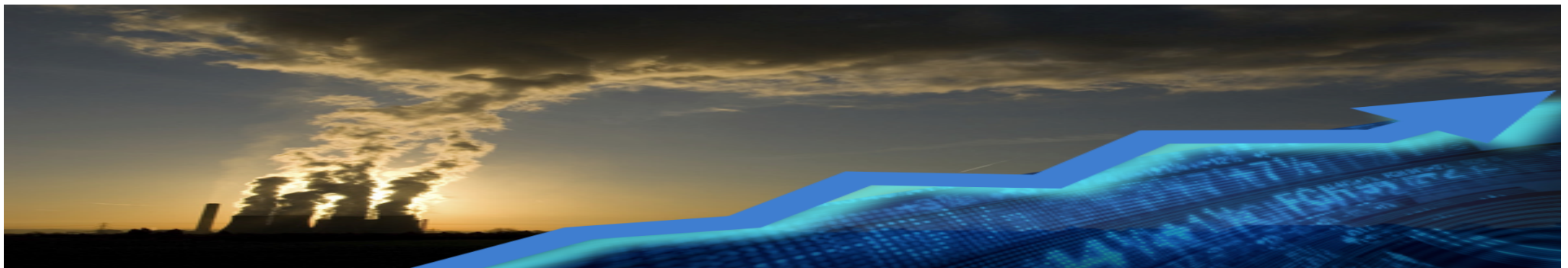


Carbon Market

EE 376

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Outline



- Carbon emission permits and carbon market
- Demand and supply of Carbon emission permits
- Equilibrium of carbon market
- Comparison of carbon taxes and carbon market
- Clean Development Mechanism (CDM)

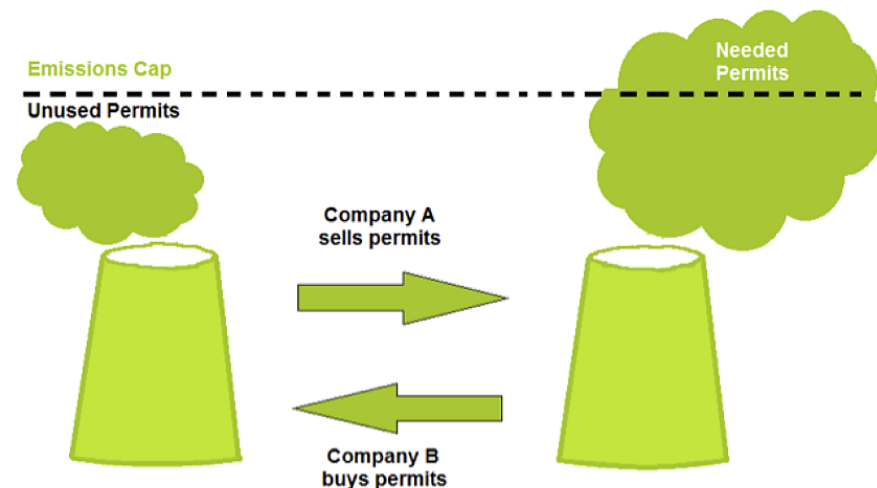
Carbon emission permits and carbon market



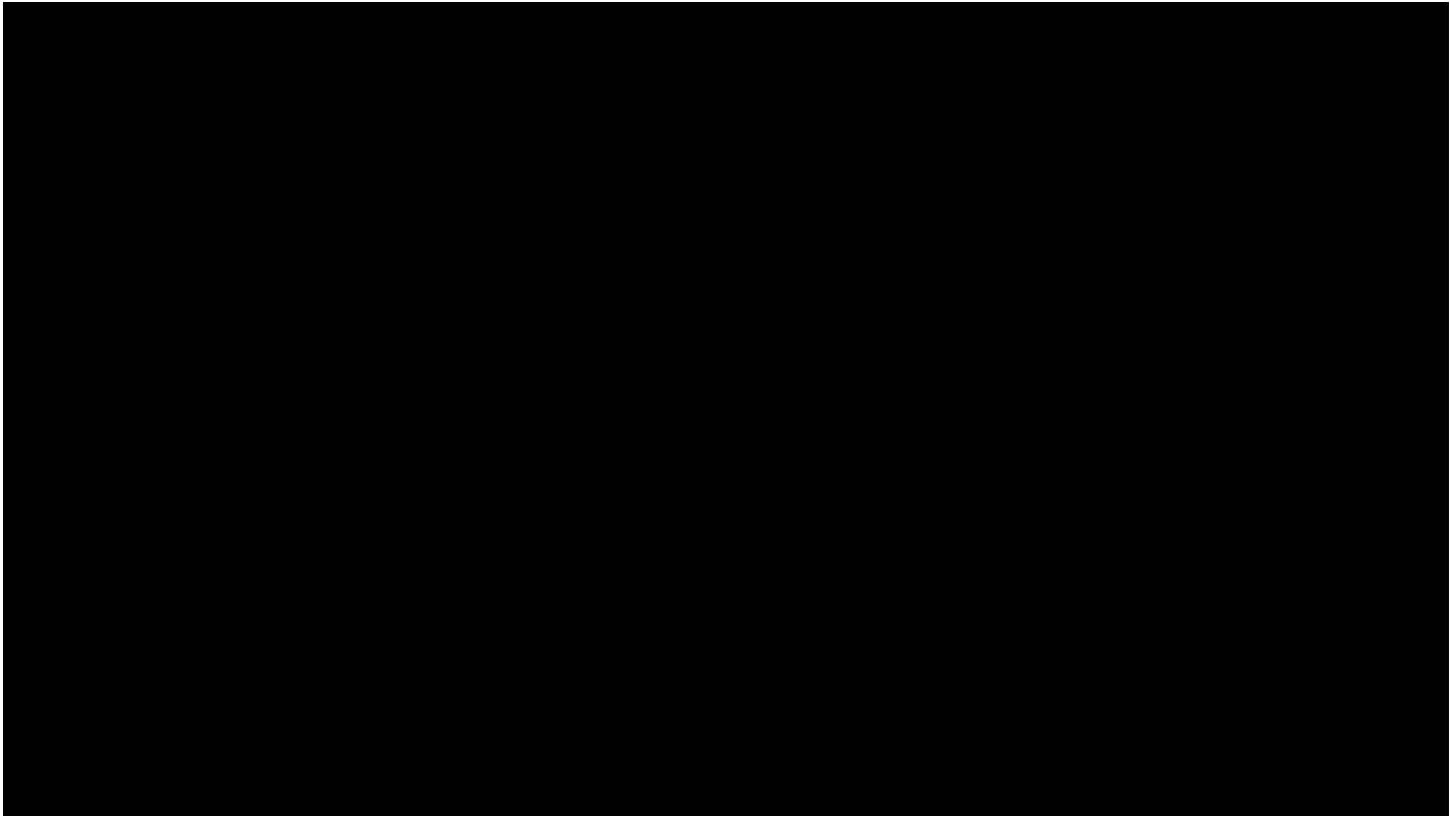
- Carbon emission permits or carbon allowance is the amount of carbon dioxide equivalent (tCO_2e) that the permit holder can use for emission or trade in the carbon market
- A Cap-and-Trade System or Emission Trading System (ETS) or Carbon Market is one of the carbon pricing system that can be used to mitigate GHGs by limiting the maximum amount of emission, then converts them into transferable permits or allowances

