Washington's Greenhouse Gas Reporting Rule
WAC 173-441
October 2009 Workshops

DEPARTMENT OF ECOLOGY
State of Washington

Basic Information Covered

- What information is to be collected
- Location of formulas to refer to
- Monitoring, and recordkeeping

Overview of Tiers of Emissions Accuracy

- 3 basic tiers of accuracy
  - A, B, and C
- A is most accurate, C is least accurate
- Accuracy relates to how accurate the input information is
- For comparison, the routine state emissions inventory is mostly of Tier B and C quality

DEPARTMENT OF ECOLOGY
State of Washington

Information to be Collected for the 3 Tiers

Tier Level	Default factors	Fuel Quantity	Heat Content	Carbon Content	CO2 CEMS	N_2O and CH_4 Monitoring
A1	None				X	X
A2	None	X	X	X		X
B	N_20 and CH_4 Emissions Factors	X	X			
C	Heat Content, CO_2, N_2O and CH_4 Emissions	X				

Where to Find the Formulas to Use

- Most methods referenced in the rule are located in the General Reporting Protocol developed by The Climate Registry
- A few Ecology methods were copied from the proposed EPA monitoring rule and are located in the rule starting at section 500
- Methods from other sources such as the final EPA reporting rule and IPCC methods can be used upon request, especially where there is no TCR or Ecology method specified

Monitoring and Recordkeeping

- In general, adequate monitoring and recordkeeping is needed to support the emissions calculations for the Tier(s) you will be using
- Some of the Ecology adopted methods and most EPA methods require significant amounts of monitoring and recordkeeping

What Monitoring is Required

- Minimum –
  - How much fuel is used by type
    - Weigh belts/scales
    - Flow meters
    - Fuel purchase records
  - Raw materials used/product produced for process emissions
  - Fugitive loss information
  - Electrical usage records

What Monitoring is Required (2)

- Additional monitoring to support higher tiers
  - Unit specific monitoring
    - Operating rates
    - Operating hours
    - Production rates
  - Fuel heat content
  - Fuel carbon content
  - Sulfur content of some fuels and SO_2 control system effectiveness
  - CEM information and calibration data

What Records Must be Kept

- Minimum
  - All fuel type and usage information collected and used for reporting or calculating emissions
  - The method used for calculating emissions
  - Calibration records for meters, etc.
- More elements and detail for higher tiers.
  - Fuel quality information
  - Fuel carbon content
  - Fuel measurement methods
  - Unit specific operational data

Stationary Source Emissions

- Examples covered
  - Fossil fuel and biomass fired power plant
  - Cabinet manufacturing facility
  - Fruit juice concentrate production
  - Lumber mill

Fossil Fuel and Biomass Power Plant

- Electric power generation facility
  - Boiler Design heat input – 750 MMBtu/hr
  - Fuel, Design, annual average capacity
    - 500 MM Btu/hr wood
    - 250 MMBtu/hr bituminous coal
  - Electrical output 60 MW, 88% CF
  - Dry limestone scrubber for SO_2 control, 70% removal
  - Office and area lighting uses purchased power
  - Operating schedule
    - Generation, full rate for 50 weeks per year
    - Office 52 weeks per year

Assumptions for the Power plant Example

- Fuels
  - Douglas fir wood, Sulfur content ≈ 0.00% by weight
  - Bituminous coal with sulfur content of 1%, by weight
- Use Tier A2 Method for coal and wood, Tier B for all else
- Include CO_2 from sulfur dioxide control
- Indirect electricity
- SF_6 emissions from plant owned and operated switchyard

Power Plant Example Calculation

- Direct CO_2, CH_4, and N_2O from wood
- Direct CO_2, CH_4, and N_2O from coal
- Direct CO_2 from the SO_2 control system
- Direct fugitive emissions from SF_6 losses
- Indirect electricity usage
- Quantity of wood and coal used is known.
- Carbon content of coal and wood used is known

Boiler Fuel Usage

- Uses 205,883 short tons/year of Douglas fir
- Uses 75,732 short tons/year of an Illinois #6 type coal

- Douglas fir has average characteristics of
  - 9,000 Btu/lb, dry, 52.3% carbon by weight
- Coal used has average characteristics of
  - 12,233 Btu/lb, 78.91 % carbon by weight

Wood Calculations

				CO_2e	
Pollutant	Firing Rate, MMBtu/hr	Emission Factor, kg/MMBtu	GWP	kg/hr	Metric tons/hr
N_2O	500	0.0056	310	763.84	0.76
CH_4	500	0.0093	21	85.93	0.09
	Fuel use, ton/hour	Carbon content, %	Heat content, Btu/lb		
CO_2	24.44	0.52	9000		42.52
	Total CO_2e per hour				43.37
	Total CO_2e for 50 week year				365,332
CO_2 from wood, 50 weeks per year					358,173

DEPARTMENT OF ECOLOGY
State of Washington

Coal Calculations

				CO_2e	
Pollutant	Firing Rate, MMBtu/hr	Emission Factor, kg/MMBtu	GWP	kg/hr	Metric tons/hr
N_2O	250	0.0611	310	4,167.02	4.17
CH_4	250	0.001	21	4.62	0.00
	Fuel use, ton/hour	Carbon content, %	Heat content, Btu/lb		
CO_2	8.99	0.79	12233		23.60
	Total CO_2e per hour				27.77
	Total CO_2e for 50 week year				233,926

SO_2 Control Calculations

The SO_2 control uses limestone as the reactant.

