Greenhouse Gas and Climate Change
Impact Analysis

Sacramento Metropolitan Air Quality
Management District Workshop
April 20, 2009
9 AM- 4 PM

Welcome!
Tim Taylor, Division Manager
Jeane Berry Borkenhagen
ICF Jones & Stokes

- Logistics
- Introductions
- District remarks
- Agenda
AGENDA

• Greenhouse Gas and Climate Change Basics
• Regulatory Framework
• GHG Quantification and Tools
• Lunch & Robert Christopherson
• Project GHG analysis
• Threshold and Impact Analysis
Science of Climate Change – An Overview

• Most people have varying Climate Change (CC) backgrounds
• Purpose of this presentation is to provide a common vocabulary and backdrop for the ensuring policy discussions

A Show of Hands – A Straw Poll

• CC a hoax and/or overstated?
• CC is not due to humans?
• You have seen a documentary about a PowerPoint presentation?
The Changing “Climate” for Climate Change

• “It is the sense of the scientific community that carbon dioxide from unrestrained combustion of fossil fuels potentially is the most important environmental issue facing mankind”

• Source: Department of Energy

• April 2, 1979
Climate Change – The Basics

• Key definitions
  – Climate change
  – Global warming
  – Greenhouse effect
  – Greenhouse gases (GHG)
  – IPCC
  – Feedback loops
  – Tipping Point
  – Greenhouse Gas Inventories

Climate Change

• Global Warming – An increase in GHG emissions leads to an increase in average global temperature
• Climate Change – as a consequence of global warming, our climate is expected to change due to changes in weather patterns, average sea level, ocean acidification, changes chemical reaction rates, changes precipitation rates, etc.
Greenhouse Effect is due to Greenhouse Gasses

- Without the effect, our planet would not be inhabitable by humans
- GHG gasses are those that absorb infrared radiation in the spectrum emitted by our Earth
- GHG gasses can be emitted by natural processes (e.g. volcanoes) or from anthropogenic sources (those due to man)
Climate Change Consequences

- Warmer Temperatures
- Drought and Wildfire
- More intense rainstorms
- Deadly heat waves & spread of disease
- More powerful hurricanes
- Melting glaciers, early ice thaw
- Sea-level rise
- Species extinction
- Mass human migration – political turmoil

Effect of Climate Change on California

<table>
<thead>
<tr>
<th>Emissions Scenarios*</th>
<th>Summary of Projected Global Warming Impact, 2070 to 2099 (as compared with 1961-1990)</th>
<th>Statewide Temperature Rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher emissions: Major, fossil-fuel intensive growth</td>
<td>84% loss in Sierra isnowa (year)</td>
<td>Higher warming range 4-8°F</td>
</tr>
<tr>
<td>Medium-high emissions: Minor, fuel-related growth and/or improvements in energy efficiency</td>
<td>76-89% loss in Sierra isnowa (year)</td>
<td>Medium warming range 3.5-6°F</td>
</tr>
<tr>
<td>Low emissions: Less fossil-fuel dependent growth, with heavy investment in cleaner technologies</td>
<td>61-64% loss in Sierra isnowa (year)</td>
<td>Lower warming range 3.5-6°F</td>
</tr>
</tbody>
</table>

*Source: Sacramento Air Quality Management District, “California Climate Change Mitigation: Options for the 21st Century.”

Summary:
- More intense heat waves
- Increased sea-level rise
- More frequent and intense wildfires
- Ecosystem disturbances
- Increased frequency of extreme weather events
- Impacts on human health and safety

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California with Warmer Temperatures

- Milder winters, hotter summers
- Salmon declines
- Decline in water supplies
- Native plant & animal populations decline
- Changing growing seasons
- Wetlands decline
- More human disease
- More pests in forests & crops
California with Reduced Snowpack

- Reduced snow pack
- Receding glaciers
- Lower summer stream flows
- Salmon declines

- Lower groundwater tables
- Hydropower loss
- Recreational loss
- More water pollution

California with Rising Sea Level

- Rising sea level
- Coastal community flooding
- Coastal erosion & landslides

- Seawater intrusion in wells
- Lost wetlands & estuaries
California with Extreme Weather

- Extreme weather
- Droughts
- Floods more extreme & often
- More Landslides

More stormwater = more pollution
Earlier river runoff
Changing growing season
Multiple emergency response needs

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California Snowpack Will Shrink

<table>
<thead>
<tr>
<th>2010-2090</th>
<th>2050-2090</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Emissions</td>
<td>Higher Emissions</td>
</tr>
<tr>
<td>76% remaining</td>
<td>60% remaining</td>
</tr>
<tr>
<td>22% remaining</td>
<td>11% remaining</td>
</tr>
</tbody>
</table>

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The Most Important GHGs

- Carbon Dioxide (CO₂)
- Methane (CH₄)
- Nitrous Oxide (N₂O)
- Hydrofluorocarbons (HFC)
- Perfluorocarbons (PFC)
- Sulfur hexafluoride (SF₆)
- Water (H₂O)
- Ozone (O₃)
Sources of CO2 and CH4

A. Sources of CO2

B. Sources of CH4

Source: Pew Center on Global Climate Change
Describing the Complex Soup of GHGs

- Each GHG has different chemical reactivity & lifetimes
- Commonly combine all GHG emissions into the equivalent emissions of carbon dioxide (CO2E)
- Normalization process requires the specification of the Global Warming Potential (GWP) of each gas and the evaluation timeframe (use 100 years in general)

