

# Electricity market game

(from Stanford PESD)

# Overview

- Realistic game based on California electricity markets
- Goals:
  - Understand how bidding and profits work in deregulated markets
  - Explore possibilities for market power
  - Study how a carbon tax works in this market

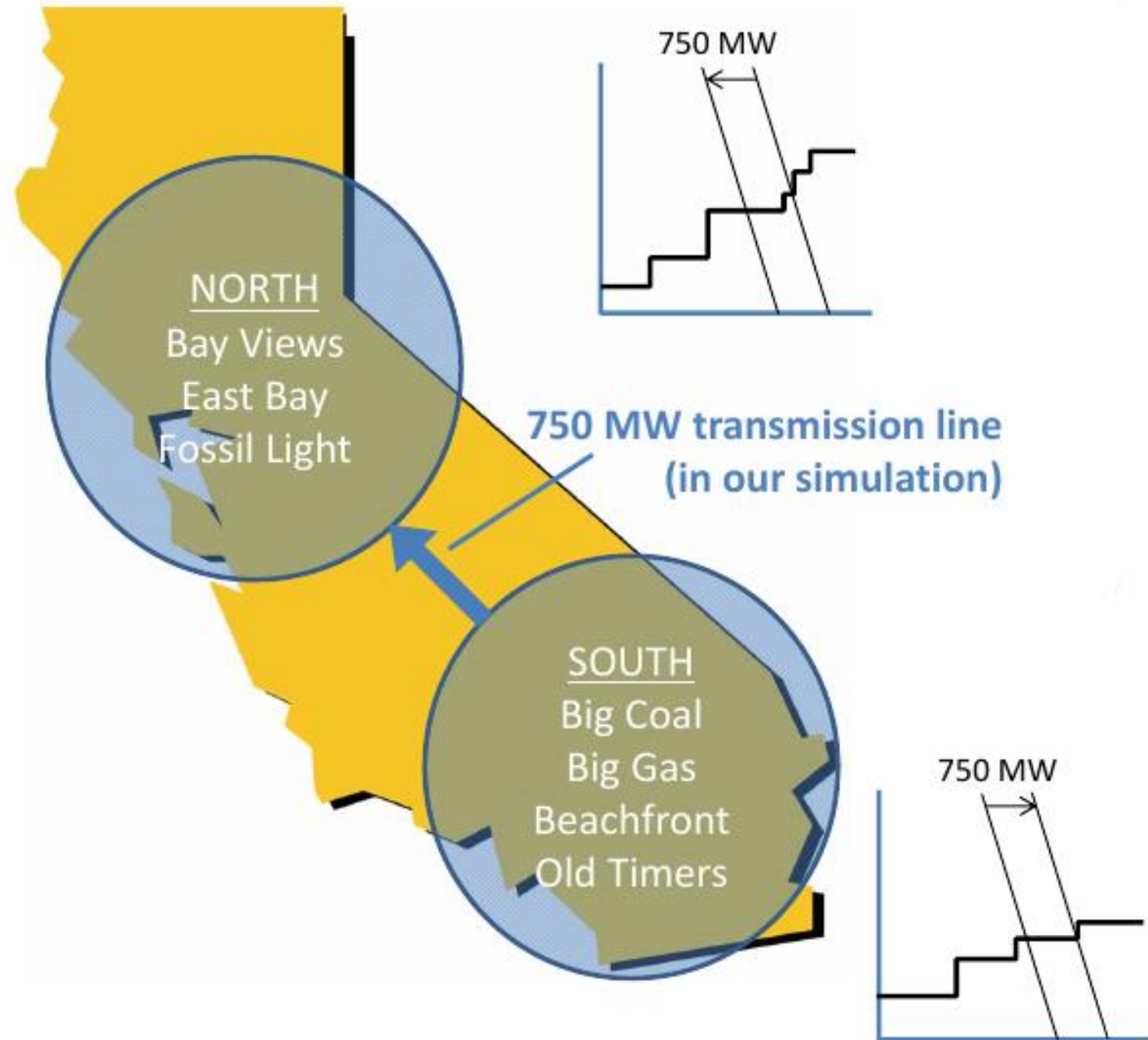
More info: [Manual](#)

## 7 Generation companies ([full portfolios](#))

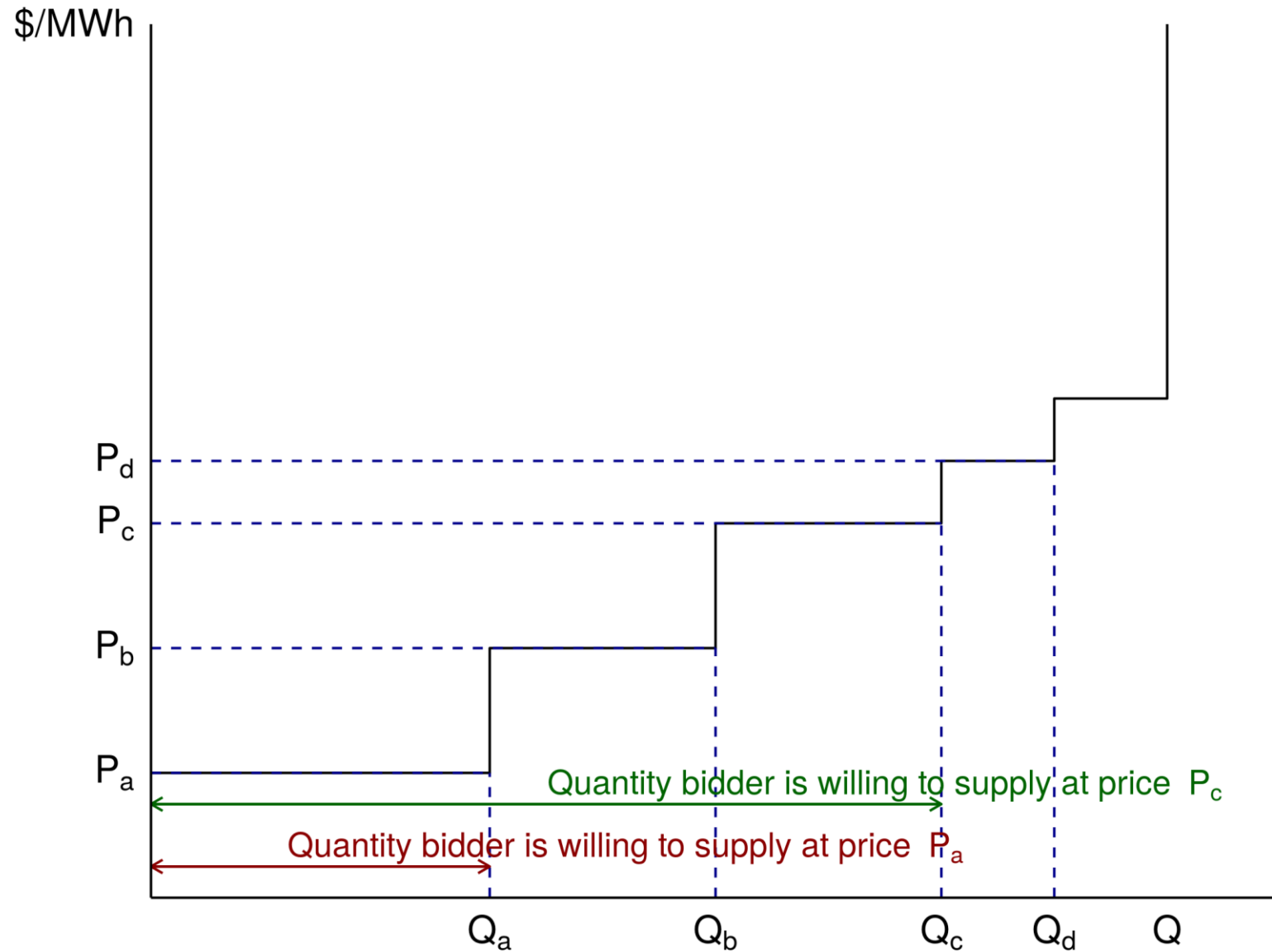
<b>Portfolio</b>	<b>Location</b>	<b># of Units</b>	<b>Capacity by Fuel</b>	<b>Range of Unit Variable Costs</b>	<b>Base Case Emissions, 4 Days (tons CO<sub>2</sub>)</b>
Big Coal	South	6	1900MW coal; 2000MW gas	\$19.00- 51.50/MWh	23,436
Big Gas	South	7	3600MW gas	\$29.00- 62.50/MWh	10,701
Beachfront	South	8	3800MW gas	\$26.50- 52.50/MWh	14,323
Old Timers	South	5	1500MW coal; 250MW gas; 1000 MW hydro	\$0.00- 37.50/MWh	11,936
Bay Views	North	5	2650MW gas	\$23.00- 42.50/MWh	10,449
East Bay	North	6	3000MW gas	\$25.50- \$48.50/MWh	8,492
Fossil Light	North	5	650MW gas; 800MW hydro; 1000MW nuclear	\$0.50- 53.00/MWh	1,310

