Carbon tax: Theory

EE 376

Chayun Tantivasadakarn

Faculty of Economics, Thammasat University

Outline

- Concept of carbon taxes
- A carbon tax for solving market failure
- Optimal carbon dioxide emissions
- Effects of a carbon tax on multiple sources of emissions
- Pros and cons of carbon taxes
- Applications of carbon taxes
- Impact assessment of carbon tax for Thailand

Concept of carbon taxes

- GHGs generate negative externalities
- The market price does not reflect the social costs correctly since producers and consumers consider only the private costs and ignore the external costs
- Pigou (1920) proposed pollution taxes to internalize the externality back to the polluters
- With an appropriate carbon tax rate, the carbon emission will be decreased to the optimal level

External costs

External costs are ignored

Private costs

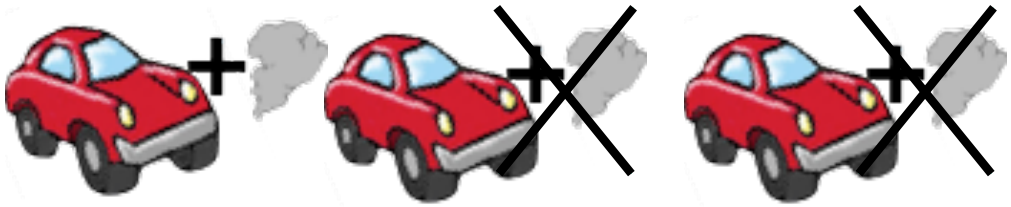
Private costs < Social costs → over emission

External costs

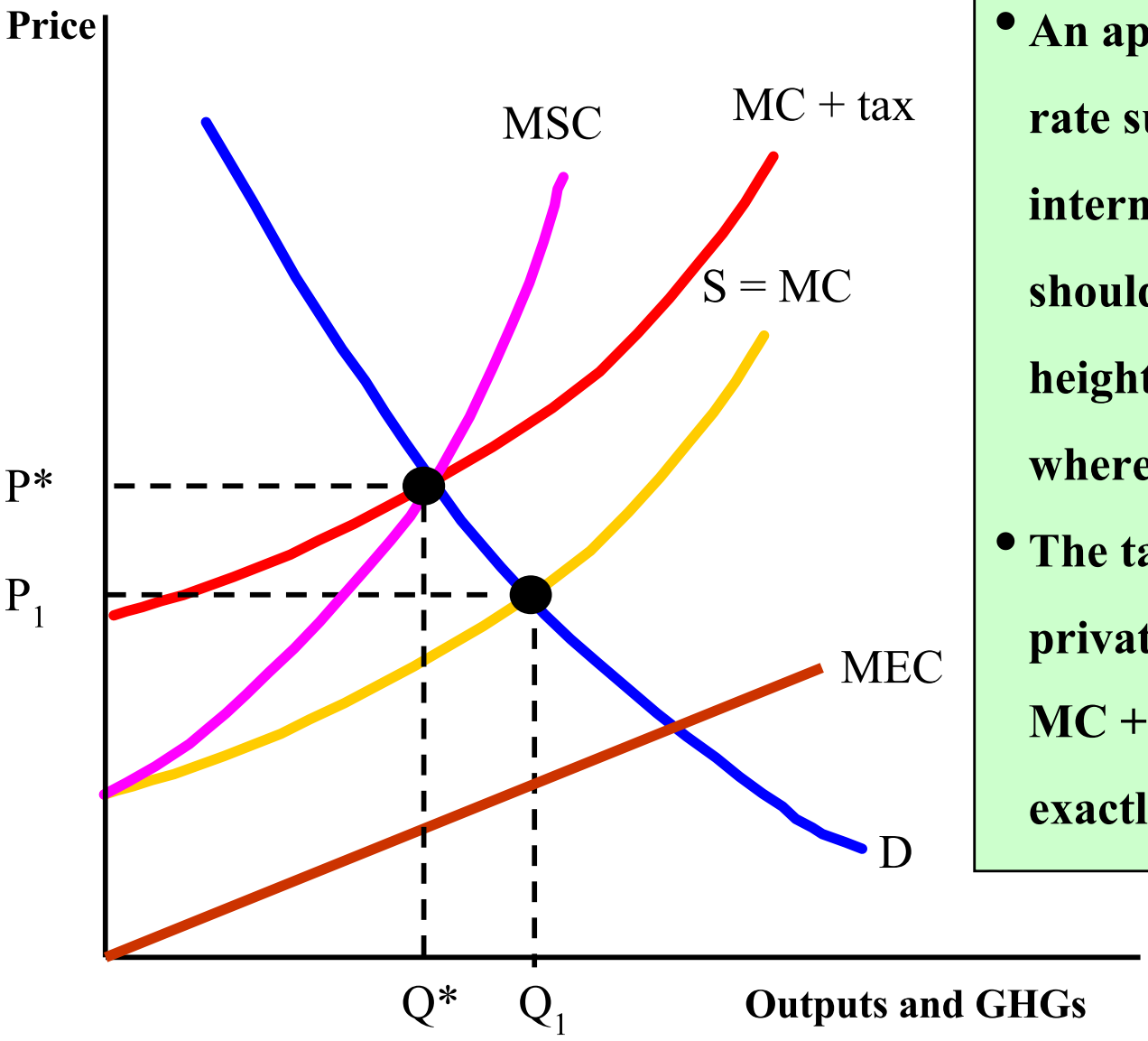
External costs are internalized by emission taxes

