



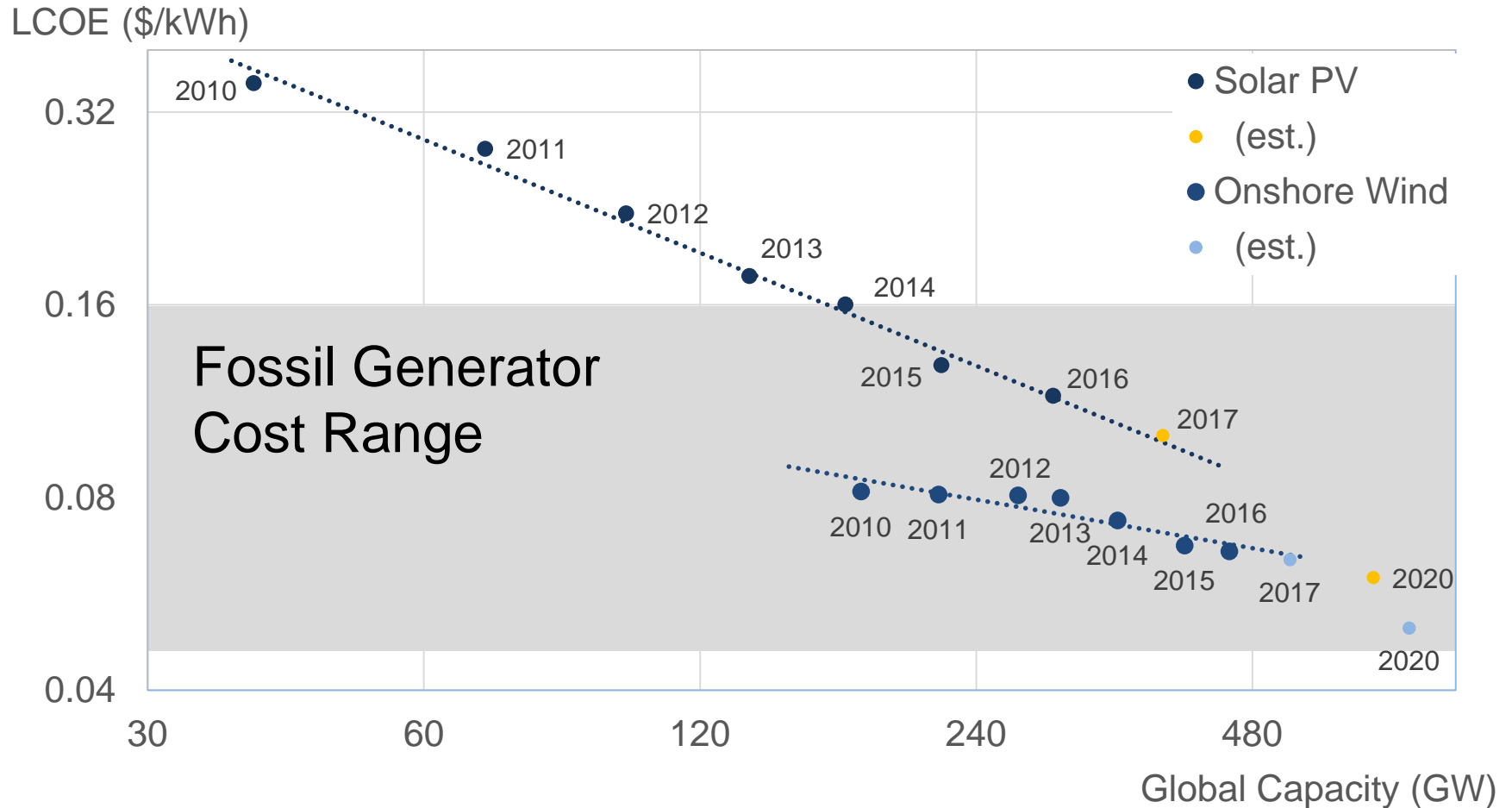
A Tale of Two Markets

Richard Green

IAEE European Conference, 2019

It was the best of times,

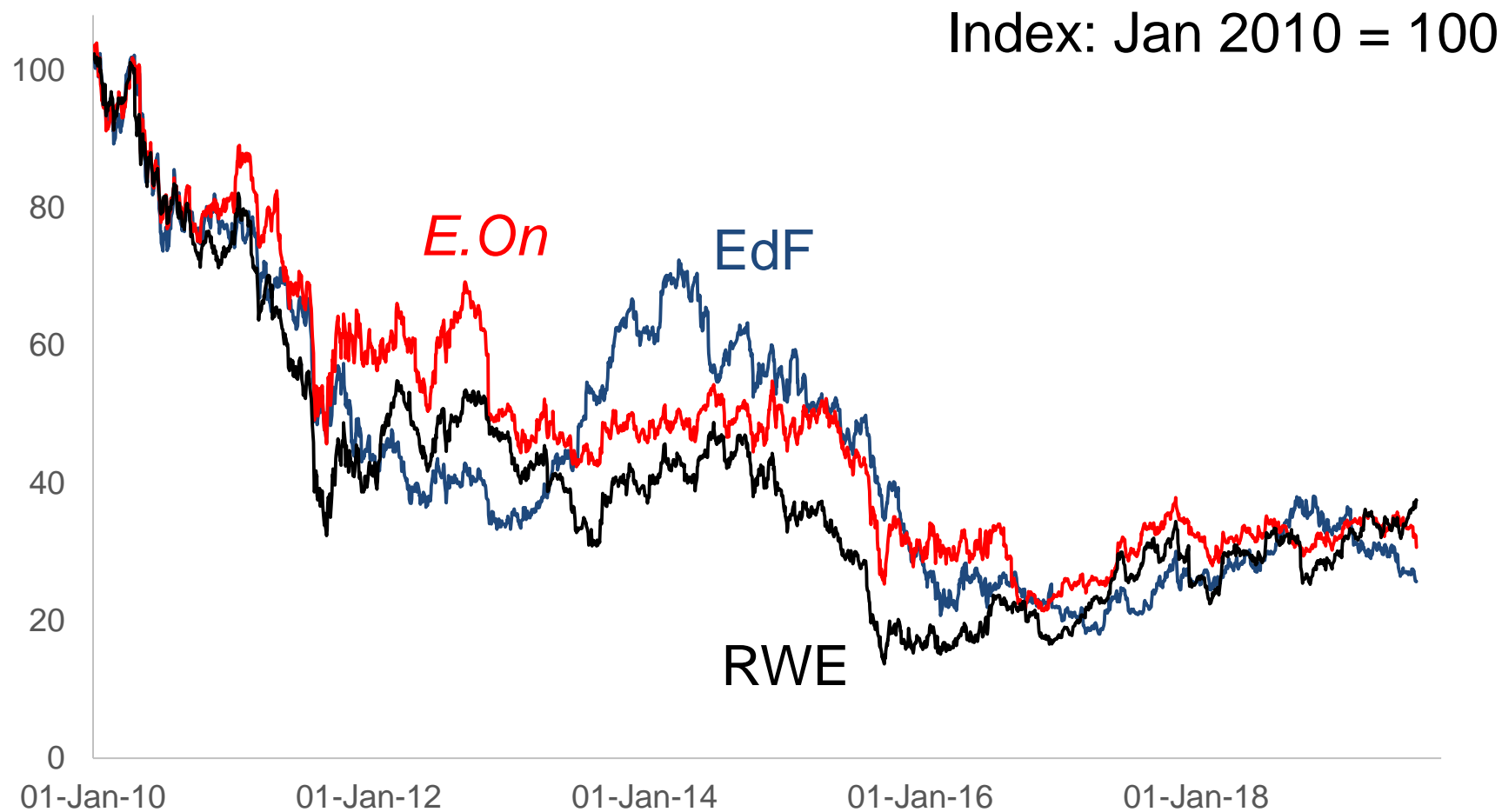
Learning Curves for Wind and Solar PV