# 2 regions

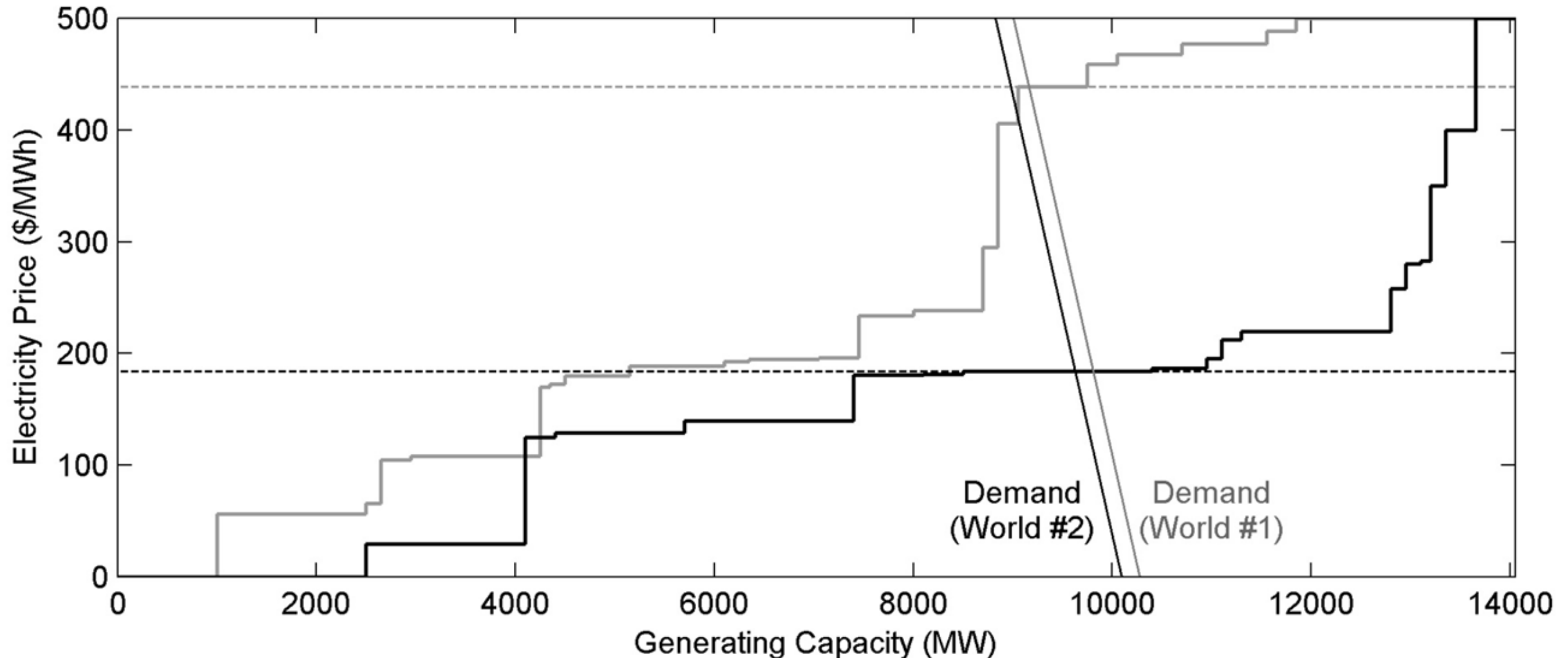
[with congestion]



# Gencos bid in the capacity of their units



ISO generates aggregate supply curve and crosses with demand to determine which plants run



