Market power in cost-based wholesale electricity markets

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Cost-based wholesale electricity markets look superficially similar to the standard bid-based market model

- Generation firms submit price and quantity offers to the system operator who uses them to set dispatch quantities and prices
  - In a cost-based market, offer prices equal marginal cost
  - If possible, offer quantities should be equal to plant capacity
- For hydro plants, system operator runs a dynamic optimization problem to determine opportunity cost of water
- All Latin American markets (except Colombia) are cost-based

Mexico chose the cost-based model when it began the restructuring of its electricity industry in 2014

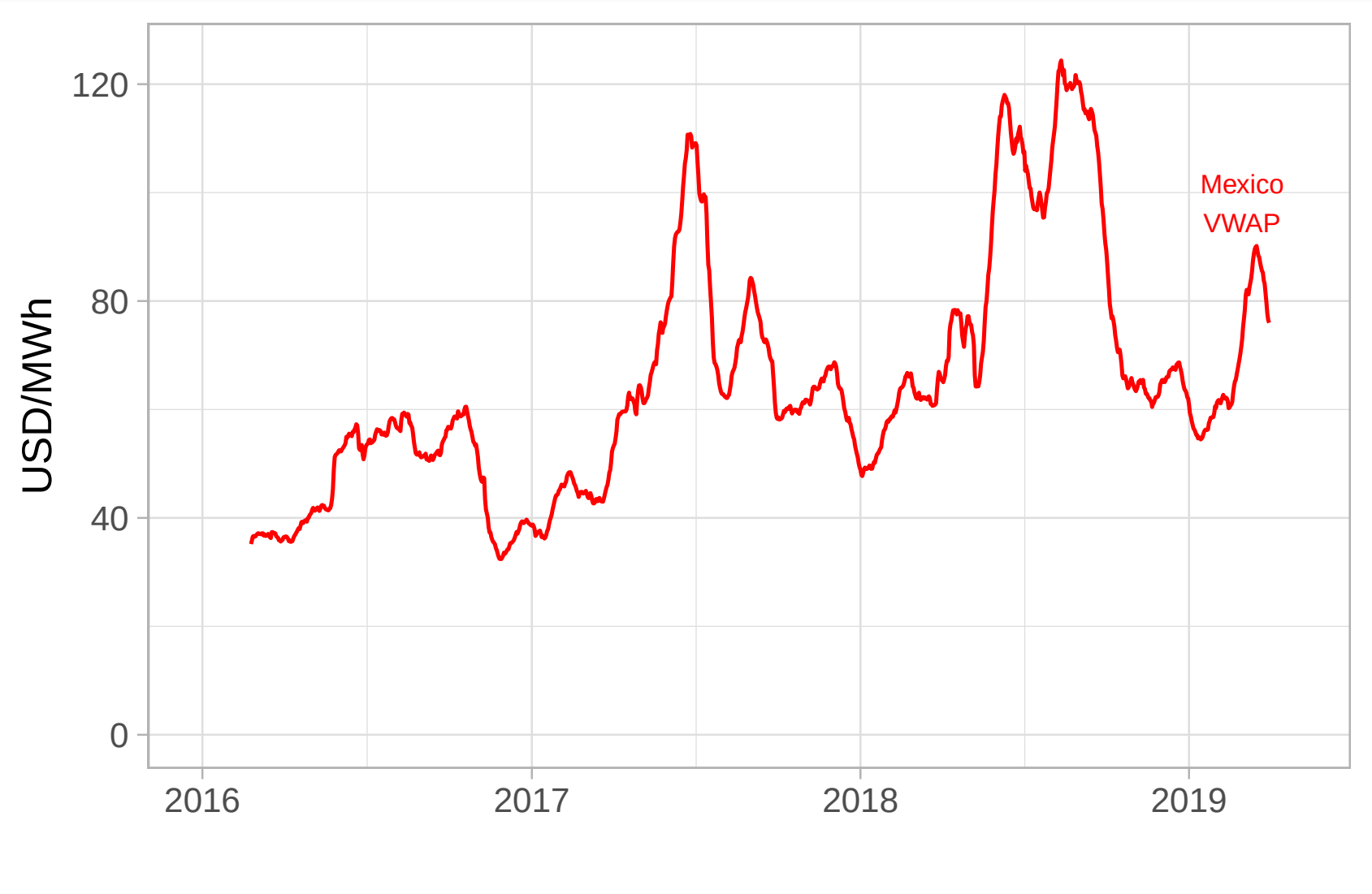
Previous market structure

- Vertically-integrated, government-owned monopoly: CFE
- Some privately-owned generation

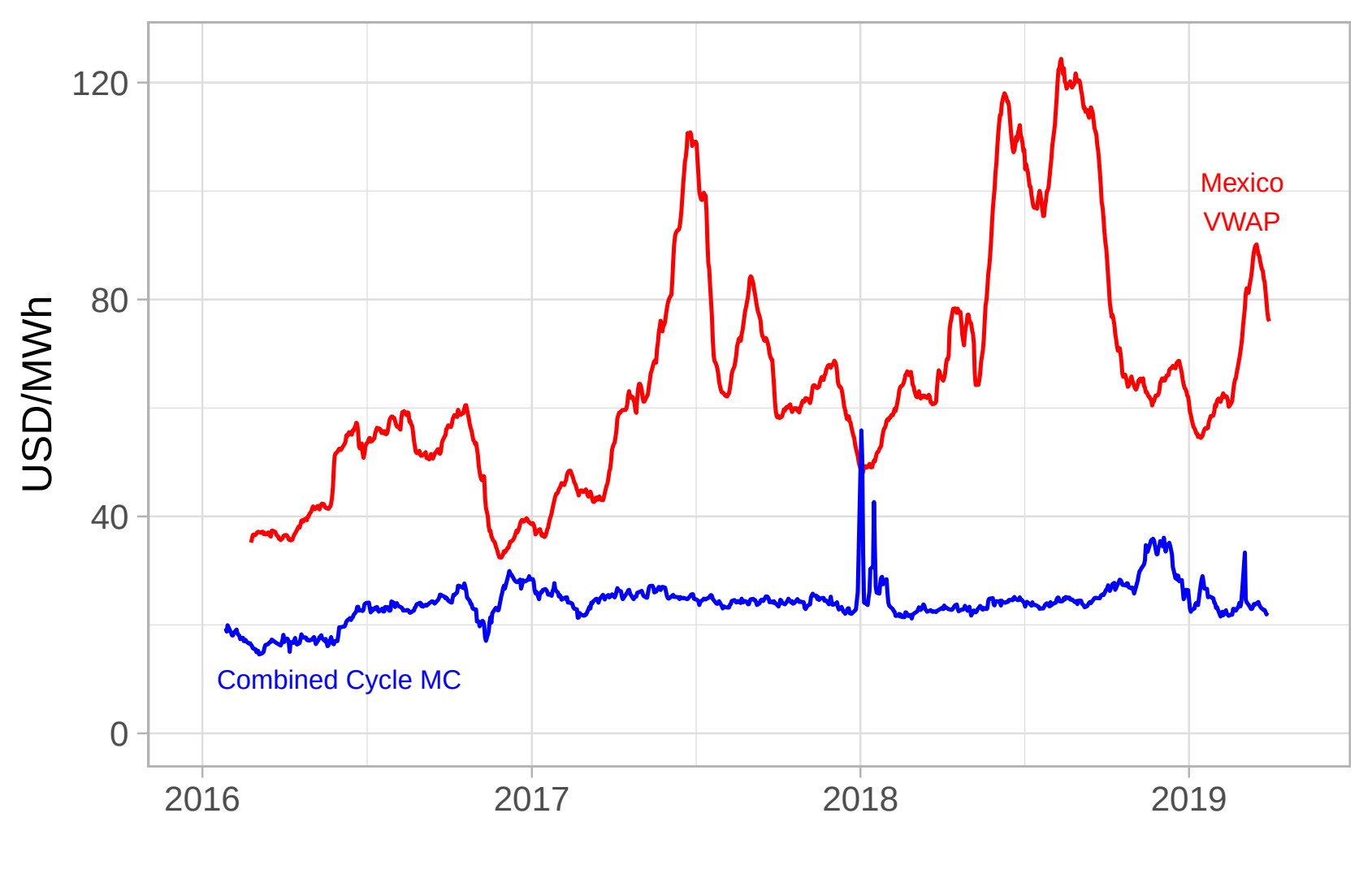
New market structure

- CFE split vertically: CFE Transmission, CFE Distribution, CFE Retailing (Regulated), CFE Retailing (Competitive), etc
- CFE Generation split into five Gencos
- All CFE components still government-owned
- Independent system operator: CENACE
- Competition allowed in generation and retailing

Wholesale electricity prices in Mexico increased from mean of $46/MWh in 2016 to $81/MWh in 2018



Natural gas price benchmarks have stayed almost flat since the start of the market in 2016



Is it possible that periods of high prices in the Mexican electricity market are due to the exercise of market power?

- Market power has been a major concern throughout the design and implementation of the Mexican wholesale market
  - Choice of cost-based wholesale market model reflected concerns about market power
  - Allocation of CFE generation plants to five CFE subsidaries minimized market power index (HHI) in each local market
  - Market rules included mechanisms for monitoring potential abuse of market power (*Manual de Vigilancia del Mercado*)

I will consider three questions about market power in the wholesale electricity market during today's presentation

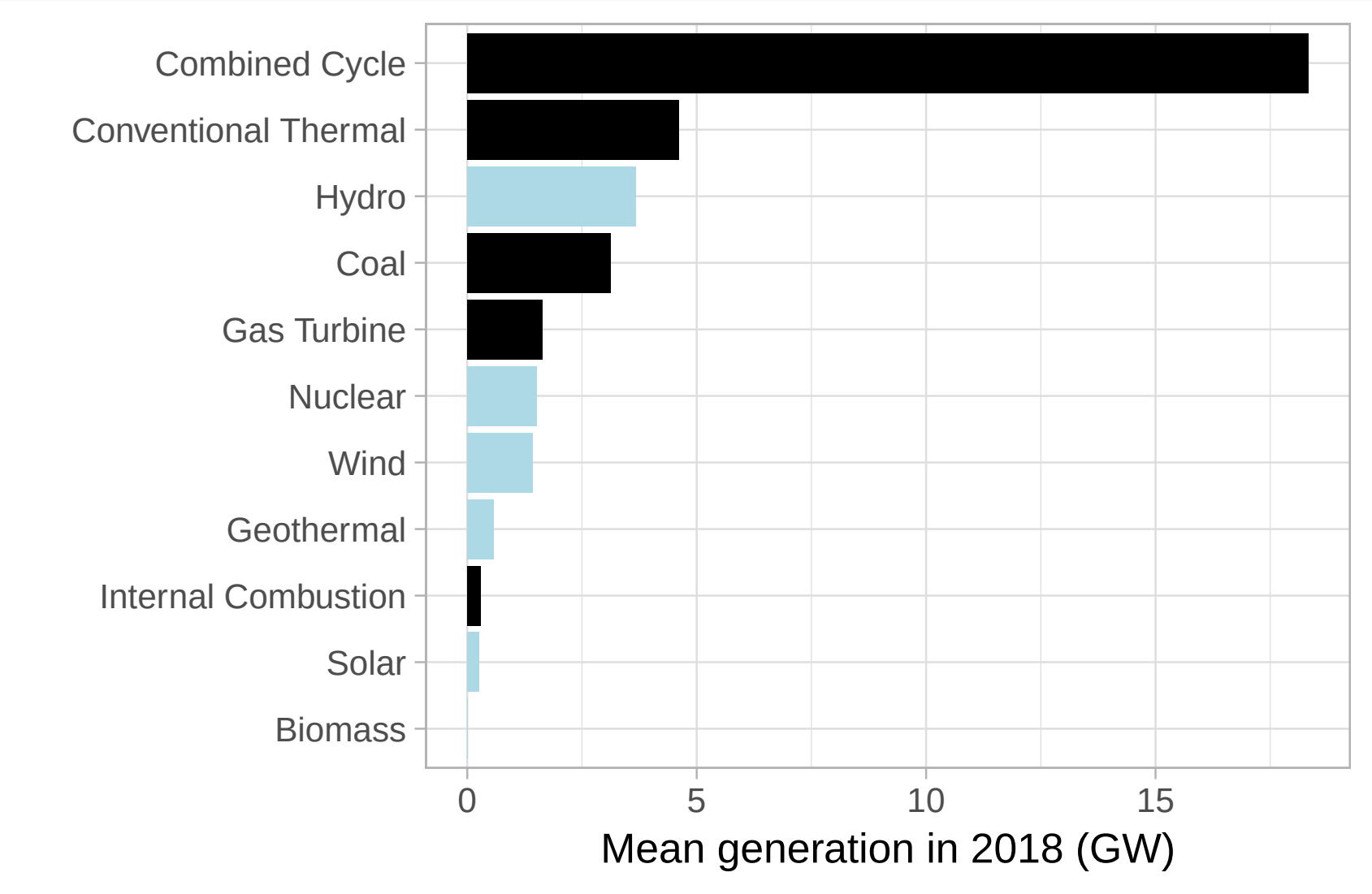
1. Do the large generation firms have the **ability** to exercise market power?
2. Do the large generation firms have the **incentive** to exercise market power?
3. Are there disadvantages of the existing market structure based on regulated cost-based bids?