Private costs

Private costs = Social costs → optimal emission



A carbon tax for solving market failure



- **An appropriate carbon tax rate sufficient to internalize the externality should be equal to the height of MEC at Q^* where MSC = D**
- **The tax rate shifts the private cost curve up to MC + tax and cuts D curve exactly at P^* and Q^***

Optimal carbon dioxide emissions

- In the previous handout, we assume 1 unit of output generate 1 unit of emission
- However, in order to simplify the analysis, here the it will be assumed that production and emission are independent so that the analysis can emphasize on carbon emissions and carbon abatement
- The objective is to determine the level of emission and abatement that minimize the summation of total external costs and total abatement costs

Optimal carbon dioxide emissions

Costs related to the emission consist of

- Total External Costs (TEC): the total costs from losses and damages which are positively related to the level of emission (E)
  - Its function is given by TEC(E)
  - The Marginal External Cost function or the change of total external cost with respect to emission is defined as

$$\text{MEC(E)} = \frac{d\text{TEC(E)}}{d\text{E}}$$

Optimal carbon dioxide emissions

- Total Abatement Cost (TAC), which its function is given by TAC(A), is the total costs of cleaning up the emission

  where A is the amount of emission being abated and A = – E or the total amount of abatement must be equal to the amount of emission being decreased

  – The Marginal Abatement Cost function is defined as

$$MAC(A) = -MAC(E) = \frac{dTAC(-E)}{dE}$$

Optimal carbon dioxide emissions

- The social-optimal emission level is the amount of emission which minimizes the Total Social Costs or TSC = TEC + TAC)
- We need to solve the following problem:

$$\underset{E}{Min} \quad TSC(E) = TEC(E) + TAC(-E)$$

- The minimum is at E^* which causes $dTSC/dE = 0$ or

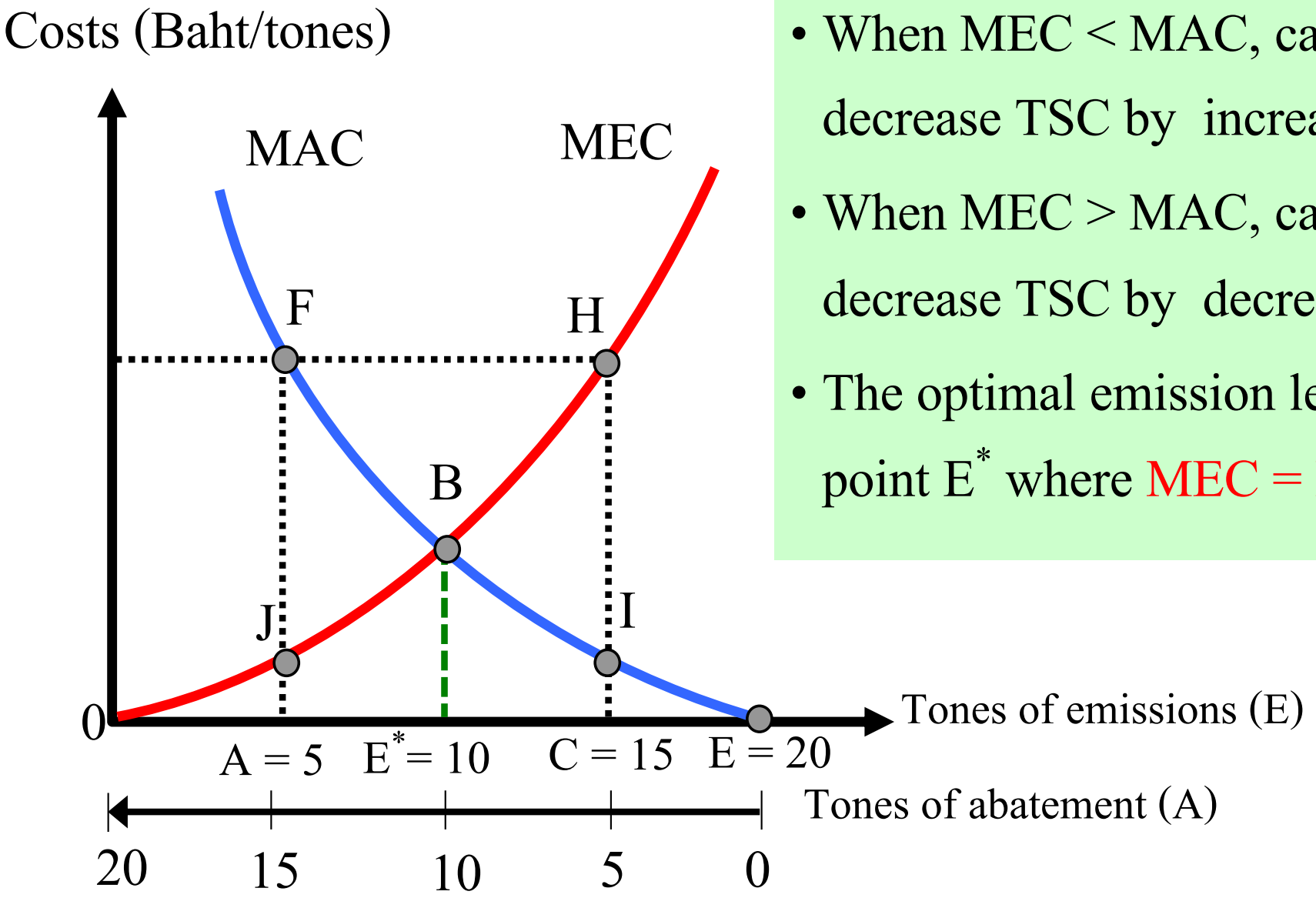
$$\frac{dTSC(E)}{dE} = MEC(E) - MAC(E) = 0$$

$$\boxed{MEC(E) = MAC(E)}$$

Optimal carbon dioxide emissions

- The MEC(E) is an increasing function of emission with positive slope since the higher the emission level, the greater the external cost
- The MAC starts from zero with no abatement (or E is at the maximum level) and increase with higher abatement (or when E is less). Hence the MAC(A) curve is an increasing function of A and a decreasing function of E
- Let the horizontal axis measures E (reading from left to right) and measures A on the opposite direction (reading from right to left)

Optimal carbon dioxide emissions



- When MEC < MAC, can decrease TSC by increasing E
- When MEC > MAC, can decrease TSC by decreasing E
- The optimal emission level is at point E^* where MEC = MAC