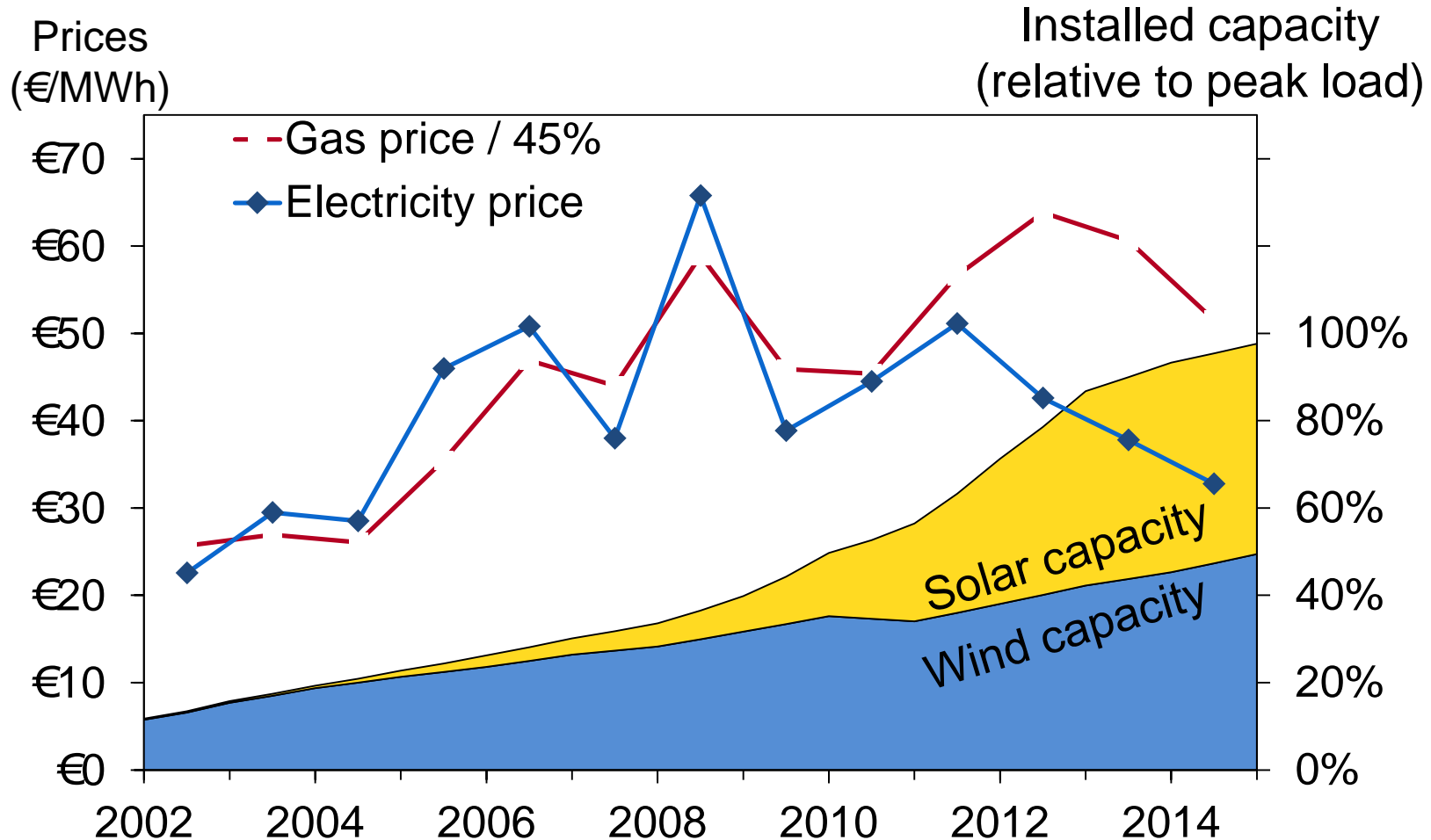


It was the worst of times

Share prices for Incumbent Utilities



German Energy Prices: The Merit Order Effect



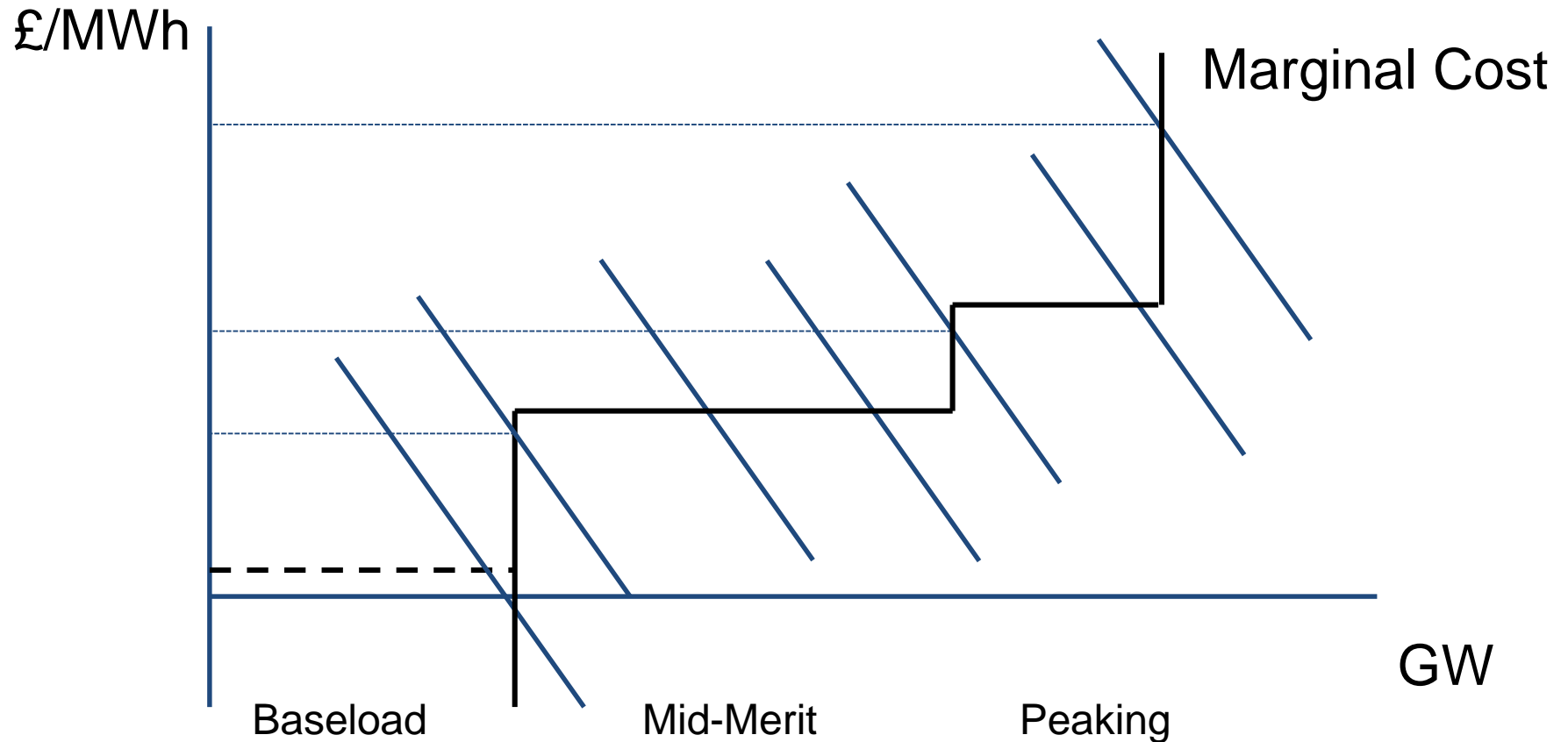


Is there a problem in theory?