I will consider three questions about market power in the wholesale electricity market during today's presentation

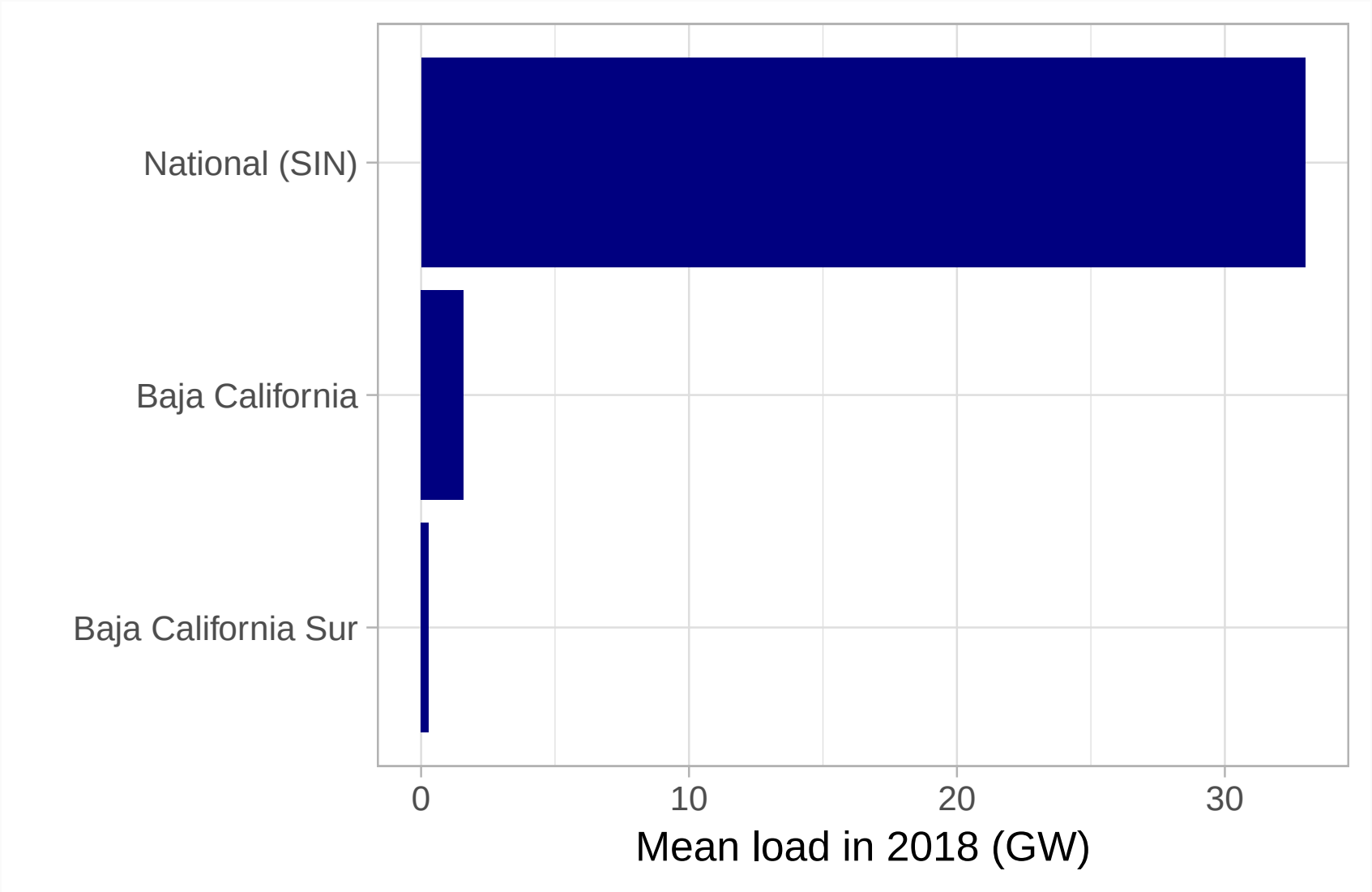
1. Do the large generation firms have the **ability** to exercise market power? YES
2. Do the large generation firms have the **incentive** to exercise market power? PROBABLY
3. Are there disadvantages of the existing market structure based on regulated cost-based bids? YES

Mexican electricity market

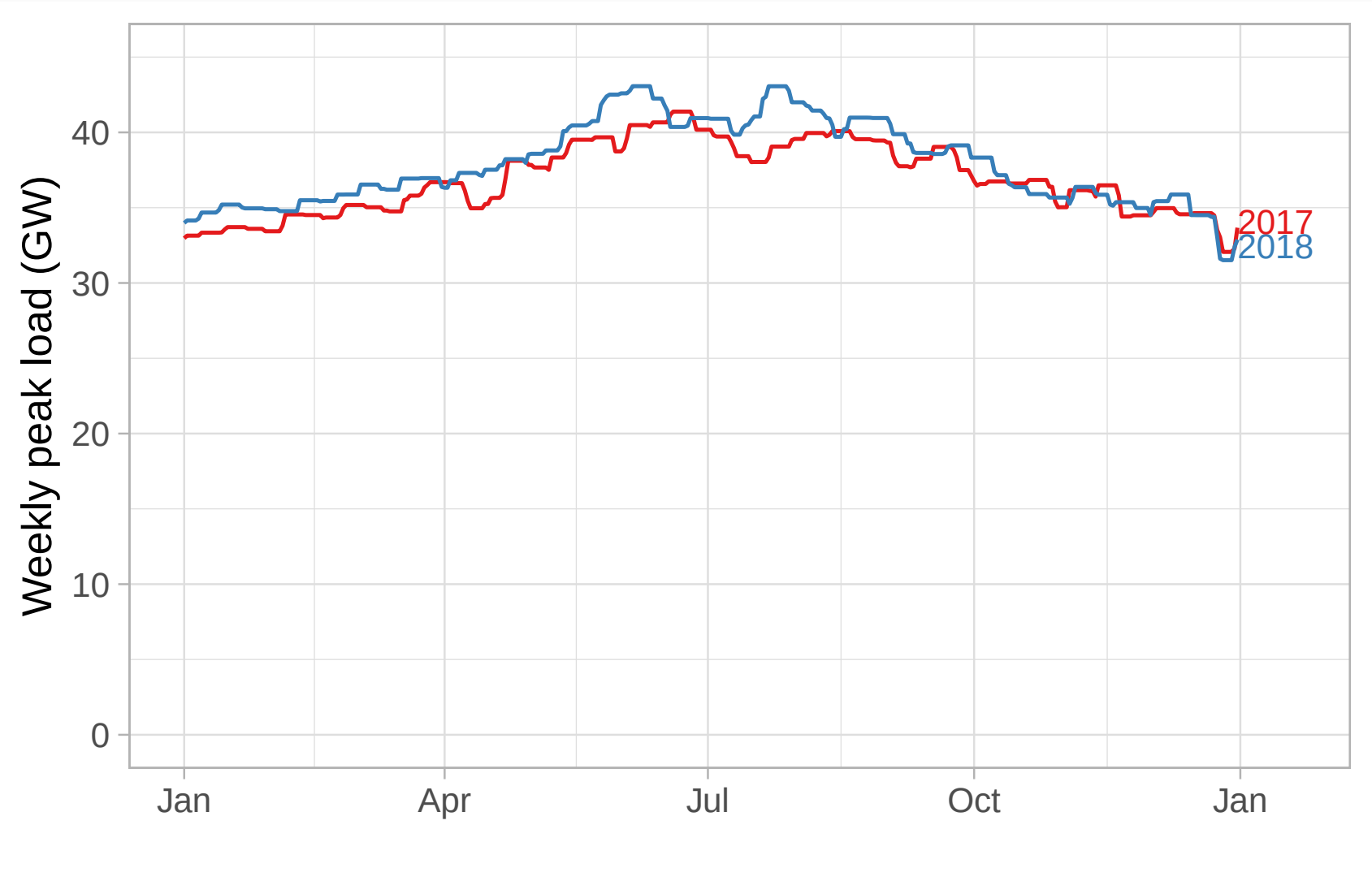
Large increase in combined cycle capacity over past 20 years: now more than half of total generation



Three separate systems in Mexico: focus on the largest (SIN) covering all of the country except Baja California

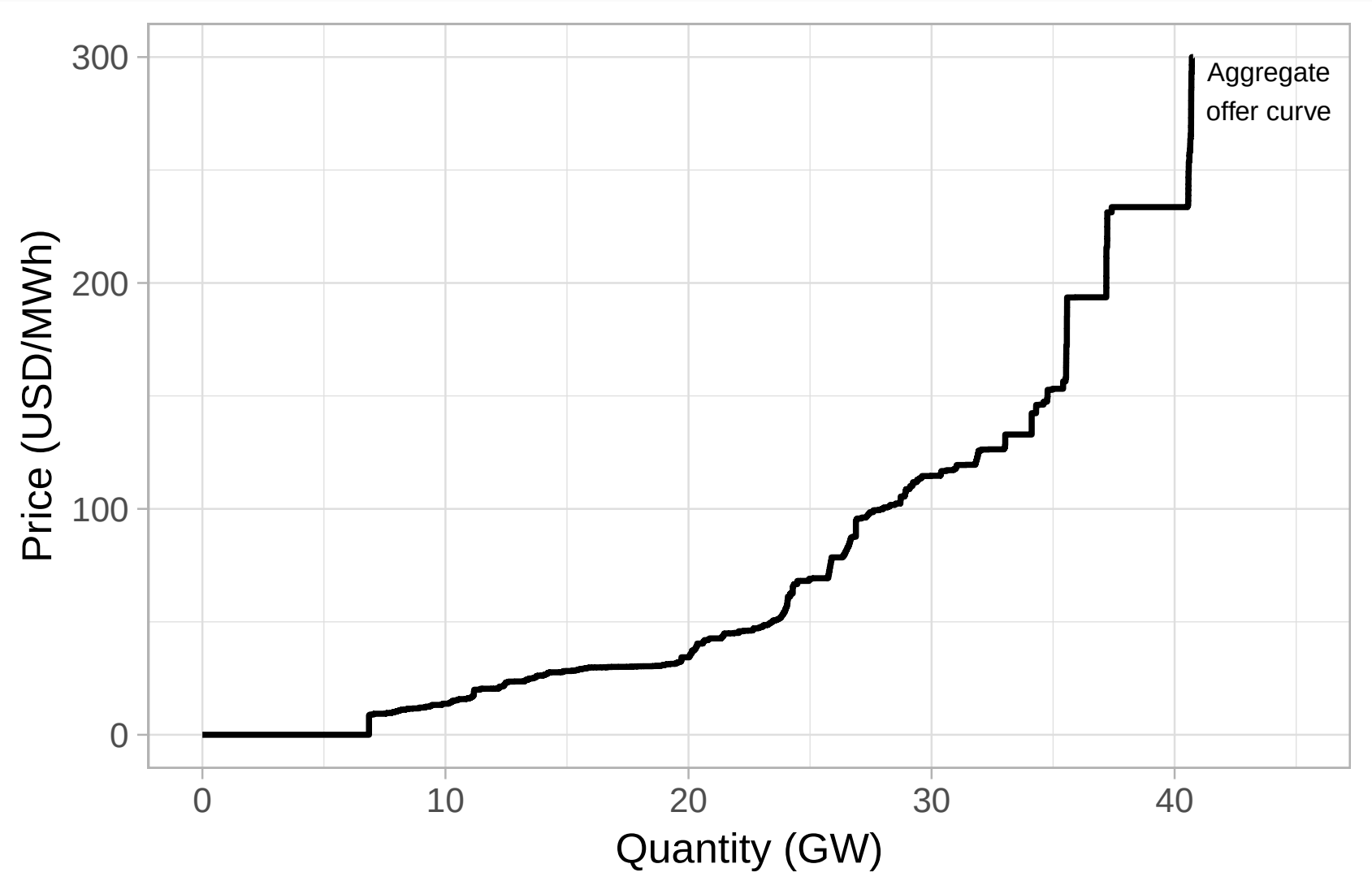


Peak load for the SIN is slightly more than 40 GW and occurs in early summer (June)

