

# An Alternative Approach to Establishing Trade-offs among Greenhouse Gases

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# Outline

- Global Warming
- Greenhouse gases
- Kyoto Protocol
- Global Warming Potentials
- Shortcomings of GWPs
- An Alternative approach based on CGE

# Global Warming

- Earth's climate is determined by complex interactions between the sun, ocean, atmosphere, land and living things.
- The composition of the atmosphere is important because certain gases absorb heat radiated from the Earth's surface (*Greenhouse effect*).

- Changes in the composition of the atmosphere alter the intensity of the greenhouse effect
- Human activities alter the balance.
- Raising concentrations of greenhouse gases are *intensifying* Earth's natural greenhouse effect.

- As a results, *the world is becoming warmer.*
- The global mean surface temperature has increased by over 1 °F (0.6 °C) during the 20<sup>th</sup> century.

# Impacts of Global Warming

- Increased warming
- Drought and flash floods
- Vulnerable ecosystem
- Water supply
- Secure food supply
- Sea-level rise
- And so on...

# Greenhouse Gases

- Naturally occurring greenhouse gases include water vapor, **carbon dioxide (CO<sub>2</sub>)**, **methane (CH<sub>4</sub>)**, **nitrous oxide (N<sub>2</sub>O)**, and ozone (O<sub>3</sub>).
- ***Human activities*** add additional quantities of these gases, thereby changing their global average atmospheric concentrations.

# Causes of Greenhouse Gases

- **CO<sub>2</sub>**
  - Combustion of fossil fuels, solid waste & wood
- **CH<sub>4</sub>**
  - Production/transportation of coal, natural gas or oil,
  - Decomposition of organic waste in landfills,
  - Raising of livestock and rice
- **N<sub>2</sub>O**
  - Fertilization, legume, and manure industry activities
  - Combustion of fossil fuels and waste.



# Kyoto Protocol

- In 1997, the first international agreement to **LIMIT EMISSIONS** was established in *Kyoto*, Japan.
- Solving GHG emission problem implies *reducing net emissions of GHG* and *stabilizing atmospheric concentrations* at acceptable level.

# Global Warming Potential

- GHG differ in their *ability to absorb heat* in the atmosphere.
  - CH<sub>4</sub> traps over 21 times more heat than CO<sub>2</sub>
  - N<sub>2</sub>O absorbs 310 times more heat than CO<sub>2</sub>
  - HFCs and PFCs are the most heat absorbent.

- GWP is the physical measure established to compare *emission equivalence of other gases to CO<sub>2</sub>*.
- GWP is a *quantified measure* of the globally averaged relative radiative forcing impacts of a particular greenhouse gas through a set of time horizons (see Table 1).

# Table 1. GWPs

|                  | Global Warming Potential (years) |     |     |
|------------------|----------------------------------|-----|-----|
|                  | 20                               | 100 | 500 |
| CO <sub>2</sub>  | 1                                | 1   | 1   |
| CH <sub>4</sub>  | 56                               | 21  | 6.5 |
| N <sub>2</sub> O | 280                              | 310 | 170 |

# Shortcomings of GWPs

- The *arbitrary choice of time horizon* for calculating cumulative radiative forcing.
- The *failure to incorporate damages and abatement costs*.
- GWPs assume that the *trade-off ratios remain constant over time*.

- GWPs assume that they are *independent of the ultimate goal*.
- Clearly, neither of these assumptions makes economic sense.

# Ideal Index

- The outcome of an analysis that minimizes the *discounted present value of damages and mitigation costs*.
- The alternative proposed extends beyond purely physical considerations in calculating trade-offs among gases

# MERGE

- The analysis is based on a CGE model called MERGE.
- A **M**odel for **E**valuating the **R**egional and **G**lobal **E**ffects of GHG Reduction Policies
- Model structure and specification will be discussed in the class.



- The CGE model calculate the *price of the various greenhouse gases*.
- These prices express how much one should be willing to pay to emit an additional ton of each gas.
- The trade-offs are then *relative prices of each gas*.

# Scenarios (Shock to CGE)

- The goal of climate policy is to limit the future increase in mean global temperature.
- Using MERGE, they identify an economically efficient strategy for staying within the limit (or ceiling)

- There are two scenarios
  - Temperature ceiling 2 °C and 3 °C in absolute temperature change.
  - Additional restriction – Decadal temperature change is limited within 10%

# The Prices of CH<sub>4</sub> and N<sub>2</sub>O relative to that of CO<sub>2</sub>