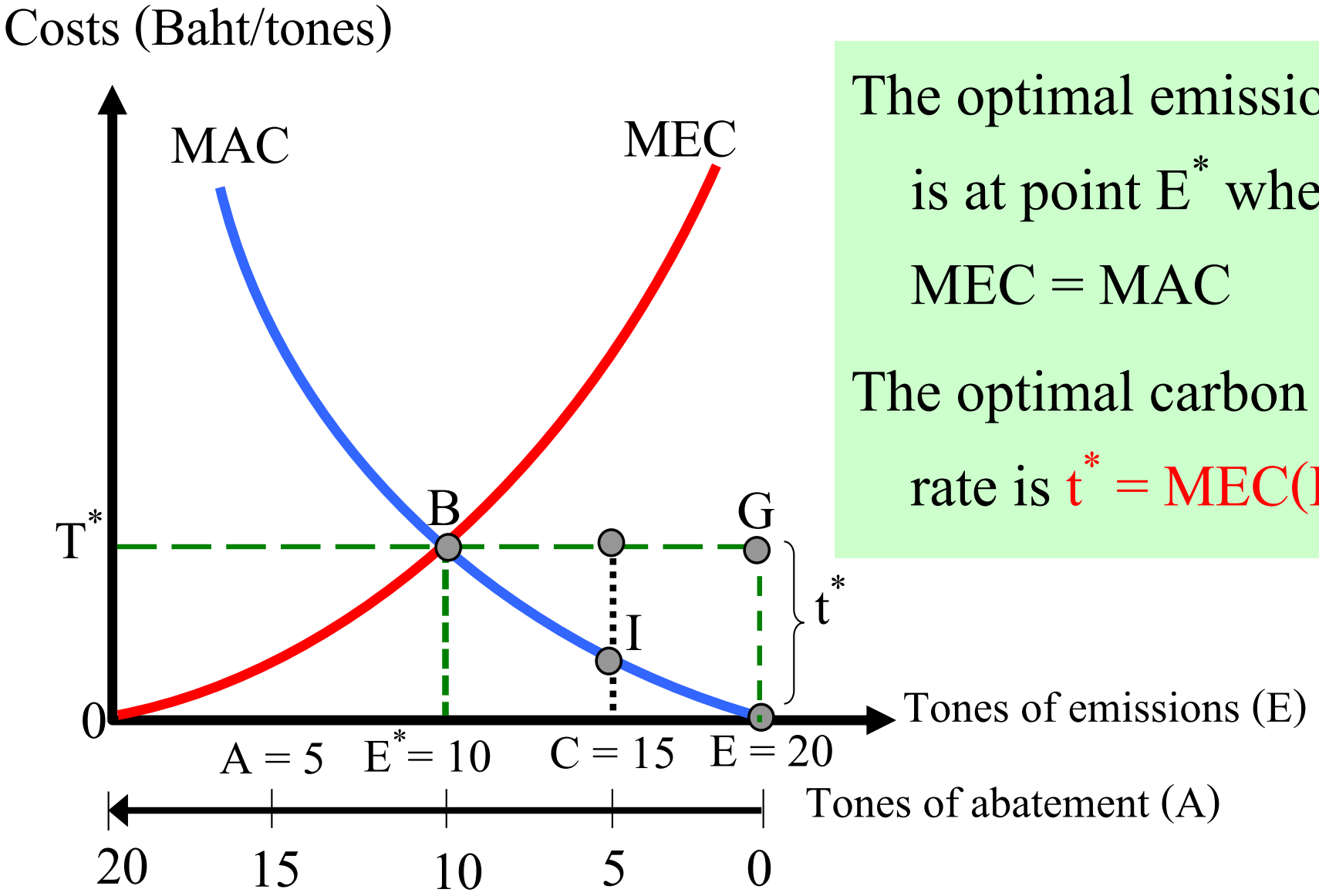
Optimal carbon dioxide emissions

- The optimal emission level is at E* where MEC = MAC
- At A = 5 tones: increasing E to 10 tones will increase TEC = area AJBE*, but will save TAC = area AFBE*

  → A net decrease in TSC = area BFJ
- At C = 15 tones: decreasing E to 10 tones will save TEC = area CHBE*, but will increase TAC = area CIBE*

  → A net decrease in TSC = area BIH
- At E* = 10 tones, TEC = area OBE* and TAC = area EBE*.
- Thus the total social costs = area OBE (shaded areas)

