Subject: Environmental economics
Course code: ECON3029
Topic: Conventional Solutions to Environmental Problems: Command-and-control Approach
B.A. Economics (6th Semester)

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1. Standards in Environmental Policy

- Types of environmental standards

(1) Ambient Standard - A standard that determines the quality of the environment to be attained, expressed as the maximum allowable pollutant concentration.

(2) Technology-based standard - a standard that specifies the equipment or method used to achieve certain reduction levels

(3) Performance-based standard - a standard that specifies the extent of pollution to be achieved, but does not set the technology

Implications of Using Standards

- Two key implications:
  - Are standards set to achieve **allocative efficiency**?
    - where MSB of abatement = MSC of abatement
  - Given some environmental objective, is that objective being achieved in a manner that is **cost-effective**?

2. Are Environmental Standards Allocatively Efficient?

$$MSB_{Abatement} = MSC_{Abatement}$$

Additional social gains as pollution abatement increases

Measured as reduction in damages or costs caused by pollution

Represents society's D for environmental quality

-Implies MSB is *negatively* sloped

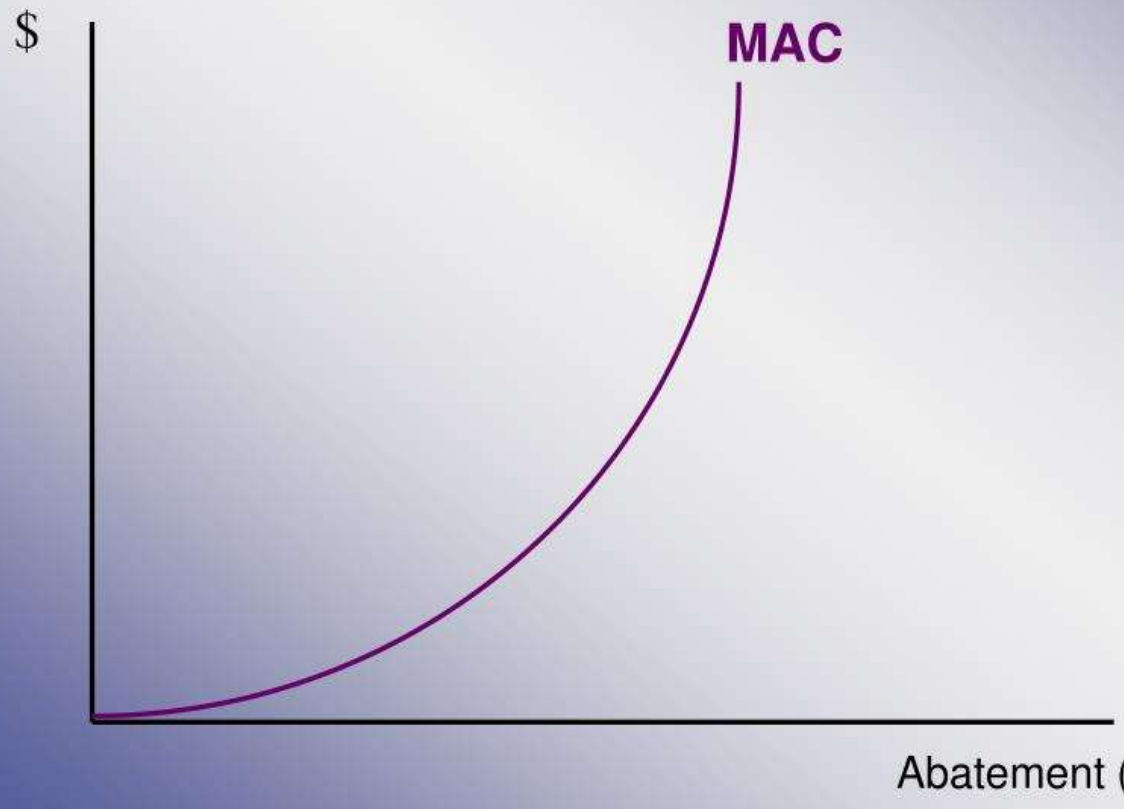
MSC of Abatement

- Sum of all polluters' marginal abatement costs plus government's marginal cost of enforcement
- MSC = MAC_{MKT} + MCE
- MAC_{MKT} is the sum of all polluters' individual marginal abatement cost (MAC) functions ;
  - $MAC_{MKT} = \Sigma MAC_i$
- MCE: change in government's cost of monitoring and enforcing abatement
- MSC is *positively* sloped

