

**LIFE CYCLE ASSESSMENT OF SOME VEHICLE  
FUELS IN ROMANIA**

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# **INTRODUCTION**

- **IN THE PROCESS OF TRANSITION TO A MARKET ECONOMY CENTRAL AND EAST EUROPEAN COUNTRIES ARE CONFRONTED WITH THE PROBLEM OF PROLIFERATION OF PASSENGER CARS WITH ALL ASSOCIATED NEGATIVE IMPACTS ON THE ENVIRONMENT**
- **PRESENTATION PROPOSES AN APPLICATION OF LCA FOR THE ANALYSIS OF SOME AUTOVEHICLE FUELS IN USE IN ROMANIA (CONVENTIONAL GASOLINE, DIESEL FUEL AND LIQUID PETROLEUM GAS-LPG) IN ORDER TO DEMONSTRATE ENVIRONMENTAL PERFORMANCE OF THESE FUELS.**

# SOME PROPRIETIES OF THE ANALYSED FUELS

GASOLINE PREMIUM			DIESEL FUEL			LPG (autogaz)		
'Charact.	U/M	Values	Charact	U/M	Values	'Charact.	U/M	Values
RONmin	-	95	CN min	-	47	Hidroc C3	% gr	12
MONmin	-	83	P.I.	° C	55	Hidroc C4	% gr	87
RVP	KPa	66.7-80	T°min.	° C	-15° <sub>wint.</sub>	Hidroc C5	% gr	1
			FILTR.max		-5° <sub>summ</sub>			
Density	Kg/ m <sup>3</sup>	740	Density	Kg/ m <sup>3</sup>	820-860	Density liquid 50°C	Kg/m <sup>3</sup>	525
Pb max	g/l	0.32	Soot. max	% gr	0.01	Density gas	Kg/m <sup>3</sup>	2,55
S max	%gr	0.1	S max	% gr	0.2	S total max	mg/m <sup>3</sup>	500
LHV	KJ/l	36100	LHV	KJ/l	38140	LHV	KJ/l	26200

LEGEND: RON/MON=RESEARCH/MOTOR OCTANE NUMBER; RVP= REID VAPOUR PRESSURE; LHV=LOW HEATING VALUE; CN=CETANE NUMBER;P.I.=POINT OF INFLAMABILITY; FILTR=FILTRABILITY.

# **GOAL DEFINITION AND SCOPING FOR AUTOVEHICLE FUELS**

## **GOAL OF THE STUDY:**

- COMPARISON OF THE ENVIRONMENTAL PERFORMANCES OF THREE AUTOVEHICLE FUELS USED IN ROMANIA: GASOLINE, DIESEL FUEL AND LIQUID PETROLEUM GAS (LPG), IN ORDER TO FIND AND ORIENTATE THE BEST IMPROVEMENT OPTIONS FOR THE PROTECTION OF THE ENVIRONMENT**

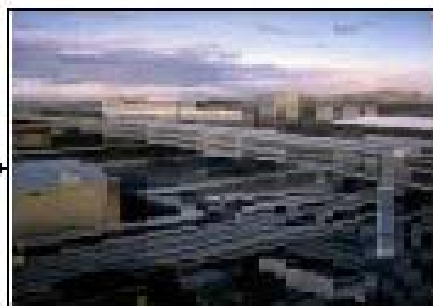
## **SYSTEM BOUNDARIES:**

- SPATIAL BOUNDARIES: THE TERRITORY OF ROMANIA INCLUDING BLACK SEA CONTINENTAL SHELF**
- TEMPORAL LIMITS: 1999-2000 (THE YEARS WITH THE LAST STATISTICAL DATA)**
- FUNCTIONAL UNIT: 100.000 km/car (the total distance in Km in the full life cycle of a car (5 years\*20000 km/year))**