Demand and Supply

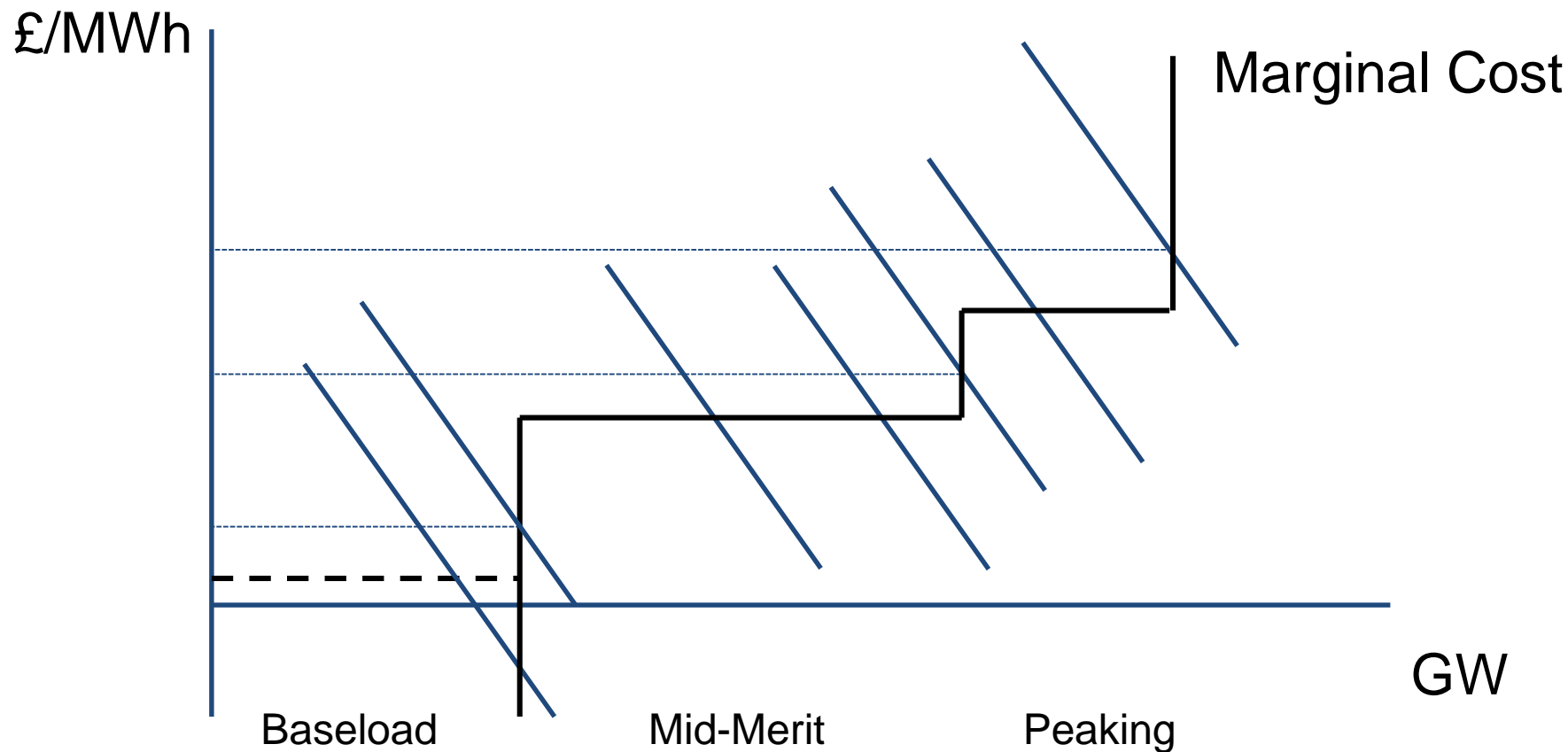
The merit order effect





Demand and Supply

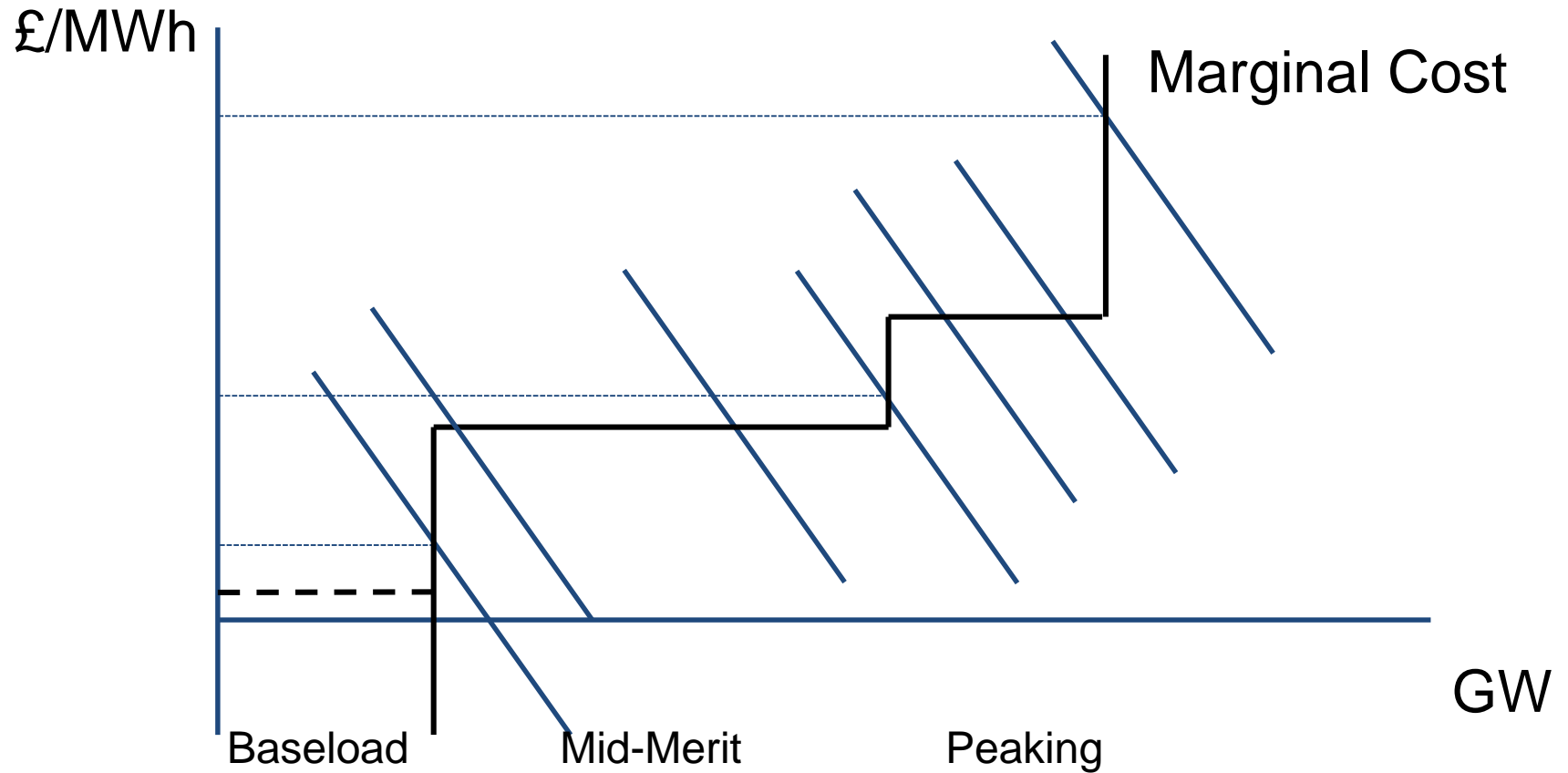
The merit order effect





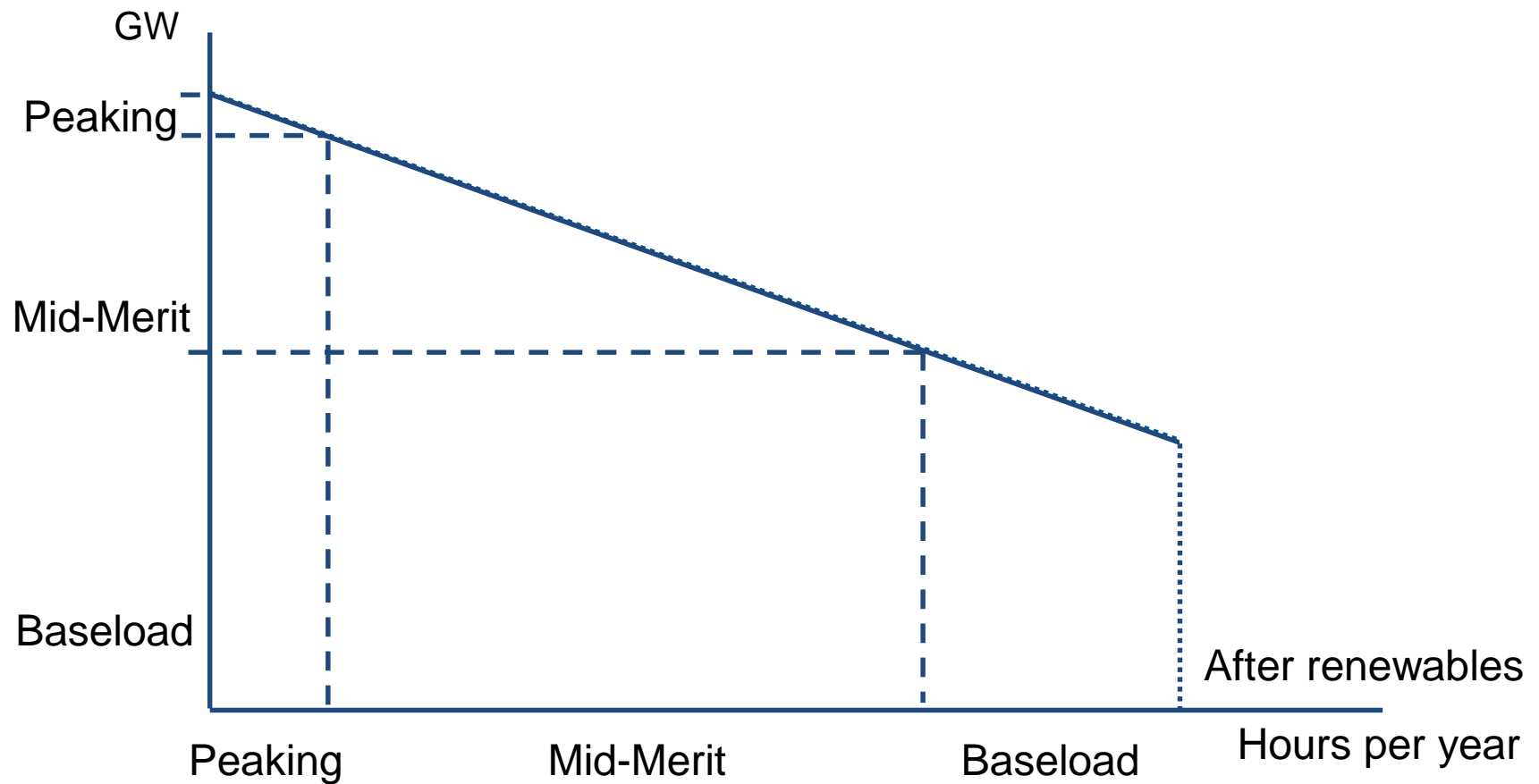
