MADRID

urbanismo,
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# INVENTORY OF MADRID CITY AIR POLLUTANT EMISSIONS 2022


## Directorate General for Sustainability and Environmental Control

## Sub-directorate of Energy and Climate Change

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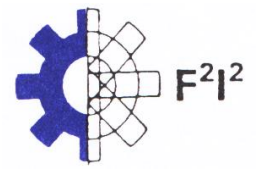
***DG for Sustainability and Environmental Control***

***Sub-directorate of Energy and Climate Change***

***October 2024***

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# 1 INTRODUCTION

The Department of Environment and Mobility of the City of Madrid, annually elaborates the Air Pollutant Emissions Inventory of Madrid city. This Inventory is a useful tool for decision making regarding environmental policy as well as being an essential element for a basic understanding of the activities affecting air quality, sustainable energy management and Climate Change mitigation.

For the elaboration of the Air Pollutant Emissions Inventory of Madrid city 2022 (hereinafter Inventory 2022), the working team of the *Fundación para el Fomento de la Innovación Industrial* (F2I2) has followed the methodology of the air pollutant emission inventory guidebooks published by the European Environment Agency (EMEP/EEA air pollutant emission inventory guidebook 2009, 2013, 2016, 2019 y 2023). Base information has been compiled from questionnaires sent to major local industries as well as from data provided by the National Statistics Institute, the Ministry for the Ecological Transition and the Demographic Challenge (MITECO) and the Energy Balance of the municipality of Madrid in 2022, among others.

The relevant emitting activities considered in the Inventory 2022 have been gathered according to the Selected Nomenclature for sources of Air Pollution (SNAP). This nomenclature considers 11 categories at the higher level of aggregation. These categories are referred to as activity groups (Table 1). As for the pollutants considered, Table 2 shows those included in the Inventory, distinguishing between greenhouse gases (GHG), acidifying gases and ozone precursors and particulate matter.

**Table 1. SNAP Nomenclature. Activity groups**

| | |
|---|---|
| 01 | Combustion in energy and transformation industries (*) |
| 02 | Non-industrial combustion plants |
| 03 | Combustion in manufacturing industry |
| 04 | Production processes |
| 05 | Extraction and distribution of fossil fuels and geothermal energy |
| 06 | Solvent and other product use |
| 07 | Road transport |
| 08 | Non-road transport |
| 09 | Waste treatment and disposal |
| 10 | Agriculture |
| 11 | Other sources and sinks (nature) |

*(*) Without emissions in the municipality of Madrid.*

**Table 2. Pollutants**

| | | |
|---|---|---|
| Greenhouse gases (GHG) | $CH_4$ | Methane |
| | $CO_2$ | Carbon dioxide |
| | HFC | Hydrofluorocarbons |
| | $N_2O$ | Nitrous oxide |
| | PFC | Perfluorocarbons |
| | $SF_6$ | Sulphur hexafluoride |
| Acidifying gases and ozone precursors | CO | Carbon monoxide |
| | NMVOC | Non-methane volatile organic compounds |
| | $NH_3$ | Ammonia |
| | $NO_X$ | Nitrogen oxides ($NO+NO_2$), as $NO_2$ |
| | $SO_X$ (hereinafter $SO_2$) | Sulphur oxides ($SO_2+SO_3$), as $SO_2$ |
| Particulate matter | $PM_{2.5}$ | Particles with aerodynamic diameter less than 2.5 microns |
| | $PM_{10}$ | Particles with aerodynamic diameter less than 10 microns |
| | TPM | Total particulate matter |
| | BC | Black Carbon (*see Appendix I*) |

# 2 EMISSIONS IN MADRID CITY

## *2.1 Total emissions*

Table 3 shows the annual total emissions of Madrid city for each of the pollutant evaluated from 1999 to 2022.

**Table 3. Total emissions by pollutant[1]**

| Pollutant | Unit | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $CH_4$ | t | 47 545 | 47 738 | 45 084 | 42 324 | 37 192 | 19 879 | 20 787 | 20 540 | 19 441 | 19 417 | 19 571 | 19 867 |
| CO | t | 113 008 | 96 054 | 79 576 | 69 880 | 57 119 | 51 372 | 42 273 | 36 217 | 31 214 | 27 194 | 22 066 | 19 222 |
| $CO_2$ (*) | kt | 8 045 | 8 071 | 7 927 | 7 976 | 8 104 | 8 445 | 8 476 | 8 333 | 8 160 | 7 966 | 7 530 | 7 135 |
| COVNM | t | 51 463 | 48 142 | 43 656 | 38 673 | 36 572 | 34 251 | 31 659 | 29 444 | 27 883 | 25 369 | 23 265 | 22 313 |
| HFC-125 | kg | 18 396 | 27 027 | 36 371 | 44 955 | 54 451 | 63 854 | 75 399 | 98 825 | 121 211 | 133 091 | 121 159 | 121 677 |
| HFC-134a | kg | 57 662 | 72 170 | 85 272 | 95 703 | 121 332 | 130 878 | 147 042 | 170 249 | 193 300 | 204 501 | 191 263 | 189 049 |
| HFC-143a | kg | 14 384 | 19 798 | 25 705 | 31 111 | 37 075 | 42 934 | 50 162 | 57 129 | 64 087 | 68 047 | 64 230 | 64 385 |
| HFC-152a | kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| HFC-227ea | kg | 92 | 106 | 156 | 203 | 249 | 305 | 372 | 420 | 516 | 621 | 731 | 837 |
| HFC-23 | kg | 223 | 300 | 377 | 439 | 533 | 581 | 595 | 577 | 597 | 617 | 625 | 625 |
| HFC-236fa | kg | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| HFC-32 | kg | 4 730 | 7 909 | 11 315 | 14 460 | 17 944 | 21 426 | 25 691 | 29 911 | 34 061 | 36 313 | 34 013 | 34 102 |
| $N_2O$ | t | 828 | 850 | 800 | 793 | 803 | 776 | 816 | 887 | 866 | 862 | 823 | 809 |
| $NH_3$ | t | 1 177 | 1 357 | 1 482 | 1 496 | 1 793 | 1 737 | 1 697 | 1 902 | 1 758 | 1 733 | 1 613 | 1 662 |
| $NO_X$ | t | 30 201 | 29 923 | 28 694 | 28 554 | 27 610 | 28 612 | 28 374 | 27 617 | 25 389 | 23 676 | 21 570 | 19 738 |
| PFC-116 | kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PFC-14 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PFC-218 | kg | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 4 | 5 | 4 | 4 |
| PFC-410 | kg | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| $PM_{10}$ | t | 2 363 | 2 281 | 2 116 | 2 051 | 1 974 | 1 992 | 1 919 | 1 909 | 1 745 | 1 611 | 1 495 | 1 341 |
| $PM_{2.5}$ | t | 2 093 | 2 010 | 1 844 | 1 769 | 1 696 | 1 706 | 1 633 | 1 630 | 1 477 | 1 353 | 1 248 | 1 093 |
| $SF_6$ | kg | 278 | 285 | 303 | 321 | 347 | 387 | 435 | 470 | 508 | 539 | 563 | 592 |
| $SO_2$ | t | 4 586 | 3 848 | 3 221 | 2 826 | 2 720 | 2 641 | 2 142 | 2 259 | 2 144 | 1 565 | 1 362 | 1 178 |
| TPM | t | 2 668 | 2 591 | 2 422 | 2 370 | 2 286 | 2 313 | 2 234 | 2 212 | 2 048 | 1 902 | 1 775 | 1 609 |
| **Pollutant** | **Unit** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** |
| $CH_4$ | t | 18 982 | 18 550 | 17 453 | 16 425 | 15 934 | 16 349 | 13 998 | 15 477 | 15 601 | 15 471 | 14 788 | 14 770 |
| CO | t | 16 554 | 13 282 | 12 678 | 11 837 | 11 440 | 10 409 | 10 356 | 10 413 | 10 316 | 7 572 | 6 969 | 7 276 |
| $CO_2$ (*) | kt | 6 542 | 6 367 | 6 171 | 5 852 | 6 043 | 6 279 | 6 254 | 6 663 | 6 431 | 5 133 | 5 541 | 5 062 |
| COVNM | t | 21 161 | 19 345 | 18 522 | 18 307 | 18 411 | 18 175 | 18 128 | 18 291 | 18 309 | 15 680 | 16 129 | 15 860 |
| HFC-125 | kg | 121 547 | 122 849 | 123 408 | 121 803 | 66 328 | 60 902 | 46 476 | 31 782 | 29 088 | 23 373 | 24 087 | 31 600 |
| HFC-134a | kg | 186 939 | 185 857 | 185 694 | 182 862 | 127 113 | 135 461 | 120 179 | 95 736 | 98 906 | 86 122 | 87 617 | 97 985 |
| HFC-143a | kg | 63 434 | 61 096 | 60 029 | 60 333 | 25 014 | 24 945 | 13 028 | 7 373 | 6 605 | 4 640 | 4 242 | 3 837 |
| HFC-152a | kg | 21 | 80 | 107 | 83 | 164 | 281 | 273 | 168 | 115 | 75 | 49 | 34 |
| HFC-227ea | kg | 991 | 1 204 | 1 341 | 1 279 | 1 408 | 1 495 | 1 399 | 1 153 | 1 000 | 877 | 769 | 674 |
| HFC-23 | kg | 615 | 596 | 570 | 524 | 477 | 430 | 390 | 355 | 321 | 297 | 266 | 236 |
| HFC-236fa | kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| HFC-32 | kg | 35 027 | 38 772 | 40 450 | 38 639 | 27 667 | 26 707 | 26 023 | 20 509 | 24 097 | 20 371 | 22 707 | 34 808 |
| $N_2O$ | t | 764 | 661 | 598 | 583 | 560 | 577 | 594 | 561 | 553 | 541 | 550 | 534 |
| $NH_3$ | t | 1 584 | 1 024 | 775 | 693 | 653 | 685 | 723 | 799 | 785 | 698 | 739 | 696 |
| $NO_X$ | t | 17 659 | 16 392 | 15 438 | 14 903 | 15 098 | 14 753 | 15 207 | 15 108 | 14 669 | 10 602 | 10 678 | 11 025 |
| PFC-116 | kg | 0 | 0 | 0 | 5 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 |
| PFC-14 | kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PFC-218 | kg | 4 | 4 | 3 | 4 | 47 | 39 | 58 | 48 | 45 | 40 | 170 | 95 |
| PFC-410 | t | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $PM_{10}$ | | 1 211 | 1 129 | 1 085 | 1 058 | 1 057 | 1 014 | 1 011 | 982 | 952 | 767 | 752 | 681 |
| $PM_{2.5}$ | t | 972 | 902 | 869 | 842 | 831 | 786 | 785 | 759 | 732 | 601 | 566 | 513 |
| $SF_6$ | kg | 581 | 590 | 586 | 586 | 607 | 623 | 622 | 643 | 653 | 667 | 674 | 672 |
| $SO_2$ | t | 1 110 | 993 | 928 | 851 | 828 | 798 | 767 | 748 | 728 | 584 | 685 | 568 |
| TPM | t | 1 469 | 1 367 | 1 312 | 1 292 | 1 301 | 1 272 | 1 257 | 1 225 | 1 198 | 955 | 955 | 873 |