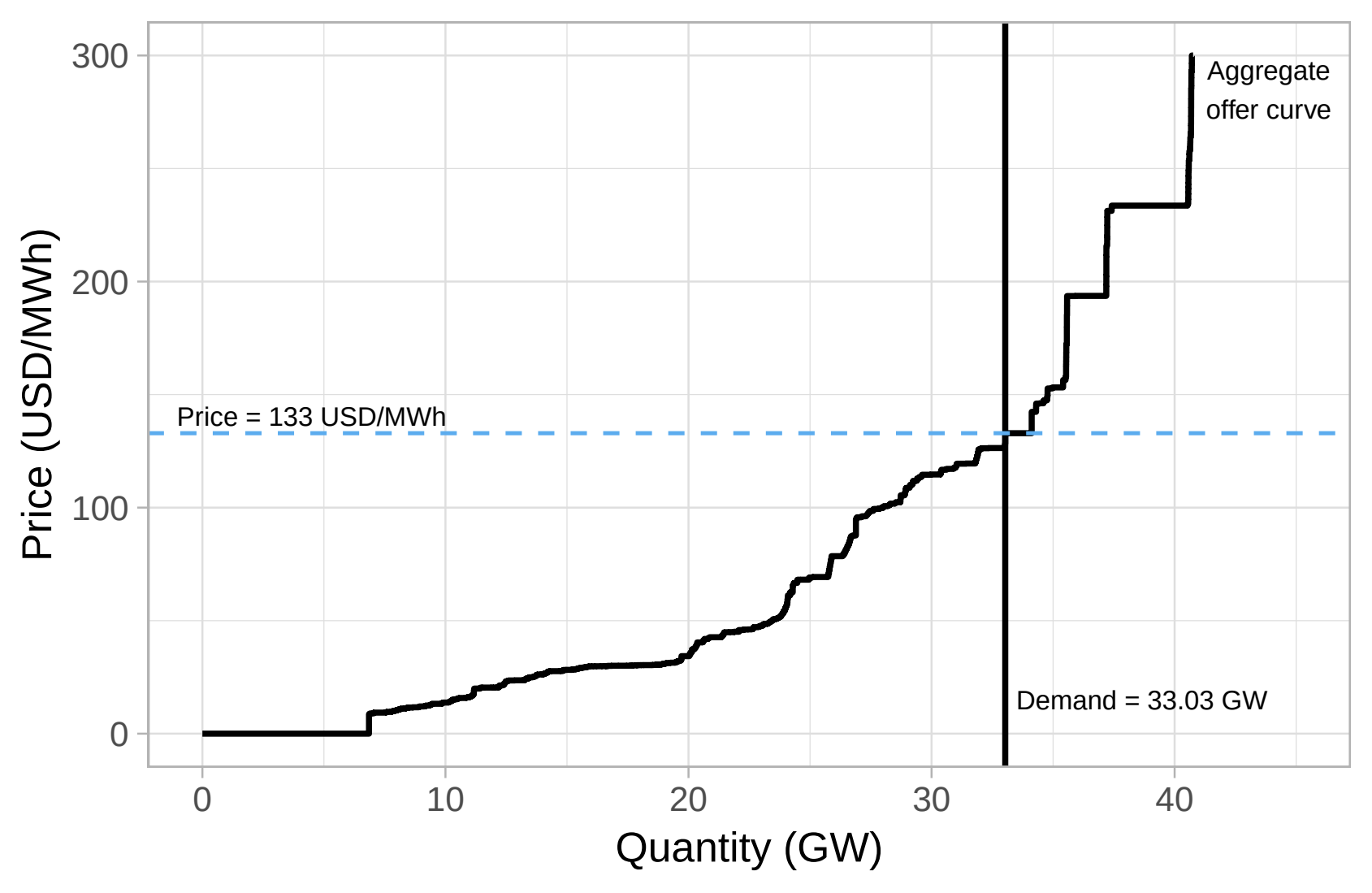


Ability to exercise market power

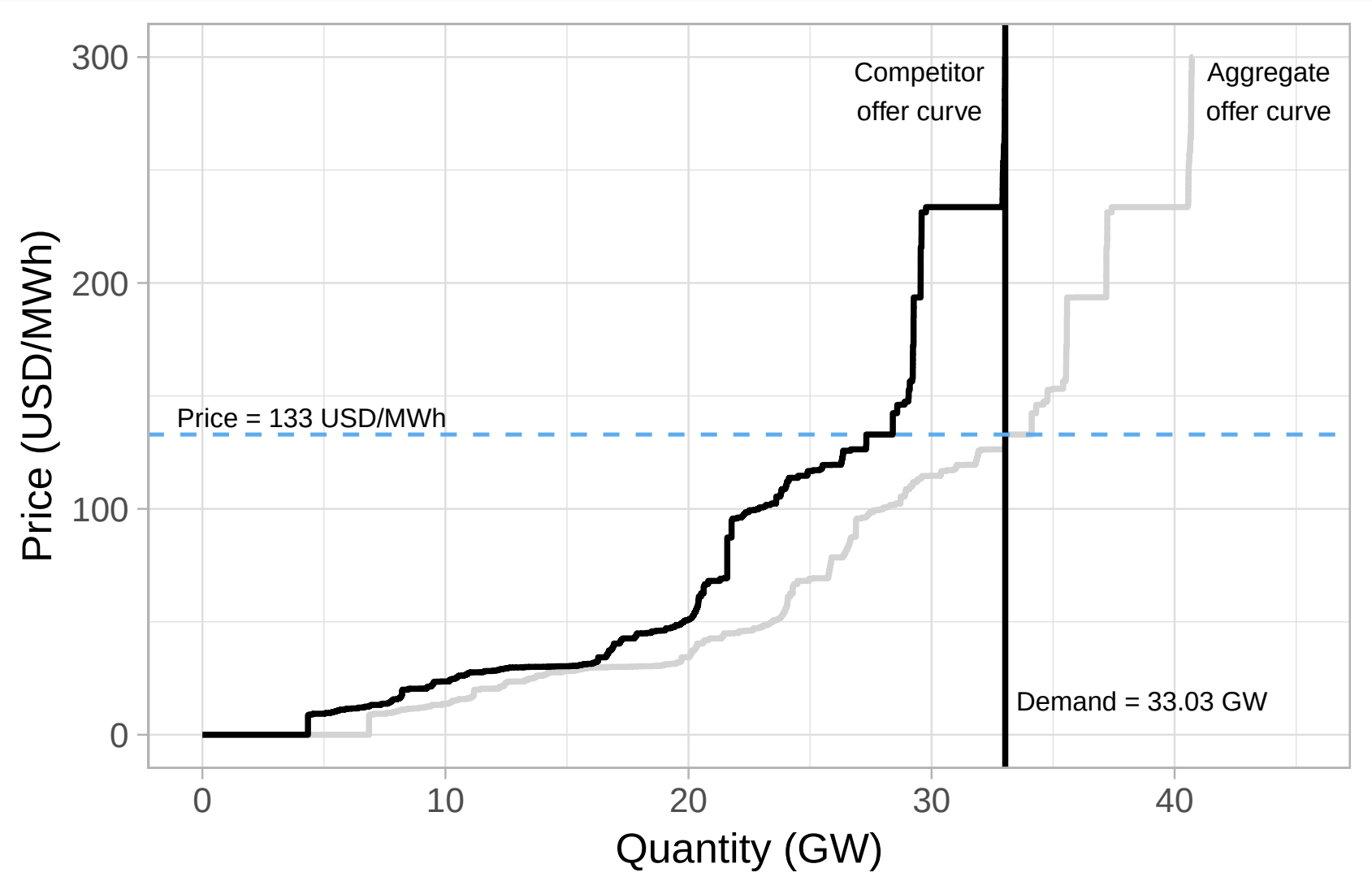
Construct the aggregate offer curve for SIN for an example date and hour: 7:00PM on September 26, 2018



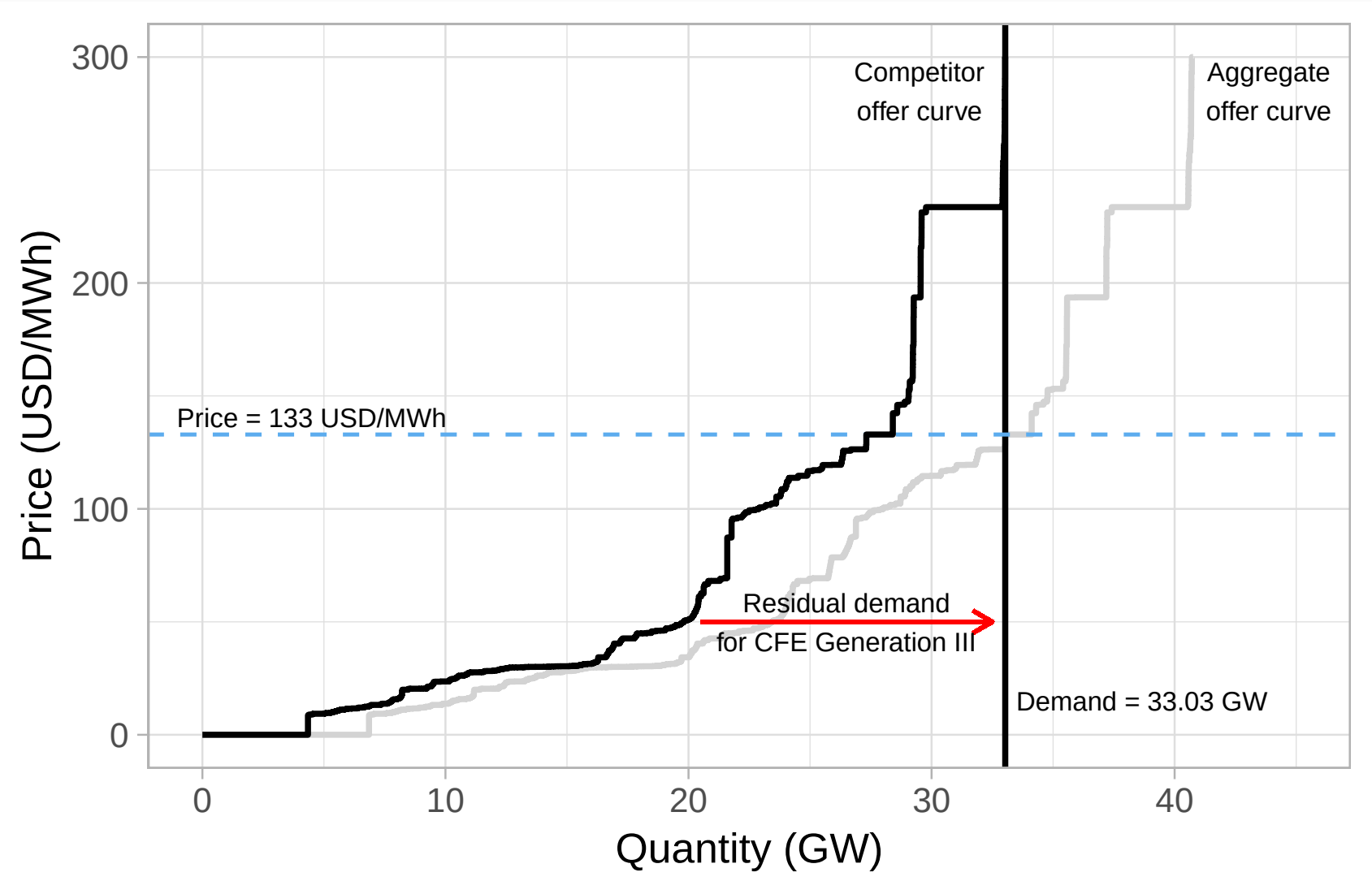
The system demand intersects the aggregate offer curve at the market price in that hour



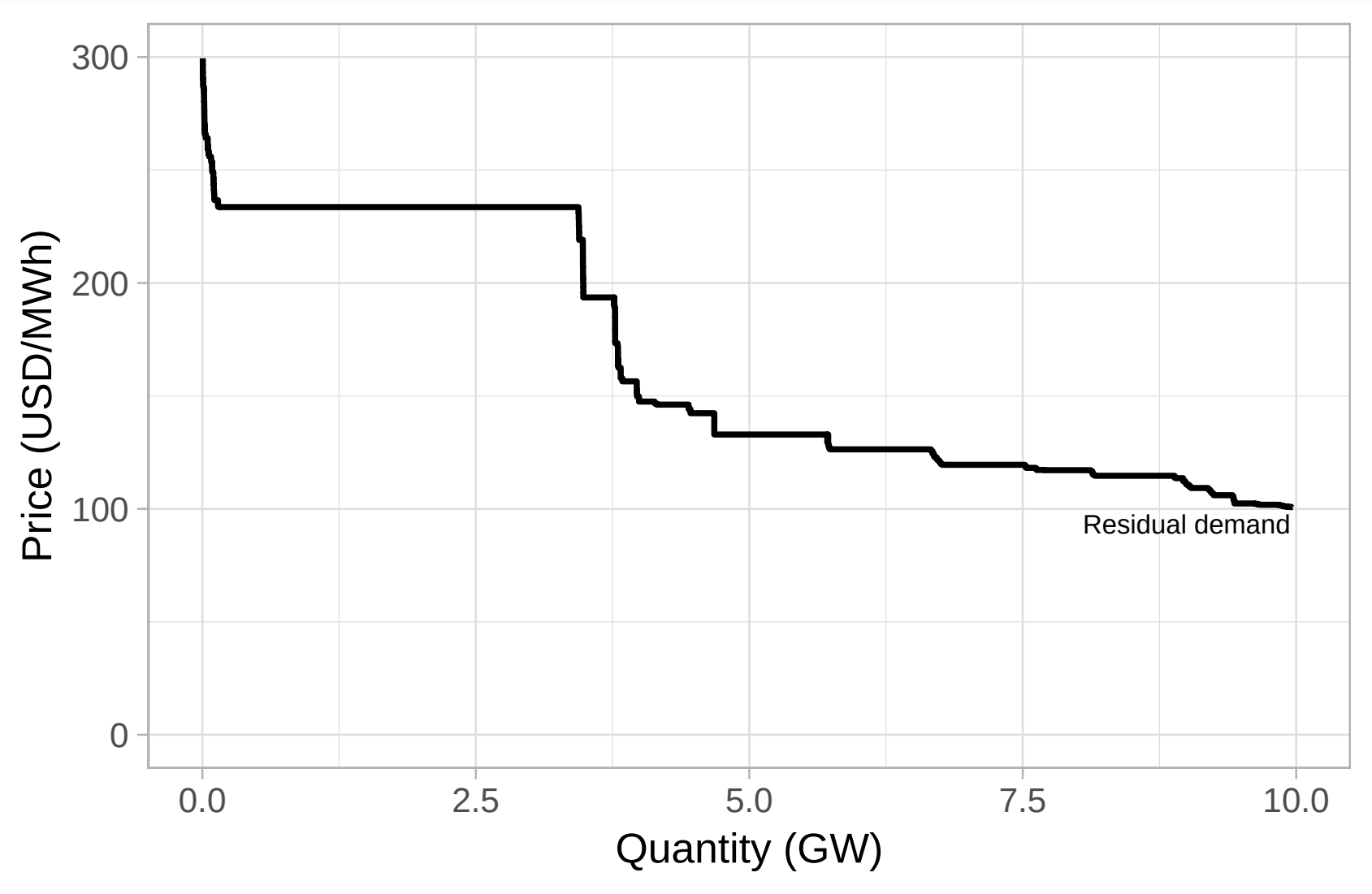
Pick one firm (CFE Genco III) and construct the offer curve for all of its competitors



