

Week 10 Notes: Performance standard versus cap-and-trade

ENVS 30, Fall 2025 - Anna Pede

These notes will guide you in understanding the difference between a uniform performance standard and a cap-and-trade system. In this example, both systems aim to reduce (abate) CO2 emissions. This example demonstrates how the goal of reducing CO2 emissions can be achieved through different policy instruments, but each imposes a different total abatement cost.

Assume California has only two industry emitters of CO2. Consider the units (q) are tons of CO2. Each industry has the following marginal cost of CO2 abatement:

$$MC_1 = 30 + 3q_1 \quad (1)$$

$$MC_2 = 30 + 6q_2 \quad (2)$$

$$(3)$$

California's government is trying to determine the optimal CO2 abatement policy. The following marginal benefits of CO2 abatement were estimated:

$$MB = 90 - q \quad (4)$$

Given that the marginal abatement costs and benefits are known, California's government can calculate the optimal abatement level q^* for the state. To do that, first we need to find the **social marginal abatement cost curve** - which represents the total cost of CO2 abatement in the state across all industries. For this reason, we sum across each industry contribution to abatement - q_1 and q_2 :

$$q = q_1 + q_2 \quad (5)$$

$$q = \frac{p - 30}{3} + \frac{p - 30}{6} \quad (6)$$

$$q = \frac{2p - 60 + p - 30}{6} \quad (7)$$

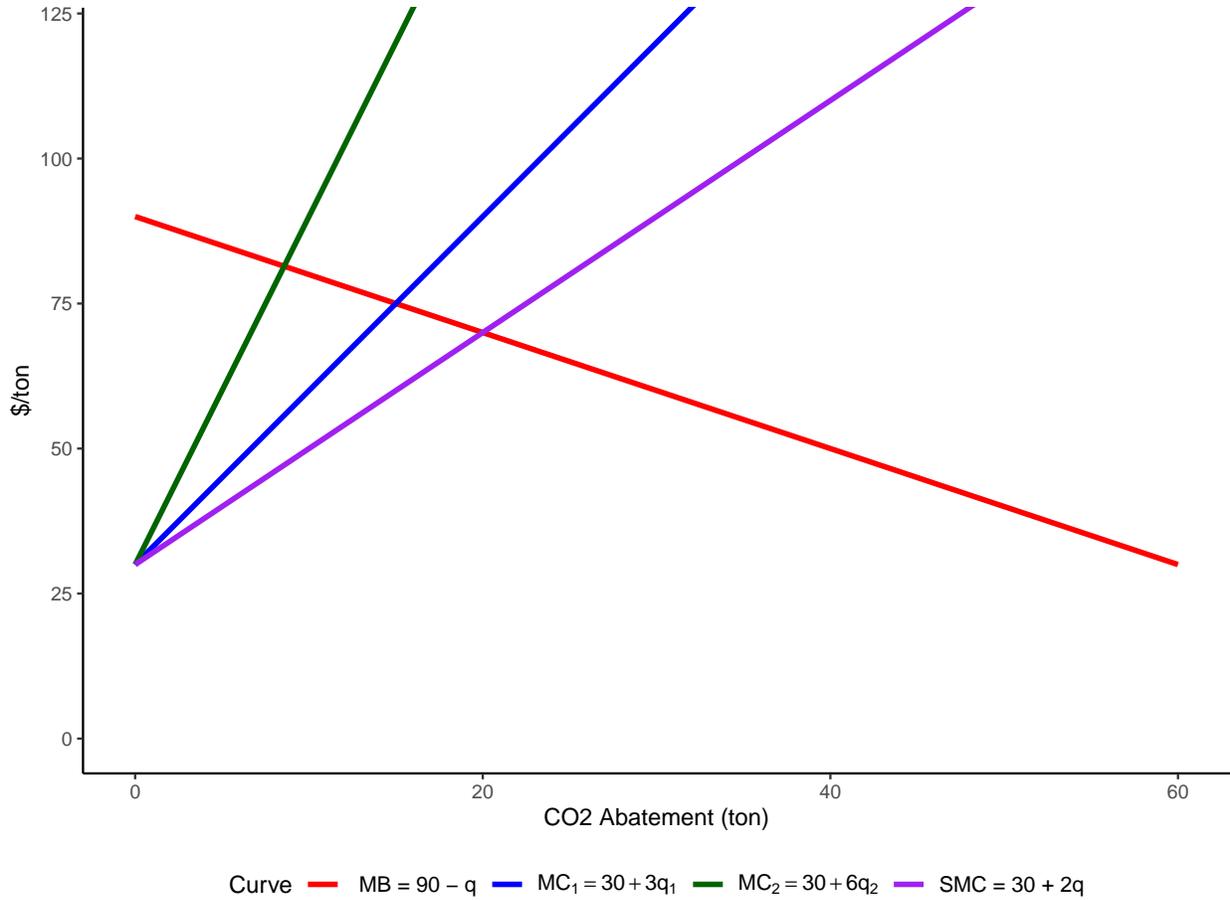
$$q = \frac{3p - 90}{6} \quad (8)$$

$$6q = 3p - 90 \quad (9)$$

$$p = \frac{90 + 6q}{3} \quad (10)$$

$$p = 30 + 2q \quad (11)$$

We can plot the industry-level marginal abatement cost curves, the social marginal abatement cost curve and the marginal benefit curve of abatement:



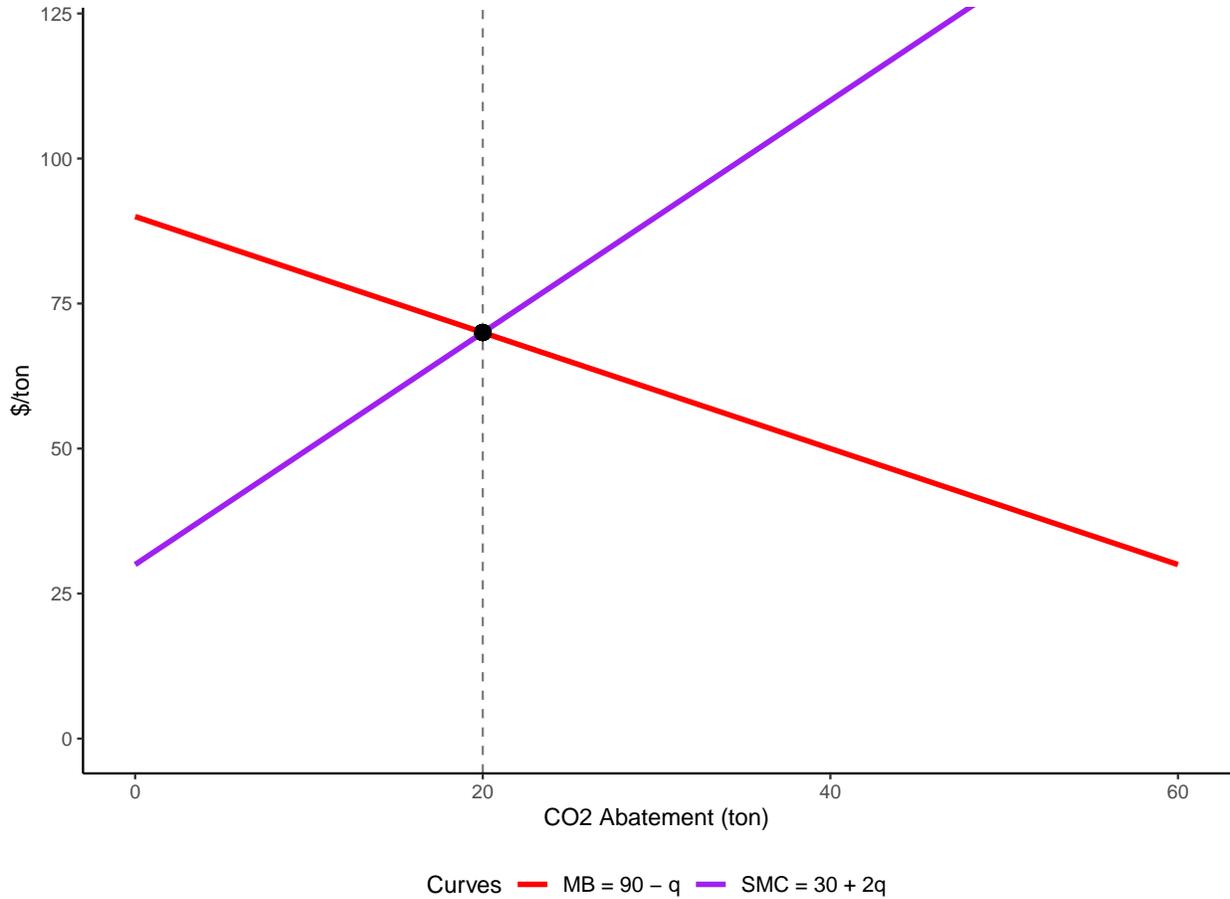
Now that we found the SMC, we can calculate the optimal CO2 abatement q^* (emissions reduction) for California:

$$SMC = MB \tag{12}$$

$$30 + 2q = 90 - q \tag{13}$$

$$q^* = 20 \tag{14}$$

We can graphically represent the optimal abatement as:



Given that California should have 20 units of abatement, this can be achieved by the uniform standard or through a cap-and-trade system. Now, I will show the difference between the two policies.

Uniform Performance Standard

Suppose a uniform performance standard will require each industry to contribute with half of the optimal abatement $q^* = 20$. Hence, each industry will have to abate:

$$q_1 = q_2 = 10 \tag{15}$$

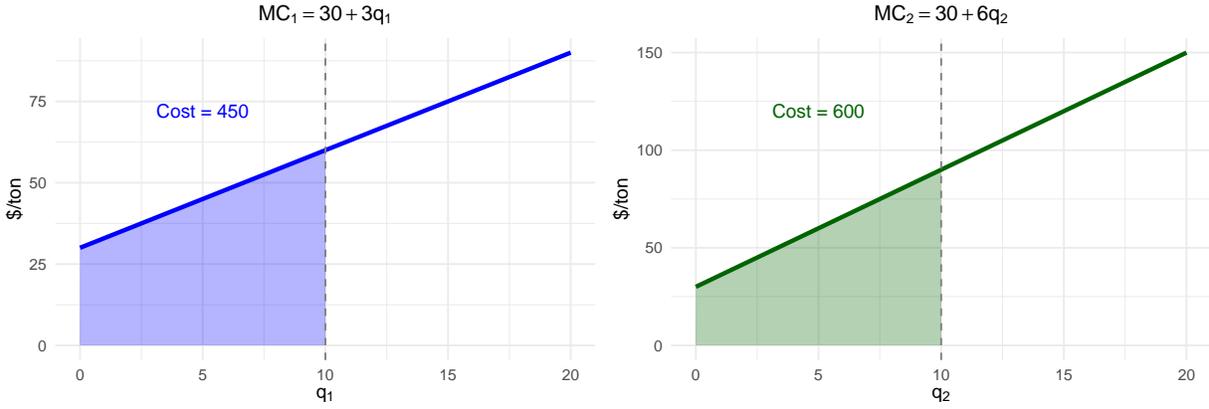
To calculate the cost of this policy, we simply need to find the area under each MC curve. This will result in:

$$TC_u = 450 + 600 \tag{16}$$

$$= 1050 \tag{17}$$

Graphically representing the cost of a uniform standard:

Marginal Cost Curves and costs of abating 10 units each



Cap-and-trade

Can the $q^* = 20$ units of abatement be achieved at a lower cost? Let's find the most cost-effective way to achieve 20 units of abatement. That is, how much each industry should contribute to abatement (q_1 and q_2) to minimize the total abatement cost.

