Methodology ASIF:

examples of its application in Rio de Janeiro Projects

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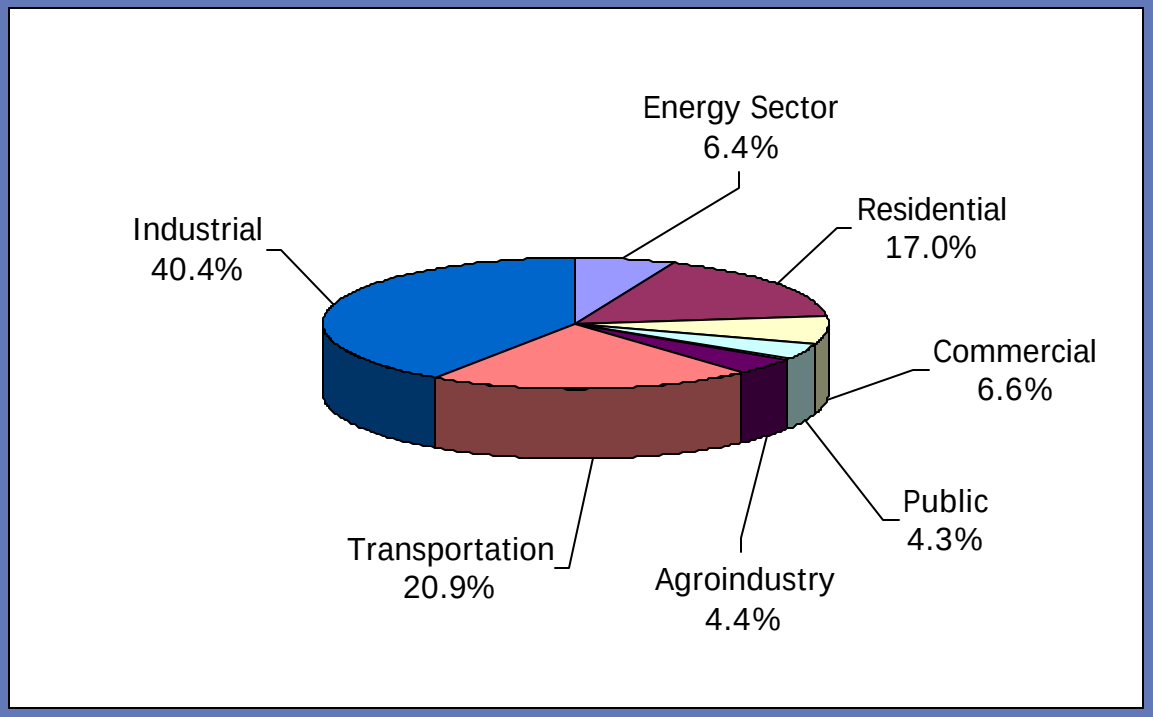
Alternatives for Reducing CO_2 Emissions by Transport Sector

- Modifying the **Activity**: numbers of trips for carrying cargo/passengers (tons or passengers per kilometer)
- Modifying the **Structure**: division between passenger.kilometer or ton.kilometer shipped by different means of transportation (road, rail, pipeline,water)
- Modifying the **Intensity**: efficiency with which the energy is used to carry passenger and cargo by each mode (energy/passenger or tons)
- Modifying the types of **Fuel**: each fuel has an specific quantity of carbon per energy unit supplied.