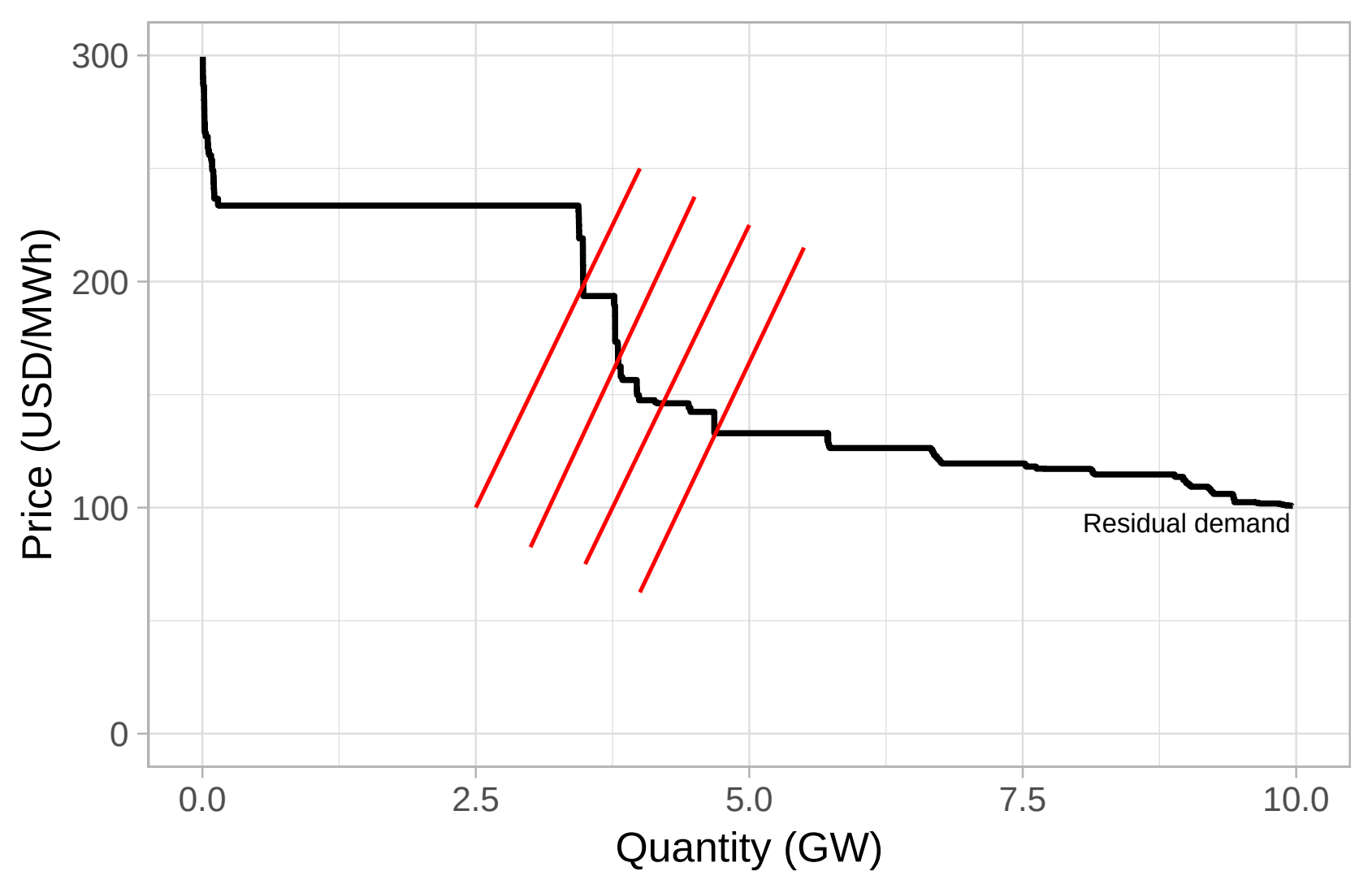
Residual demand faced by CFE Genco III is the difference between market demand and offer curve of its competitors



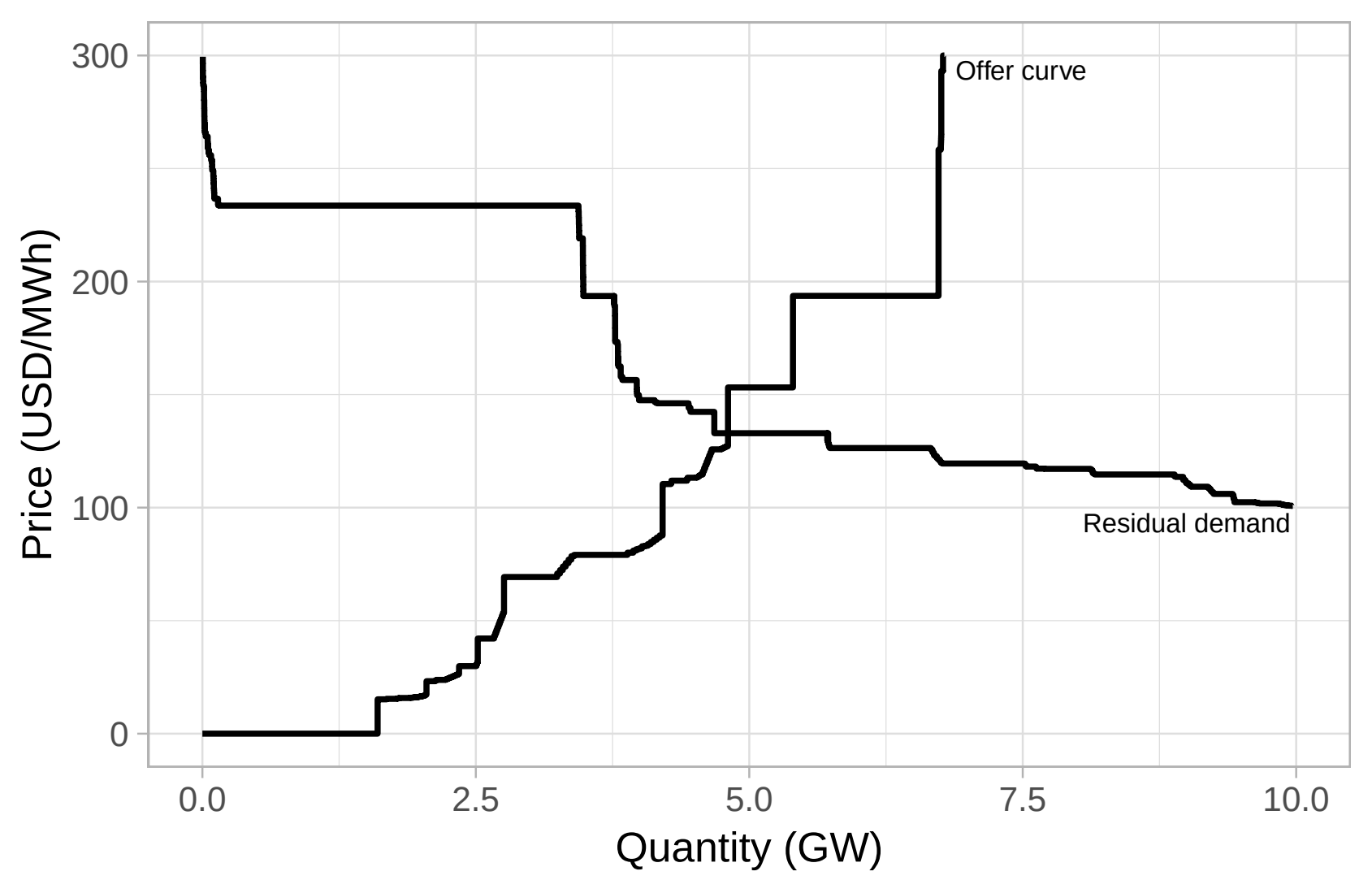
Plot the residual demand for CFE Genco III at 7:00PM on September 26, 2018



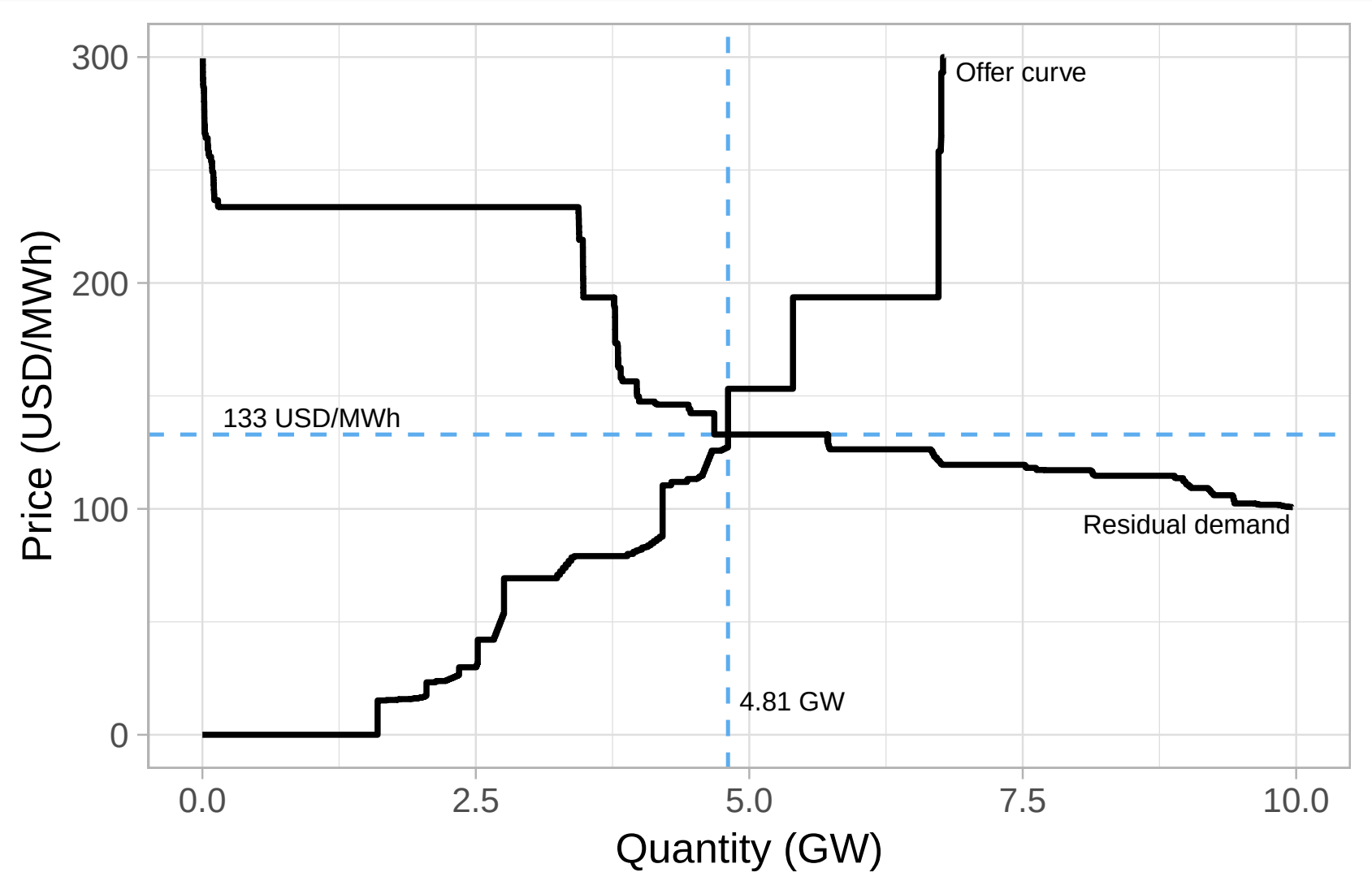
In a bid-based market, generator can choose the combination of price and quantity offers that will maximize profits