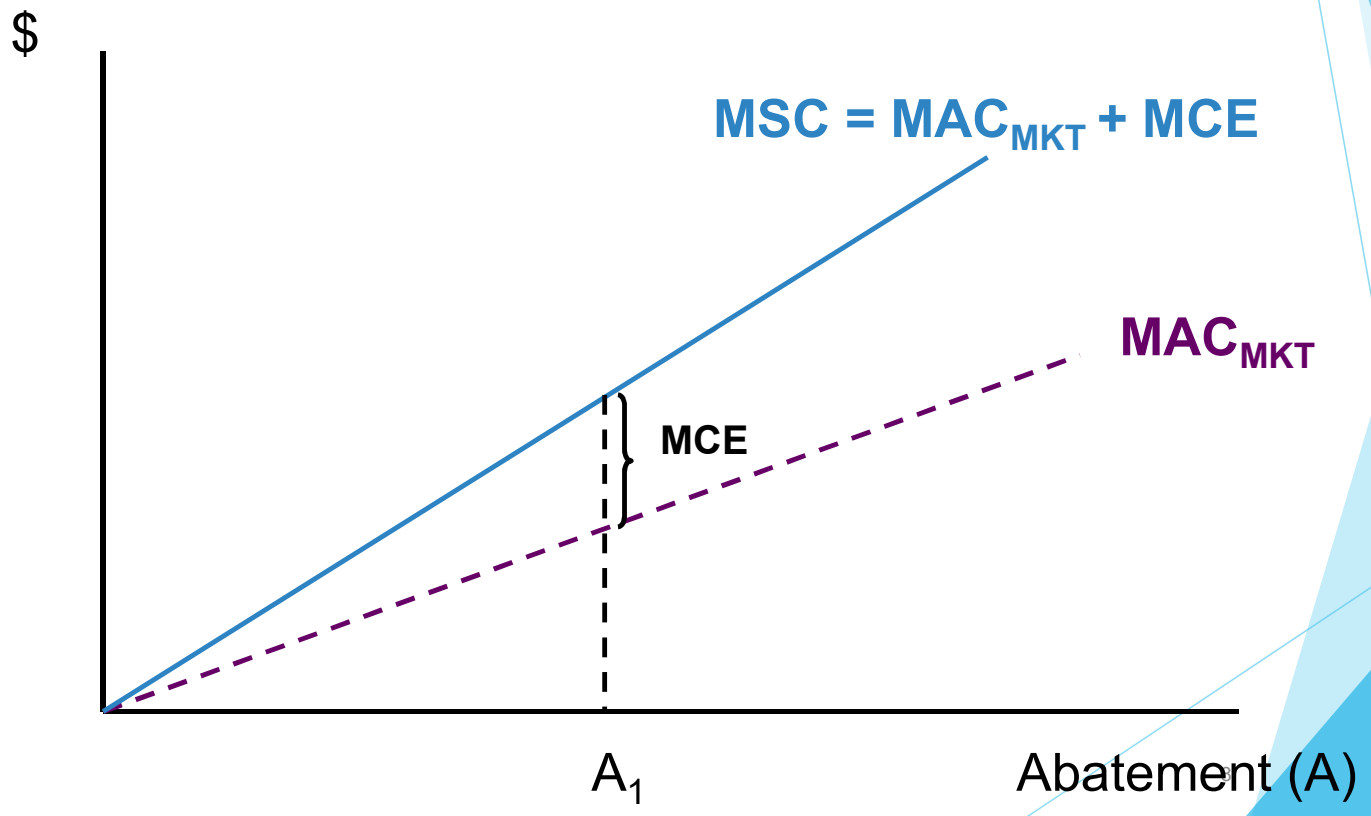
Firm-Level MAC

- Measures the change in cost from reducing pollution, using least-cost method
  - Equals forgone Mp if the least-cost abatement method is to reduce output
  - Typically positively sloped and increasing at increasing rate
  - For simplicity, it is usually assumed that MAC is linear

