

Vehicle Emissions Modelling

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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

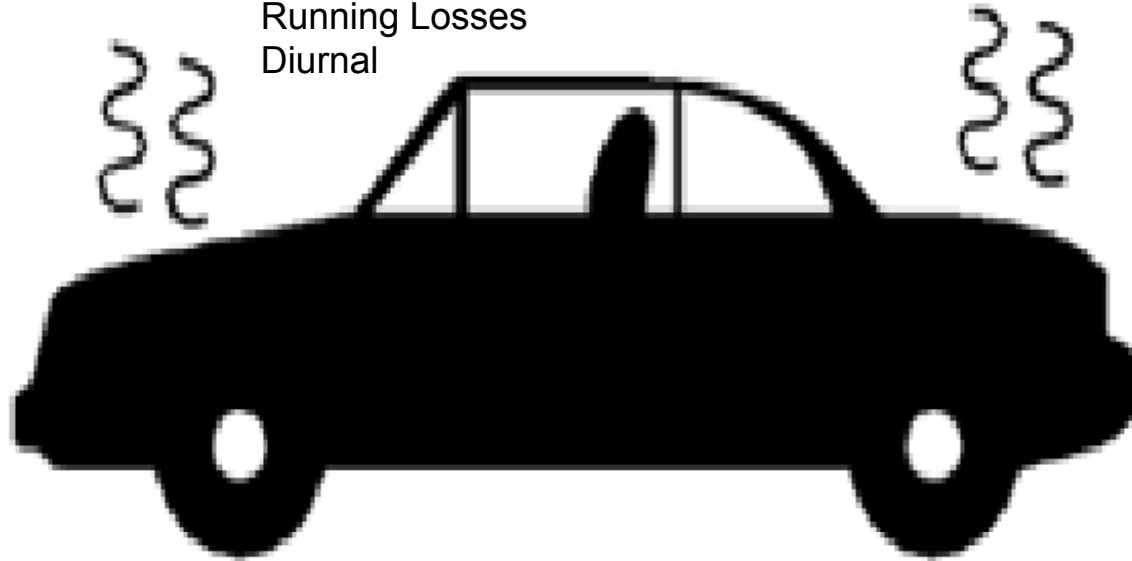
Why Model Vehicle Emissions?

- 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

CO₂

Estimated based on
fuel consumption

Exhaust Emissions

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

Two Processes

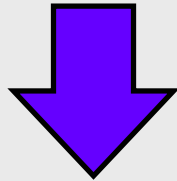
Combustion (Exhaust System)
Evaporation (Fuel Storage and Delivery System)

Emission Modelling Defined

- Predicts HC, CO, and NO_x 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

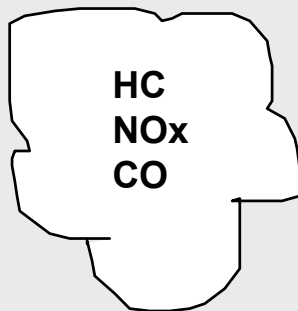
- Empirical model developed by EPA
- Estimates emissions of HC, NO_x, CO in grams / mile, NOT air quality
- Based on extensive laboratory testing
- Assumes “average” driver behaviour and trip characteristics

Emissions = Base Emission Rate * Adjustment Factors * VKT

Model Integration

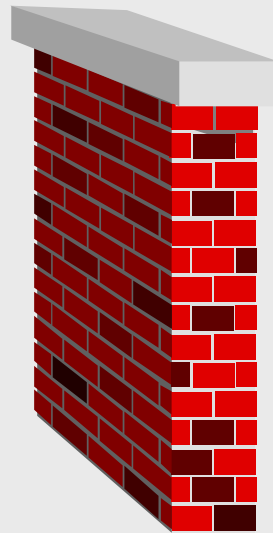
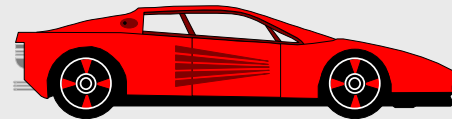
Emission Models

MOBILE5

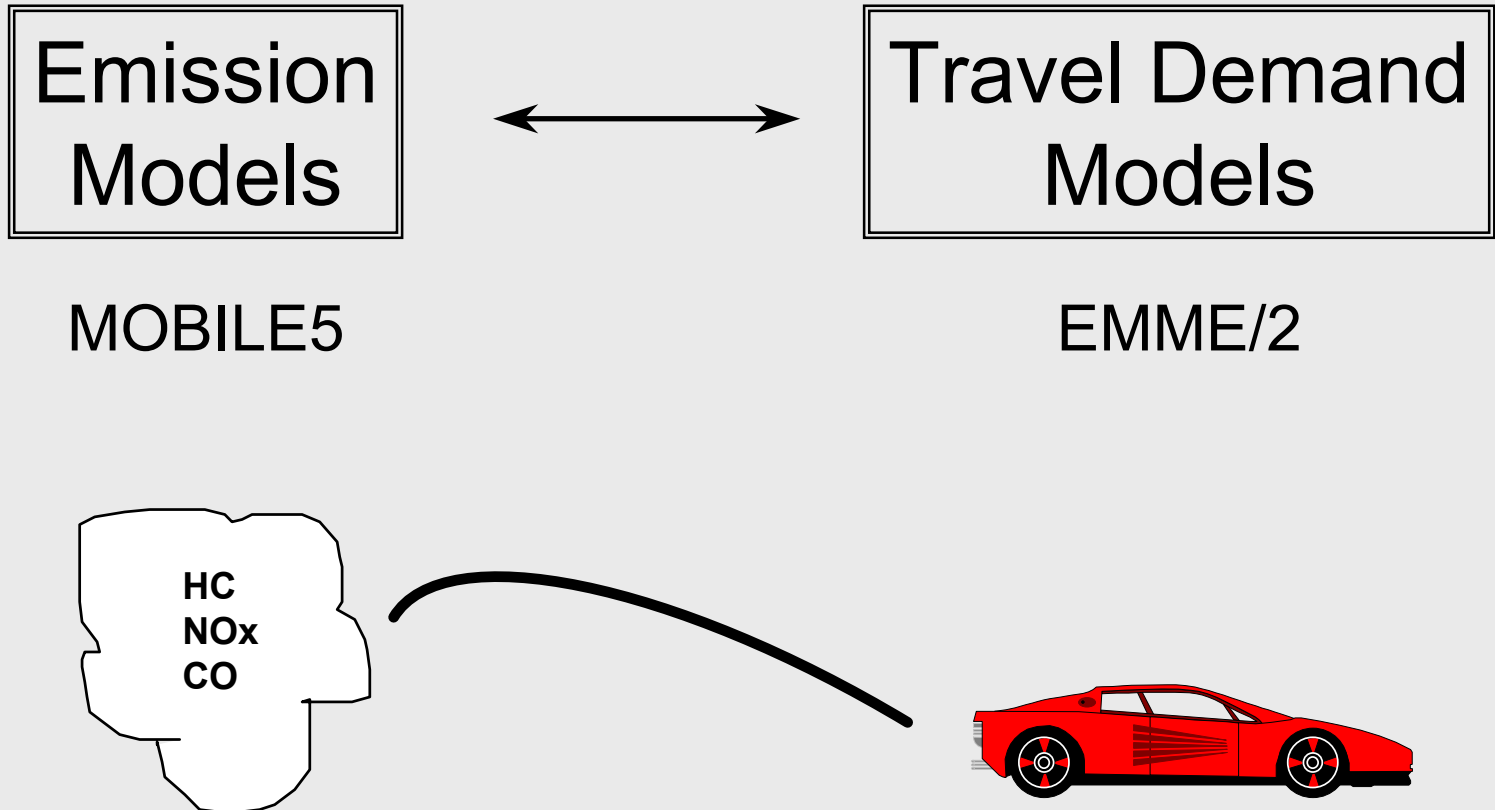


Travel Demand Models

EMME/2



Model Integration



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.