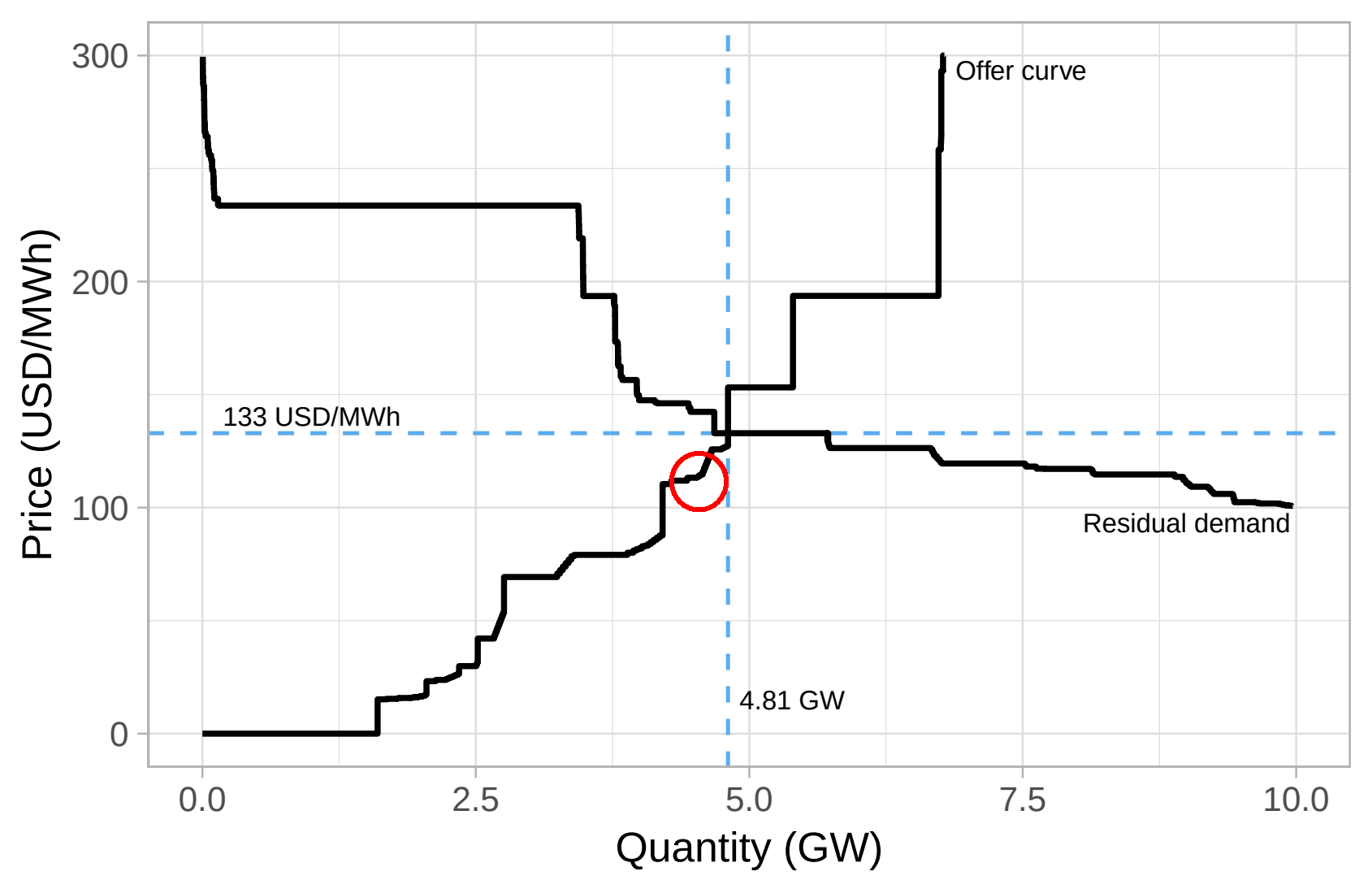
In a cost-based market like Mexico, the prices along the offer curve are set by a regulatory formula to reflect costs



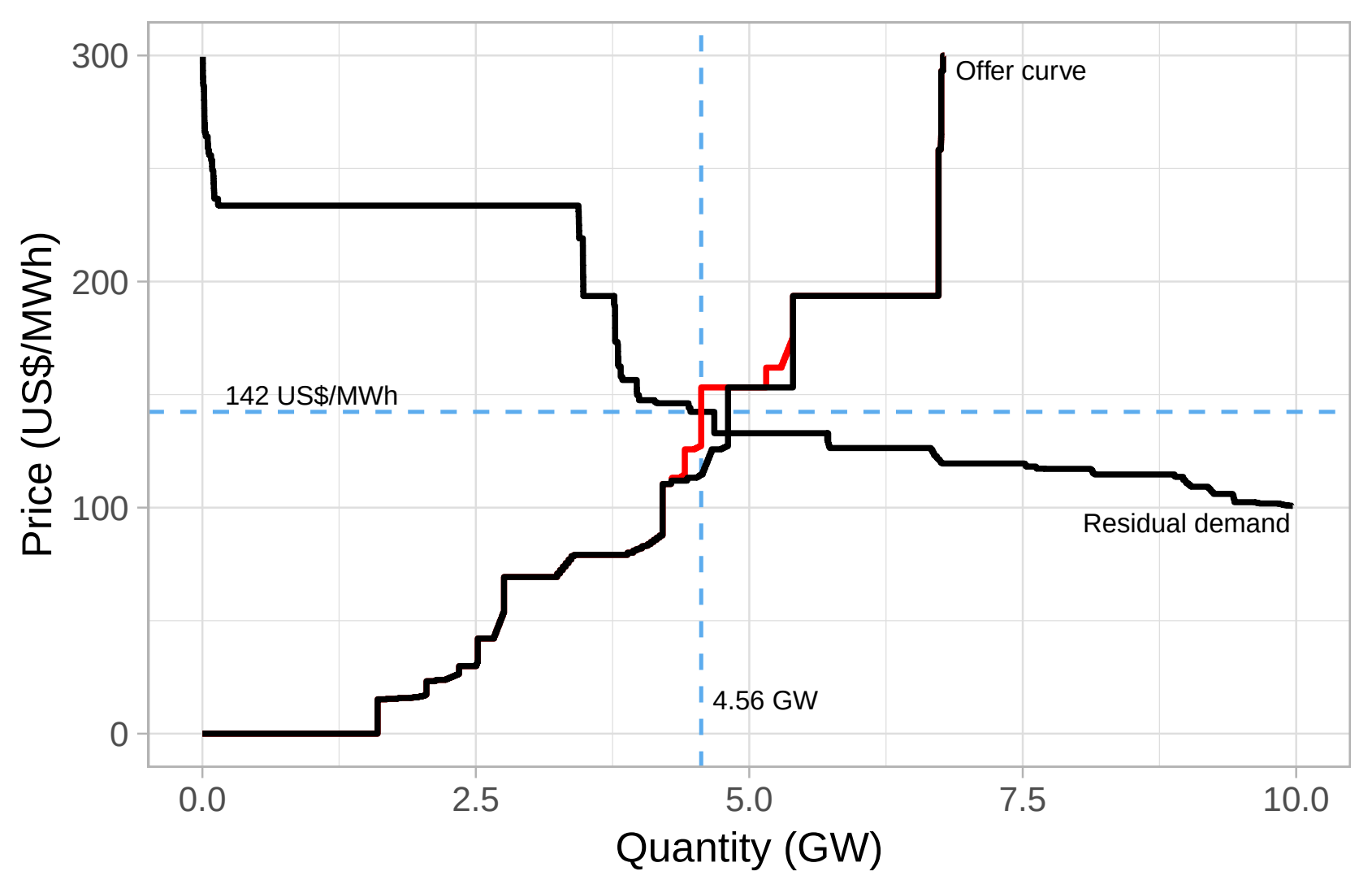
In this hour, CFE Genco III produces 4.81 GW and the average SIN price is just over US$130/MWh



What would happen if CFE Genco III could increase the offer price for the highlighted unit (Pacific coast thermal)?



The higher offer price increases the system price by 7% and CFE Genco III's generation revenue by 1.5%



How is it possible to increase the offer price for a unit in a cost-based market with regulated offer prices?

- Higher fuel procurement costs—exert less effort to pay a lower price for fuel
  - This would not be a problem if offer prices are strictly indexed to international fuel price benchmarks
  - But generators can request a revision of the fuel price index (Ch. 11.1 of *Manual de Vigilancia del Mercado*)
- Switch to alternative fuels that are more expensive (e.g. natural gas to diesel)
- Invest in less-efficient generation or reduce efficiency of existing plants

How realistic is it for the offer price of a unit to jump overnight by $50/MWh, when offer prices are regulated?