# FLOW DIAGRAM WITH UNIT PROCESSES AND SYSTEM BOUNDARIES FOR THE ANALYSED PRODUCTS



Oil Extraction



Transport 1

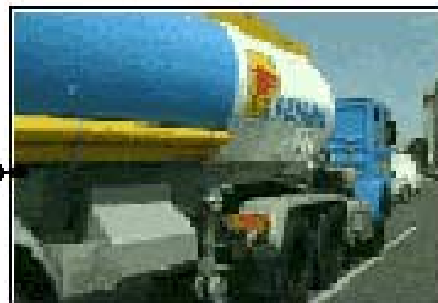


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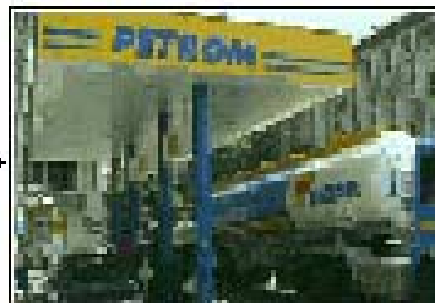
*Gasoline*

*Diesel fuel*

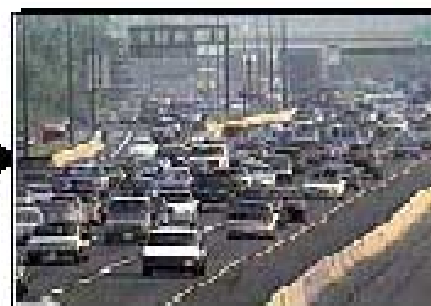
*LPG*



Transport 2



Distribution



Use



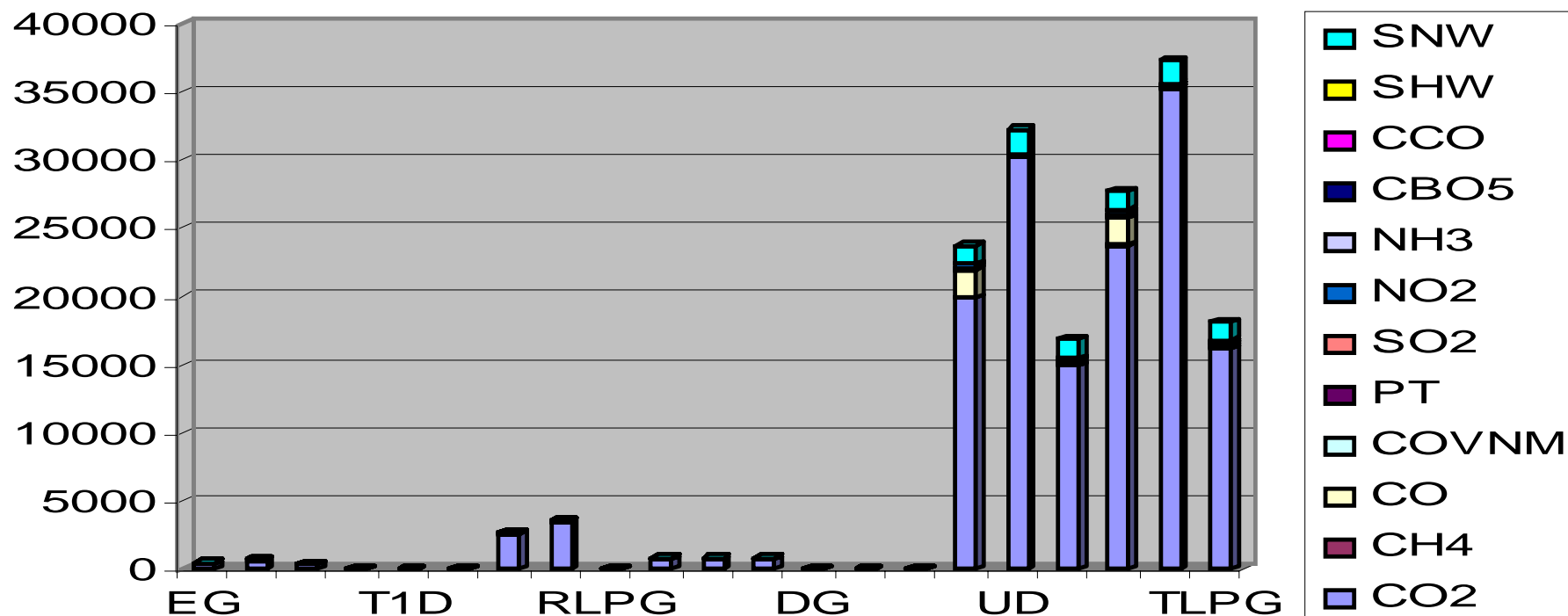
## **OTHER INITIAL ASSUMPTIONS OF THE STUDY**

