Greenhouse Gases 101: Understanding GHG Reduction and Climate Change

*Please place your telephone on MUTE*
Today’s Webinar

1. Common Terms
2. Common GHGs
3. GHG Sources
4. “Scopes” of Emissions
5. Basic Climate Change Science and Effects
6. E.O. 13514
7. GYA Inventory and Action Plan
8. Dates to Remember
Some Common Terms and Definitions

- **Weather** - Meteorological conditions of the next day to month
- **Climate** – Long-term conditions and trends of meteorology over decades to centuries
- **Greenhouse Gases (GHGs)** – Heat trapping gases in the atmosphere, some naturally occurring, some not
- **Units**: MTCE v. MTCO$_2$E

Some Common GHGs

- Water Vapor (H₂O)
- Carbon Dioxide (CO₂)
- Methane (CH₄)
- Ozone (O₃)
- Nitrous Oxide (N₂O)
- Fluorinated Gases (CFCs, HCFs, PFCs and halons)

Source: http://www.globalchange.gov
Common Sources and Global Warming Potentials

<table>
<thead>
<tr>
<th>Greenhouse Gas</th>
<th>Common Sources/Uses</th>
<th>GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide (CO$_2$)</td>
<td>Mobile and stationary combustion</td>
<td>1</td>
</tr>
<tr>
<td>Methane (CH$_4$)</td>
<td>Coal mining and combustion, agriculture</td>
<td>21</td>
</tr>
<tr>
<td>Nitrous oxide (N$_2$O)</td>
<td>Fuel combustion, fertilizers</td>
<td>310</td>
</tr>
<tr>
<td>Hydrofluorocarbon group of gases (HFCs)</td>
<td>Older refrigerants, various mfg processes</td>
<td>140-11,700</td>
</tr>
<tr>
<td>Perfluorocarbon group of gases (PFCs)</td>
<td>Various mfg processes</td>
<td>6,500-17,700</td>
</tr>
<tr>
<td>Sulfur hexafluoride (SF$_6$)</td>
<td>Electrical equipment</td>
<td>23,900</td>
</tr>
</tbody>
</table>

Source: Dr. James E. Hansen, http://www.columbia.edu/~jeh1/
Breakdown of Anthropogenic GHG Sources

About 87 percent of U.S. greenhouse gas emissions come from energy production and use, as shown in the left pie chart. The right pie chart breaks down these emissions by greenhouse gas.

Adapted from U.S. EPA\textsuperscript{202}
## Anthropogenic Emissions “Scopes”

<table>
<thead>
<tr>
<th>Scope 1</th>
<th>Direct Emissions – sources owned and controlled by the agency</th>
<th>Mobile and stationary combustion of fossil fuels, and “fugitive” emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope 2</td>
<td>Indirect Emissions</td>
<td>Offsite electricity (or steam) production</td>
</tr>
<tr>
<td>Scope 3</td>
<td>Indirect Emissions that are a consequence of agency activities, but not owned or controlled by the agency</td>
<td>Employee air travel and commuting; waste disposal; extraction, production and transportation of goods; water pumping; fertilizer; refrigerants; contractor-owned vehicles; etc.</td>
</tr>
</tbody>
</table>
Figure. Scope 1, 2, and 3 Emissions

Source: http://www.globalchange.gov
From Emissions to a Changing Climate...

"Keeling Curve"

Monthly Mauna Loa CO₂

Source: Dr. James E. Hansen, http://www.columbia.edu/~jeh1/
History, Observation, and Modeling

Increases in concentrations of these gases since 1750 are due to human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion molecules of air.

Source: http://www.globalchange.gov
Predicted Emissions

Source: Dr. James E. Hansen, http://www.columbia.edu/~jeh1/
Predicted Temperature Rise

Observed and projected changes in the global average temperature under three IPCC no-policy emissions scenarios. The shaded areas show the likely ranges while the lines show the central projections from a set of climate models. A wider range of model types shows outcomes from 2 to 11.5°F. Changes are relative to the 1960-1979 average.

