Vehicle Emissions Modelling

Jennifer Armstrong
Carleton University
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Presentation Overview

- Background
- Research tasks
  - intra-zonal travel
  - commercial traffic
  - operating mode fractions
  - the “Emission Calculator”
- Vehicle emissions in the NCR
- Conclusions

Why Model Vehicle Emissions?

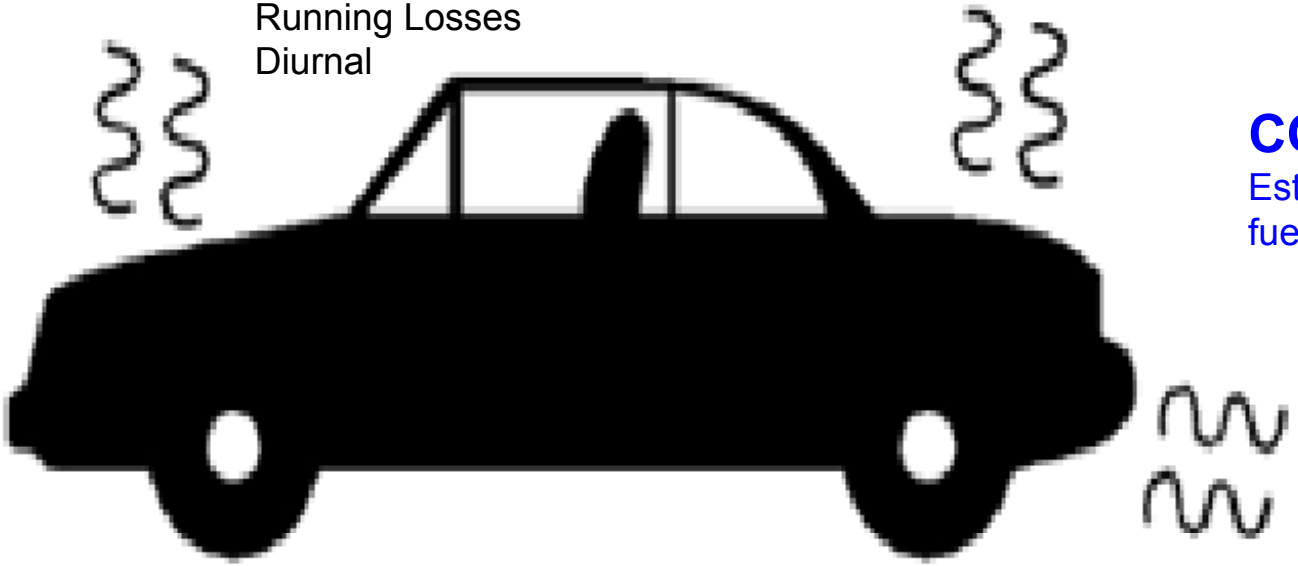
- Analyze the environmental impacts of transportation and land use policies
  - HOV lanes / TDM measures
  - major road network modifications
  - changes in transit ridership
- Evaluate methods to improve air quality

Automobile Pollution

Evaporative Emissions

Hot Soak
Running Losses
Diurnal

Refuelling Emissions



CO_2
Estimated based on fuel consumption

Exhaust Emissions

NOx - High temperatures from combustion
CO - Incomplete combustion
HC - Escaping fuels

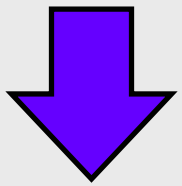
Two Processes
Combustion (Exhaust System)
Evaporation (Fuel Storage and Delivery System)

Emission Modelling Defined

- Predicts HC, CO, and NOx emissions as a function of:
  - vehicle fleet composition
  - operating speed and mode
  - trip length distribution
  - temperature
- Assumes “average” driver behaviour and trip characteristics

Emission Modelling Defined

- Emission models require as input:
  - number of vehicle kilometers travelled
  - average operating speed
  - trip length distribution



these are predicted using

TRAVEL DEMAND MODELS

Travel Demand Models

- Used to predict future traffic levels based on a region's demographic and socio-economic characteristics
- Regional EMME/2 model can predict:
  - number of vehicles per road segment
  - average operating speed
  - trip length distribution

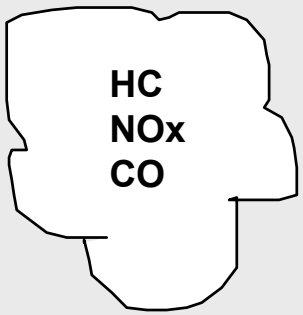
Emission Modelling: MOBILE5

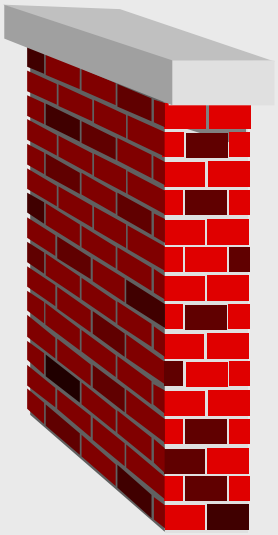
- Empirical model developed by EPA
- Estimates emissions of HC, NOx, CO in grams / mile, NOT air quality
- Based on extensive laboratory testing
- Assumes “average” driver behaviour and trip characteristics

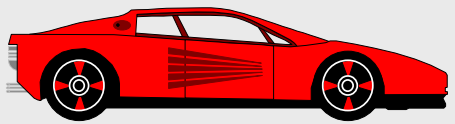
Emissions = Base Emission Rate * Adjustment Factors * VKT

Model Integration

Emission Models	Travel Demand Models
MOBILE5	EMME/2







Model Integration

Emission Models	⟷	Travel Demand Models
MOBILE5		EMME/2

Research Tasks - Phase 1

- Estimate intra-zonal travel
- Study vehicle operating mode characteristics in the NCR
- Estimate commercial travel
- Determine the vehicle age distribution in the study area
- Analyze temperature data

Research Tasks - Phase 2

- Develop macros to estimate vehicle emissions
  - EMME/2 macros
  - the “Emission Calculator”

Analysis Periods

- Selected 5 analysis periods with similar travel characteristics

Analysis Period	Time Interval	Representative Hour
Early Morning	4:00 a.m. - 7:00 a.m.	5:30 a.m. - 6:30 a.m.
AM Peak Period	7:00 a.m. - 9:30 a.m.	8:00 a.m. - 9:00 a.m.
Midday	9:30 a.m. - 3:30 p.m.	12:30 p.m. - 1:30 p.m.
PM Peak Period	3:30 p.m. - 6:00 p.m.	4:45 p.m. - 5:45 p.m.
Evening	6:00 p.m. - 4:00 a.m.	8:00 p.m. - 9:00 p.m.