Carbon Market

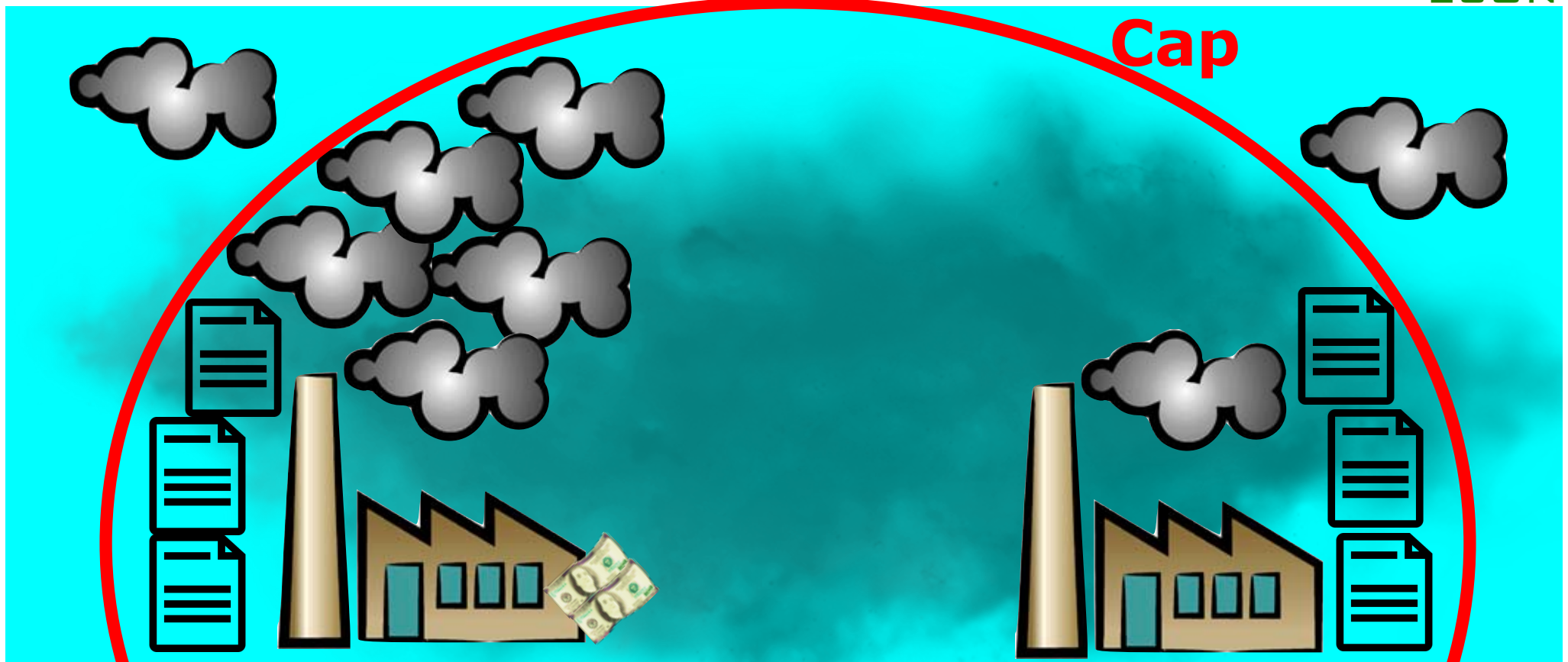
- A carbon permit is the way to define the property rights for clean atmosphere which is normally a common property and open to any one to access
- The allocated carbon permit change the common property to private property that can resolve the tragedy of commons



The EU Emissions Trading System (EU ETS)



How does the carbon market work?



- The cap changes CO₂ emissions to valuable goods
- Less polluted firms can earn revenue from selling the un-used permits, while the more polluted firms need to buy the insufficient permits

Carbon market

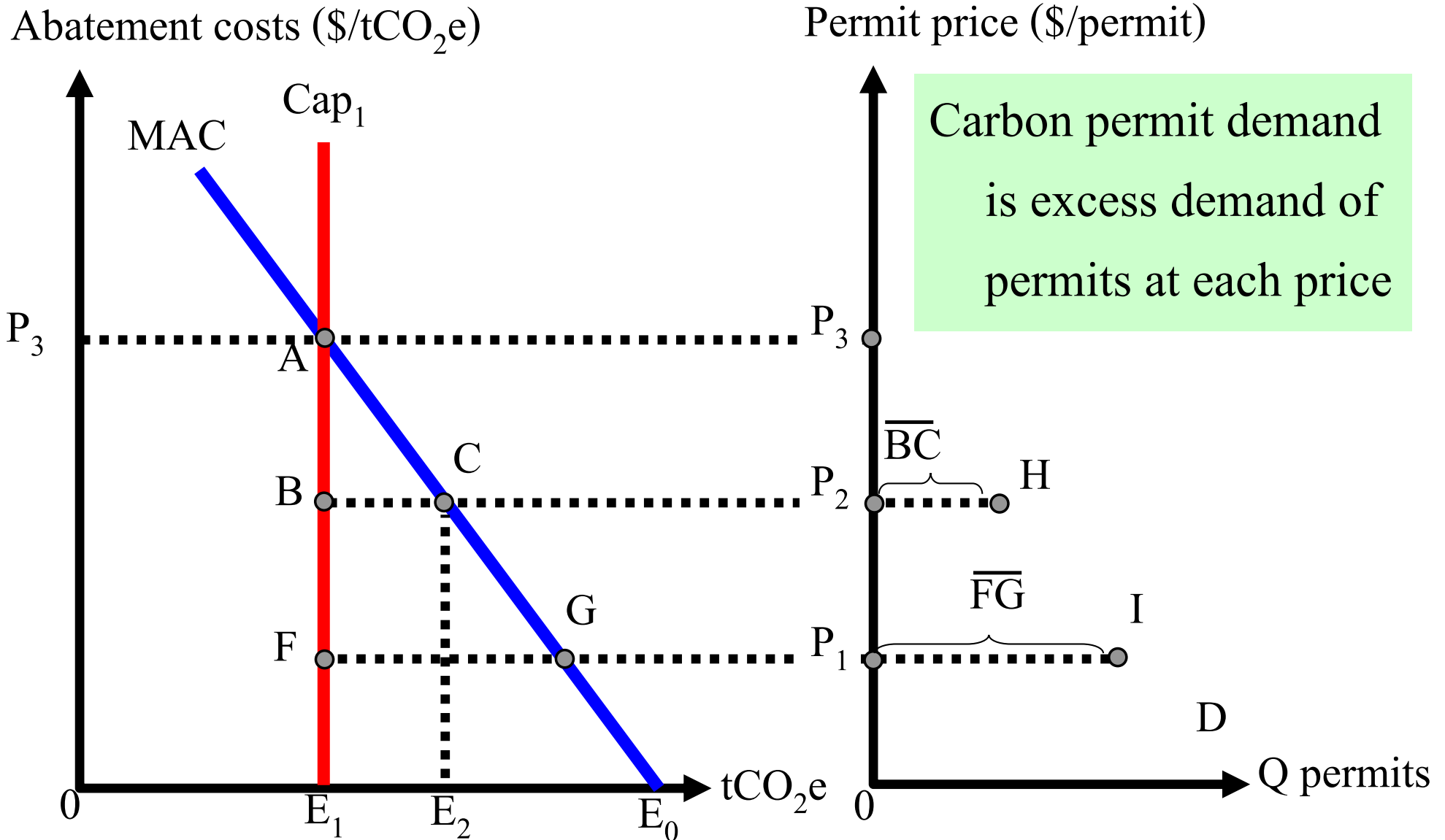


- Any firms that release emissions more than their available permits must buy the extra permits (demand) from the firms that has left over permits (supply)
- Since the total CO₂ emissions is decreased or capped, the carbon permits is forced to have a price that has an opportunity cost
- The opportunity cost of carbon emission under this system is the way to internalize the externalities of carbon emissions