That can be found by combining the facts that (i) the two industries are the only ones doing the abatement - $q_1 + q_2 = 20$; and (ii) that, by the equimarginal principle, the proportion of each contribution is given by $MC_1 = MC_2$. Therefore:

$$MC_1 = MC_2 \tag{18}$$

$$30 + 3q_1 = 30 + 6q_2 \tag{19}$$

$$q_1 = 2q_2 \tag{20}$$

$$\tag{21}$$

Since $q_1 + q_2 = 20$:

$$q_1 + q_2 = 20 \tag{22}$$

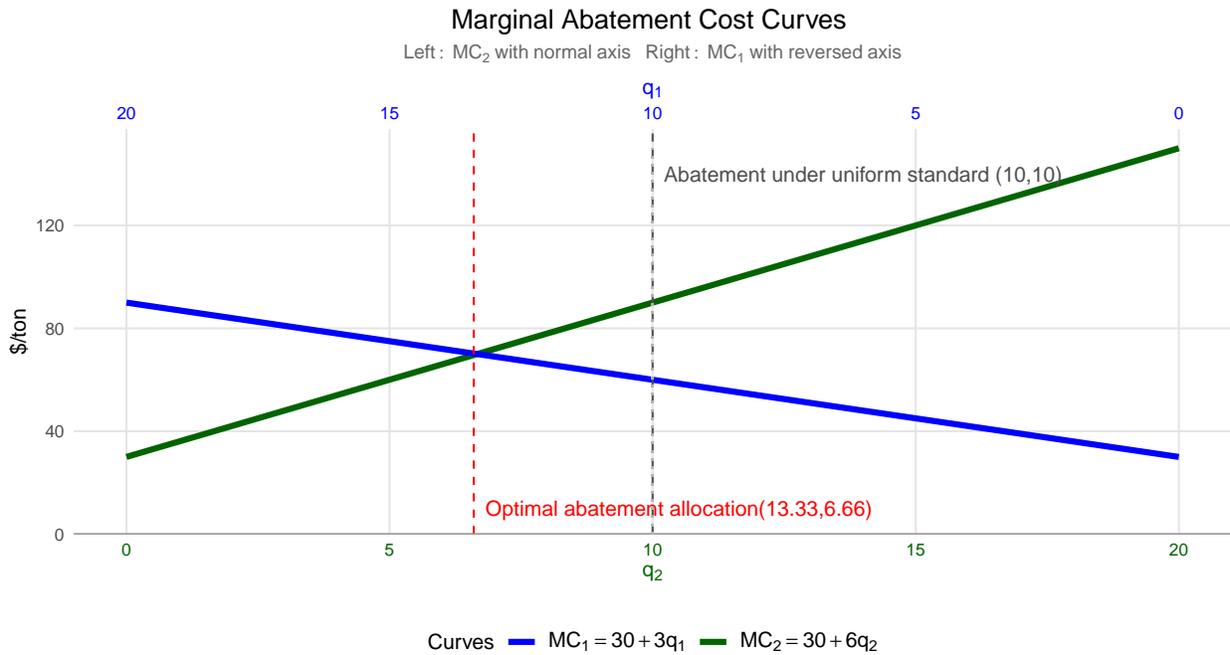
$$2q_2 + q_2 = 20 \tag{23}$$

$$q_2 = \frac{20}{3} = 6.666 \tag{24}$$

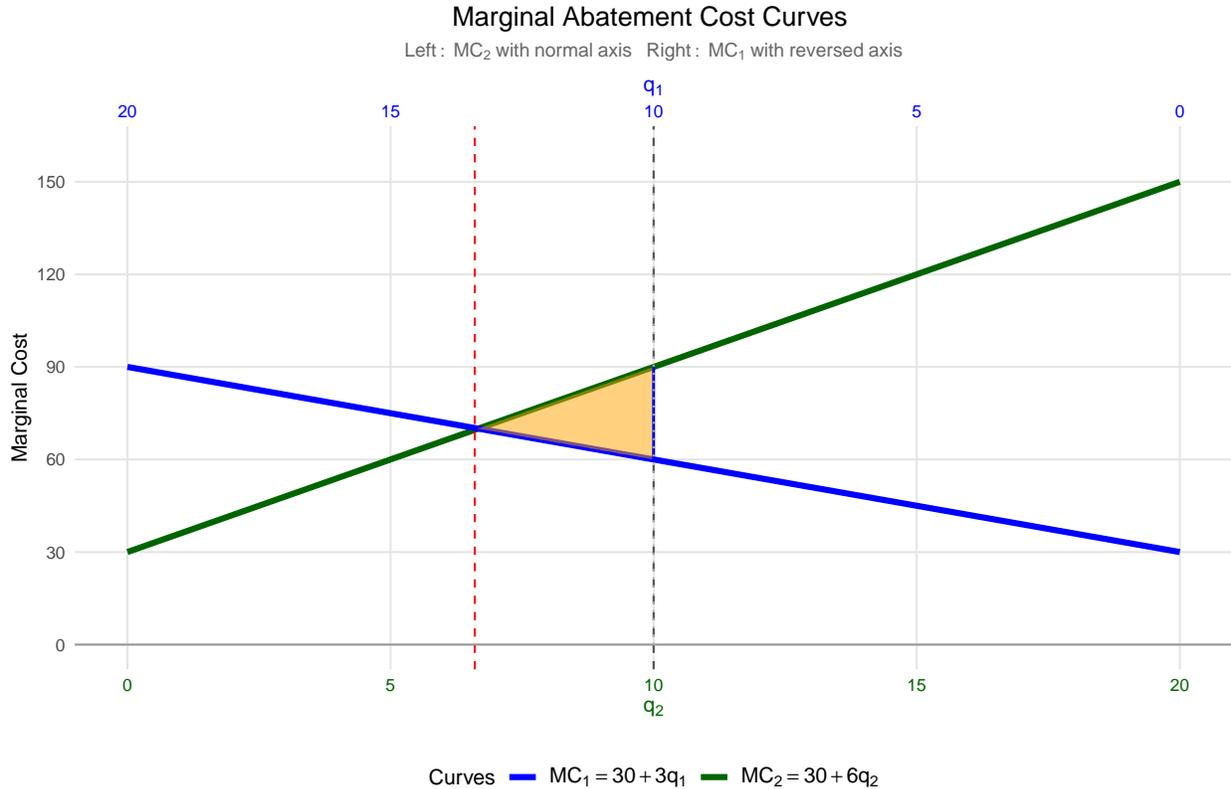
$$q_1 = \frac{40}{3} = 13.333 \tag{25}$$

$$\tag{26}$$

The graph below shows the optimal abatement allocation (13.33, 6.66) versus the performance standard (10, 10). The graph plots the marginal cost curves. The x-axis represents how the 20 units of optimal abatement are allocated between industry 1 and industry 2.



Note the orange area represented below. That area represents a dead weight loss arising from the uniform standard allocation (10,10). In other words, it is the excess cost paid for the total abatement of 20 units at the (10,10) allocation relative to the allocation (13.33,6.66). Note that between $q_2 = 6.66$ and $q_2 = 10$ the MC curve for industry 2 is above the MC curve for industry 1. Hence, it is more cost-effective for Industry 1 to undertake those abatement units.