- EXTRACTION OF THE OIL ON THE CONTINENTAL BLACK SEA SHELF (OFF-SHORE);**
- TRANSPORT TO REFINERY BY PIPES;**
- RAFINATION IN THE WORST CONDITIONS FOR ROMANIA (THE REFINERY WITH THE OLDEST TECHNOLOGY) ;**
- TRANSPORT FOR RETALIATION BY AUTOTRACK;**
- THE AUTOVEHICLES IN THE USE PHASE MANUFACTURED IN ROMANIA: DACIA 1310 BREAK (GASOLINE+LPG, CYLINDER CAPACITY OF THE ENGINE (CC) 1300 cm<sup>3</sup>, 54 HP) ARO 10.41.9 (DIESEL FUEL, CC 1870 cm<sup>3</sup>,64 HP);**
- AVERAGE VEHICLE SPEED: 65 Km/h.**

# **LIFE CYCLE INVENTORY**

- DATA CONCERNING MATERIALS, ENERGY AND ENVIRONMENTAL EMISSIONS FOR THE SIX DEFINED UNIT PROCESSES HAVE BEEN COLLECTED;**
- ECONOMIC ALLOCATION IN THE OIL EXTRACTION STEP (OIL/ASSOCIATED NATURAL GAS) AND IN THE REFINERY PROCESS (GASOLINE/DIESEL FUEL/LPG)**
- THE FINAL INVENTORY TABLE INCLUDES ENVIRONMENTAL EMISSION DATA FOR 42 POLLUTANTS (28 IN THE AIR, 12 IN WATER AND 2 ON THE SOIL) ;**
- THE RESULTS FROM THE COMPLETION OF THE INVENTORY PRESENTED IN THE FOLLOWING CHART, ALLOW THE OPPORTUNITY TO TACKLE A FIRST PARTIAL INTERPRETATION.**

# PARTIAL INTERPRETATION OF LCI RESULTS: THE REPARTITION OF SOME POLLUTANTS IN THE UNIT PROCESSES OF THE LIFE CYCLE



## LEGEND

EG=EXTRACTION OF GASOLINE; ED=EXTRACTION OF DIESEL;  
 EGPL=EXTRACTION OF LPG,T1G=TRANSPORT1 GASOLINE;T1D=TRANSPORT  
 DIESEL etc. TLPG= TOTAL LPG; PT= PARTICULATES TOTAL; SHW=SOLID  
 HAZARDOUS WASTE; SNW=SOLID NONHAZARDOUS WASTE