## 4 Demand periods

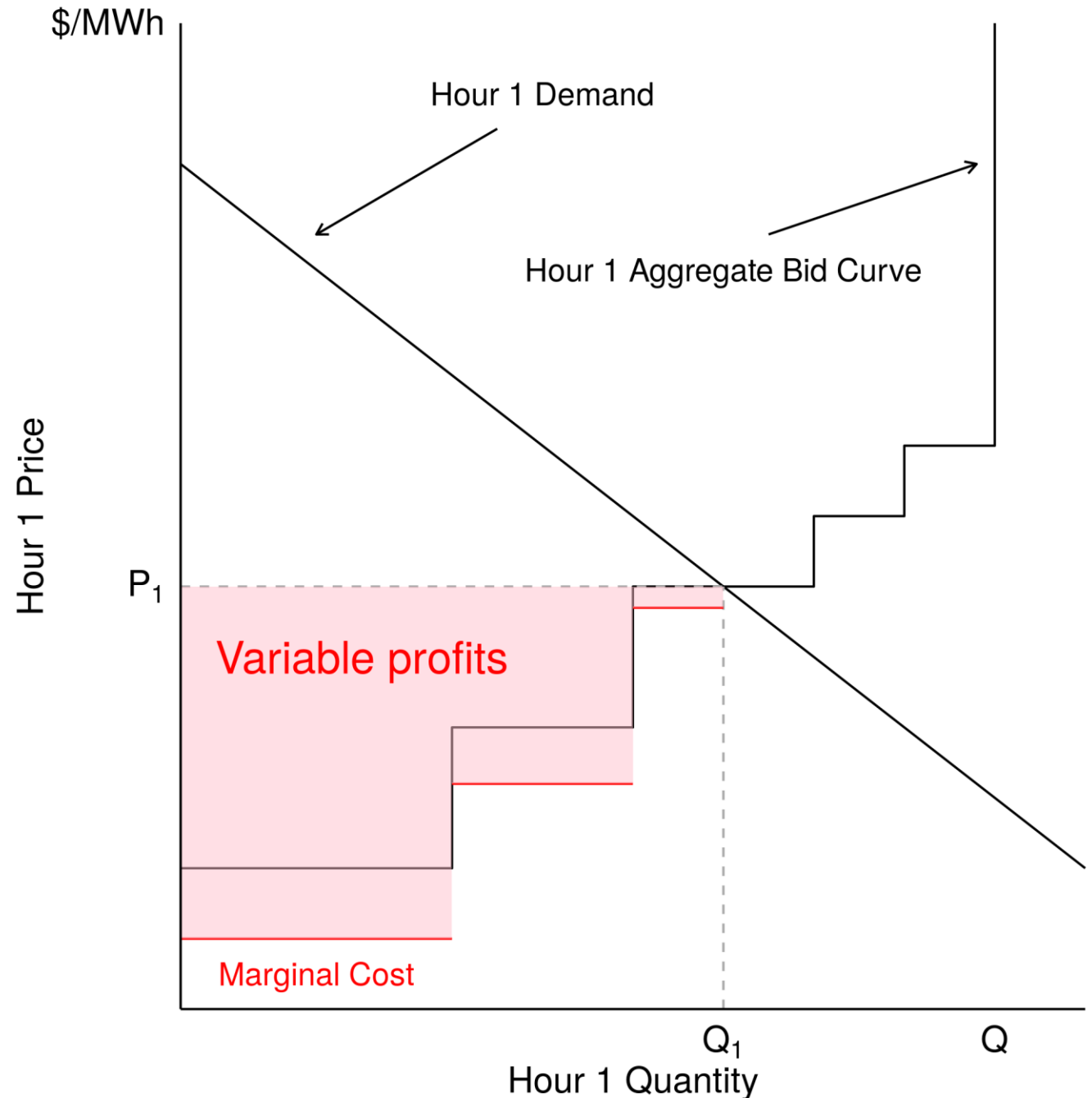
Period	Location	Load intercept	Load slope
1 (Day 1 4am)	North	4020	-2
1 (Day 1 4am)	South	7035	-2
2 (Day 1 10am)	North	4020	-2.54
2 (Day 1 10am)	South	11055	-2.54
3 (Day 1 4pm)	North	8786	-2.41
3 (Day 1 4pm)	South	12631	-2.41
4 (Day 1 10pm)	North	6709	-2.54
4 (Day 1 10pm)	South	12132	-2.54

- The realized demand intercept in both North and South regions is a random variable with mean equal to the forecast demand intercept and standard deviation equal to 3% of the forecast demand intercept

# First price [uniform] Auction

[2 when there is congestion]

- Every generator submits a bid
- Cheapest bidders dispatched until supply = demand
- All dispatched plants get highest dispatched bid





# Getting started (5 mins)

- Take a minute to figure out the best way to keep track of things with your team
  - It may be useful to start a new google sheet where you can keep track costs/ profits
- Go to the Google sheet I emailed
  - Click on your team's link for the "base game 1 – Intro"
- Go to the "Game Conditions" and take a look at your genco portfolio (also in the "Plant List" tab in the google sheet)
- How many plants of each type do you have?
  - Copy these over to your new google sheet. What are their capacities (MW)?
  - what are their marginal costs? ("fuelcost" + variable o&m "varom")
- Go to the "place bids" tab, and confirm the default bids match these marginal costs.
- More info: [Manual](#)

# Instructions – Setting bids each period

- Go to the Google sheet I emailed
- Click on your team's link for the relevant game
- Place bids
  - Enter bid for each generator for relevant period
- GM will increment period (1 to 4)
- Each team can “view market results”
  - Go to "display files" > "genco display.csv"
  - Copy your team's total profits into Google sheet

More info: [Manual](#)

# Base game 1

**Leave bids as is (= MC)!**

## **Questions to think about:**

- Which of your units will be dispatched?
- What do you think the price will be?
  - How would you figure it out?
- We will walk through the periods 1 by 1