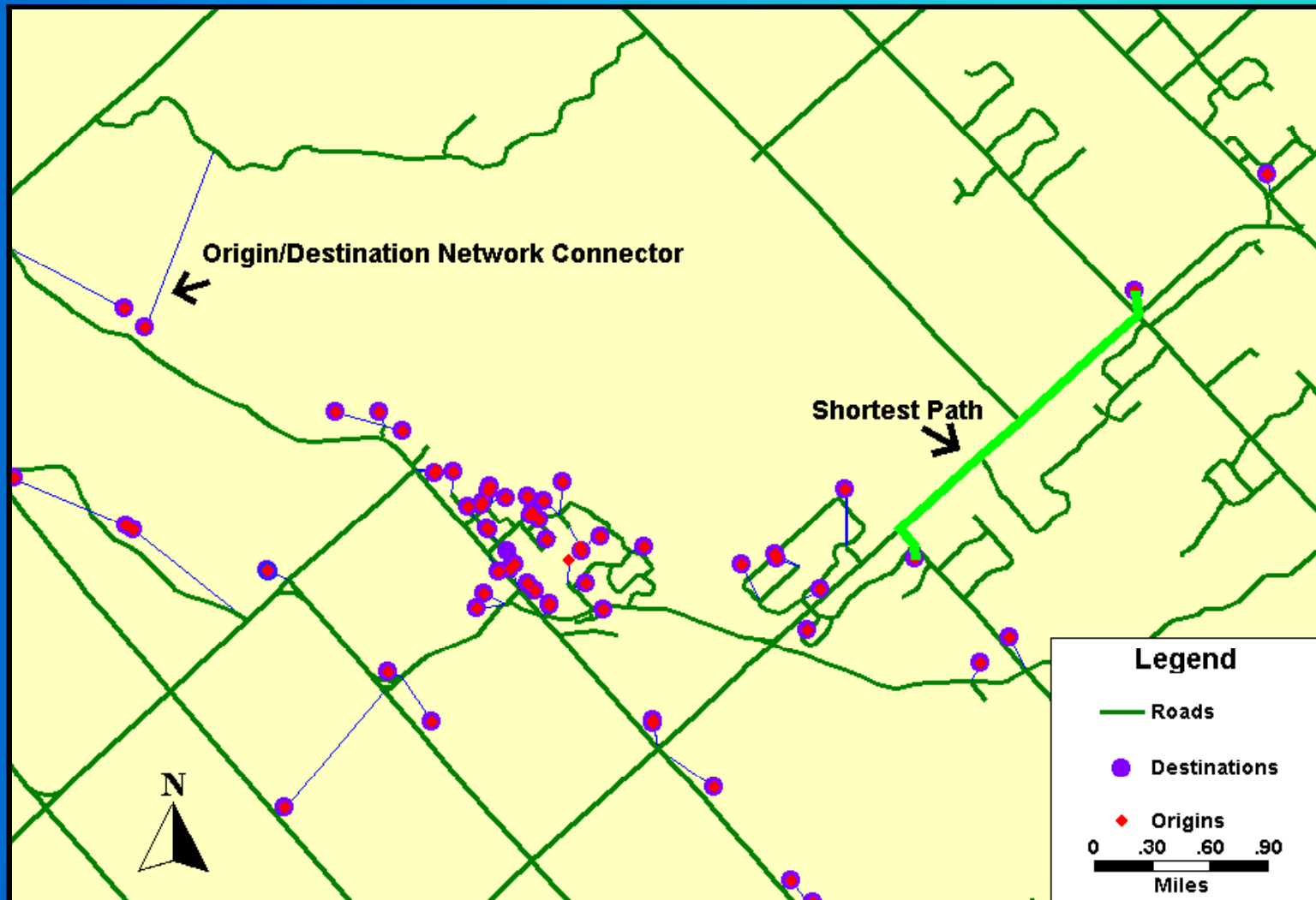
Road Classification Scheme

- 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

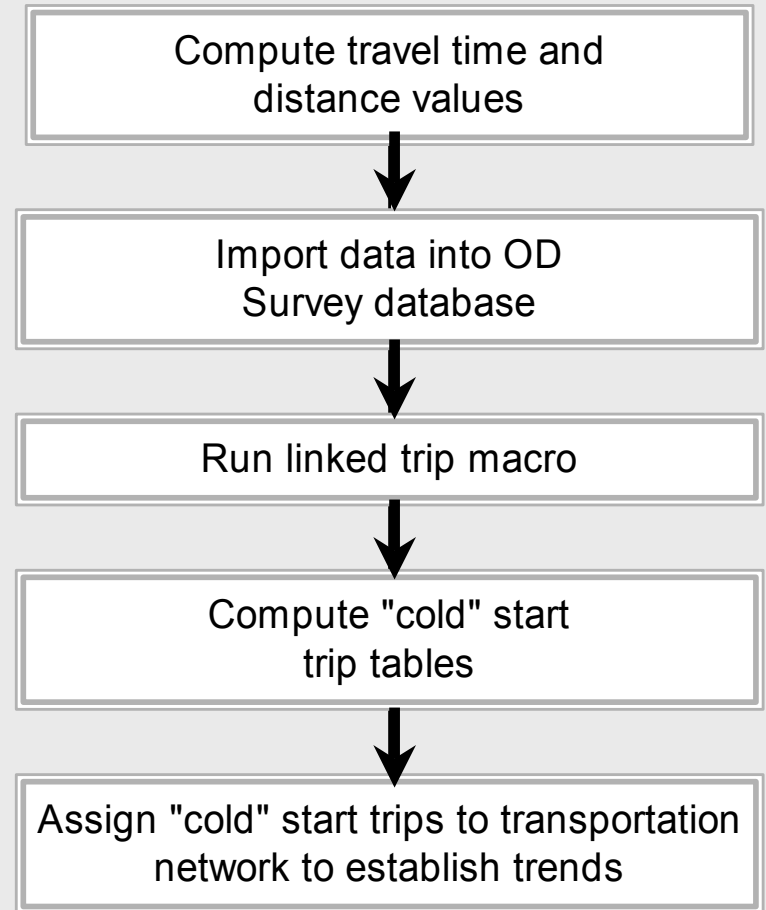
- It is important to know the total volume of traffic using the transportation network
 - improve travel time estimates
 - improve vehicle emission estimates
- EMME/2 only predicts passenger vehicle travel