Source: http://www.globalchange.gov
Why all of the build-up?

**What if we stop increasing emissions?**

Even at the current emissions rate, CO2 is released into the atmosphere nearly twice as fast as it is removed—so the bathtub will continue to fill.

**How do we cause CO2 emissions?**

Four-fifths is from burning fossil fuels. Nearly all the rest is from deforestation and other changes in land use.

**How does CO2 cause warming?**

It absorbs some of the heat radiation coming off Earth’s sunbaked surface and reradiates it back downward.

**Where does our CO2 go?**

Plants and soil absorb about a third each year, and ocean surface waters about a quarter. The rest stays airborne for a long time.

- 45% REMAINS IN ATMOSPHERE
- 30% ABSORBED BY PLANTS & SOILS
- 25% ABSORBED BY OCEANS
- <1% ABSORBED BY SEDIMENT & ROCKS

*Percentages do not add up to 100 because of rounding.

**How much is too much?**

No one is sure. Some scientists think we need to reduce the CO2 level back down to 350 parts per million (ppm)—equivalent to 745 billion metric tons of carbon—to avoid serious climate impacts. But if current emissions trends continue, 480 ppm will be passed well before mid-century.

**CUT**

5 billion metric tons a year

**Hasn’t CO2 been this high before?**

Not for at least 800,000 years, say the oldest air bubbles found in Antarctic ice cores—and probably not for millions of years.

Source: http://ngm.nationalgeographic.com/big-idea/05/carbon-bath
Atmospheric Build-up
A Warming World

Source: http://www.globalchange.gov
This Affects...

- Precipitation and Fresh Water
- Flora and Fauna
- Pests and Weeds
- Ocean acidity, salinity and productivity
- Agriculture
- Population Demographics
- Severe Weather Events

- Ecosystem Changes
- Polar and Ice-Dependent Processes
- Ecosystem Services
- Energy
- Air Quality
- Development
- Soil Conservation
- Wildfire
Water

The water cycle exhibits many changes as the earth warms. Wet and dry areas respond differently.
Water

Trends in end-of-summer drought as measured by the Palmer Drought Severity Index from 1958 to 2007 in each of 344 U.S. climate divisions.\textsuperscript{144} Hatching indicates significant trends.

Source: http://www.globalchange.gov
Pests and Weeds

The left photo shows weeds in a plot grown at a carbon dioxide (CO2) concentration of about 380 parts per million (ppm), which approximates the current level. The right photo shows a plot in which the CO2 level has been raised to about 680 ppm.233 (Photos by Lewis Ziska)

Source: http://www.globalchange.gov
Polar and Ice-Dependent Ecosystems

Arctic sea ice reaches its annual minimum in September. The satellite images above show September Arctic sea ice in 1979, the first year these data were available, and 2007.

Source: http://www.globalchange.gov
Severe Weather

Weather-related insurance losses in the United States are increasing. Typical weather-related losses today are similar to those that resulted from the 9/11 attack (shown in gray at 2001 in the graph). About half of all economic losses are insured, so actual losses are roughly twice those shown on the graph. Data on smaller-scale losses (many of which are weather-related) are significant but are not included in this graph as they are not comprehensively reported by the U.S. insurance industry.
Incidents Caused by Severe Weather

The number of incidents caused by extreme weather has increased tenfold since 1992. The portion of all events that are caused by weather-related phenomena has more than tripled from about 20 percent in the early 1990s to about 65 percent in recent years. The weather-related events are more severe, with an average of about 180,000 customers affected per event compared to about 100,000 for non-weather-related events (and 50,000 excluding the massive blackout of August 2003). The data shown include disturbances that occurred on the nation’s large-scale “bulk” electric transmission systems. Most outages occur in local distribution networks and are not included in the graph. Although the figure does not demonstrate a cause-effect relationship between climate change and grid disruption, it does suggest that weather and climate extremes often have important effects on grid disruptions. We do know that more frequent weather and climate extremes are likely in the future, which poses unknown new risks for the electric grid.
Dr. Steven Running’s
“5 Stages of Climate Grief”

1. **Denial** – The world isn’t getting warmer, and it’s not our fault if it is.
2. **Anger** – I don’t want to change MY lifestyle!
3. **Bargaining** – Warming will make it nicer...
4. **Depression** – It’s too late, we’re doomed.
5. **Acceptance** – This is the world we now live in. Let’s get to work to solve this problem. We can do it, and we have to!
What can we do about Climate Change?

