4. Economic Efficiency and the Environment

4.1 Efficiency as Social Surplus Maximization

- For the most part we will define efficiency in terms of social surplus maximization.

- Social surplus is maximized if _

- That is, an allocation is efficient if it has the highest social surplus of any feasible allocation.

- Let *z* denote the resource to be allocated. Then we will denote the efficient allocation by z^*.

- Under certain plausible assumptions, z^* is defined by

(4.1) $MSB(z^*) = MSC(z^*)$

where *MSB* denotes marginal social benefit and *MSC* denotes marginal social cost. For most of our analysis we will take this condition as our efficiency condition.

- Condition (4.1) states that we should allocate resources in such a way that _

- The logic can seen most clearly in figure 4.1

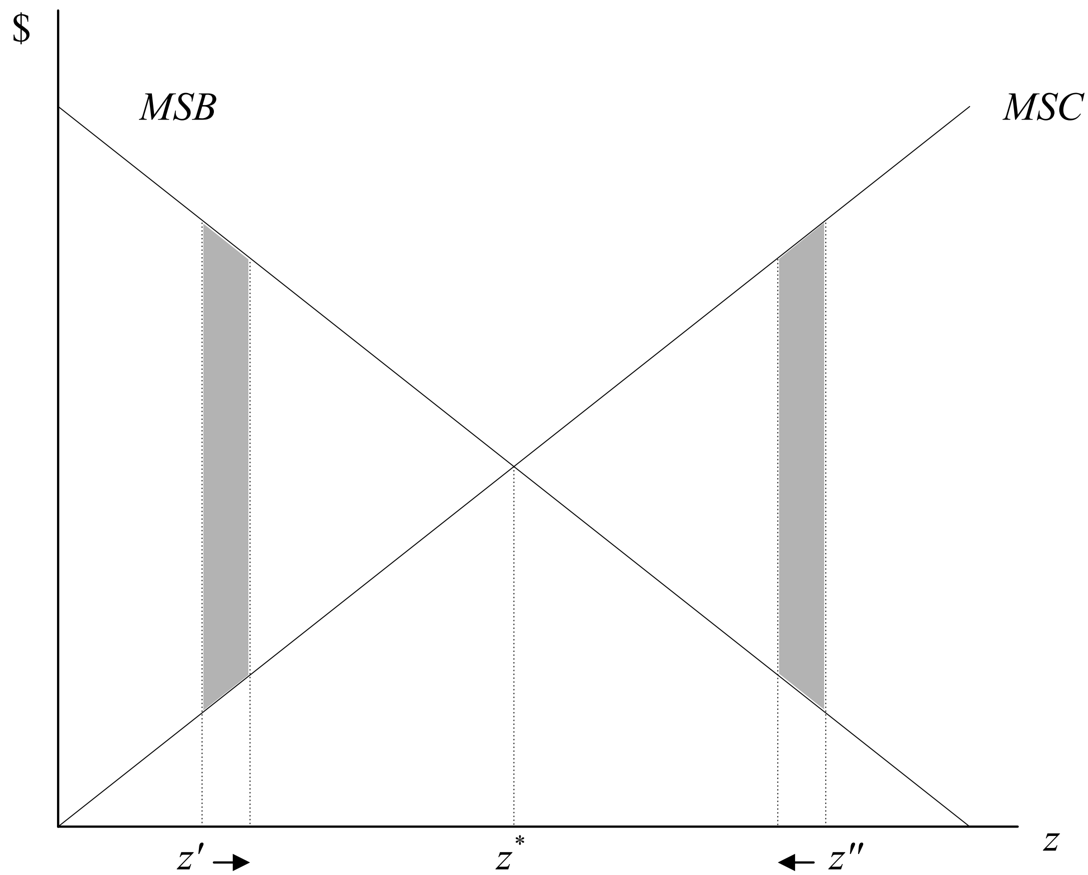

Figure 4.1

- The negative slope of the *MSB* schedule reflects _______ marginal social benefit from this activity.
- The positive slope of the *MSC* schedule reflects the ______ social cost of devoting resources to this acitivity(taking resources away from some alternative activity).
- Note that moving towards z* from either *z'* or *z''* will increase social surplus.