Firm's MAC (typical shape)



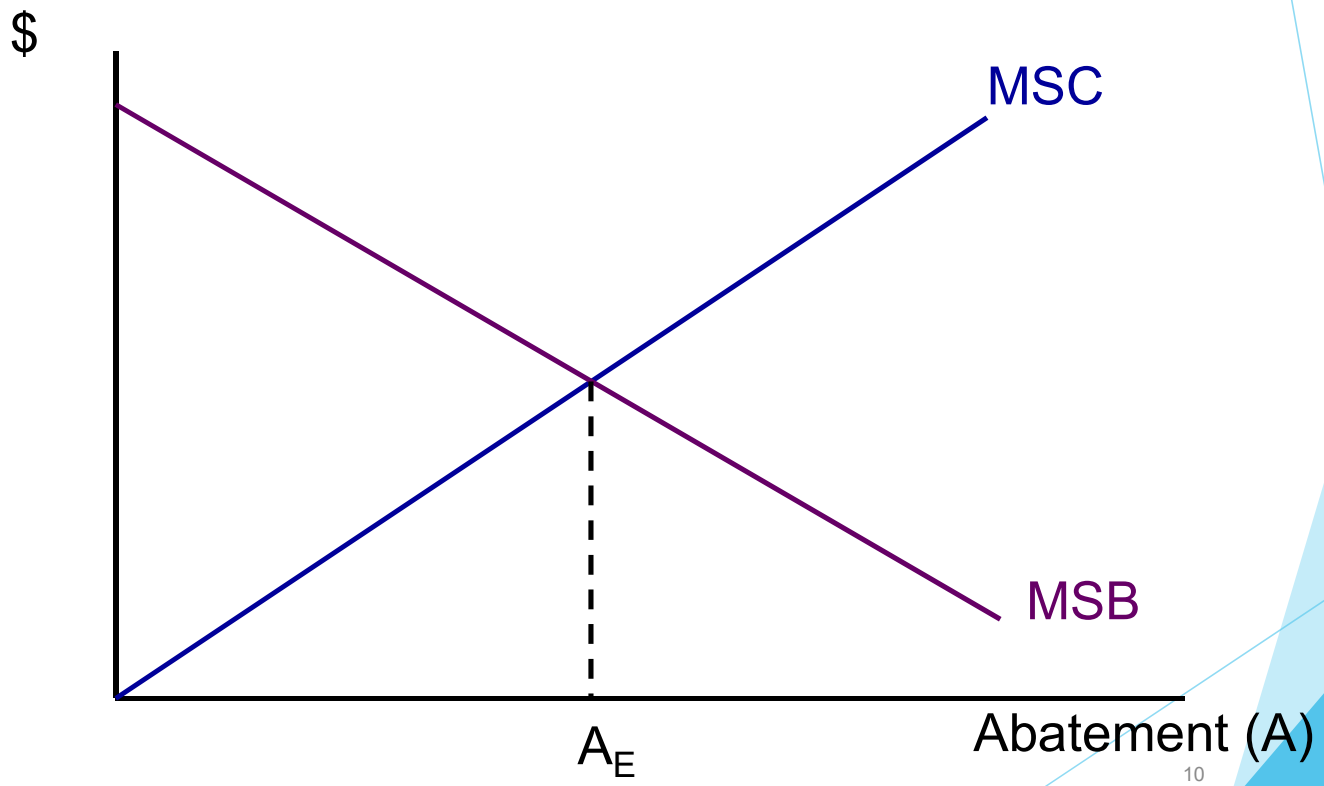
MSC of Abatement



Allocatively Efficient Level of A (A_E)

- A_E occurs at the point where:
  - MSB of abatement = MSC of abatement
  - Graphically where the two curves intersect

Modeling A_E



Why Standards May Not Be Efficient

- (1) Legislative Constraints
  - Many standards are benefit-based, i.e., set to improve society's well-being with no consideration for the associated cost
- (2) Imperfect information
  - Inability to identify MSB and/or MSC
    - MSB: difficulty in identifying each consumer's WTP
    - MSC: difficulty in identifying each firm's MAC, including implicit costs