Optimal carbon dioxide emissions



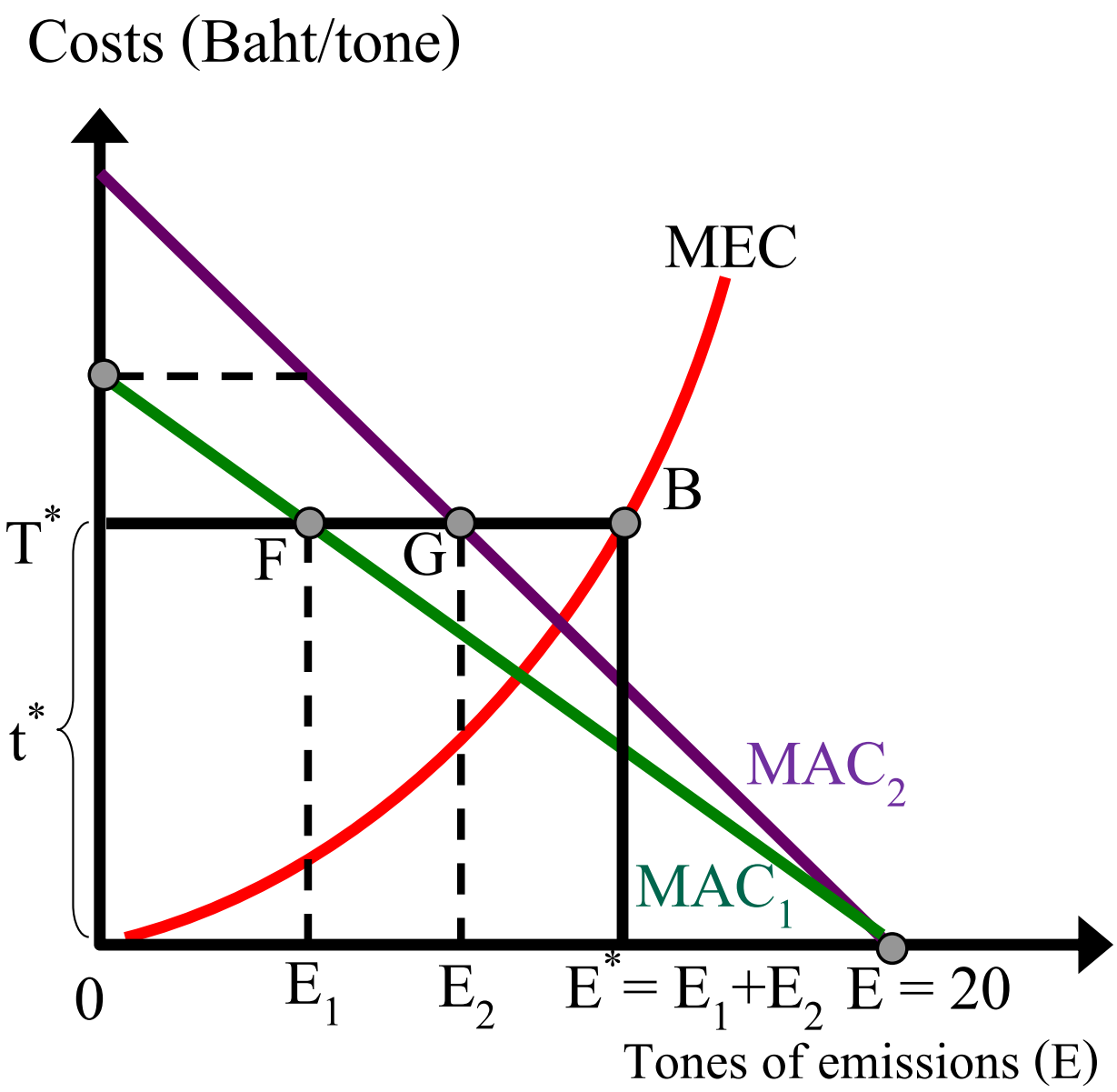
The optimal emission level is at point E^* where MEC = MAC

