CISMOB
Interreg Europe

Technical paper 3

Assessment of road traffic emissions and related costs in Romania

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PP1, PP4, PP5

1. Introduction

Road traffic emissions are a major source of air pollution exposures in urban environments, with several impacts on public health. In 2014, transport sector was responsible in Romania for approximately 15.3million tonnes of CO2 emissions, 14.8 million tonnes of which accounts for road transport [4]. European Union (EU) has been regulating the vehicle emissions by introducing several Euro standards [1]. Nevertheless, this sector is responsible for significant contributions to emissions of Carbon Monoxide (CO), Carbon Dioxide (CO2), Nitrogen Oxides (NOX), Hydrocarbons, specially volatile organic compounds (VOC) and non-methane volatile organic compounds (NMVOC), and particulate matter (PM).

This report presents a study on major pollutant on-road emissions for all relevant road vehicle types from 2000 to 2014 based on Romania car fleet data aand related costs. The analysis takes into consideration each vehicle category contribution to the amount of emissions.

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It is organized as follows:

- The first section presents the methodology and data source used in the study.
- The second section provides an analysis of emissions and related costs in Romania.

2. Methodology and data sources used

The software COPERT v.4 [3] was used with country-specific data of Romania to estimate all factor emissions for the period between 2000 and 2014.

Pollutants, such as CO, CO2, VOC, NMVOC, NOX and PM2.5 were considered in the analysis. Environmental effects of different types of vehicles were also considered. Lack of specific information on the data to use in COPERT did not permitted to present results on the emissions of SO2. Costs were estimated for emissions of PM 2.5, NMVOC and NOX based on the damage costs of main pollutants from transport, in € per tonne (2010), from [3]. Estimation of costs related to CO2 emissions were based on a cost of 90€ per tonne [3].

The damage costs values for each country of the CISMOB consortium are displayed in the following table.

Country	CO2	NMVOC	NOX	PM 2.5		
				highway	rural	urban
Portugal	90	1048	1957	18371	49095	196335
Romania		1796	22893	56405	84380	231620
Spain		1135	4964	14429	48012	195252
Sweden		974	5247	14578	50210	197450

Table 1. Damage costs of main pollutants from transport, in € per tonne [3].

Emissions were calculated using the COPERT v.4 software and COPERT database format. We had to purchase country-specific data to be able to study the emissions and related costs for a long-term period of 15 years. COPERT vehicle fleet and activity data is obtained using the latest official statistics available. Data include several Excel sheets of, e.g., population, mileage in km/year, percentage of activity on urban, rural and highway areas, …

Based on the Romania vehicle fleet and activity data, we estimate the emissions and then, calculated associated costs per km of several pollutants. It is worthwhile mentioning that the emission estimation was obtained for different vehicle categories.

3. Analysis of Romania vehicle fleet emissions

3.1. Total Emissions and Costs

The following table shows the annual emissions of CO, CO2, VOC, NMVOC, NOX and PM2.5 for all types of vehicles of the Romanian fleet.

	2000	2001	2002	2003	2004	2005	2006	2007
CO	468705,76	568512,70	512959,01	487136,97	477396,15	398156,56	340028,85	296867,44
CO2	8182097,49	10538462,24	10800996,79	11682725,07	12162101,61	11627619,86	12113762,39	12349020,93
VOC	62111,26	75046,49	69353,67	67379,03	67640,25	58000,25	51659,13	45290,59
NMVOC	59904,13	72272,70	66732,41	64767,21	64995,54	55691,41	49571,83	43409,12
NOX	77102,37	97019,26	95333,88	100308,45	101074,66	91981,10	94094,54	86192,56
PM2.5	3779,49	4709,57	4677,19	4889,34	4606,53	4175,764	4385,91	3975,80

	2008	2009	2010	2011	2012	2013	2014
CO	257983,76	226204,41	188728,86	187323,06	192346,88	178971,79	174180,63
CO2	13911404,68	14479456,65	13269244,09	13740513,80	14437119,97	13937405,50	13937501,01
VOC	41513,68	38157,40	32519,91	33821,32	34446,66	32552,16	31816,49
NMVOC	39753,56	36484,76	31163,45	32348,23	32941,44	31148,38	30451,74
NOX	91792,32	88549,70	77942,92	84100,64	87295,83	83200,77	81315,65
PM2.5	4294,55	3852,16	3449,52	3934,02	3987,76	3728,52	3573,83

Table 2. Total emissions in Romania in tonnes.

It can be easily seen that the CO2 emissions have been varying over the years. The highest value (almost 14,5 million tonnes) was achieved in 2009, and the lowest (almost 8,2 million tonnes) was registered in the beginning of the studied period. Comparing the highest value with that registered in 2014, there can be verified a reduction of only 3,7%. Regarding the other pollutants, we can see more clearly the behavior in Figure 1. The CO, NMVOC and VOC emissions have in general been decreasing between 2001 and 2011. There was a slight increase between 2011 and 2012, but the decreasing tendency can be verified since then. Comparing the values registered in 2000 with those from 2014, we can refer a reduction on all emissions, except in CO2 and NOX with augments of 70% and 5%, respectively. In particular, there were registered reductions around 63% in CO, 49% for VOC and NMVOC and 5% in the case of PM 2.5.