1. **Avoidance** – Reducing or eliminating our GHG emissions
2. **Mitigation** - Slowing or offsetting CO2 sources
3. **Adaptation** - Preparing for the climate changes that we have already committed ourselves to
4. **Sequestration** - Actively removing CO2 from the atmosphere (and storing in carbon sinks)
E.O. 13514

- Signed October 5, 2009
- Within 90 days, agencies must set **Scope 1 & 2 GHG reduction targets for 2020** (Jan, 2010)
- Within 240 days, agencies must set a **Scope 3 reduction target for 2020** (June)
- Within 15 months, agencies must **inventory GHG emissions using a FY 2010 baseline** (Jan, 2011)

Source: [http://www.globalchange.gov](http://www.globalchange.gov)
E.O. 13514

- Also addresses footprint reduction targets for:
  - Energy
  - Fleet
  - Water
  - Waste
  - Sustainable Communities
  - Green Building
  - Contracting
  - Green Purchasing

- Creates an Office of Sustainability

Source: http://www.globalchange.gov
Late Breaking News:

- GHG emissions reduction goal for federal agencies: **28% by 2020**
- 88 millions tons of CO2e
- Aggregate of 35 agency targets
- 2008 baseline
- Direct emissions only
- Cost: $8-$11 billion
The Greater Yellowstone GHG Inventory and Action Plan

- 3 Federal Agencies
- 10 Agency Units
  - 6 Forests
  - 2 Parks
  - 2 Refuges
- Focus: Operational Control
Project Overview

- Fiscal Year 2007 baseline
- Inventory tools:
  - EPA Climate Leaders (USFS and USFWS)
  - Climate Leadership in Parks – CLIP (NPS)
- Anthropogenic emissions of 3 GHGs:
  - Carbon Dioxide (CO2)
  - Methane (CH4)
  - Nitrous Oxide (N2O)
- Inventory Completed in April 2009
Emissions Sources

Included:

• Stationary sources
• Purchased electricity
• Mobile sources
• Employee air travel
• Employee commuting

Not Included:

• Prescribed fire & wildfire suppression
• Refrigerants
• Fire extinguishers
• Gas waste stream
• Imported heat
• Product transport
• Off-site waste disposal
GHG Emissions from Stationary Sources Across the Ecosystem

- 6 National Forests
- Grand Teton National Park
- Yellowstone National Park
- 2 National Refuges

Metric Tons of CO$_2$e
GHG Emissions from Mobile Sources Across the Ecosystem

5,000
4,000
3,000
2,000
1,000
0
6 National Forests
Grand Teton National Park
Yellowstone National Park
2 National Refuges

Metric Tons of CO$_2$e
GHG Emissions from Purchased Electricity Across the Ecosystem

![Bar graph showing GHG emissions from national forests and national parks.](image-url)
Total GHG Emissions from Across the Ecosystem

Metric Tons of CO$_2$e

- 6 National Forests
- Grand Teton National Park
- Yellowstone National Park
- 2 National Refuges

Chart showing emissions breakdown for different areas.
Some Findings and Differences

Distribution of GHG Emissions from National Forests in GYA

- Mobile Sources: 54%
- Purchased Electricity: 22%
- Business Air Travel: 1%
- Employee Commuting: 8%
- Stationary Sources: 15%
The GYA Climate Action Plan

- The metrics aren’t perfect, but we need to act
- Iterative process
- Tiered goals: Unit-level and GYA-wide (with EMS)
- Coordinated implementation
- New territory... and a great opportunity
GYCC Definition of Success