Demand and Supply

The merit order effect



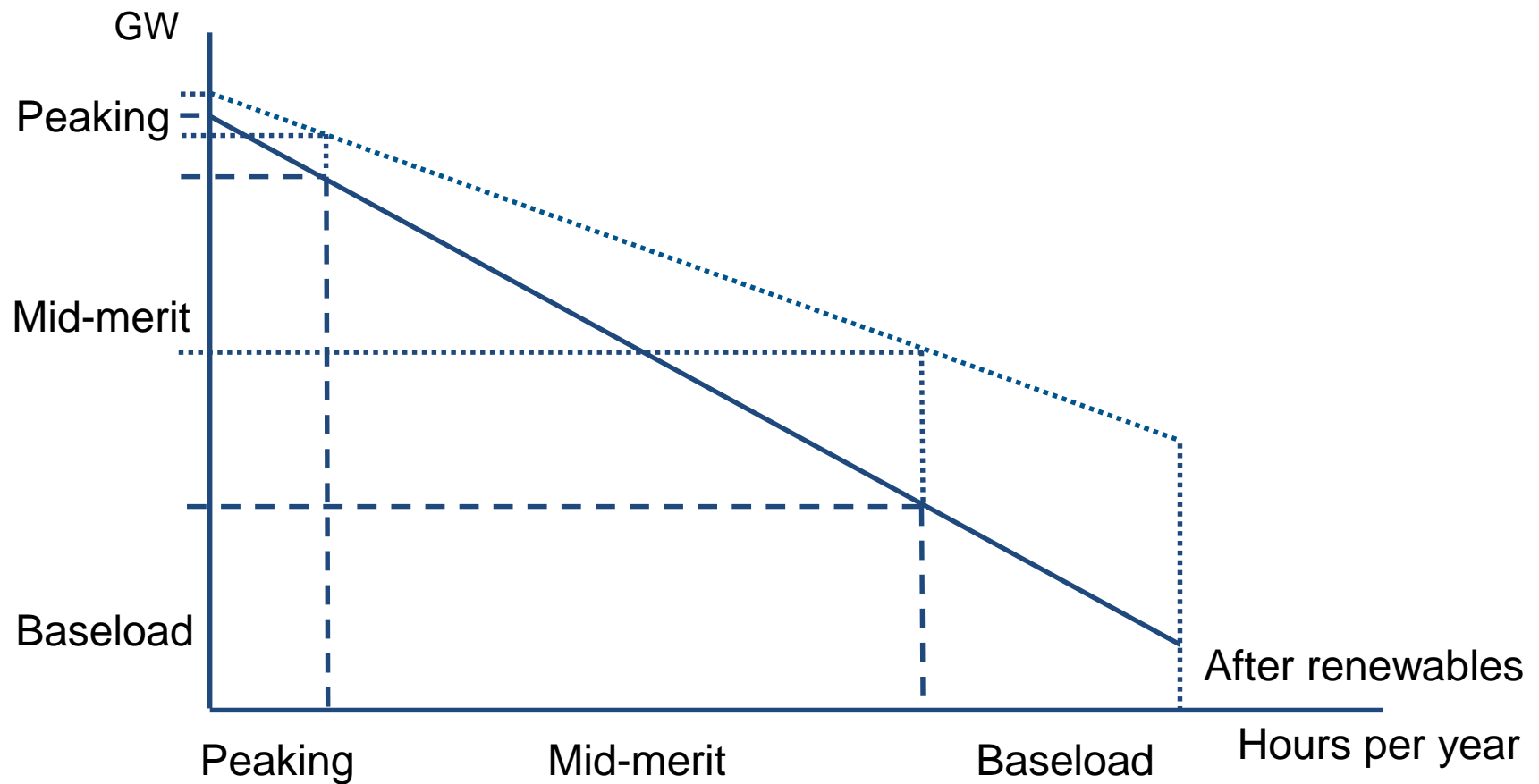


Capacity and Load





Capacity and Load

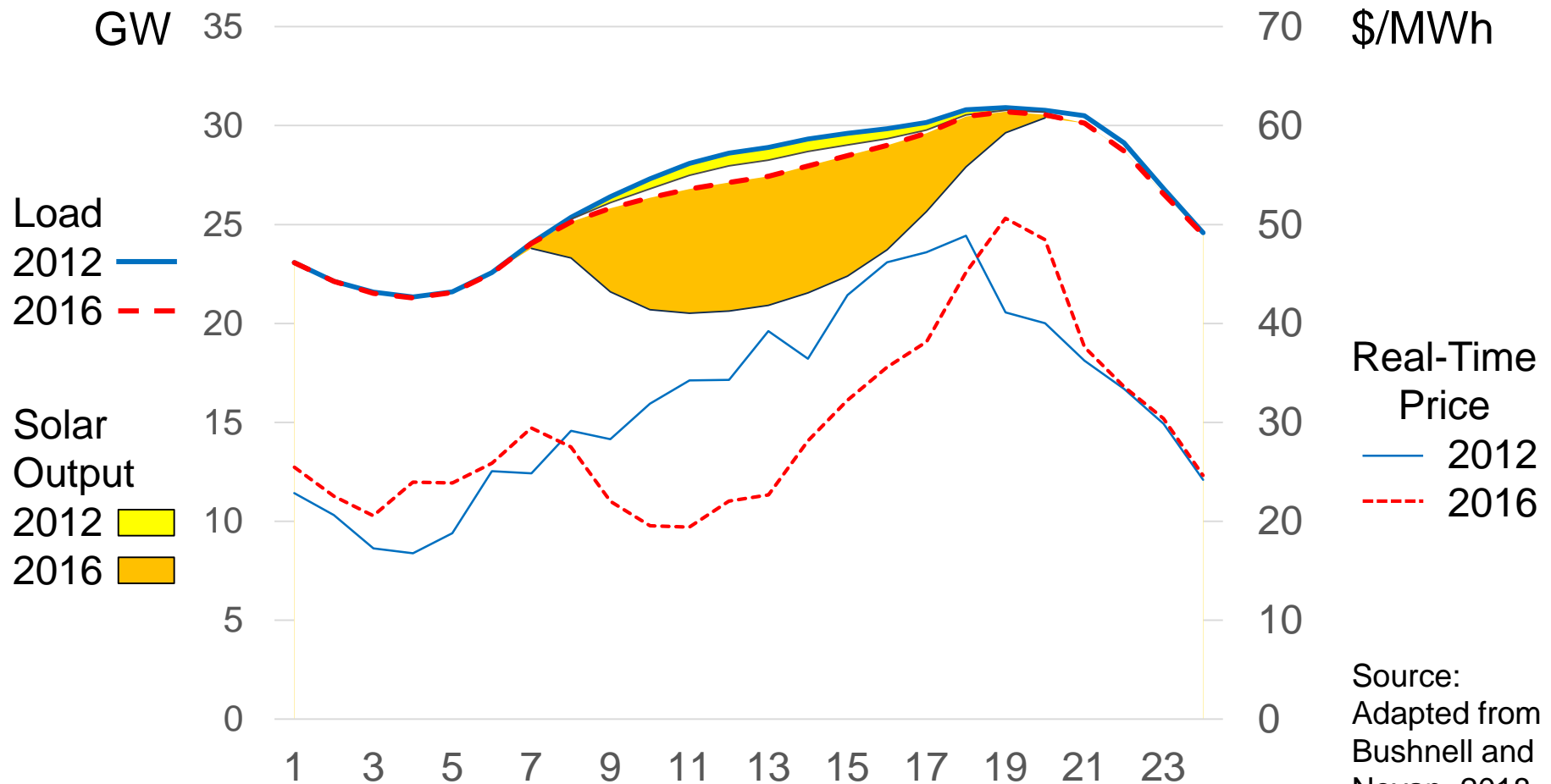




What are the investment signals in practice?