The optimal carbon tax rate is $t^* = MEC(E^*)$

A carbon tax and market failure from externalities

- Since the size of the MEC at the optimal $E^* = 0T^*$, the optimal carbon tax rate should be = t^* which is the height of MEC at $MEC(E^*) = MAC(E^*)$
- At the given tax rate, if the firm still emits GHGs = 20 tones, the firm must pay tax = area $0T^*GE$ which costs more than abating the emission by the firm
- For instance, at point C where the firm abate 5 tones (E = 20-5 = 15), the $MAC(5) = CI < t^*$
- If the firm continues to abate until MCA = t^*, it will save. = area EBG
- The tax will induce the firm to automatically abate and has emission = E^* which is the the optimal one

Effects of a carbon tax on multiple sources of emissions



- $MAC_T = MAC_1 + MAC_2$
- The optimal emission level is at point B where $MEC(E^*) = MAC_T(E^*)$
- The optimal carbon tax rate is $MEC(E^*) = t^*$
- Firm 1 emission E_1, abatement = $20 - E_1$ Firm 2 emission E_2, abatement = $20 - E_2$
- The tax encourages the efficient firm to abate more

Additional consideration

- CO_2 is one of the GHGs. May need to consider other GHGs by calculating in carbon dioxide equivalent units
- Atmospheric Lifetime of many GHGs are very long
  - The optimal emission and tax rate need intertemporal optimization
  - The size of MEC varies with the accumulation of GHGs, so the optimal tax rate may need to be increased over time until it reach the Steady State Equilibrium

Additional consideration

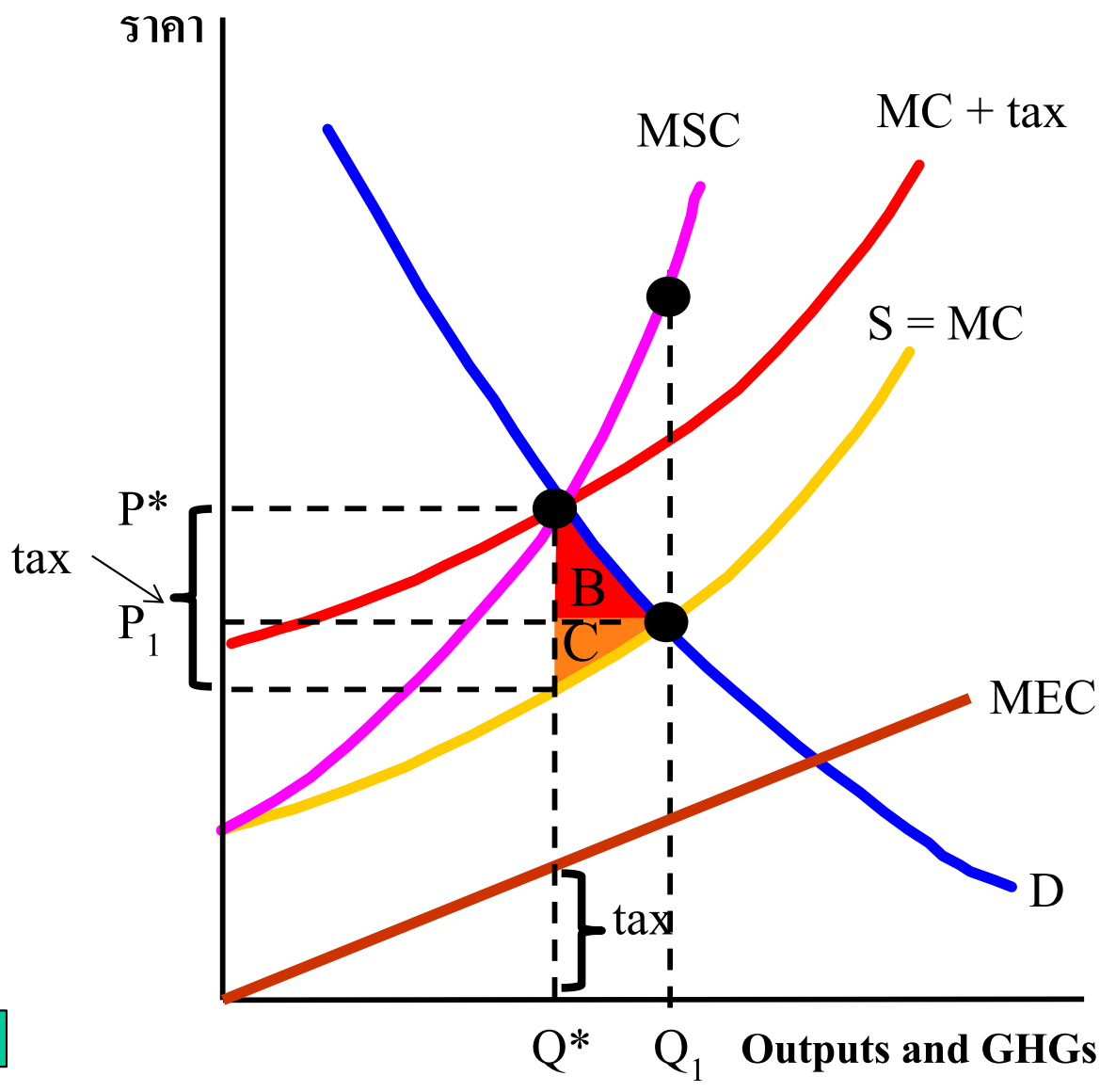
- GHGs are transboundary pollution where the impacts depend on the world accumulation of GHGs, not one individual emission
  - The optimal GHGs and tax rate should be done at the global level or to at the point where