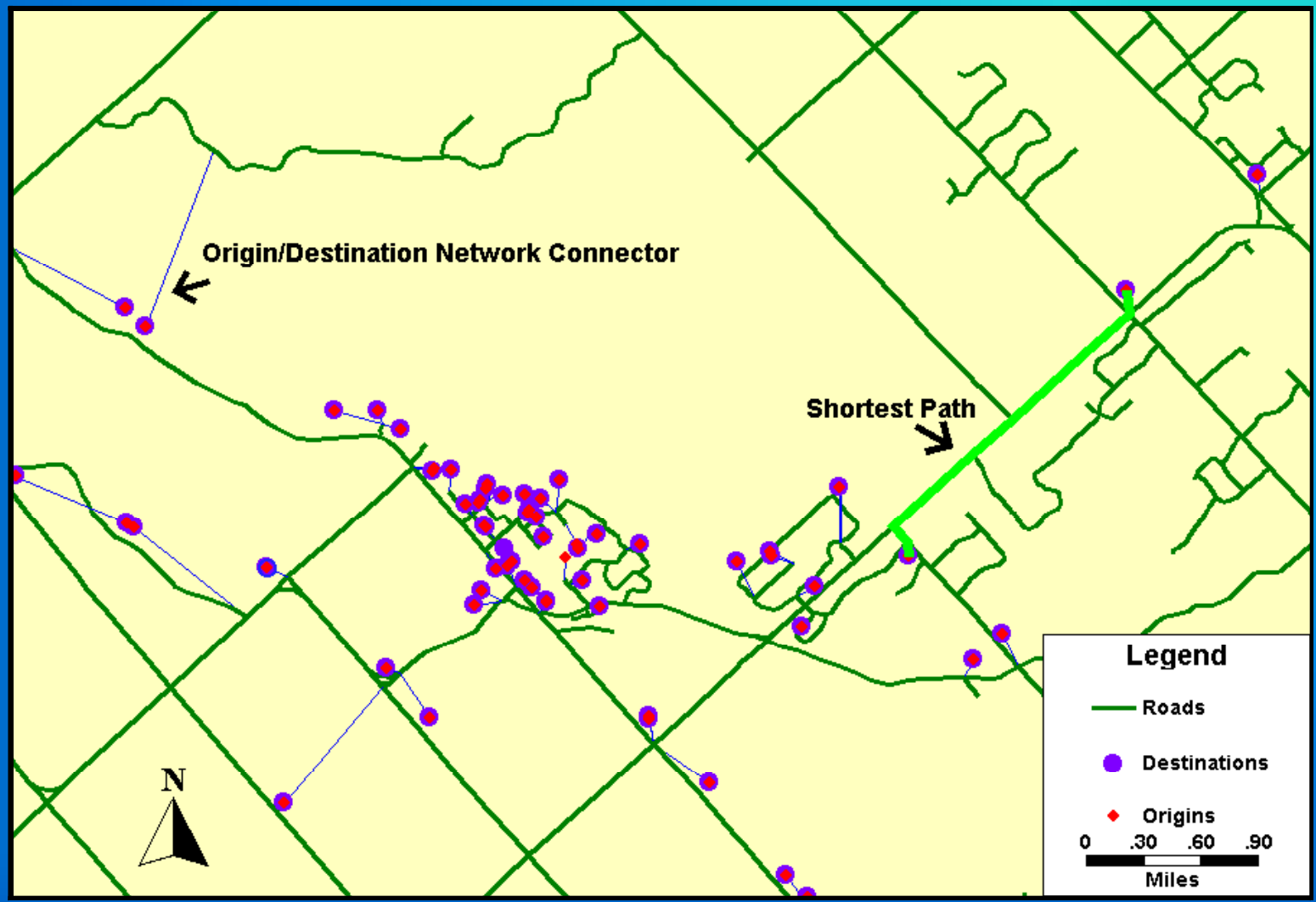
Road Classification Scheme

- Developed a classification scheme based on:
  - road capacity
    - local roads / centroid connectors
    - “major” and “minor” arterial/collectors
    - freeways and rural highways
    - transit-only roads
  - location within the study area
    - core, urban, suburban, rural

Intra-zonal Travel

- Trips which begin and end in the same traffic zone are not assigned to the transportation network in EMME/2
- To estimate the amount of travel associated with intra-zonal trips, TransCAD GIS was used to compute the shortest path between trip origins and destinations

Intra-zonal Travel - Analysis



“Background” Traffic

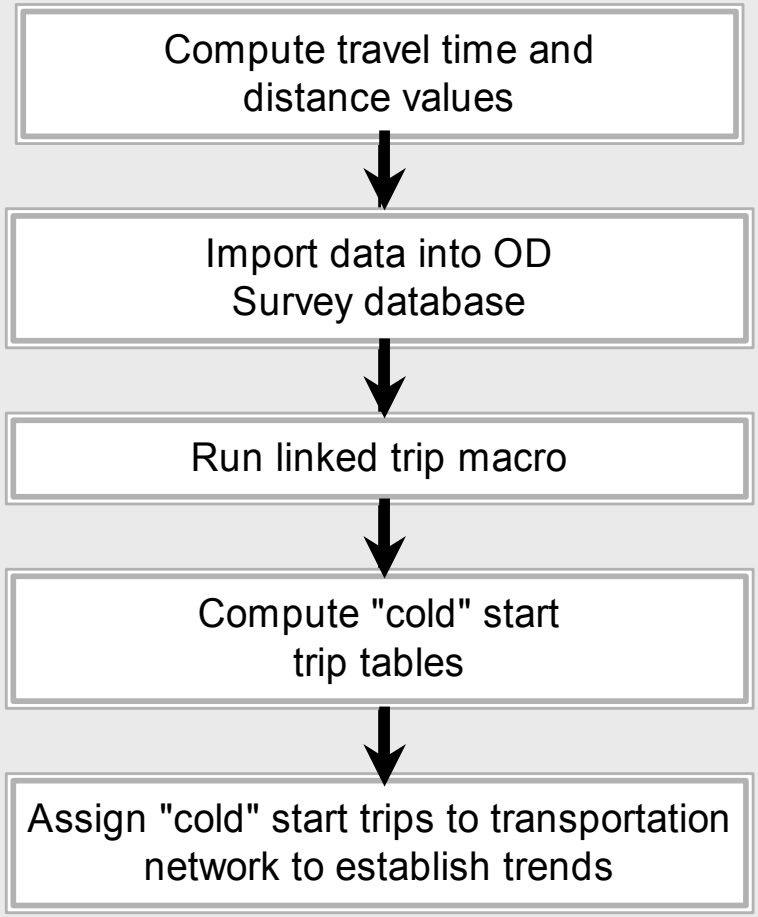
- It is important to know the total volume of traffic using the transportation network
  - improve travel time estimates
  - improve vehicle emission estimates
- EMME/2 only predicts passenger vehicle travel

“Background” Traffic

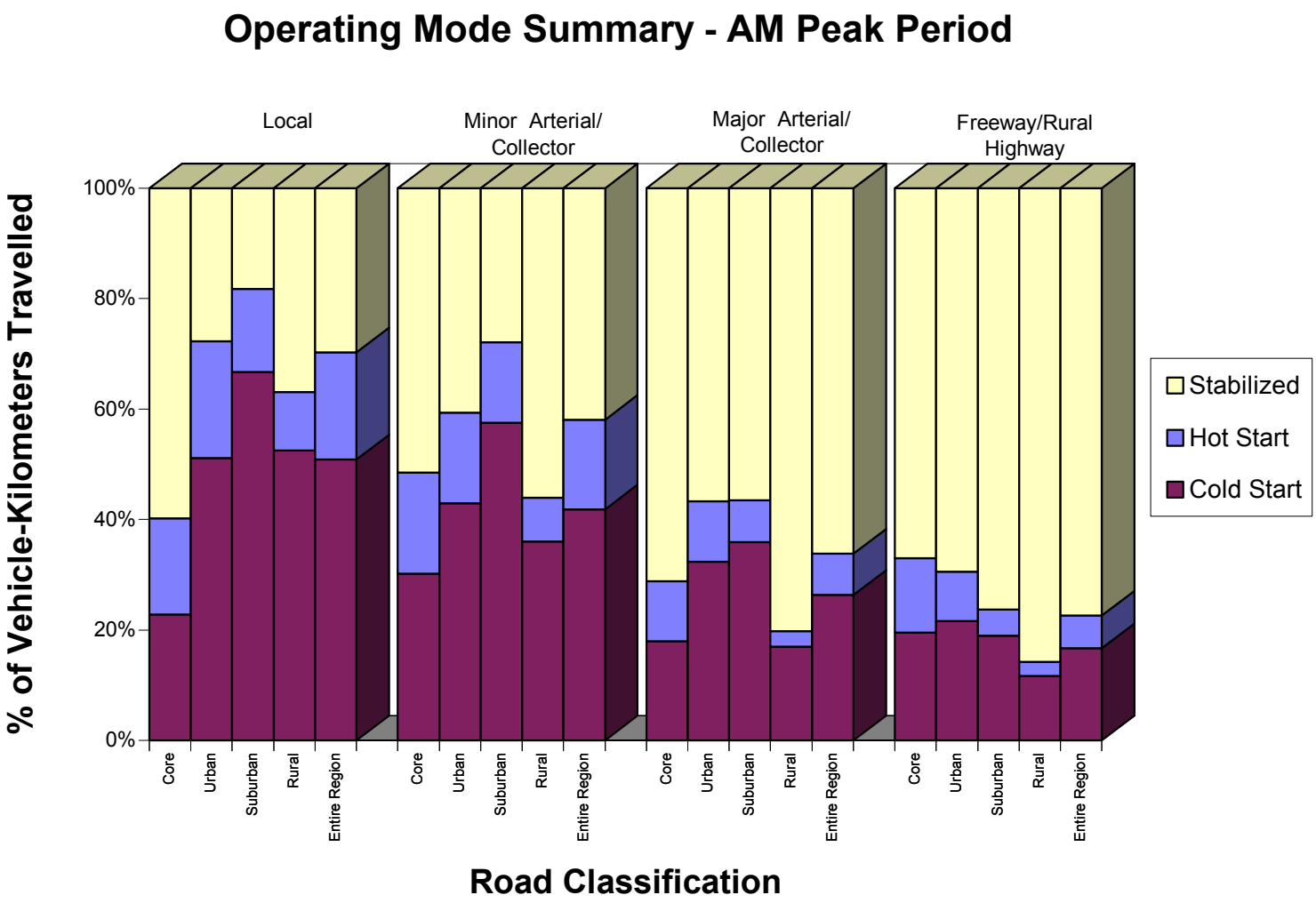
- Analyzed data from the 1996 C&O counts to determine the amount of commercial vehicle travel
- Established vehicle mix ratios for freeways, and for arterial/collector roads in urban, suburban, and rural areas
- Made assumptions regarding vehicle weight categories and fuel types