Demand and supply of carbon permits

Derivation of the demand for carbon permits



Derivation of the demand for carbon permits

- The the left panel shows the MAC curve of a firm
- Let E_0 be the initial total CO₂ emissions of this firm
- Assume that the government allocate carbon permits as a free allowance to this firm at $E_1 < E_0$ given by line Cap₁
- This firm can release emission up to E_1 without any payment
- Since the available permits is less than the total emission, this firm must abate all the remaining $E_0 - E_1$ with the total abatement costs = area AE_0E_1 and the

$$MAC = P_3$$

Derivation of the demand for carbon permits

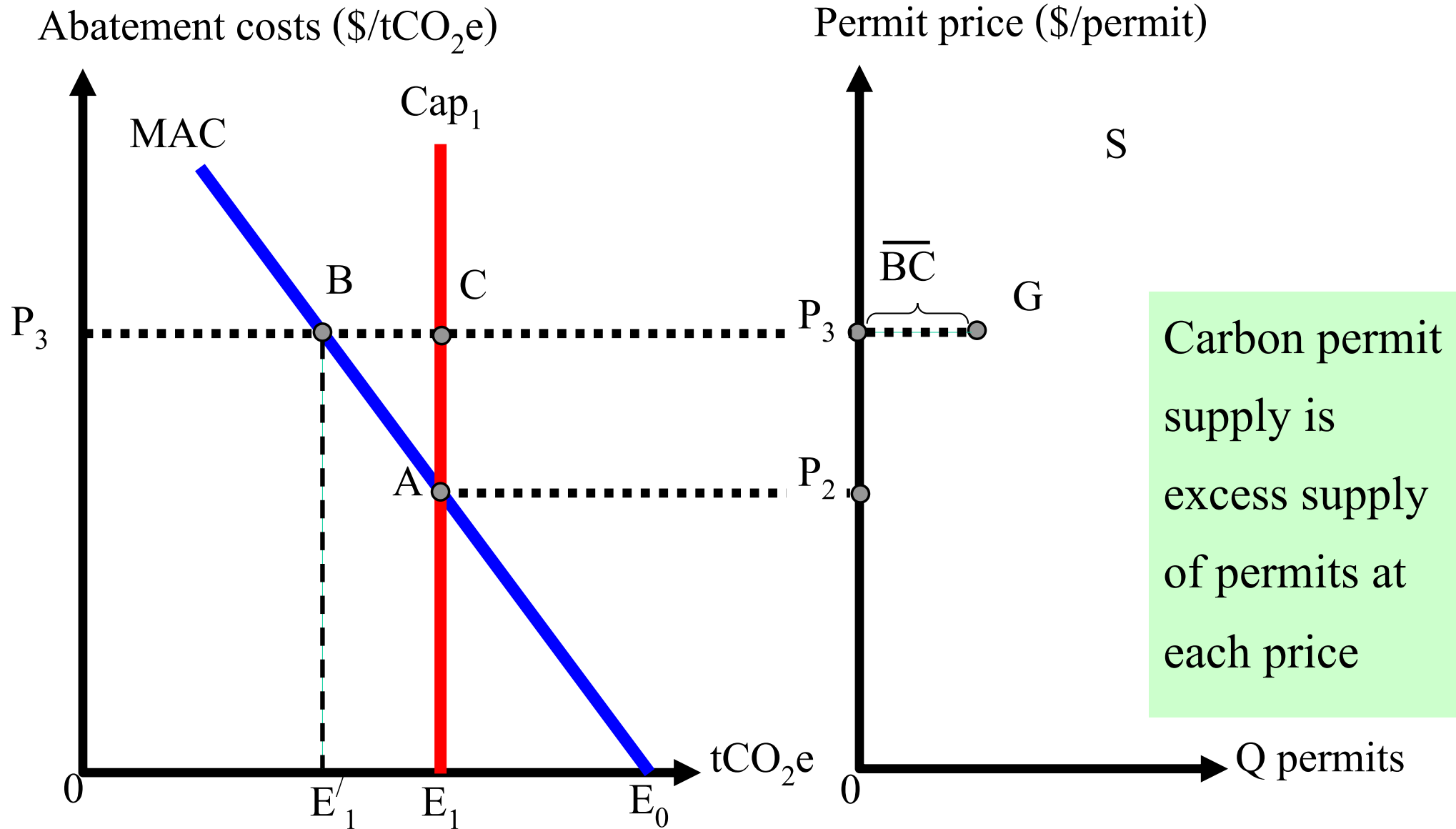


- It can buy more permits from the market if the permit price is lower than its marginal abatement costs
- Assuming 1 unit of permit allows 1 tCO₂e emission
- If the price is at P₃ which is equal to the MAC at E₁, this firm would have no reason to buy any extra permits
- It means that at P₃, the demand for permits from this firm is zero unit and can be represented by point P₃ on the right panel

Derivation of the demand for carbon permits

- If the permit price is at P_2 , this firm can buy permits equals to $E_2 - E_1$ (or \overline{BC}) at a cheaper cost than abating by itself and this will save the cost = area ABC
- At P_2 it should buy \overline{BC} units of permits. The size of the demand is represented by point H on the right panel
- Similarly, at P_1 , the firm should buy FG units of permits, represented by point I on the right panel
- Connecting all those points, P_3 , H, and I, gives D curve
- The demand curve is the excess demand of permits (the gap between the MAC and Cap) at each market price

Derivation of the supply of carbon permits



Derivation of the supply of carbon permits



- Assume that the government allocate carbon permits at $E_1 < E_0$ given by line Cap_1
- Line Cap_1 intersects MAC at point A at price P_2
- If the price is at P_2 , this firm will use up the permit and will not abate the emission any further or zero supply
- At P_3 , if the firm abate $E'_1 E_1$ tonnes more, equal to the length \overline{BC} , and use this remaining permit to sell
- The additional total abatement cost = area $AB E'_1 E_1$, but the revenue from selling permit is = area $BC E'_1 E_1$ with a profit = area ABC