# **LIFE CYCLE IMPACT ASSESSMENT**

## **METHODS USED FOR VALUATION (WEIGHTING)**

- ECO-INDICATOR 95**

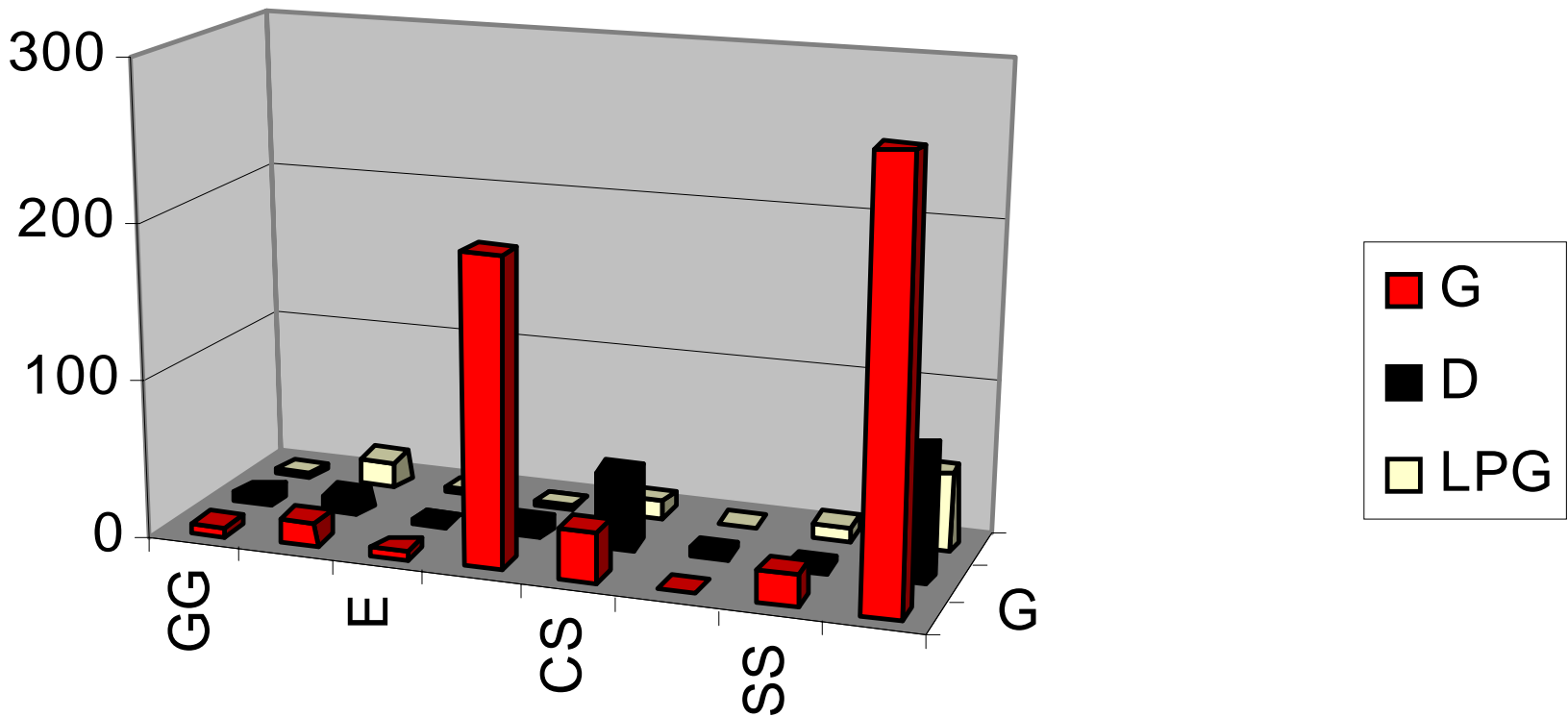
- ECO-INDICATOR 99**

- THESE METHODS WERE DEVELOPED AS INSTRUMENTS FOR THE PROMOTION OF THE CONCEPT “DESIGN FOR THE ENVIRONMENT”**

- ECO-INDICATOR 95 HAS BEEN DEVELOPED BASED ON THE METHODOLOGY “DISTANCE TO TARGET”**

- ECO-INDICATOR 99 PROPOSES ON THE BASIS OF THE “CULTURAL THEORY” THREE ANSWERS FOR THE VALUATION STEP IN LCA REPRESENTING THREE PERSONS WITH DIFFERENT VISIONS ON THE WORLD: HIERARCHIST (DEFAULT), EGALITARIAN AND INDIVIDUALIST.**