Operating Mode Analysis

- Three operating modes:
  - hot start
  - cold start
  - hot stabilized
- If the engine has been turned off for more than an hour, the trip is defined as “cold” start



Operating Mode - Results

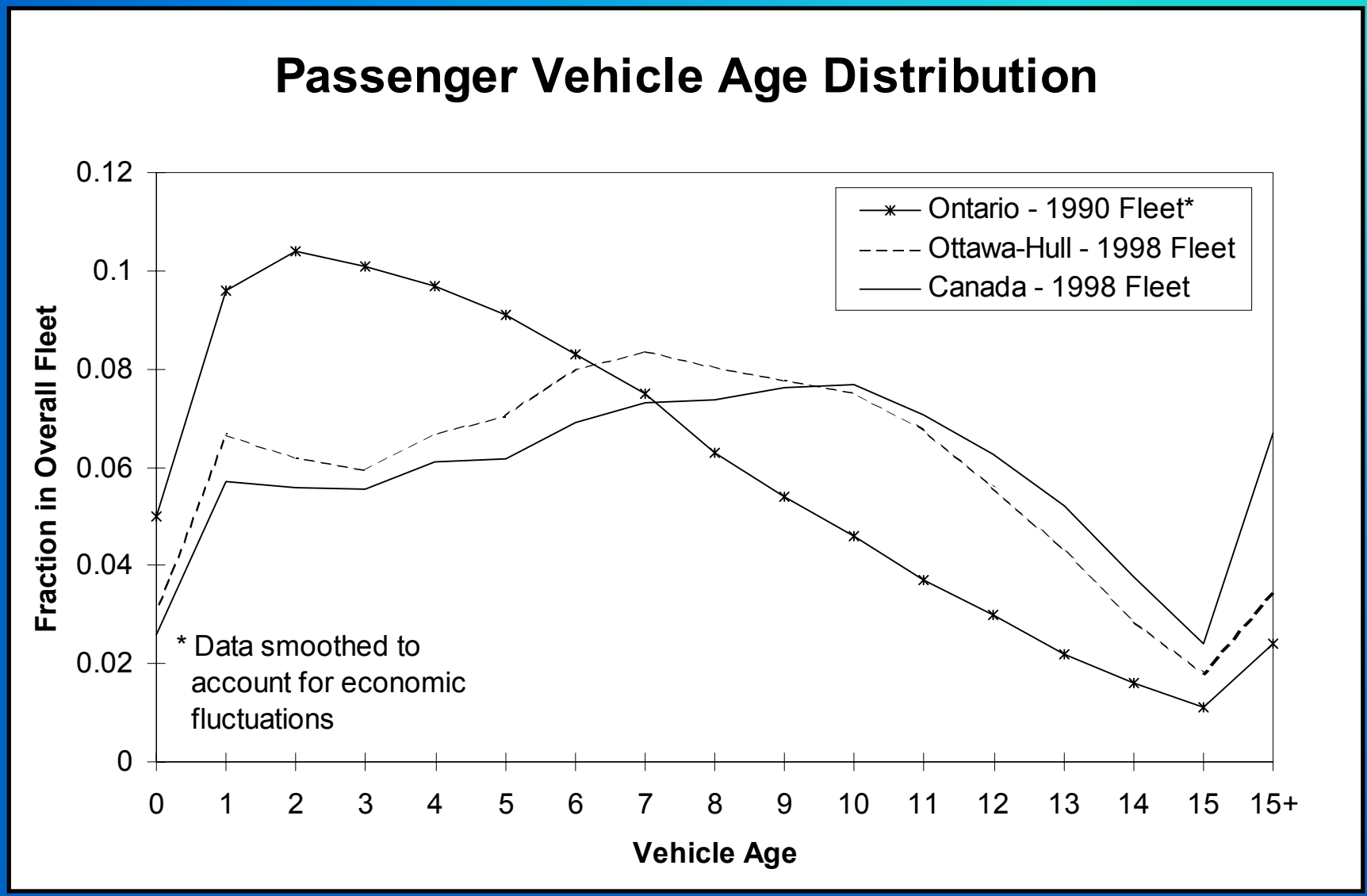


Temperature Inputs

- Correspond to a “typical” October day
- Based on temperature data measured at the Ottawa Int’l Airport

Early Morning	5.0 °C
AM Peak Period	6.3 °C
Midday	10.6 °C
PM Peak Period	10.8 °C
Evening	8.2 °C
AM Peak Hour	6.0 °C
PM Peak Hour	11.0 °C
Maximum Daily Temperature	12.5 °C
Minimum Daily Temperature	3.7 °C

Vehicle Age Distribution



EMME/2 Macros

- Create an output file which summarizes travel data (vkt, link speed, trip length distribution, ...)

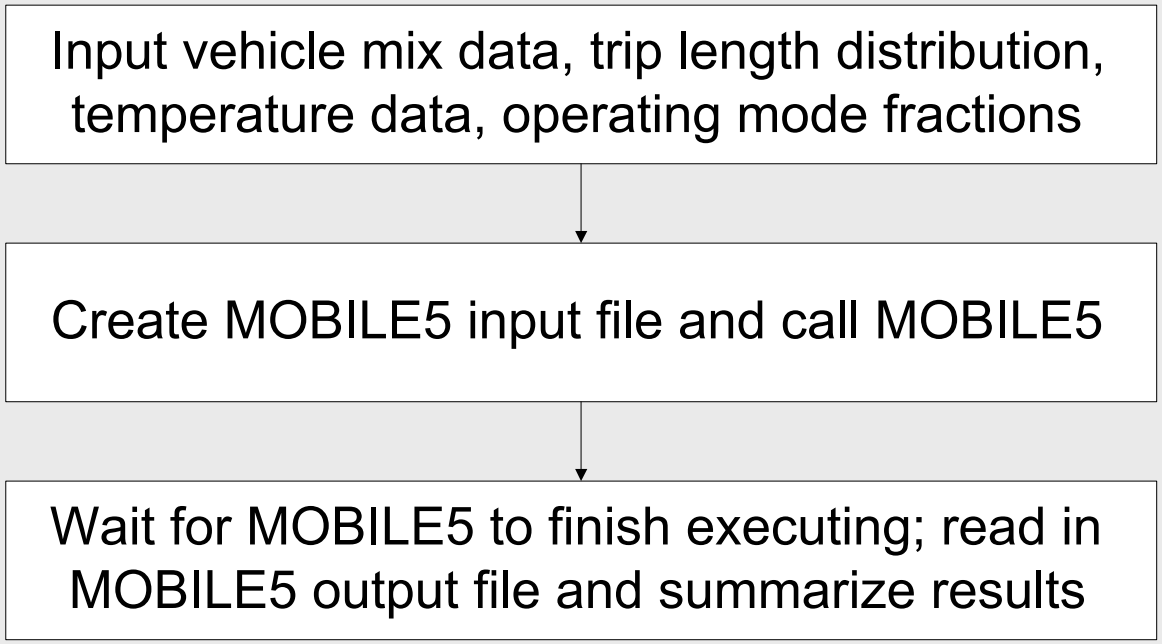
```
Operating mode variable = 2
Additional vkt variable = 1
Number of link locations = 9
Number of link types = 6

                                                Vehicle Kilometers Travelled
     Node ID         Area     Link    Speed    Total    Start     Cold    Transit

  inode   jnode     @area    @link   @speed      ul1   @start      ul3      ul2     result
      1    1007         1        5 18.1818  2.93796  2.93795   .03314        0    30.0909
      1    1022         1        5 18.1818  2.97065   2.9706   .11294        0     30.236
      2    1027         1        5 18.1818  2.07064  2.07064   .17714        0    28.5002
      2    1044         1        5 18.1818  3.80411   3.8041   .29046        0    32.0805
      3    1048         1        5 18.1817  4.42378  4.42378   4.0525        0    37.0818
      4    2138         1        5 27.2727  6.42342  6.42342  6.41634        0    52.5359
```