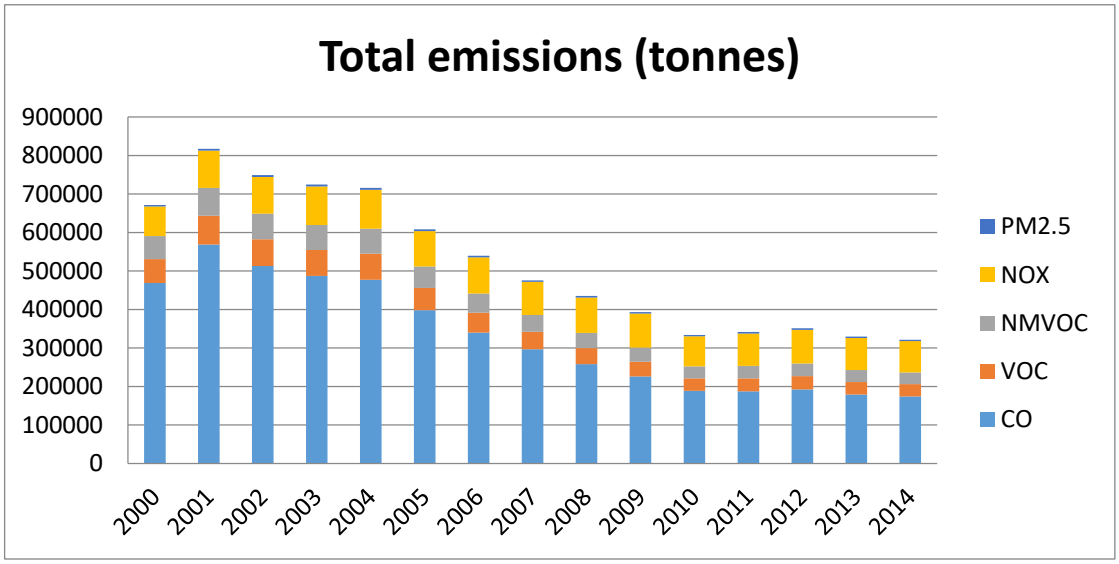

Figure 1. Total emissions of VOC, NMVOC, NOX and PM2.5 (tonnes).

Table 3 presents the emission costs by each pollutant, given in Million Euros, and Figure 2 presents the total costs in Million Euros.

	2000	2001	2002	2003	2004	2005	2006	2007
CO2	736,39	948,46	972,09	1051,45	1094,59	1046,49	1090,24	1111,41
NMVOC	107,59	129,80	119,85	116,32	116,73	100,02	89,03	77,96
NOX	1765,10	2221,06	2182,48	2296,36	2313,90	2105,72	2154,11	1973,21
PM2.5	646,01	803,71	799,18	833,33	782,85	706,90	741,83	674,02

	2008	2009	2010	2011	2012	2013	2014
CO2	1252,03	1303,15	1194,23	1236,65	1299,34	1254,37	1254,38
NMVOC	71,40	65,53	55,97	58,10	59,16	55,94	54,69
NOX	2101,40	2027,17	1784,35	1925,32	1998,46	1904,72	1861,56
PM2.5	729,16	652,27	584,13	664,16	672,52	627,94	601,13

Table 3. Emission costs in Romania in Million €.

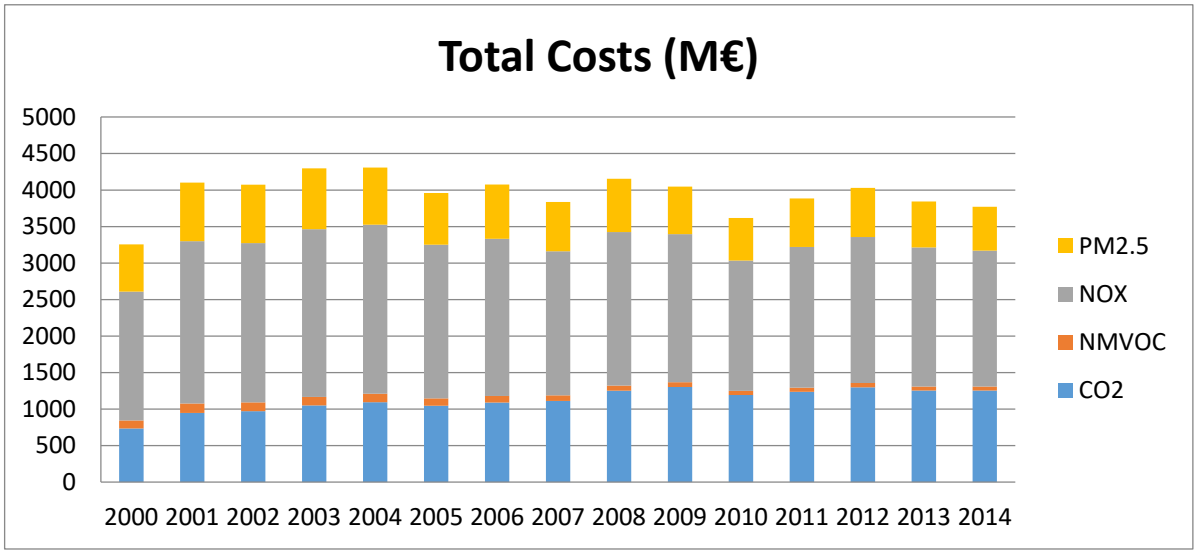

Figure 2. Total costs in Romania in Million €.

We can see that the costs with NOX are very high, in particular, they are always higher than CO2 costs. The costs with NOX are, in average, around 2041M€, while with CO2 are 1123M€. The costs with NMVOC have in general been decreasing over the years. Regarding the costs with PM 2.5, they have been ranging from 584M€ (2010) up to 834M€ (2003). Comparing the total costs with the emissions of the studied pollutants in the period between 2000 and 2014, we can verify that there was an augment of almost 16%.

The following table and figure show the emission costs per km (€/km).

	2000	2001	2002	2003	2004	2005	2006	2007
CO2	0,02991	0,02964	0,02927	0,02926	0,02833	0,02821	0,02904	0,02772
NMVOC	0,00437	0,00406	0,00361	0,00324	0,00302	0,00270	0,00237	0,00194
NOX	0,07169	0,06941	0,06573	0,06391	0,05990	0,05675	0,05739	0,04921
PM2.5	0,02624	0,02512	0,02407	0,02319	0,02026	0,01905	0,01976	0,01681

	2008	2009	2010	2011	2012	2013	2014
CO2	0,02757	0,02712	0,02707	0,02742	0,02751	0,02757	0,02756
NMVOC	0,00157	0,00136	0,00127	0,00129	0,00125	0,00123	0,00120
NOX	0,04627	0,04219	0,04045	0,04269	0,04231	0,04186	0,04090
PM2.5	0,01605	0,01358	0,01324	0,01473	0,01424	0,01380	0,01321

Table 4. Emission costs in Romania in €/km.