# RESULTS ECO-INDICATOR 95

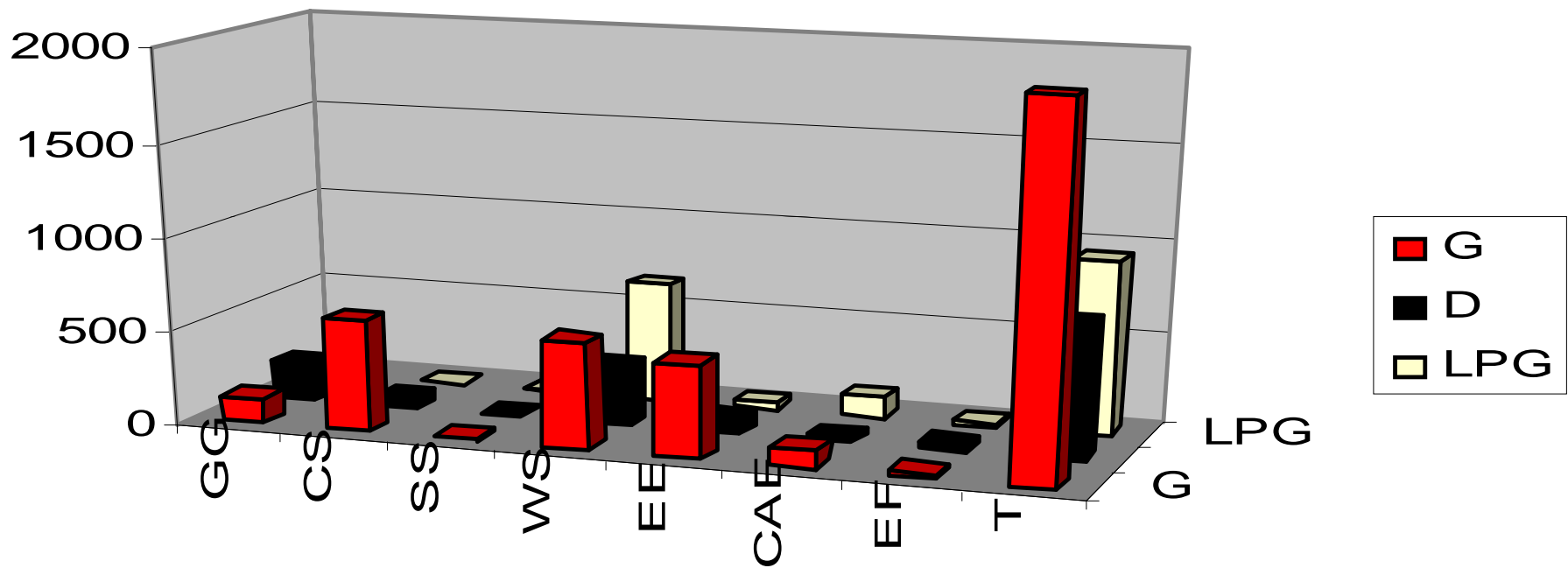


## LEGEND

GG= GREENHOUSE GASES; A=ACIDIFICATION; E=EUTROPHICATION;HM= HEAVY METALS; CS=CARCINOGENIC SUBSTANCES; WS=WINTER SMOG; SS= SUMMER SMOG; T=TOTAL

