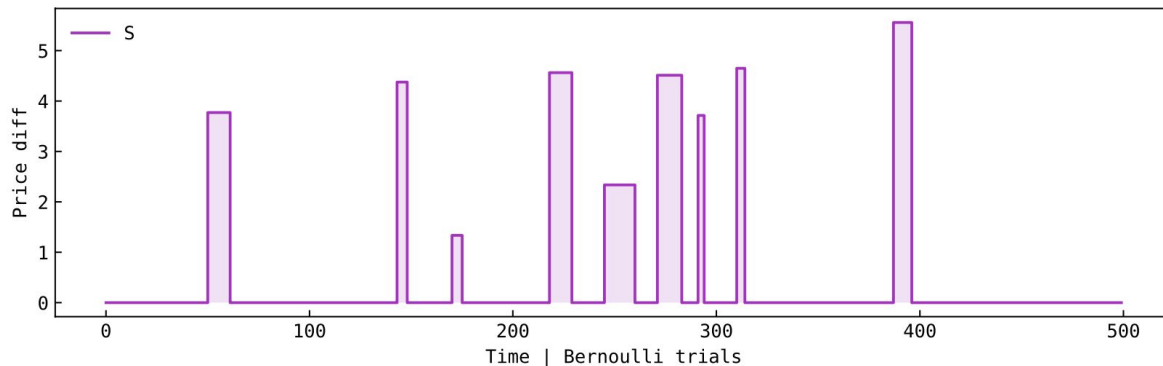
$$S = S_{GO} - S_{DA}$$

Price process

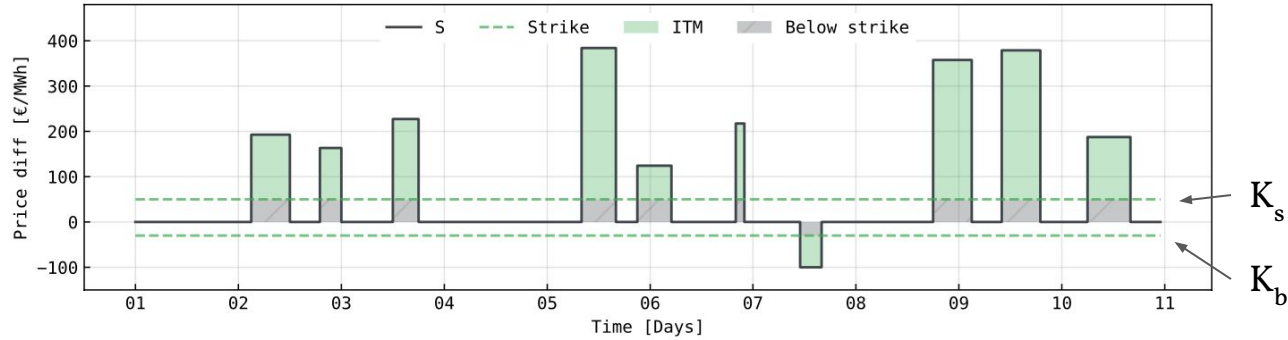
- **PP1**: simple RV
- **PP2**: simulating bidding

$$\Delta S = \epsilon I(S = 0)\alpha - S\beta$$

$$I(x) = \begin{cases} 1 & \text{if } x \text{ is True} \\ 0 & \text{else} \end{cases}$$