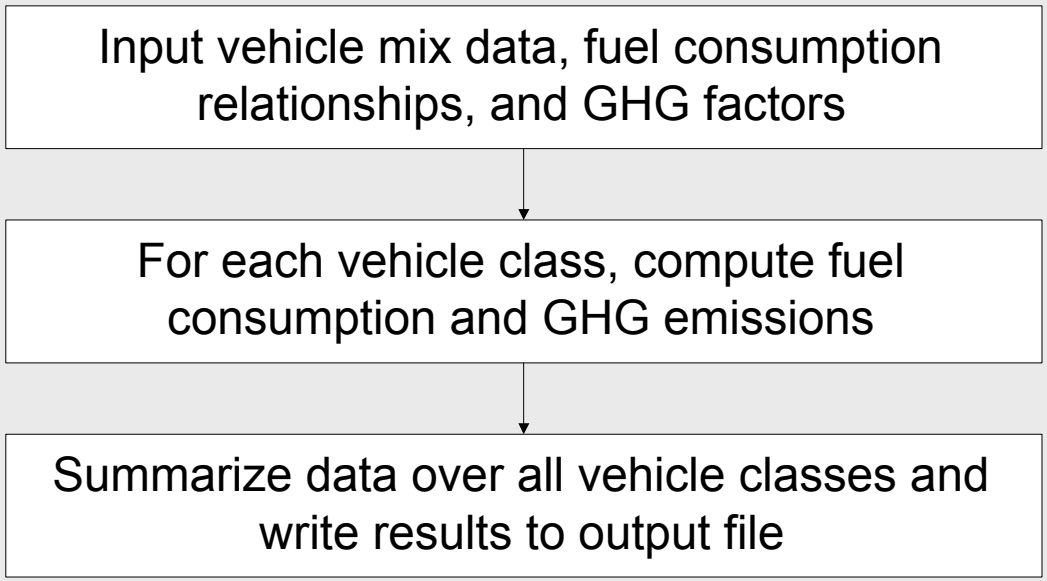
The Emission Calculator

- Computes CO, NO_X, and HC emissions using MOBILE5



The Emission Calculator

- Computes greenhouse gas emissions using fuel consumption equations specified by the user



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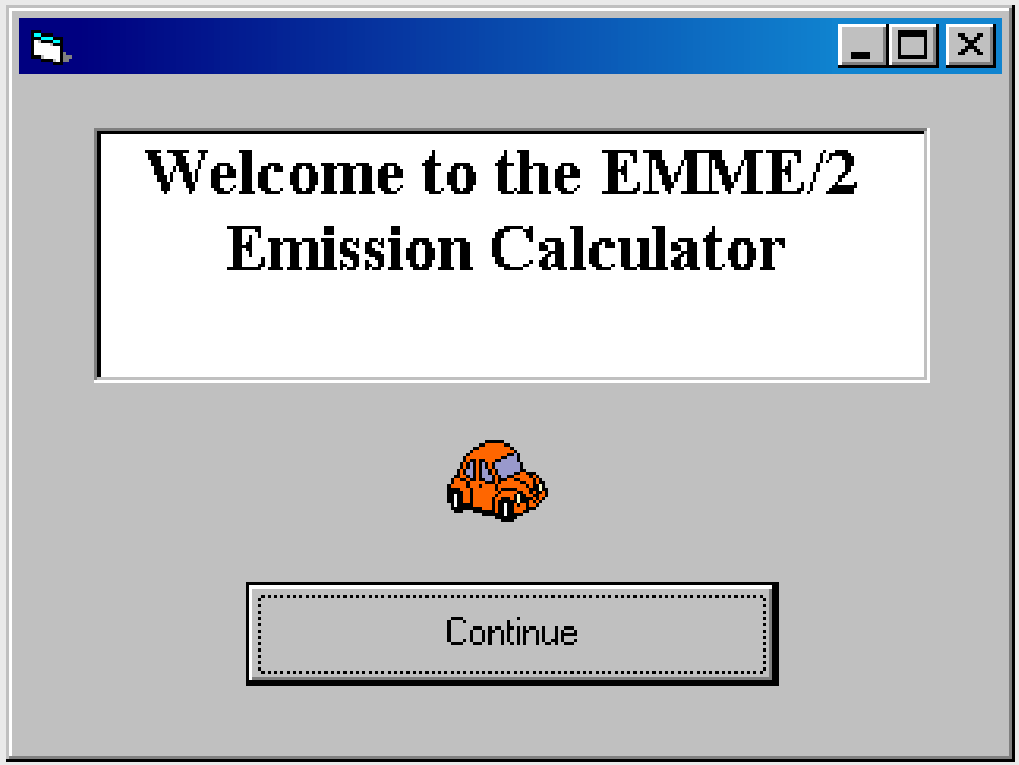

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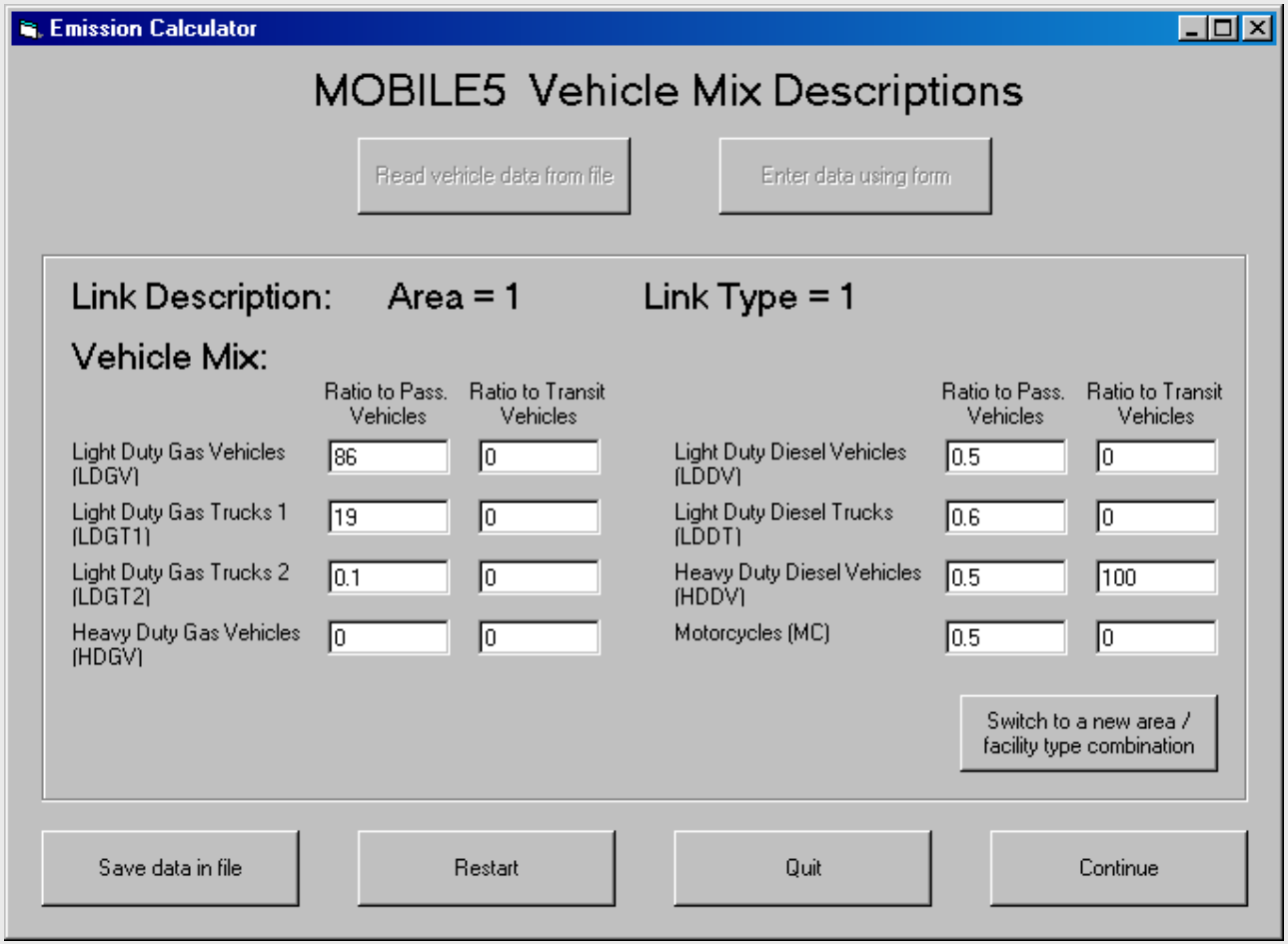