## Base game 1 - Results

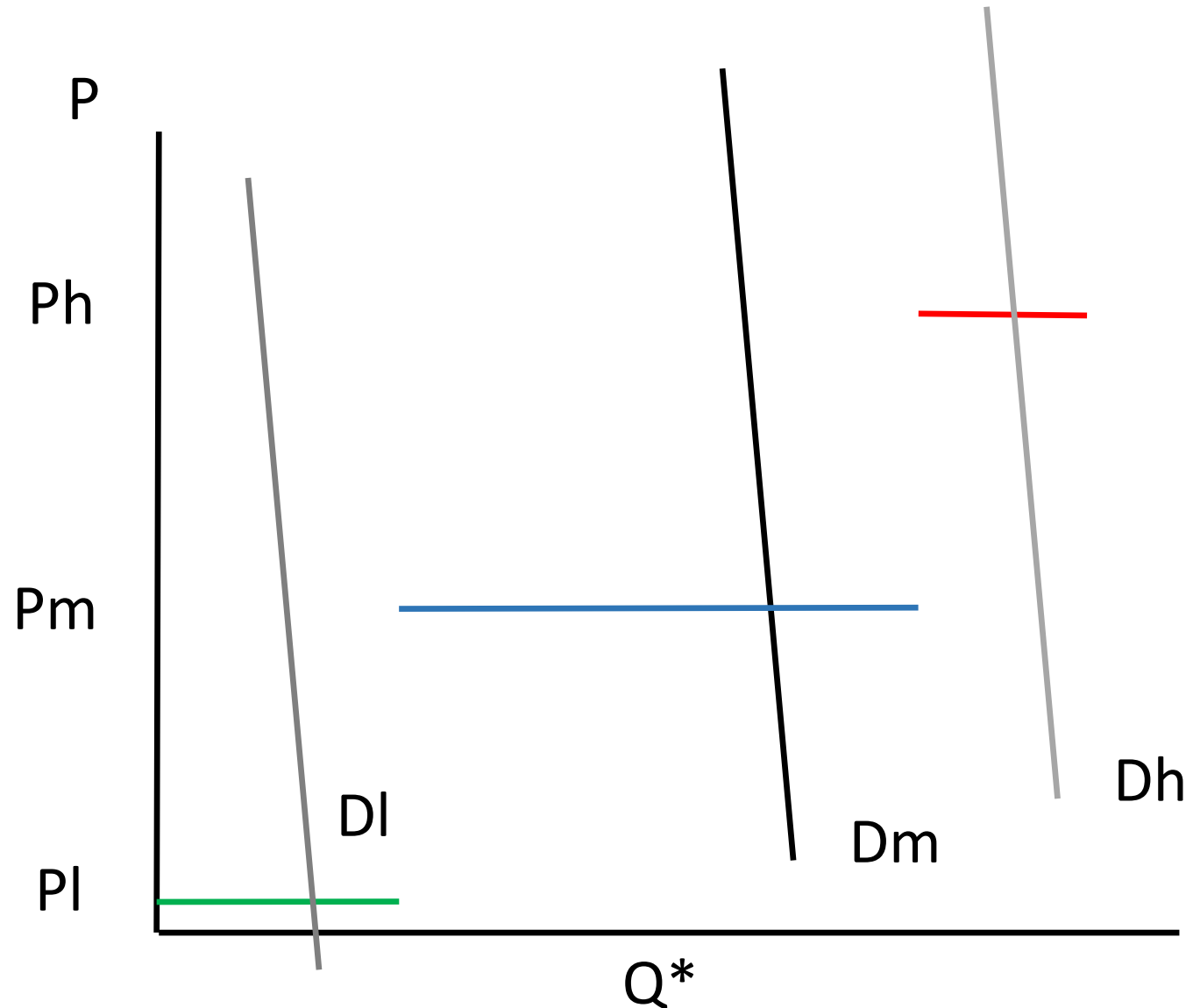
- For each period:
  - Which firm had the “marginal” generator?
  - Does anyone wish they had bid differently?
- Each team can “view market results”
  - Go to "display files" > "genco display.csv"
  - Copy your team's total profits into Google sheet




- Base game 2
  - New demand shocks
  - Submit bids
    - **Submit bids for the first two periods**
    - I will then compute the equilibrium and show you the results.
    - You will then submit bids for the last two periods and we will discuss.
- Try to increase profits relative to game 1.

- Base game 2 (cont)
  - Whose profits went up?
  - What was your strategy?
  - Now that you see the price, do you wish you bid differently?

# Market Power

# Consider a market with three types of technology



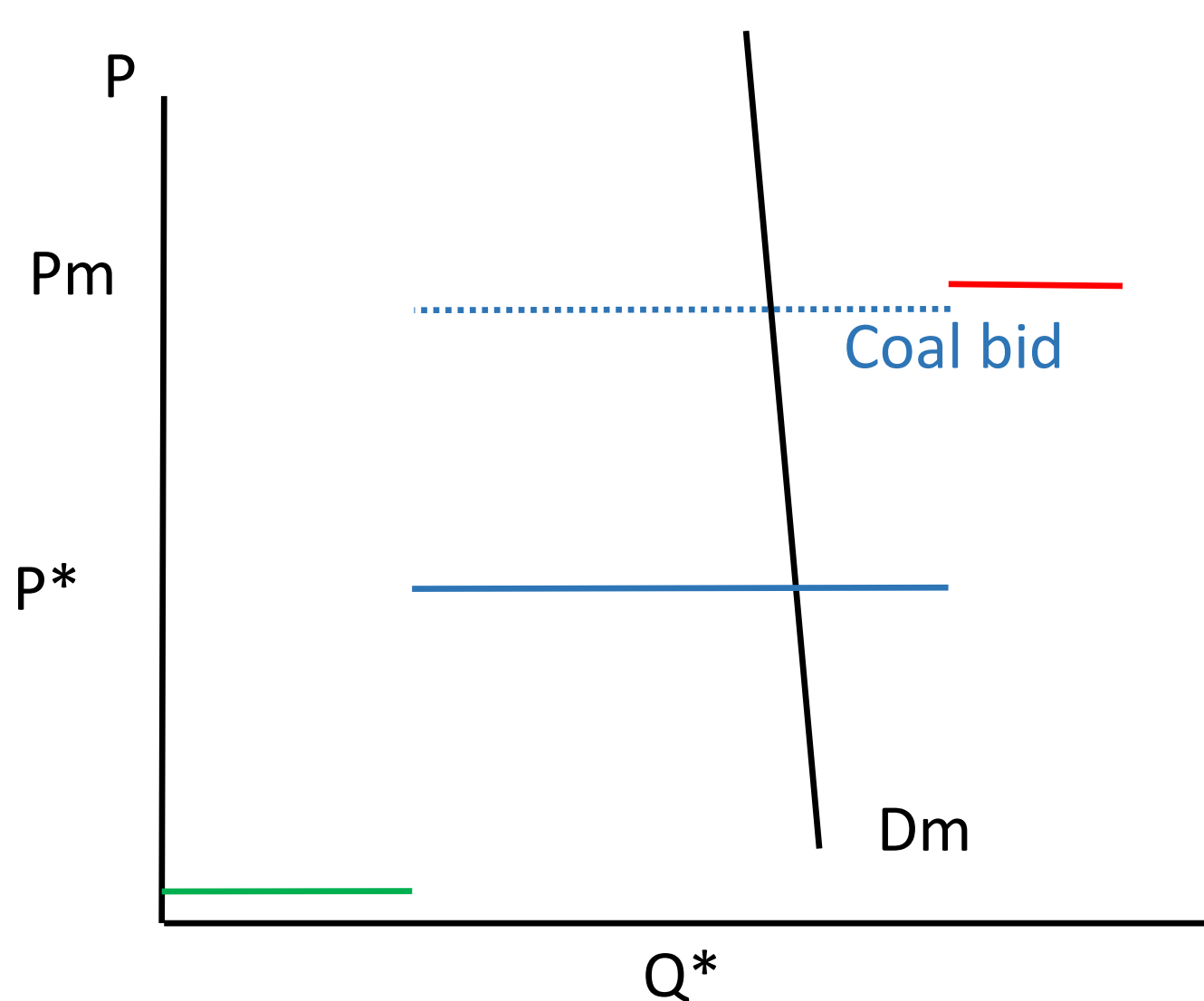
<u>Marginal costs</u>	
Gas	
Coal	
Renewable	




