



Carbon Game Handout

Background: You are a small electric utility having a coal plant and a renewable energy plant. Due to a CO₂ cap policy in place, for each unit of energy you generate using coal, you must have an accompanying CO₂ credit, to offset the impact of its emissions.

The following table lists your assets and their specifications (MWy=megawatt-year, i.e. the amount of energy generated in a year by a 1 MW power source running continuously throughout the year):

Asset Type	Capacity (MW)*	Generation cost (\$/MWy)	CO ₂ credits required per unit of energy generated (#/MWy)	Sale price of energy (\$/MWy)
 Coal plant	200	10	1	30
 Renewable energy plant	100	20	0	30

* Assume you can run each plant at full capacity continuously throughout the year, e.g. the coal plant can generate 200 MW-years of energy in one year.

Recent demand has been as follows (the game begins in year 9):

Year	1	2	3	4	5	6	7	8
Load (MWy)	253	249	246	251	250	253	246	244

Game play: The game consists of several rounds, each representing one year. Each round proceeds as follows:

1. Players buy CO₂ credits via auction (described below).
2. Electricity demand (aka “load”) for the round is determined and apportioned to each player. (Note: players will have access to “historical” load data, but will not know in advance what the load is going to be when they purchase the CO₂ credits.)
3. Fulfillment of each player’s load is determined in a profit-maximizing manner factoring in how many CO₂ credits the player has and the plant capacities. (See example below.)
4. Profit (or loss) for each player is calculated.

Objective: The player with the most money (sum of profits from each year) at the end of the last round wins. The only decisions players make is how many credits to buy in the auction in each round.

Profit = Revenue from selling energy – costs to generate energy – CO₂ credit costs
 = \$30 * energy sold - \$10 * coal energy generated - \$20 * renewable energy generated
 – auction price * credits purchased

Appendix A

CO₂ credit auction

In each round, CO₂ credits are auctioned off.

- There are a limited number of credits in each round.
- The price per credit starts at an initial price.
- The auction proceeds as follows:
 - Each player bids on how many credits he/she would like to purchase at the current price.
 - If the total number of credits being bid for does not exceed the amount available, then each player receives his/her bid amount at the current auction price, and the auction ends.
 - Otherwise, the price increases and players submit new bids for how many credits they would like at the new price.¹

Example of load fulfillment

Suppose player X purchases 150 credits at \$8 per credit and that her share of the load turns out to be 200 MWy. Her coal capacity is 200, but because she only has 150 credits, she can only run 150 MWy of it. The remaining 50 MWy must come from the renewable plant. Had the load turned out to be 100 MWy, then she would have met it with 100 MWy of coal, not using 50 of the credits.

Pre-game exercises

1. Assume the demand will be 250 MWy. How many credits would you bid for if the auction price was:
a. \$5 b. \$10 c. \$15 d. \$20 e. \$21
2. Does your answer to question #1 change depending on the assumed demand? If so, how (i.e. repeat question #1 for a different demand if it leads to different bid amounts)?
3. This game is a vast oversimplification of the true system. What real factors might be brought into the game next? How?
4. In its current form, the game rewards players who aim to maximize profit. How could it be modified to reward some combination of profit maximization and emissions minimization?
5. If you could increase the capacity of one of your plants, how much would you spend to do so? (To answer this, make assumptions about demand, auction price and required payback period.)
6. Create a simple spreadsheet calculator to confirm any strategy you devise based on questions 1 and 2. You can use it during the actual game. A team that does well early on has a better chance of winning the game.

¹ If all players bid 0 in a given round, the bids for the previous round are scaled down proportionally so that the total is less than or equal to the available amount, and the credits are sold at the price from the previous round.