    Global MEC = Global MAC
- Thus, the actual carbon tax rate are not normally set at the optimal one, but set at the rate that will decrease carbon emission up to a certain target

Pros and cons of carbon taxes: Pros

- A carbon tax can correct the distortion created by the negative externalities of carbon emissions
- Generates double dividend: carbon taxes can both reduce pollution (the first **dividend**) and reduce the overall economic costs associated with the **tax** system by using the revenue generated to displace other more distortionary taxes (e.g., VAT, income taxes) that slow economic growth (the second **dividend**)
  - The use of tax revenue this way is called Revenue Recycling
  - Fiscal neutrality: a net-zero increase in overall tax burden

A carbon tax for solving market failure



- **ΔCS =**
- **ΔPS =**
- **ΔGR =**
- **ΔEX =**

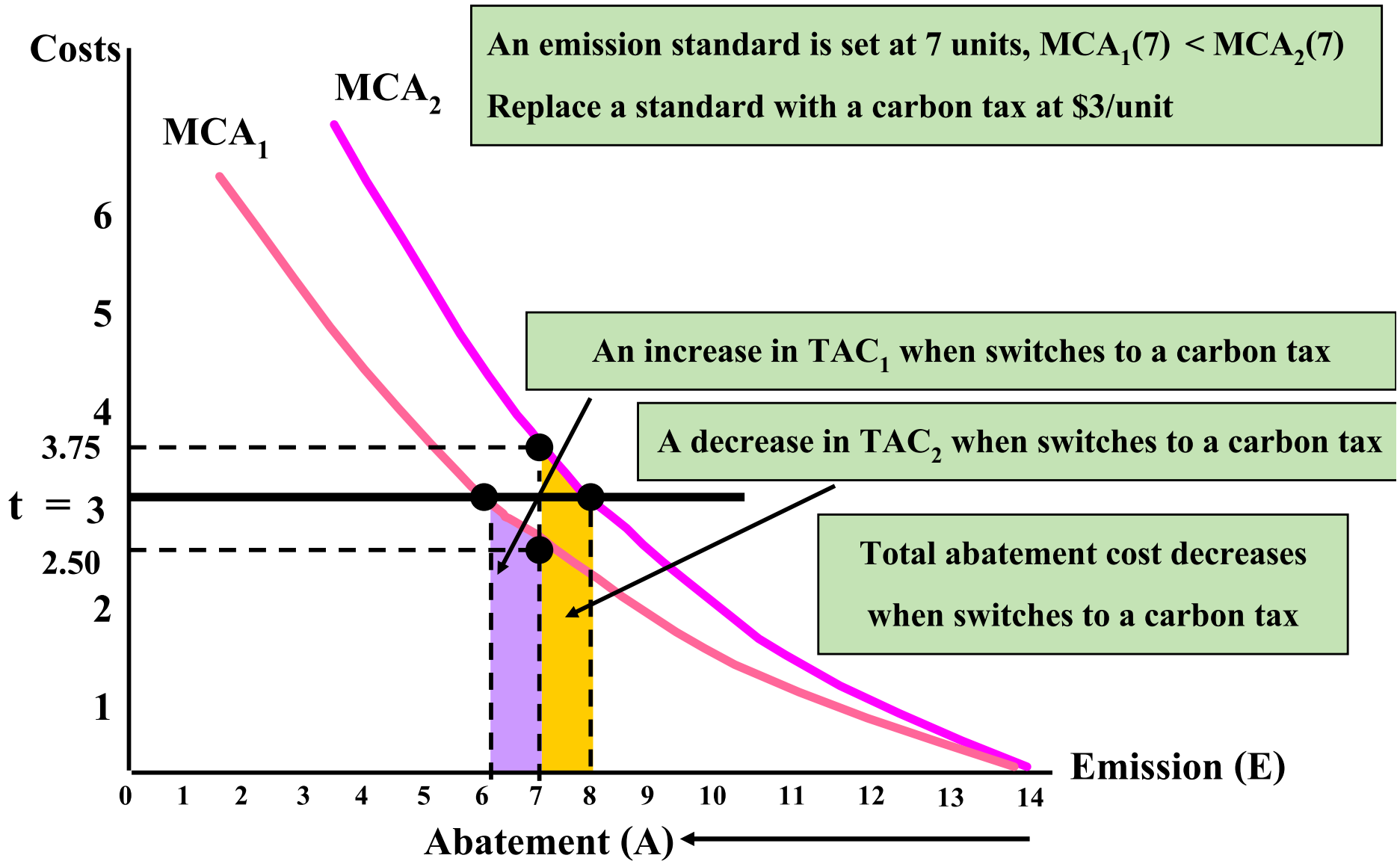
  Net =
- **An optimal rate of carbn tax rate correct the externality and market failure**
- **The social welfare is improved by the area of L, or the tax recovers all the losses of externalities**

Pros and cons of carbon taxes: Pros

- A carbon tax has the lowest compliance costs than a standard
- A carbon tax encourage the firm with lower MAC to abate more with less abatement costs,
- while the firm with higher MAC to abate less
