

## Economics Games - The Carbon Game

Welcome to the carbon game

### The Tutorial

First, start by playing the tutorial for about 30 minutes (click on « the carbon game tutorial » here: <https://lud.io/environmental-economics>). It is only intended to introduce you to the structure and interface of the game, do not spend too much time thinking about your best strategies (and anyway the robots of the tutorial are not particularly smart competitors).

Just make sure that you have tried a “volume based strategy” (producing a lot and selling at a very low price) before the real game: This strategy does not work here.

### The Real Game

You are competing with 3 other firms on several separate markets subject to different environmental policies. Each firm is active on each market.

#### Demand

Demand is identical from one market to another and is proportional to the demand of the tutorial. If every firm chooses the same price, then each firm sells about:

Price	30	40	50	60	70	80	90	100	110
Sales/firm	1389	1280	1183	1096	1016	941	869	804	741

Price	120	130	140	150	160	170	180	190	200
Sales/firm	680	622	566	512	461	409	361	313	267

Of course, your sales will depend on the price that is set by your competitors, which in practice will not be equal to yours, but this table can still be helpful to help you determine how much potential customers are willing to pay for the products.

## Costs

The technos are the same as in the tutorial.

Technology	Techno specific fixed cost (by round), $F_T$	Unit production cost, $c_1$	Unit distribution cost, $c_2$	CO2 emissions (tons) per good produced
Techno1	€0	€10	€30	0.11
Techno2	€0	€20	€18	0.11
Techno1Eco	€1000	€11	€33	0.09
Techno2Eco	€1000	€22	€20	0.09

Note that a new techno, Techno1SuperEco will appear at some point in the game.

Technology	Techno specific fixed cost (by round), $F_T$	Unit production cost, $c_1$	Unit distribution cost, $c_2$	CO2 emissions (tons) per good produced
Techno1SuperEco	€2,000	€13	€39	0.07

Also, as in the tutorial, you will have to pay about  $F = 8000€$  of fixed cost by market **by round**. You can avoid these costs only if you decide to leave a market (i.e. if you produce 0 goods)

Then, during the first 4 years, your shareholders will limit your "investment" expenses,  $F_T + c_1 Q_p$ , to a maximum of 30000€ per round and market. If you select more than that, the game will ask you to play again (Be careful, you have probably seen during the tutorial that it is very difficult to sell 1400 goods in one round: Consequently, this investment constraint is not very strong...).

## Scenario

The scenario will be detailed on screens before the start of the years. **You will also find all of this info in a synthetic table at the end of this document.**

### Year 1-3

In year 1, there is no environmental policy on markets: They will appear in year 2.

In Year 2 and 3:

- There are taxes on markets 2 and 3: 50€/ton on market 2 and 250€/ton on market 3.
- There is an additional fixed cost of 20000€/round on market 4 (in addition to the 'usual' fixed cost of  $F = 8000\text{€/round}$ ).
- Nothing special on market 1. Market 5 opens in year 3 (nothing special on this market either).

The second part of the game is more elaborate and **scores will be reset at the beginning of year 4:**

### Years 4-8

Here is what will happen during the years of the "second" game (years 4 – 8). **Note that in order to make the best possible decisions in year 4, you should start by reading the whole scenario.**

#### 1- Only Taxes on market 6

All along the game, market 6 is subject to taxes based on CO<sub>2</sub> emissions: 250€/ton in year 4, 400€/ton in year 5, 550€/ton in year 6, 700€/ton in year 7, 850€/ton in year 8.

#### 2- Emissions permits on markets 1 to 5, in year 5 and after

In year 5 and after, emissions on each of the markets from 1 to 5, are regulated by emission permits. These permits are constraining: When you select your production, if you do not have enough permits to produce what you want to produce, then you have to reduce your production.

Pay attention to the difference between emissions over a round and emission over the year. If you want to produce 1000 goods (by round) with Techno1, this means that you will emit  $1000 \cdot 0.11 = 110$  tons of CO<sub>2</sub> per round, which is equivalent to 220 tons per year. In order to be able to do so, you must have 220 permits at the start of the year!

#### 3- Permit Allocations on markets 1 to 5, in year 5 and after

Some of the permit allocations depend on what has happened before, so you should know this before playing year 4!

On all markets except market 1, there is no banking: If you do not use some of your permits during one year, these permits are lost. On market 1, however, banking is allowed: Permits that you do not use during one year, will be kept for the year after (this is automatically managed by the game).

On **market 3**, from year 5 until the end of the game, at the start of each year, you will be granted, for free, a number of permits equal to 80% of your emissions of the previous year (on this market).

On each of the other **markets, 1-2-4-5**, the **total** number of permits to be shared between the 4 firms of the market at the start of each year, is fixed but decreasing from one year to another (600 permits per market in year 5, 480 in year 6, 384 in year 7, 307 in year 8).

On **markets 1 and 2**, each firm will receive, for free, the same number of permits. For example, in year 6, each firm will receive  $480/4 = 120$  permits (remember that this is the number of permits for the whole year → with 120 permits, you will be able to emit 60 tons of CO<sub>2</sub> per round). Also remember that on market 1, in addition to that, you will also keep permits that you did not use the previous year.