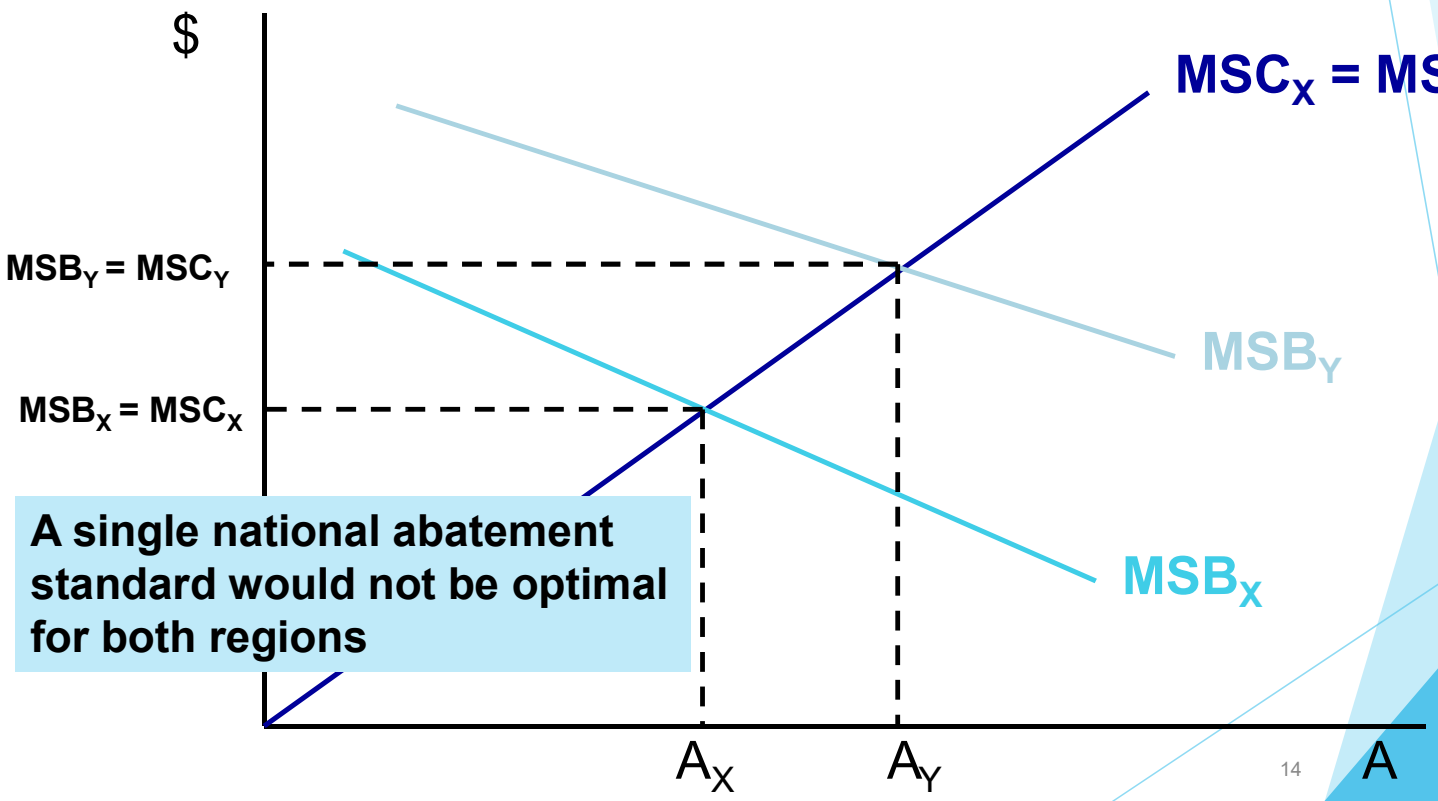
Why Standards May Not Be Efficient (continued)