The control is 70% effective at removing SO_2.

The coal is 1% Sulfur by weight

How much CO_2 is released per hour by the control system?

tons of sulfur removed per hour = 18.99 *0.7 * 0.1 = 0.0629 t/hr

kg/hr CO_2 produced = $\frac{0.0629 * 44}{32}$ = 0.209 metric ton/hr

0.209 kg/hr = 1,763 metric ton CO_2/year

SF_6 Direct Fugitive Losses

SF_6 losses from plant owned switch gear on plant site.

Emissions calculated by inventory method

	SF_6 Quantity, lb	GWP	CO2e metric tons/year
Jan 1 storage inventory	15		
Purchased	25		
Sold back to supplier	17		
Dec. 31 inventory	18		
Difference lost to atmosphere	5 (2.27 kg)	23,900	54.2

Indirect Electricity Emissions

The office and perimeter lighting is served by purchased power at a rate of 2000 kW per day.

Use E-grid Default factors for 2005

Pollutant	Electrical usage, kWh/day	E-Grid Factor, lb/MWh	GWP	CO_2e kg/day	CO_2e metric ton/year
CO_2	2000	902.24	1	818.5	298.8
N_2O	2000	0.0149	310	4.2	1.5
CH_4	2000	0.01913	21	0.4	0.1
	Total Indirect Emissions			823.1	300.4

Total Power Plant Emissions

Source	Metric tons/year
Direct Combustion – biomass CO_2	358,173
Direct Combustion -fossil fuel CO_2, fossil and biomass N_2O, CH_4	205,943
CO_2 from control system	1,763
SF_6 losses	54.2
Total Direct Emissions	565,933
Indirect Emissions	300.4
Total direct and indirect emissions	566,233

This plant would report to Ecology and to EPA

Cabinet Shop Example

- Large Industrial Shop
- Emissions to account for
  - Incineration of 240 ton/yr of VOC from surface coating
  - 13 MMBtu/hr capacity natural gas space heating
  - 80 MMBtu/hr capacity wood waste boiler for space heating and waste disposal

Assumptions for Cabinet Shop Example

- Fuels
  - Mixed soft and hardwoods fired at annual average 65 MMBtu/hr
  - Natural gas metered via single plant meter.
    - Annual average of 9.75 MMBtu/hr
  - Volatile hydrocarbons from surface coating operations,
    - dominant chemical methyl isobutyl ketone,
    - natural gas as necessary to incinerate
- Use Tier B and C Methods

DEPARTMENT OF ECOLOGY
State of Washington

Wood Calculations

				CO_2e	
Pollutant	Firing Rate, MMBtu/hr	Emission Factor, kg/MMBtu	GWP	kg/hr	Metric tons/hr
CO_2	65	93.87	1	6,101.33	6.10
N_2O	65	0.0056	310	112.84	0.11
CH_4	65	0.0093	21	12.69	0.01
	Total CO_2e per hour			6,226.87	6.23
	Total CO_2e for 52 week year			54,547,362	54,547
CO_2 from wood, 52 weeks per year				53,447,680	53,448

Natural Gas Calculations

				CO_2e	
Pollutant	Firing Rate, MMBtu/hr	Emission Factor, kg/MMBtu	GWP	kg/hr	Metric tons/hr
CO_2	9.75	53.06	1	517.30	0.52
N_2O	9.75	0.0009	310	2.72	0.00
CH_4	9.75	0.0009	21	0.18	0.00
	Total CO_2e per hour			520.21	0.52
	Total CO_2e for 52 week year			4,557,014	4,557

Surface Coating Incineration Calculations

Natural gas used in incinerator included with rest of natural gas combustion

Methyl isobutyl ketone - MW = 100

carbons = 6

240 short tons/year = 217.73 metric tons/year

Metric tons CO_2 =

$$\left(\frac{44}{12}\right)\left(\frac{72}{100}\right)(217.73) = 574.8 \quad \text{Metric tons/year}$$

DEPARTMENT OF ECOLOGY
State of Washington

Indirect Emissions

Pollutant	Electrical usage, kWh/day	E-Grid Factor, lb/MWh	GWP	CO_2e kg/day	CO_2e metric ton/year
CO_2	4800	902.24	1	1,964.5	717.0
N_2O	4800	0.0149	310	10.1	3.7
CH_4	4800	0.01913	21	0.9	0.3
	Total Indirect Emissions			1,975.4	721.0