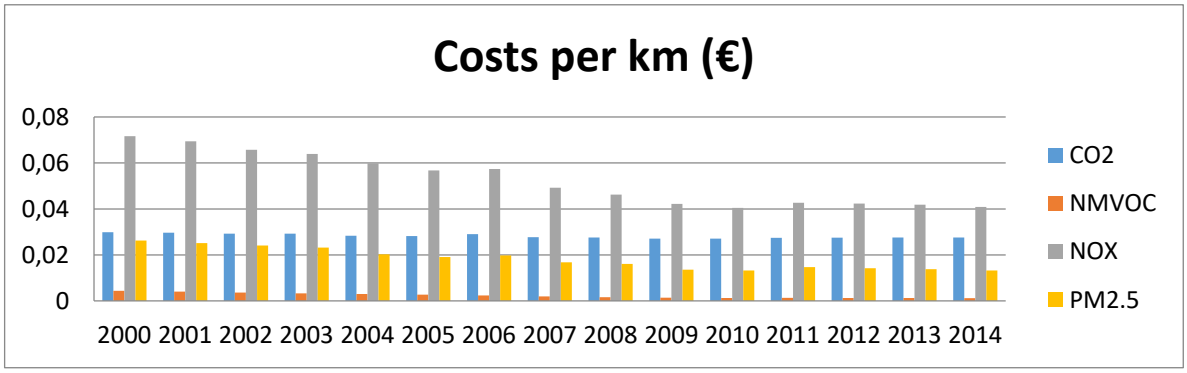

Figure 3. Costs per km (€).

It can be observed that in the studied period, NOX presents the highest values, sometimes surpassing 0,06€, while NMVOC presents the lowest. The cost of CO2 per km is in average around 0,0282€. The highest values of PM 2.5, 0,0262€, were achieved in 2000. We can see that the costs with PM 2.5 have in general been decreasing until 2011, where an augment can be verified. After 2011, there is a tendency to decrease. In 2014, the costs per km of PM 2.5 was 0,0132€. Comparing the values of CO2, NMVOC, NOX and PM 2.5 between 2000 and 2014, we can observe a reduction around 8%, 73%, 43% and 50%, respectively.

3.2. Emissions by type of vehicles

The following figures are displayed using a logarithmic scale (to show magnitude) in order to emphasize the differences between the pollutant emissions.

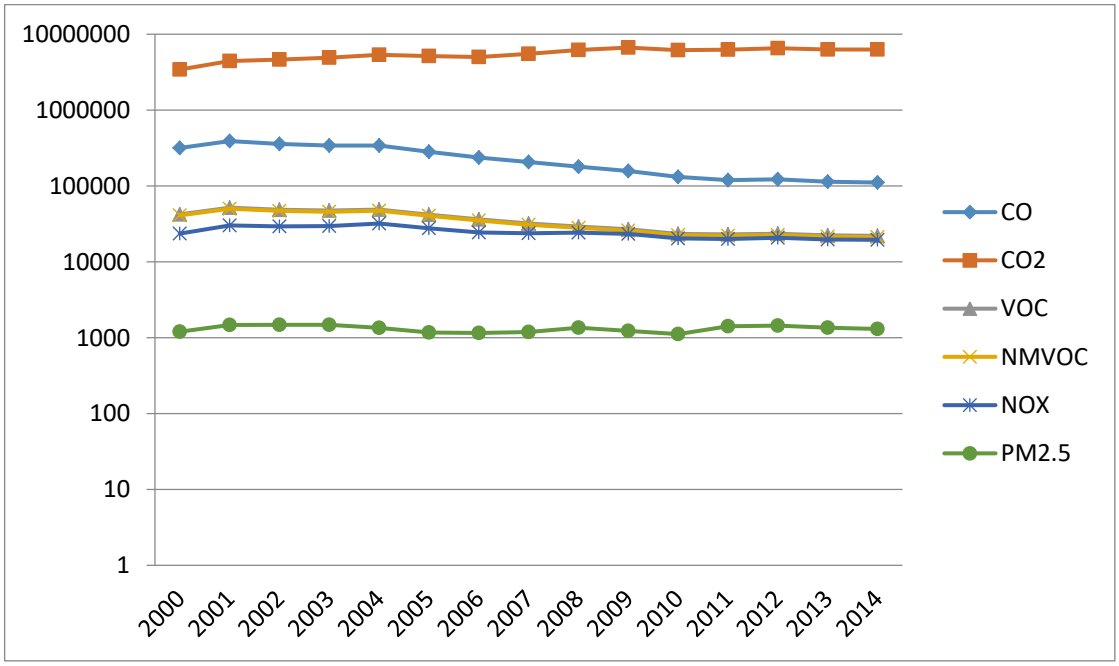

Figure 4. Passenger cars – annual emissions in tonnes (logarithmic scale).

A first observation we can make is that the CO2 emissions have in general been increasing over the years. In particular, comparing the values between 2000, where the minimum was achieved (more than 3,4 million tonnes), and 2014 (almost 6,3 million tonnes), we can verify an augment of almost 84%. With respect to the emissions of CO, VOC, NMVOC and NOX, there is a decreasing tendency since 2001. Regarding the PM 2.5 emissions we can say that such values are in average, 1314tonnes.

