

# **Climate Change Business Planning**

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# Lingo Glossary

- Adaptation
- CCS – Carbon Capture and Storage
- CO<sub>2</sub>-Equivalence
- Cap and Trade
- Carbon Footprint
- Direct Emissions
- Geo-Engineering
- GWP – Global Warming Potential (relative to CO<sub>2</sub>)
- Indirect Emissions
- Precautionary Principle
- Radiative Efficiency (in W/m<sup>2</sup>/ppb)
- RPS – Renewal Portfolio Standards
- Sequestration
- Stabilization

# Are Regulations Inevitable?

- **Federal Legislation**
  - Lieberman-Warner Climate Stewardship and Innovation Act: Cap-and-trade program, multi-sector, six GHGs, reductions to 1990 levels by 2020
  - Bingaman Climate and Economy Insurance Act: Includes “high-GWP gases”
- **Regional Greenhouse Gas Initiative**
  - 9 Northeast and Mid-Atlantic states designing cap and trade program
  - Starting with power plants January 1, 2009, but will later expand to other industries
  - Preparing to launch the first-in-the nation auction of carbon dioxide (CO<sub>2</sub>) allowances
- **California**
  - Vehicle Emissions Standards
  - Assembly Bill 32: Goal of 25% emissions reductions by 2020, Targets “significant” sources, including for semiconductor industry PFCs
  - Public Utilities and Energy Commissions: Implementing regulations setting CO<sub>2</sub> emissions performance standards for power plants
  - Regional Reduction Agreement with Arizona, New Mexico, Oregon and Washington



# Are Regulations Inevitable?

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- **Renewable Portfolio Standards**
  - Even Texas has goals for “wind, geothermal, hydroelectric, wave, or tidal energy, or on biomass or biomass-based waste products, including landfill gas”
- **Energy Company CEOs**
  - Accepting science, desire uniform Federal regulatory approach
  - Promoting cap and trade or emissions tax
    - (See [www.washingtonpost.com](http://www.washingtonpost.com), November 25, 2006)
- **Wal-Mart**
  - Goal to use 100% renewable energy
- **US Supreme Court Case**
  - Massachusetts vs. EPA: Ruled 5 to 4 on April 2, 2007 that the EPA has the authority to regulate greenhouse gases in automobile exhaust
  - EPA must protect public welfare unless it makes a scientific determination that GHGs do not contribute to climate change
    - Advance Notice of Proposed Rulemaking issued July 11, 2008

# **Precautionary Principle in Action**

**All of the Domestic Initiatives are  
Independent of Kyoto Protocol!**



# Assessing Risk

- Start by calculating greenhouse gas emissions baseline
- Combustion Emissions – CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O
  - Boilers
  - Generators
  - Fire Pumps
  - Solvent Abatement
- Process Emissions - N<sub>2</sub>O, NF<sub>3</sub>, SF<sub>6</sub>, PFC and HFC
  - Diffusion, CVD (Passivation) - N<sub>2</sub>O
  - Etch – process gases
    - NF<sub>3</sub>, SF<sub>6</sub>, C<sub>4</sub>F<sub>8</sub>, CF<sub>4</sub>, C<sub>2</sub>F<sub>6</sub>, C<sub>3</sub>F<sub>8</sub>, CHF<sub>3</sub>
  - CVD – clean gases
    - NF<sub>3</sub>, C<sub>2</sub>F<sub>6</sub>, CF<sub>4</sub>
  - Process Equipment Chiller Units
    - Fluorinated Heat Transfer Fluids
- Indirect Emissions – CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O
  - Electricity Use



# Assessing Risk – Combustion Calculations

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- 2006 IPCC Guidance for National Greenhouse Gas Inventories
  - Available at <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm>
  - Volume 2 Stationary Combustion
  - Results in emissions for CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub>
- Or, in US, Use AP 42, Fifth Edition, Volume I
  - Boilers: Chapter 1: External Combustion Sources
  - Generators, Fire Pumps and Oxidizers: Chapter 3: Stationary Internal Combustion Sources

# Assessing Risk – PFC Calculations

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- 2006 IPCC Guidance for National Greenhouse Gas Inventories
  - Volume 6 Electronic Industry Emissions (formerly PFC, HFC, SF6 Emissions from Semiconductor Manufacturing)
  - Typically use Tier 2a, 2b or 3 methods – require site specific gas consumption and emissions control efficiencies
  - Results in emissions for CF<sub>4</sub>, C<sub>2</sub>F<sub>6</sub>, CHF<sub>3</sub>, C<sub>3</sub>F<sub>8</sub>, C<sub>4</sub>F<sub>6</sub>, C<sub>4</sub>F<sub>8</sub>, C<sub>4</sub>F<sub>8</sub>O, C<sub>5</sub>F<sub>8</sub>, C<sub>6</sub>F<sub>14</sub>, NF<sub>3</sub>, SF<sub>6</sub> and by-products from F<sub>2</sub> and COF<sub>2</sub>



# Assessing Risk – PFC Calculations

## EQUATION 6.2

### TIER 2a METHOD FOR ESTIMATION OF FC EMISSIONS

$$E_i = (1 - h) \cdot FC_i \cdot (1 - U_i) \cdot (1 - a_i \cdot d_i)$$

Where:

$E_i$  = emissions of gas  $i$ , kg

$FC_i$  = consumption of gas  $i$ , (e.g.,  $CF_4$ ,  $C_2F_6$ ,  $C_3F_8$ ,  $c-C_4F_8$ ,  $c-C_4F_8O$ ,  $C_4F_6$ ,  $C_5F_8$ ,  $CHF_3$ ,  $CH_2F_2$ ,  $NF_3$ ,  $SF_6$ ), kg

$h$  = fraction of gas remaining in shipping container (heel) after use, fraction

$U_i$  = use rate of gas  $i$  (fraction destroyed or transformed in process), fraction

$a_i$  = fraction of gas  $i$  volume used in processes with emission control technologies (company- or plant-specific), fraction

$d_i$  = fraction of gas  $i$  destroyed by the emission control technology, fraction

- From IPCC Guidance for National Greenhouse Gas Inventories
- Also similar equations available for  $CF_4$  and  $C_2F_6$  by-products emissions

# Assessing Risk – Electricity Calculations

## Emissions from purchased electricity

Emitted GHG	Emission Factor (kg/kWh)
CO <sub>2</sub>	0.63
CH <sub>4</sub>	5x10 <sup>-6</sup>
N <sub>2</sub> O	9x10 <sup>-6</sup>

- Above Per US EPA Clean Energy Site
- Also reportedly available from EMEP/CORINAIR Emission Inventory Guidebook

# Assessing Risk - Conversion to Carbon - Equivalent

$$MMTCE = \sum_i^7 \frac{Q_i(GWP_{100})_i}{10^9} \left( \frac{12}{44} \right)$$

$Q_i$  = the quantity of GHG<sub>i</sub> released in kg (from IPCC algorithms)

$(GWP_{100})_i$  = the equivalent CO<sub>2</sub> mass with same radiative efficiency for GHG<sub>i</sub> integrated over a 100 year time horizon (Accounts for time and wavelengths of absorbance effects.)

MMT(CO<sub>2</sub>)E = same equation as above without conversion from CO<sub>2</sub> to C (12/44)

Compound	Lifetime	GWP <sub>100</sub>
Carbon Dioxide	variable	1
Methane	8.4/12	23
Nitrous Oxide	120/114	296
<b>Select HFC, PFC and SF</b>	<b>6</b>	
CHF <sub>3</sub>	260	12000
CF <sub>4</sub>	>50000	5700
C <sub>2</sub> F <sub>6</sub>	10000	11900
C <sub>3</sub> F <sub>8</sub>	2600	8600
c-C <sub>4</sub> F <sub>8</sub>	3200	10000
NF <sub>3</sub>	>500	10800
SF <sub>6</sub>	3200	22200

Source: IPCC TAR

GWP<sub>100</sub> = Global Warming Potential, 100 year time horizon  
GHG = Greenhouse Gas





# Assessing Risk – Project Future Emissions

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- Any planned expansions of overall facilities?
  - New combustion sources?
  - Increased electricity usage?
- Any planned process expansion or change?
  - Increases in process emissions?
- Estimate annual change in MMT(CO<sub>2</sub>)E

# Reducing Risk

- Based upon project future emissions, will you be a purchaser or generator of MM(CO<sub>2</sub>)E credits under cap and trade program?
  - Chicago Climate Exchange (CCX) at \$4.15/MMT(CO<sub>2</sub>)E
- Assess options for reducing emissions/increasing credits
  - Combustion
    - HVAC Optimization
    - Oxidizer Temperature Evaluation
  - In-Direct
    - Energy/electricity reductions through equipment replacement and optimization
  - Process
    - Process optimization
    - Chemical Replacement
    - Abatement
  - Are third party offset reductions (i.e. CDMs), renewable energy or capture and storage (i.e. sequestration) viable options?

# Reducing Corporate Risk

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- Involve stakeholders (facilities, process, management) in preparing a GHG Business Plan
  - Track Policy Developments, Including MACT/NSPS Type Controls and RPS
  - Conduct a Baseline Inventory and Project Future
  - Evaluate Voluntary Program Participation
  - Prepare for Adaptation of Business
  - Set Corporate “Targets and Timetables” for Reduction of “Carbon Footprint”



# Assessing Business Opportunities

- Consider Opportunities to Profit
  - Sell Credits or CDMs
  - Produce Renewable Energy
  - Produce Infrastructure
    - Photovoltaic Systems
    - Wind Turbines
  - Participate in Carbon Capture and Storage
    - Build Pipelines
    - Own Repositories
- Position Existing Products as “Green”, “Carbon Neutral”, etc.
  - R&D for New Green Products
- National Cap-and-Trade Will Result in a New Economy
  - EPA’s Climate Change Credit Corporation Is Projected to Handle \$6.7 trillion from 2012 to 2050

# What Can an Individual Do?

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- Seven Ways an Individual Can Slow Global Warming
  1. Choose green power
  2. Be fuel-efficient
  3. Choose energy saving appliances
  4. Reduce, reuse, recycle
  5. Be water wise
  6. Compute (see EPA's Personal Emissions Calculator)
  7. Explore and enjoy your nearby world

Ref: Natural Resources Defense Council, [www.nrdc.org](http://www.nrdc.org)