*1) $CO_2$ removals by nature sinks are not included (SNAP activity Group 11). $CH_4$ and $N_2O$ emissions from said Group are included.*

With the exception of fluorine compounds (HFCs, PFCs and $SF_6$), emissions decreased in this period of time. Particularly relevant are the reductions of $CH_4$, CO, NMVOC, $SO_2$ and $PM_{2.5}$, reaching 69, 94, 69, 88 and 76%, respectively.

Table 4 and Figure 1 show the total GHG emissions in Madrid city expressed in terms of $CO_2$ equivalent ($CO_2$-eq). For this purpose, emissions of each GHG have been weighted by their corresponding global warming potential (GWP), in accordance with the recommended values of the Fifth Assessment Report of Intergovernmental Panel on Climate Change (IPCC, 2013), available at: http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#.UVq7jDdOnZc

**Table 4. Total GHG emissions (kt $CO_2$-eq)[1]**

| Pollutant | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $CH_4$ | 1 331 | 1 337 | 1 262 | 1 185 | 1 041 | 557 | 582 | 575 | 544 | 544 | 548 | 556 |
| $CO_2$ | 8 045 | 8 071 | 7 927 | 7 976 | 8 104 | 8 445 | 8 476 | 8 333 | 8 160 | 7 966 | 7 530 | 7 135 |
| HFC | 209 | 284 | 362 | 432 | 528 | 601 | 697 | 838 | 975 | 1 049 | 974 | 974 |
| $N_2O$ | 220 | 225 | 212 | 210 | 213 | 206 | 216 | 235 | 230 | 228 | 218 | 214 |
| PFC | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,1 | 0,0 | 0,0 |
| $SF_6$ | 7 | 7 | 7 | 8 | 8 | 9 | 10 | 11 | 12 | 13 | 13 | 14 |
| **TOTAL** | **9 811** | **9 924** | **9 771** | **9 811** | **9 894** | **9 818** | **9 981** | **9 992** | **9 921** | **9 799** | **9 283** | **8 894** |
| **Pollutant** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** |
| $CH_4$ | 532 | 519 | 489 | 460 | 446 | 458 | 392 | 433 | 437 | 433 | 414 | 414 |
| $CO_2$ | 6 542 | 6 367 | 6 171 | 5 852 | 6 043 | 6 279 | 6 254 | 6 663 | 6 431 | 5 133 | 5 541 | 5 062 |
| HFC | 967 | 962 | 960 | 950 | 525 | 517 | 393 | 283 | 276 | 229 | 232 | 275 |
| $N_2O$ | 203 | 175 | 158 | 154 | 148 | 153 | 157 | 149 | 147 | 143 | 146 | 142 |
| PFC | 0,0 | 0,0 | 0,0 | 0,1 | 0,5 | 0,4 | 0,5 | 0,5 | 0,4 | 0,4 | 1,5 | 0,9 |
| $SF_6$ | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 16 | 16 | 16 |
| **TOTAL** | **8 257** | **8 038** | **7 792** | **7 431** | **7 178** | **7 422** | **7 212** | **7 543** | **7 306** | **5 954** | **6 350** | **5 908** |

*1) $CO_2$ removals by nature sinks are not included (SNAP activity Group 11). $CH_4$ and $N_2O$ emissions from said Group are included.*

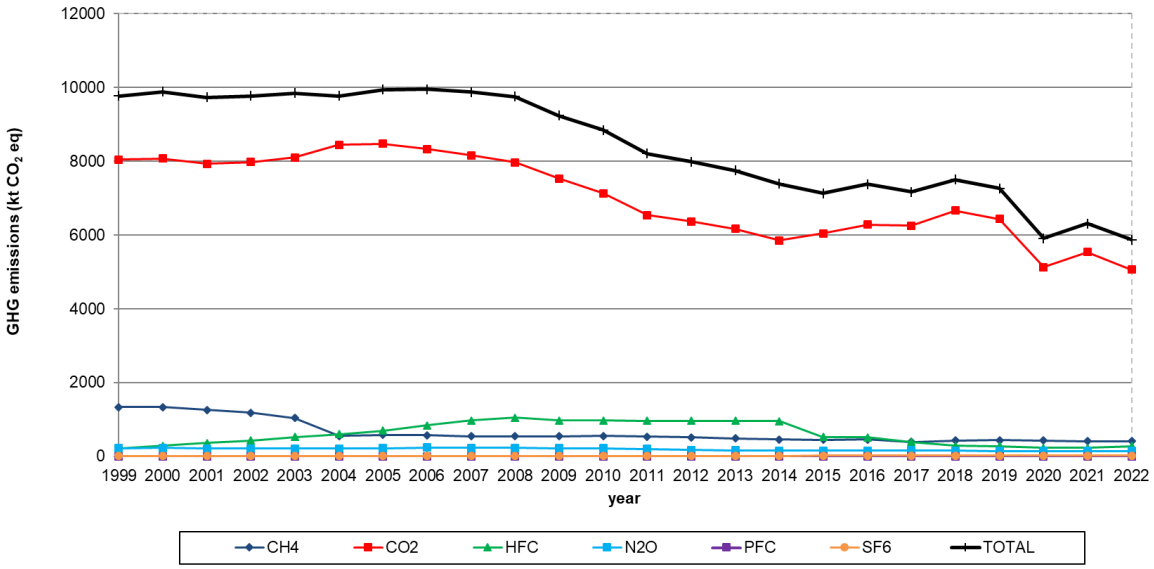


**Figure 1. GHG emissions trend by compound**

Total GHG emissions in 2022 declined by 40% compared to 1999, mainly due to the reduction of $CO_2$ emissions in the "Road transport" (group 07) sector and $CH_4$ emissions from "Waste treatment and disposal" (group 09). In 2021, GHG emissions are 7% higher than in 2020, due to the return of normal activity after the COVID-19 pandemic. In 2022, GEI emissions decreased once again and reached a slightly lower value than that of 2020.

The contribution of each GHG to total $CO_2$-eq figures is shown in Figure 2. $CO_2$ is the single most important specie with an average contribution of 83% in the period 1999 – 2022. Unlike the rather

constant contribution of $CO_2$, Figure 2 shows a decreasing contribution of $CH_4$ and the increasing relevance of HFCs until the year 2015.

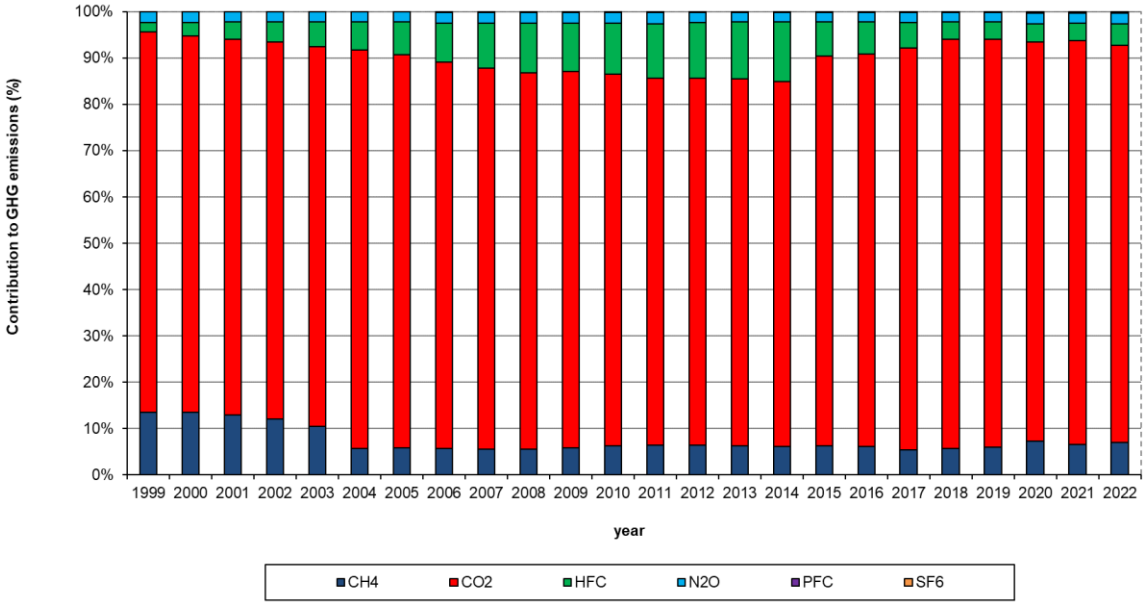


**Figure 2. GHG emissions breakdown by compound (%)**

## *2.2 Emissions disaggregated by pollutant and SNAP group*

### 2.2.1 Greenhouse gases

Table 5 and Figure 3 show the GHG emissions by activity group expressed in terms of $CO_2$ equivalent. It is noticeable that the total GHG emissions have not undergone major changes in the period inventoried until 2008, when emissions began to decrease. This is mainly due to the reduction of emissions from the "Road transport" sector as a result of the decrease of the total distance travelled within the city, the promotion of mopeds and motorcycles, the turnover of the fleet and the improvement of the municipal public transport system, among others.