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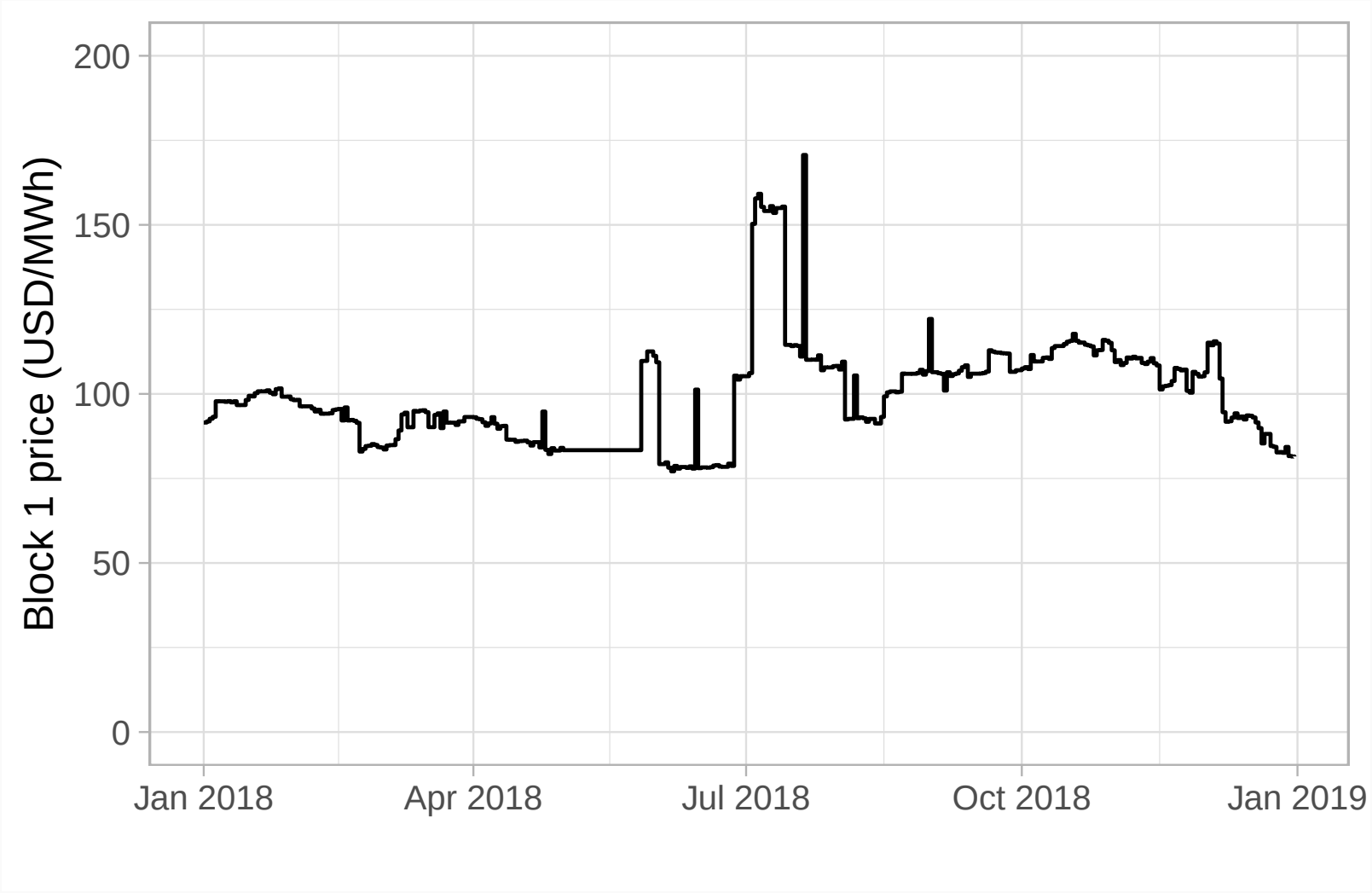
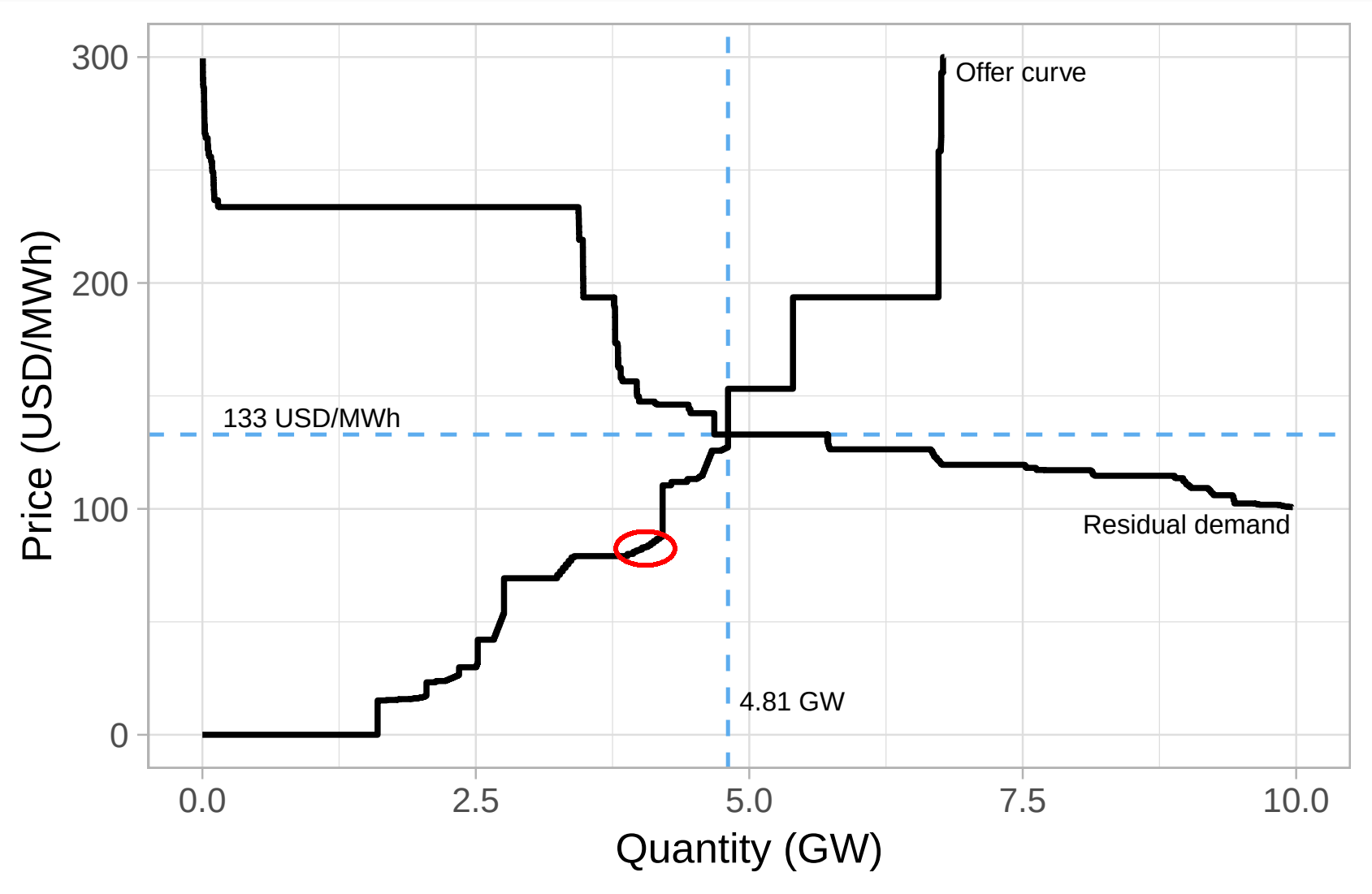
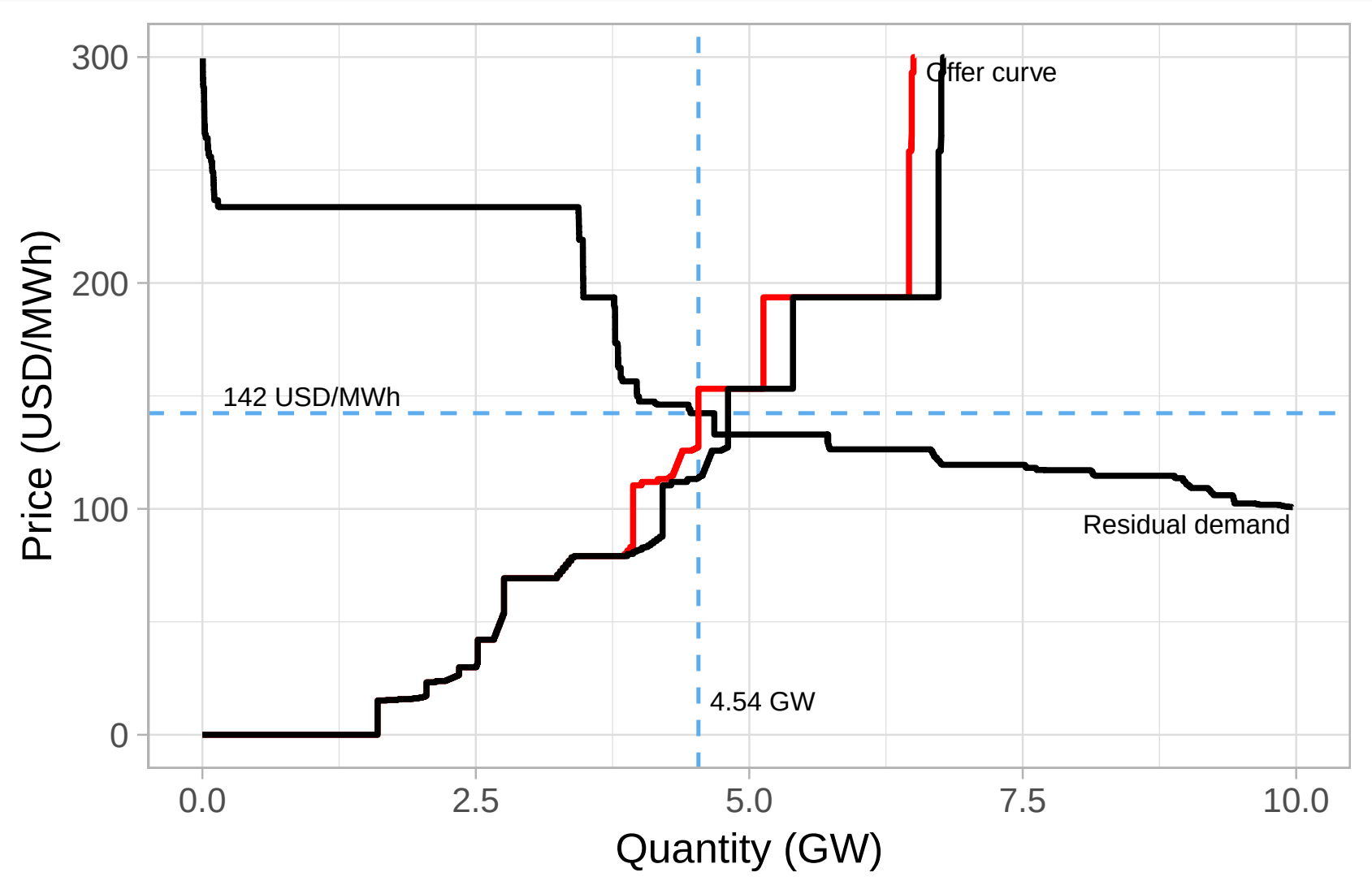
Offer price for the thermal unit shown on the previous figure



Generators have flexibility to adjust the quantity component of their offers—such as for this combined cycle plant



Submitting only the minimum quantity for this plant shifts in the offer curve, increasing the system price by 7%



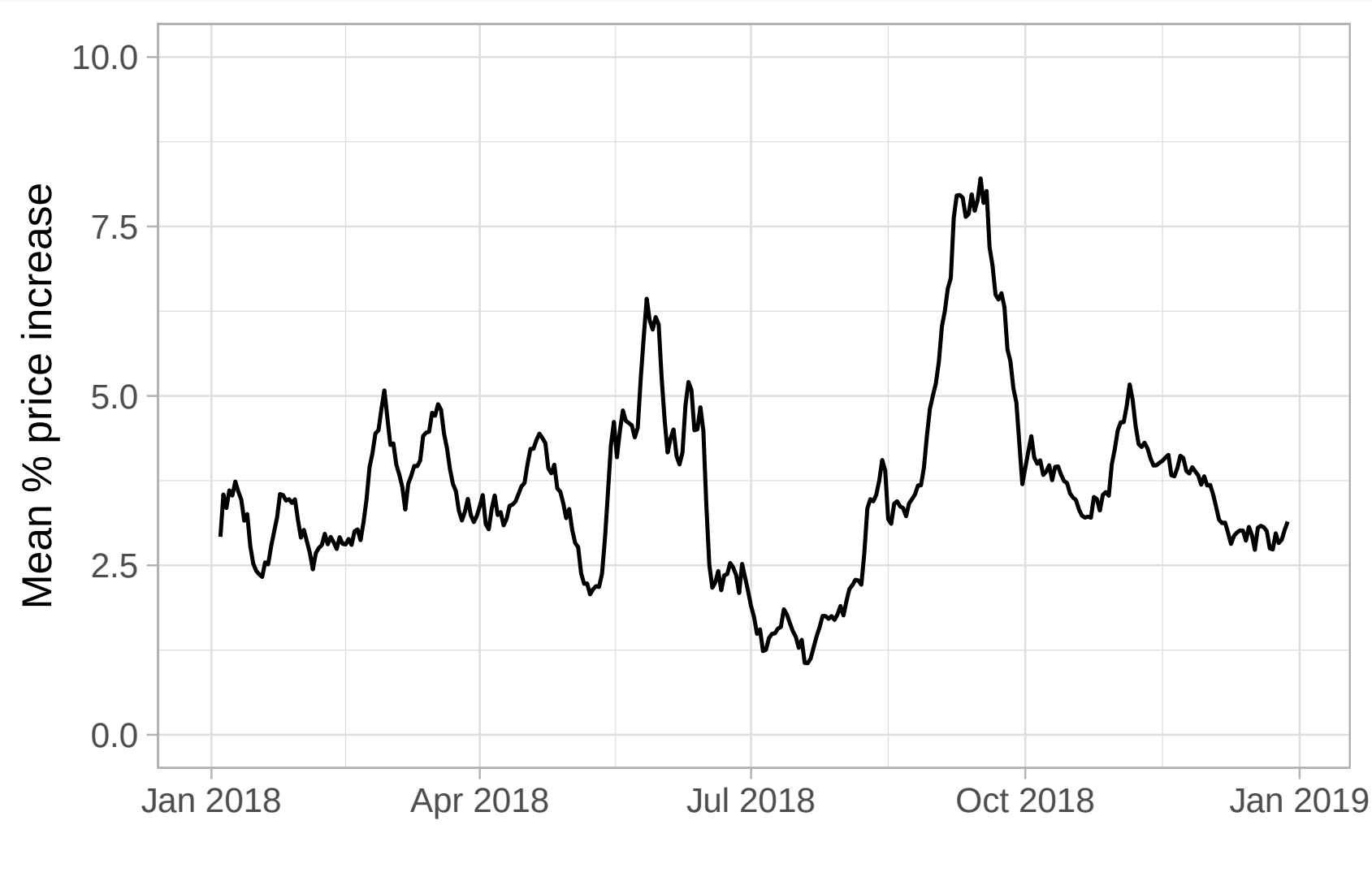
Generators in a cost-based market can exercise market power by reducing their available generation capacity

- Capacity withholding is prohibited in the market rules and CENACE will notify the market monitor of suspected cases (Ch. 6.2 of *Manual de Vigilancia del Mercado*)
- However, there are many valid reasons for withholding capacity: fuel shortages, planned or unplanned maintenance, forced outages, etc etc
- It is nearly **impossible** to distinguish between legitimate and strategic withholding

