

**AAE / Econ / Env. St. 343**  
**Environmental Economics**

**Homework #2**  
**Suggested Answers**

Please read the following outside articles posted on the course website (next to the homework download) for this assignment:

Reading #1: Landry, C.J., and C. Peck. 1998. "Dealing for Water." *Montana Farmer-Stockman*, December. (Subtitle: Western states are creating water markets without compromising the prior appropriation doctrine.)

Reading #2: Barringer, F., and K. Galbraith. 2008. "States Aim to Cut Gases by Making Polluters Pay." *The New York Times*, September 16.

Short answers please. Questions 1 and 2 refer to the first reading: "Dealing for Water".

1. Explain why the "Dealing for Water" article illustrates the Coase Theorem result. Be sure to discuss how property rights to water are defined and how this affects the applicability of the Coase Theorem.

*In the 'Dealing for Water' article, the prior appropriation doctrine endows farmers with the property right to use river water for irrigation. In Montana this property right is transferable. As described in the article, a coalition of fishing groups has bargained with farmers to achieve a reallocation of irrigation water back into the river for "in-stream" uses. Thus, as the Coase Theorem predicts, the allocation of property rights to using the river has led the two parties to the negotiation table with the result being a reallocation of some water from irrigation to in-stream uses in rivers.*

2. The article refers to Trout Unlimited, which is a non-profit organization representing recreational anglers. What role does Trout Unlimited play in making the Coase Theorem feasible?

*A principal assumption for the Coase Theorem to achieve an efficient allocation of resources is for there to be low transactions costs between the affected parties. Without an organization such as Trout Unlimited, transactions costs would be high because all affected fishers would have to bargain individually with all the farmers along the river. However, with such an organized group doing the negotiating, the transactions costs should be lower.*

The following information applies to questions 3 through 5. Two firms can control pollution with the following marginal abatement costs:  $MAC_1 = \$150q_1$ ,  $MAC_2 = \$100q_2$ , where  $q_1$  and  $q_2$  are, respectively, the amount of pollution reduced by the first and second firms. Assume that with no control at all, each firm would be emitting 10 units of

pollution, or a total of 20 units for both firms. Suppose that the government sets a pollution goal of 10 units of total pollution.

3. Suppose the government wants to achieve the pollution goal at least-cost by taxing pollution. What tax rate should be set? What is the final allocation of pollution reduction?

Pollution Unit	MC <sub>1</sub>	MC <sub>2</sub>
10	150	100
9	300	200
8	450	300
7	600	400
6	750	500
5	900	600
4	1050	700
3	1200	800
2	1350	900
1	1500	1000

*The least cost allocation of pollution control responsibility ensures that the marginal abatement costs of cleaning up the last unit of pollution are equal across firms. In this example, the least-cost allocation of pollution control responsibility occurs when firm 1 cleans up 4 units (units 10 through 7) and firm 2 cleans up 6 units (units 10 through 5). The optimal tax rate for cleaning up pollution always equates MAC across both firms. Given the information above, a tax rate of  $t^* = \$601$  would ensure that 10 total units are cleaned up, because firm 1 is better off cleaning up units 10 through 7 and firm 2 is better off cleaning up units 10 through 5 than paying the tax of  $t^* = \$601$ .*

4. Suppose the government wants to achieve the pollution goal by distributing a total of 10 tradable permits to the two firms, where each firm is initially allocated 5 permits. After trading, what is the equilibrium permit price and allocation of permits to the two firms? Does the equilibrium permit price and allocation of permits depend on the initial allocation? Explain.

*Using the table above, firm 1 has an incentive to buy a 6<sup>th</sup> permit from firm 2 because firm 1 is willing to pay anything less than \$750 for a 6<sup>th</sup> permit (since their MAC is \$750 for that unit) while firm 2 is willing to accept anything over \$600 to give up their 5<sup>th</sup> permit (since their MAC is \$600 for that unit). So, there is incentive to trade. There is no incentive to trade another permit because firm 1 is only willing to pay \$600 for a 7<sup>th</sup> permit while firm 2 needs at least \$700 in compensation for their 4<sup>th</sup> permit. So, the final allocation is for firm 1 to have 6 permits and firm 2 to have 4 permits. The equilibrium price will be between \$600 and \$750.*

*To show that the initial allocation of permits doesn't matter, assume that firm 1 begins with 7 permits while firm 2 has 3 permits. Firm 2 has an incentive to buy a 4<sup>th</sup> permit from firm 1 since firm 2 is willing to pay anything under \$700 for a 4<sup>th</sup> permit*

while firm 1 only needs \$600 in compensation to give up their 7<sup>th</sup> permit. There will not be incentive to trade another permit since firm 2 is willing to pay less for a 5<sup>th</sup> permit (\$600) than firm 1 needs in compensation to give up the 6<sup>th</sup> permit (\$750). So, again the final allocation is for firm 1 to have 6 permits and firm 2 to have 4 permits.

5. Now consider the incentives for the firms to innovate. Suppose that the two firms are regulated with the permit system and have traded to the final distribution that you identified in question #4. Further, suppose that by innovating, the second firm can reduce its costs from  $MAC_2 = \$100q_2$  to  $MAC_2^I = \$80q_2$ . If the second firm innovates, how many permits will it be able to sell to the first firm? How much is the second firm willing to pay for the innovation? Show your work.