**Table 5. GHG emissions by SNAP group (kt $CO_2$-eq)[1,2]**

| Year | G_02 | G_03 | G_04 | G_05 | G_06 | G_07 | G_08 | G_09 | G_10 | G_11 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1999** | 2 595 | 604 | 19 | 21 | 347 | 3 997 | 675 | 1 537 | 6 | 9 | **9 811** |
| **2000** | 2 551 | 556 | 23 | 21 | 424 | 4 037 | 742 | 1 555 | 6 | 9 | **9 924** |
| **2001** | 2 479 | 496 | 20 | 19 | 503 | 3 990 | 761 | 1 489 | 6 | 9 | **9 771** |
| **2002** | 2 358 | 449 | 23 | 19 | 566 | 4 131 | 717 | 1 533 | 6 | 9 | **9 811** |
| **2003** | 2 559 | 495 | 23 | 21 | 655 | 4 013 | 669 | 1 445 | 6 | 10 | **9 894** |
| **2004** | 2 676 | 459 | 26 | 20 | 722 | 4 200 | 705 | 995 | 4 | 10 | **9 818** |
| **2005** | 2 695 | 455 | 27 | 18 | 827 | 4 186 | 728 | 1 032 | 3 | 10 | **9 981** |
| **2006** | 2 558 | 458 | 33 | 18 | 979 | 4 041 | 881 | 1 012 | 3 | 10 | **9 992** |
| **2007** | 2 615 | 485 | 29 | 19 | 1 114 | 3 770 | 913 | 964 | 3 | 10 | **9 921** |
| **2008** | 2 611 | 480 | 26 | 17 | 1 180 | 3 627 | 852 | 993 | 3 | 10 | **9 799** |
| **2009** | 2 508 | 380 | 13 | 19 | 1 092 | 3 439 | 781 | 1 037 | 3 | 10 | **9 283** |
| **2010** | 2 373 | 367 | 19 | 18 | 1 087 | 3 264 | 726 | 1 026 | 3 | 10 | **8 894** |
| **2011** | 2 236 | 353 | 14 | 19 | 1 070 | 2 873 | 724 | 955 | 3 | 10 | **8 257** |
| **2012** | 2 327 | 325 | 1 | 20 | 1 052 | 2 718 | 672 | 911 | 3 | 10 | **8 038** |
| **2013** | 2 341 | 368 | 1 | 20 | 1 040 | 2 612 | 595 | 801 | 3 | 10 | **7 792** |
| **2014** | 2 107 | 364 | 1 | 17 | 1 031 | 2 629 | 602 | 667 | 3 | 10 | **7 431** |
| **2015** | 2 046 | 377 | 1 | 17 | 601 | 2 823 | 658 | 643 | 3 | 10 | **7 178** |
| **2016** | 2 202 | 413 | 1 | 19 | 595 | 2 792 | 724 | 663 | 3 | 10 | **7 422** |
| **2017** | 2 073 | 407 | 1 | 18 | 472 | 2 848 | 751 | 628 | 3 | 10 | **7 212** |
| **2018** | 2 360 | 439 | 1 | 21 | 363 | 2 761 | 808 | 777 | 3 | 10 | **7 543** |
| **2019** | 2 220 | 378 | 1 | 20 | 356 | 2 697 | 851 | 771 | 3 | 10 | **7 306** |
| **2020** | 2 087 | 380 | 1 | 19 | 302 | 2 005 | 405 | 742 | 3 | 10 | **5 954** |
| **2021** | 2 038 | 411 | 1 | 20 | 308 | 2 251 | 496 | 812 | 3 | 10 | **6 350** |
| **2022** | 1 790 | 442 | 1 | 19 | 350 | 1 924 | 703 | 666 | 3 | 10 | **5 908** |

*1) G_02: Non-industrial combustion; G_03: Combustion in manufacturing industry; G_04: Production processes; G_05: Extraction and distribution of fossil fuels; G_06: Solvent and other product use; G_07: Road transport; G_08: Non-road transport; G_09: Waste treatment and disposal; G_10: Agriculture; G_11: Other sources and sinks (nature).*

*2) $CO_2$ removals by nature sinks are not included (SNAP activity Group 11). $CH_4$ and $N_2O$ emissions from said Group are included.*

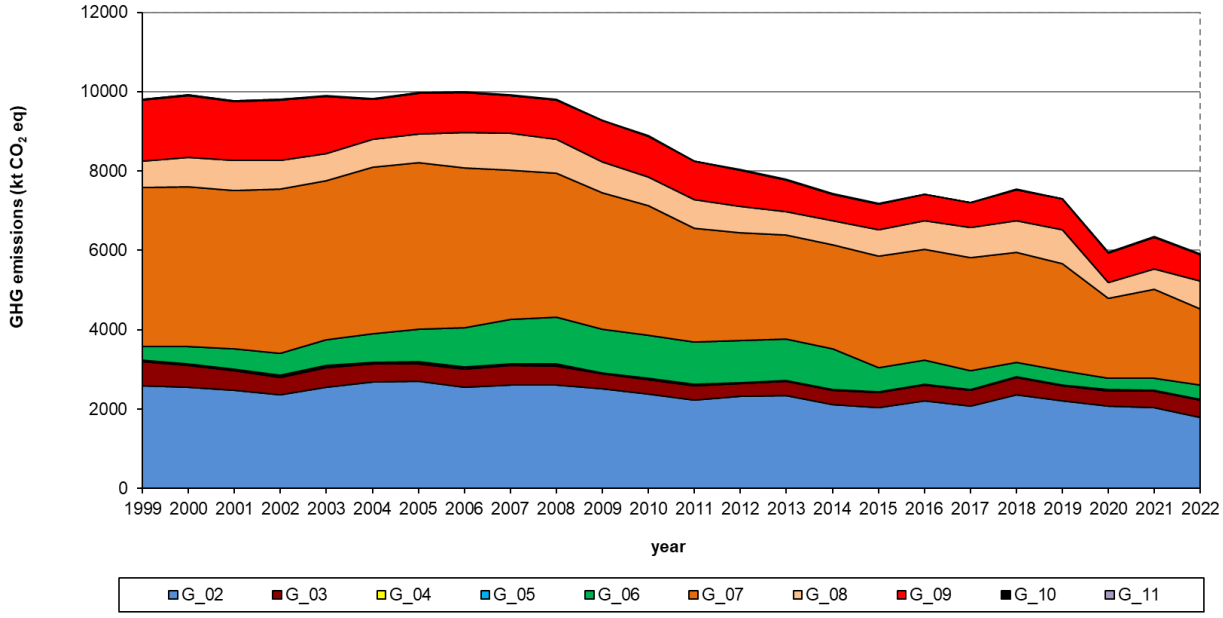


**Figure 3. GHG emissions trend by SNAP group (kt $CO_2$-eq)**

Figure 4 shows the relative contribution to total GHG emissions of each group. The SNAP groups 02 and 07 combined account for about 65% of GHG emissions in the period inventoried. Other SNAP groups, such as 03, 06, 08 y 09, have a lower contribution to total emissions (ranging from 5% to 12%).

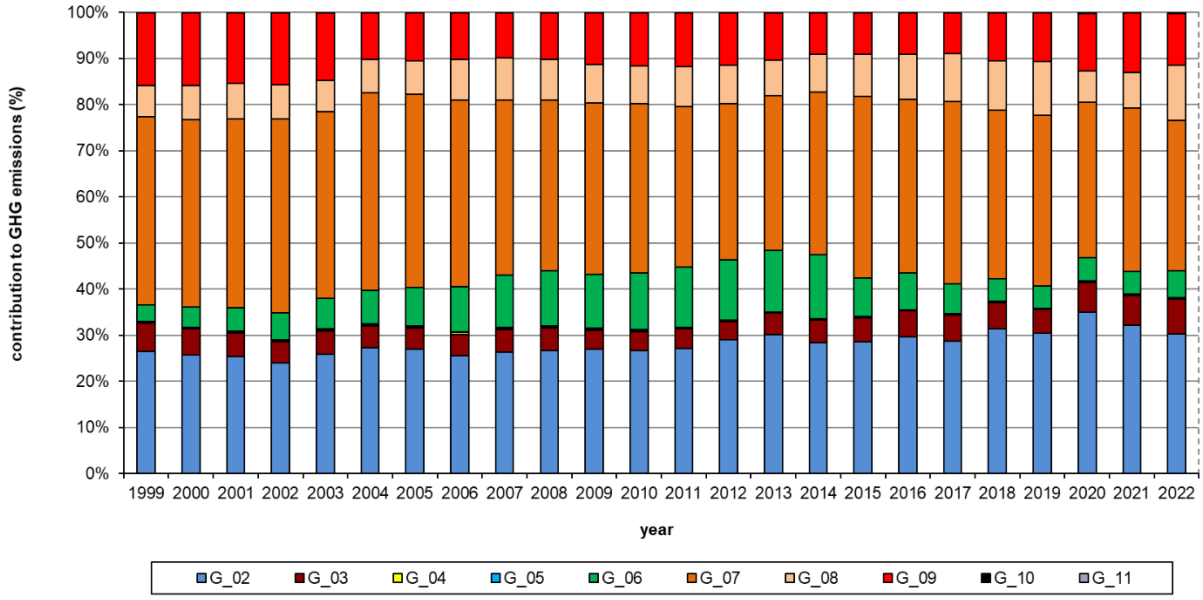


**Figure 4. GHG emissions breakdown by SNAP group (%)**

Figure 5 shows the relative change of GHG emissions for each SNAP group between 1999 and 2022, taking 1999 emissions as a reference. It can be seen that the emissions from SNAP groups 02, 03, 04, 05, 06, 07, 08, 09 and 10 decreased while those from SNAP group 11 increased. The significant rise of emissions from group 06 up to 2014 is mainly due to the increasing use of HFC in refrigeration, air conditioning and firefighting equipment. However, the emissions of these compounds have followed a decreasing trend since 2008, and especially since 2014.