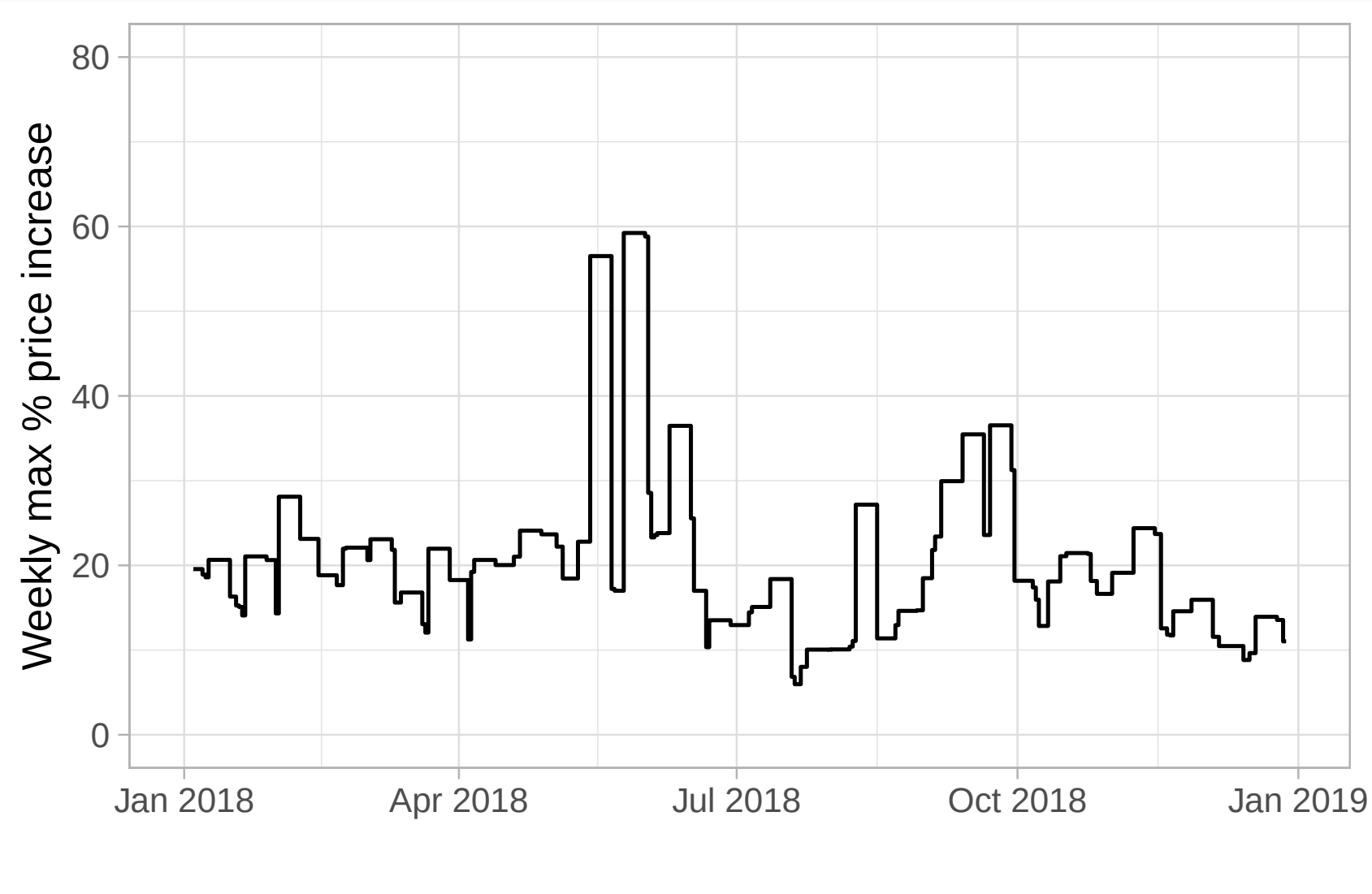
I extended this analysis for the other generation companies and for all hours during 2018

- In the example for September 26, 2018, CFE Genco III could increase the system price by **10%** by reducing its output by **10%**
  - Output could have been reduced by increasing offer prices or by reducing offer quantities
- I calculated this number for every hour in 2018: the % increase in price for a 10% reduction in output by the firm

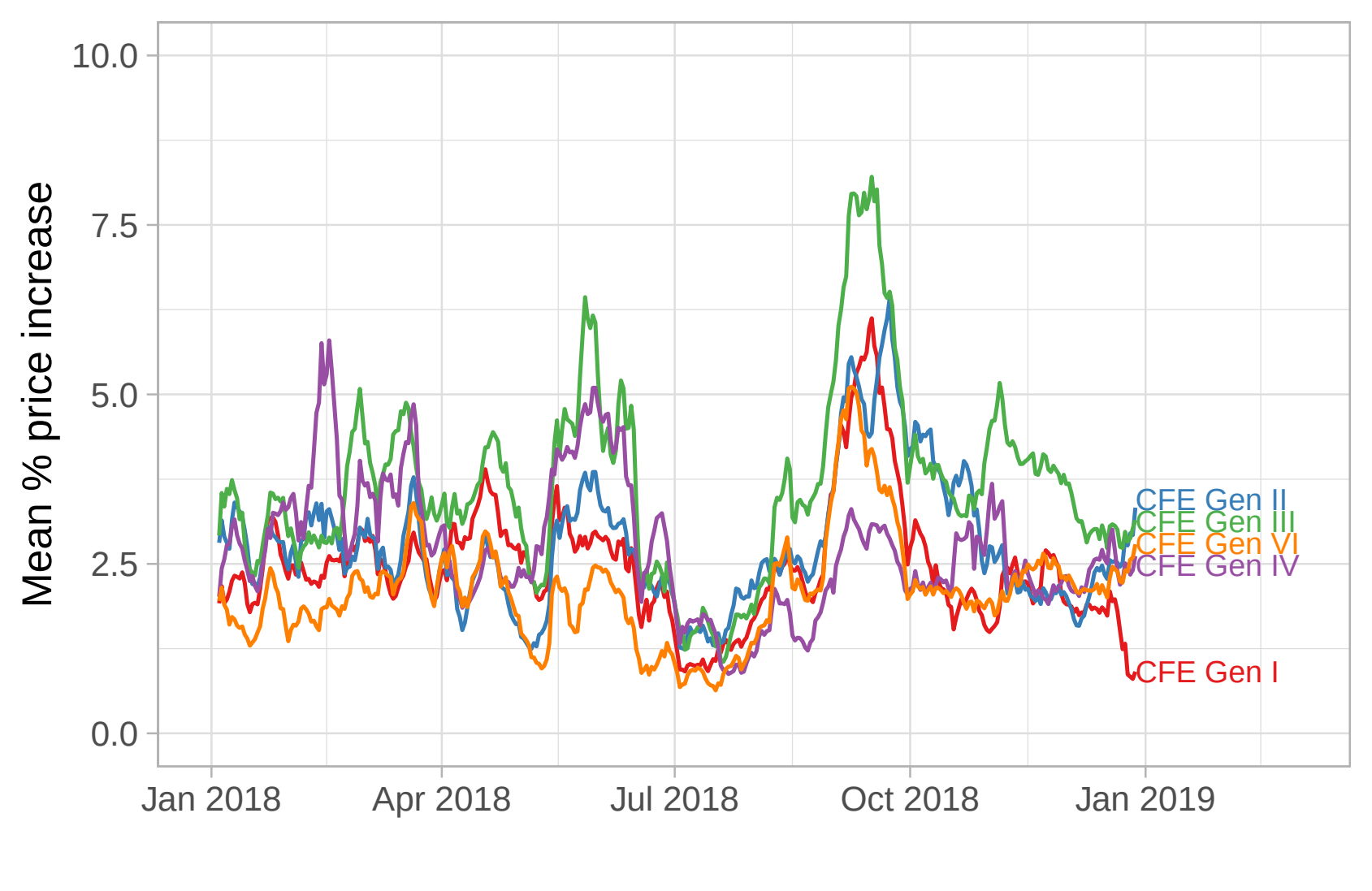
On average during 2018, CFE Genco III could have pushed up the price by 3.65% by a 10% reduction in its output



However, there were 730 hours during the year when the price increase would have exceeded 10%



CFE Genco III had the greatest ability to increase price, but all firms had some degree of market power



What ability did the CFE generation companies have to increase the system price by withholding their capacity during 2018?

Firm	Mean % P $\uparrow$	Hours P $\uparrow > 10\%$
CFE Genco I	2.45%	238
CFE Genco II	2.79%	357
CFE Genco III	3.65%	730
CFE Genco IV	2.71%	334
CFE Genco VI	2.11%	202

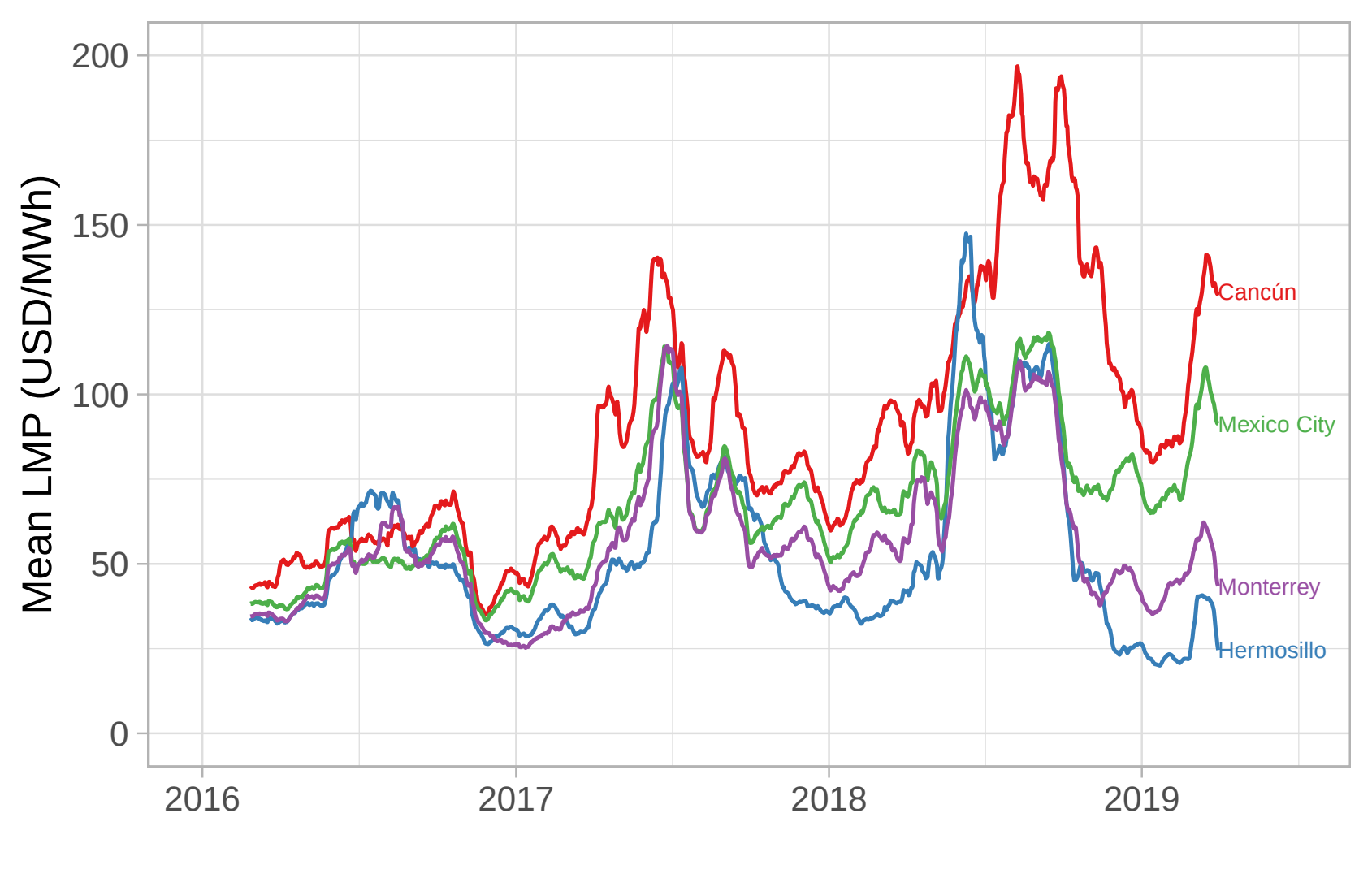
Table shows mean price increase from withholding 10% of generation output, and the number of hours for which this exceeds 10%, for all hours during 2018. Results shown for SIN only.

Enhanced abilities to exercise market power

Transmission constraints may provide generation firms with additional ability to exercise market power

- Previous analysis assumed a single market with one price
- In practice, transmission constraints restrict the size of the market supplied by a generation plant
    - Firms can even create binding transmission constraints by withholding capacity
- With a smaller market and fewer competitors, firms face a steeper residual demand curve
- We can calculate a transmission-constrained version of the residual demand analysis

Weekly mean nodal prices have differed across regions by as much as $100/MWh since late 2018



Complex bidding procedures provide additional opportunities to exercise market power

- Generation offers contain many components and parameters: startup costs, minimum generation levels, minimum revenues, ramping constraints, etc
- Generators also make simultaneous offers of ancillary services
- It is impossible for the regulator to set the "competitive" values for all of these parameters
  - Even setting the correct marginal cost is a challenging exercise
- There may be profitable opportunities to manipulate these parameters in order to increase generation revenues

Incentives to exercise market power

Forward contracts between generators and retailers create a strong disincentive for firms to exercise market power

- With fixed-price forward contracts, generators may no longer wish to withhold generation capacity to increase market price
- Firms only benefit from the higher price on their generation in excess of the contract quantity
- If generation is less than the contract quantity, firms will pay the market price for the shortfall
    - Market price will be **higher** because of the withholding

Vesting contracts between new generation and retailing firms were a valuable part of restructuring process

- Each of the five CFE Generators has vesting contracts with CFE Retailing for a portion of their generating capacity
- Contract price is linked to benchmark fuel prices
- Two reasons why generators may still have an incentive to exercise market power in spite of these contracts
  - Contracts are gradually expiring between 2018 and 2046, currently with nothing to replace them
  - No contract obligation for plants that are not operating...