4.2 Efficient Pollution

- Recall that any activity that consumes resources must generate waste.(by the first law of thermodynamics)
- Our concern is with that waste which is not assimilated:
  - *pollution* is defined as waste in excess of assimilative capacity.
- We will henceforth refer to the waste produced from some activity as *emissions* or *effluent.*

- The efficient level of pollution is that which just balances the _____ imposed by pollution against the _______ derived from the activity that produces the emissions.
- We will refer to the costs of pollution as *environmental damage* (or sometimes as just damage).
- We will refer to the benefits foregone when waste is reduced as *abatement cost*.

- The costs of pollution include:
  –

It is crucial to understand that our definition of environmental damage includes *all* costs associated with pollution.

- The cost of abating pollution may involve_

- Example:

- Abatement cost is defined as the least-cost combination of measures to reduce emissions.

- The efficient level of emissions is that which ______ social surplus.

- Let e^* denote the efficient level of emissions.
- Then under certain plausible assumptions, e^* is defined by

(4.2) $$MAC(e^*) = MD(e^*)$$

where *MAC* denotes marginal abatement cost and *MD* denotes marginal damage. See figure 4.2

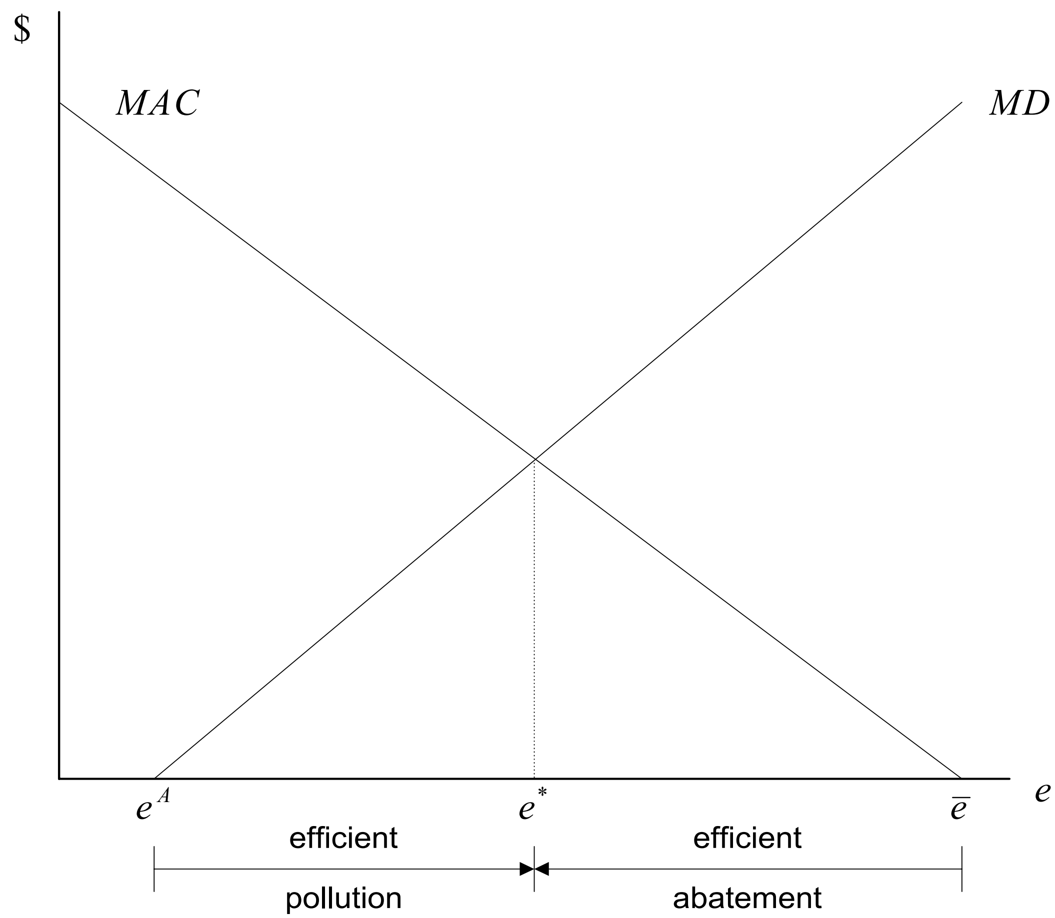

Figure 4.2

- Figure 4.2 depicts a case where the efficient level of pollution is ________.
- That is, the benefits associated with the activity are high enough to warrant incurring some environmental damage.
- This need not be the case. If marginal damage is infinite (*MD* is vertical at assimilative capacity), or if abatement is costless, then zero pollution is efficient.