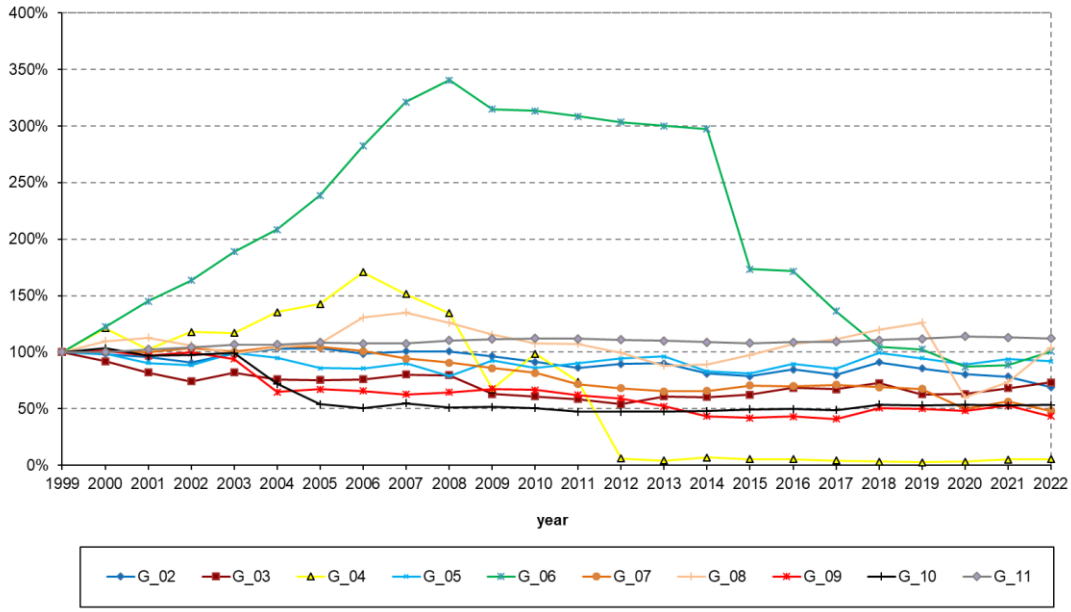


**Figure 5. GHG emissions trend by SNAP group compared to 1999 (1999 = 100)**

### 2.2.2 Acidifying gases

This section includes information on $NO_X$, $SO_2$ and $NH_3$ emissions.

As it can be seen in Table 6 and Figure 6, $NO_X$ emissions decreased by 64% from 1999 to 2022 in Madrid city. This is mainly due to the reduction of emissions from group 07. The emissions of groups 02, 03, 10 and 11 show small variation in the period and those of group 08 increased by 41% from 1999 to 2019, but decreased in the years 2020 and 2021. The global reduction reached in 2021 was 18%; however, in 2022, SNAP 08 emissions increased by a 15%. The $NO_X$ emissions of group 09 grew by up to 77% between 1999 and 2012. However, later 2013, it can be observed a sharp decrease of emissions due to the cessation of sewage sludge drying. There are no emissions from activity group 04 since 2012 as a result of the interruption of steel production in the municipality.

**Table 6. $NO_X$ emissions by SNAP group (t)[1]**

| Year | G_02 | G_03 | G_04 | G_05 | G_06 | G_07 | G_08 | G_09 | G_10 | G_11 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1999** | 2 855 | 1 854 | 71 | 0 | 0 | 21 830 | 2 979 | 592 | 4 | 16 | **30 201** |
| **2000** | 2 845 | 1 738 | 82 | 0 | 0 | 21 315 | 3 317 | 606 | 3 | 16 | **29 923** |
| **2001** | 2 794 | 1 561 | 71 | 0 | 0 | 20 194 | 3 455 | 601 | 2 | 16 | **28 694** |
| **2002** | 2 645 | 1 504 | 74 | 0 | 0 | 20 027 | 3 289 | 995 | 2 | 16 | **28 554** |
| **2003** | 2 882 | 1 414 | 80 | 0 | 0 | 18 812 | 3 147 | 1 256 | 2 | 17 | **27 610** |
| **2004** | 3 032 | 981 | 90 | 0 | 0 | 19 594 | 3 324 | 1 572 | 2 | 16 | **28 612** |
| **2005** | 3 059 | 959 | 89 | 0 | 0 | 19 293 | 3 411 | 1 544 | 1 | 17 | **28 374** |
| **2006** | 2 901 | 978 | 109 | 0 | 0 | 17 443 | 4 960 | 1 207 | 1 | 17 | **27 617** |
| **2007** | 2 963 | 1 011 | 108 | 0 | 0 | 15 500 | 4 798 | 992 | 1 | 16 | **25 389** |
| **2008** | 2 952 | 1 042 | 99 | 0 | 0 | 14 094 | 4 361 | 1 110 | 1 | 16 | **23 676** |
| **2009** | 2 832 | 895 | 52 | 0 | 0 | 12 797 | 3 940 | 1 038 | 1 | 16 | **21 570** |
| **2010** | 2 669 | 1 101 | 75 | 0 | 0 | 11 336 | 3 448 | 1 093 | 1 | 16 | **19 738** |
| **2011** | 2 512 | 1 027 | 61 | 0 | 0 | 9 569 | 3 427 | 1 045 | 1 | 17 | **17 659** |
| **2012** | 2 622 | 995 | 0 | 0 | 0 | 8 417 | 3 295 | 1 046 | 1 | 17 | **16 392** |
| **2013** | 2 643 | 1 003 | 0 | 0 | 0 | 8 093 | 2 886 | 796 | 1 | 16 | **15 438** |
| **2014** | 2 376 | 978 | 0 | 0 | 0 | 8 374 | 2 868 | 289 | 1 | 17 | **14 903** |
| **2015** | 2 305 | 1 027 | 0 | 0 | 0 | 8 388 | 3 114 | 245 | 1 | 17 | **15 098** |
| **2016** | 2 481 | 1 062 | 0 | 0 | 0 | 7 503 | 3 457 | 232 | 1 | 17 | **14 753** |
| **2017** | 2 333 | 1 067 | 0 | 0 | 0 | 7 942 | 3 614 | 233 | 1 | 17 | **15 207** |
| **2018** | 2 650 | 1 100 | 0 | 0 | 0 | 7 138 | 3 914 | 289 | 1 | 16 | **15 108** |
| **2019** | 2 490 | 1 000 | 0 | 0 | 0 | 6 542 | 4 113 | 505 | 1 | 17 | **14 669** |
| **2020** | 2 339 | 852 | 0 | 0 | 0 | 4 876 | 2 043 | 475 | 1 | 17 | **10 602** |
| **2021** | 2 295 | 1 017 | 0 | 0 | 0 | 4 391 | 2 454 | 503 | 1 | 16 | **10 678** |
| **2022** | 2 000 | 946 | 0 | 0 | 0 | 4 327 | 3 427 | 306 | 1 | 18 | **11 025** |

*1) G_02: Non-industrial combustion; G_03: Combustion in manufacturing industry; G_04: Production processes; G_05: Extraction and distribution of fossil fuels; G_06: Solvent and other product use; G_07: Road transport; G_08: Non-road transport; G_09: Waste treatment and disposal; G_10: Agriculture; G_11: Other sources and sinks (nature).*

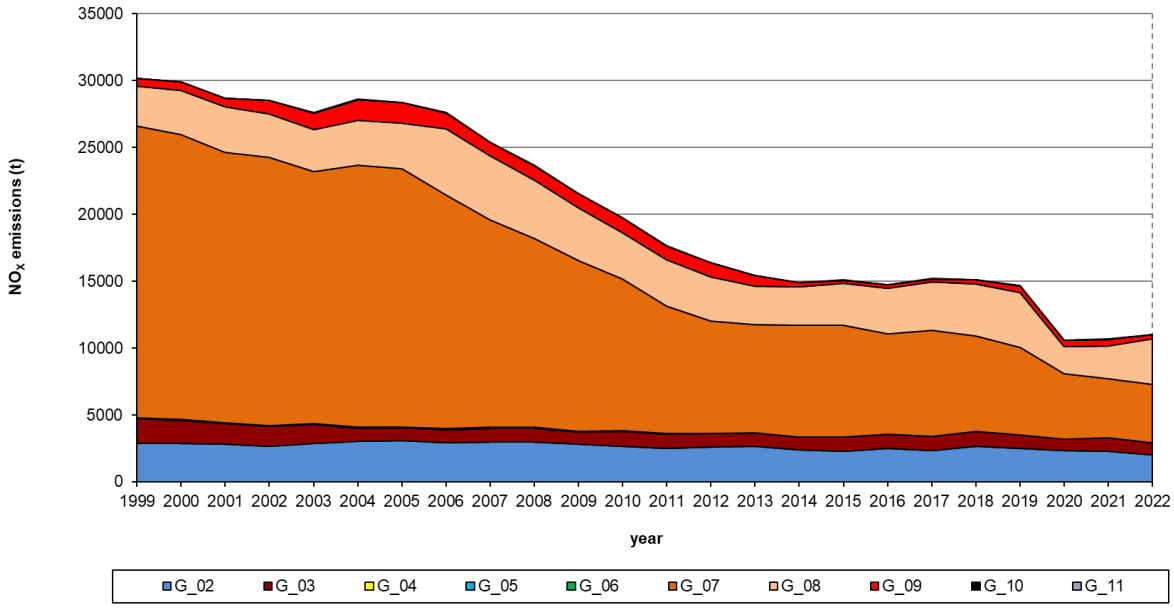


**Figure 6. $NO_X$ emissions trend by SNAP group (t)**

As for the contribution of each group to total $NO_X$ emissions, Figure 7 shows that "Road transport" is the most relevant emitting group, accounting for approximately 60% of Madrid's $NO_X$ emissions as an average in the period inventoried. It should be highlighted that the share of $NO_X$ has steadily decreased in the period (varying from 72 to 42% in the period inventoried). This trend can be partially explained by the policies and abatement efforts implemented in the last years by the Madrid City Council in the

local traffic. Groups 02 and 08 follow in importance, with emission shares of 18 and 31% in 2022, respectively. Emissions from groups 03 and 09 make up a minor portion of the total, contributing with approximately 9 and 3% to total $NO_X$ emissions, respectively. The remaining groups combined represent only 0.17% of the emissions.