Load, PV Output and Prices

California, 2012 and 2016

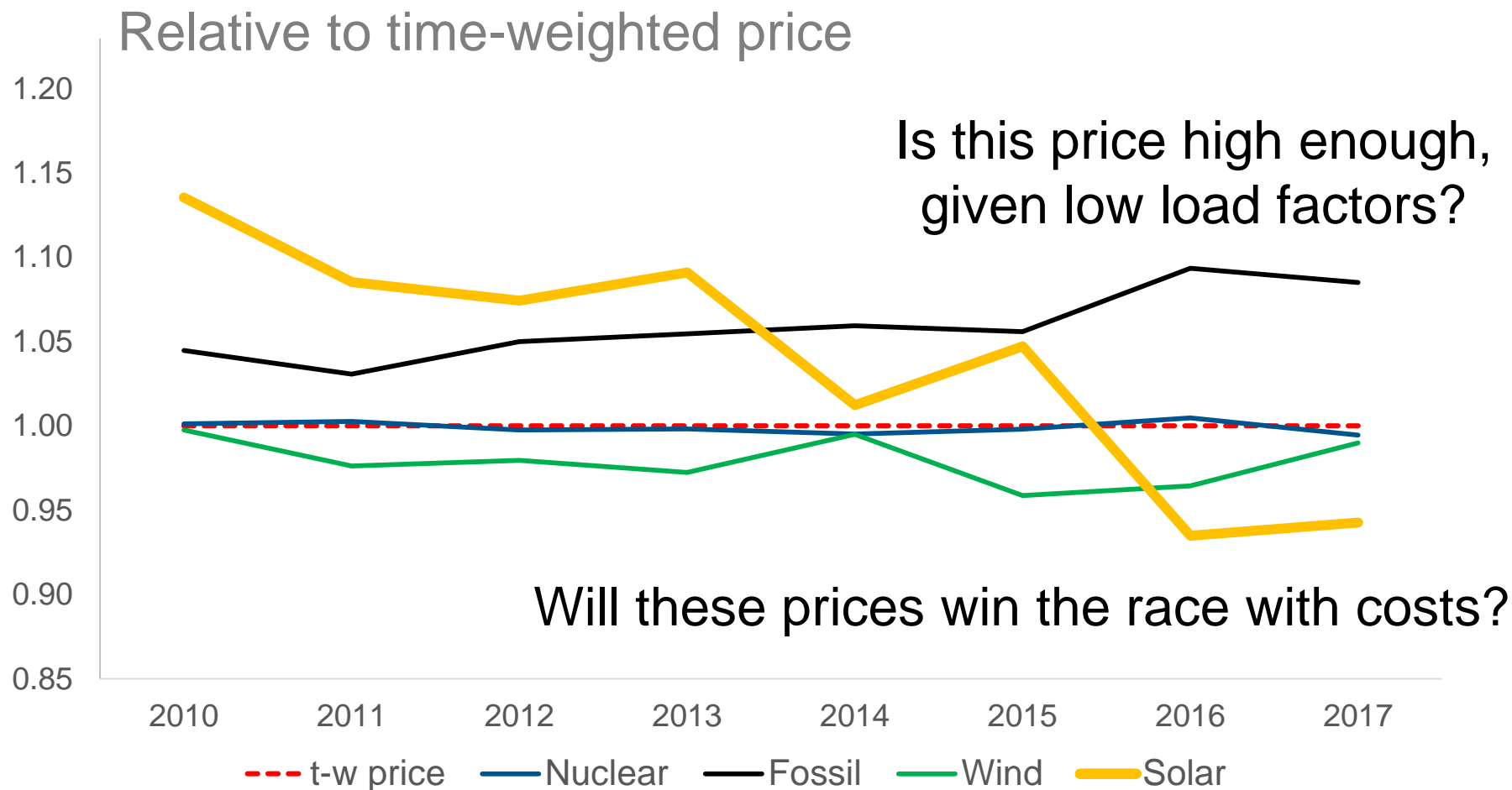


Source:
Adapted from
Bushnell and
Novan, 2018



Output-weighted prices

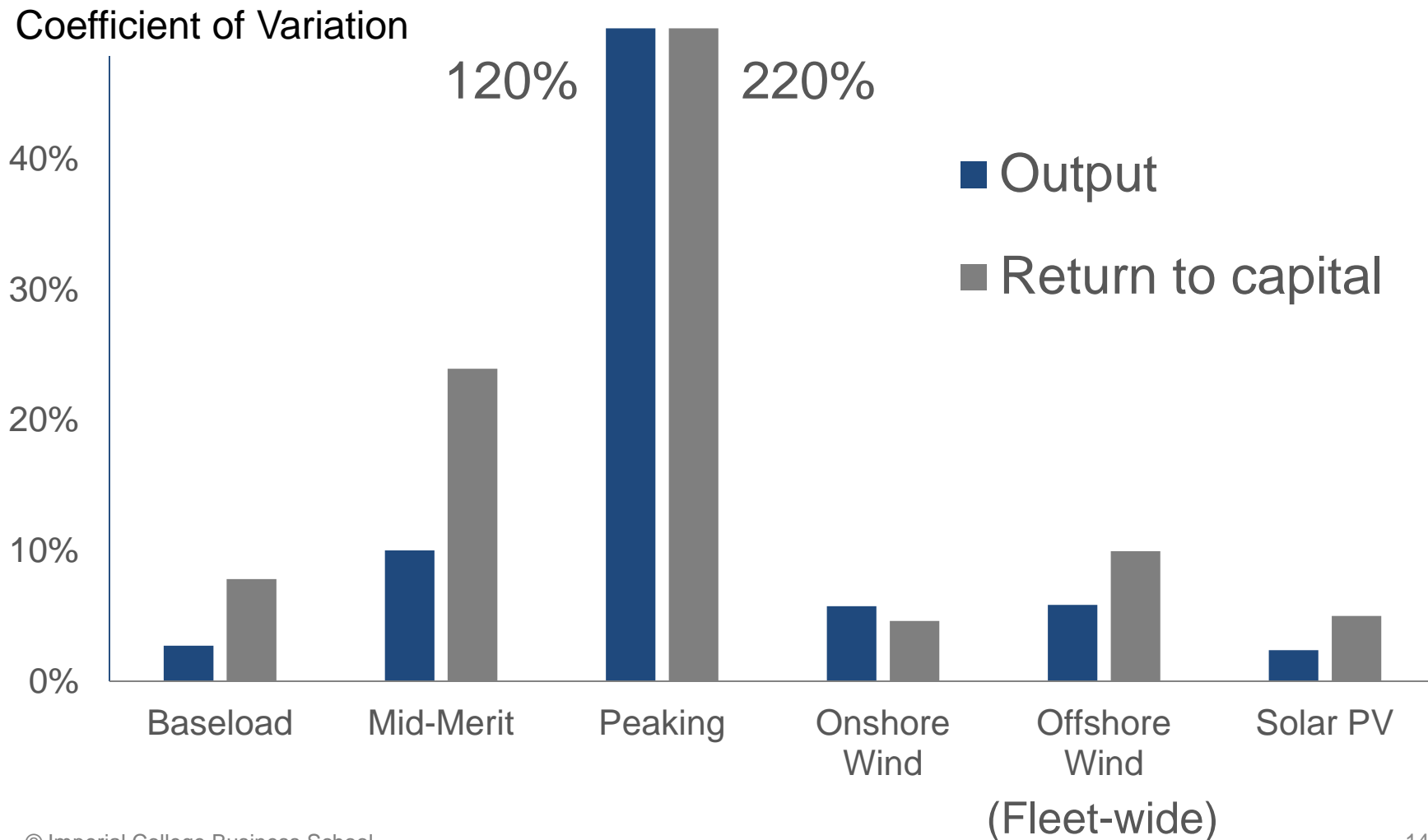
Great Britain, 2010-17





Risks to generators

CV of annual figures over 17 years





The case(s) for two markets



How to stop contamination

Must zero-MC power kill cost recovery?