Energy Consumption in Brazil

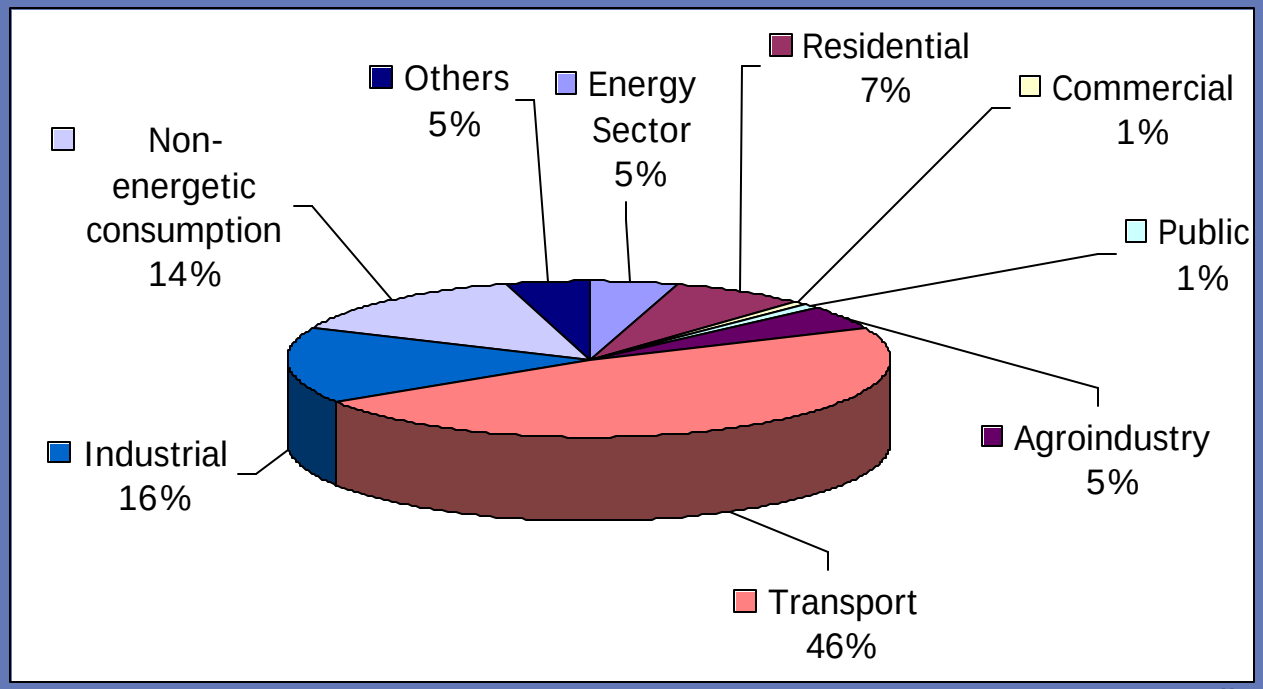
Energy Final Consumption by Sector – 2000
(total energy consumption 221,914*10^3 toe)



Oil Products Consumption in Brazil

Oil Products Consumption by Sector – 2000

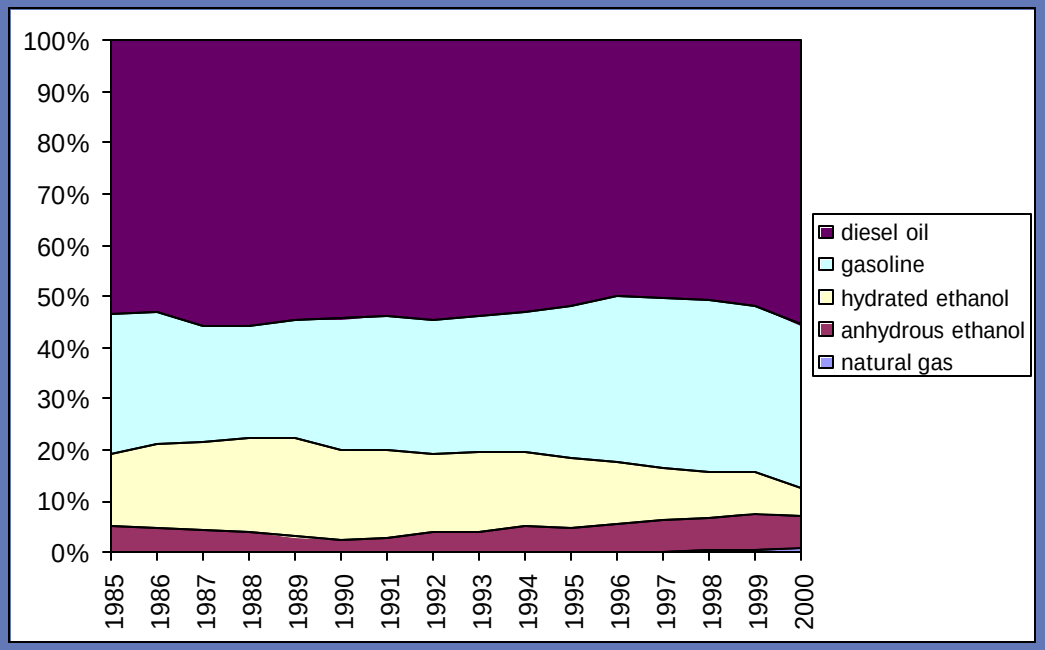
(total oil products consumption 82,665 *10^3 toe)



Fuel Consumption by the Transport Sector

- Main fuels: diesel oil, gasoline and ethyl alcohol. Small amounts of natural gas consumed by light vehicles.