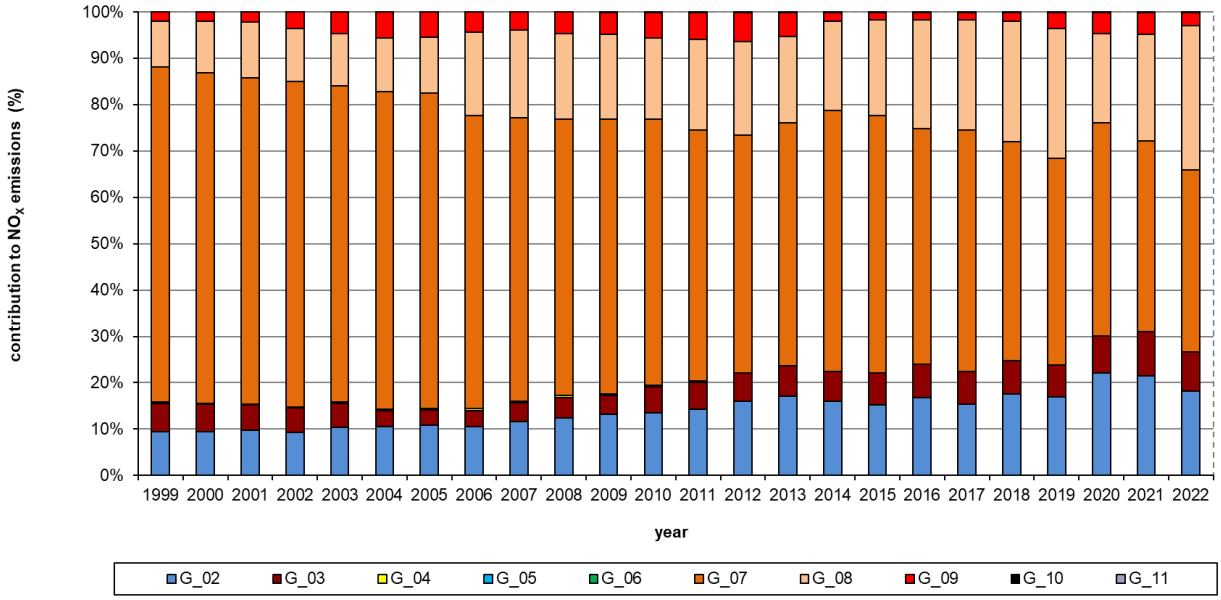


**Figure 7. $NO_X$ emissions breakdown by SNAP group (%)**

Figure 8 shows the relative change of $NO_X$ emissions for each SNAP group between 1999 and 2022. Except for group 11 and group 08, the emissions in 2022 are lower than in 1999 mainly due to a reduction in fuel consumption.

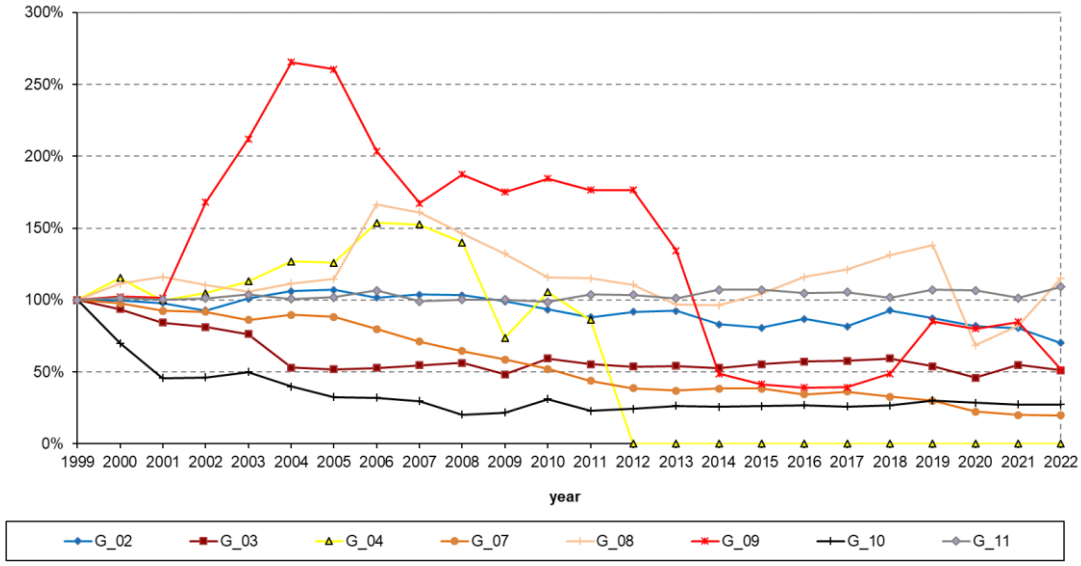


**Figure 8. Evolution of $NO_X$ emissions by SNAP group compared to 1999 (1999 = 100)**

The emissions of group 11 slightly change between 1999 and 2022. However, emissions from group 08 are highly influenced by the activity of the airports. Consequently, the increase of activity of this mode of transport since 2014 explains the increase of $NO_X$ emissions compared to those of 1999

(around 34%). However, in 2020 and 2021, during and after the COVID pandemic and due to the drastic drop in air traffic, the $NO_X$ emissions decreased approximately in a 25 and 15% from 1999, respectively.

Table 7 and Figure 9 show the evolution of $SO_2$ emissions from 1999 to 2022. A significant reduction in emissions over this period (88%) is observed, especially from groups 02 and 07, as a result of a lower sulphur content in liquid fuels and the decreasing use of fuels with high-sulphur content (coal and fuel oil).

**Table 7. $SO_2$ emissions by SNAP group (t)[1]**

| Year | G_02 | G_03 | G_04 | G_05 | G_06 | G_07 | G_08 | G_09 | G_10 | G_11 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1999** | 2 653 | 441 | 46 | 0 | 0 | 1 242 | 200 | 4 | 0 | 0 | **4 586** |
| **2000** | 2 353 | 380 | 53 | 0 | 0 | 827 | 224 | 12 | 0 | 0 | **3 848** |
| **2001** | 2 034 | 284 | 46 | 0 | 0 | 614 | 237 | 6 | 0 | 0 | **3 221** |
| **2002** | 1 776 | 242 | 48 | 0 | 0 | 521 | 236 | 3 | 0 | 0 | **2 826** |
| **2003** | 1 691 | 210 | 52 | 0 | 0 | 520 | 243 | 3 | 0 | 0 | **2 720** |
| **2004** | 1 623 | 152 | 59 | 0 | 0 | 555 | 252 | 1 | 0 | 0 | **2 641** |
| **2005** | 1 577 | 149 | 58 | 0 | 0 | 97 | 260 | 1 | 0 | 0 | **2 142** |
| **2006** | 1 528 | 141 | 71 | 0 | 0 | 94 | 425 | 0 | 0 | 0 | **2 259** |
| **2007** | 1 451 | 121 | 70 | 0 | 0 | 87 | 413 | 0 | 0 | 0 | **2 144** |
| **2008** | 999 | 70 | 65 | 0 | 0 | 84 | 346 | 1 | 0 | 0 | **1 565** |
| **2009** | 929 | 66 | 34 | 0 | 0 | 16 | 316 | 1 | 0 | 0 | **1 362** |
| **2010** | 826 | 43 | 49 | 0 | 0 | 19 | 240 | 1 | 0 | 0 | **1 178** |
| **2011** | 780 | 34 | 40 | 0 | 0 | 16 | 239 | 1 | 0 | 0 | **1 110** |
| **2012** | 742 | 28 | 0 | 0 | 0 | 16 | 207 | 1 | 0 | 0 | **993** |
| **2013** | 702 | 24 | 0 | 0 | 0 | 15 | 186 | 1 | 0 | 0 | **928** |
| **2014** | 658 | 22 | 0 | 0 | 0 | 15 | 155 | 1 | 0 | 0 | **851** |
| **2015** | 622 | 21 | 0 | 0 | 0 | 16 | 167 | 1 | 0 | 0 | **828** |
| **2016** | 590 | 20 | 0 | 0 | 0 | 16 | 170 | 1 | 0 | 0 | **798** |
| **2017** | 553 | 18 | 0 | 0 | 0 | 16 | 179 | 1 | 0 | 0 | **767** |
| **2018** | 525 | 19 | 0 | 0 | 0 | 16 | 188 | 1 | 0 | 0 | **748** |
| **2019** | 493 | 21 | 0 | 0 | 0 | 15 | 197 | 3 | 0 | 0 | **728** |
| **2020** | 463 | 15 | 0 | 0 | 0 | 11 | 87 | 8 | 0 | 0 | **584** |
| **2021** | 531 | 25 | 0 | 0 | 0 | 12 | 116 | 1 | 0 | 0 | **685** |
| **2022** | 365 | 17 | 0 | 0 | 0 | 11 | 168 | 7 | 0 | 0 | **568** |

*1) G_02: Non-industrial combustion; G_03: Combustion in manufacturing industry; G_04: Production processes; G_05: Extraction and distribution of fossil fuels; G_06: Solvent and other product use; G_07: Road transport; G_08: Non-road transport; G_09: Waste treatment and disposal; G_10: Agriculture; G_11: Other sources and sinks (nature).*