“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

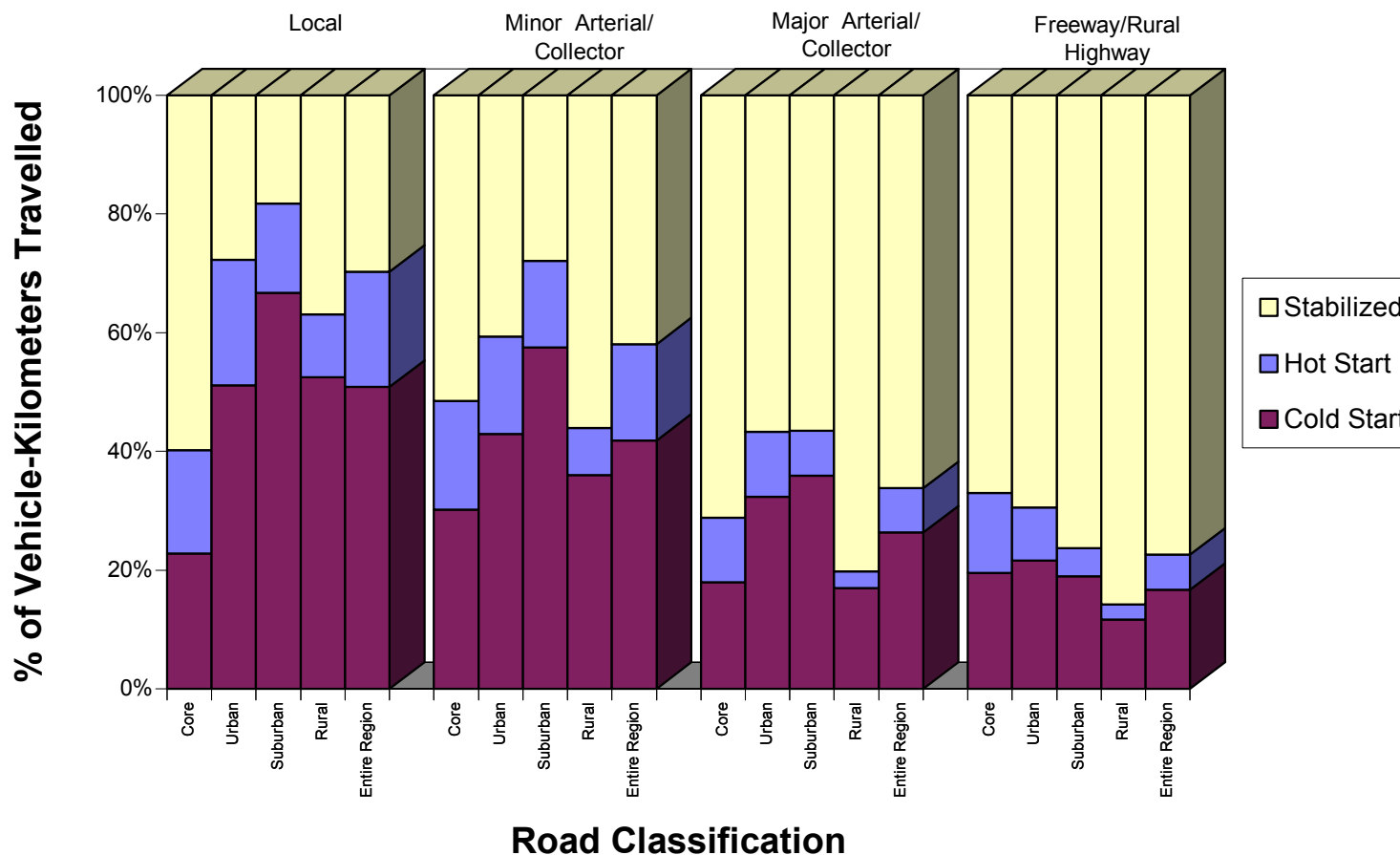
Operating Mode Analysis

- 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

Operating Mode Summary - AM Peak Period



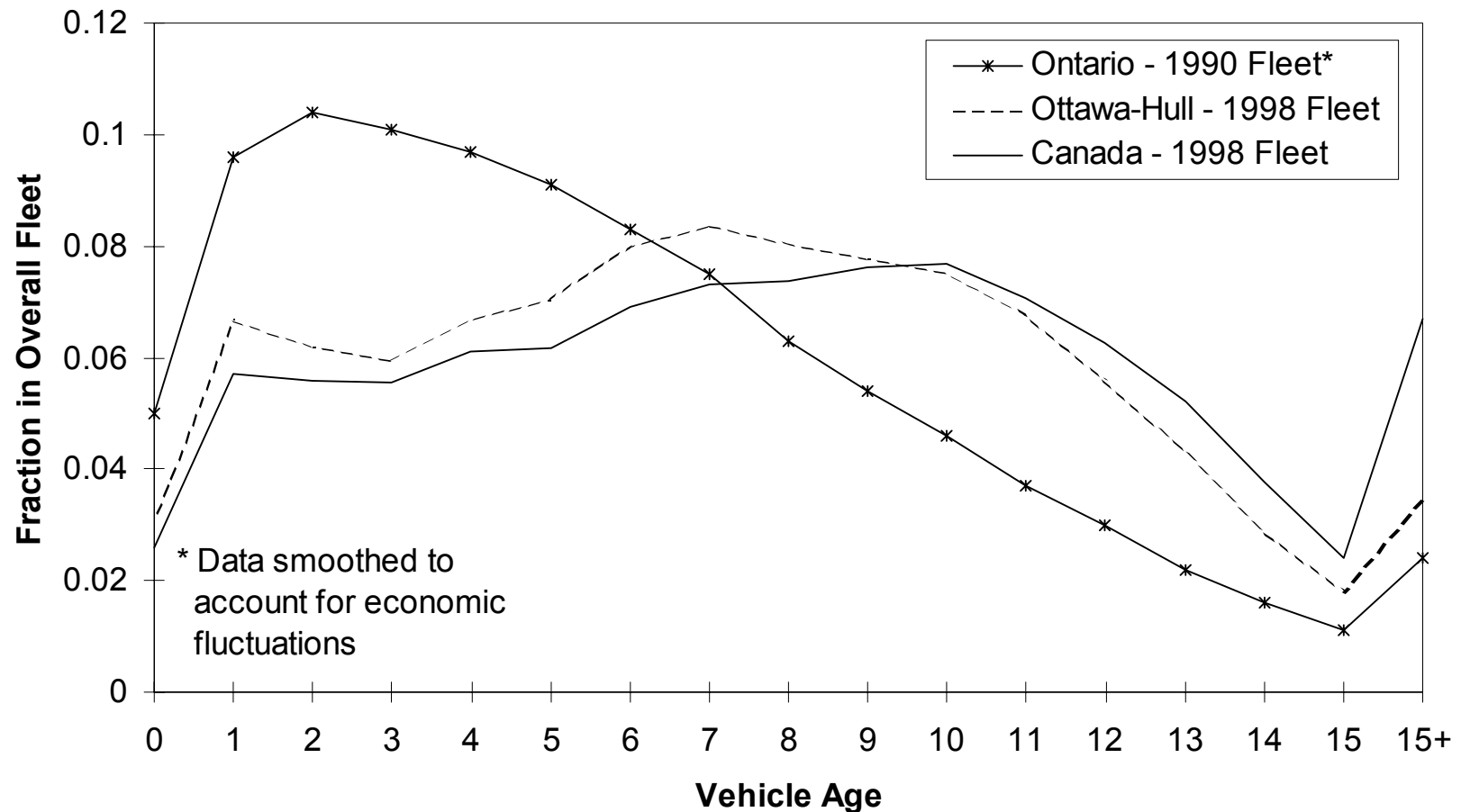
Temperature Inputs

- 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

Passenger 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
```

Node ID		Area	Link	Speed	Vehicle Kilometers Travelled				
					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

Input vehicle mix data, trip length distribution,
temperature data, operating mode fractions



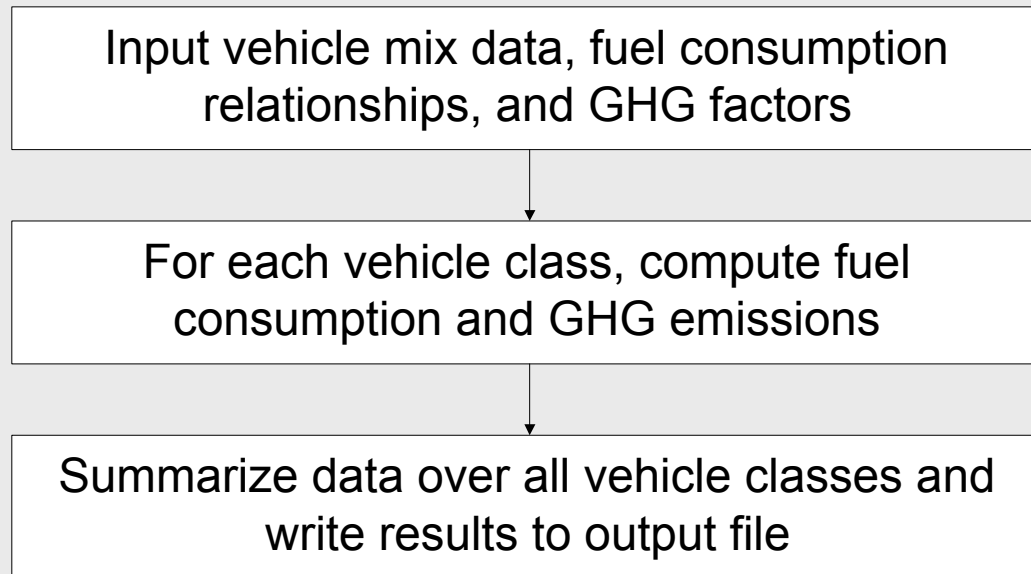