Consumption (%) by energy source in the road transportation sector in Brazil



- 2000: consumption of oil by products in the transport sector reached 47.3% of the total.

- Possibilities of Fuel Change :

  CNG

  Ethanol

Natural Gas Use by Transport Sector in Brazil

- 2002: Brazil had some 350,000 vehicles converted to natural gas*.
- used mainly as taxi-cabs and light commercial vehicles.
- current vehicle conversion rate to natural gas around 6,000 new vehicles per month*.
- Fifteen of Brazil's 27 States already have natural gas service stations.
- Natural gas will represent 5% of the total Brazilian fleet by 2005*.

* Gas cylinders manufacturer estimative. There is no official data on these figures.

Natural Gas Use by Transport Sector in Rio de Janeiro

- Rio de Janeiro City: 2,500 vehicles are converted each month to natural gas (mostly taxi-cabs and commercial vehicles).
- natural gas distribution company calculates an increase at around 20%/year of NG consumption until 2005.
- In Rio de Janeiro State, there were only 21 NG service stations in 1999, while this figure had risen to 133 by Dec 2002, reflecting an impressive growth rate of 533% in three years.

Rio de Janeiro Transportation Sector

- the city has a large fleet of automotive vehicles, which expanded rapidly during the late 1990s*.

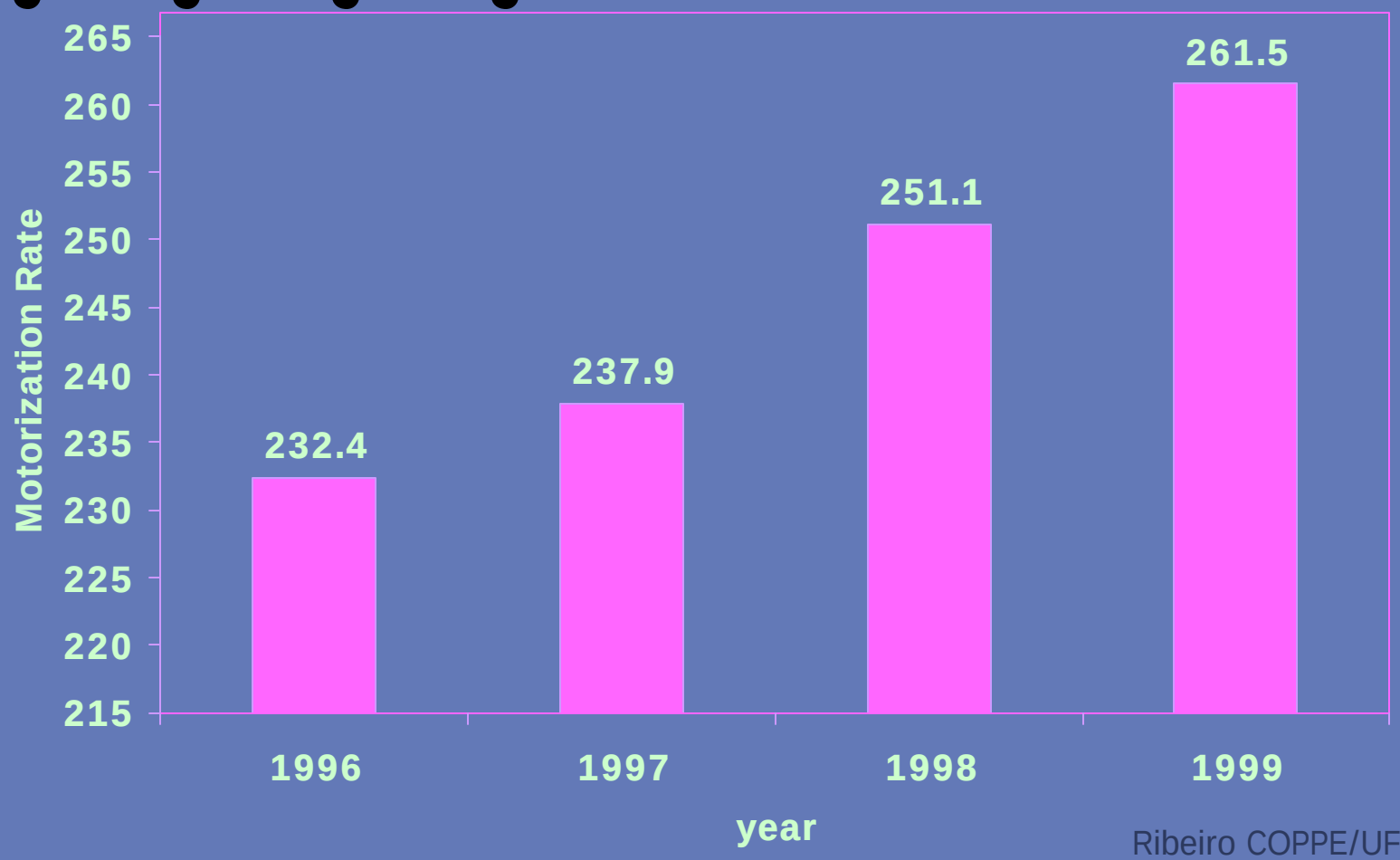
- The light vehicle fleet expanded at an average annual rate of 4.37% from 1996 through 1999, while the population of Rio de Janeiro rose only 0.33% over the same period.