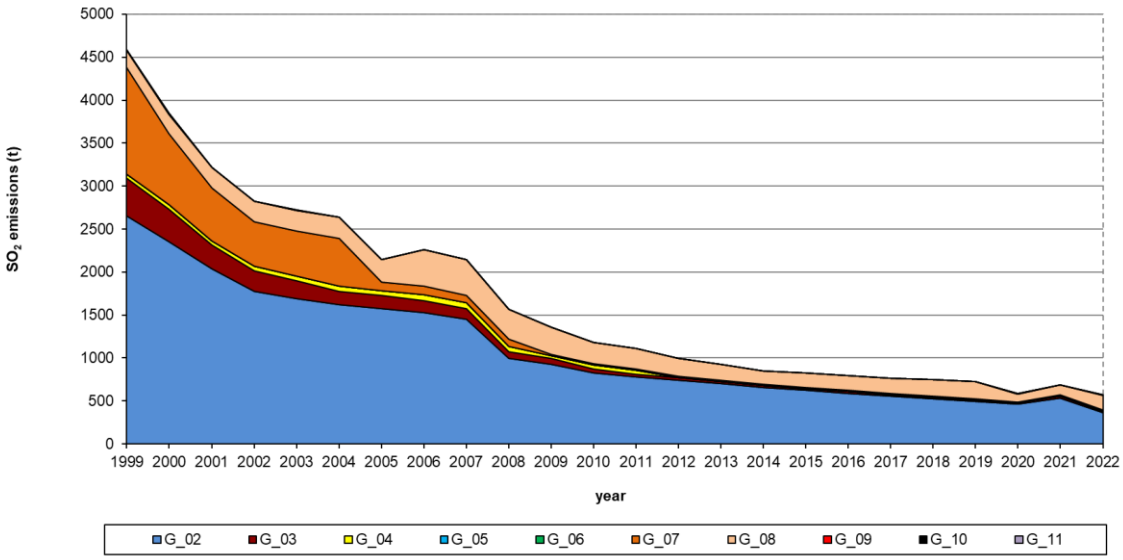


**Figure 9. $SO_2$ emissions trend by SNAP group (t)**

As for the contribution of each group to total $SO_2$ emissions, Figure 10 clearly reflects that group 02 is the main emitting sector, accounting for 64% of emissions in 2022. Over the earlier years of the inventoried period, group 07 had a relevant contribution to $SO_2$ emissions. However, the sharp decrease of sulphur content of automotive fuels explains the lower importance of this group from 2005 onwards. The decreasing emissions from the aforementioned groups along with the increased consumption of kerosene and gas-oil accounted for the higher contribution of group 08 since 2006.

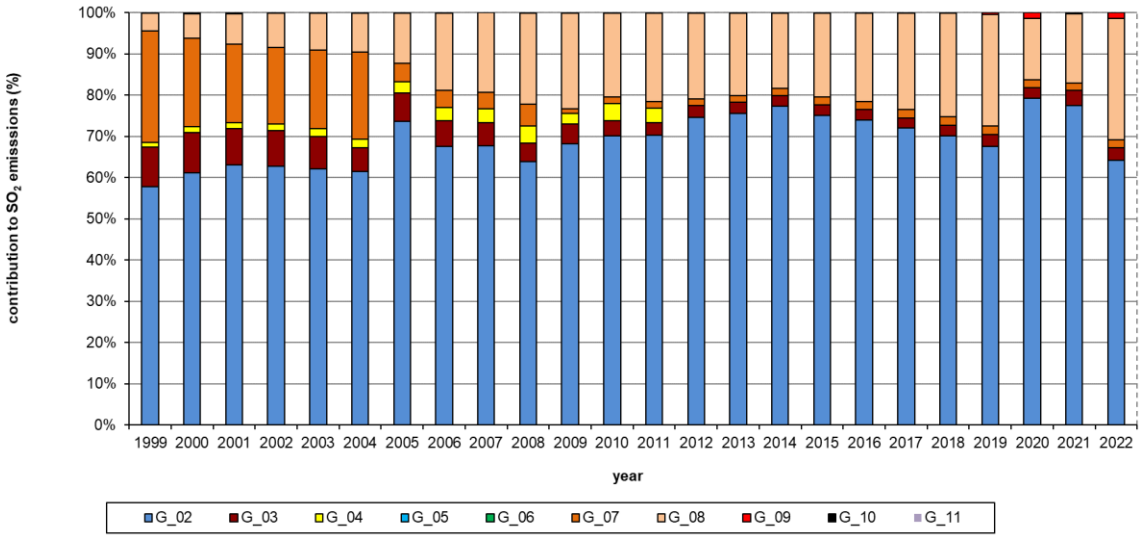


**Figure 10. $SO_2$ emissions breakdown by SNAP group (%)**

Table 8 and Figure 11 present the $NH_3$ emissions trend in Madrid city.

**Table 8. $NH_3$ emissions by SNAP group (t)[1]**

| Year | G_02 | G_03 | G_04 | G_05 | G_06 | G_07 | G_08 | G_09 | G_10 | G_11 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1999** | 1 | 0 | 0 | 0 | 6 | 412 | 0.1 | 568 | 47 | 144 | **1 177** |
| **2000** | 1 | 0 | 0 | 0 | 6 | 420 | 0.1 | 742 | 44 | 144 | **1 357** |
| **2001** | 0 | 0 | 0 | 0 | 6 | 394 | 0.1 | 895 | 38 | 148 | **1 482** |
| **2002** | 0 | 0 | 0 | 0 | 6 | 426 | 0.1 | 875 | 38 | 151 | **1 496** |
| **2003** | 0 | 0 | 0 | 0 | 6 | 371 | 0.1 | 1 221 | 40 | 155 | **1 793** |
| **2004** | 0 | 0 | 0 | 0 | 6 | 360 | 0.1 | 1 181 | 34 | 155 | **1 737** |
| **2005** | 0 | 0 | 0 | 0 | 6 | 322 | 0.1 | 1 181 | 29 | 158 | **1 697** |
| **2006** | 0 | 0 | 0 | 0 | 6 | 270 | 0.5 | 1 438 | 30 | 156 | **1 902** |
| **2007** | 1 | 0 | 0 | 0 | 6 | 222 | 0.4 | 1 344 | 28 | 157 | **1 758** |
| **2008** | 1 | 0 | 0 | 0 | 6 | 204 | 0.3 | 1 337 | 24 | 161 | **1 733** |
| **2009** | 1 | 0 | 0 | 0 | 5 | 191 | 0.3 | 1 227 | 26 | 163 | **1 613** |
| **2010** | 2 | 0 | 0 | 0 | 4 | 204 | 0.2 | 1 259 | 29 | 164 | **1 662** |
| **2011** | 2 | 0 | 0 | 0 | 4 | 185 | 0.2 | 1 205 | 25 | 163 | **1 584** |
| **2012** | 2 | 0 | 0 | 0 | 4 | 173 | 0.2 | 657 | 26 | 162 | **1 024** |
| **2013** | 2 | 0 | 0 | 0 | 5 | 166 | 0.2 | 415 | 27 | 160 | **775** |
| **2014** | 2 | 0 | 0 | 0 | 5 | 167 | 0.2 | 334 | 26 | 158 | **693** |
| **2015** | 2 | 0 | 0 | 0 | 6 | 172 | 0.2 | 288 | 27 | 157 | **653** |
| **2016** | 2 | 0 | 0 | 0 | 6 | 158 | 0.3 | 333 | 27 | 158 | **685** |
| **2017** | 2 | 0 | 0 | 0 | 10 | 158 | 0.3 | 366 | 27 | 159 | **723** |
| **2018** | 2 | 0 | 0 | 0 | 10 | 162 | 0.4 | 431 | 31 | 161 | **799** |
| **2019** | 3 | 0 | 0 | 0 | 8 | 164 | 0.3 | 414 | 33 | 163 | **785** |
| **2020** | 3 | 0 | 0 | 0 | 10 | 121 | 0.3 | 365 | 32 | 167 | **698** |
| **2021** | 3 | 0 | 0 | 0 | 11 | 161 | 0.3 | 367 | 32 | 165 | **739** |
| **2022** | 3 | 0 | 0 | 0 | 8 | 161 | 0.3 | 328 | 32 | 164 | **696** |

*1) G_02: Non-industrial combustion; G_03: Combustion in manufacturing industry; G_04: Production processes; G_05: Extraction and distribution of fossil fuels; G_06: Solvent and other product use; G_07: Road transport; G_08: Non-road transport; G_09: Waste treatment and disposal; G_10: Agriculture; G_11: Other sources and sinks (nature).*

In 2022, total emissions of ammonia are 41% lower than in 1999. From 1999 to 2011, the $NH_3$ emissions rose by 39%, mainly due to the increase of $NH_3$ emissions related to domestic waste composting. However, in 2012, part of the municipal waste formerly composted is treated by biomethanization, resulting in a sharp decrease of emissions. In 2016 returns composting activity in one of the plants. Despite the aforementioned, Figure 12 shows that group 09 is still the most important for this pollutant, accounting for 47% of emissions in 2022. Groups 07 and 11 contribute with 22 and 23% of emissions in 2022, respectively.

