Greenhouse Gases

Climate Change Impacts

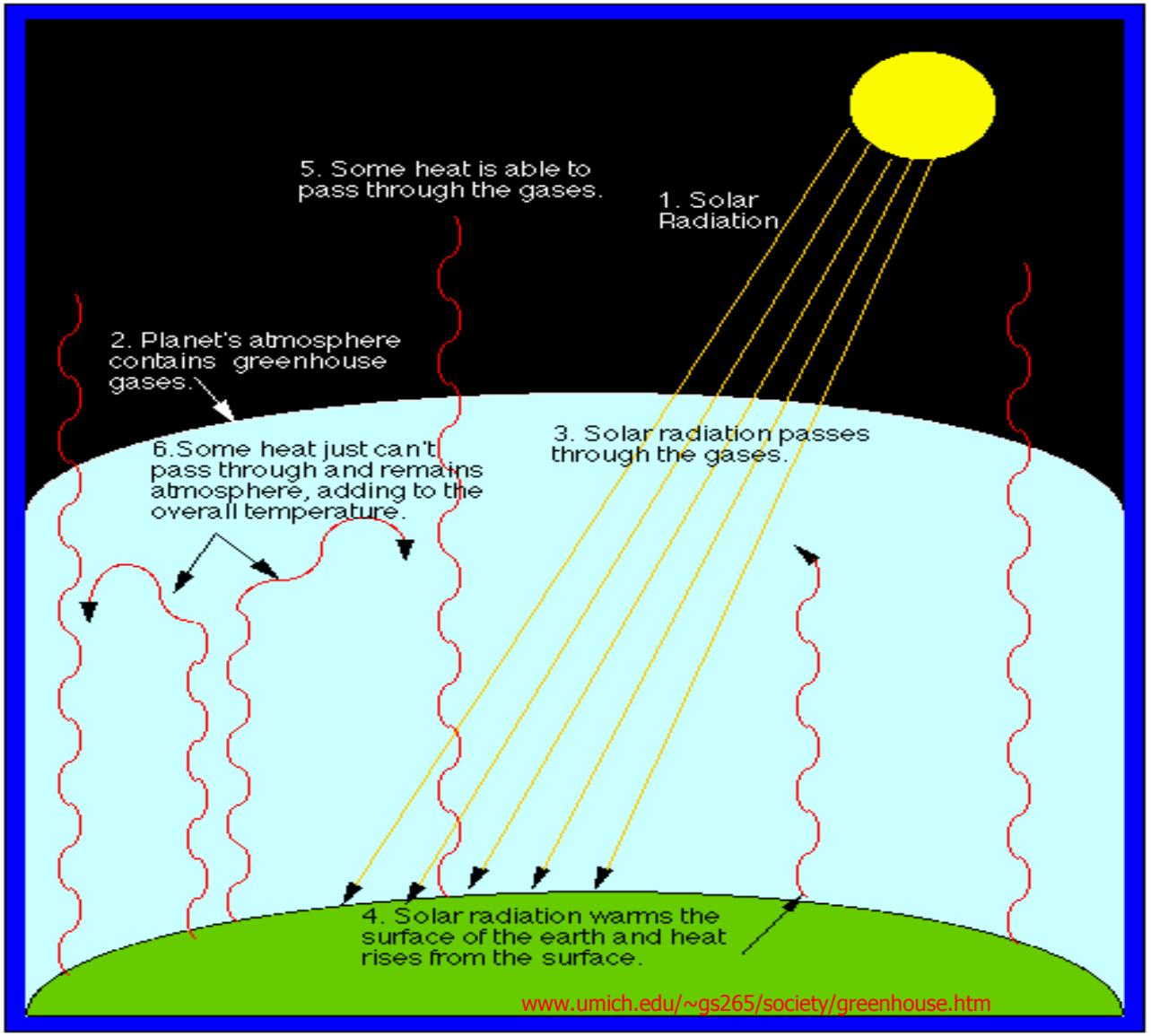
Emissions Reporting/Calculations

Federal and State Actions

November 10, 2009

PENC, Statesville, NC

Warming Mechanism



Key GHGs

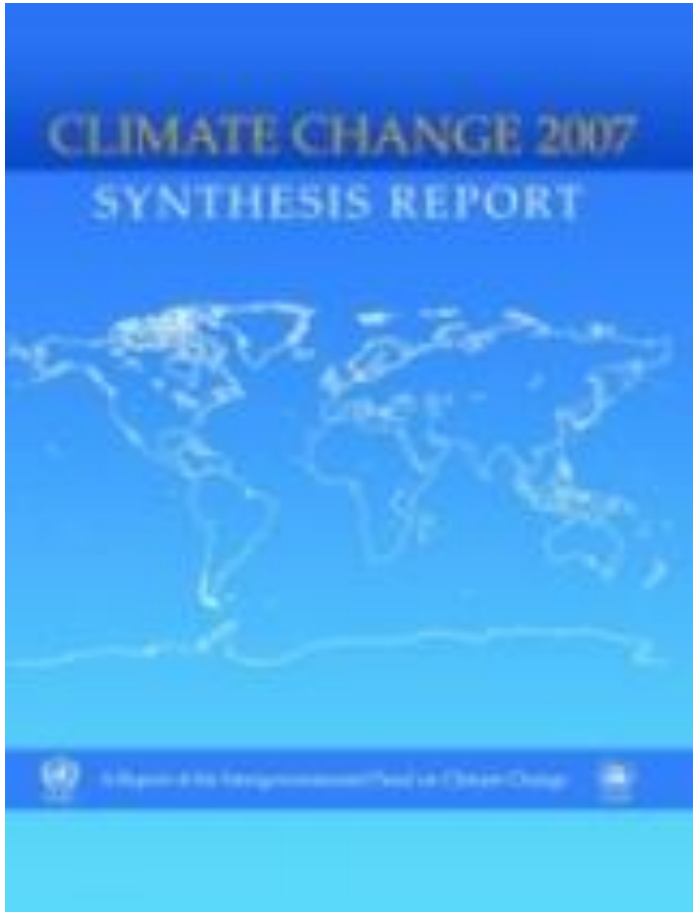