Derivation of the supply of carbon permits

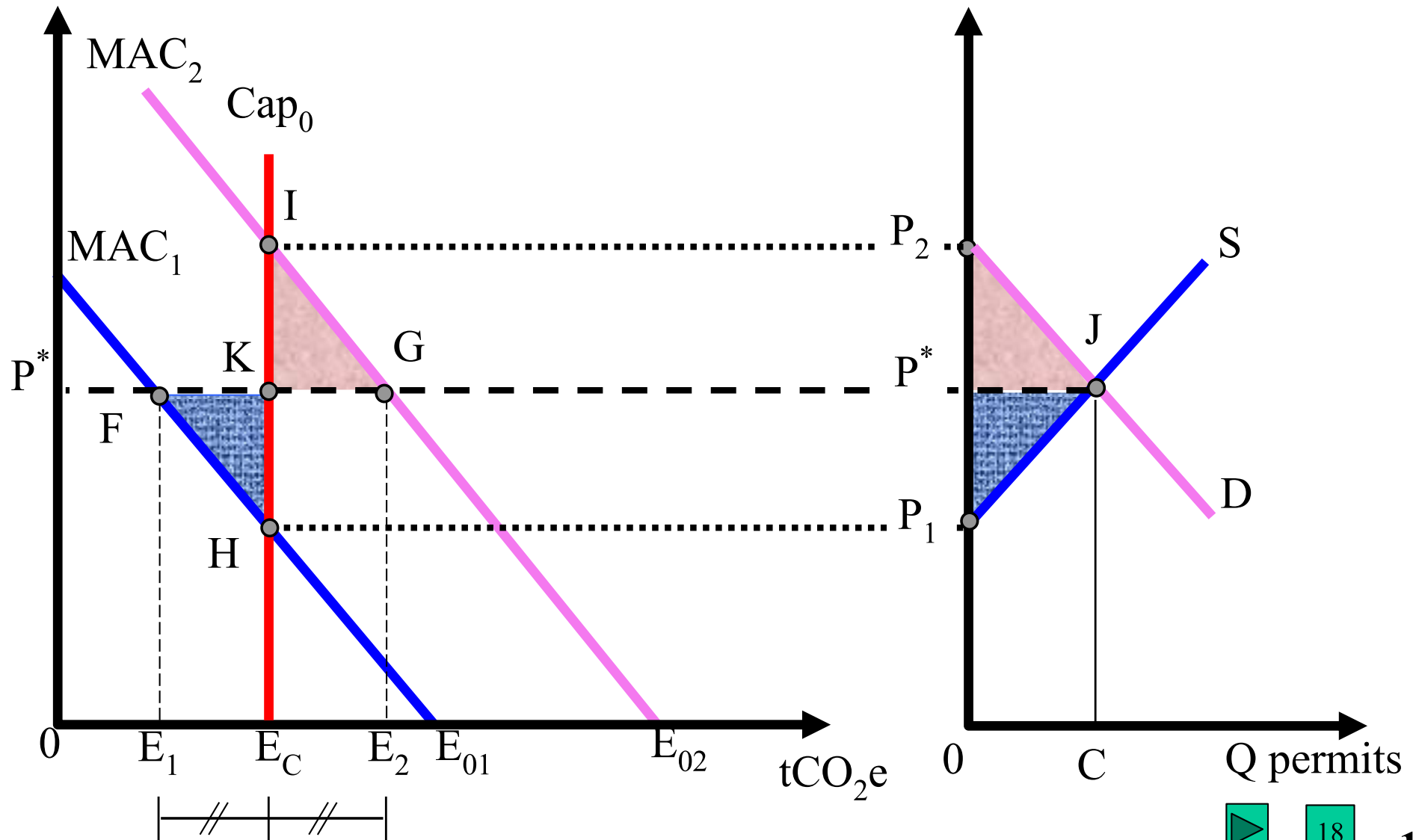


- Plotting the amount of supply of permit \overline{BC} on the right panel gives point G
- Connecting G with P_2 yields the supply curve S
- The supply curve of permits is the excess supply of permits (the gap between the MAC and Cap) at each market price level

Carbon Market Equilibrium

Abatement costs (\$/tCO₂e)

Permit price (\$/permit)



Carbon Market Equilibrium



- Assume that there are 2 firms with MAC_1 and MAC_2 and the government gives free allowances for both firms equally at E_C given by line Cap_0
- Firm 1 has a lower MAC with left over permits and the supply curve S , while firm 2 has a higher MAC with insufficient permits and demand curve D
- The carbon market equilibrium is at point J . The equilibrium price = P^* and equilibrium quantity = C
- Note that at P^* , $E_1 E_C = E_C E_2 = 0C$

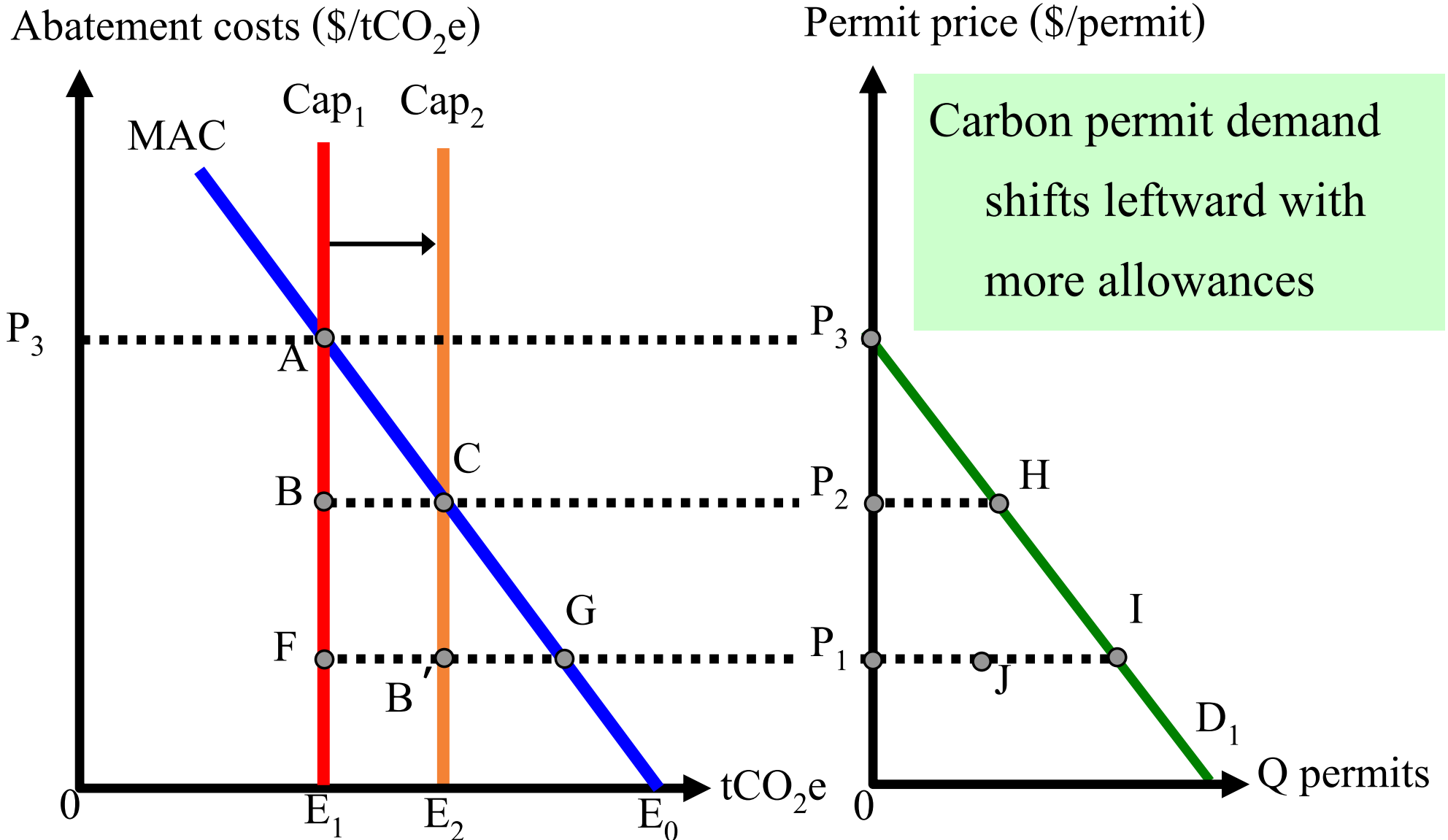


Carbon Market Equilibrium



- Firm 1 sells carbon permits and receives $= E_1 F K E_C$ but pay abatement costs $= E_1 F H E_C$ with a producer surplus $= F H K$ on the left panel or $= P^* J P_1$ on the right
- Firm 2 buys carbon permits and pays $= E_C K G E_2$ which is cheaper than paying abatement cost $= E_C I G E_2$ and saves $= G I K$ which is the consumer surplus shown on the left panel or $= P^* J P_2$ on the right