## How it's supposed to work:

- Plants bid their true MC into the auction
- Cheapest MC plants produce.
- Price to customers is the MC of the last producer



# What if coal knows its going to be a mild (m) day?

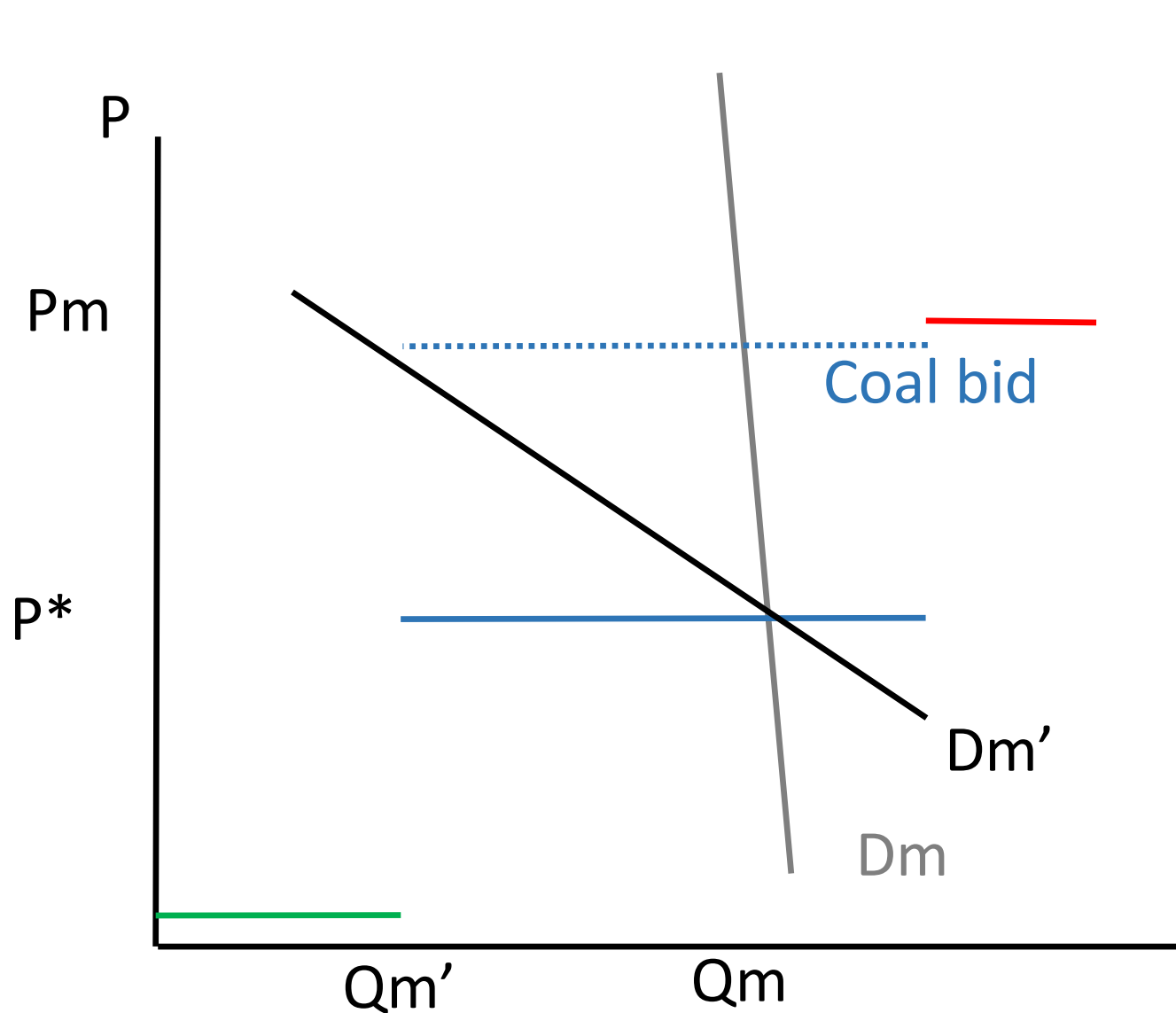


<u>Marginal costs</u>	
Gas	
Coal	
Renewable	

Imagine coal bids right below gas's MC

- Still cheaper than gas.
- Since demand is very inelastic, little change in  $Q$
- But the price is **much** higher