- (3) Non-uniformity of pollutants
  - Changes in emissions do not have uniform effects on environment
    - e.g., if polluters are at different distances from populations or ecosystems, MSB would vary
- (4) Regional Differences
  - Even if A_E is identified at the *national* level, it is not likely to be efficient at *regional* level

Modeling Regional Differences

- Consider two regions, X and Y, with same MSC of abatement
- Suppose their MSB of abatement curves differ, such that $MSB_X < MSB_Y$
- Result: Allocatively efficient level of abatement for region X (A_X) would be *lower* than for region Y (A_Y)

Regional Differences



3. General Approaches to Implementing Environmental Policy

- If allocatively efficient standards are unlikely, we use cost-effectivenss to evaluate how standards are implemented
- Cost-effectiveness depends on the approach
  - **Command-and-control**: using standards or rules to *control* pollution
  - **Market**: using incentives and market forces to *motivate or encourage* abatement and conservation

4. Is the Command-and-Control Approach Cost-Effective?

- Two Standards to Examine

  --Technology-based standard

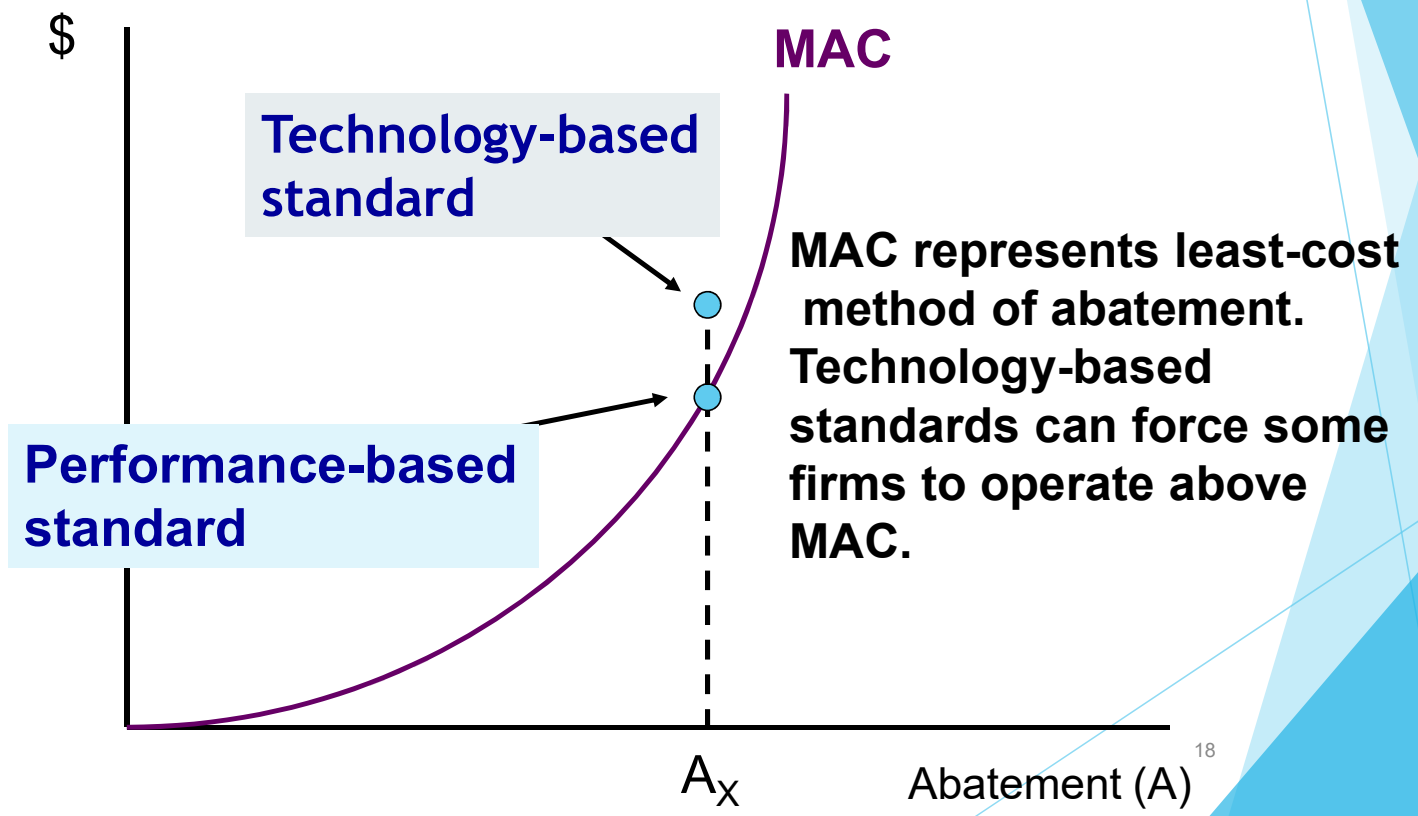
  --Uniform standard

Technology-Based Standards

- **Technology-based standards** specify the type of abatement equipment or method to be used
- By definition, these standards potentially ***prevent*** firms from selecting and using the least-cost abatement method

- Technology-based standard
  - If prevented from using the least-cost abatement method, firms would operate above their MAC curve
- **Performance-based standard**
