



Ecology Fleet Calculations  
October 24, 2008



# Ecology Fleet Emissions

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- Response to input from September meeting
- Using Ecology's 2007 emissions as a case study
- What is involved in calculating emissions using TCR methods?
- HFC emission calculations
- What percentage of total emissions come from CH<sub>4</sub>, N<sub>2</sub>O, and HFCs?
- How does this relate to de minimis? – Covered in afternoon presentation



# Gathering Data

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- Took approximately 1 hour
- Figuring out who to talk to key
- Ecology fleet database
  - Data from vehicle logs and fuel purchases
  - Organized by vehicle – includes make, model, and year
  - Total fuel consumed per vehicle – fuel type from purchase records
  - Fuel purchased at pumps across state – no fuel characteristics data
  - Total miles per vehicle
  - No data for HFC emissions
  - Assumed all travel in state



# Organizing Data

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- Getting data into a workable format – 1 hour
- Vehicle categorization – 2 hours
  - Amount of time needed depends on data available and calculation method
  - Cross checked with web references (<http://www.epa.gov/greenvehicles>)
- Cleaning up and looking for outliers



# Ecology's Fleet

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| Fuel Type | Number of Vehicles | Gallons Used | Miles Driven |
|-----------|--------------------|--------------|--------------|
| Gasoline  | 433                | 202,380      | 4,073,514    |
| Diesel    | 14                 | 9,854        | 144,703      |
| Biodiesel | 1                  | 20*          | 5,359        |
| CNG       | 1                  | 149          | 5,189        |
| Total     | 449                | 212,403      | 4,228,765    |

\* Fuel use and mileage do not match. Calculated with higher value (mileage) and average 2006 mpg for vehicle.



# Ecology's Fleet

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| Vehicle Type                 | EPA Tier 0 | EPA Tier 1 | EPA Tier 2 |
|------------------------------|------------|------------|------------|
| Gasoline passenger cars      | 0          | 63         | 93         |
| Gasoline light trucks        | 7          | 144        | 95         |
| Gasoline heavy duty vehicles | 1          | 22         | 9          |
| Diesel light trucks*         | 0          | 1          | 14         |

\* Moderate or advanced control.



# Choosing Calculation Methods

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- CO<sub>2</sub> – Tier B, fuel use with default emission factors by fuel type
  - Total gallons x emission factor (kg CO<sub>2</sub> / gal) / 1,000 (kg / metric ton) = MT CO<sub>2</sub> emissions
- CH<sub>4</sub> & N<sub>2</sub>O – Tier A, mileage with default emission factors by control technology
  - Total miles x control technology emission factor (g / mi) / 1,000,000 (g / metric ton) = MT emissions x GWP = MT CO<sub>2</sub>e emissions
- HFCs – TCR GRP Screening Method
  - (TCR GRP Chapter 16, pg 128–131)



# CO<sub>2</sub> Emissions

| Fuel Type | Gallons Used | Emission Factor<br>(kg CO <sub>2</sub> / gal) | MT CO <sub>2</sub> e |
|-----------|--------------|---|----------------------|
| Gasoline  | 202,380      | 8.81  | 1,783                |
| Diesel    | 9,854        | 10.15   | 100                  |
| Biodiesel | 430*         | 9.46  | 4                    |
| CNG       | 149          | 4.46  | 1                    |
| Total     | 212,813      | NA  | 1,888                |

\* Fuel use and mileage do not match. Calculated with higher value (mileage) and average 2006 mpg for vehicle.



# CH<sub>4</sub> Emissions

| Vehicle Type                           | Miles     | Emission Factor<br>(g / mi) | MT CH <sub>4</sub> | MT CO <sub>2</sub> e |
|--|-----------|-----------------------------|--------------------|----------------------|
| Gasoline passenger cars (Tier 1)       | 562,109   | 0.0271                      | 0.02               | 0.32                 |
| Gasoline passenger cars (Tier 2)       | 1,223,831 | 0.0173                      | 0.02               | 0.44                 |
| Gasoline light trucks (Tier 0)         | 23,535    | 0.0776                      | 0.002              | 0.04                 |
| Gasoline light trucks (Tier 1)         | 975,975   | 0.0452                      | 0.04               | 0.93                 |
| Gasoline light trucks (Tier 2)         | 966,060   | 0.0163                      | 0.02               | 0.33                 |
| Gasoline heavy duty vehicles (Tier 0)  | 3,939     | 0.2630                      | 0.001              | 0.02                 |
| Gasoline heavy duty vehicles (Tier 1)  | 192,527   | 0.0655                      | 0.01               | 0.26                 |
| Gasoline heavy duty vehicles (Tier 2)  | 125,538   | 0.0333                      | 0.004              | 0.09                 |
| Diesel light trucks (moderate control) | 3,313     | 0.0009                      | 0.000              | 0.00                 |
| Diesel light trucks (advanced control) | 141,390   | 0.0010                      | 0.000              | 0.00                 |
| Biodiesel light trucks                 | 5,359     | 0.0550                      | 0.000              | 0.01                 |
| CNG Light Duty Vehicles                | 5,189     | 0.7370                      | 0.004              | 0.08                 |
| Total                                  | 4,228,765 | NA                          | 0.12               | 2.5                  |