- In less extreme cases the efficient level of pollution is not zero; it will generally be positive.
- This represents a balance of two extreme possibilities: one that pays no heed to environmental damage (which would indicate a level of emissions equal to_____), and one that pays no heed to the costs associated with foregoing a valued activity (which would indicate a level of emissions equal to or below_____).

4.3 Efficiency with Multiple Sources

- It is useful to think in terms of a two stage process for characterizing the efficient solution:
  - (i) choose the emissions for each source to achieve a given target level of aggregate emissions at minimum abatement cost;
  - (ii) choose the target level of aggregate emissions to maximize social surplus.

Stage one: minimizing abatement cost

- Suppose the target level of aggregate emissions: $\hat{E}$
- To achieve this at minimum abatement cost: equate marginal abatement costs across sources such that the aggregate target is met.
- To see why this is so, consider an example with just two sources.

Suppose these two sources have different marginal abatement cost. See Figures 4.3.

- Suppose the aggregate emissions target is initially met by assigning half of the target to each source: $e_1 = \hat{E}/2$ and

  $e_1 = \hat{E}/2$.

- This allocation does not minimize total abatement cost. To see this, suppose we increase the emissions allocation for source 1 by one unit and reduce the allocation for source 2 by one unit. (Note that the aggregation target is still met).

- Abatement cost for source 2 rises by ΔAC_2 but abatement cost for source 1 falls by ΔAC_1. The total abatement cost across the two sources falls. Thus, the initial allocation could not have been one that minimized total abatement cost.

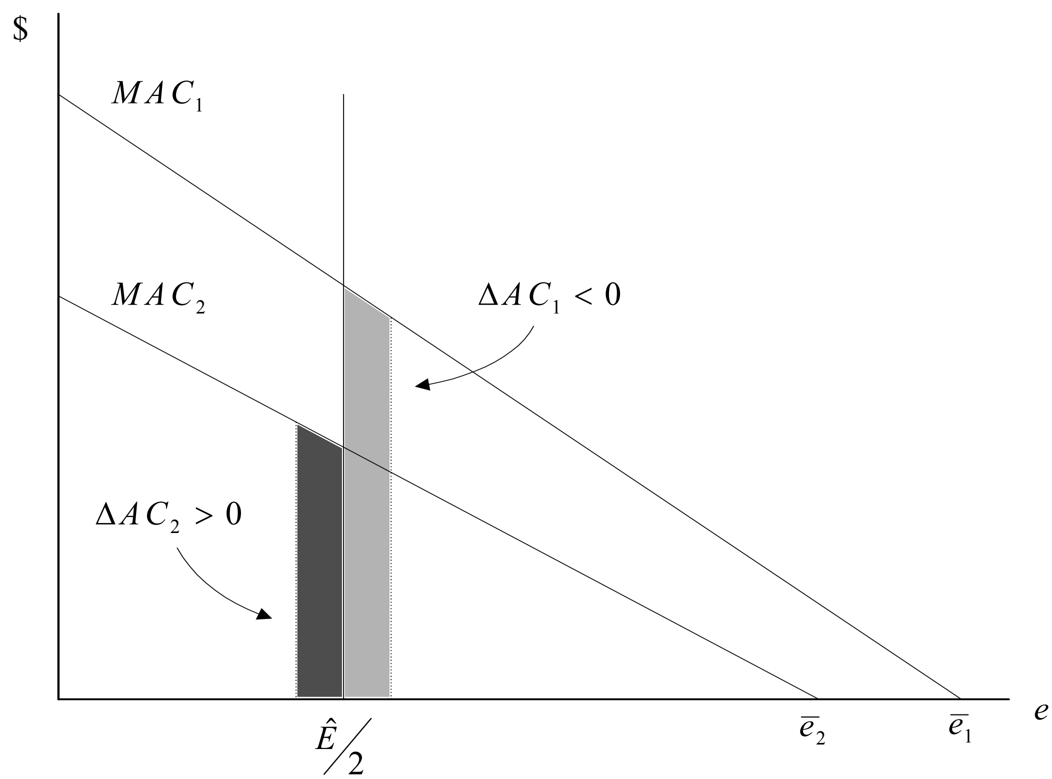

Figure 4.3 (Not Efficient)

- Figure 4.4 illustrates an allocation in which the emission for each source is set so that marginal abatement costs are equated.