Inefficiencies associated with cost-based markets

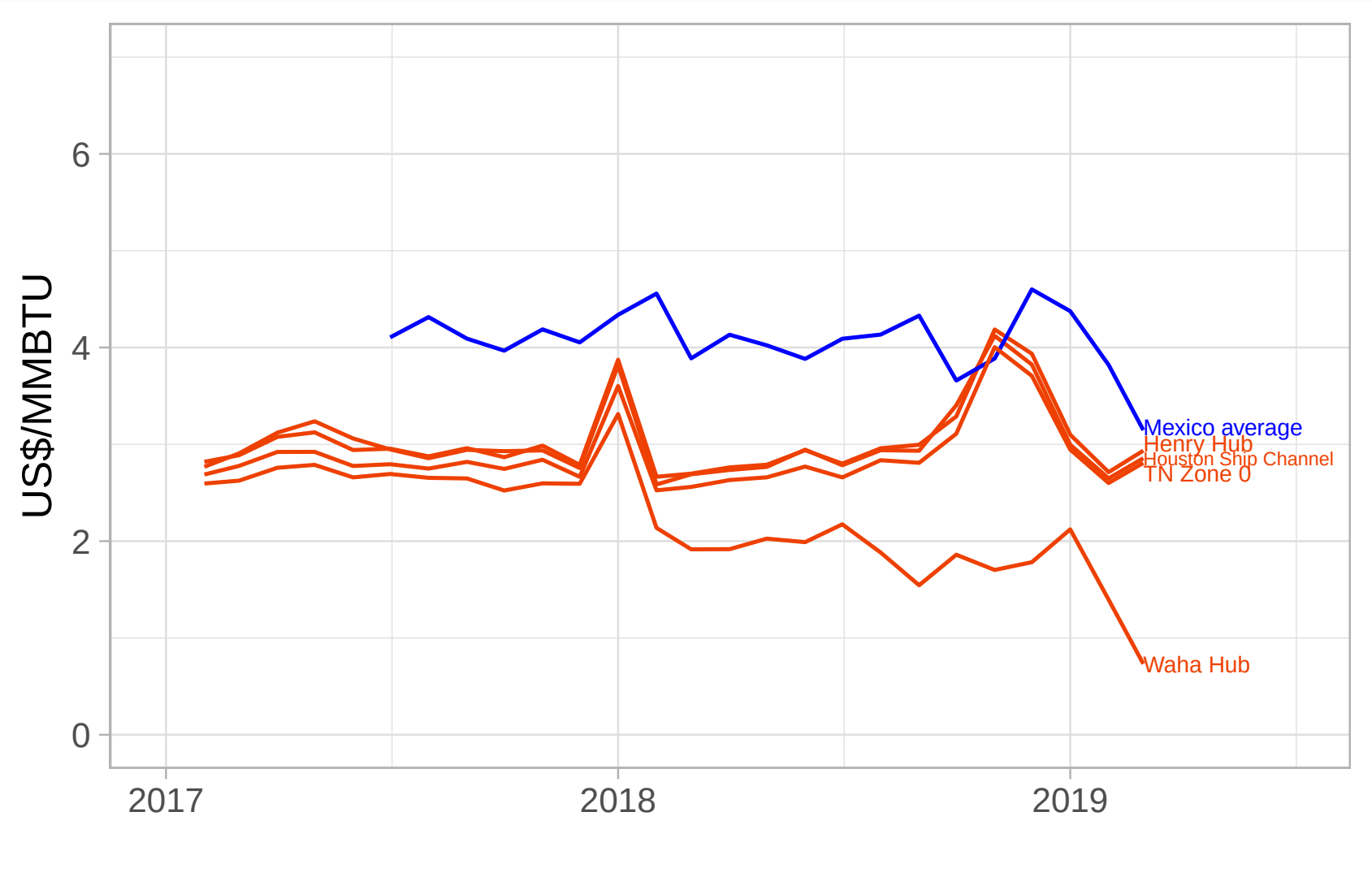
Do we still get the benefits of electricity industry restructuring using a cost-based market?

- Fundamental problem for all regulators: **information**
  - Firms know more about local market conditions than regulators
  - Firms may not have an incentive to truthfully report all relevant information to regulators
- Fundamental advantage of a market mechanism: **aggregation** of information from many market participants
  - Market prices reflect the behavior of many market participants, large and small
- Regulating the offer prices in the electricity market leads to the loss of this information and a more inefficient market operation

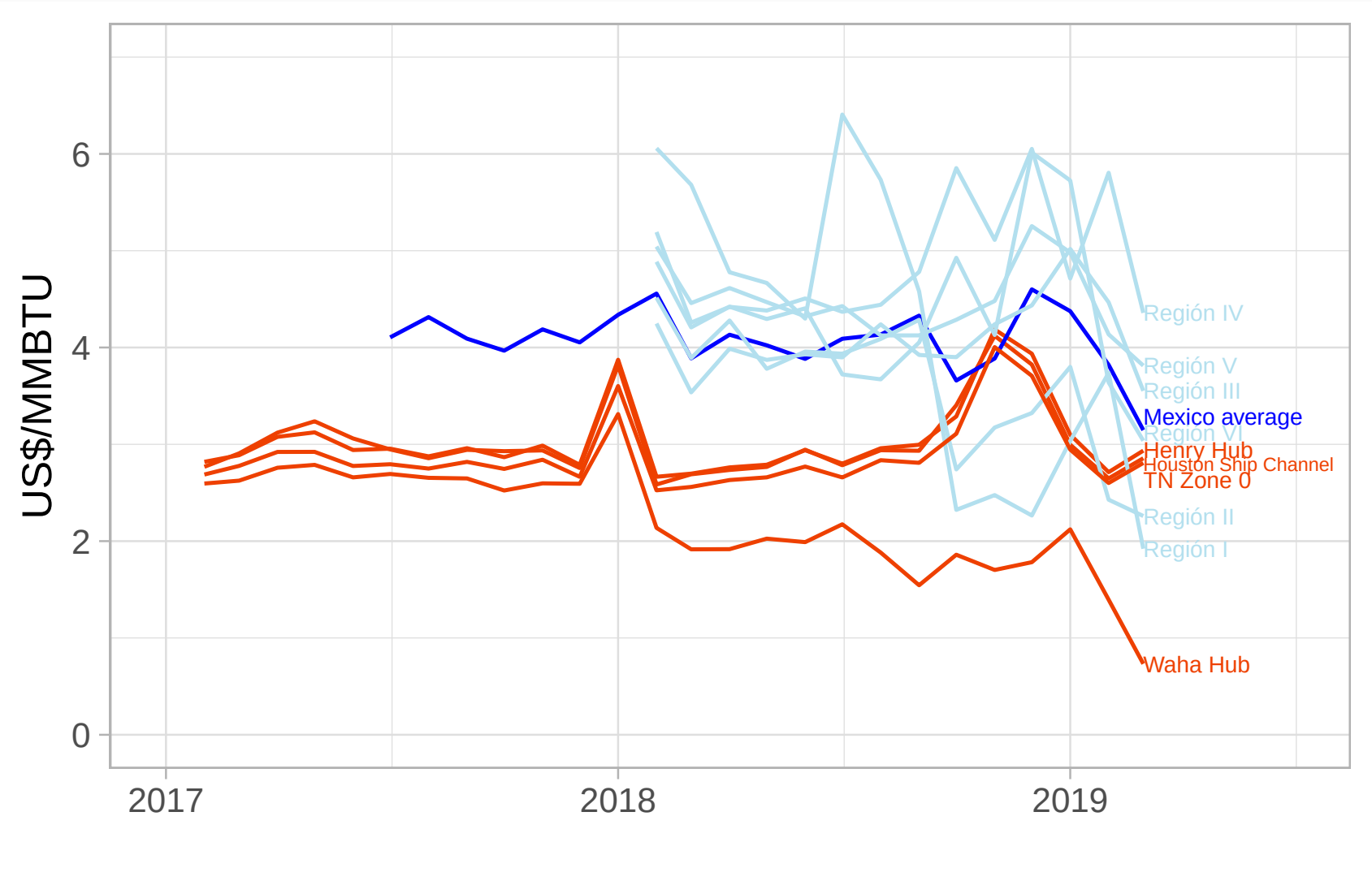
Example 1: what is the correct fuel price to use for the offer prices of the thermal generation plants?

- International benchmarks?
  - Local prices may be very different due to transportation constraints
- Regional benchmarks?
  - Potentially prone to manipulation
  - May also not reflect local conditions near the plant
- Plant-level prices?
  - Will definitely create potential for strategic manipulation
- Setting the fuel price too low may mean the plant prefers not to operate, while setting the fuel price too high will lead to transfers from consumers to generators

Before mid-2018, the Mexican natural gas index price was consistently US$1/MMBTU above the U.S. benchmarks



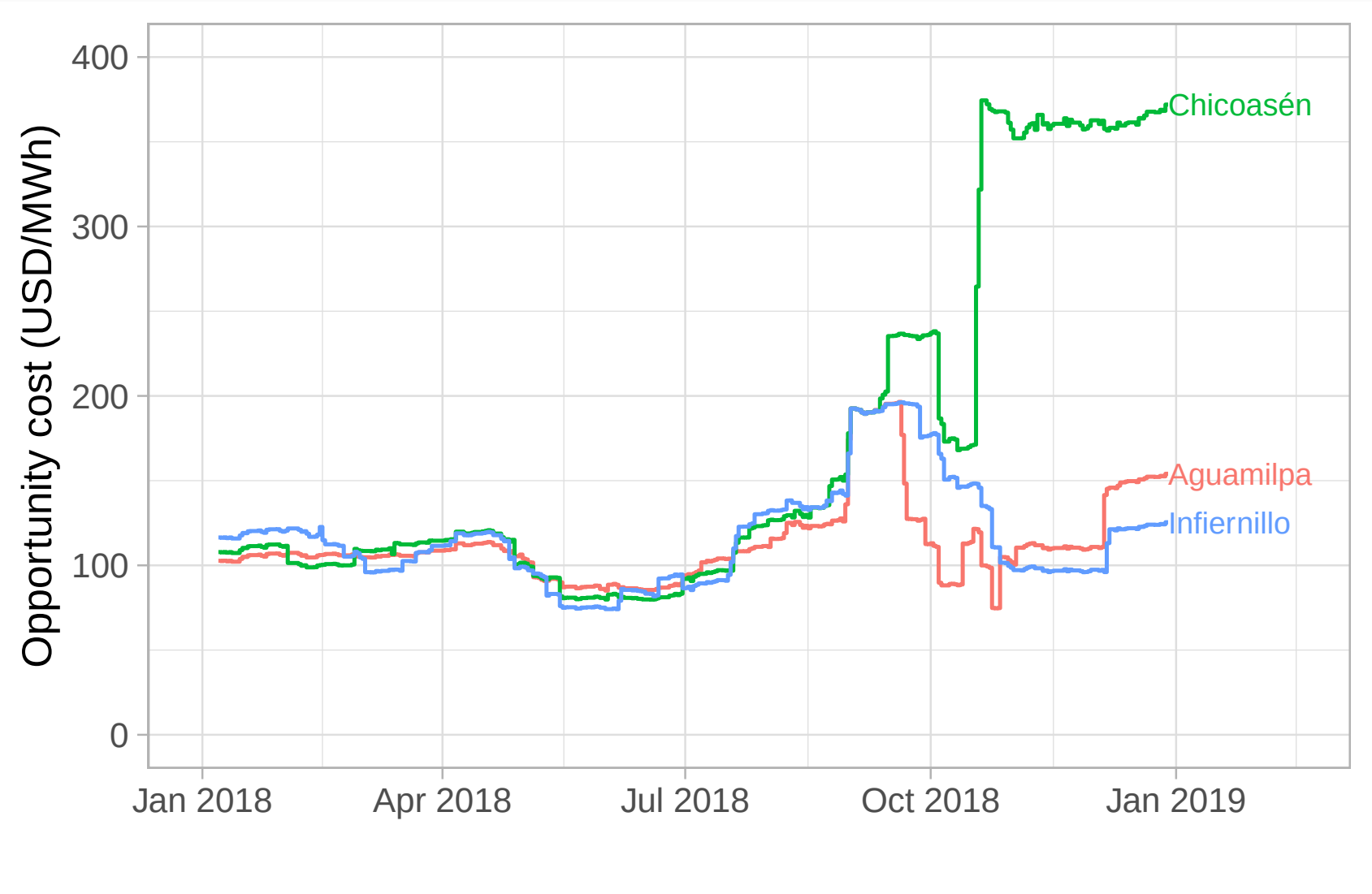
There has been considerable divergence in natural gas prices in Mexico in recent months, reflecting transportation constraints



Example 2: what is the correct opportunity cost of water to use in the offer prices of the hydro generators?

- This is a complex problem requiring the solution of a dynamic stochastic program
- Many unknown parameters that enter this problem: how will the system operator choose the parameter values?
- In a decentralized bid-based market, prices reflect the changes in expectations and information of each individual firm
  - Hydro offer prices tend to change gradually over time
  - For example, a gradual increase as firms update their subjective probabilities of a future shortfall in inflows
- Cost-based hydro market see sudden swings in opportunity costs from parameter changes

Hydro reservoirs in Mexico saw large jumps and falls in the calculated value of their opportunity cost of water



Conclusions

Cost-based versus bid-based wholesale electricity markets

- Market power is a potential problem in wholesale electricity markets but there are ways to mitigate it in a bid-based market
  - Forward contracts + market monitoring
- Implementing a cost-based market **does not** solve the problem of market power on its own
  - We saw that firms still have the ability to push up prices
- But cost-based markets may introduce a whole new set of inefficiencies associated with regulation and the lack of information