  → total cost saving and lower total abatement costs

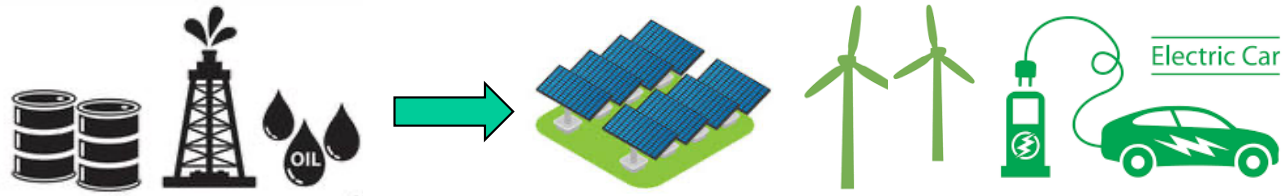
Slide 22

A carbon tax has lower abatement costs than a standard



Pros and cons of carbon taxes: Pros

- Encourage switching to low carbon energy sources to lower the tax burden in the short run
- Induce R&D and adoption of lower carbon technology
  - Standard only encourage adoption of the best available technology



- Tax rates are more flexible to be adjusted than standards

Pros and cons of carbon taxes: Cons

- Need accurate information of price and cross-price elasticities for calculating the appropriate tax rates
  - Adjusting the rates to correct for the errors
- The rates may be too high if used on top of some existing regulations which can lead to deadweight losses
- Has higher political resistance
- It is a regressive tax since shares of energy consumption of the poor are higher than those of the rich
  - Should accompany by a lump-sum transfer to the household or has a minimum allowance for low income groups

Pros and cons of carbon taxes: Cons

- May affect the international competitiveness since the tax increase the relative costs and prices
  - Harmonization of tax rates among similar countries to level the playing field
  - Use fiscal neutrality scheme to cancel the tax burdens