- **Carbon Dioxide (CO_2)**
- **Methane (CH_4)**
- **Nitrous Oxide (N_2O)**
- Sulfur Hexafluoride (SF_6)
- Perfluorocarbons (PFCs)
- Hydrofluorocarbons (HFCs)

- Other Fluorinated Gases

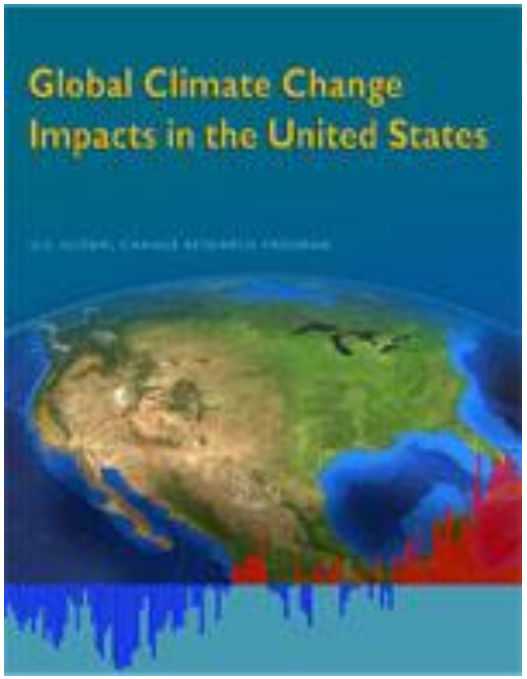
Other GHGs and aerosols have climatic warming effects