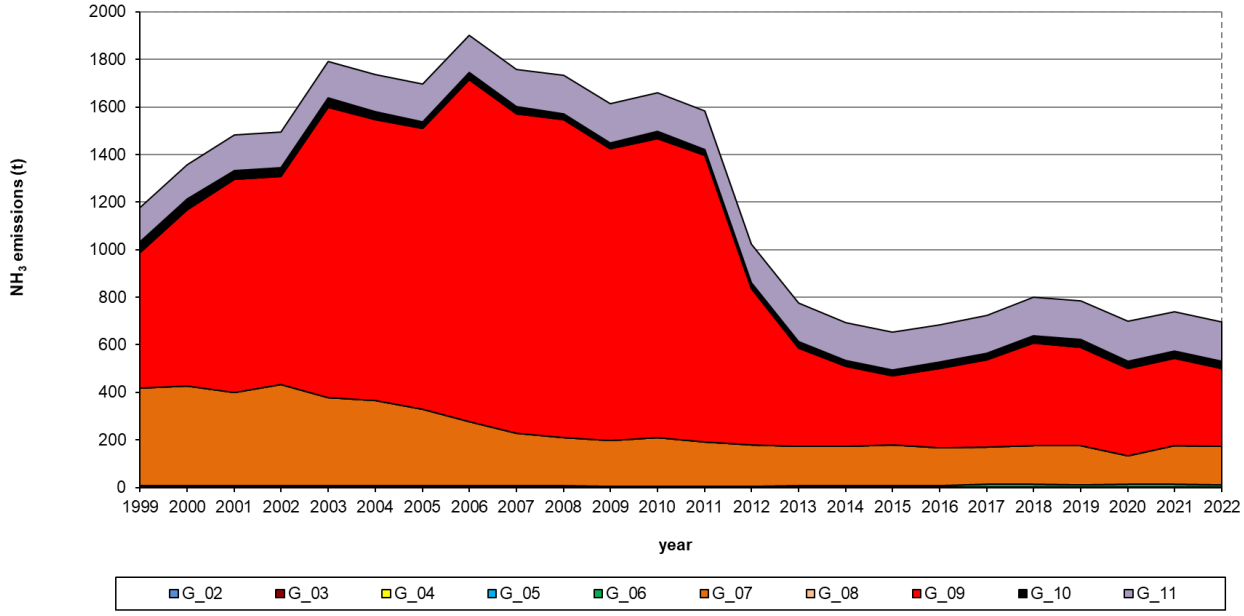


**Figure 11. $NH_3$ emissions trend by SNAP group (t)**

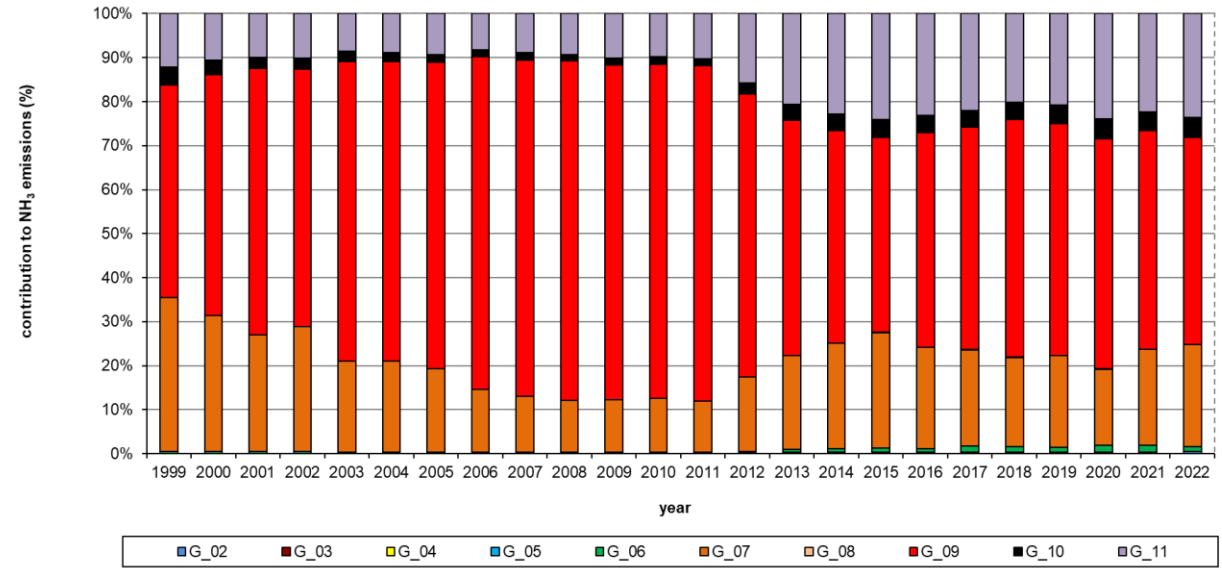


**Figure 12. $NH_3$ emissions breakdown by SNAP group (%)**

### 2.2.3 Ozone precursors

This section includes the emissions of NMVOC and CO. Although $NO_X$ are important precursors of tropospheric ozone, their emissions were presented in the previous section (acidifying gases).

Table 9 and Figure 13 show the NMVOC emissions trend. From 1999 to 2022, total emissions decreased by 69%. Especially relevant is the reduction of emissions from group 07, close to 96%. This mainly has to do with the increasing implementation of measures to reduce NMVOC emissions at vehicles themselves (on-board canisters in gasoline vehicles).

**Table 9. NMVOC emissions by SNAP group (t)[1]**

| Year | G_02 | G_03 | G_04 | G_05 | G_06 | G_07 | G_08 | G_09 | G_10 | G_11 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1999** | 885 | 140 | 225 | 1 429 | 24 606 | 21 585 | 166 | 7 | 30 | 2 390 | **51 463** |
| **2000** | 861 | 133 | 226 | 1 196 | 25 387 | 17 772 | 179 | 13 | 25 | 2 350 | **48 142** |
| **2001** | 829 | 121 | 208 | 1 096 | 23 619 | 15 148 | 186 | 12 | 20 | 2 418 | **43 656** |
| **2002** | 766 | 110 | 208 | 996 | 23 537 | 10 688 | 183 | 18 | 20 | 2 147 | **38 673** |
| **2003** | 816 | 106 | 222 | 852 | 22 798 | 9 033 | 185 | 93 | 22 | 2 445 | **36 572** |
| **2004** | 849 | 85 | 233 | 695 | 22 461 | 7 301 | 187 | 139 | 18 | 2 283 | **34 251** |
| **2005** | 856 | 79 | 240 | 575 | 21 362 | 5 789 | 188 | 151 | 17 | 2 402 | **31 659** |
| **2006** | 817 | 80 | 256 | 490 | 20 369 | 4 492 | 352 | 140 | 15 | 2 433 | **29 444** |
| **2007** | 826 | 81 | 246 | 451 | 20 050 | 3 559 | 312 | 105 | 12 | 2 241 | **27 883** |
| **2008** | 813 | 94 | 243 | 439 | 18 212 | 2 915 | 265 | 125 | 11 | 2 253 | **25 369** |
| **2009** | 789 | 78 | 230 | 436 | 16 057 | 2 641 | 229 | 119 | 13 | 2 673 | **23 265** |
| **2010** | 764 | 225 | 249 | 431 | 14 950 | 3 011 | 180 | 120 | 14 | 2 368 | **22 313** |
| **2011** | 732 | 205 | 230 | 415 | 14 101 | 2 644 | 179 | 114 | 12 | 2 530 | **21 161** |
| **2012** | 759 | 207 | 204 | 410 | 12 907 | 2 068 | 177 | 123 | 13 | 2 477 | **19 345** |
| **2013** | 765 | 199 | 211 | 392 | 12 355 | 1 925 | 150 | 98 | 14 | 2 412 | **18 522** |
| **2014** | 705 | 193 | 219 | 385 | 12 148 | 1 859 | 144 | 7 | 14 | 2 634 | **18 307** |
| **2015** | 685 | 219 | 228 | 375 | 12 383 | 1 713 | 155 | 6 | 14 | 2 632 | **18 411** |
| **2016** | 718 | 213 | 236 | 391 | 12 336 | 1 522 | 176 | 6 | 15 | 2 563 | **18 175** |
| **2017** | 681 | 207 | 243 | 395 | 12 327 | 1 474 | 190 | 6 | 14 | 2 590 | **18 128** |
| **2018** | 747 | 212 | 246 | 435 | 12 555 | 1 393 | 208 | 7 | 15 | 2 473 | **18 291** |
| **2019** | 712 | 194 | 237 | 445 | 12 587 | 1 320 | 205 | 12 | 17 | 2 580 | **18 309** |
| **2020** | 679 | 168 | 213 | 318 | 10 422 | 1 143 | 125 | 10 | 16 | 2 587 | **15 680** |
| **2021** | 657 | 203 | 225 | 334 | 11 037 | 1 047 | 146 | 12 | 15 | 2 453 | **16 129** |
| **2022** | 572 | 177 | 233 | 451 | 10 565 | 963 | 177 | 8 | 15 | 2 700 | **15 860** |

*1) G_02: Non-industrial combustion; G_03: Combustion in manufacturing industry; G_04: Production processes; G_05: Extraction and distribution of fossil fuels; G_06: Solvent and other product use; G_07: Road transport; G_08: Non-road transport; G_09: Waste treatment and disposal; G_10: Agriculture; G_11: Other sources and sinks (nature).*

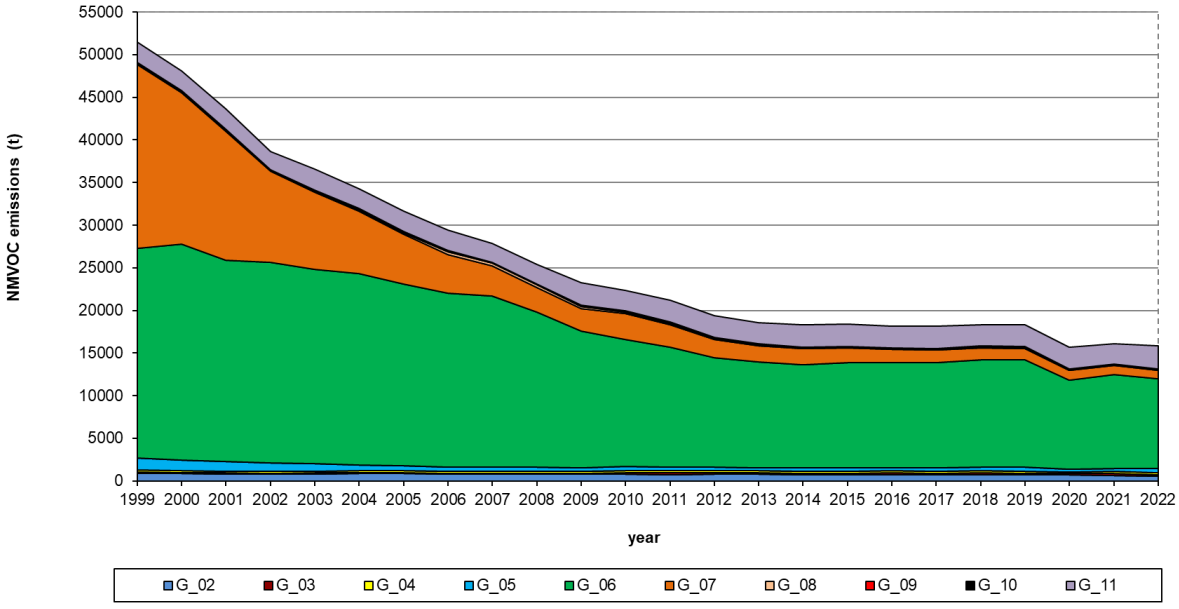


**Figure 13. NMVOC emissions trend by SNAP group (t)**

A breakdown of NMVOC emissions by group is shown in Figure 14. The most important contributor is group 06. In 2022, the share of this group was as high as 67%, even though emissions in this sector have been reduced by 57% from 1999. Groups 07 and 11 accounted for 6 and 17% of emissions, respectively. The rest of groups present a less significant contribution.