# Incentive to raise price related to demand elasticity



Marginal costs

Gas 

Coal 

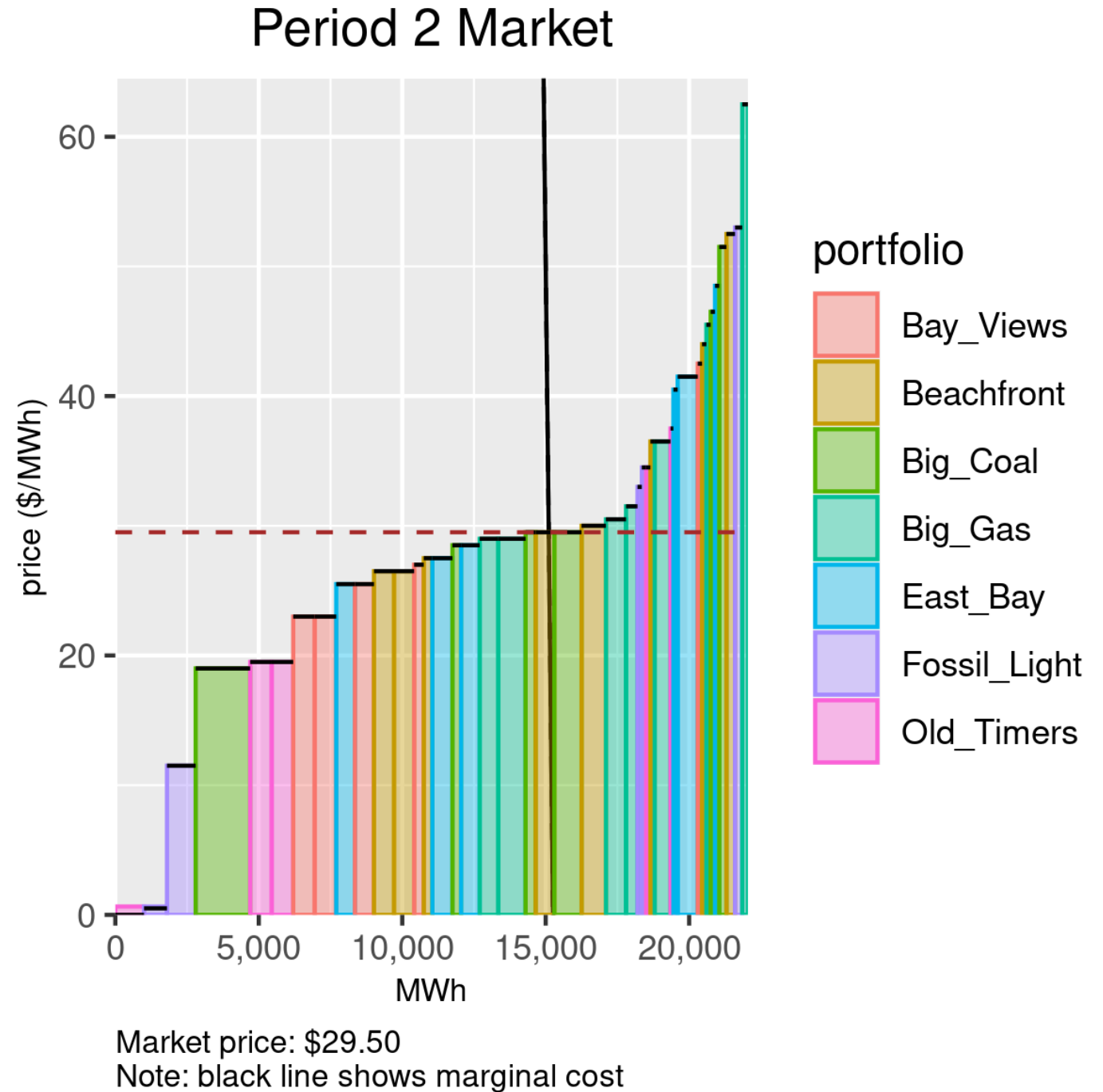
Renewable 

Imagine demand were much more responsive to P

- Raising price now significantly reduces Q.
- Therefore the gains to raising price are much smaller.
- Note many firms own both types of plants....

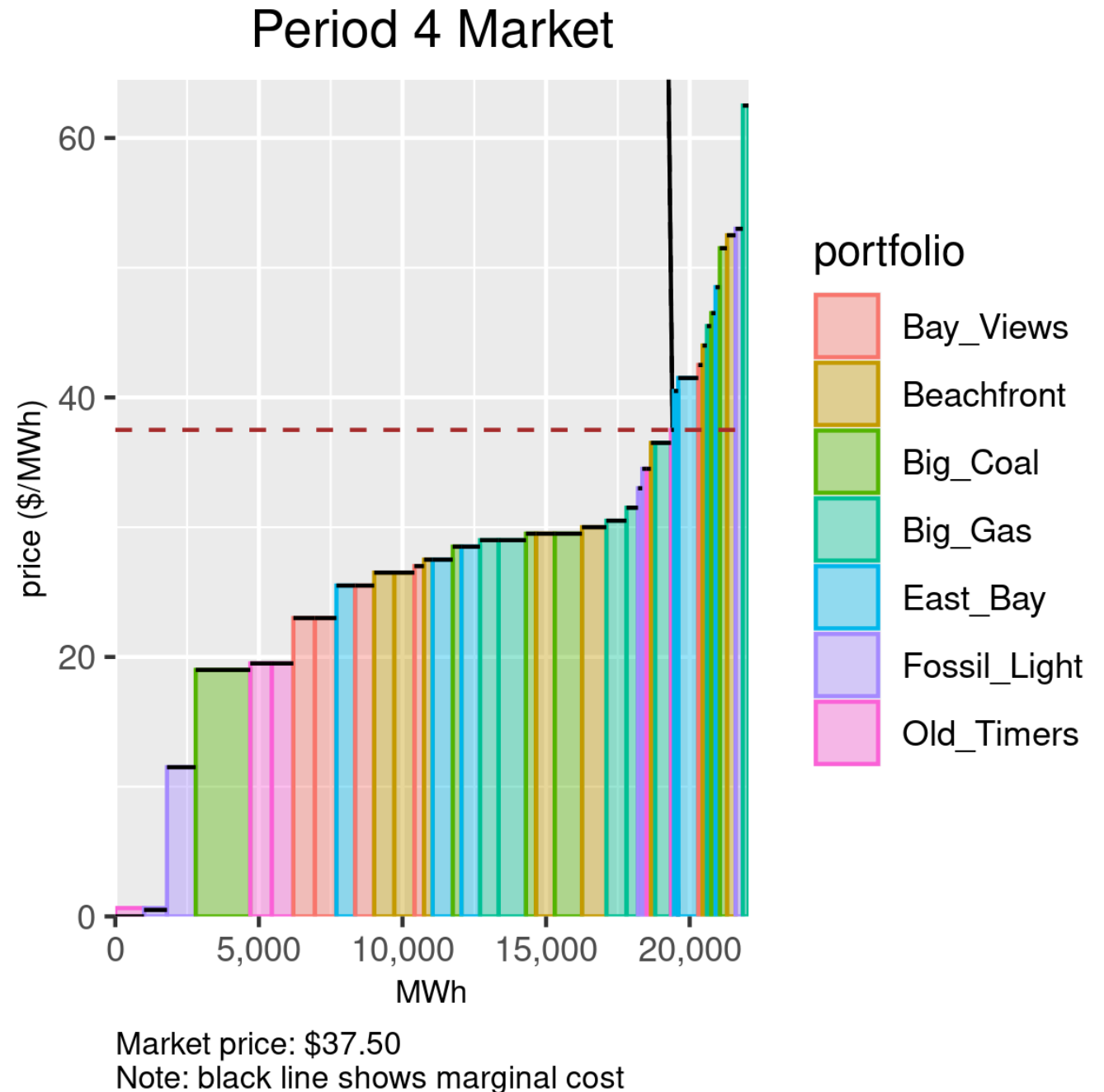
Prices are determined by the *marginal* bidder

- Which plants had a bid of \$29.50?
- What would happen if they unilaterally raised their bids?



# What about Period 4?

- Which plants had a bid of \$37.50?
- What would happen if they unilaterally raised their bids?



# Base game 3

- Let's try one more breakout session
- Review what you did last time (base game 2)
  - What was your plan? Did it work as expected?
- Enter your profits from each game in the spreadsheet
- Submit new bids for base game 3, for all 4 periods
- If time: “congestion” limits trade btw north and south.
  - How will that affect your company? (south generally sends power north)

For discussion, tell me:

1. What did you try? Did it work as expected?
2. Which of your plants is the least valuable?
3. Are there any plants you wish you could close? IE do you have plants whose fixed costs exceed their operating profits?