- “Design the future around multiple power markets”
- “clearly-defined, separate markets for variable power and dispatchable power”
 - Liebreich (Bloomberg New Energy Finance, 2017, p.2, p.3)
- “Separate markets for different sorts of power (‘on demand’ and ‘as available’) at both producer and consumer ends”
 - Keay and Robinson (Oxford Inst. Energy Stud., 2017, p.1)



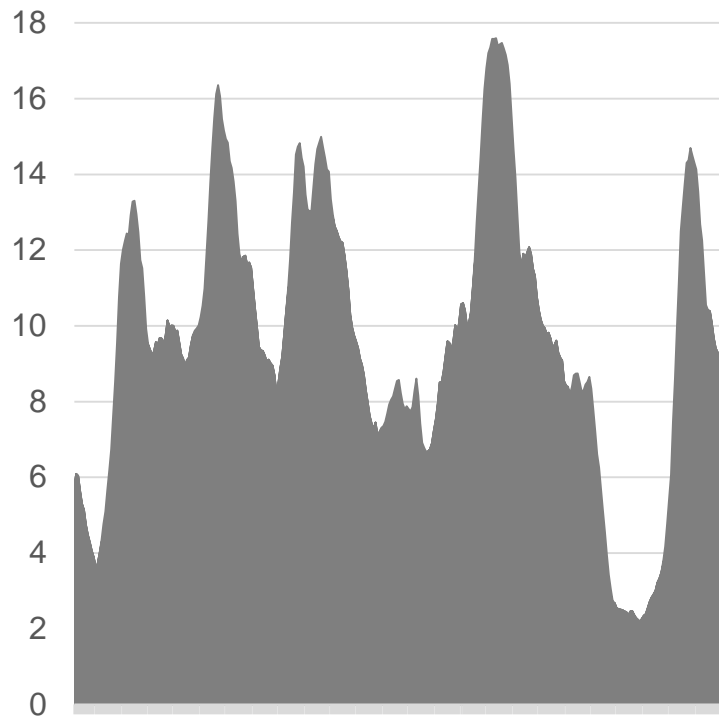
Two types of electricity?



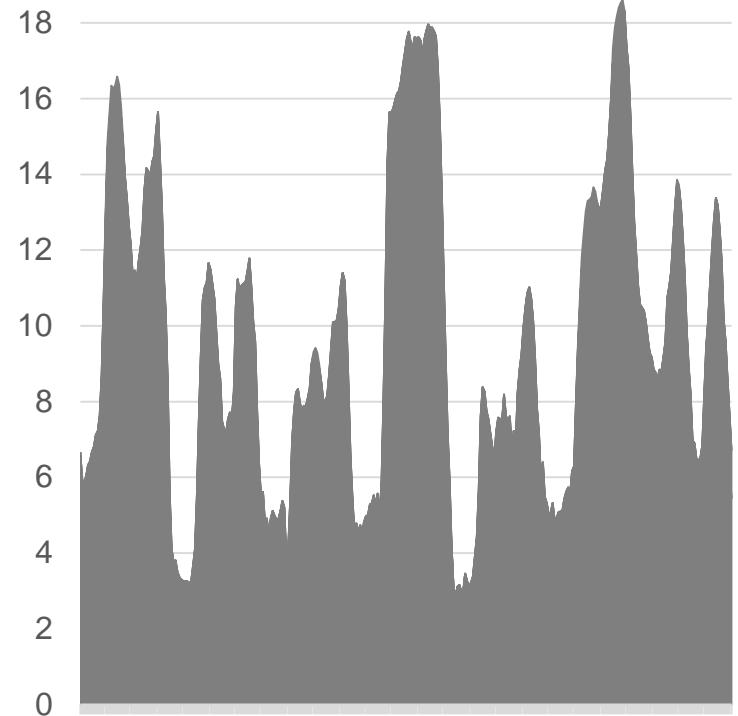
Variable Generators

Coal, Gas and Oil, versus Wind and Solar

GW



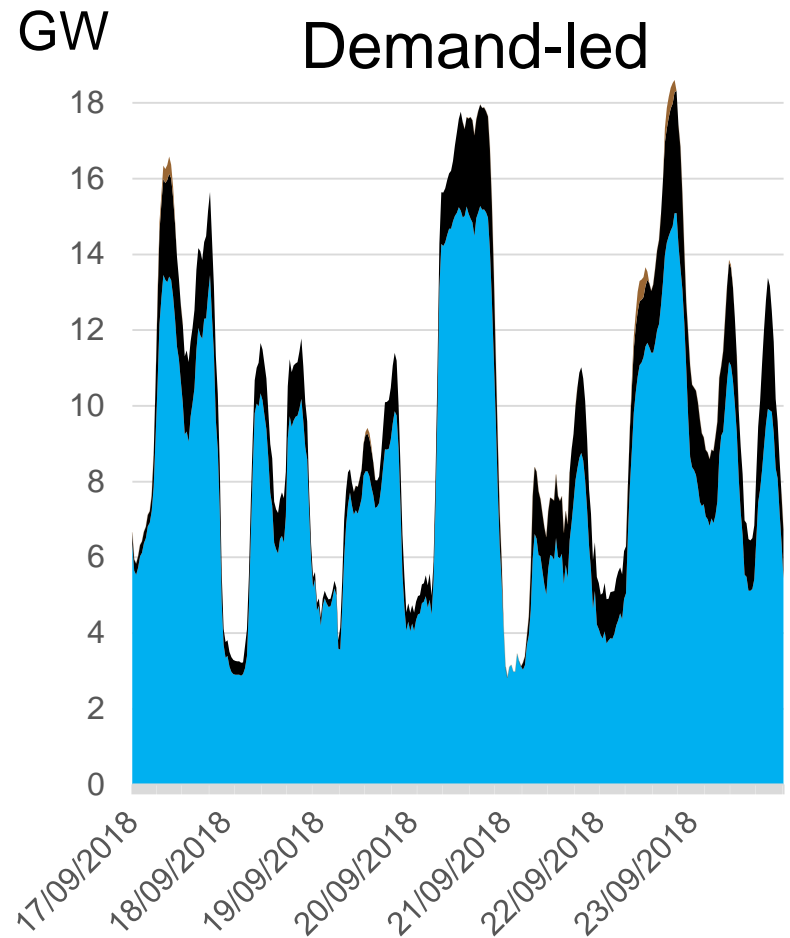
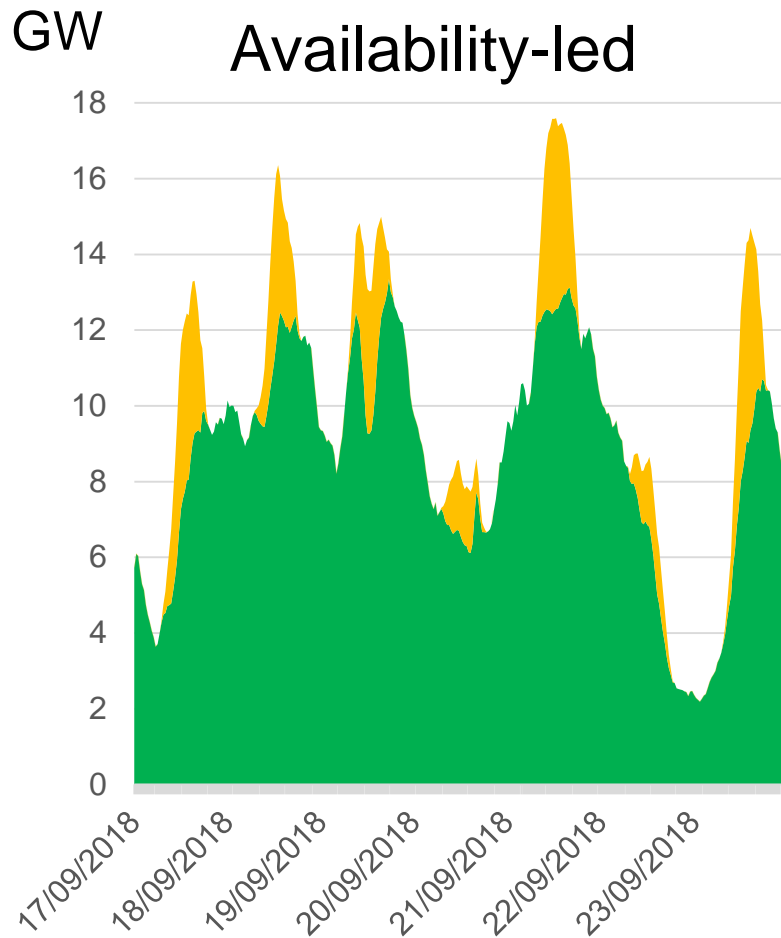
GW





Variable Generators (x2)