$MAC_1(\hat{e}_1) = MAC_2(\hat{e}_2)$ such that $\hat{e}_1 + \hat{e}_2 = \hat{E}$

- From this allocation it is not possible to further reduce total abatement cost.

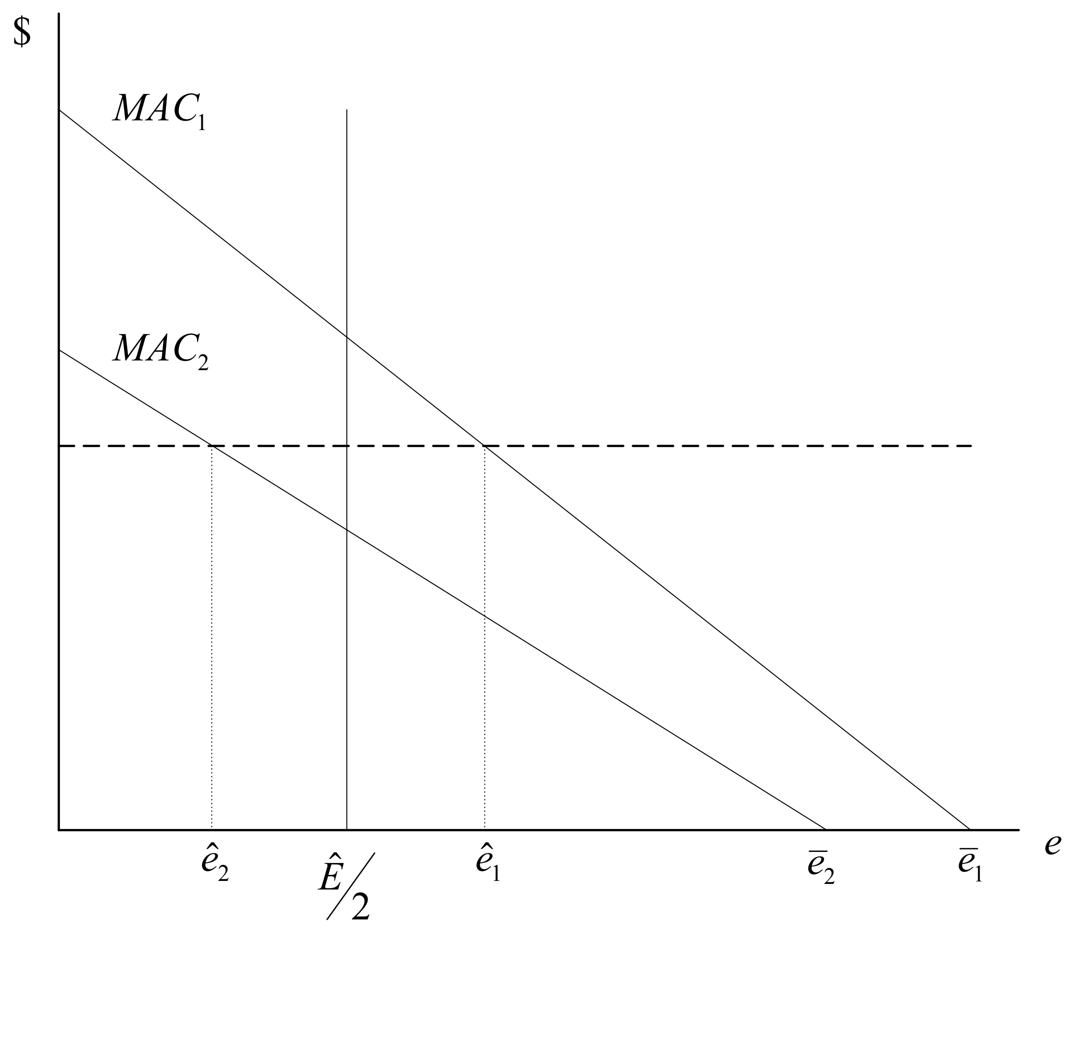

Figure 4.4 (Efficient)

Stage two: maximizing social surplus

- The problem in this stage is to choose the aggregate emissions target to maximize social surplus.
- The surplus maximization problem can be cast as one of minimizing the sum of _____________ and ____________ (since abatement cost represents benefits foregone when emissions are reduced).
- Recall that for a single source the solution to the problem is to set e^* so that ______________________. The same basic result extends to the case of multiple sources.
- The optimal level of aggregate emissions when there are two sources is given by E^* such that