# N<sub>2</sub>O Emissions

| Vehicle Type                           | Miles     | Emission Factor<br>(g / mi) | MT N <sub>2</sub> O | MT CO <sub>2</sub> e |
|--|-----------|-----------------------------|---------------------|----------------------|
| Gasoline passenger cars (Tier 1)       | 562,109   | 0.0429                      | 0.02                | 7.48                 |
| Gasoline passenger cars (Tier 2)       | 1,223,831 | 0.0036                      | 0.004               | 1.37                 |
| Gasoline light trucks (Tier 0)         | 23,535    | 0.1056                      | 0.002               | 0.77                 |
| Gasoline light trucks (Tier 1)         | 975,975   | 0.0871                      | 0.09                | 26.35                |
| Gasoline light trucks (Tier 2)         | 966,060   | 0.0066                      | 0.006               | 1.98                 |
| Gasoline heavy duty vehicles (Tier 0)  | 3,939     | 0.2135                      | 0.001               | 0.26                 |
| Gasoline heavy duty vehicles (Tier 1)  | 192,527   | 0.1750                      | 0.03                | 10.44                |
| Gasoline heavy duty vehicles (Tier 2)  | 125,538   | 0.0134                      | 0.002               | 0.52                 |
| Diesel light trucks (moderate control) | 3,313     | 0.0014                      | 0.000               | 0.00                 |
| Diesel light trucks (advanced control) | 141,390   | 0.0015                      | 0.000               | 0.07                 |
| Biodiesel light trucks                 | 5,359     | 0.0670                      | 0.000               | 0.11                 |
| CNG Light Duty Vehicles                | 5,189     | 0.0500                      | 0.000               | 0.08                 |
| Total                                  | 4,228,765 | NA                          | 0.16                | 49.4                 |



# HFC Emissions

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- TCR GRP Chapter 16, pg 121
- Tier A – Mass balance method
- Tier B – Simplified mass balance method
- “Tier D” – TCR GRP Screening Method
  - TCR considers simplified estimation method, but Ecology will accept it as a tiered method
  - (TCR GRP Chapter 16, pg 128–131)



# HFC Calculations

## Equation 16e

## Estimating Emissions of Each Type of Refrigerant using the Screening Method

For each type of refrigerant:

$$\text{Total Annual Emissions (metric tons)} = \left[ \begin{matrix} (C_N \times k) & + & (C \times x \times T) & + & (C_D \times y \times (1 - z)) \end{matrix} \right] \div 1,000$$

(kg) (%)
(kg) (%) (years)
(kg) (%)
(%)
(kg/metric ton)

Where:

$C_N$  = quantity of refrigerant charged into the new equipment <sup>1</sup>

$C$  = total full charge (capacity) of the equipment

$T$  = time in years equipment was in use (e.g., 0.5 if used only during half the year and then disposed)

$C_D$  = total full charge (capacity) of equipment being disposed of <sup>2</sup>

$k$  = installation emission factor <sup>1</sup>

$x$  = operating emission factor

$y$  = refrigerant remaining at disposal <sup>2</sup>

$z$  = recovery efficiency <sup>2</sup>

<sup>1</sup> Omitted if no equipment was installed during the reporting year or the installed equipment was pre-charged by the manufacturer

<sup>2</sup> Omitted if no equipment was disposed of during the reporting year

| Type of Equipment       | Capacity (kg) | Installation Emission Factor k (% of capacity) | Operating Emission Factor x (% of capacity / year) | Refrigerant Remaining at Disposal y (% of capacity) | Recovery Efficiency z (% of remaining) |
|-------------------------|---------------|--|--|---|--|
| Mobile Air Conditioning | 0.5 – 1.5     | 0.5 %  | 20 %   | 50 %  | 50 %                                   |



# HFC Calculations

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- New equipment =  $(C_N \times k)$ 
  - Pre-charged by manufacturer, so omitted
- Retired equipment =  $(C_D \times y \times (1 - z))$ 
  - $C_D$  = number of retired vehicles x charge per vehicle  
= 31 new vehicles x 1.5 kg per vehicle = 46.5 kg
  - $46.5 \text{ kg} \times 50\% \times (1 - 50\%) = 11.63 \text{ kg}$
- Vehicle use =  $(C \times x \times T)$ 
  - $1.5 \text{ kg} \times 20\% \times 1 \text{ year} = 0.3 \text{ kg per vehicle} \times 449 \text{ vehicles} = 134.7 \text{ kg}$



# HFC Calculations

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- Total emissions = omitted + 11.63 kg + 134.7 kg  
= 146.3 kg / 1,000 = 0.146 MT HFCs
- HFCs = HFC-134a, GWP = 1,300  
0.146 MT HFCs x 1,300 = 190.2 MT CO<sub>2</sub>e



# Total Emissions

|                  | Fossil Fuel<br>MT CO <sub>2</sub> e | Biogenic<br>MT CO <sub>2</sub> e | Total<br>MT CO <sub>2</sub> e | % of Total<br>Emissions |
|------------------|-------------------------------------|----------------------------------|-------------------------------|-------------------------|
| CO <sub>2</sub>  | 1,884                               | 4.1                              | 1,888                         | 88.6%                   |
| CH <sub>4</sub>  | 2.5                                 | NA                               | 2.5                           | 0.1%                    |
| N <sub>2</sub> O | 49.4                                | NA                               | 49.4                          | 2.3%                    |
| HFCs             | 190.2                               | NA                               | 190.2                         | 8.9%                    |
| Total            | 2,126                               | 4.1                              | 2,130                         | –                       |



# Time to Calculate Fleet Emissions

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- 1 hr to get data
- 1 hr to get data into a workable format
- 2 hrs to categorize the vehicles
- 2 hrs to do most of the calculations
- 2 hrs to deal with outliers
- 2 hrs to organize results and check calculations
  
- Total of approximately 10 hours



# *Climate Change*

*global warming*

Questions?