Total Cabinet Shop Emissions

Source	Metric tons/year
Direct Combustion – biomass CO_2	53,448
Direct Combustion -fossil fuel CO_2, fossil and biomass N_2O, CH_4	5,656
VOC incinerator emissions	574.8
Total Direct Emissions	59,678
Indirect Emissions	721
Total direct and indirect emissions	60,400

This plant would report to Ecology but not to EPA;
Biomass emissions not included in reporting threshold for EPA

Fruit Juice Concentrator Example

- Produces single strength and concentrated juices, commercial packaging, no retail products
- Emissions to account for
  - Boilers rated at 1500 hp total, operate at 70% CF
    - Natural gas for 6500 hours/year
    - #6 oil for 900 hours/year
  - 10 MMBtu/hr Natural gas space heating for 7000 hr/yr
- Ammonia based refrigeration

Boiler Calculations

Natural Gas Combustion					
				CO_2e	
Pollutant	Firing Rate, MMBtu/hr	Emission Factor, kg/MMBtu	GWP	kg/hr	Metric tons/hr
CO_2	50.17	53.06	1	2,662.02	2.66
N_2O	50.17	0.0009	310	14.00	0.01
CH_4	50.17	0.0009	21	0.95	0.00
	Total CO_2e per hour			2,676.97	2.68
	Total CO_2e for 6500 hr year			17,400,278	17,400

#6 Oil Combustion					
				CO_2e	
Pollutant	Firing Rate, MMBtu/hr	Emission Factor, kg/MMBtu	GWP	kg/hr	Metric tons/hr
CO_2	50.17	78.8	1	3,953.40	3.95
N_2O	50.17	0.0003	310	4.67	0.00
CH_4	50.17	0.003	21	3.16	0.00
	Total CO_2e per hour			3,961.22	3.96
	Total CO_2e for 900 hr year			3,565,100	3,565

Total CO_2e from boiler use 20,965 metric tons/year

DEPARTMENT OF ECOLOGY
State of Washington

Space Heating Calculations

				CO_2e	
Pollutant	Firing Rate, MMBtu/hr	Emission Factor, kg/MMBtu	GWP	kg/hr	Metric tons/hr
CO_2	10	53.06	1	530.57	0.53
N_2O	10	0.0009	310	2.79	0.00
CH_4	10	0.0009	21	0.19	0.00
	Total CO_2e per hour			533.55	0.53
	Total CO_2e for 7000 hr year			3,734,820	3,735

Indirect Electricity Emissions

Pollutant	Electrical usage, kWh/day	E-Grid Factor, lb/MWh	GWP	CO_2e kg/day	CO_2e metric ton/year
CO_2	1957	902.24	1	800.9	292.3
N_2O	1957	0.0149	310	4.1	1.5
CH_4	1957	0.01913	21	0.4	0.1
	Total Indirect Emissions			805.4	294.0

Total Fruit Juice Concentrator Emissions

Source	Metric tons/year
Direct Combustion – Boiler	20,965
Direct Combustion –Space heating	3,735
Total Direct Emissions	24,700
Indirect Emissions	294
Total direct and indirect emissions	24,994

This plant would report to Ecology but not to EPA;
Direct emissions less than 25,000 metric ton threshold of EPA

Lumber Mill Example

- 18 MMBtu/hr wood fired boiler to operate Dry kilns
- All other equipment uses electric motors for operation
- No incineration of VOCs from the dry kilns
- Electric heat used for space heating

Assumptions for Lumber Mill Example

- Fuels
  - Pines fired at average rate of 12 MMBtu/hr, 48 weeks per year
- Use Tier C Methods

DEPARTMENT OF ECOLOGY
State of Washington

Wood Calculations

				CO_2e	
Pollutant	Firing Rate, MMBtu/hr	Emission Factor, kg/MMBtu	GWP	kg/hr	Metric tons/hr
CO_2	12	93.87	1	1,126.40	1.13
N_2O	12	0.0056	310	20.83	0.02
CH_4	12	0.0093	21	2.34	0.00
	Total CO_2e per hour			1,149.58	1.15
	Total CO_2e for 48 week year			9,270,178	9,270
CO_2 from wood, 48 weeks per year				9,083,290	9,083

DEPARTMENT OF ECOLOGY
State of Washington

Indirect Electricity Emissions

Pollutant	Electrical usage, kWh/day	E-Grid Factor, lb/MWh	GWP	CO_2e kg/day	CO_2e metric ton/year
CO_2	7000	902.24	1	2,864.9	1,045.7
N_2O	7000	14.9	310	14,666.8	5,353.4
CH_4	7000	19.13	21	1,275.6	465.6
	Total Indirect Emissions			18,807.3	6,864.7

Total Lumber Mill Emissions

Source	Metric tons/year
Direct Combustion – Biomass CO_2	9,083
Direct Combustion – Biomass N_20 and CH_4	187
Total Direct Emissions	9,270
Indirect Emissions	6,864.7
Total direct and indirect emissions	16,135

This plant would not report to Ecology or EPA

Questions?