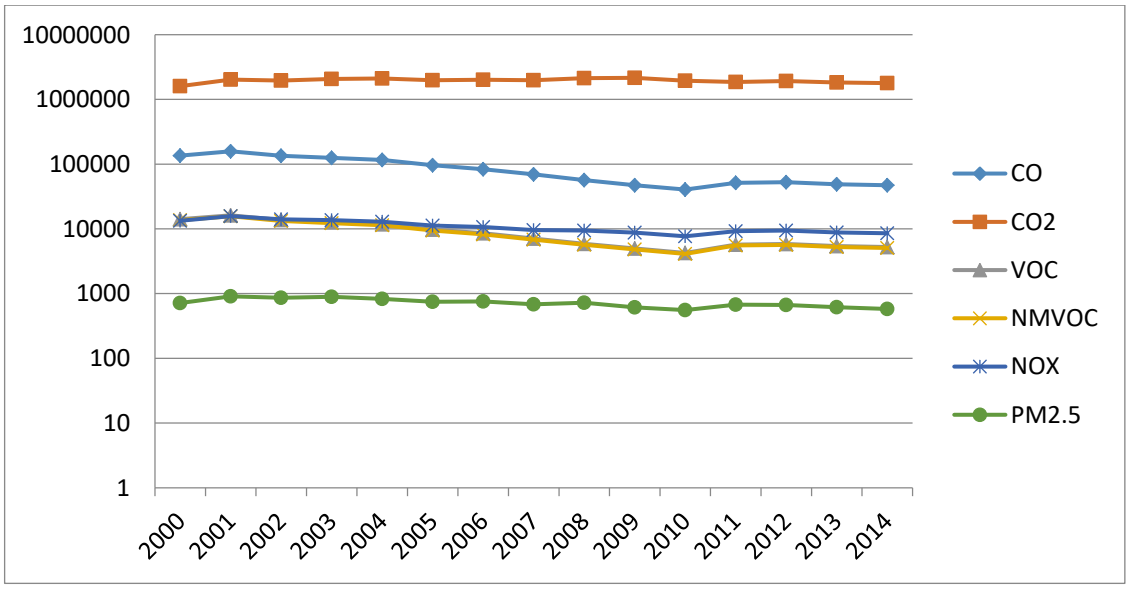

Figure 5. Light Commercial Vehicles – annual emissions in tonnes (logarithmic scale).

Regarding the emissions produced by LCV, and comparing the values in 2000 with those registered in 2014, we can observe that for CO2 there was an augment of almost 12%. Considering the emissions of CO, NOX, VOC and NMVOC there can be observed a decreasing tendency from 2001 until 2011, where an increase was registered. The values of such emissions in 2014 presented augments in the order of 17%, 12%, 23% and 23,4%, respectively, facing the minimum values from 2010. With respect to the levels of PM 2.5 emissions, such values have been ranging from 556 up to 907tonnes.

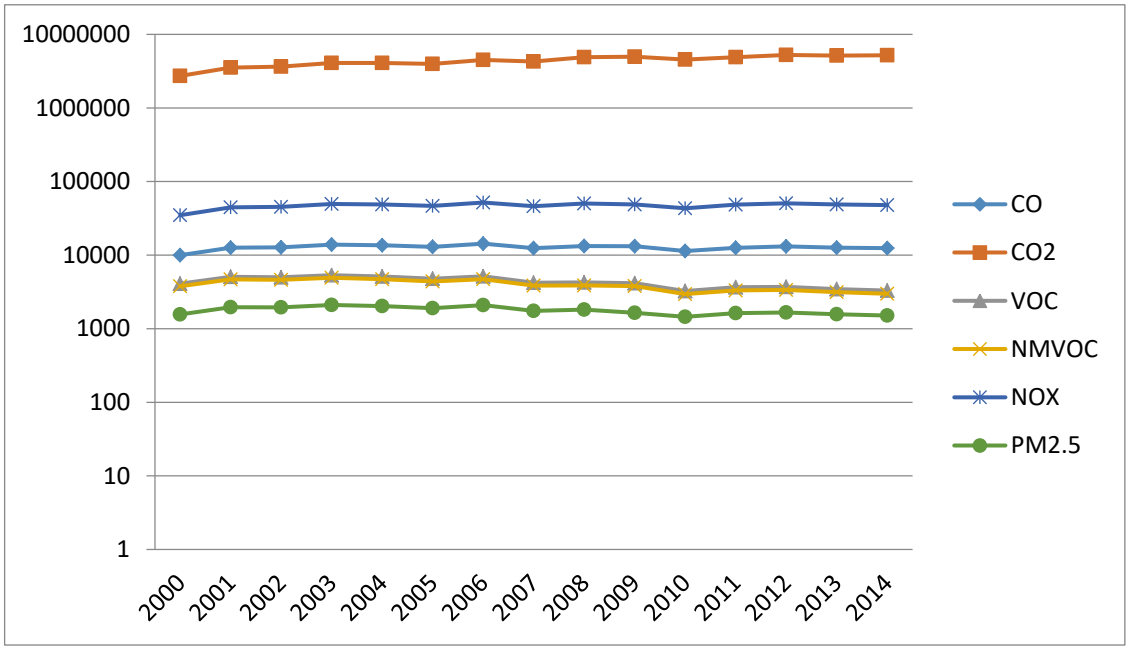

Figure 6. Heavy Duty Trucks – annual emissions in tonnes (logarithmic scale).

A first observation is that, in general, the emissions of CO2 have been increasing over the years. Such emissions are in average around 4,4 million tonnes. We can see that there are more emissions of NOX than CO, contrary to what happens in the cases of PC and LCV. For NOX, NMVOC, VOC, CO and PM 2.5, there is a minimal value in 2010. Comparing such values with those from 2014, we can see that there were minimal reductions, concretely, 9,56%, 0,95%, 1,54%, 8,48% and 4,04%, respectively.

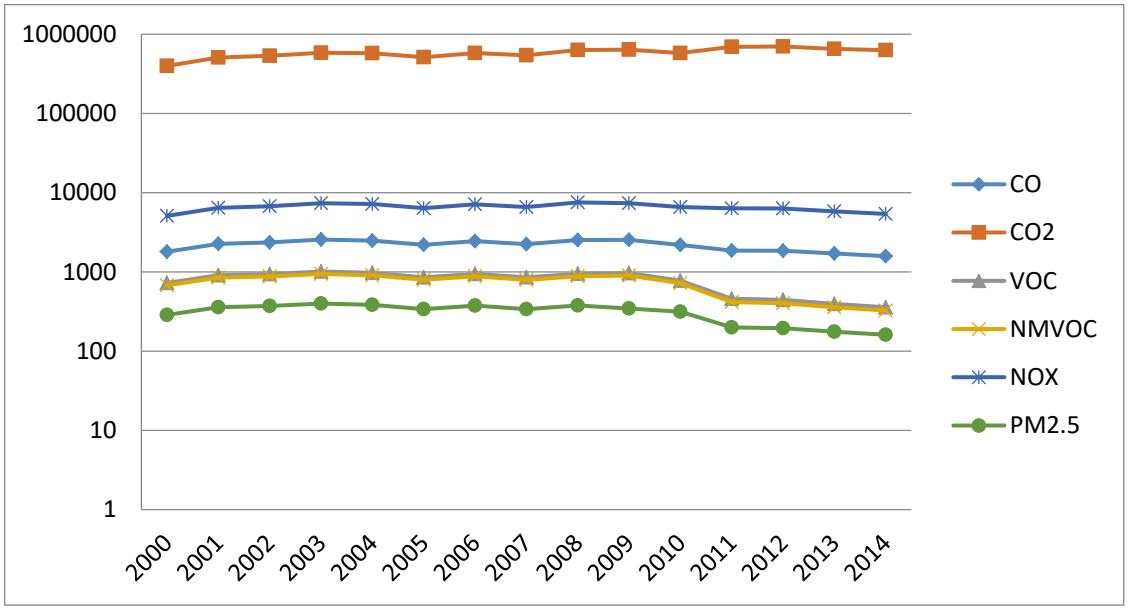

Figure 7. Buses – annual emissions in tonnes (logarithmic scale).