Finally, we can think about what a cap-and-trade system would do. A cap-and-trade system would aim to limit the combined emissions of Industries 1 and 2. Imagine the industries combined currently emit 80 tons. We found that the optimal abatement is of $q^* = 20$. Therefore, the cap-and-trade system would allocate 60 emission allowances (permits to emit CO_2), since this would force industries to reduce their emissions by 20 tons (from 80 to 60).

But how will the CO_2 abatement be achieved? In the uniform standard, this was achieved by requiring each industry to abate 10 units. Under cap-and-trade, the industries will trade their emissions allowances. And why will they trade? Because they have different marginal abatement costs!

Note that Industry 1 has a lower marginal abatement cost than Industry 2 (MC_1 curve lies below MC_2 in the first graph). Industry 2 could propose to buy an emission allowance from Industry 1. Note that when $q_1 = q_2 = 10$, the marginal abatement cost for Industry 1 is \$ 60 while it is \$ 90 for Industry 2. In this context, Industry 1 would reduce its emissions by 1 ton and sell the resulting extra CO_2 emission permit to Industry 2. Industry 1 would be willing to do this for any price above \$60, and Industry B would be willing to pay up to \$90. This is a clear example where there are “gains from trade”.

Note that these gains exist from $q_1 = q_2 = 10$ all the way to $q_2 = 6.66$. Therefore, across all these units, there will be an opportunity to trade and reduce the total abatement costs relative to the uniform standard. In other words, an opportunity to reduce the costs represented by the orange triangle.