(4.4)

- The first part of this condition follows from equation (4.3): total abatement cost must be minimized at the social optimum.
- To understand the second part of the condition, consider an allocation where it does not hold. Such an allocation is illustrated in figure 4.5. In this case we have an allocation where

(4.5)

From this allocation it is possible to reduce e_1 and e_2 , with a consequent increase in abatement cost equal to the sum of the shaded area under the MAC schedules, and thereby reduce damage by an amount equal to the shaded area under the MD(E) schedule. The reduction in damage more than offsets the increase in total abatement cost, and social surplus is thereby increased.

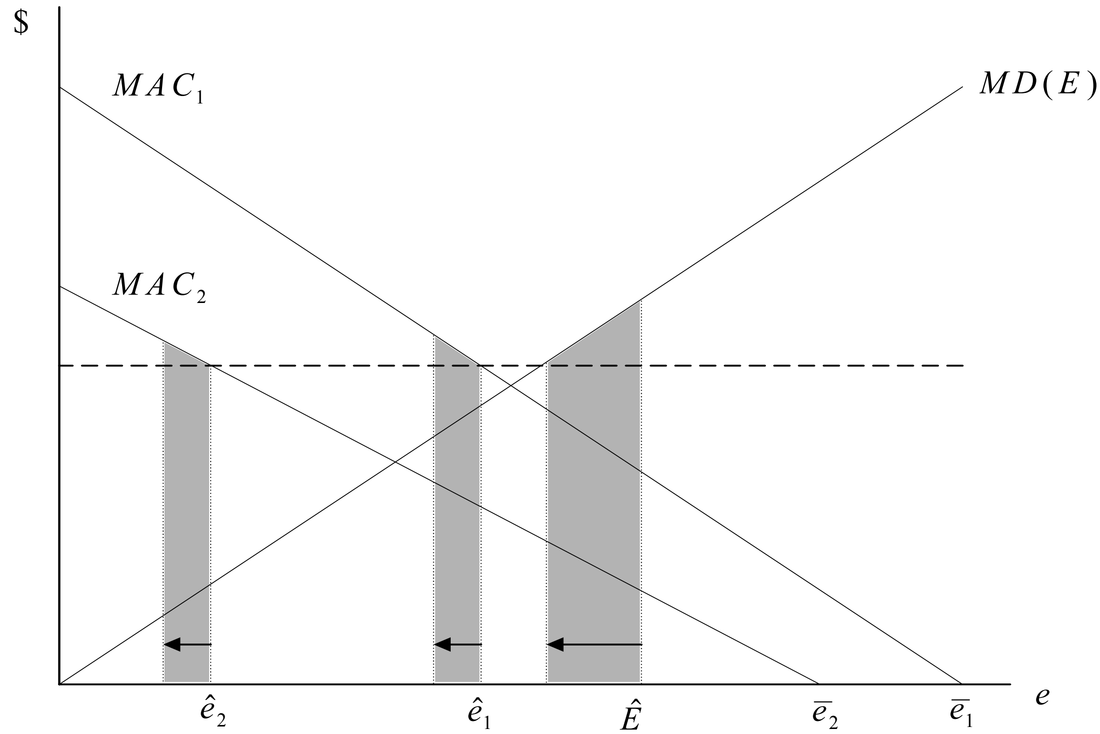

Figure 4.5 (Not Efficient)