- CFCs, HCFCs other ozone depleters – Being phased out
  - HCFC-22 or "R-22" is a common example
- Water vapor – not considered an anthropogenic forcing agent of climate change
- Tropospheric ozone ("smog") – covered as a public health issue
- Black Carbon (light absorbing aerosols)- emerging as a potent warmer, comes from biomass burning, diesel exhaust, cooking with solid fuels

Climate Change Impacts: Major References



Intergovernmental Panel On Climate Change (IPCC), 4th Assessment Report, 2007



US Global Change Research Program (June 2009)

Pew Center on Global Climate Change (Jan 2009)

WORLD RESOURCES INSTITUTE

Summary of Climate Science: 2008

Greenhouse Gases (GHGs)- Impacts

- GHGs have experienced increasing levels -- CO_2 up from 280 ppm to over 380 ppm, and currently climbing at 2 ppm per year
- Global average temperature
  - Up by about 1.5ºF since 1900
  - Projected to rise another 2 to 11.5º F by 2100
- Global mean sea level rise
  - 1.7 mm/year over the past 100 years
  - Recent study (journal Geology) finds larger impact of 3.3 mm/yr in North Carolina
- Increase in ground-level ozone (component of smog)
- Bleaching of coral, and more ocean acidification
- Glaciers all over the world are receding faster than ever

Sea-level Rise and Salt Water Intrusion: Alligator River National Wildlife Refuge

Ditches promote salt water intrusion

Building oyster reefs can buffer ocean currents

Planting cypress trees and other salt-tolerent species can help ecosystems hold together

Emissions Reporting Concepts and Terminology

Metric Tons of CO_2 Equivalent (CO_2e)

GHG Emissions *usually* reported in <u>metric tons</u> of CO_2e

metric tons CO_2e = tonnes CO_2e = mtCO_2e= MT CO_2e

1 metric ton = 1000 kilograms = 1 megagram

1 metric ton = 1.10231 ton (short)
where, 1 short ton = 2,000 pounds

25,000 metric tons = 27,557 short tons

25,000 short tons = 22,680 metric tons.

CO_2e: Carbon Dioxide Equivalent

- CO_2 is the most abundant GHG – used as the basis for quantifying all GHGs
- GHG emissions are converted to the *equivalent amount of CO_2*, hence "carbon dioxide equivalent" or **CO_2e**
- Each GHG has a unique conversion factor for calculating CO_2e
- The conversion factor is called the Global Warming Potential, or GWP
- GWP incorporates both the heat-trapping ability and atmospheric lifetime of each GHG, and is used to develop comparable numbers by adjusting all GHGs relative to the GWP of CO_2.

Some GWPs

- CO_2: GWP = 1
- CH_4: GWP = 21
- N_2O: GWP = 310
- SF_6: GWP = 23,900
- HFCs and PFCs: multiple compounds, each has unique GWP
  - E.g., HFC-134a, GWP = 1,300

Converting GHG Emissions Into CO_2e

- Multiply amount of any GHG by its GWP to get CO_2e
- CH_4 has a GWP of 21
- 1 mt CH_4 x 21 = 21 mtCO_2e

If a landfill generates 1,080 short tons of CH_4 (= 1,191 mtCH_4) then it generates 25,000 mtCO_2e

CO_2e Emissions (metric tons)

Hybrid Car, 20,000 miles
4 mtons

truck, 20,000 miles
14 mtons

Reporting threshold for most facilities under EPA Reporting rule:
25,000 mtons/yr

One 500-MW coal-fired power plant:
3 million mtons/yr

NC GHG Inventory (2005): 192 million mtons

USA GHG Inventory (2007): 7,150 million mtons

Biogenic CO_2 Vs. Anthropogenic CO_2

- Biogenic CO_2 comes from combustion of biomass
- Biomass is non-fossilized, biodegradable **organic material** originating from **plants, animals, and micro-organisms**.
  - wood, landfill gas, digestor gas, animal fat, black liquor solids from pulp mill…
- Biogenic CO_2 tracked separately from anthropogenic CO_2
- CH_4, N_20, and the fluorinated gases are always anthropogenic