  - If allowed to select an abatement method to achieve some performance level, profit-maximizing firms will choose the least-cost method and operate on the MAC curve

Modeling Cost-Ineffectiveness



Uniform Standards

- Uniform standards waste economic resources as long as abatement costs differ among polluting sources
- Cost savings can be obtained if low-cost abaters do more cleaning up than high-cost abaters
  - Let's prove this by building a model of 2 hypothetical firms

Model

- Assumptions
  - 2 polluting sources in some region
  - Each generates 10 units of pollution
  - Government sets emission limit of 10 units for region or 5 units per firm
  - Uniform standard: each firm must abate **5** units
- Cost conditions

Polluter 1: $\mathbf{TAC_1 = 1.25(A_1)^2}$

$\mathbf{MAC_1 = 2.5(A_1)}$

- where A_1 is pollution abated by Polluter 1

Polluter 2: $\mathbf{TAC_2 = 0.3125(A_2)^2}$

$\mathbf{MAC_2 = 0.625(A_2)}$

- where A_2 pollution abated by Polluter 2

- Find the total abatement costs using the uniform standard
- Solution:
- The TACs for each firm are

$$TAC_1 = 1.25(A_1)^2 = 1.25(5)^2 = \$31.25$$

$$TAC_2 = 0.3125(A_2)^2 = 0.3125(5)^2 = \$7.81$$

  - Sum of TACs = $39.06, which represents the value of resources given up by society to clean up the pollution

- Use MACs to prove that the uniform standard is not cost-effective
- Solution
  - With uniform standards, the MACs are not equal
    - $MAC_1 = 2.5(5) =$ $12.50
    - $MAC_2 = 0.625(5) =$ $3.125
    - Shows that Polluter 2 has a cost advantage
      - The 5th unit of A (i.e., the marginal unit) costs Polluter 2 $9.375 less than it costs Polluter 1
  - It would be cheaper if Polluter 2 did more of the abating, but it lacks an incentive to do so