G=GASOLINE; D=DIESEL FUEL; LPG= LIQUID PETROLEUM GAS

# RESULTS ECO-INDICATOR 99- HIERARCHIST PERSPECTIVE

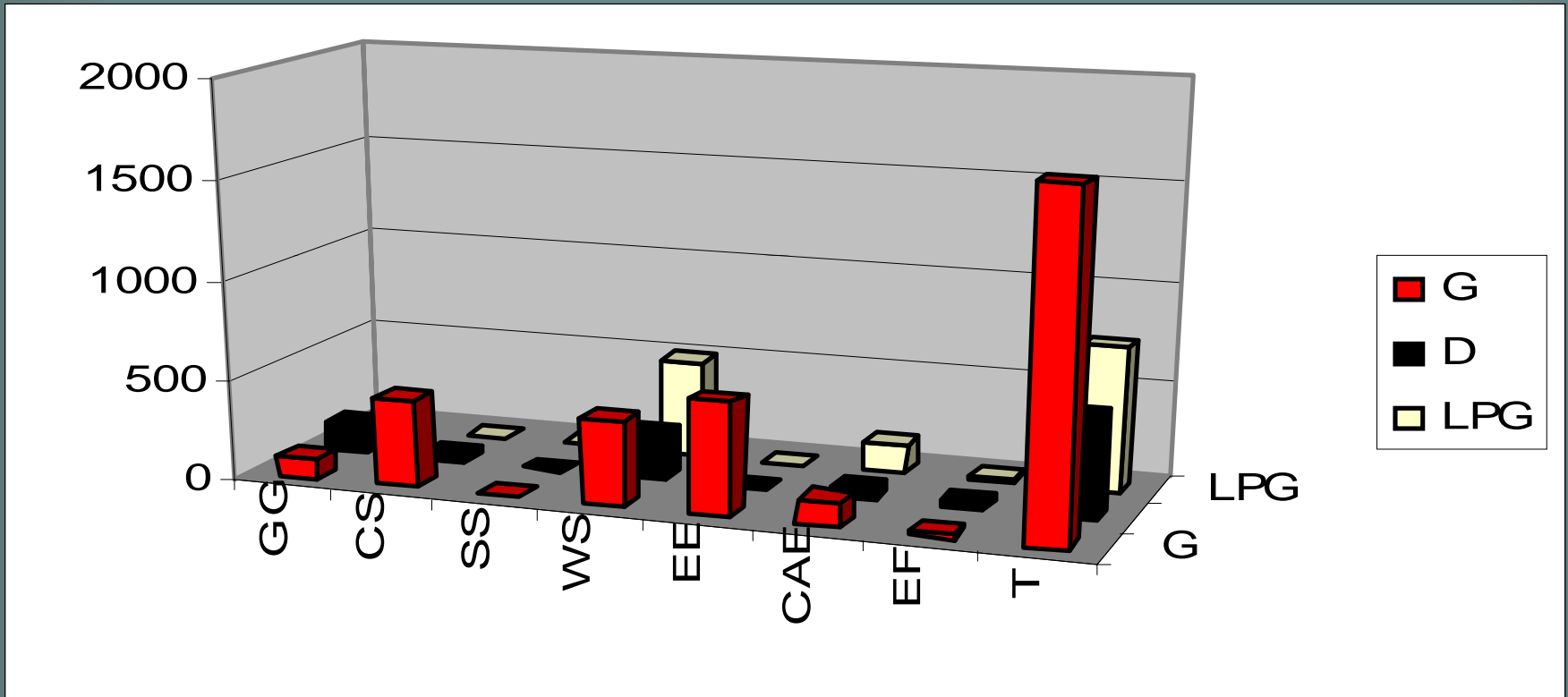


## LEGEND

GG= GREENHOUSE GASES; CS= CARCINOGENIC SUBSTANCES; SS= SUMMER SMOG; WS= WINTER SMOG; EE ECOTOXIC EMISSIONS; CAE= COMBINED ACIDIFICATION/EUTROPHICATION; EF= EXTRACTION OF FUELS T=TOTAL