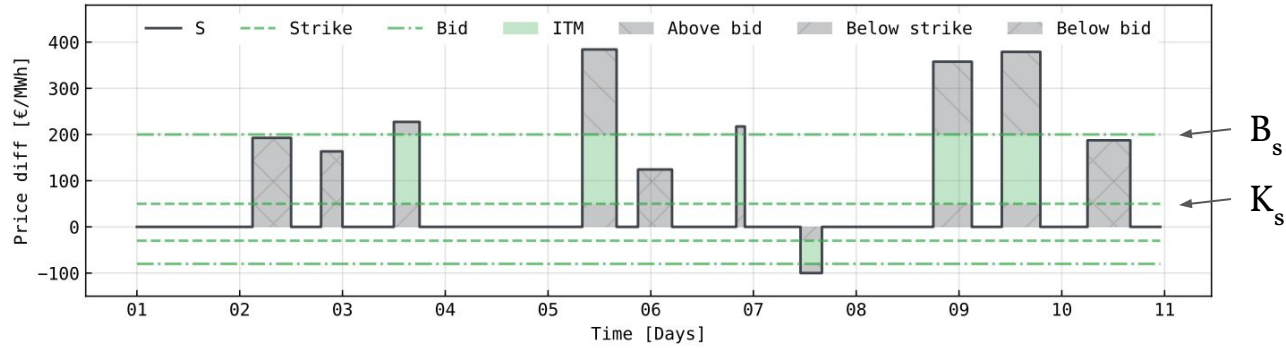
Real Options: European



$$C_E = \max(0, S - K_s)$$

$$P_E = \max(0, K_b - S)$$

Real Options: Digital

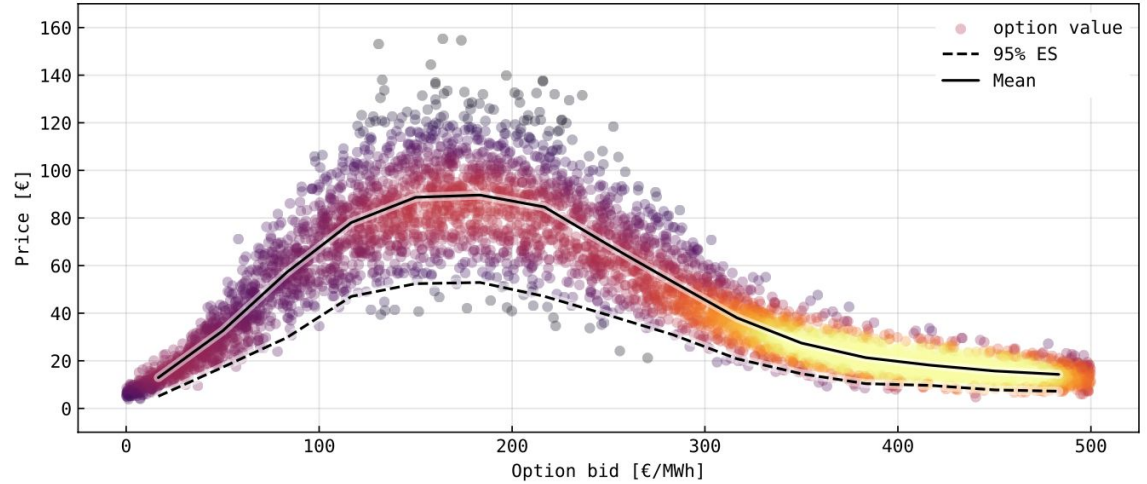


$$C_D = (B_s - K_s)I(\max(B_s, K_s) < S)$$

$$P_D = (K_b - B_b)I(\min(B_b, K_b) > S)$$

Results

- finding the best bid price
- various bidding strategies
- scatter-based
- sensitivity analysis**
- Case study in NL



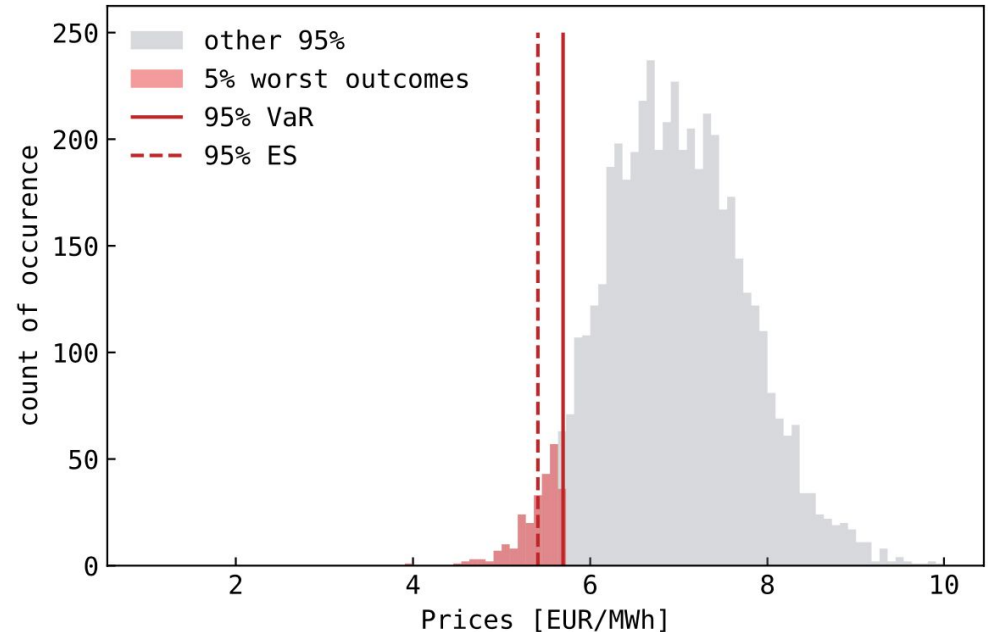
FA Size		5 MW			20 MW			100 MW		
Strike		0	50	100	0	50	100	0	50	100
B	Bid	175	200	200	175	200	225	200	200	225
	Mean	61.5k	38.7k	23.5k	21.9k	14k	9k	5.37k	3.28k	1.87k
	SD	7.2k	4.49k	3.03k	2.65k	1.73k	1.01k	561	363	225
	VaR95	50.3k	31.6k	19.2k	17.3k	11.3k	7.3k	4.6k	2.77k	1.55k
	ES95	47.4k	29.8k	17.9k	16.3k	10.4k	6.98k	4.38k	2.65k	1.46k

Risks and Uncertainties

RQ3: *What are the risks and uncertainties in participation in GOPACS and our valuation thereof?*

- measured with VaR and ES (CVaR)
- Model Risk through assumptions
- Other risks and uncertainties

		5 MW
		0
B	Bid	175
	Mean	61.5k
	SD	7.2k
	VaR95	50.3k
	ES95	47.4k



Conclusion

- investigated GOPACS
- developed a model to simulate it
- valuation of FA with real options

Questions?