Concerning the buses fleet, the average of CO2 emissions over the studied period was almost 0,6 million tonnes. Just like the previous case, the NOX emissions are higher than CO. Since 2009, the NOX and CO emissions have been decreasing, reaching around 5393 and 1583tonnes, respectively, in 2014. Regarding the other pollutants, it can be observed a more pronounced slope between 2010 and 2011. In fact, the emissions of VOC, NMVOC and PM 2.5, went down to 458, 416 and 199tonnes, respectively. Comparing the levels of all pollutants between 2000 and 2014, we can verify reductions around 12%, 51%, 52% and 44% for, respectively, CO, VOC, NMVOC, and PM,2.5, and an augment of more than 57% for CO2 and 5,7% for NOX.

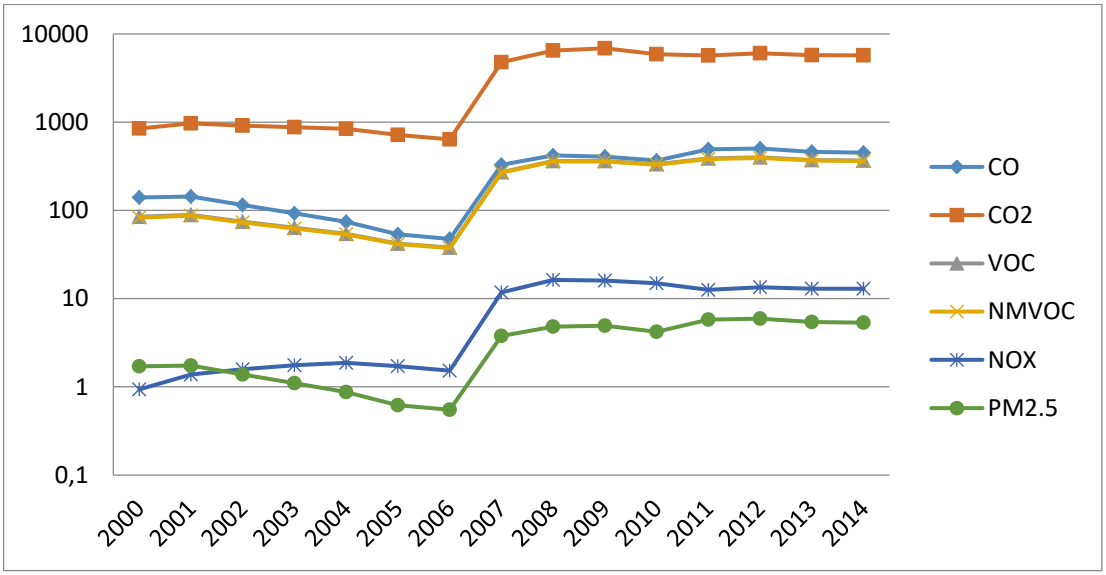

Figure 8. Mopeds – annual emissions in tonnes (logarithmic scale).

The variation of emissions for Mopeds is not consistent over the years. For all pollutants, except NOX, it can be observed a decreasing tendency between 2001 and 2006. In 2007, all emissions had a considerable augment, in particular, there were augments in the order of 650%, 593%, 617%, 617%, 673% and 588%, for CO2, CO, VOC, NMVOC, NOX, PM 2.5, respectively. The maximum of emissions were achieved in 2009 for CO2, 2008 for NOX and the remaining pollutants achieved their maximum values in 2012. In the last few years, the levels of emissions tend to slightly decrease.

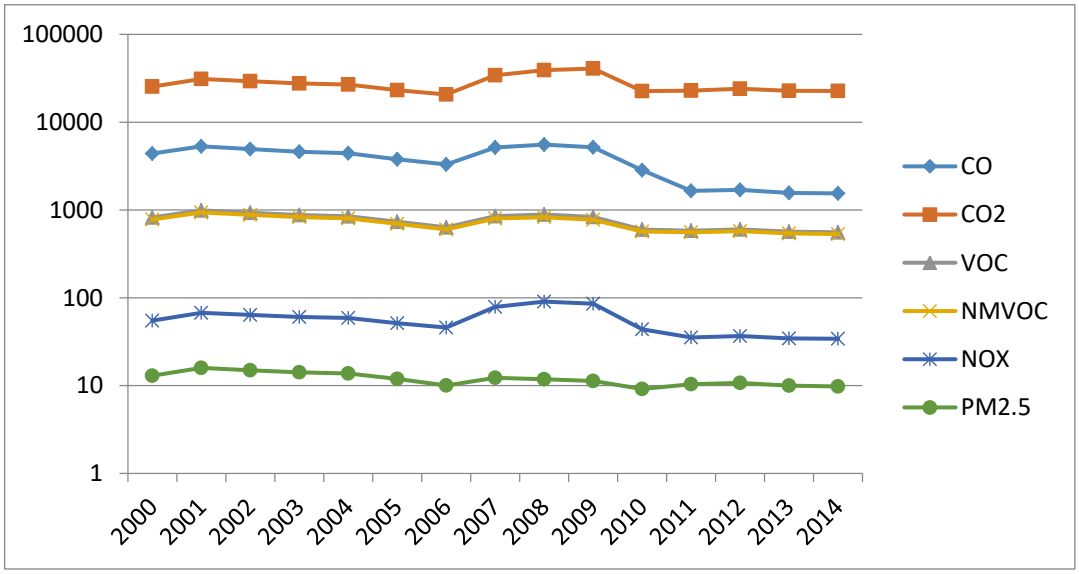

Figure 9. Motorcycles – annual emissions in tonnes (logarithmic scale).