G=GASOLINE; D= DIESEL FUEL ; LPG= LIQUID PETROLEUM GAS

# ECO- INDICATOR 99-EGALITARIAN PERSPECTIVE

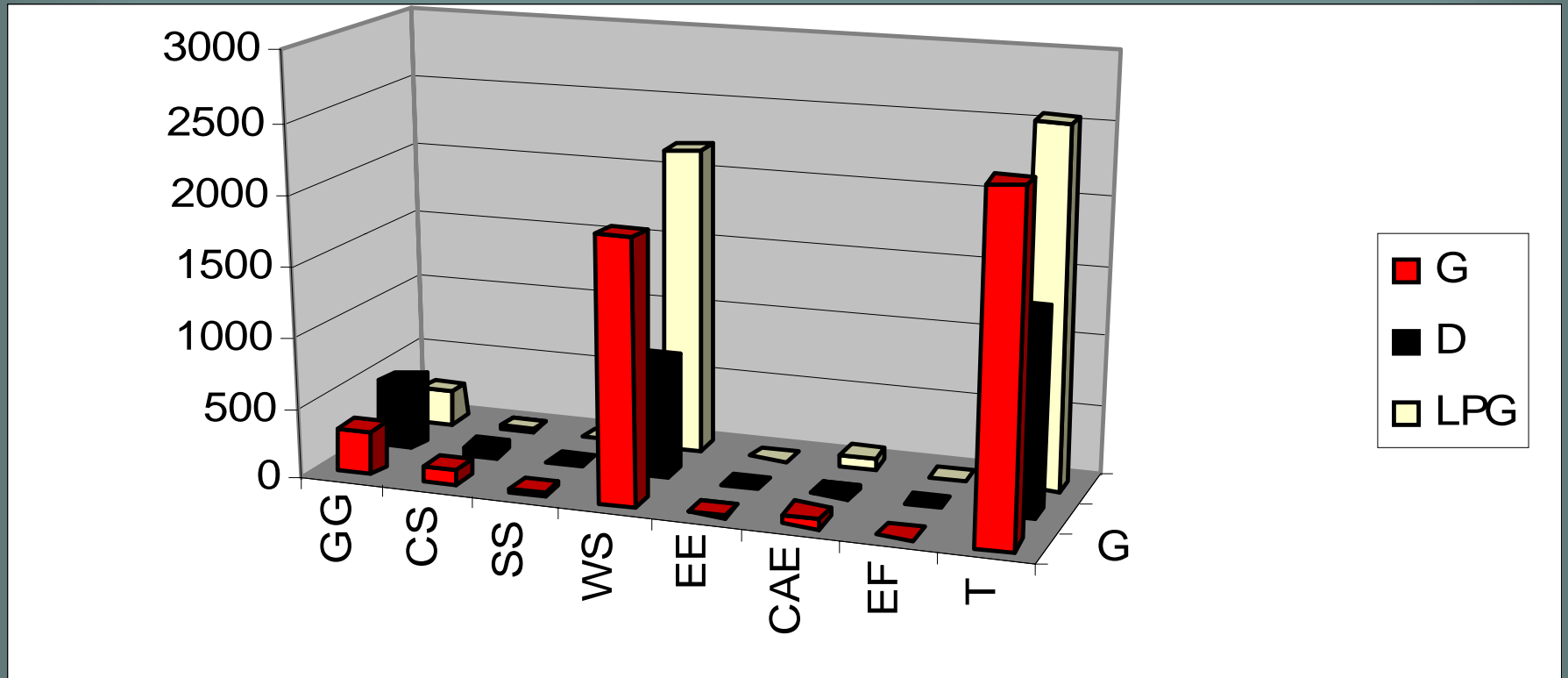


## LEGEND

**GG= GREENHOUSE GASES; CS= CARCINOGENIC SUBSTANCES; SS= SUMMER SMOG; WS= WINTER SMOG; EE ECOTOXIC EMISSIONS; CAE= COMBINED ACIDIFICATION/EUTROPHICATION; EF= EXTRACTION OF FUELS**

**G=GASOLINE; D= DIESEL FUEL ; LPG= LIQUID PETROLEUM GAS**

# ECO- INDICATOR 99-INDIVIDUALIST PERSPECTIVE



## LEGEND

**GG= GREENHOUSE GASES; CS= CARCINOGENIC SUBSTANCES; SS= SUMMER SMOG; WS= WINTER SMOG; EE ECOTOXIC EMISSIONS; CAE= COMBINED ACIDIFICATION/EUTROPHICATION; EF= EXTRACTION OF FUELS**

**G=GASOLINE; D= DIESEL FUEL ; LPG= LIQUID PETROLEUM GAS**

FUEL	CO	HC	NO <sub>x</sub>	HC+ NO <sub>x</sub>	PT	Date of approval/ implementation	Direct UE
Gasoline	20,25	1.681	2.04	3.721	0,02		
Diesel Fuel	0.492	0.092	0.434	0.526	0,136		
LPG	1,83	0.71	2.53	3.24	0		
EURO II B	2,2	-	-	0,5	-	01.01.96/01.01.97	94/12
EURO II M	1,0	-	-	0.7	0.08	01.01.96/01.01.97	94/12
EURO III B	2,3	0,2	0,15	-	-	01.01.00/01.01.01	98/69
EURO III M	0.64	-	0.5	-	-	01.01.00/01.01.01	98/69
EURO IV B	1,0	0,1	0,08	-	-	01.01.05/01.01.06	98/69
EURO IV M	0.5	-	0.25	0.3	0.025	01.01.05/01.01.06	98/69

**EMISSIONS OF SOME POLLUTANT SUBSTANCES IN THE EXHAUST GASES OF PASSENGER CARS IN THE USE PHASE OF FUELS. COMPARISON WITH THE EURO NORMS (g/Km)**