Direct, Indirect & Upstream Emissions

- "Direct emissions" refers to emissions from combustion devices and processes at a facility such as boilers, dryers, lime kilns, digesters, etc.
  - Includes fugitive emissions.
- "Indirect emissions" means emissions associated with the purchase of electricity, heating, cooling or steam.
- "Upstream emissions" refers to the GHG emissions potential of a quantity of industrial gas or fossil fuel supplied into the economy.

Why Report

"What gets measured gets managed"

Status of GHG Reporting

- Voluntary
  - DOE - 1605(b) program (from the Energy Policy Act of 1992) and CHP Partnership
  - EPA – Climate Leaders and non-CO_2 voluntary partnership programs
  - SmartWay Transport Partnership program
  - The Climate Registry (TCR)
  - Others
- Mandatory
  - Acid Rain Program CAA "Part 75" – reqmts for continuous emissions monitoring of SO_2, NO_x, and CO_2
  - EPA Mandatory Reporting Rule, published Oct 30 2009
  - Numerous (1-2 dozen) States have programs

Status of NC GHG Reporting Rule

- DAQ will not pursue state rule at this time
  - EPA rule expected to provide timely and complete data
  - Eliminate duplicate reporting burden for facilities
- Continue to encourage voluntary reporting using NC's Air Emissions Reporting On-line (AERO) tool
  - DAQ found about 30% of Title V sources reported voluntarily in 2008; reporting burden found to be low, particularly for combustion sources
- Will align calculation guidance for voluntary reporting with EPA's required calculation methods
- Review the EPA's reporting/data exchange system to determine if it will provide state the necessary information
- May pursue the rule depending upon outcome of review

Summary of EPA Mandatory Reporting Rule: Overview

- Sources Affected
  - Direct emitters – generally, 25,000 metric tons CO_2e/yr threshold
  - Fossil fuel suppliers and GHG suppliers
  - Vehicle and engine manufacturers (heavy-duty and off-road)
- Most Small Businesses/Commercial Bldgs Not Affected
- Specific calculations monitoring and sampling methods are provided for all source categories covered by the rule
- Annual Reports Submitted electronically to EPA
  - First emissions report due Mar. 31, 2011 for 2010 emissions
  - Reporting for Vehicle/Engine Manufacturers starts model year 2011
- Can cease reporting if emissions go below reporting thresholds
  - After 5 consecutive years of emissions < 25,000 $mtCO_2e$/yr
  - After 3 consecutive years of emissions < 15,000 $mtCO_2e$/yr

Summary of EPA Mandatory Reporting Rule: Applicability (1)

Table 1: If the facility contains any of the source categories listed in this table in any calendar year starting in 2010, the rule requires the facility to report emissions from all source categories for which calculation methodologies are provided in any subpart of the rule.

NO THRESHOLD	**PRODUCTION-BASED or OTHER THRESHOLD**
Adipic Acid Production Aluminum Production Ammonia Manufacturing Cement Production ❋ Lime Manufacturing Nitric acid production Phosphoric Acid Production ✓ Petrochemical Production Petroleum Refineries Titanium Dioxide Production Silicon carbide production Soda Ash Production HCFC-22 Production	**Municipal Landfills** – ✓ that *generate* CH_4 in amounts greater or equal to 25,000 metric tons of CO_2e annually **HFC-23 destruction processes-** that are not collocated with a HCFC-22 production facility and that destroy more than 2.14 metric tons of HFC-23 per year **Manure Management Systems-** ✓ that emit CH_4 and N_2O in amounts more than or equal to or greater than 25,000 metric tons CO_2e **Electricity Generating Facilities-** ✓ that report CO_2 emissions year round through 40 CFR part 75