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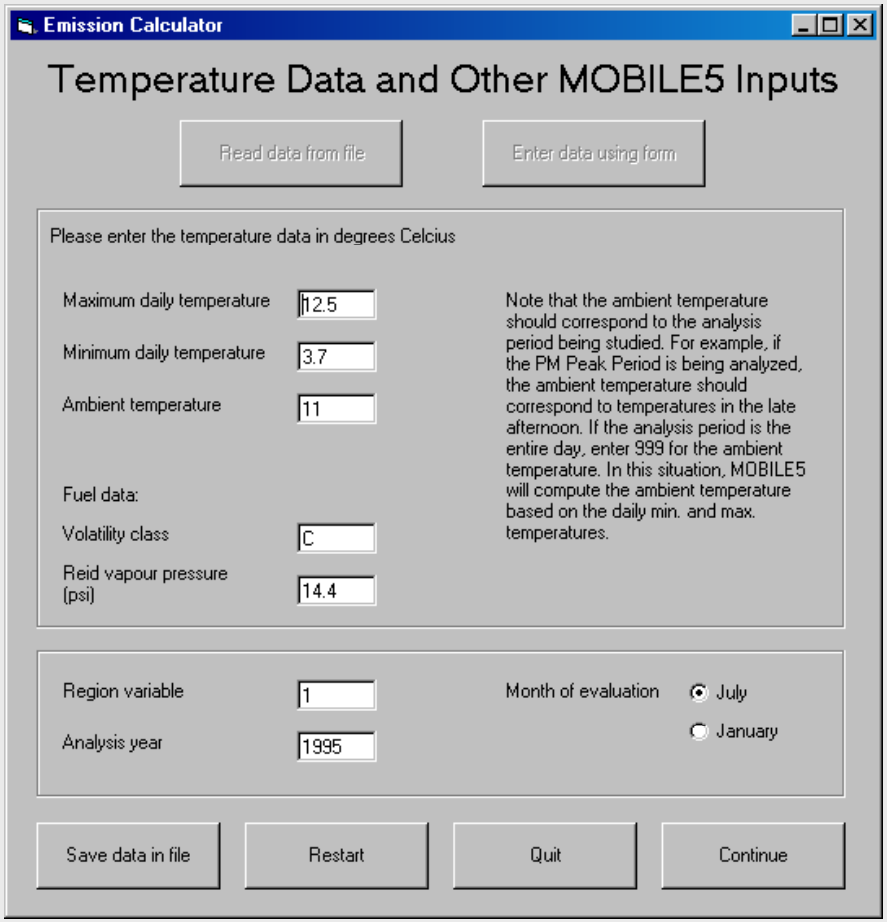
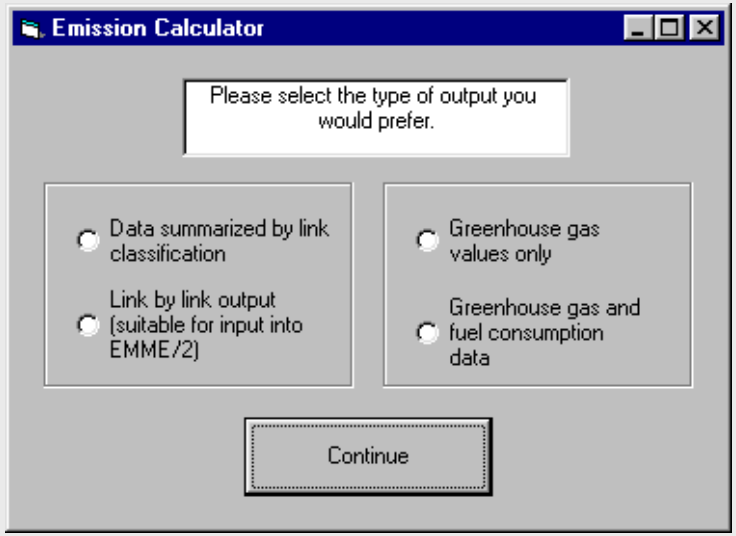
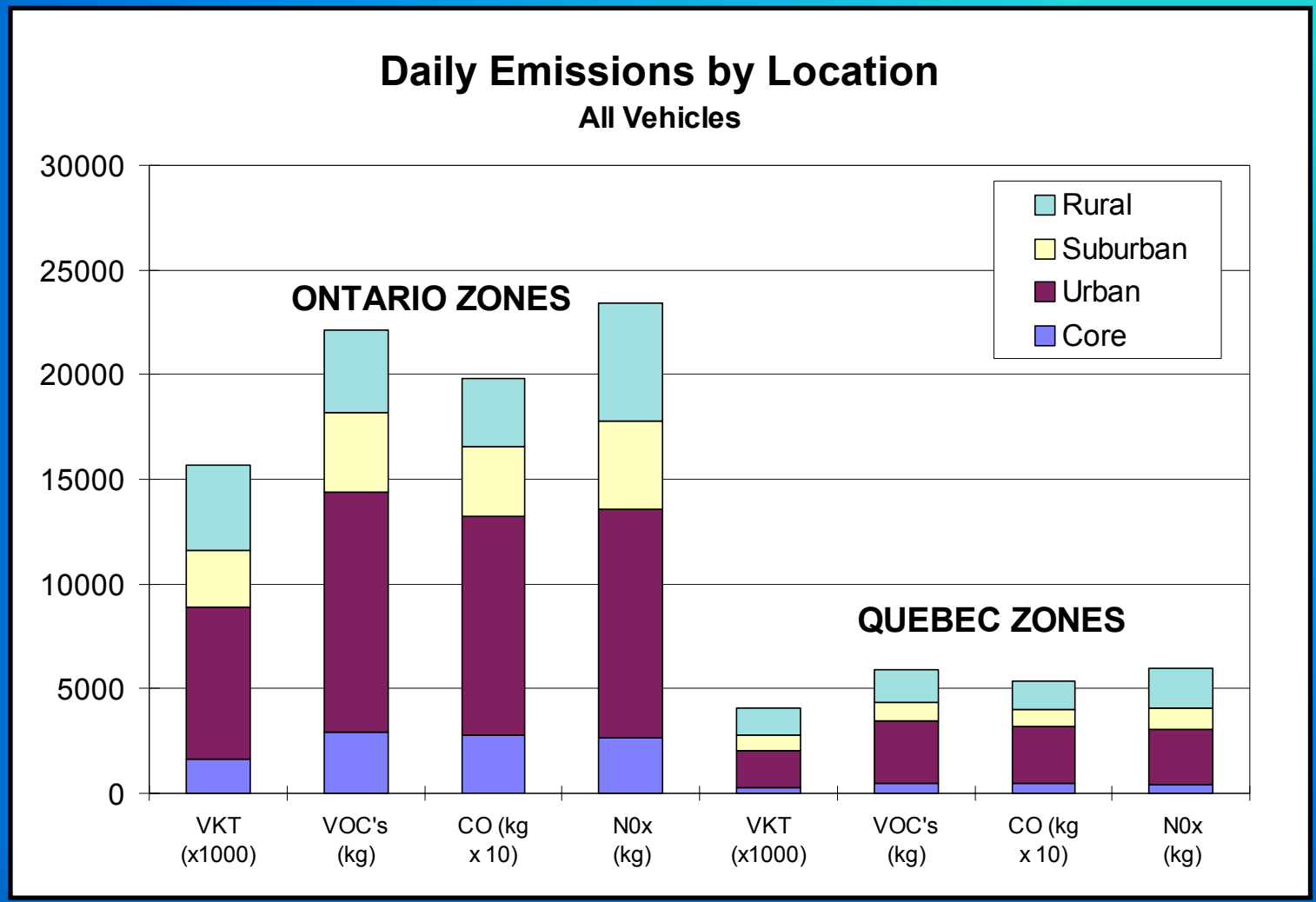