A first observation is that all pollutants experienced an increasing and decreasing behavior between 2006 and 2010. It can be observed that all emissions tend to decrease between 2001 and 2006. Since 2011, all emissions have been decreasing. Comparing the values in 2000 and 2014, we can mention reductions around 65%, 11%, 32,3%, 31,7%, 38%, and 25% for CO, CO2, VOC, NMVOC, NOX and PM2.5, respectively.

3.3. Analysis of Costs by technology – CO2

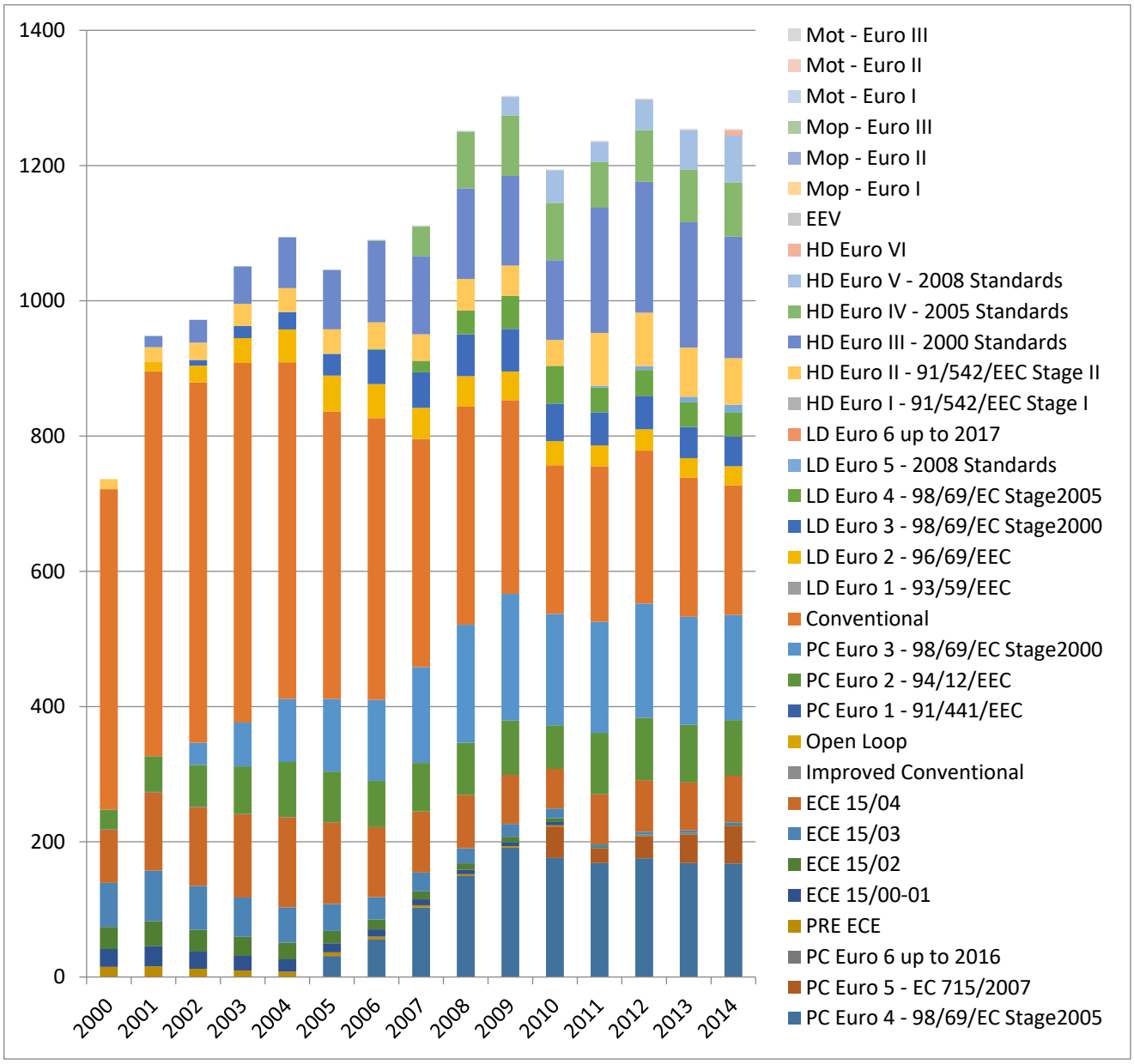

Figure 10. Total Costs of CO2 by technology in Million €.

The contribution of each technology in the CO2 annual cost emissions are displayed in Figure 10. A first observation is that the total costs have been in general increasing, with decreasing behavior punctually specifically in 2005, 2010 and 2013. The highest value was registered in 2009, reaching approximately 1303M€. In 2014, such values were around 1254M€. Comparing the highest value with that registered in 2014, represents a reduction of only 3,7%.

The most contributing technologies are Conventional, PC Euro 4, and PC Euro 3. By far, Conventional is responsible for most of the cost variations. It has been decreasing since 2001, and comparing the highest value with the lowest in 2014, we can see a reduction on costs around 66%. The PC Euro 4 contribution has been increasing between 2005 and 2009, and in 2010 there was a reduction of 8%. Since then the costs with PC Euro 4 vehicles have been ranging from 168M€ up to 176M€. The costs with PC Euro 3 have been increasing until 2009, and in the last 3 years of the study such values have been decreasing.