- Find the cost-effective abatement, A_1 and A_2
- Solution: uses 3 simple steps

(i) Set $MAC_1 = MAC_2$

$2.5A_1 = 0.625A_2$

An application of the equi-marginal principle of optimality

(ii) Set $A_1 + A_2$ = Abatement Standard

$A_1 + A_2 = 10$

(iii) Solve equations (i) and (ii) simultaneously

$2.5\ (10 - A_2) = 0.625A_2$

$25 - 2.5A_2 = 0.625A_2$, so $A_2 = 8$ $A_1 = 2$

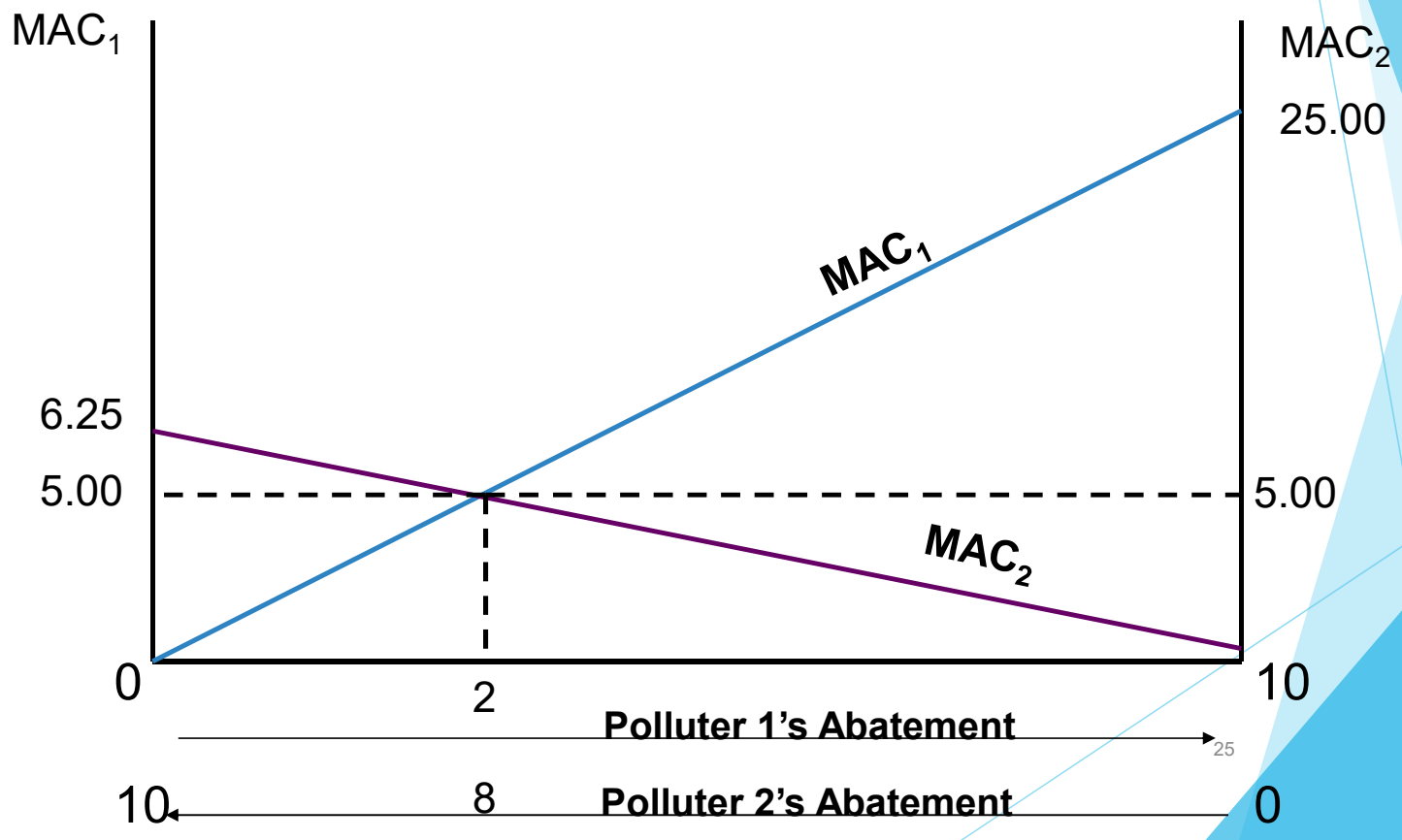
- Prove that this is cost-effective

$MAC_1 = 2.5A_1 = 2.5(2) =$ $5.0

$MAC_2 = 0.625A_2 = 0.625(8) =$ $5.0

- Show that total abatement costs are lower at this abatement allocation than the costs when a uniform standard is used
- Solution
  - $TAC_1 = 1.25(2)^2 = \$5.00$
  - $TAC_2 = 0.3125(8)^2 = \$20.00$
  - Σ TACs (cost-effective) = $25.00
  - Σ TACs (uniform standard)= $39.06
- Cost Savings= ($39.06 - $25.00) = $14.06

Graphical Model



Further Observations

- Problem: Public officials will ***not*** know where to set firm-specific standards without knowing MAC for every polluter
- Implies that a cost-effective solution is virtually impossible under Command-and-Control framework
- Result ***is*** possible using market approach