* The light vehicles fleet (private cars and light commercial vehicles) was of 1,290,034 vehicles in 1996 and reached 1,466,223 vehicles in 1999

Rio de Janeiro City Motorization Rate

(Number of vehicles per 1,000 inhabitants)

RJ population – 5.5 million inhabitants



Methodologies for Accounting CO_2 Emissions

- There are two methodologies. They basically depend on gathering the available data*:
  - **top-down methodology:** includes only carbon dioxide (CO_2) emissions based on energy production and consumption data, without entering into details of how the energy is consumed.
  - **bottom-up methodology:** includes emissions of all the gases, with the emissions being quantified and taking into consideration the type of equipment used and the respective yields.

* IPCC (1996).

CO_2 Emissions Account for Rio de Janeiro City

- Simplified methodology (top-down):
  - $QCO_2 = FC \times EF$
    - QCO_2 – amount of emitted carbon dioxide ($kgCO_2$)
    - FC – fuel consumption (mass or volume unit)
    - EF – emission factor ($kgCO_2$/mass or volume unit)

Fuel	Unit	Emission factor
Gasoline	$kgCO_2$/liter	2.272
Diesel Oil	$kgCO_2$/liter	2,671
Natural Gas	$kgCO_2/m^3$	1,947

Hypothesis for Fuel consumption Forecast

i. The expansion of the light vehicle fleet in Rio de Janeiro follows the upward trend noted in the late 90s for both Scenarios;

ii. The fuel distribution for the fleet was established based on the different assumptions of each scenario;

iii. It was used an average annual km traveled for gasoline vehicles (10.000 km/year) and CNG (20.000 km/year);

iv. The average fuel consumption assumed for gasoline vehicles was 9,5 km/L and 7,5 km/m^3 for CNG vehicles.

With these information and hypothesis the fuel consumption forecast were calculated for 2005 and 2010.

Different Scenarios

- **Scenario A:** no special efforts will be required to reduce emissions in the city for the transportation sector. Future trends will follow current indicators, with no upgrades in energy use, or reductions in GHG emissions.

Figures for Scenario A

Number of Light Vehicles by Type of Fuel – **Scenario A**

		Nº of Light Vehicles	%			Nº of Light Vehicles	%
2005	Gasoline	1,385,126	75.9%	2010	Gasoline	1,614,668	82.6%
	Alcohol	227,985	12.5%		Alcohol	160,170	7.5%
	CNG	210,765	11.6%		CNG	210,765	9.9%
	TOTAL*	1,823,876	100.0%		TOTAL*	2,135,604	100.0%

Consumption of Gasoline and Compressed Natural Gas – **Scenario A**

	Unit	2005	2010
Brazilian Gasohol (Gasoline + anhydrous alcohol)	m^3	1,454,953	1,853,627
Gasoline (pure gasoline - 78%)	m^3	1,134,863	1,445,829
Compressed Natural Gas	1,000 m^3	698,160	698,160

Note: Brazilian gasohol is a blend of 78% pure gasoline and 22% anhydrous ethanol in Scenario A.