Wind and Solar versus Coal, Gas and Oil



Two kinds of contracts

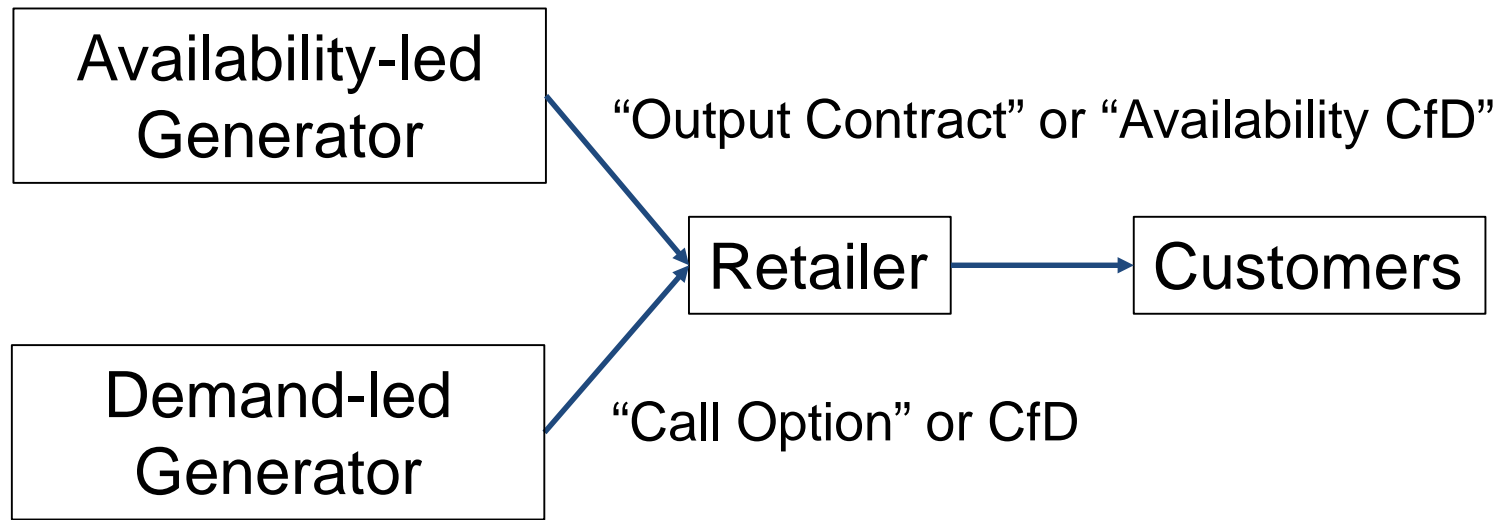
- Demand-led generators
- Fossil, biomass, storage
- Mix of capital and variable costs
- Call Options reflect these characteristics
 - Availability fee \approx fixed cost
 - Exercise price \approx variable cost
- One-way Contracts for Difference with a Pool
- Availability-led generators
- Wind and solar PV
- Capital costs dominate
- (Exclusive) Put Option gives control to the seller
 - Availability fee \approx fixed cost
 - Exercise price \approx variable cost
- “Availability CfD” might be invented for a Pool?

Availability-led contracting

- Feed-in Tariffs are a Put Option without the optionality
 - High exercise price makes it worthwhile
 - Seller takes the output risk
- Two-part (full) Output Contract partly replicates it
 - Lower exercise price would reflect marginal cost
 - Fixed fee to cover generator's fixed cost
 - Based on *ex ante* estimate of output potential?

Who holds the contracts?

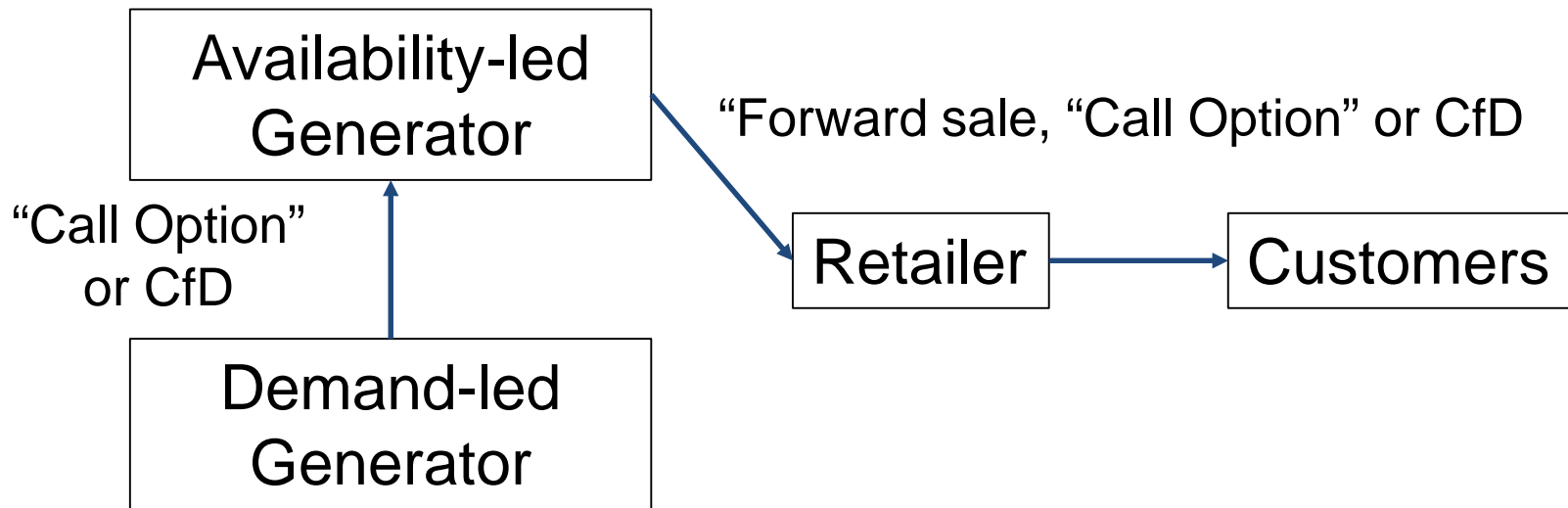
Retailer procures separately



- Availability risk split between retailer and availability-led generator, depending on exercise price
- Demand-led generator faces little risk

Who holds the contracts?

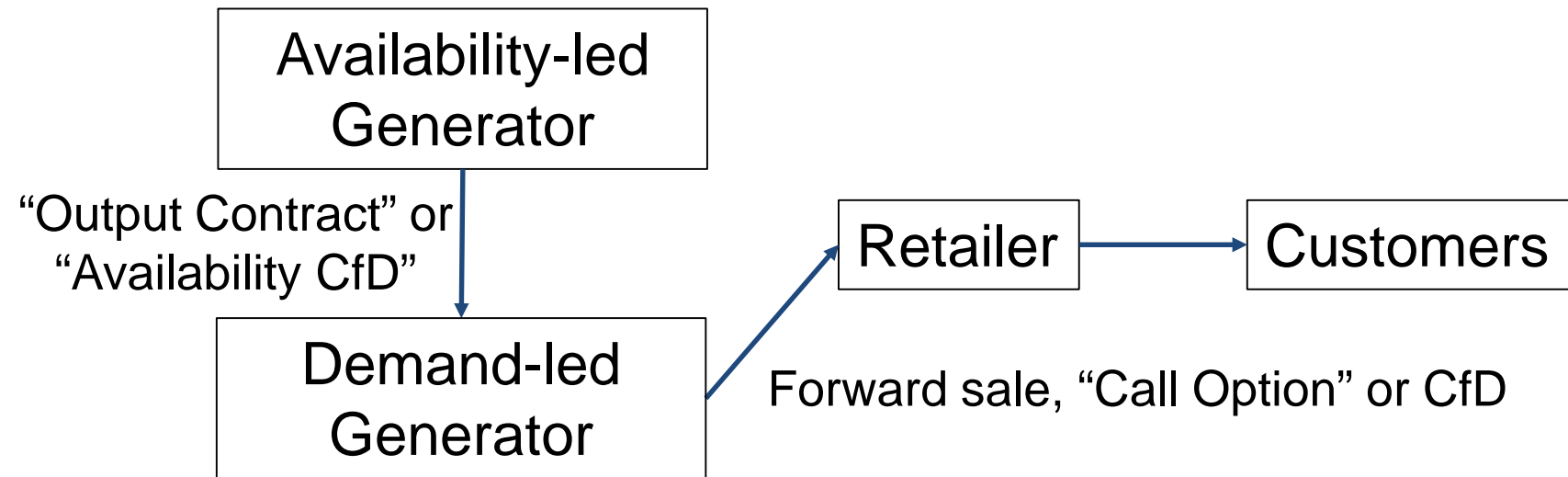
Availability-led generator buys back-up



- Availability risk carried by availability-led generator
- Demand-led generator and retailer face little risk
- Is this Helm's "Equivalent Firm Power" auction?
 - *Cost of Energy Review, 2017*

Who holds the contracts?