Vehicle Emissions in the NCR



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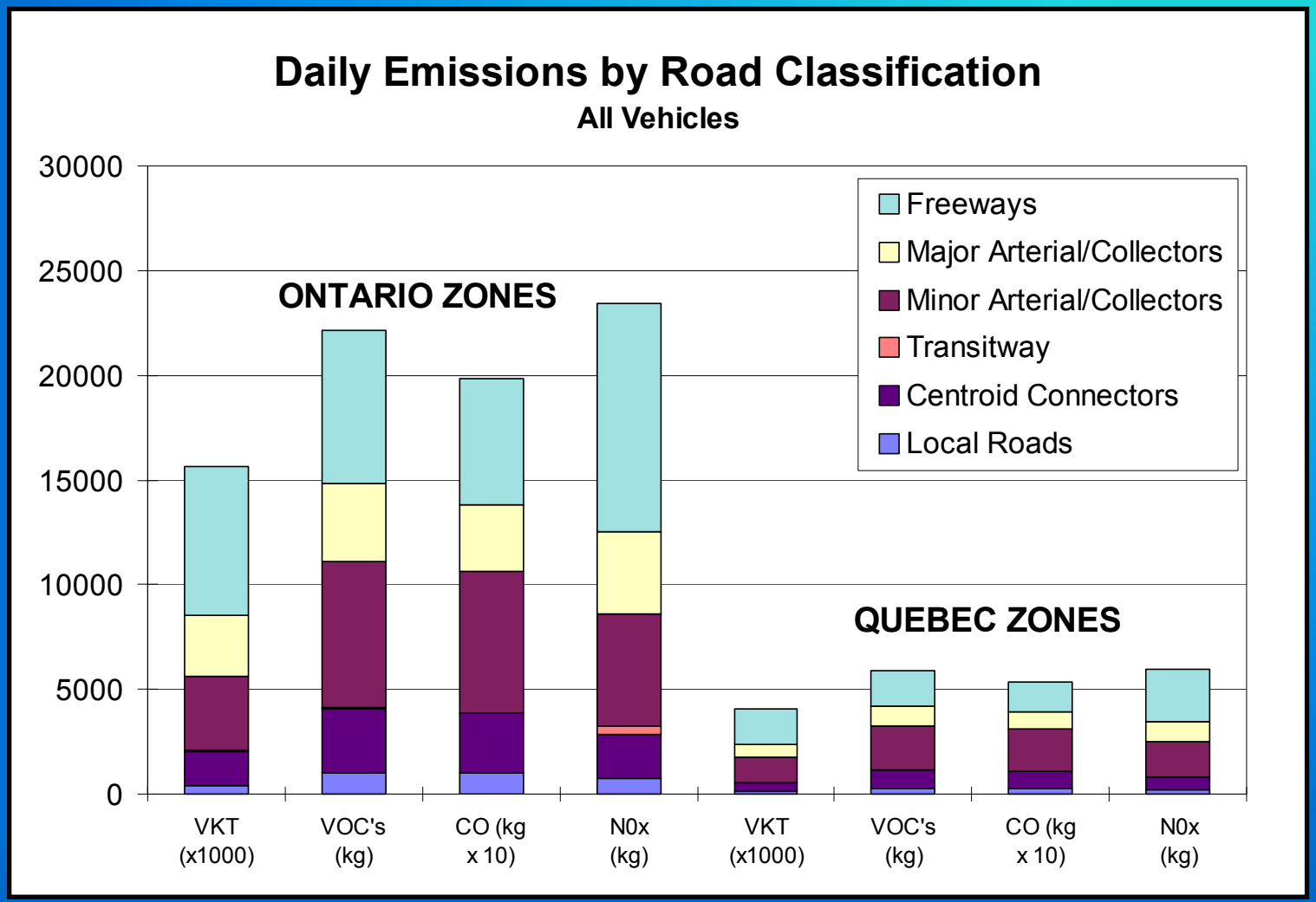

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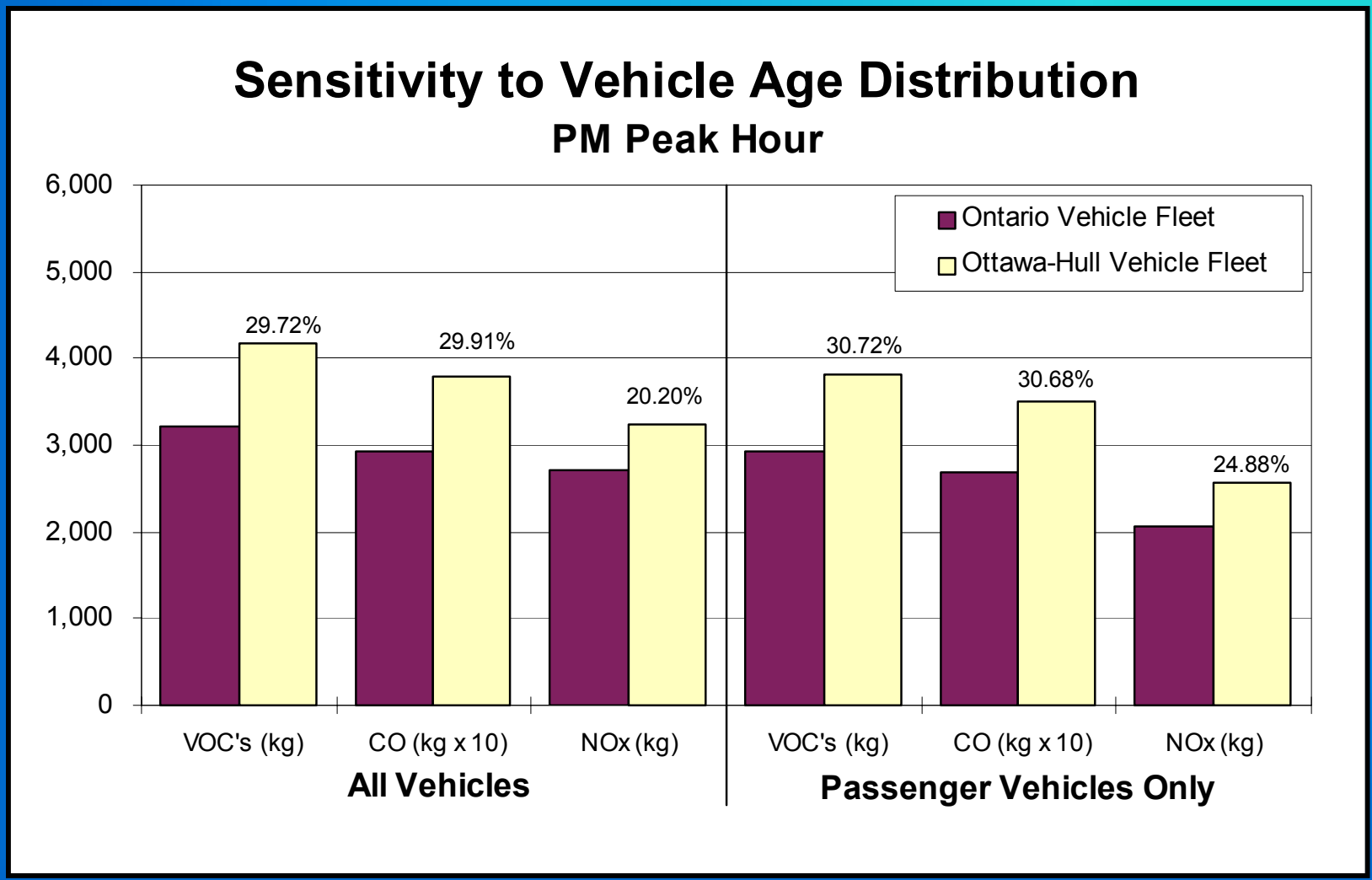

