

## ECN 371: Exercise set 2 - suggested answers

- (a) The firm's optimal emission level

$$MAC_1 = t_a \Leftrightarrow 10 - z = 3 \Leftrightarrow z = 10 - 3 = 7, \text{ i.e. } z_1^\alpha = 7$$

- (b) The firm's optimal emission level with the new technology

$$MAC_2 = t_a \Leftrightarrow 5 - \frac{1}{2}z = 3 \Leftrightarrow \frac{1}{2}z = 5 - 3 \Leftrightarrow z = 4, \text{ i.e., } z_2^\alpha = 4$$

- (c) Does it pay for the firm to adopt the new technology

Calculate the net present value of the costs of the two technology options, by using the following formulae:

$$\begin{aligned} NPV_i^\alpha &= I_i + \sum_{t=0}^{\infty} \left( \left( \frac{1}{1+r} \right)^t \left( t^\alpha z_i^\alpha + \int_{z_i^\alpha}^{z_0} MAC_i(z) dz \right) \right) \\ &= I_i + \frac{1}{r} \left( t^\alpha z_i^\alpha + \int_{z_i^\alpha}^{z_0} MAC_i(z) dz \right) \end{aligned} \quad [1]$$

where  $i$  indexes the technology, i.e.  $i \in \{1,2\}$ . For the current technology, the investment  $I_1 = 0$  in equation [1] so that the net present value of the costs simplifies to the tax revenues paid ( $t^\alpha z_i^\alpha$ ) plus the integral of the marginal abatement costs  $+\int_{z_i^\alpha}^{z_0} MAC_i(z) dz$ , all multiplied by the infinite discounting factor which in this case is 20. This gives:

$$NPV_1^\alpha = 510$$

Similarly, insert the investment costs for the new technology into the formulae, and calculate, which gives:

$$NPV_2^\alpha = 520$$

As the net present value of the total costs (investment + taxes paid + abatement costs) is larger for the new technology than for the old technology, it does not pay to invest in the new technology.

- (d) Does it pay to undertake the investment in the new technology when the emission tax rate is increased to 4?

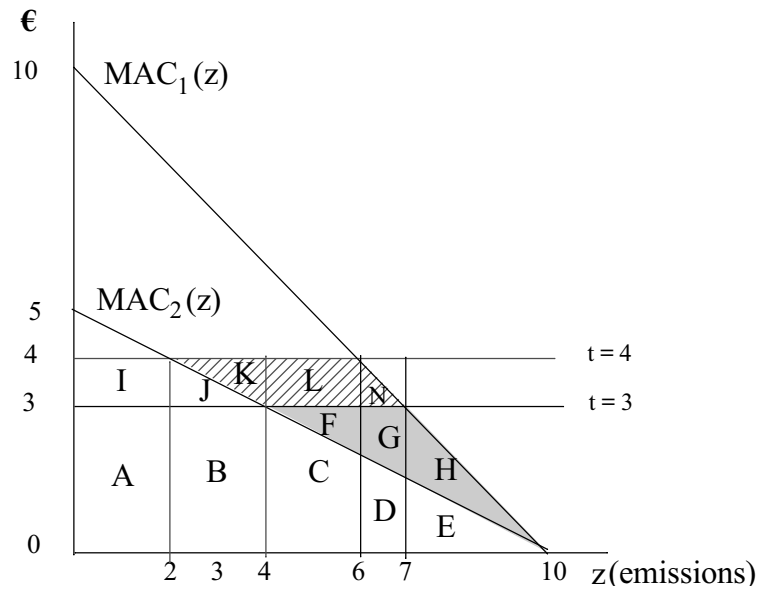
Yes, it does. To see this, calculate the optimal emission level under the new tax rate,  $t_i^\beta$  as done in (a) (gives  $z_1^\beta = 6$ ) and (b) (gives  $z_2^\beta = 2$ ). Calculate tax payments and abatement costs, and repeat the calculation in (c). This gives:

$$NPV_1^\beta = 640 \text{ and } NPV_2^\beta = 580$$

- (e) Conclusions regarding the profitability of investments in abatement technology when emission tax rates increase.

Starting assumption: the new abatement technology leads to a counter-clockwise rotation or a shift down and to the left in the marginal abatement cost curve (without strange assumption about operating costs, this is the only way the new technology is potentially interesting for investment as it entails extra investments that one needs to get paid back, one way or another).

Consider the following graph (fit to the current MAC-curves, but the general insight also holds):



When the tax with the tax rate of 3 is introduced (i.e., the tax rate is increased from 0, the pre tax situation), the overall cost savings from the new technology compared to the old technology equals areas F+G+H (the light gray shaded area). When the tax is further increased to 4, there is an additional cost savings from the new technology equalling areas K+N+L (the lined area).

Regardless of the values of the *MACs*, it is easy to see that an increase in the tax rate leads to an increase in the cost savings from introducing the the new technology.