Shifts in demand for permits by changes in allowances



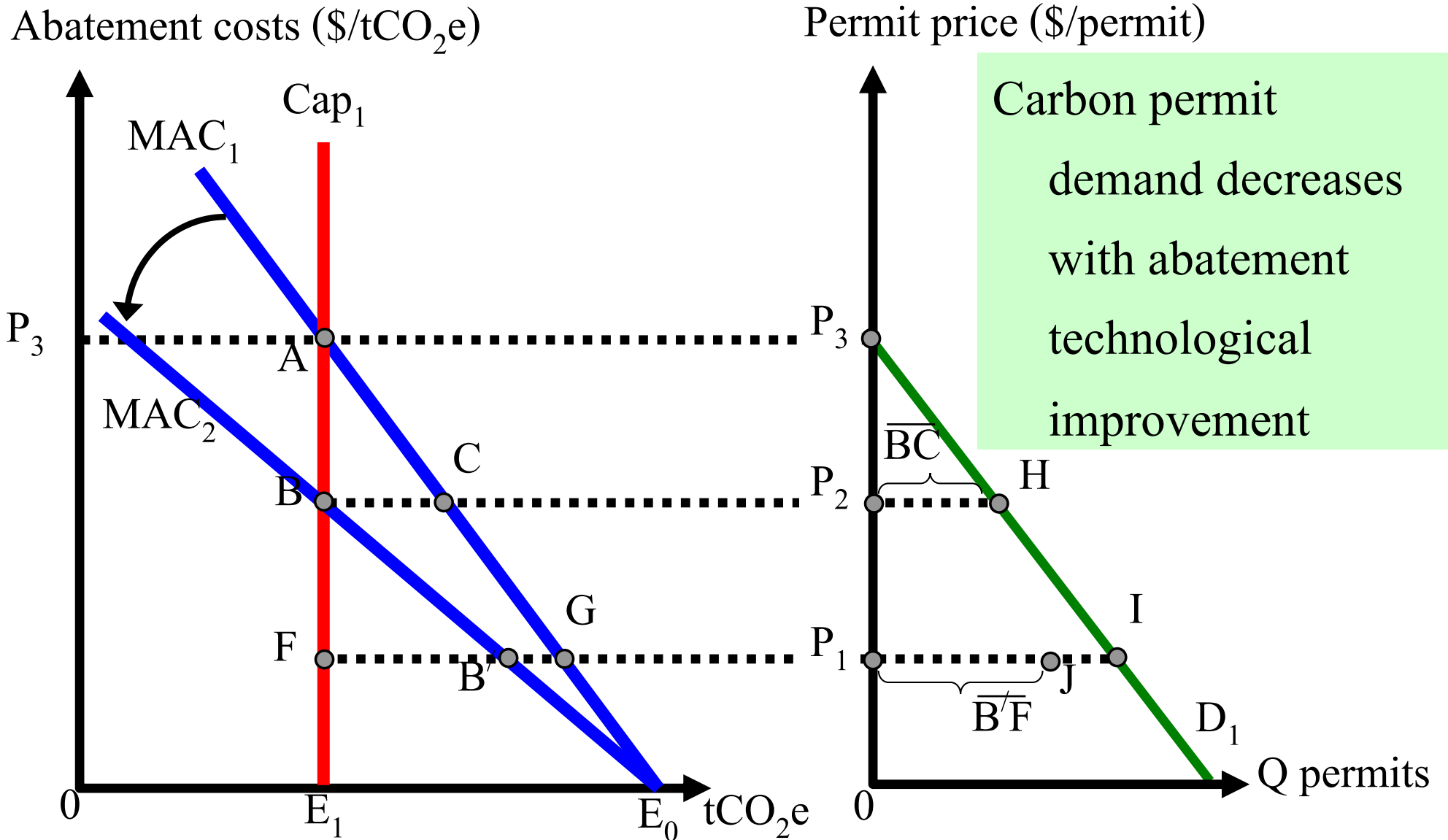
Shifts in demand for permits by changes in allowances



- Suppose the government increases the free allowance from E_1 to E_2
- The line Cap_1 is shifted to Cap_2 as shown on the left
- Line Cap_2 intersects MAC at point C and price P_2
- There is not excess demand for permits for any price level higher than P_2
- The demand for permits is shifted leftward to D_2
- The demand is less with more allowances



Shifts in demand for permits from improvement in abatement technology



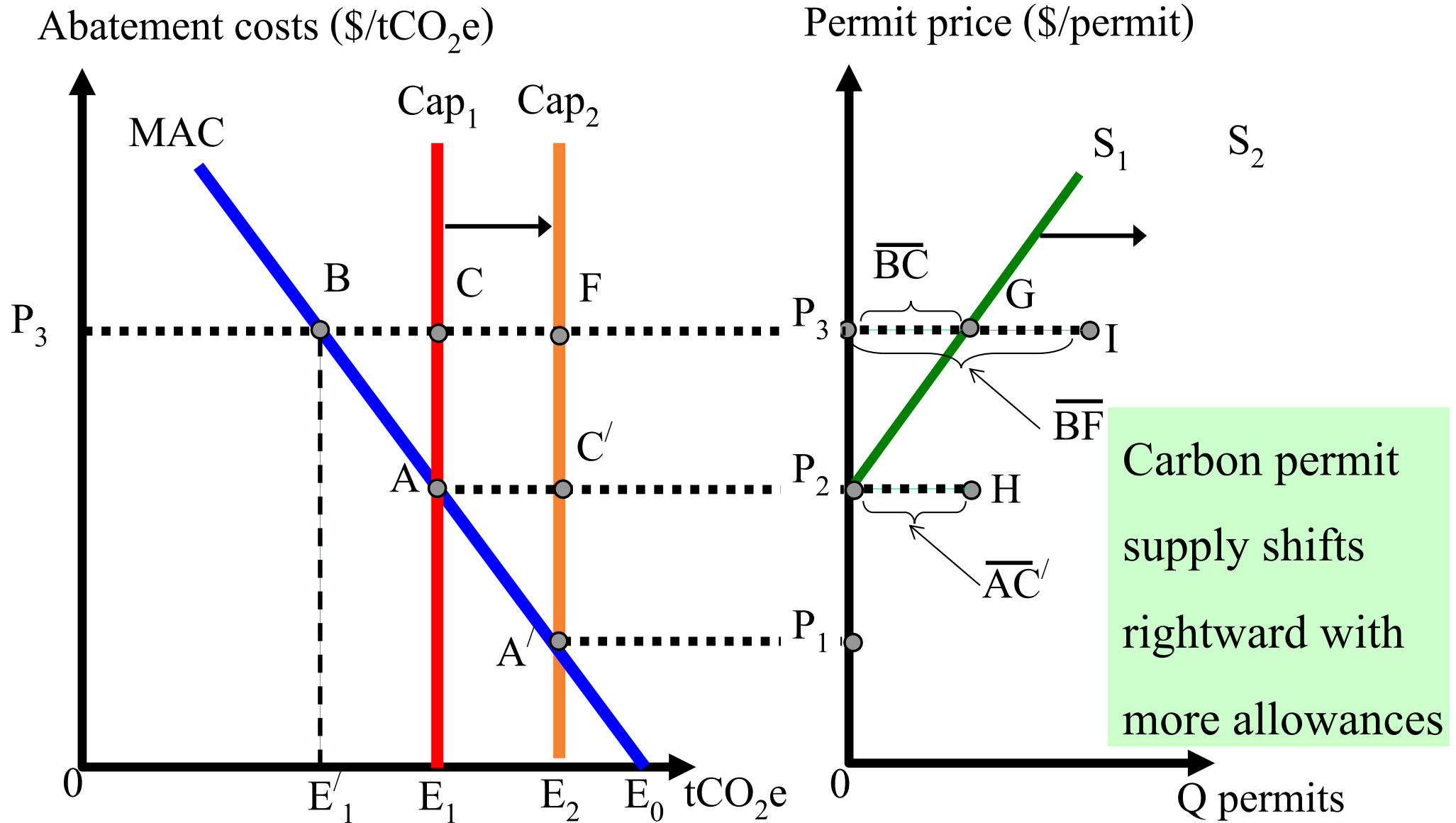
Shifts in demand for permits from improvement in abatement technology



- If the abatement technology is improved, the MAC curve will be flatter or rotate from MAC_1 to MAC_2
- The excess demand for permits D_2 will have the vertical intersect at P_2 instead of P_3 and the slope will be flatter compared to the slope of the initial D_1
- The abatement technological improvement decreases the demand for carbon permits
- Question: What if the firm develops or adopts low carbon technology, how will happen to the demand curve?