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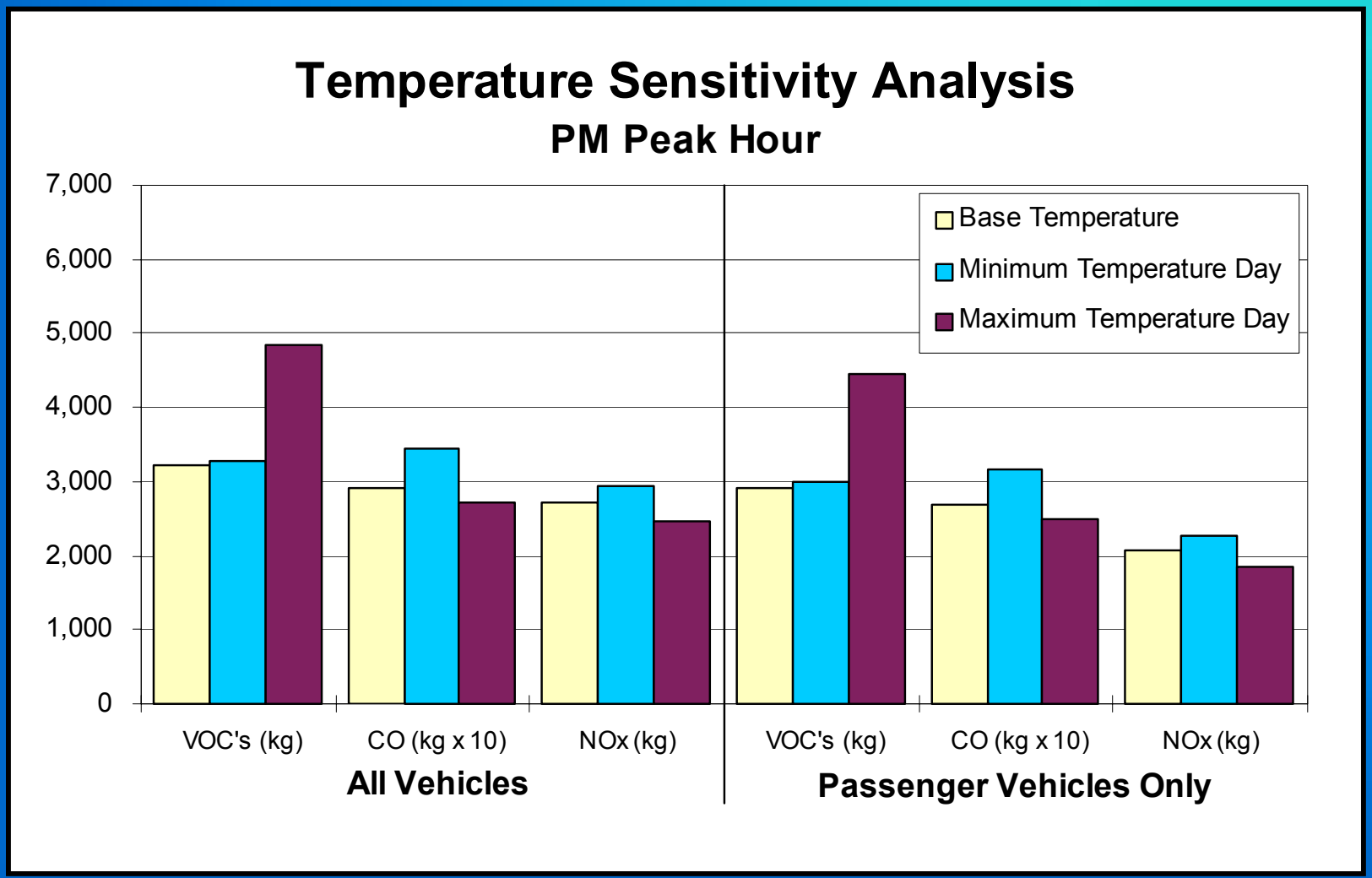
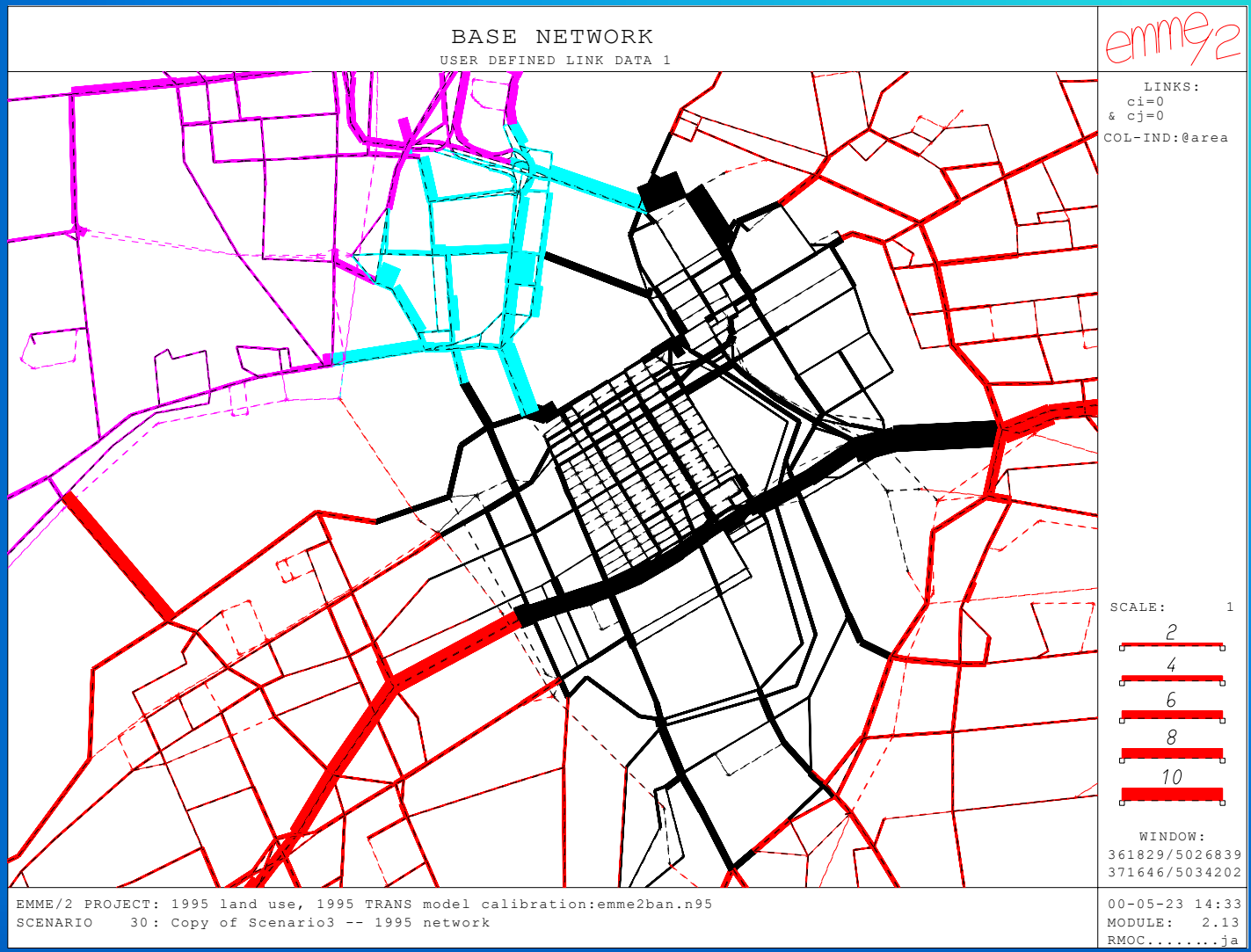
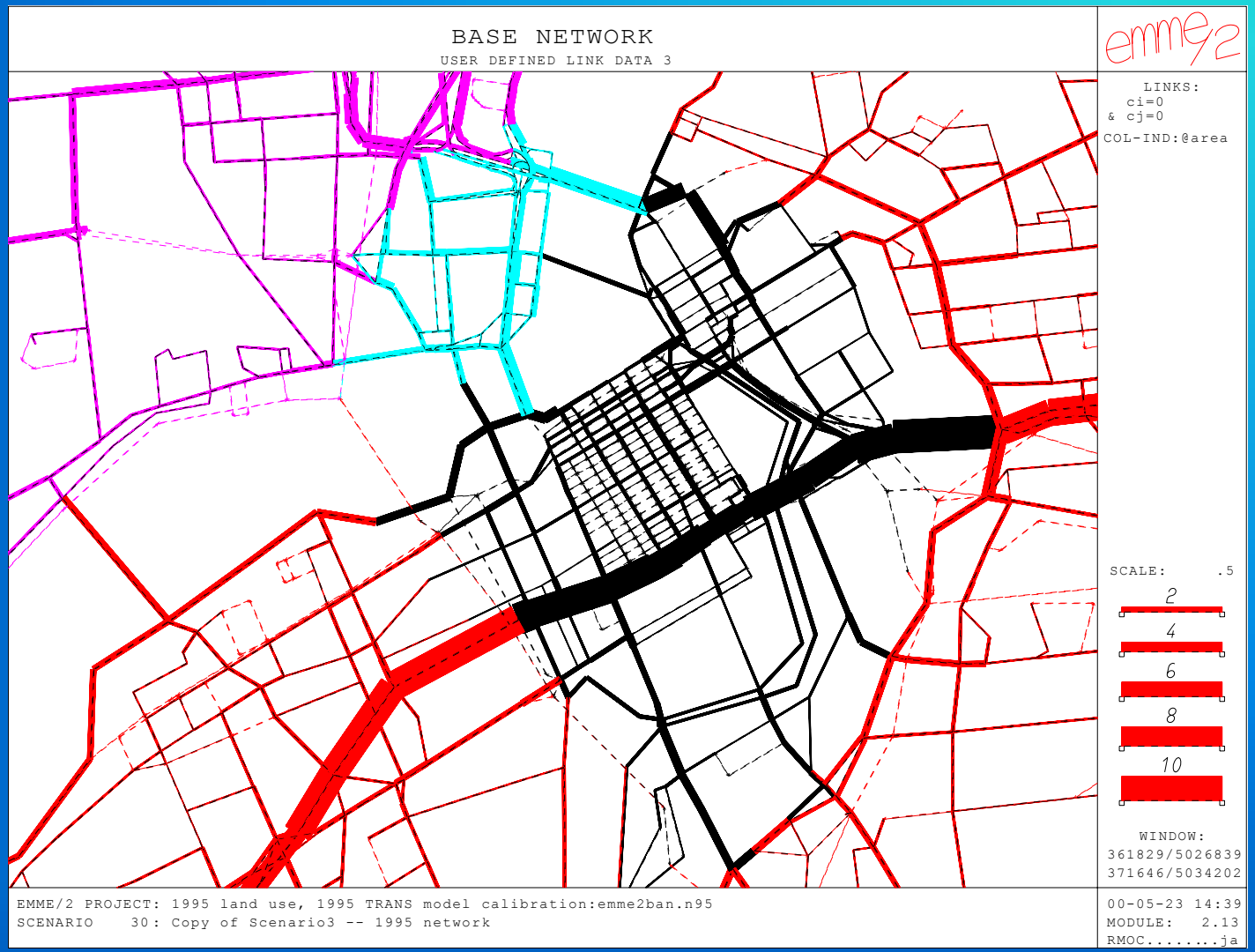