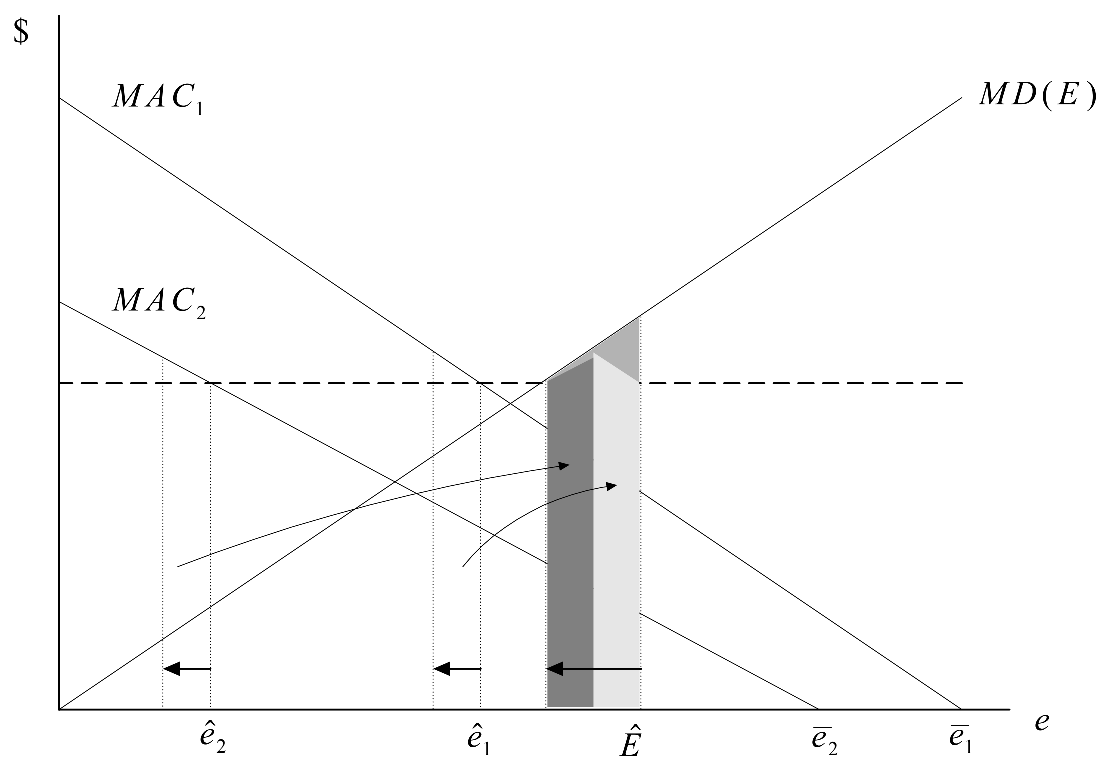

Figure 4.5a

- Figures 4.6. illustrates an optimal allocation corresponding to equation (4.4). From this allocation it is not possible to make social surplus larger by any reallocation. (consider the same experiment we conducted in figure 4.5 to confirm this)