Create MOBILE5 input file and call MOBILE5



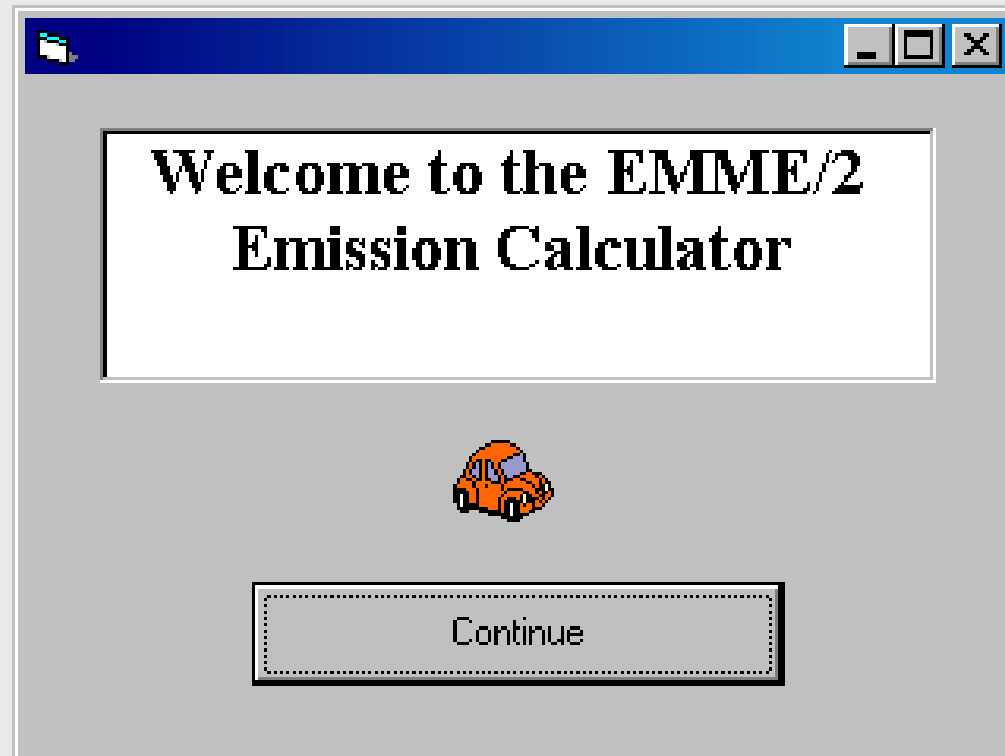
Wait for MOBILE5 to finish executing; read in
MOBILE5 output file and summarize results

The Emission Calculator

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



The Emission Calculator



The Emission Calculator

Emission Calculator

MOBILE5 Vehicle Mix Descriptions

Link Description: **Area = 1** **Link Type = 1**

Vehicle Mix:

	Ratio to Pass. Vehicles	Ratio to Transit Vehicles		Ratio to Pass. Vehicles	Ratio to Transit Vehicles
Light Duty Gas Vehicles (LDGV)	<input type="text" value="86"/>	<input type="text" value="0"/>	Light Duty Diesel Vehicles (LDDV)	<input type="text" value="0.5"/>	<input type="text" value="0"/>