3.4. Analysis of Costs by technology – NMVOC

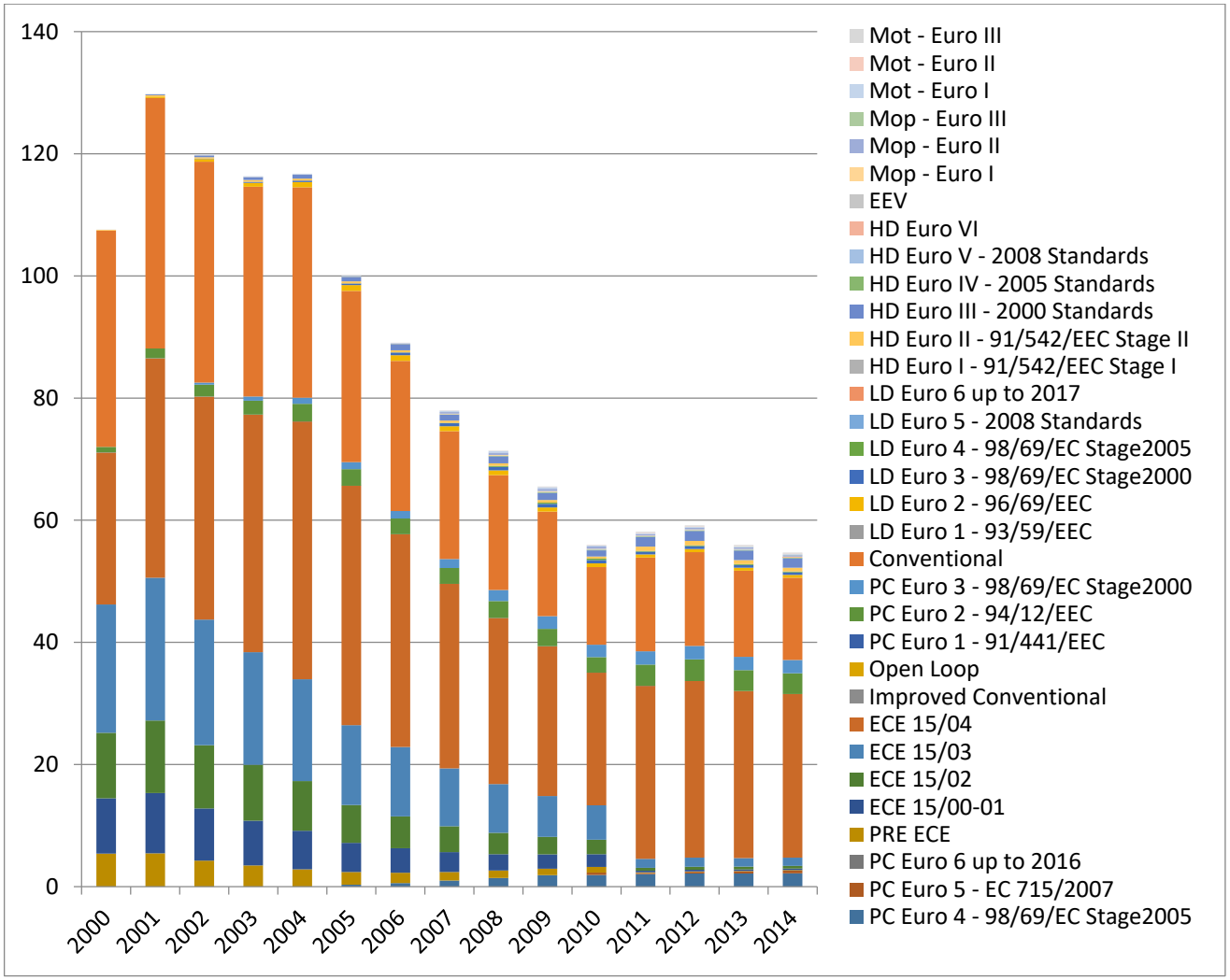

Figure 11. Total Costs of NMVOC by technology in Million €.

From Figure 11, we can refer that the costs with NMVOC emissions have been in general showing a decreasing tendency since 2001. However, between 2010 and 2012, the costs tended to slightly augment. Comparing the highest value achieved in 2001 with the lowest in 2014, we can verify a reduction of 49%.

The most contributing technologies are ECE 15/04, Conventional and ECE 15/03. The cost with ECE 15/04 has been increasing until 2004, and in 2005 it begins to decrease. Comparing the highest with the lowest values we can refer a reduction of almost 49%. However, in 2011, it was verified an augment of more than 30%, facing the costs in 2010. The costs with Conventional vehicles have in general been decreasing until 2010. In 2011, there was an augment, and then the decreasing tendency remains, reaching in 2014 almost 13,5M€. With respect to the costs with ECE 15/03, we can observe its decreasing tendency since 2001.