Shifts in supply of permits by changes in allowances



Shifts in supply of permits by changes in allowances



- Suppose the government increases the free allowance from E_1 to E_2 . Cap_1 is shifted to Cap_2
- The firm can release more emissions up to E_2 with no cost
- The supply of permits starts at point P_1 instead of P_2
- At P_2 excess supply = $\overline{AC'}$ corresponding to point H while at P_3 excess supply increases to \overline{BF} (point I)
- Connecting P_1 , H, and I, yields the new supply S_2
- The supply of permits is shifted rightward to S_2
- The supply is more with more allowances

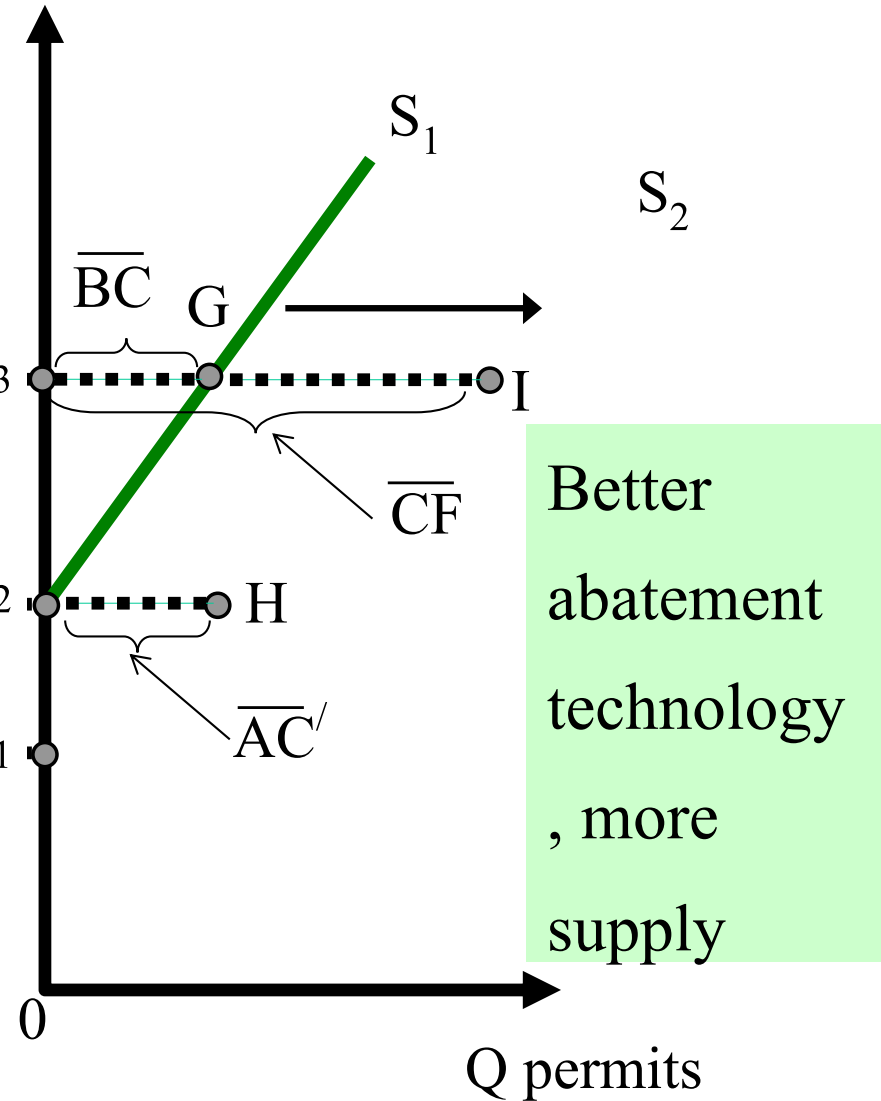
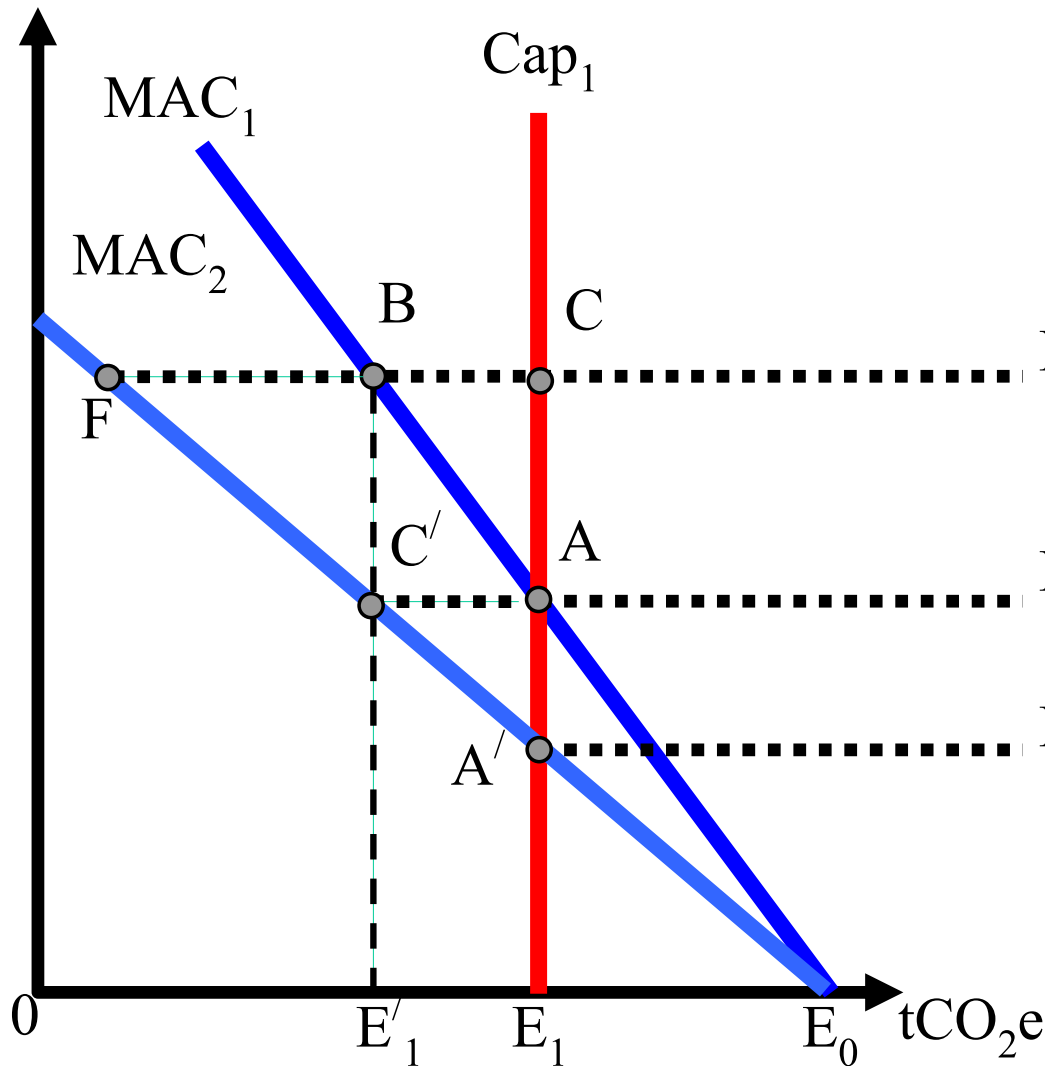


Shifts in supply of permits from improvement in abatement technology



Abatement costs (\$/tCO₂e)

Permit price (\$/permit)



Better
abatement
technology
, more
supply

Shifts in supply of permits from improvement in abatement technology



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- The abatement technological improvement increases the supply of carbon permits
- Question: What if the firm develops or adopts low carbon technology, how will happen to the supply curve?