Light Duty Gas Trucks 1 (LDGT1)	<input type="text" value="19"/>	<input type="text" value="0"/>	Light Duty Diesel Trucks (LDDT)	<input type="text" value="0.6"/>	<input type="text" value="0"/>
Light Duty Gas Trucks 2 (LDGT2)	<input type="text" value="0.1"/>	<input type="text" value="0"/>	Heavy Duty Diesel Vehicles (HDDV)	<input type="text" value="0.5"/>	<input type="text" value="100"/>
Heavy Duty Gas Vehicles (HDGV)	<input type="text" value="0"/>	<input type="text" value="0"/>	Motorcycles (MC)	<input type="text" value="0.5"/>	<input type="text" value="0"/>

The Emission Calculator

Emission Calculator

Temperature Data and Other MOBILE5 Inputs

Please enter the temperature data in degrees Celcius

Maximum daily temperature	<input type="text" value="12.5"/>	<small>Note that the ambient temperature should correspond to the analysis period being studied. For example, if the PM Peak Period is being analyzed, the ambient temperature should correspond to temperatures in the late afternoon. If the analysis period is the entire day, enter 999 for the ambient temperature. In this situation, MOBILE5 will compute the ambient temperature based on the daily min. and max. temperatures.</small>
Minimum daily temperature	<input type="text" value="3.7"/>	