# Carbon Taxes

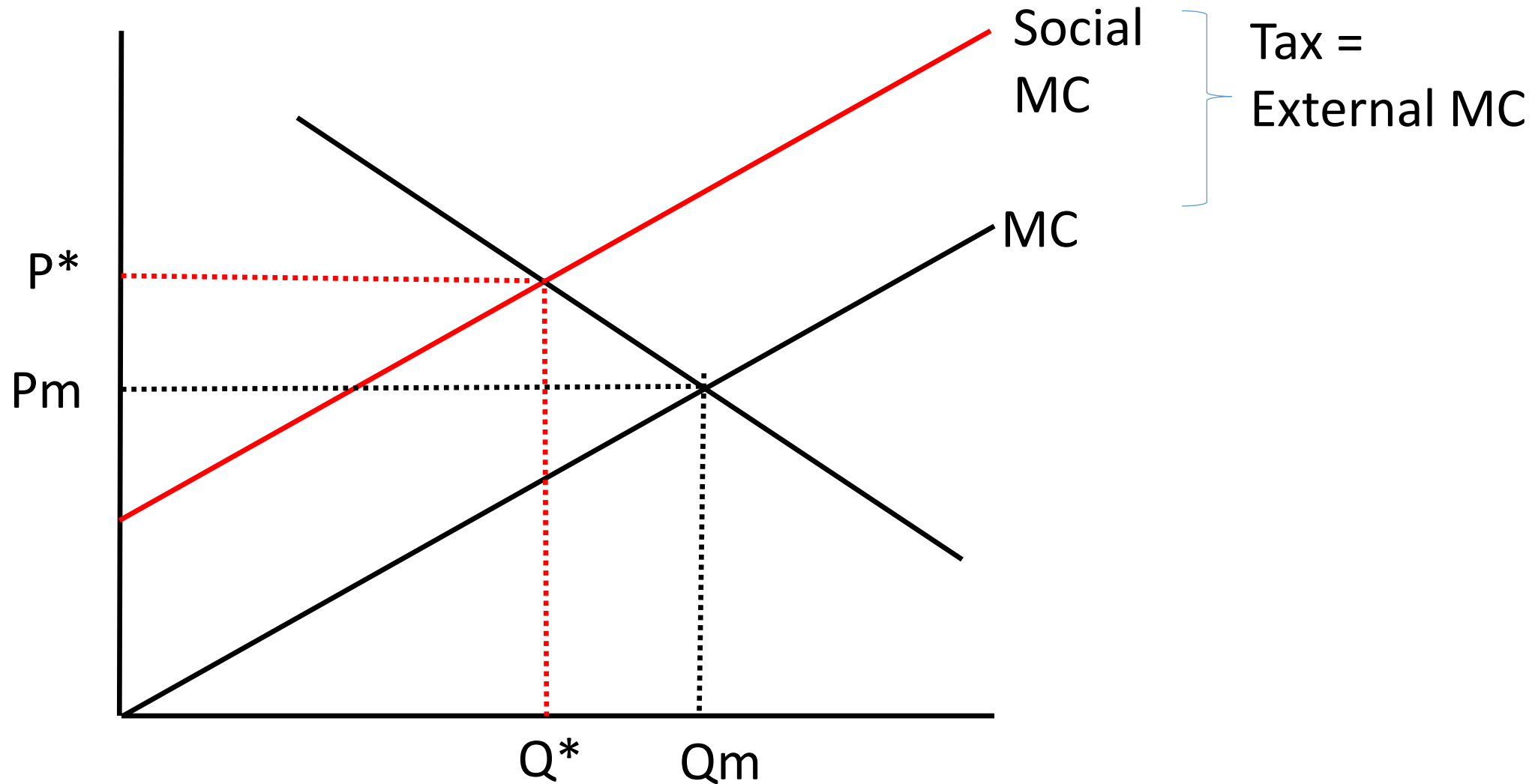
# How would a carbon tax change this market?



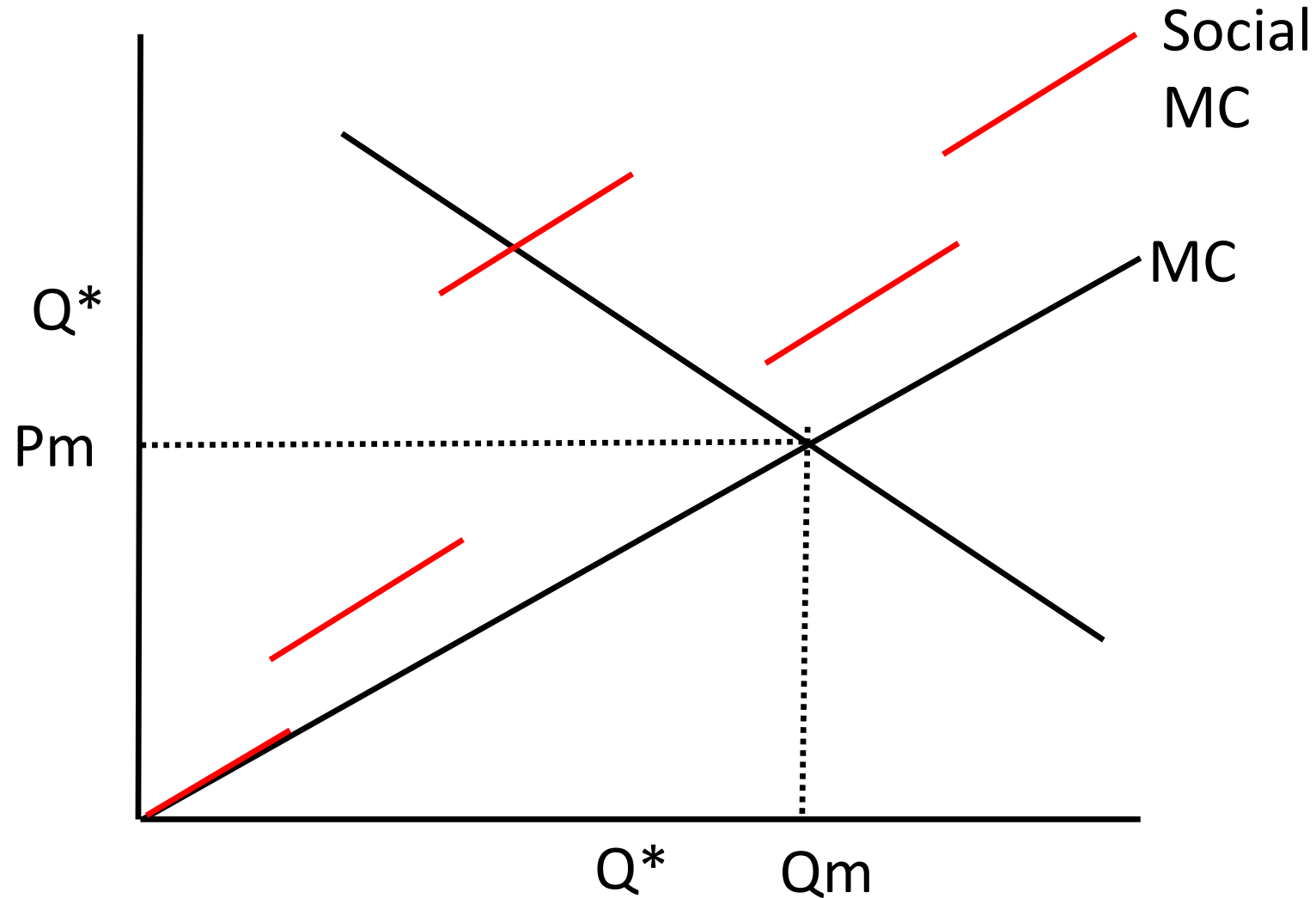
Q1: What are the channels through which a tax on carbon emissions from electric generators reduces carbon emissions?