Carbon market helps decreasing compliant costs



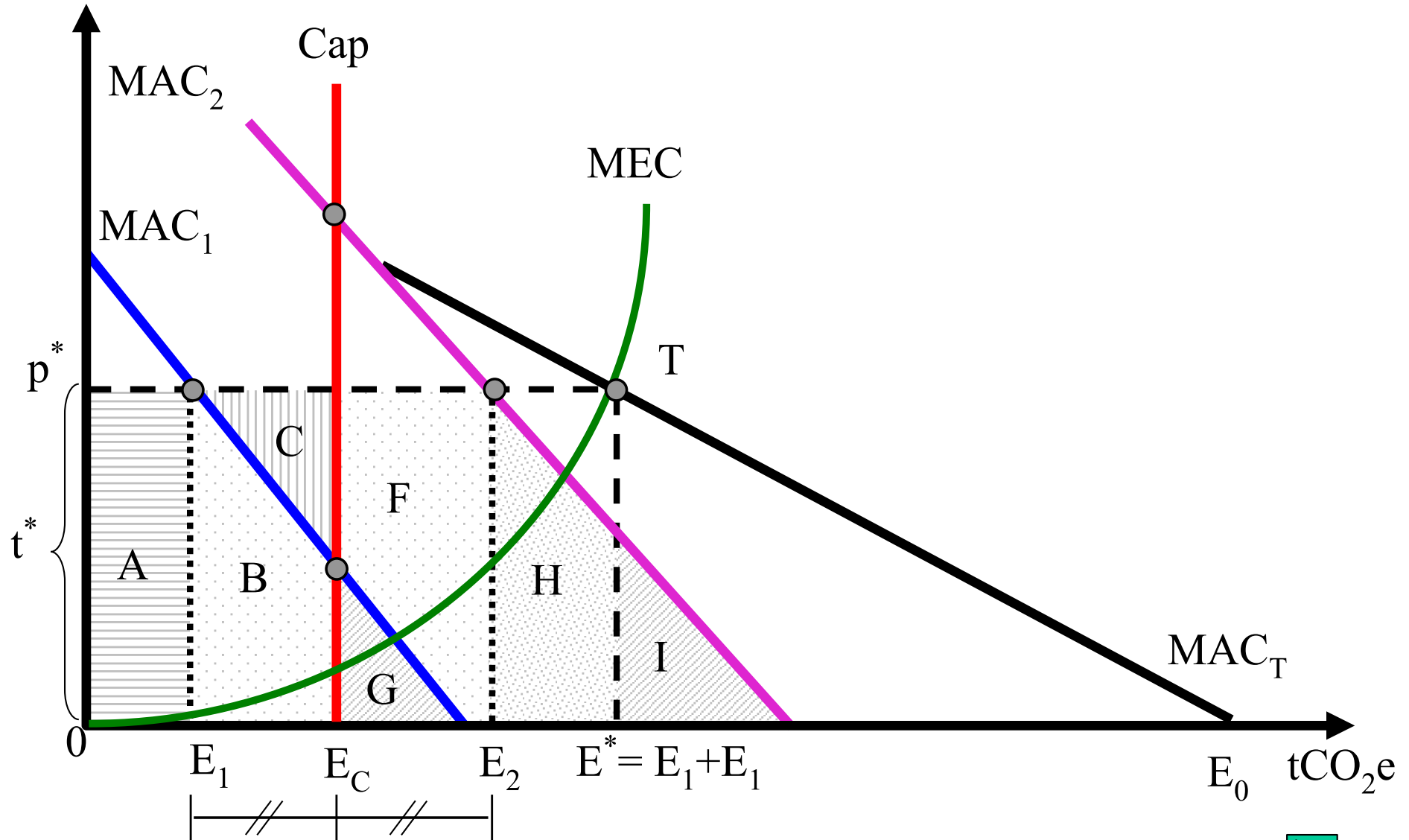
Non-Market	Firm	Emission	Abatement	Cost	Total Cost
	A	5	5	10	50
	B	5	5	5	25

Assumptions: $MAC_A = 10$, $MAC_B = 5$, $E_A = E_B = 10$, Allowance = 5, $P = 7$ /credit

Market	Firm	Emission	Abatement	Abatement costs	Excess demand	Cost of credits	Total costs
	A	8	2	20	$5 - 2 = 3$	21	41
	B	2	8	40	$5 - 8 = -3$	-21	19

Carbon Tax vs. Carbon market

Abatement costs (\$/tCO₂e)



Carbon Tax vs. Carbon market



- Let MAC_1 and MAC_2 be the abatement cost curves for firm 1 and firm 2, respectively.
- Summing the two curves horizontally to get MAC_T which intersects the horizontal axis at E_0
- The optimal emission level, E^* , is at point T where $MAC_T = MEC$



Carbon Tax vs. Carbon market



- Under a carbon tax system, the optimal tax rate should be set at t^* which is the height of MEC at E^*
- Firm 1 will abate until $MAC_1 = t^* = P^*$ and release E_1 incurs an abatement cost = $B + G$ and pay tax = A or the total costs = area $B + G + A$
- Firm 2 will abate until $MAC_2 = t^* = P^*$ and release E_2 incurs an abatement cost = $H + I$ and pay tax = $A + B + C + F + G$ or the total costs = area $A + B + C + F + G + H + I$

Carbon Tax vs. Carbon market



- Under carbon market system that set the cap at E_C shown by line Cap
- The Cap intersect MAC_1 of firm 1 at a point lower than the intersection with MAC_2 of firm 2
- Firm 1 would be the one that has excess supply of carbon permits, while firm 2 would be the one with excess demand for carbon permits
- The carbon market equilibrium is established at price $= p^*$ which makes $E_1 E_C = E_C E_2$

Carbon Tax vs. Carbon market



- Firm 1 will abate $E_1 E_C$, release E_1 , and sell the remaining permits to firm 2 which exceeds the allowance by $E_C E_2$
- Firm 1 incurs abatement costs = $B + G$
- Firm 2 incurs abatement costs = $H + I$
- Total abatement costs = $B + G + H + I$
- Total emissions by both firms = $E_1 + E_2 = E^*$ which is the optimal emission level
- Either carbon tax or carbon market system can achieve the same optimal emission level.