3.5. Analysis of Costs by technology – NOX

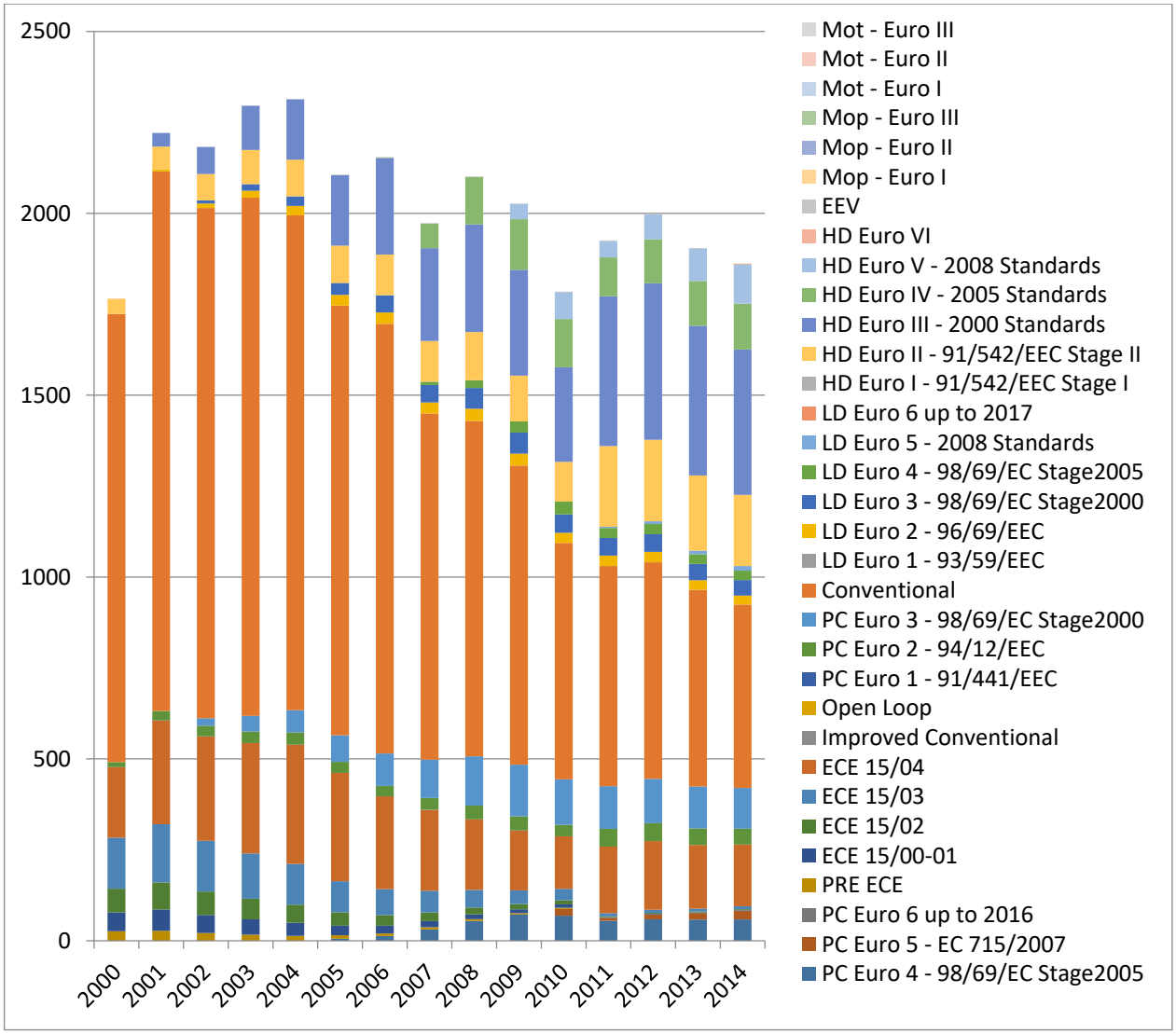

Figure 12. Total Costs of NOX by technology in Million €.

In average, the costs with NOX emissions have been approximately 2041M€. In 2014, such values are around

1862M€.

By far, the most contributing norm for the variation of costs is Conventional, which have been in general decreasing since 2001. Comparing the values in 2001 and 2014, we can verify a reduction around 66%.

3.6. Analysis of Costs by technology – PM 2.5

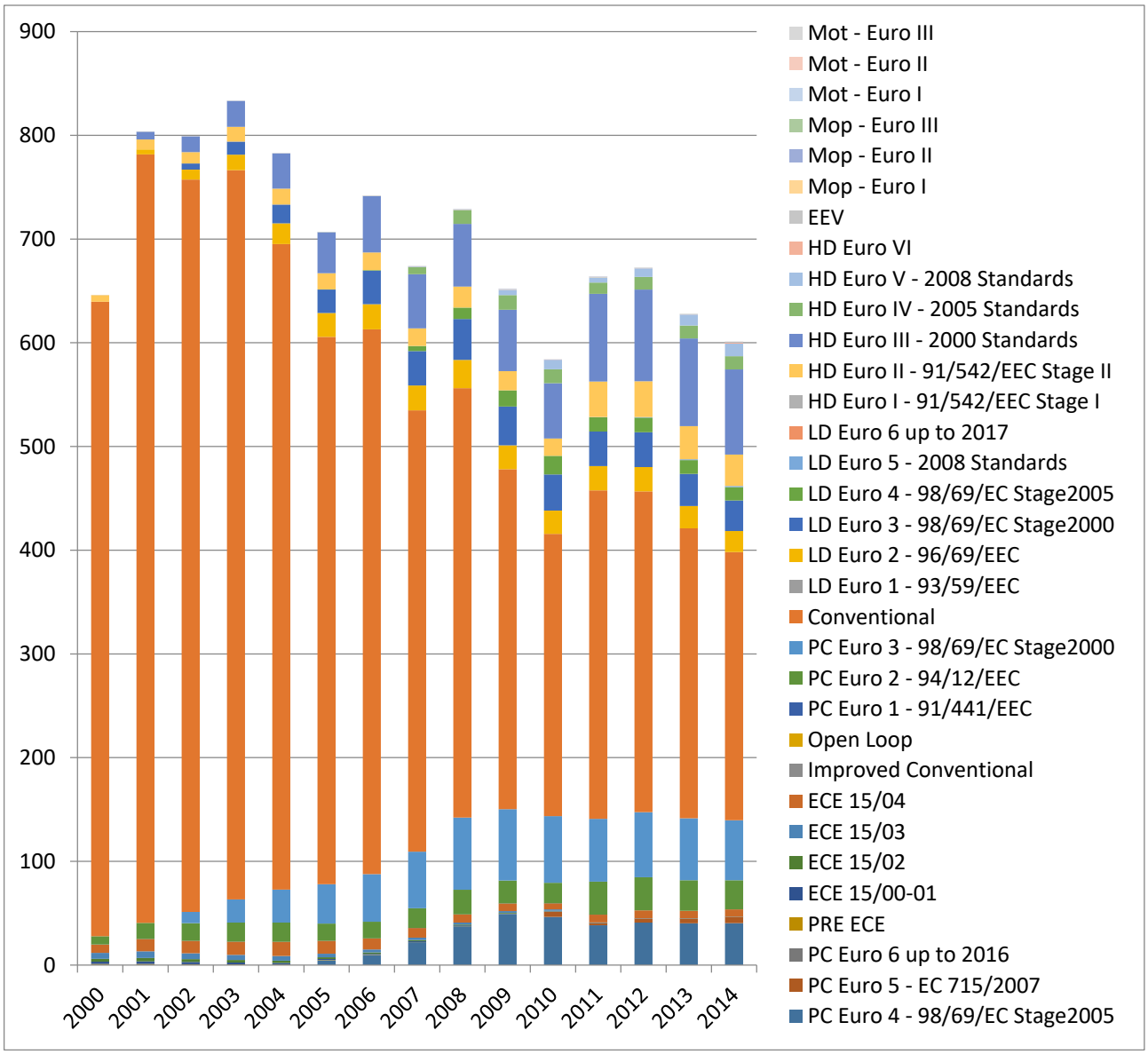

Figure 13. Total Costs of PM2.5 by technology in Million €.

There is no evident tendency on the variation of costs along the studied period. In average, the costs are around 701M€. We can mention a decreasing tendency since 2012, reaching 601M€ in 2014.

Similarly to the previous case, Conventional is the most contributing norm. In fact, it is responsible for almost all costs with PM 2.5 emissions. The costs with such vehicles have been decreasing since 2001until 2010. There was an augment of more than 16% in 2011, facing the costs in 2010. It tends to decrease since then.

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