Climate Change Regulations

SESHA Hill Country Chapter
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Acknowledgement to Chris Nauert, PE, Freescale Semiconductor

"Green House Gas Management and Emissions Reporting"

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Are Regulations Inevitable?

- Regional Greenhouse Gas Initiative
  - 9 Northeast and Mid-Atlantic states designing cap and trade program
  - Would start with power plants, but later expand to other industries
- California
  - Vehicle Emissions Standards
  - Pending emissions targets, including for semiconductor industry PFCs
- 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”

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Are Regulations Inevitable?

- **Energy Company CEOs**
  - Accepting science, desire Federal regulatory approach
  - Promoting cap and trade or emissions tax

    (See www.washingtonpost.com, November 25, 2006)
- **US Supreme Court Case**
  - Massachusetts vs. EPA
  - Does Section 202 of the CAA direct EPA to regulate tailpipe emissions that "may reasonably be anticipated to endanger public health or welfare“?

All Independent of Kyoto Protocol!

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Assessing Risk

- Start by calculating greenhouse gas emissions baseline
- Combustion Emissions – CO_2, CH_4, N_2O
  - Boilers
  - Generators
  - Fire Pumps
  - Solvent Abatement
- Process Emissions - N_2O, NF_3, SF_6, PFCs and HFCs
  - Diffusion, CVD (Passivation) - N_2O
  - Etch – process gases
    - NF_3, SF_6, C_4F_8, CF_4, C_2F_6, C_3F_8, CHF_3
  - CVD – clean gases
    - NF_3, C_2F_6, CF_4
  - Process Equipment Chiller Units - HTFs
    - Perfluorinated Heat Transfer Fluids
- Indirect Emissions – CO_2, CH_4, N_2O
  - Electricity Use

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Assessing Risk – Combustion Calculations

- 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 CO2, N2O and CH4
- 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

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Assessing Risk – PFC Calculations

- 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 method – requires site specific gas consumption and emissions control efficiencies
  - Results in emissions for CF4, C2F6, CHF3, C3F8, NF3, SF6 and C6F14

Note: May already be reporting PFCs to SIA for EPA MOU supporting WSC agreement for 10% reduction from 1995

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Assessing Risk – PFC Calculations

EQUATION 3.27

$$\text{Emissions of } FC_i = (1 - h) \bullet \sum_p [FC_{i,p} \bullet (1 - C_{i,p}) \bullet (1 - a_{i,p} \bullet d_{i,p})]$$

Where:

p = Process or process type (etching or CVD chamber cleaning)

$FC_{i,p}$ = kg of gas i fed into process/process type p (CF_4, C_2F_6, C_3F_8, C_4F_8, CHF_3, NF_3, SF_6)

h = Fraction of gas remaining in shipping container (heel) after use

$C_{i,p}$ = Use rate (fraction destroyed or transformed) for each gas i and process/process type p (in kgs)

$a_{i,p}$ = Fraction of gas volume fed into in processes with emission control technologies (company-or plant-specific)

$d_{i,p}$ = Fraction of gas i destroyed by the emission control technology (If more than one emission control technology is used in process/process type p, this is the average of the fraction destroyed by those emission control technologies, where each fraction is weighted by the quantity of gas fed into tools using that technology)

- From IPCC Guidance for National Greenhouse Gas Inventories
- Also similar equation available for by-products emissions

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Assessing Risk – Electricity Calculations

Emissions from purchased electricity

Emitted GHG	Emission Factor
	(kg/kWh)
CO_2	0.63
CH_4	$5x10^{-6}$
N_2O	$9x10^{-6}$

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

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Assessing Risk - Conversion to Equivalent CO_2

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

Qi = the quantity of GHGi released in kg (from IPCC algorithms)

(GWP100)i = the global warming potential for GHGi integrated over a 100 year time horizon

MMT(C02)E = same equation as above without conversion from CO2 to C (12/44)

Compound	Lifetime	GWP_{100}
Carbon Dioxide	variable	1
Methane	8.4/12	23
Nitrous Oxide	120/114	296
Select HFC, PFC and SF_6		
CHF_3	260	12000
CF_4	>50000	5700
C_2F_6	10000	11900
C_3F_8	2600	8600
c-C_4F_8	3200	10000
NF_3	>500	10800
SF_6	3200	22200

Source: IPCC TAR

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Assessing Risk – Project Future Emissions

- 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(CO2)E

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Reducing Risk

- Based upon project future emissions, will you be a purchaser or generator of MM(CO2)E credits under cap and trade program?
  - Chicago Climate Exchange (CCX) at $4.15/MMT(CO2)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
    - Plasma remote clean
    - Process optimization
    - Chemical Replacement
    - Abatement
- Involve stakeholders (facilities, process, management) in preparing contingency plan

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