In markets with *constant* externalities,  
primary channel is through demand response

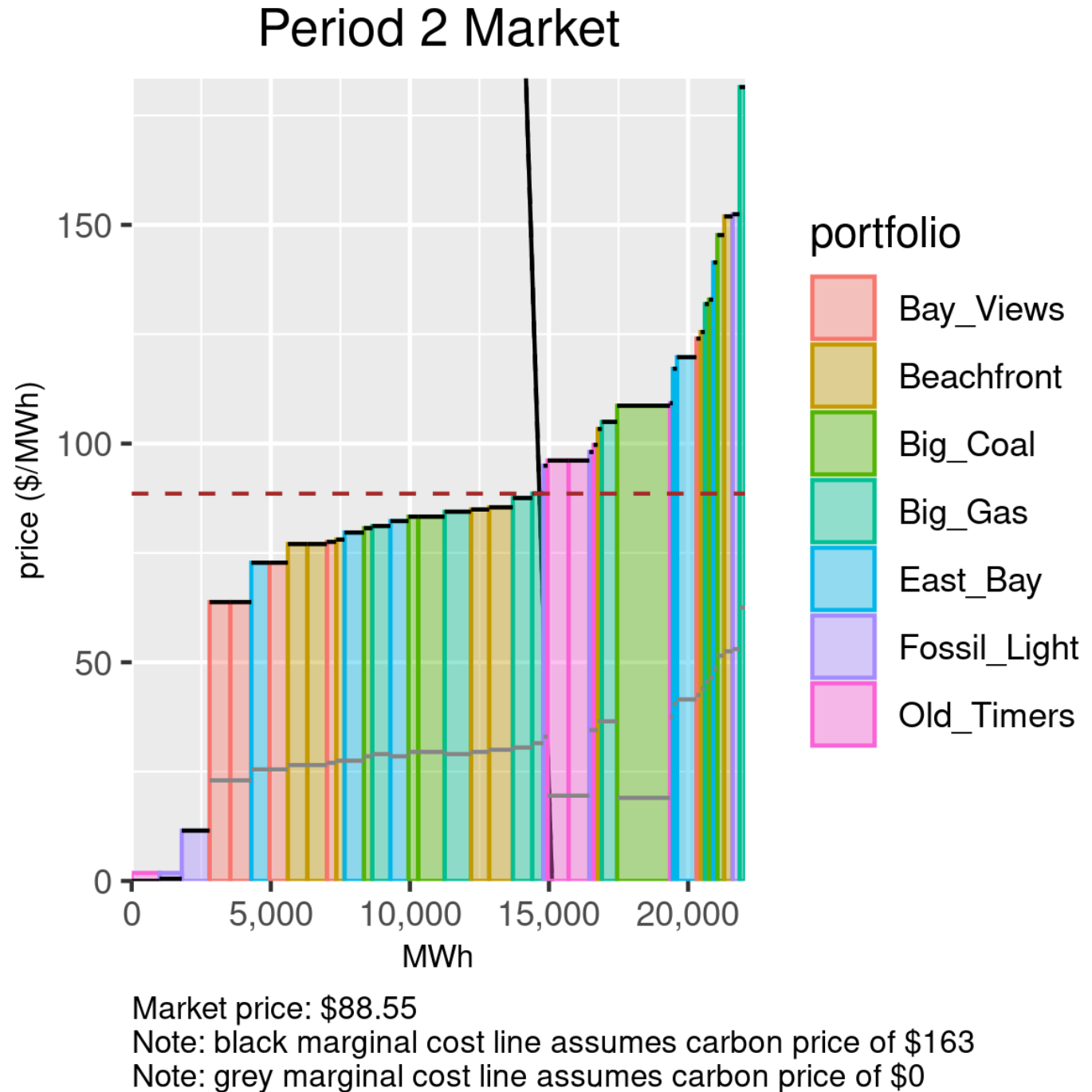


In markets with heterogeneous externalities,  
can reorder production to make it cleaner



In the simulated carbon tax game, I recomputed game 1 with a \$163/ton carbon tax

- Can see that the bids change, but the *ordering* also changes
- If a coal plant doesn't produce as many hours, is it worth it incurring large fixed costs?



# Carbon Taxes

Q2: Which channel do you think will be most important (ie will result in the biggest drop in emissions)? Why?

# Games

- Game 6 – Carbon tax
  - Demand shocks reset to game 1
  - Uniform auction, no congestion
  - Now there will be a \$163/ ton carbon tax
    - Based on the carbon content of each generator
  - This should be reflected in your new pre-filled in marginal costs
  - Recompute all 4 auctions
  - What happened to each teams profits?
    - Did anyone's profits go up? Down?
  - Are there any plants you wish you could close now?

# Carbon Taxes

Q3: We know that a carbon tax will raise electricity prices. Who is most hurt by this tax, producers or consumers?

Why is that?

UNUSED THIS YEAR

# Games

- Base game 3 – Market power
  - Demand shocks reset to game 1
  - Go back and see which plant was on the margin during each period
  - Have teams set the bid for that plant in that period equal to something really high (999)
  - Recompute all 4 auctions
  - What happened to each teams profits?
    - Did anyone's profits go up? Down?
  - What does this tell you about market power in electricity markets?



# Games

- Game 4 – Pay as bid
  - Demand shocks reset to game 1
  - Now you will be paid your bid (rather than the highest bid)
- Recompute all 4 auctions
- What was your strategy?
- What happened to each teams profits?
  - Did anyone's profits go up? Down?

# Pay as bid auction

- Every generator submits a bid
- Cheapest bidders dispatched until supply = demand
- Dispatched plants get paid the price they bid at.
- If bid = MC, no profits