Scenario B

- We considered a switch of fuels for buses and light vehicles in order to reduce the amount of emitted carbon.
- Buses: part of diesel oil will be replaced by natural gas.
- Light vehicles: more hydrous alcohol and vehicular natural gas will be used, instead of gasohol.

Scenario B- Assumptions

- **2005**: Light Vehicles

25% Ethanol/ 14% CNG/ 61% Gasoline

Heavy Vehicles

25% CNG/ 75% diesel

2010: Light Vehicles

30% Ethanol/ 24%CNG/ 26% Gasoline

Heavy Vehicles

50% CNG /50% diesel

Scenario Results (A&B)

CO_2 emissions (1,000 tons CO_2) for light vehicles and buses: 2005 and 2010

YEAR	2005	2010
Scenario A – Light Vehicles + Buses	5,102	6,837
Scenario B – Light Vehicles + Buses	4,701	6,352
Difference between B and A	401	485
Reduction (percentage)	7.9%	7.1%

Scenarios Results – Extrapolation

Rio de Janeiro fleet (light vehicles/ comercial vehicles and Buses) is around 11% of the total fleet of the 15 States which already have avaiable CNG

The same methodology and considerations made for RJ (fleet profile, operation conditions, etc) were applied for those 15 States. The results are shown in the Table bellow

	2005	2010	Local
Diferença entre A e B	401	485	Rio de Janeiro
Diferença entre A e B	3248,1	3928,5	15 estados

Increase of 8 times

Scenario C

- based on the assumption of **a return to the hydrous alcohol program for vehicles**, boosting the sales of new vehicles fuelled by alcohol; and
- the fabrication of dual-fuel vehicles that can run on hydrous alcohol and some other fuel (gasoline or natural gas), which would encourage car-owners to use this fuel.

Obs: Years covered by scenarios were 2005 and 2010

Figures for Scenario C

Number of Light Vehicles by Type of Fuel – **Scenario C**

		Nº of Light Vehicles	%			Nº of Light Vehicles	%
2005	Gasoline	1,047,709	57.4%	2010	Gasoline	1,048,581	49.1%
	Alcohol	565,402	31.0%		Alcohol	875,597	41.0%
	CNG	210,765	11.6%		CNG	210,765	9.9%
	TOTAL*	1,823,876	100.0%		TOTAL*	2,134,944	100.0%

Consumption of Gasoline and Compressed Natural Gas – **Scenario C**

	Unit	2005	2010
Brazilian Gasohol (Gasoline + anhydrous alcohol)	m^3	1,100,526	1,101,442
Gasoline (pure gasohol - 74%)	m^3	814,389	815,067
Compressed Natural Gas	1,000 m^3	698,160	698,160

Note: In Scenario C, Brazilian gasohol is a blend of 74% pure gasoline and 26% anhydrous ethanol.

Scenarios Results (A&C)

YEAR	2005	2010
Scenario A – Light Vehicles	3937.8	4664.4
Scenario C – Light Vehicles	3209.6	3211.2
Difference between C and A	18.5%	31.1%

Main Conclusions

- This study shows that by merely using the Fuel Factor, by raising the ethanol fuel use or CNG, one achieved significant reductions in CO_2 emissions for the road transport mode.
- It is worth mentioning that ethanol vehicles sales have been increasing again, because of oil prices turbulences and environmental issues. Another possible reason is that ethanol vehicles work better in a dual fuel system (CNG + Ethanol) than gasoline.

Main Conclusion - Continuation

- **Transportation Sector** offers large potential for reducing CO_2 emissions, in addition to other associated benefits like less local pollution; a better life quality in the city; lower energy consumption and others.
- It is important to highlight that in this study nothing regarding new technology, traffic management or even public transportation incentives were considered.