Global Warming Potentials

<table>
<thead>
<tr>
<th>Gas</th>
<th>Lifetime (years)</th>
<th>GWP Time horizon</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20 years</td>
<td>100 years</td>
</tr>
<tr>
<td>Methane</td>
<td>12</td>
<td>62</td>
<td>23</td>
</tr>
<tr>
<td>Nitrous oxide</td>
<td>114</td>
<td>275</td>
<td>296</td>
</tr>
<tr>
<td>HFC -134a (hydrofluorocarbon)</td>
<td>13.8</td>
<td>3,300</td>
<td>1300</td>
</tr>
<tr>
<td>HFC -23 (hydrofluorocarbon)</td>
<td>260</td>
<td>9,400</td>
<td>12,000</td>
</tr>
<tr>
<td>Sulfur hexafluoride</td>
<td>3,200</td>
<td>15,100</td>
<td>22,200</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>50-200</td>
<td>1</td>
<td>1</td>
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</table>
Carbon Equivalent/CO$_{2E}$ – Units

- Inventories are based on annual emissions
- State GHG inventories are in MMT/year (million metric tons of CO$_{2E}$) (1 metric ton=1000 kg)
- 1 MMT = ~215,000 passenger cars
- 1 car at 20 miles/gal @ 10,000 miles/year = ~5 tons CO$_{2E}$/year

Carbon Cycle – Biogenic and Anthropogenic
An Unmistakable Warming Trend

Global Temperature Since 1861
Combined annual land air and sea surface temperatures from 1861-2004

Source: Climatic Research Unit, University of East Anglia and Hadley Centre, Tyndall Centre, UK.
Temperature are Hitting Historic Highs

- 10 hottest years on record have occurred in the last 15 years
- 2007 data is not in yet – but it is projected to be the hottest year on record
- Official hottest year on record – 2006
- Previous hottest year on record – 2005
Intergovernmental Panel on Climate Change (IPCC)

- IPCC is the scientific body tasked to evaluate the risk of climate change caused by human activity.
- Created in 1988 by two UN organizations
  - World Meteorological Organization (WMO) & the
  - United Nations Environment Programme (UNEP)
- Does not carry out research or monitoring, rather it distills peer reviewed literature on CC and periodically creates special reports
- Widely considered the authoritative body on CC
- Creates summaries for policymakers and scientists

IPCC Report Release Dates

- 1990 – First Assessment
  - 1992 – Supplementary Assessment
- 1995 Second Assessment Report (SAR)
- 2001 – Third Assessment Report (TAR)
- 2007 – Fourth Assessment Report (AR4)
IPCC 2007 Findings

- Warming of the climate system is unequivocal.
- The probability that this is caused by natural climatic processes alone is less than 5%.
- World temperatures could rise by between 1.1 and 6.4 °C (2.0 and 11.5 °F) during the 21st century (table 3) and that:
  - Sea levels will probably rise by 18 to 59 cm (7.08 to 23.22 in)

Feedback loops

- Feedback loop – output of process is fed back into the input. Can be negative or positive.
- Negative feedback is self regulating
  - more heat -> more cloud cover
- Positive feedback can go out of control
  - Ice melting will reduce reflectivity of earth increasing
Tipping Points

- Tipping Point - the levels at which the momentum for change becomes unstoppable

Tipping Points Scenarios

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<th>Substantial Mitigation</th>
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Stabilization Goal

- The scientific community is not envisioning a future without climate change
- In fact, almost all predictions and policy goals anticipate some climate changes as a consequence of GHG emissions
- The current goal is to have global temperatures raise by less than 2 degrees Celsius (4° F) to avoid the catastrophic consequences of climate change
- It is currently thought that the industrialized countries will have to reduce emissions 80% below their 1990 to meet the stabilization goal.

CA, US, & Global GHG Projections

2020 and 2050 milestones if CA meets goals but rest of the world is business-as-usual
- 2020 World Up 13,000 MMT
- 2050 World Up 26,000 MMT

- 2020 U.S. Up 2,000 MMT
- 2050 U.S. Up 4,000 MMT

- 2020 CA Down 164 MMT
- 2050 CA Down 347 MMT
Uncertainty in Future Predictions

Scenarios for GHG emissions from 2000 to 2100 (in the absence of additional climate policies) and projections of surface temperatures

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Sacramento County
Emissions by sector (CO2e)

- Waste: 741,528 metric tons (5.3%)
- Residential: 2,439,527 metric tons (17.5%)
- Commercial and Industrial: 2,292,627 metric tons (16.5%)
- Transportation: 6,731,929 metric tons (48.3%)
- Other*: 1,729,016 metric tons (12.4%)

Total: 13,934,627 metric tons CO2e

* Includes off-road equipment, high GWP gases, industrial-specific, agriculture, wastewater treatment, and the Sacramento International Airport

Sacramento County
Emissions by jurisdiction (CO2e)

- Sacramento: 4,550,515 metric tons (32.8%)
- Rancho Cordova: 577,820 metric tons (4.0%)
- Citrus Heights: 427,918 metric tons (3.2%)
- Elk Grove: 842,040 metric tons (6.1%)
- Galt: 172,428 metric tons (1.2%)
- Isleton: 20,382 metric tons (0.1%)
- Folsom: 158,975 metric tons (1.2%)
- Unincorporated: 6,555,802 metric tons (47.2%)

Total: 13,866,899 metric tons CO2e
Total per capita emissions (CO2e)

What is the point of climate change policy?

- Perform a GHG inventory because they create interesting graphics?
- Create an inventory to avoid a AG lawsuit
- Perform a GHG inventory to allow decision makers to make the best and most cost effective strategies to help mitigate a global catastrophe?
Always Remember

• An inventory for the sake of an inventory is not nearly as useful as an inventory created from the outset help craft a GHG reduction plan!