Carbon Tax vs. Carbon market



- Carbon market, as a quantity measure, can control total emissions more exact than a carbon tax system, as a pricing measure, which the emission results may vary depending on the economic conditions
- On the other hand, carbon market may end up with volatile carbon pricing depending on the economic conditions, while the carbon tax is a price base measure which remain the same

ราคา CER ของ the European Emissions Trading ช่วง 2010-2012



Price



European Energy Exchange, Certified Emission Reductions Futures

Carbon Tax vs. Carbon market

- **Carbon Taxes: price measures, stable price with uncertain emissions**

- **Adjust automatically with economic conditions and has unchanging incentive for mitigation**

- **Carbon market: quantity measures, exact emissions with volatile prices**



- **Not flexible by nature and need periodical adjustment: become more stringent during economic boom and become more lenient during recession**

Carbon Tax vs. Carbon Market



- **Lower administrative costs since the government can use the existing tax system to manage and deal with tax invasion**
- **Higher administrative costs as it need an allowance allocation system, permit exchange system, and verification system**
- **More resistance by the public**
- **Allocation of allowances may be distorted by politic and interest groups**
- **Under imperfect competition, the price of permits may be influent by dominant firms**

NO NEW TAX!

Carbon Tax vs. Carbon market



- A carbon market does not require the abatement costs information and elasticities. The market can determine the price and abatement levels automatically after setting the total cap and allowances are allocated, while a carbon tax need accurate information
- A carbon market has irregular impacts on mitigation: more stringent during economic boom but lenient during recession, the authority needs to adjust the cap to counteract. A carbon tax has unchanging incentive for mitigation

Carbon Tax vs. Carbon market



- A carbon tax has less administrative costs since it can rely on the existing tax system to operate and monitor
- A carbon market has higher administrative costs as it need to establish completely new allowance allocation system, a permit exchange system, and a verification system
 - Firms that buy permits from others have no incentive to check whether the selling firms under reports their emission or not
- A carbon tax system has higher public resistance

Carbon Tax vs. Carbon market



- Allocation of allowances may be distorted by politic and interest groups
- Under imperfect competition, the price of permits may be influent by dominant firms. For example, if there are too few buying firms, they may understate the price
- Both carbon pricing systems can affect the international competitiveness of the high carbon intensive industries while enhance the low carbon intensive industries
- Both carbon pricing systems can be used to defend against the border carbon adjustment used by foreign countries

Clean Development Mechanism



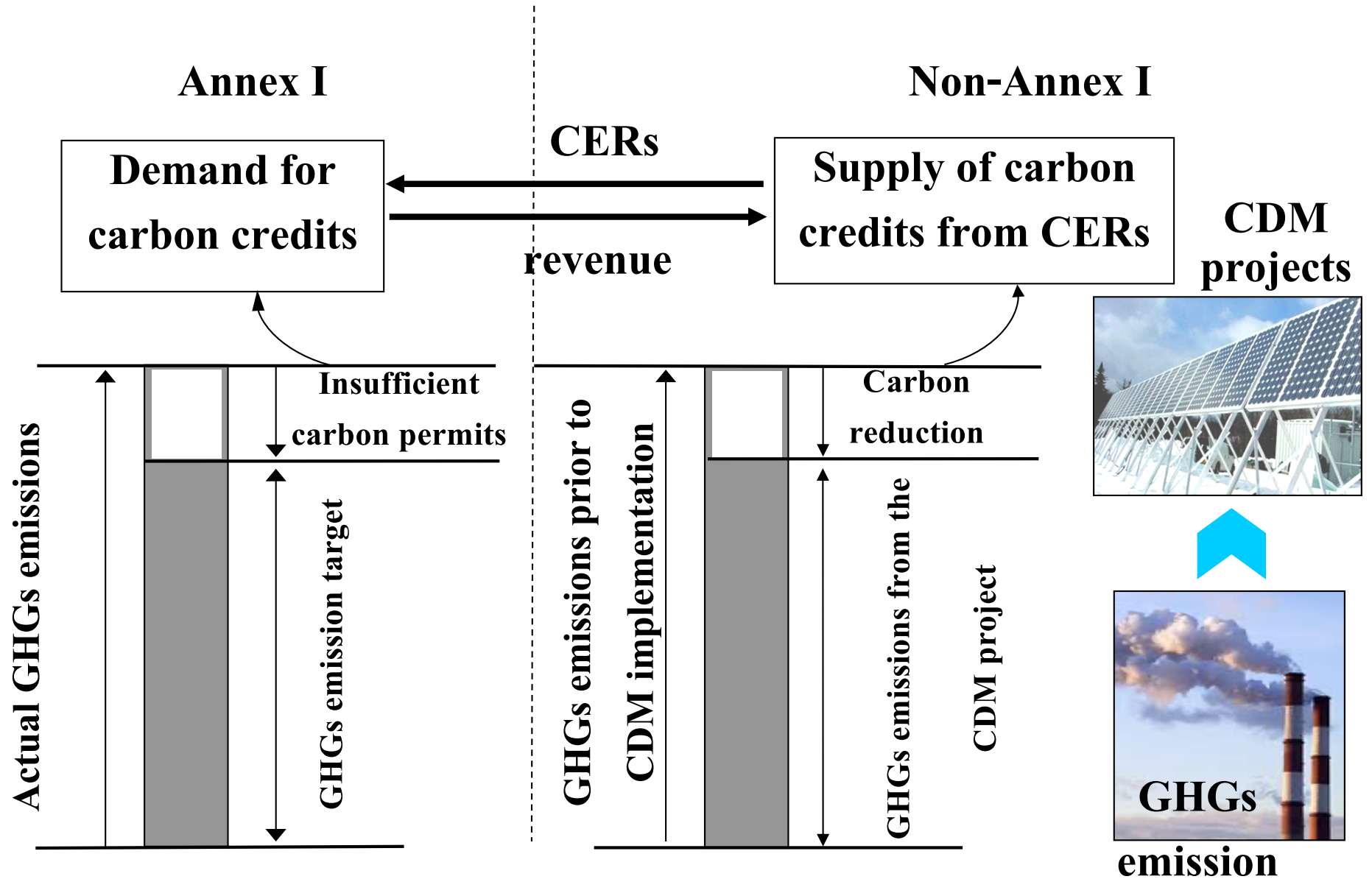
- Clean Development Mechanism (CDM) is a mechanism specified in Kyoto Protocol that creates cooperation between Annex I countries and Non-Annex I countries
- It encourages Annex I countries to assist emissions reduction projects of the Non-Annex I countries
- Annex I countries may buy carbon credits from the emissions reduction projects of the Non-Annex I countries that have been certified. These certified credits are called CERs

Clean Development Mechanism



- Certified Emission Reduction (CERs) are measured in tCO₂e units under Article 12 of the Kyoto Protocol
- The main objective of CERs is to help countries in Annex I to achieve their mitigation commitment easier (as they increase the supply carbon permits) while simultaneously encourage Non-Annex I countries to reach sustainable development goals

Concepts of CDMs



Concepts of CDMs



- The demand for CERs is generated by firms in the Annex I countries which release GHGs higher than what they have committed in the Kyoto Protocol (represented by the white block on top of the gray block on the left panel) which they can normally buy extra permits from within the Annex I group
- However, CDMs are created for more flexibility and for supporting Non-Annex I country toward the sustainable development goals and encourage them to join the mitigation efforts

Concepts of CDMs



- Non-Annex countries I may develop solar energy plant to substitute for petroleum sources which can lower the emission (shown by the white block on top of the gray block on the right panel)
- Such CDM projects that pass the certification process as CERs will turn in to supply of carbon credits that can be traded with firms in Annex I
- This can generate revenue for that countries as well as counting as emission reduction for that country's GHGs inventory (notice that the CERs are counted twice)

Conditions for CERs certification



- The CDM project that can be counted as CERs must be certified by the CDM Executive Board (CDM EB) when it satisfies 3 conditions:
 1. Voluntary: must be voluntary actions which are not parts of usual practices to satisfy rules and regulation
 2. Sustainable: must not be a temporary project which results in reductions in emissions in the long run
 3. 3. Additionality: must mitigate GHGs above-and-beyond the business-as-usual that would occur in the absence of the project activity.