Ambient temperature	<input type="text" value="11"/>	
Fuel data:		
Volatility class	<input type="text" value="C"/>	
Reid vapour pressure (psi)	<input type="text" value="14.4"/>	

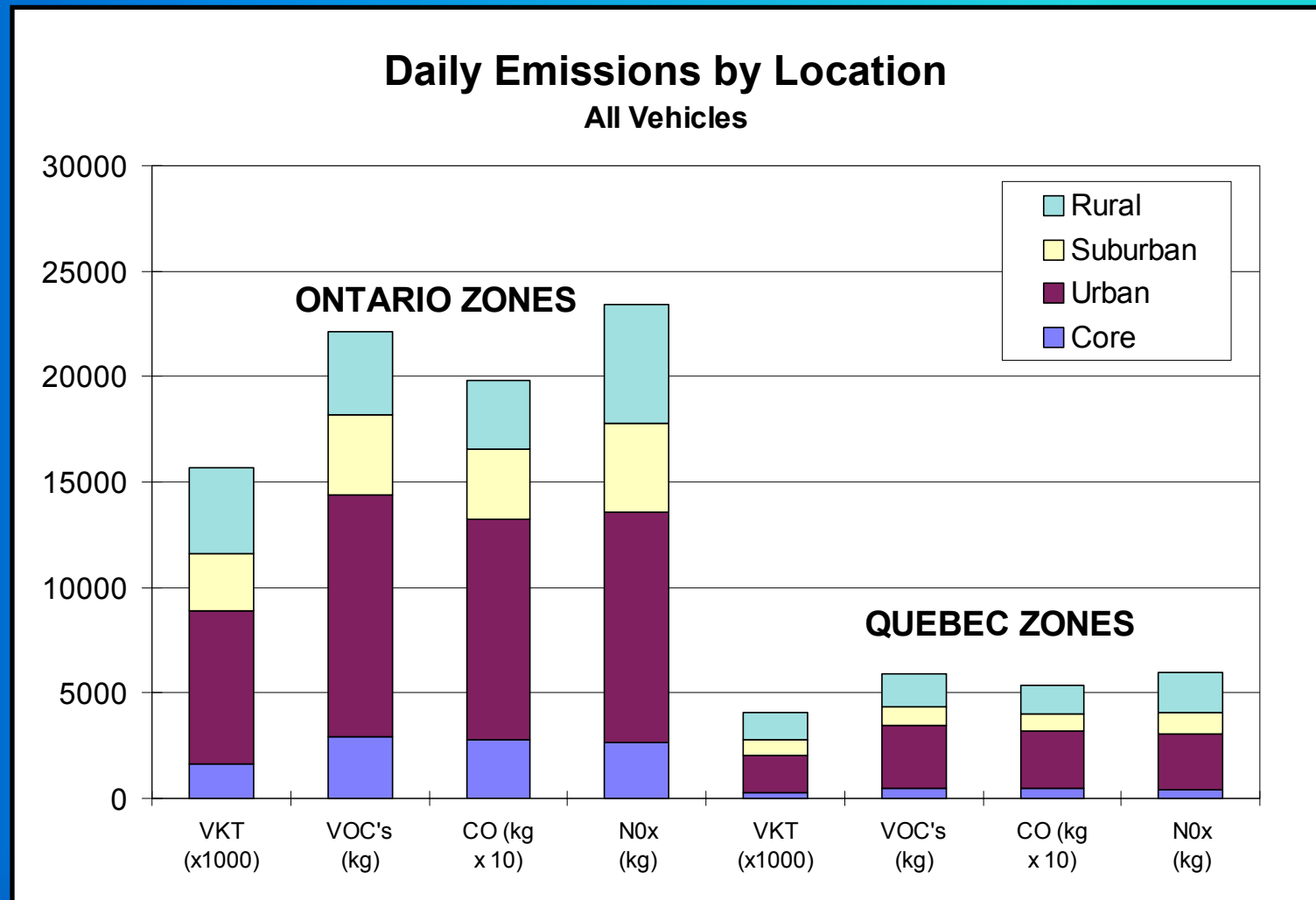
Region variable	<input type="text" value="1"/>	Month of evaluation	<input checked="" type="radio"/> July
Analysis year	<input type="text" value="1995"/>		<input type="radio"/> January

Emission Calculator

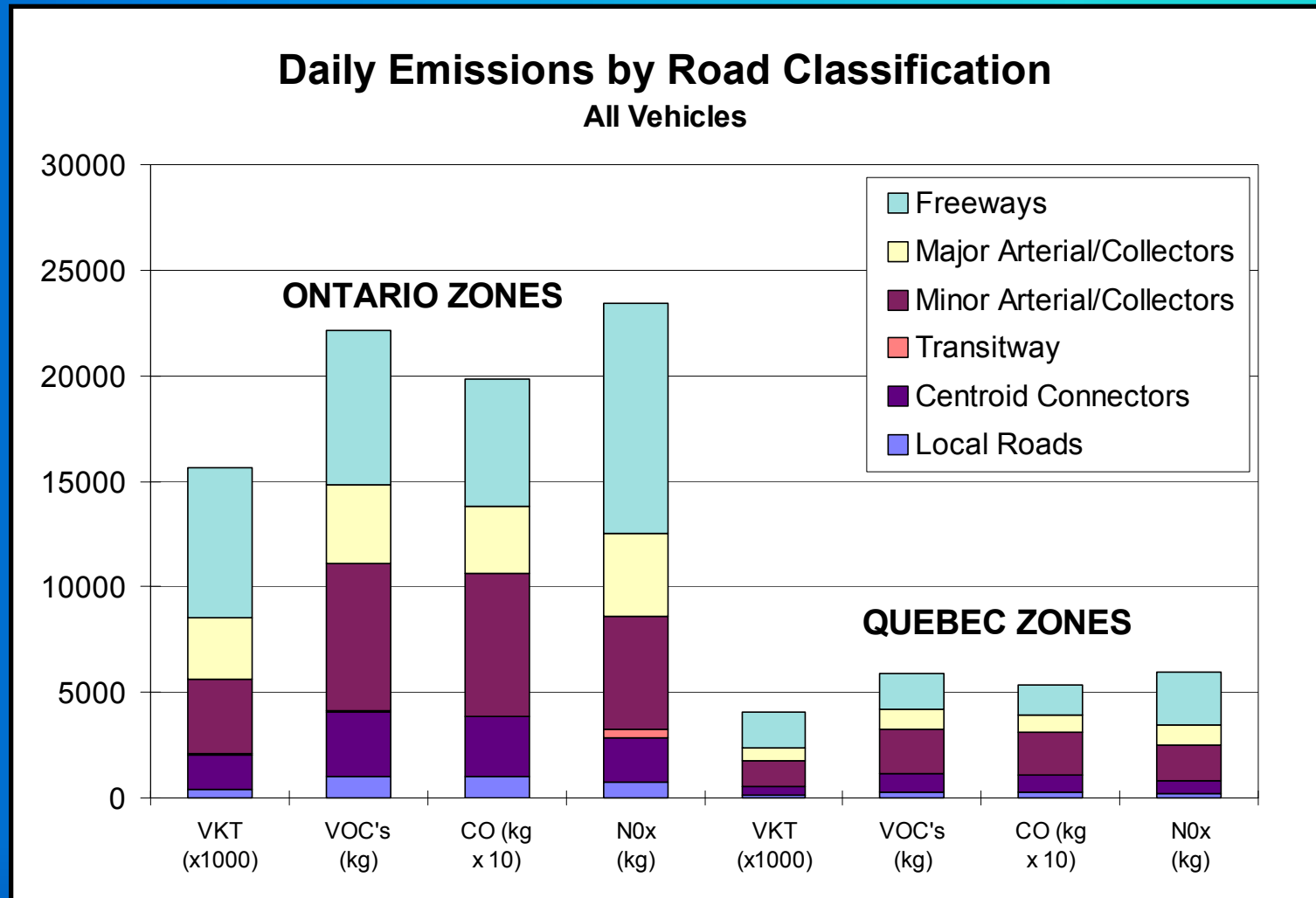
Please select the type of output you would prefer.

<input type="radio"/> Data summarized by link classification	<input type="radio"/> Greenhouse gas values only