Source: General Provisions, fact sheet, EPA-430-F-09-006R

✓ Means this category is present in NC

❋ May have in the future

Summary of EPA Mandatory Reporting Rule: Applicability (2)

Table 2: ***If a facility is not covered in Table 1 & emits ≥ 25,000 mtCO$_2$e combined emissions from any of below categories, stationary source combustion*, and miscellaneous carbonate use: Report emissions from ALL source categories for which there are calculation***

Ferroalloy Production
Glass Production ✓
Hydrogen Production
Iron and Steel Production ✓
Lead Production
Pulp and Paper Manufacturing ✓
Zinc Production

✓ Means this category is present in NC

Table 3: ***If a facility is not covered in Tables 1 or 2 & emits ≥ 25,000 mTCO$_2$e[1] from ALL stationary combustion sources combined,* report emissions from stationary source combustion devices only.***

Boilers ✓
Stationary Engines ✓
Process Heaters ✓
Combustion Turbines ✓
Incinerators ✓
Other Fuel Combustion Equipment[2] ✓

[1] If the maximum combined heat input capacity is less than 30 million Btu per hour, no reporting required.
[2] Excludes portable equipment, emergency generators, emergency equipment, agricultural irrigation pumps, and hazardous waste combusters (except co-fired fossil fuels), and flares
** Excludes CO2 emissions from combustion of biogenic fuels*

Source: General Provisions, fact sheet, EPA-430-F-09-006R,

Summary of EPA Mandatory Reporting Rule: Do NOT have to report at this time

- Electronics Manufacturing ✓
- Ethanol Production
- Fluorinated GHG Production
- Food Processing ✓
- Industrial Landfills ✓
- Magnesium Production
- Oil and Natural Gas Systems ✓
- SF6 From Electrical Equipment ✓
- Underground Coal Mines
- Wastewater Treatment ✓

✓ Means this category is present in NC

Additional Resources for EPA's Rule

- Federal Register version on EPA's website www.epa.gov/climatechange/emissions/ghgrulemaking.html
- Information & Training Resources
  - On-line applicability tool to assist facilities to assess if they need to report
  - Webinars & Training Sessions
  - Guidance documents/Information sheets

Stationary Source Combustion Calculations

- Expected GHGs
  - Carbon Dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous Oxide (N_20)
- Methodology: EPA rule Subpart C
- DAQ will update Spreadsheets to assist in calculations (currently Utilize DAQ methodology)

Stationary Source Combustion GHG Emission Estimation Methods

- Direct Measurement via Continuous Emission Monitoring System (CEMS)

- Calculation using Emission Factors (EFs)
  - 3 calculation tiers
  - Tier required is based on upon unit size, fuel type, & more

Calculation Method for CO2: Tier 1 (Easiest)

annual FUEL used * default HHV * Emission Factor (EF)

- Can use company records (which includes supplier billing records) for annual fuel use. HHV and EF from Table C-1
- Can use for
  - any unit ≤ 250 mm Btu/hr for fuel listed in Table C-1
  - any sized unit burning biofuel
  - Any unit combusting municipal solid waste and not creating steam (unless CEM is reqd)
  - CANNOT be used if you routinely perform analysis of HHV or if you receive it from your supplier

Default HHV's and Efs Provided for a large number of fuels

Generally, you don't need to compute emissions if fuel isn't in C-1

- Coal (different types) and Coke
- Natural Gas
- Petroleum products - distillate & residual oils, LPG, gasoline, aviation gas, jet fuels and more
- Fossil fuel-derived fuels– tires, municipal waste, blast furnace gas, coke oven gas
- Biomass fuels– wood, biogas (captured methane), ethanol, biodiesel, rendered animal fat, vegetable oil and more

Tier 1 Calculation Example

- Natural Gas Boiler
- 500 million scf (mmscf)
- 100 mmBtu/hr

Table C-1:

HHV = 1.028 x 10^{-3} mmBTU/scf

EF (based on Carbon Content) = 53.02 kgCO2/mmBTU

FUEL ↓ HHV ↓ EF ↓

$$500\ \text{mm scf} * 1.028 \times 10^{-3}\ \frac{\text{mmBTU}}{\text{scf}} * 53.02\ \frac{\text{kgCO2}}{\text{mmBtu}} * \frac{1\text{E6 scf}}{\text{mmscf}} * \frac{1\ \text{mton}}{1000\text{kg}}$$

=27,345 metric tons

Calculation Method for CO2: Tiers 2&3

TIER 2: Same as Tier 1 except you need to used a measured value for HHV

annual FUEL used * *measured* HHV * Emission Factor (EF)

(Note: Diffnt calculation for burning MSW or other solid fuel and producing steam)

TIER 3: Calculation based on annual fuel use and measured carbon content of that fuel.

Fuel * *measured* Carbon Content * 44/12

Tier 3 generally applies to larger units > 250mmBtu/hr

Calculation Method for CH4/N2O

Emission Factor (EF) * annual FUEL used * HHV

- If fuel isn't in C-2, no need to compute CH4/N2O
- For Tiers 1 and 3, use default HHV
- For Tier 2, used measured HHV

Calculation for CEMs (measure Heat Input continuously)

Annual Heat Input * EF

CH4/N2O Calculation Example

- Natural Gas Boiler
- 500 million scf (mmscf)
- 100 mmBtu/hr

Table C-1:
HHV = 1.028 x 10^{-3} mmBTU/scf

Table C-2:
EF = 1.0 x 10^{-3} kgCH4/mmBTU
EF = 1.0 x 10^{-4}kgN2O/mmBTU

CH4:

$$500 \text{ mm scf} * 1.028 \times 10^{-3} \frac{\text{mmBTU}}{\text{scf}} * 1.0 \times \frac{10^{-3} \text{ kgCH4}}{\text{mmBtu}} * \frac{1E6 \text{ scf}}{\text{mmscf}} * \frac{1 \text{ mton}}{1000\text{kg}}$$

CH4=0.514 metric tons → 21*0.514 = 11 mtons CO2e

N2O=0.0514 metric tons → 310*0.0514 = 16 mtons CO2e

Recall that **CO2** =27,345 mtons

Other Significant EPA Actions

- Proposed Endangerment Finding and Cause or Contribute Findings for GHGs Under the CAA- April 2009
  - Current and projected concentrations of the mix of six key greenhouse gases threaten the public health and welfare of current and future generations.
- Proposed Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards –Sept 2009
  - Sets g/mile and fuel economy
- Proposed Prevention of Significant Deterioration (PSD) and Title V GHG Tailoring Rule –Oct 2009
  - Purpose is to limit the number of sources subject to PSD and Title V
  - Once GHGs become a "regulated pollutant" permit programs are triggered; threshold is 250/100 tons per year
  - Tailoring rule sets threshold to 25,000 short tons CO2e

Federal Legislative Actions

- Waxman/Markey "House" Bill: American Clean Energy and Security Act
- Kerry/Boxer "Senate" Bill: Clean Energy Jobs and American Power Act
- Both have CAP and Trade program to get to set reduction targets
  - House: 17% reduction by 2020; 83% reduction by 2050 (2005 baseline)
  - Senate: 20% reduction by 2020; 83% reduction by 2050 (2005 baseline)
- Address energy efficiency, clean coal, alternative energy, transportation
- Include adaptation
- Address potential regulations to reduce black carbon

Key State Actions

- Climate Action Plan Advisory Committee (Final Report Oct 2008)
- Renewable Portfolio Standard Passed in 2007
- Legislative Commission on Climate Change – extended to October 2010
- Energy Plan, Petroleum Displacement Plan
- Climate Change Part of DENR Strategic Plan
  - Mitigation
  - Adaptation

More on website

The End