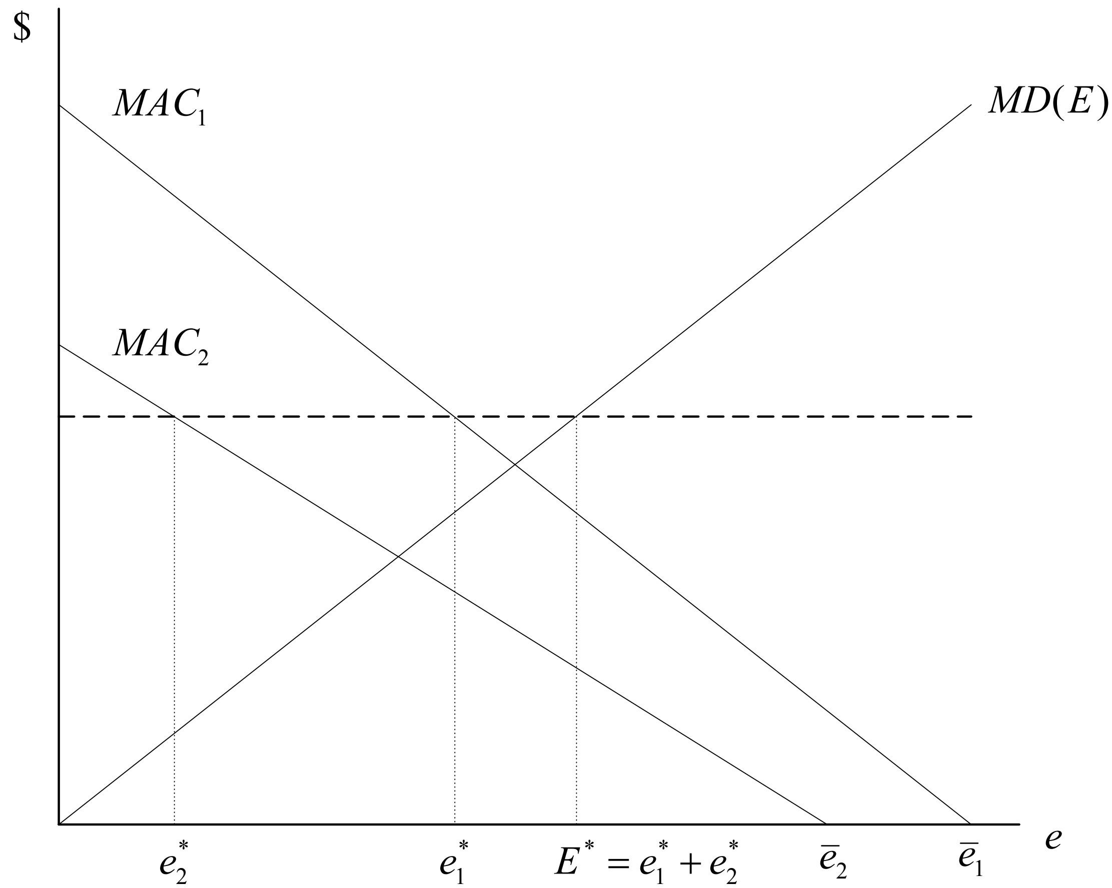

Figure 4.6

Efficient

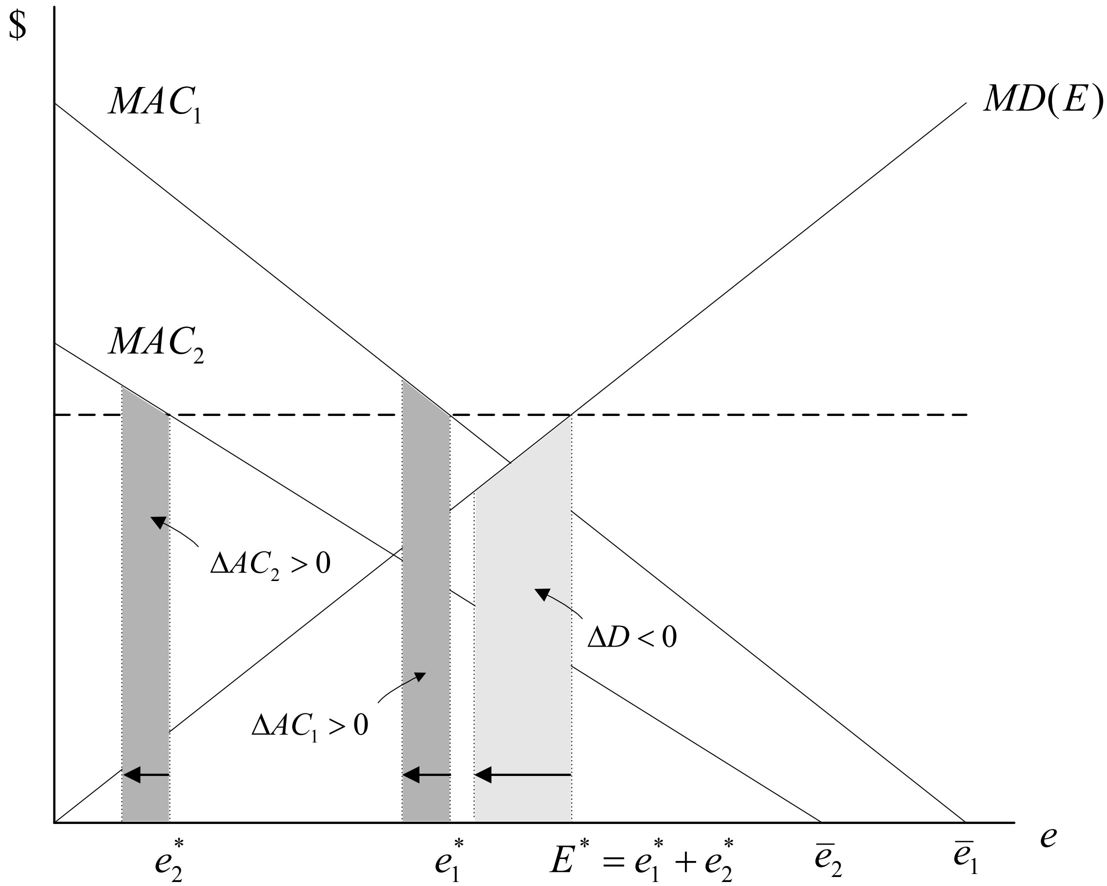

Figure 4.7

- In summary, the solution is to choose aggregate emissions such that marginal damage at that level of aggregate emissions is just equal to marginal abatement cost (equated across sources).