Demand-led generator buys cheap when it can



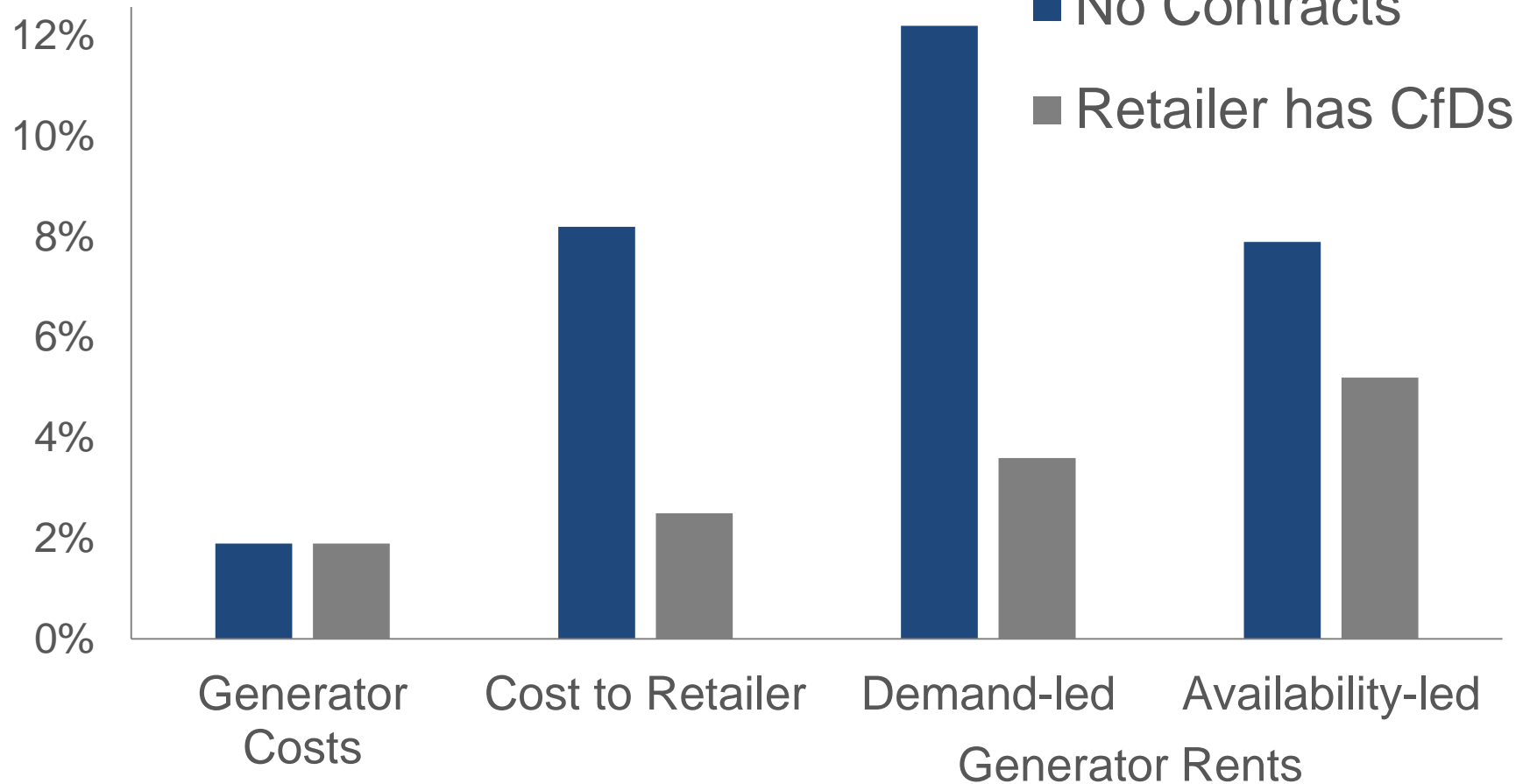
- Availability risk split between availability-led and demand-led generators, depending on exercise price
- Retailer faces little risk



Risks to the industry

Availability-led CfD with low strike price

Coefficient of Variation

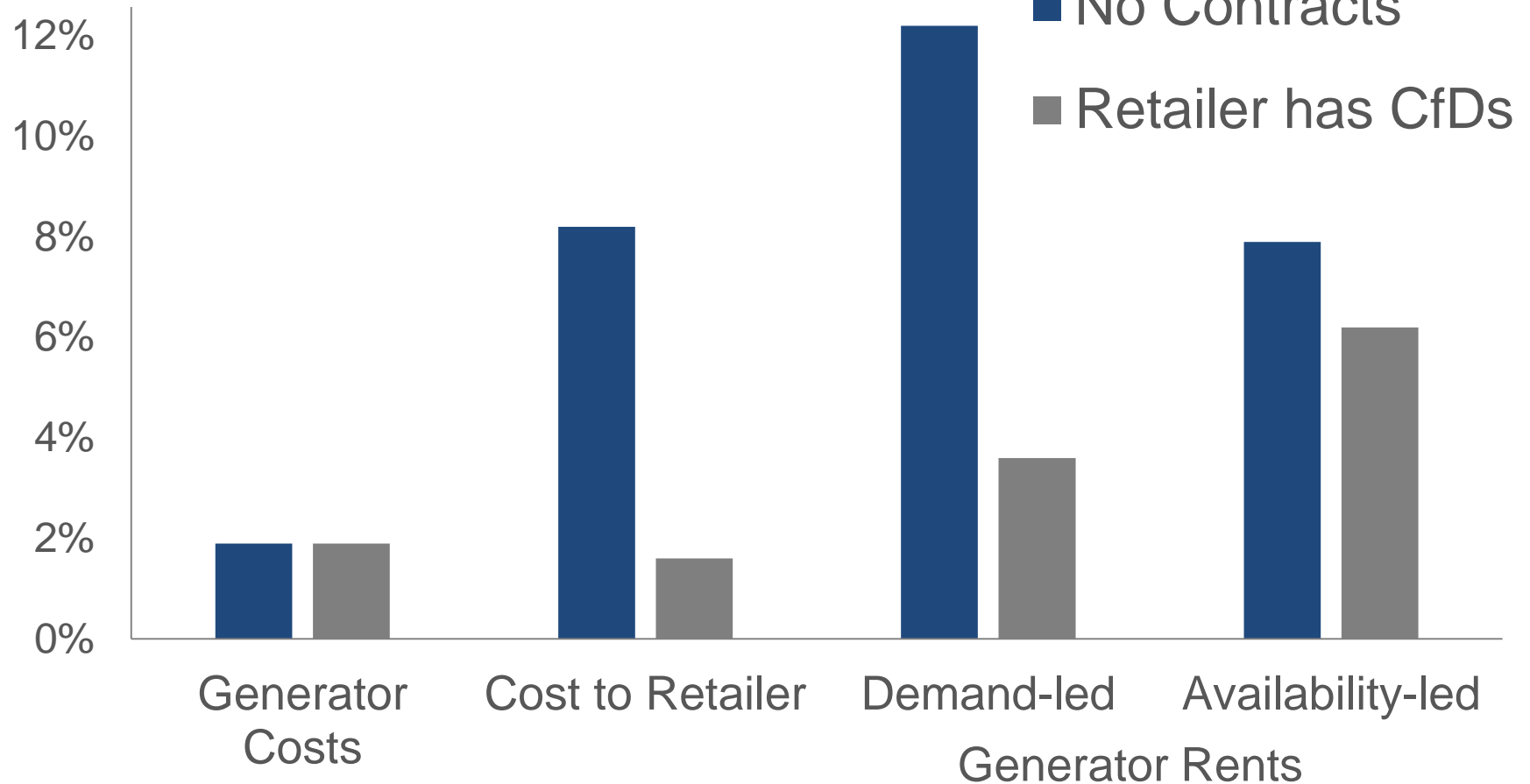




Risks to the industry

CfD strike price near mid-merit cost

Coefficient of Variation



Pricing in the short term

- Forward sales and CfDs fix volume; marginal purchases at spot price
- Call Options should not be exercised if spot price is lower than exercise price; extra purchases at spot price
- Pool plus CfD makes sensible choices more “automatic”



How many markets?

Don't only study *Energy* Economics

- Energy (before real-time)
- Balancing energy (real-time)
- Reserve
- Inertia or Fast Response



Thank you

r.green@imperial.ac.uk