1. Setting and meeting a collective, realistic and credible ecosystem-wide GHG reduction goal
2. Ensuring the capacity and leadership intent to meet the goal
3. Developing/documenting a methodology for GHG accounting and reduction that serves as a model for other footprint areas, other agencies, and the public
Where We Are

- Mitigation and Avoidance actions organized by emissions source and timeline for each unit
- A commitment by each GYA unit to reduce their GHG emissions by a minimum of 20% before FY 2020
- Currently tracking at around a 40% reduction ecosystem-wide by 2020

<table>
<thead>
<tr>
<th>UNIT</th>
<th>YEAR</th>
<th>BY 2020</th>
</tr>
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<tbody>
<tr>
<td>B-D NF</td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>B-T NF</td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>C-T NF</td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>Custer NF</td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>Gallatin NF</td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>Grand Teton NP</td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>National Elk WR</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>RRL NWR</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Shoshone NF</td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>Yellowstone NP</td>
<td></td>
<td>43%</td>
</tr>
<tr>
<td>GYA-wide Total:</td>
<td></td>
<td>Approx. 40%</td>
</tr>
</tbody>
</table>
Where We Are

A 40% reduction will reduce GYA emissions by 5542 tons of carbon, or the equivalent of...

- Annual electricity use of 2557 homes
- Annual emissions from 3376 passenger vehicles
- Burning 42,871 barrels of oil
- Burning 96.3 rail cars of coal
- Contained in 789,108 propane tanks for gas grills

Furthermore, roughly 1/3 of possible emissions reduction actions will save money
Where We’re Going

- Further planning, analysis, and goal-setting
- NREL Technical Assistance and GYA-wide Working Session
- Coordinated implementation
- Documentation of our methodology
- Expansion and Outreach
Some General Assumptions

- We make natural resources management “decisions” every day though our operational practices.
- The anthropogenic drivers of climate change are certain.
- We know enough to reduce risk through implementing avoidance actions.
- Metrics and data quality will come.
- Collaboration and integration will be key components to success, as well as the resources and synergies that they provide.
“Adapting to climate change requires making policy and management decisions that cut across traditional economic sectors, jurisdictional boundaries, and levels of government.”

“Top leadership involvement and clear lines of accountability are critical to overcoming natural resistance to change, marshalling needed resources, and building and maintaining the commitment to new ways of doing business.”
Challenges:

- Available attention and resources are focused on immediate needs
- Insufficient site-specific data on expected changes
- Lack of clear roles and responsibilities among federal, state, and local agencies
- Emerging activities are carried out in an ad hoc manner and not well coordinated

Recommendations:

- Define federal priorities (related to adaptation)
- Clarify roles, responsibilities and working relationships
- Identify mechanisms to increase capacity
- Address how resources will be made available for implementation
- Build on and integrate ongoing federal planning efforts
Some Further Resources:

- www.globalchange.gov
- www.epa.gov/climatechange/
- www.ipcc.ch/
- www.nrel.gov/
- www.climate.gov/ (new NOAA site)
- Each agency’s climate change homepage (can be found with a quick search)
Some Dates to Remember

- **GYA Fleet Webinars - Kristin Day, NREL:**
  - February 11, 2-3 PM (Data review, requests, and feedback)
  - March 30, 2-3 PM (Workshop preparation and new technology)

- **GYA Facilities Webinars - Eliza Hotchkiss, NREL:**
  - February 25th, 10-11 AM (Basics, energy intensity, outliers, priorities)
  - March 25th, 10-11 AM (Data preparation, calculations and Q&A)

- **GYA Scope 3 Emissions Webinars - John Nangle, NREL:**
  - February 18th, 10-11 AM (Overview and opportunities)
  - March 19th, 10-11 AM (Data preparation, calculations and Q&A)

- **Greater Yellowstone Interagency Climate Action Plan Working Session:**
  - April 19th-22nd, Bozeman, MT
Questions and Follow-Up

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