VOC Emissions



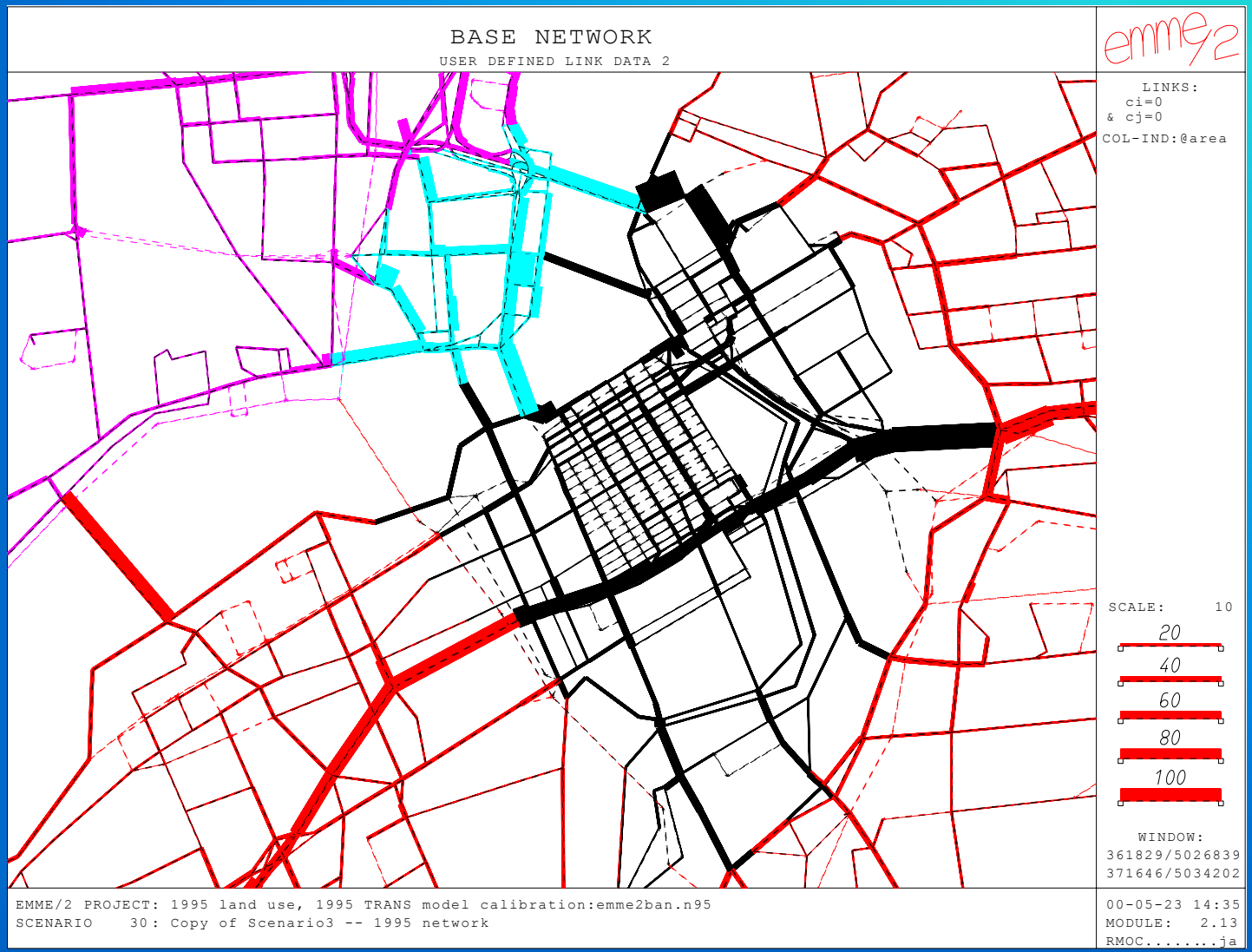
PM Peak Hour

NO_X Emissions



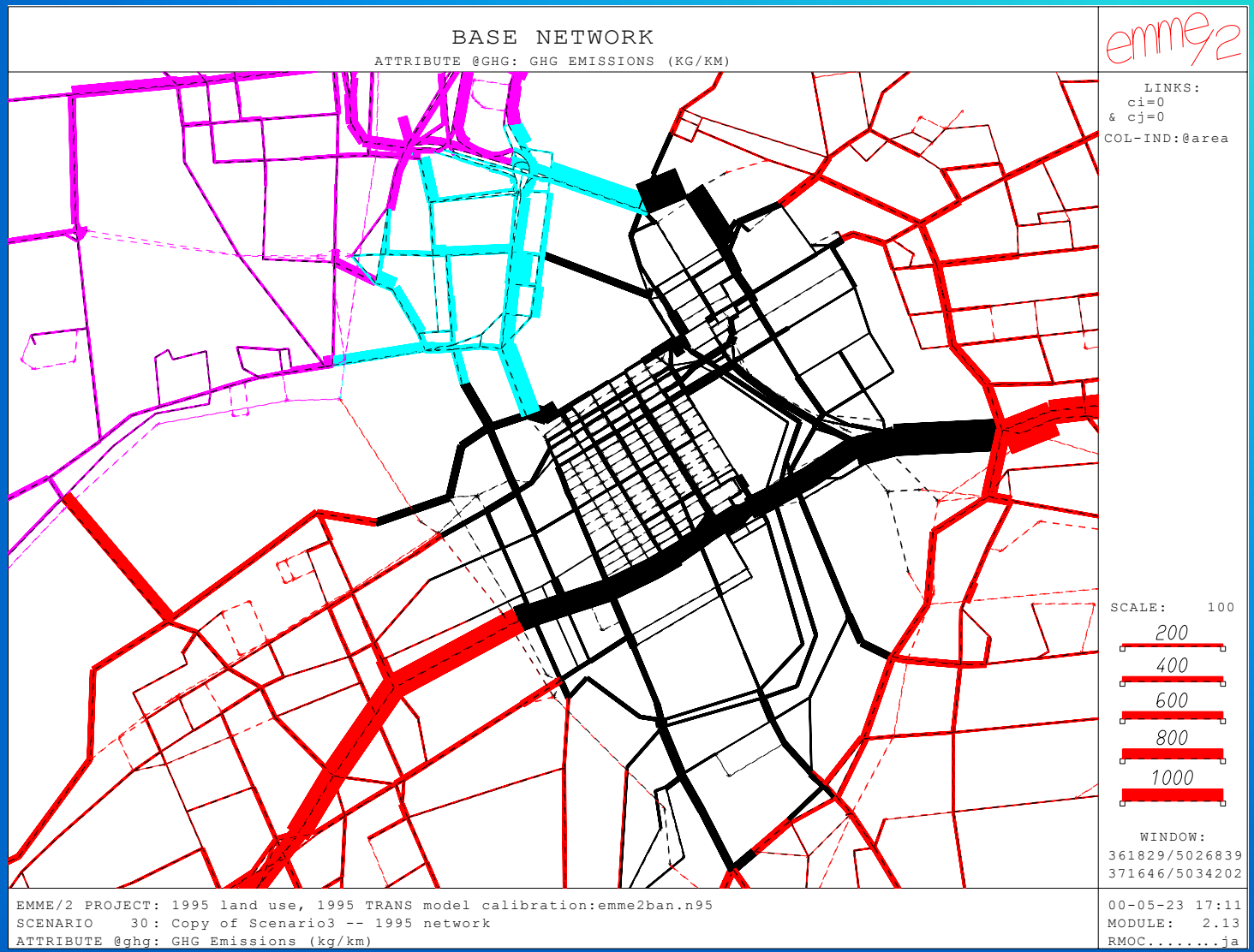
PM Peak Hour

CO Emissions



PM Peak Hour

GHG Emissions



PM Peak Hour

Conclusions

- It is very feasible to compute vehicle emissions based on the output from travel demand models
- More work is required to improve the quality of input data, particularly with respect to travel speed and vehicle age distribution