## **INTERPRETATION (CONCLUSIONS)**

- **THE USE PHASE GENERATES OVER 80% OF THE TOTAL ENVIRONMENTAL EMISSIONS ALONG ALL THE LIFE CYCLES OF FUELS REPRESENTING THE STEP ON WHICH WE MUST FOCUS IN ORDER TO IMPROVE THE ENVIRONMENTAL PERFORMANCE OF ROAD TRAFFIC.**
- **DIESEL FUEL HAS BETTER ENVIRONMENTAL PERFORMANCES THAN THE OTHER TWO FUELS. IN BOTH METHODOLOGIES USED FOR THE STUDY (EI-95 AND EI-99) DIESEL FUEL PERFORMS BETTER FOR THE MAJORITY OF THE IMPACT CATEGORIES WITH THE EXCEPTION OF GREENHOUSE GASES (GG) AND EXTRACTION OF FUELS (EF).**
- **IF WE COMPARE THE RESULTS OF THE THREE DIFFERENT PERSPECTIVES WITHIN EI-99 METHODOLOGY IT IS OBVIOUS THE SHIFT IN THE FIRST PLACE (THE WORST SCORE FOR THE ENVIRONMENT) IN THE CLASSIFICATION OF GASOLINE WITH LPG IN THE INDIVIDUALIST PERSPECTIVE IN COMPARISON WITH HIERARCHIST AND EGALITARIAN PERSPECTIVES. EXPLICATION IS THE GREAT EMPHASIS PUT IN THIS PERSPECTIVE ON THE CATEGORY OF IMPACT WS (WINTER SMOG OR ANORGANIC SUBSTANCES) IN WHICH LPG HAS THE GREATEST NO<sub>x</sub> EMISSION.**

## **INTERPRETATION (CONTINUATION)**

- **THE STUDY PRESENTS SOME DIFFERENCES IN THE RESULTS OF EI-95/EI-99 METHODOLOGIES SUCH AS CLASSIFICATION OF DIESEL FUEL/LPG. THIS DIFFERENCE HAS THE EXPLICATION THAT IN TWO IMPACT CATEGORIES WS AND CS (CARCINOGENIC SUBSTANCES) EI-99 INCLUDES MORE SUBSTANCES (LIKE NO<sub>x</sub>, METALS, FORMALDEHYDE OR ACETALDEHYDE)**
- **CONCERNING THE LEVEL OF EMISSIONS OF SOME POLLUTANT SUBSTANCES IN THE EXHAUST GASES OF PASSENGER CARS IN THE USE PHASE OF THE LIFE CYCLE, ALL THE ANALYSED FUELS DO NOT OBSERVE THE EURO NORMS. THUS GASOLINE EXCEEDS EURO II NORMS FOR ALL THE POLLUTANTS (CO, NO<sub>x</sub> +HC), LPG FOR NO<sub>x</sub>+HC AND DIESEL FUEL FOR PARTICULATES**
- **LPG REPRESENTS A BETTER ALTERNATIVE FOR THE ENVIRONMENT THAN THE GASOLINE. BUT REAL ENVIRONMENTAL IMPROVEMENTS AND CONFORMITY WITH THE EURO NORMS CAN NOT BE ACHIEVED FOR THE USE OF THIS FUEL WITHOUT FURTHER REDUCTION OF NO<sub>x</sub> AND HC EMISSIONS THE SAME PROBLEM WITH WHICH IS CONFRONTED THE GASOLINE. ALSO THE FUTURE OF DIESEL FUEL DEPENDS FIRSTLY ON THE REDUCTION OF PARTICULATE EMISSIONS IN ORDER TO REACH CONFORMITY WITH THE EURO NORMS.**
- **SOME SUBSTANCES (LIKE NO<sub>x</sub> AND METALS IN OUR STUDY) CAN PLAY A KEY ROLE IN THE LIFE CYCLE OF PRODUCTS. WE MUST FOCOCUS OUR IMPROVEMENT ACTIONS ON THESE SUBSTANCES**
- **IN THE FUTURE WE WILL EXTEND THE ANALYSIS TO OTHER AUTOMOTIVE FUELS PRESENTING INTEREST FOR THE DEVELOPMENT OF THE ROAD TRANSPORT IN THE COUNTRY.**