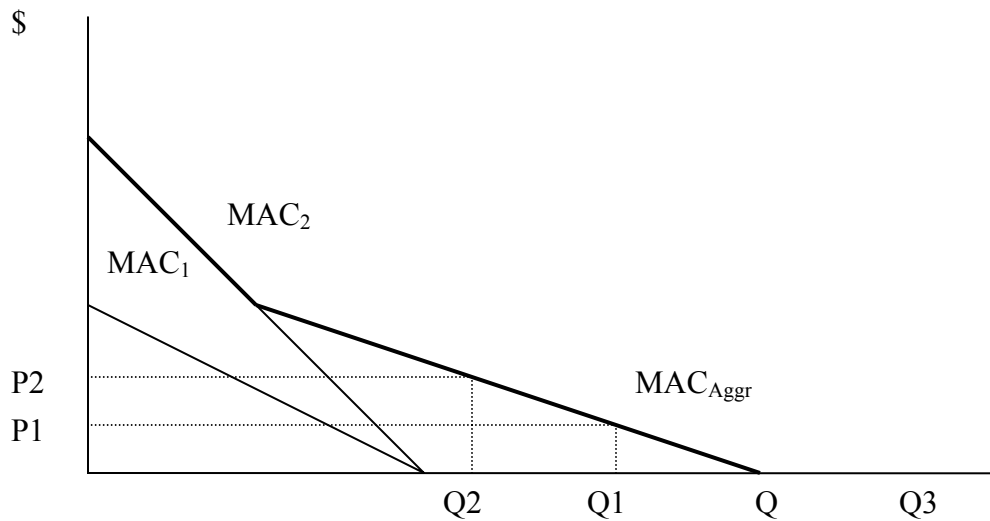
Pollution Unit	$MC_1$	$MC_2$	$MC_2^I$
10	150	100	80
9	300	200	160
8	450	300	240
7	600	400	320
6	750	500	400
5	900	600	480
4	1050	700	560
3	1200	800	640
2	1350	900	720
1	1500	1000	800

After innovating to  $MC_2^I$ , The second firm will be able to sell its 4<sup>th</sup> permit to firm 1 because firm 1 will be willing to pay anything under \$600 for a 7<sup>th</sup> permit while firm 1 will accept anything over \$560 for the 4<sup>th</sup> permit.

If the second firm couldn't sell another permit to firm 1, they receive savings from cleaning up units 10 through 5:  $(\$100 - \$80) + (\$200 - \$160) + (\$300 - \$240) + (\$400 - \$320) + (\$500 - \$400) + (\$600 - \$480) = \$420$ . By selling their 5<sup>th</sup> permit to firm 1 for a price between \$560 and \$600—assume the actual price is \$580—then firm 2 receives an extra \$20 in profits  $(\$580 - \$560)$  by cleaning up the 4<sup>th</sup> unit and selling the 4<sup>th</sup> permit to firm 1. So total savings, and thus an estimate of firm 2's willingness to pay for the innovation, is  $\$420 + \$20 = \$440$ .

Questions 6 and 7 refer to the second reading: "States Aim to Cut Gases by Making Polluters Pay" published this week in The New York Times.

6. In the article, Milo Sjardin, head of the North America division of New Carbon Finance, claims that the price of CO2 permits in the RGGI program is "not going to be high, not for the foreseeable future." Using a simple graph with different marginal abatement cost curves for two firms, illustrate the relationship between the government's choice of a pollution "cap" (e.g. total allowable pollution) and the equilibrium permit price. What is your intuition?



← Pollution Reduced

Suppose  $Q$  is the total pollution emitted by firms 1 and 2 in the absence of any regulation. If the government sets a high pollution cap ( $Q1$ ), the equilibrium permit price is the price that equates the marginal abatement costs of the two firms ( $P1$ ). A lower pollution cap ( $Q2$ ) results in a higher equilibrium permit price ( $P2$ ) as seen in the graph above. The intuition is that with a lower cap, permits are scarcer, and so they will be more valuable. Notice that the article implies a pollution cap that is above current emissions. This would be represented by  $Q3$  in the graph above, and imply a permit price of zero.

7. In the article, it's stated that the RGGI program will initially allocate permits with an auction, where each permit is sold to the highest bidder. An alternative way to initially allocate permits would be for the government to simply give each firm the same number of permits. Given a fixed number of total pollution permits, would the equilibrium allocation of permits after trading differ between the above two initial allocations of permits? According to the article, what is the relationship between the auction approach and other renewable energy programs in the participating states? Explain.

*With an auction, firms have to pay for each initial permit and have an incentive to bid no more than their marginal abatement cost for that unit of pollution. So the final allocation of permits will be identical to that achieved under a green tax, since a tax also requires firms to pay for each unit polluted. Since both green taxes and tradable permits result in least-cost pollution allocation, then the choice of an initial permit allocation strategy should have no effect on the equilibrium allocation after trading. According to the article, proceeds generated from the government's auction will go to "energy-saving and renewable energy programs in each state." Such a transfer would not be possible if permits were given away rather than auctioned.*