On **market 5**, 30% of the permits to be granted, are distributed for free and equally distributed. The remaining 70% will be sold in a uniform auction (look at the “auctions.pdf” document, that explains how the auction will work, <https://lud.io/resources/site/manual/auctions.pdf> ). In years 6, 7 and 8, you will also be able to make offers to sell during these auctions, if you prefer to sell some of the permits that you receive for free.

On **market 4**, the permits are granted for free, in proportion to the sales of the firms the previous year (on this market. Here sales are accounted on the basis of the number of goods sold, not on the revenue made).

#### 4- What happens in year 4?

In year 4, there is a 250€/ton tax over CO<sub>2</sub> emissions on markets 3, 4 and 6. Nothing on markets 1 and 5.

On market 2, you can emit 200 tons over the **year** (100 tons per round) for free. If you emit more than 200 tons, you will have to pay a tax of 250€/ton for each ton **above** 200 tons (i.e., if you emit 232 tons, you will have to pay  $32 * 250$  €). If you emit less than 200 tons, you will receive a subsidy of 250€/ton for each ton **below** 200 tons (i.e., if you emit 184 tons, you will receive  $(200-184) * 250$  €).

#### 5- A New technology, auctioned in year 5, and to be used from year 6.

A new technology, Techno1SuperEco, will be available to 2 of the 4 firms in year 6. You will find the related costs of Techno1SuperEco in the documents. As you can see, this technology is much more expensive in terms of operational expenses, but also emits much less CO<sub>2</sub>

In order to be able to use this technology, on all the markets, and in years 6, 7 and 8, you must get one of the two licences that will be auctioned, once, in the start of year 5 (at the same time as the permits for market 5). This auction has a special rule: 1-A bid below 20 000€ will be considered invalid. 2 - The two firms with the highest bids will each receive a licence and pay the second highest bid.

Be careful: this technology is auctioned at the start of year 5 but can only be used in year 6!

## Login

Your instructor will give you your login, passwords and the address of the login page.

You will be able to change your password and your login, along with your team name, once connected (please note that your login and your team name are not the same).

## SCENARIO

	Market 1	Market 2	Market 3	Market 4	Market 5	Market 6
Year 1	Open, nothing	Open, nothing	Open, nothing	Open, nothing	CLOSED	CLOSED
Year 2	Open, nothing	tax, 50€/ton	tax, 250€/ton	additional fixed cost: 20000€/rnd	CLOSED	CLOSED
Year 3	Open, nothing	tax, 50€/ton	tax, 250€/ton	additional fixed cost: 20000€/rnd	Open, nothing	CLOSED
Scores are reset						
Year 4	Open, nothing	emission rights: 200 tons per year per team (100t/rnd). Above that, tax, 250€ per ton. Below that, subsidy, 250€ per ton.	tax, 250€/ton	tax, 250€/ton	Open, Nothing	tax, 250€/ton
<p>Start Year 5: Auction for licences for Techno1SuperEco. Techno will be available on all markets, year 6 and after. 2 winners among the 4 firms. Reserve (min) Price 20000€. The 2 winners pay the second highest offer.</p>						

Year 5	permits: 600 tons per year (300t/rnd) shared between the 4 firms, equally distributed. Impossible to emit more than that. What is not used is kept for later (with banking).	permits: 600 tons per year (300t/rnd) for the 4 firms, equally distributed. Impossible to emit more than that. What is not used is not kept for later (no banking).	permits: each firm gets permits corresponding to 80% of its emissions for year 4 (on this market) . Impossible to emit more than that. What is not used is not kept for later (no banking).	permits: 600 tons per year (300t/rnd) for the 4 firms, distributed in proportion to the sales (units) of year 4 on that market. Impossible to emit more than that. No banking.	permits: 600 tons per Year (300t/rnd) for the 4 firms. 30% are allocated for free and equally distributed.The remaining 70% are sold through auctions. Impossible to emit more than that. No banking	tax, 400€/ton
Year 6	permits: 480 (-20% / Year 5), same allocation mode	permits: 480 (-20% / Year 5), same allocation mode	permits: 80% of the emissions of Year 5.	permits: 480 tons per year, distributed in proportion to the sales (units) of year 5 on that market.	permits: 480 (-20% / Year 5), same allocation mode. Sell offers are now also possible during the auctions.	tax, 550€/ton
Year 7	permits: 384 (-20% / Year 6), same allocation mode	permits: 384 (-20% / Year 6), same allocation mode	permits: 80% of the emissions of Year 6.	permits: 384 (-20% / Year 6) tons distributed according to sales of year 6.	permits: 384 (-20% / Year 6), same allocation mode	tax, 700€/ton
Year 8	permits: 307 (-20% / Year 7), same allocation mode	permits: 307 (-20% / Year 7), same allocation mode	permits: 80% of the emissions of Year 7.	permits: 307 (-20% / Year 7) tons distributed according to sales of year 7.	permits: 307 (-20% / Year 7), same allocation mode	tax, 850€/ton