<input type="radio"/> Link by link output (suitable for input into EMME/2)	<input type="radio"/> Greenhouse gas and fuel consumption data

Vehicle Emissions in the NCR

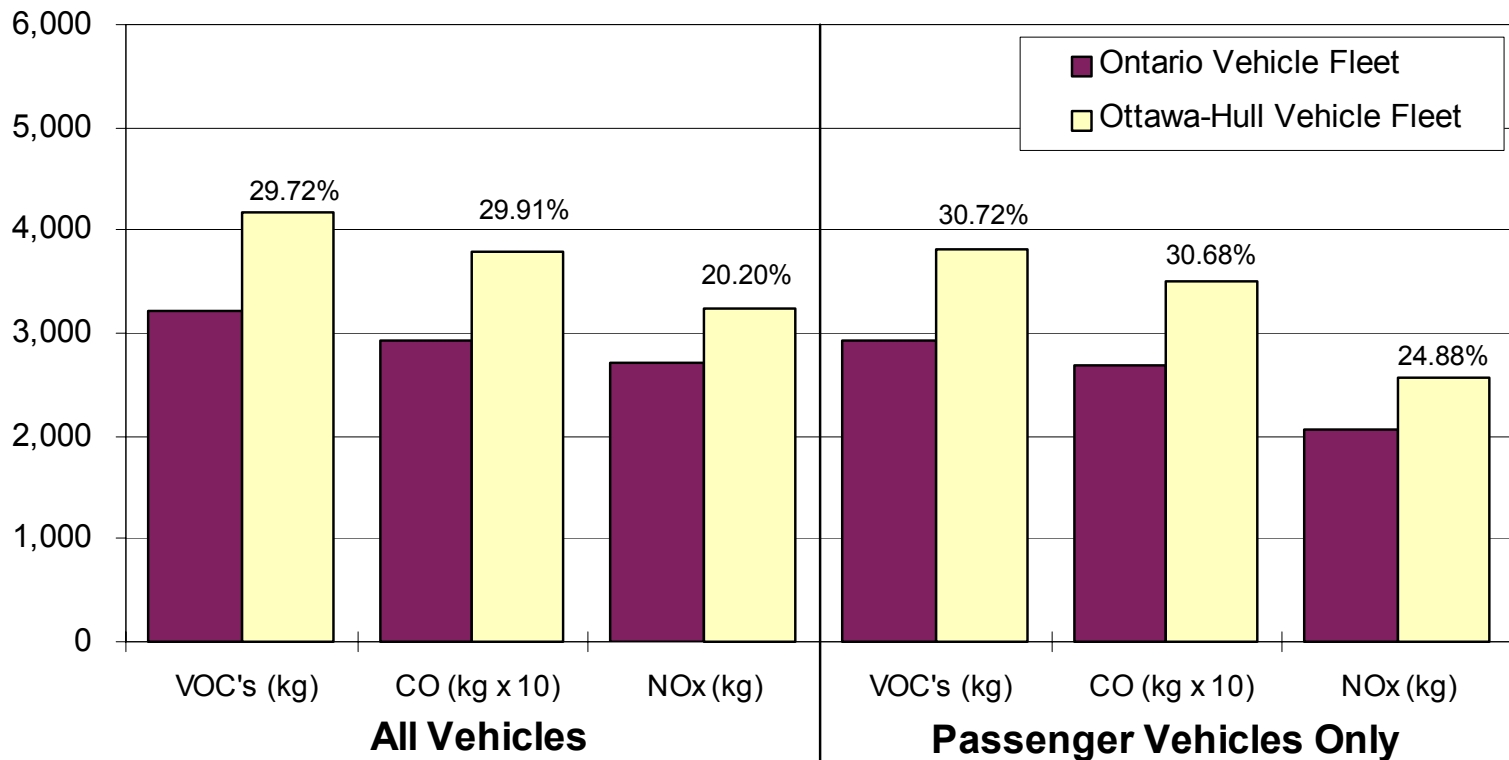


Vehicle Emissions in the NCR



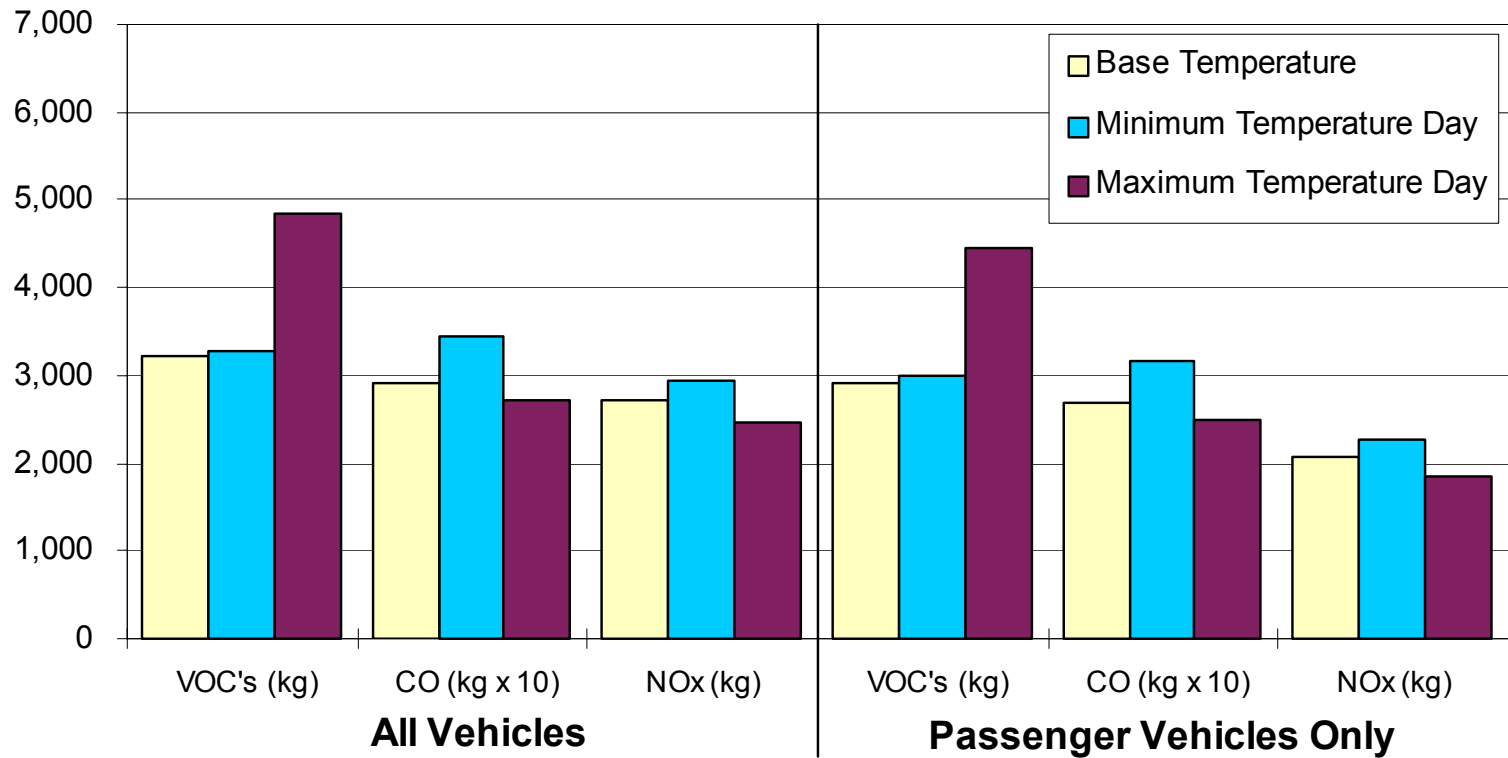
Vehicle Emissions in the NCR

Sensitivity to Vehicle Age Distribution
PM Peak Hour

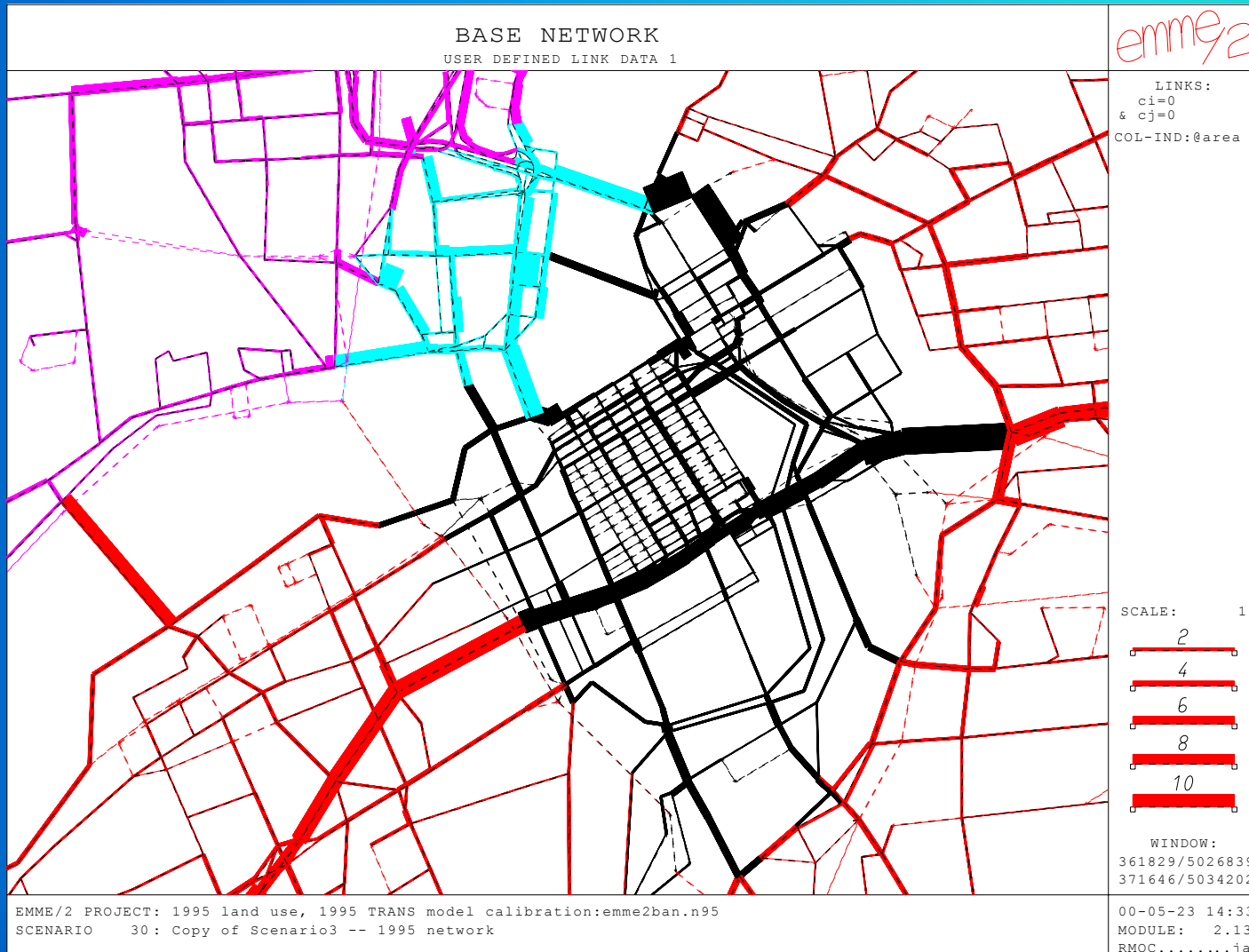


Vehicle Emissions in the NCR

Temperature Sensitivity Analysis PM Peak Hour

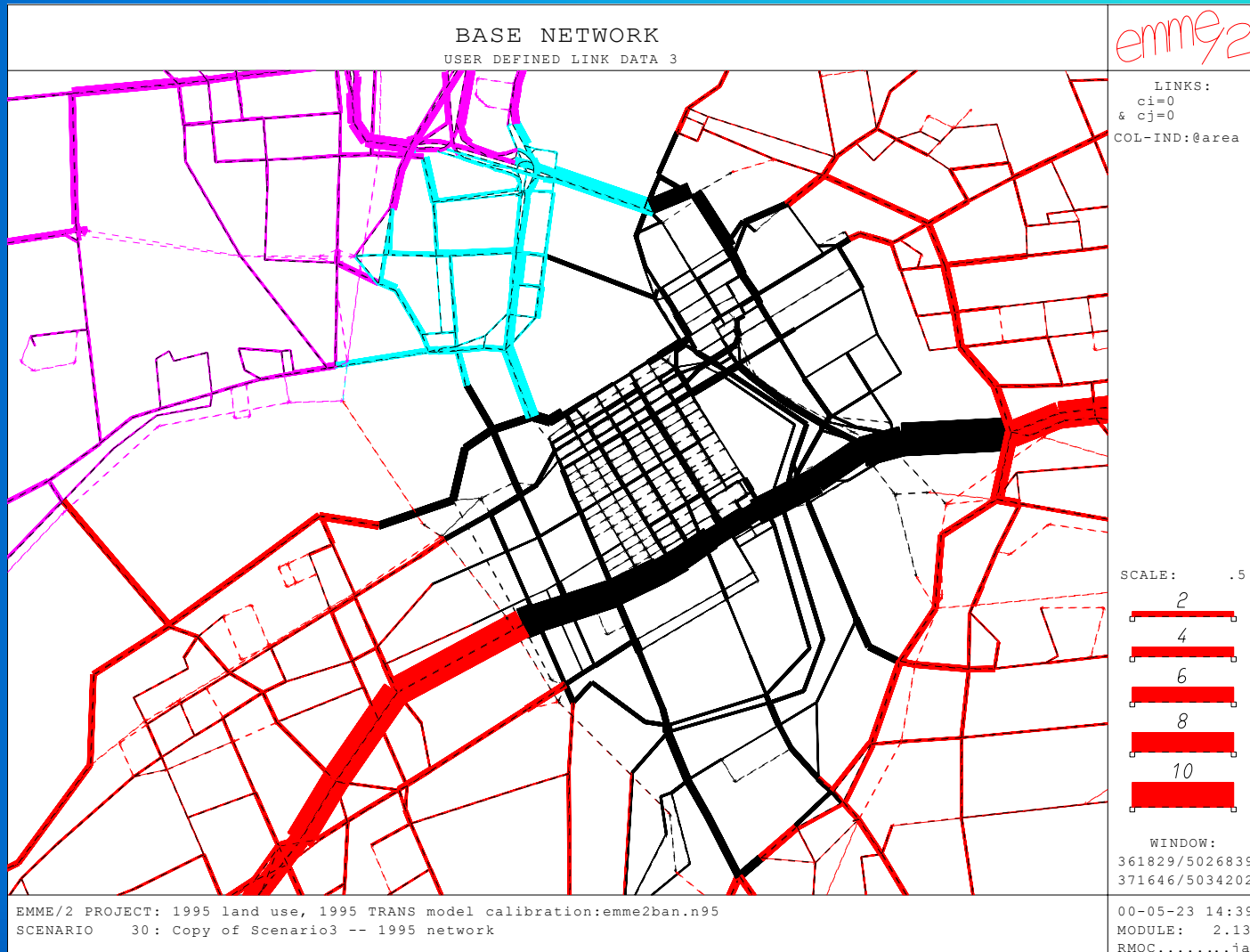


VOC Emissions



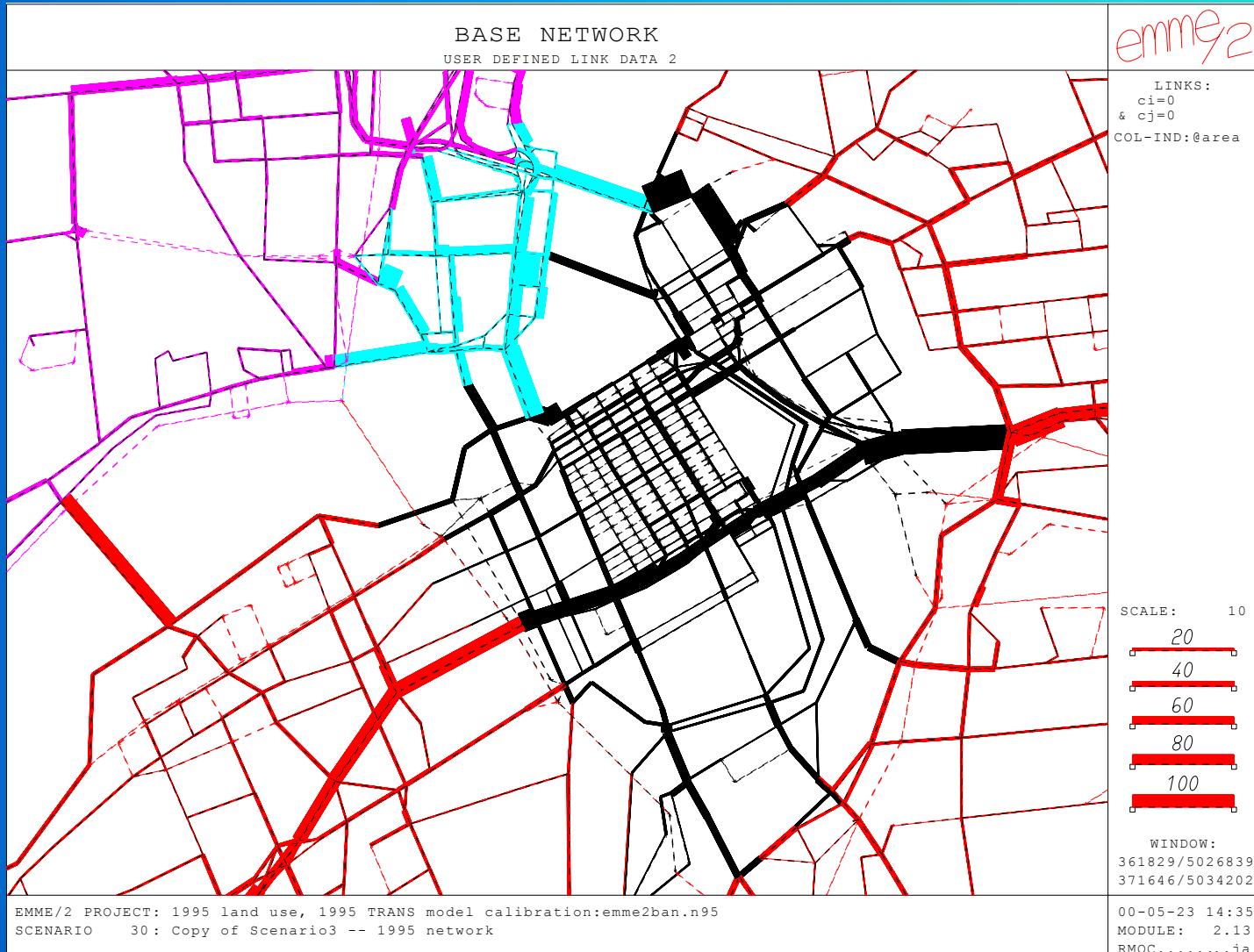
PM
Peak
Hour

NO_x Emissions



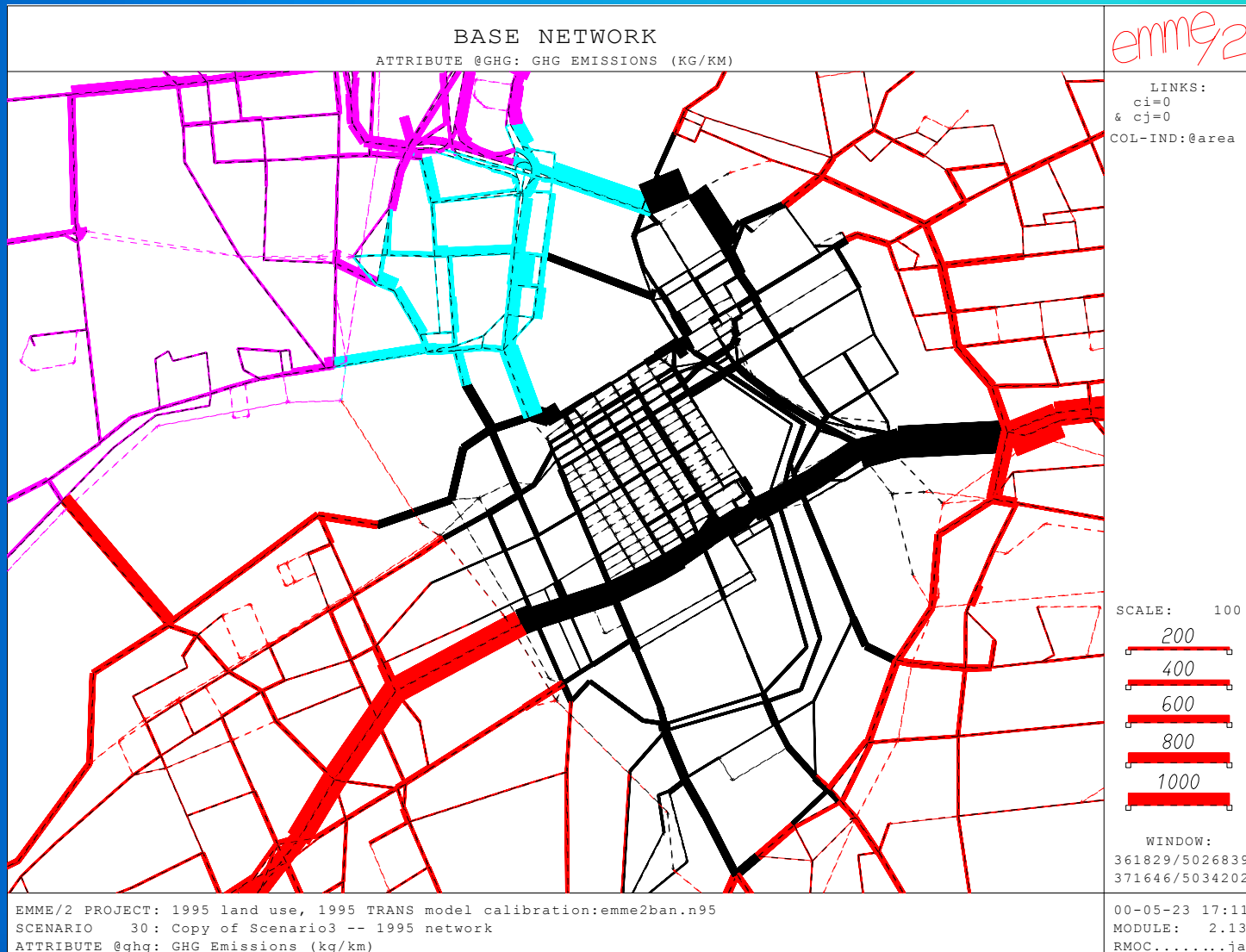
PM
Peak
Hour

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