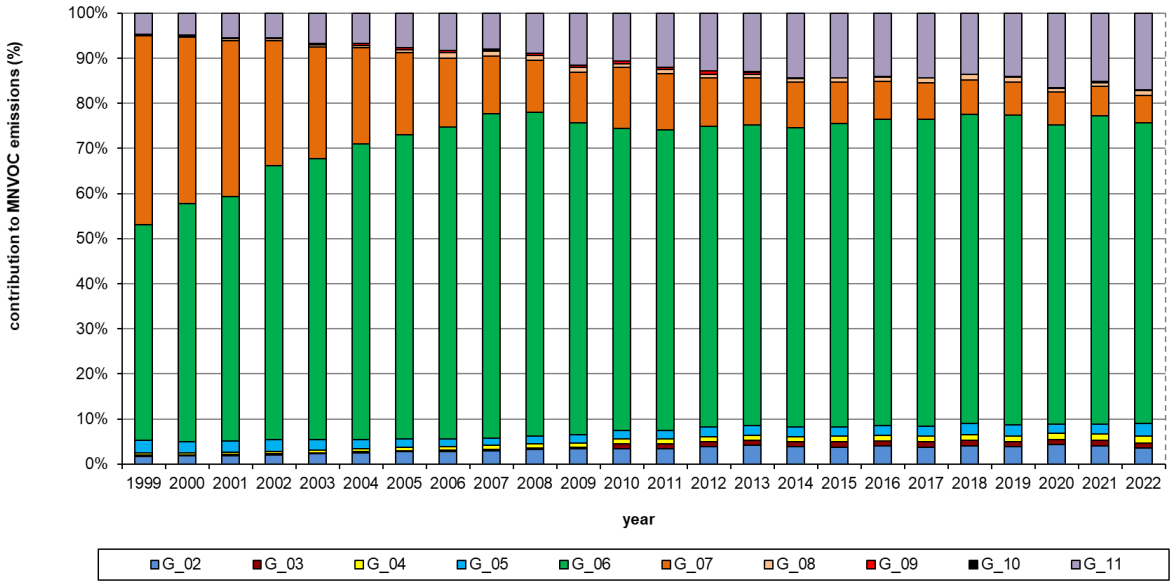


**Figure 14. NMVOC emissions breakdown by SNAP group (%)**

Regarding CO, Table 10 and Figure 15 show a sharp decrease of emissions from 1999 to 2022 (94%). According to Figure 16, most of the emissions were generated by group 07 in the early years of the period. However, the relevant reduction of emissions from “Road transport” over the last years increased the share of other activity groups in the last years, such as 02 and 08. Such a relevant reduction is mainly due to the progressive turnover of the fleet (engine technologies Euro V-VI produce much lower CO emissions per kilometre than older technologies) and the replacement of gasoline vehicles with diesel vehicles.

**Table 10. CO emissions by SNAP group (t)[1]**

| Year | G_02 | G_03 | G_04 | G_05 | G_06 | G_07 | G_08 | G_09 | G_10 | G_11 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1999** | 4 236 | 337 | 3 549 | 0 | 0 | 102 126 | 2 658 | 52 | 45.6 | 4.2 | **113 008** |
| **2000** | 3 975 | 351 | 4 095 | 0 | 0 | 84 773 | 2 749 | 85 | 14.1 | 12.3 | **96 054** |
| **2001** | 3 594 | 344 | 3 538 | 0 | 0 | 69 306 | 2 711 | 67 | 4.3 | 10.6 | **79 576** |
| **2002** | 3 160 | 318 | 3 714 | 0 | 0 | 60 025 | 2 583 | 64 | 5.2 | 9.9 | **69 880** |
| **2003** | 3 116 | 312 | 4 011 | 0 | 0 | 46 671 | 2 465 | 529 | 4.1 | 10.2 | **57 119** |
| **2004** | 3 097 | 280 | 4 503 | 0 | 0 | 40 003 | 2 517 | 961 | 0.5 | 9.2 | **51 372** |
| **2005** | 3 020 | 250 | 4 470 | 0 | 0 | 31 007 | 2 534 | 986 | 0.5 | 4.8 | **42 273** |
| **2006** | 2 901 | 258 | 5 458 | 0 | 0 | 23 634 | 3 015 | 943 | 0.6 | 6.7 | **36 217** |
| **2007** | 2 835 | 265 | 5 413 | 0 | 0 | 18 931 | 3 005 | 761 | 0.5 | 2.8 | **31 214** |
| **2008** | 2 692 | 353 | 4 968 | 0 | 0 | 15 578 | 2 765 | 835 | 0.5 | 2.1 | **27 194** |
| **2009** | 2 535 | 295 | 2 618 | 0 | 0 | 13 284 | 2 524 | 808 | 0.3 | 2.0 | **22 066** |
| **2010** | 2 338 | 1 088 | 3 745 | 0 | 0 | 8 806 | 2 347 | 897 | 0.4 | 0.6 | **19 222** |
| **2011** | 2 229 | 991 | 3 058 | 0 | 0 | 7 004 | 2 355 | 914 | 0.4 | 2.4 | **16 554** |
| **2012** | 2 227 | 1 011 | 0 | 0 | 0 | 7 182 | 2 093 | 760 | 0.4 | 9.4 | **13 282** |
| **2013** | 2 186 | 955 | 0 | 0 | 0 | 6 951 | 1 844 | 734 | 0.5 | 7.1 | **12 678** |
| **2014** | 2 021 | 923 | 0 | 0 | 0 | 6 777 | 1 857 | 256 | 0.3 | 2.3 | **11 837** |
| **2015** | 1 933 | 1 058 | 0 | 0 | 0 | 6 157 | 2 013 | 275 | 0.3 | 3.4 | **11 440** |
| **2016** | 1 963 | 1 018 | 0 | 0 | 0 | 5 054 | 2 124 | 247 | 0.3 | 2.5 | **10 409** |
| **2017** | 1 840 | 993 | 0 | 0 | 0 | 5 061 | 2 213 | 246 | 0.2 | 1.6 | **10 356** |
| **2018** | 1 963 | 1 007 | 0 | 0 | 0 | 4 869 | 2 341 | 232 | 0.3 | 0.6 | **10 413** |
| **2019** | 1 853 | 928 | 0 | 0 | 0 | 4 804 | 2 449 | 272 | 0.4 | 10.6 | **10 316** |
| **2020** | 1 752 | 788 | 0 | 0 | 0 | 3 531 | 1 226 | 266 | 0.4 | 7.8 | **7 572** |
| **2021** | 1 652 | 963 | 0 | 0 | 0 | 2 481 | 1 590 | 280 | 0.3 | 2.7 | **6 969** |
| **2022** | 1 342 | 816 | 0 | 0 | 0 | 2 888 | 2 007 | 219 | 0.3 | 2.7 | **7 276** |

*1) G_02: Non-industrial combustion; G_03: Combustion in manufacturing industry; G_04: Production processes; G_05: Extraction and distribution of fossil fuels; G_06: Solvent and other product use; G_07: Road transport; G_08: Non-road transport; G_09: Waste treatment and disposal; G_10: Agriculture; G_11: Other sources and sinks (nature).*

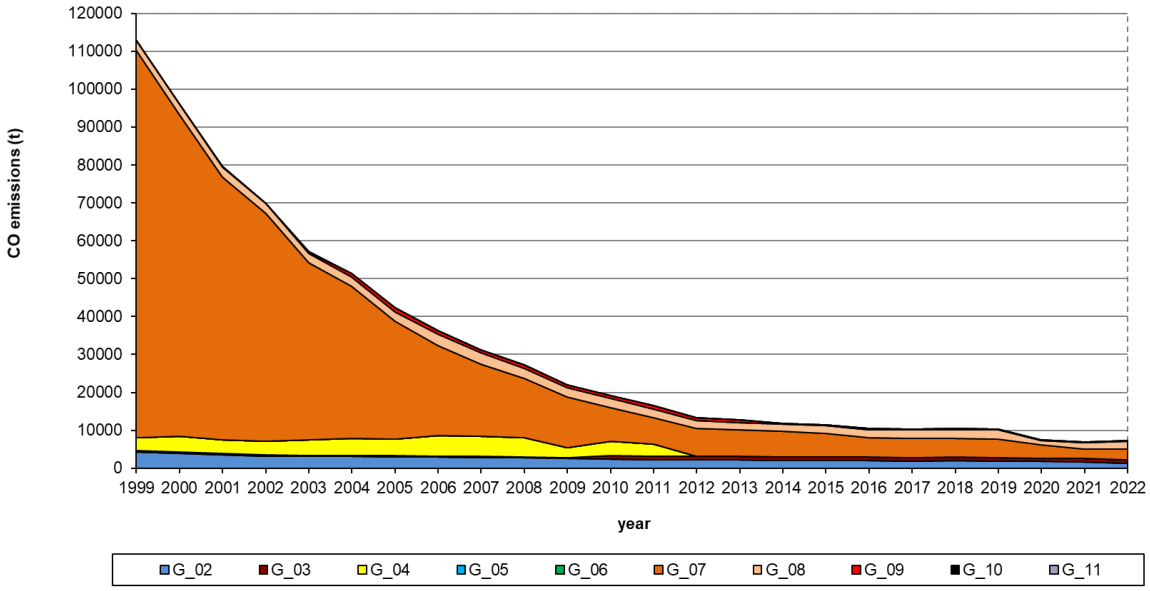


**Figure 15. CO emissions trend by SNAP group (t)**

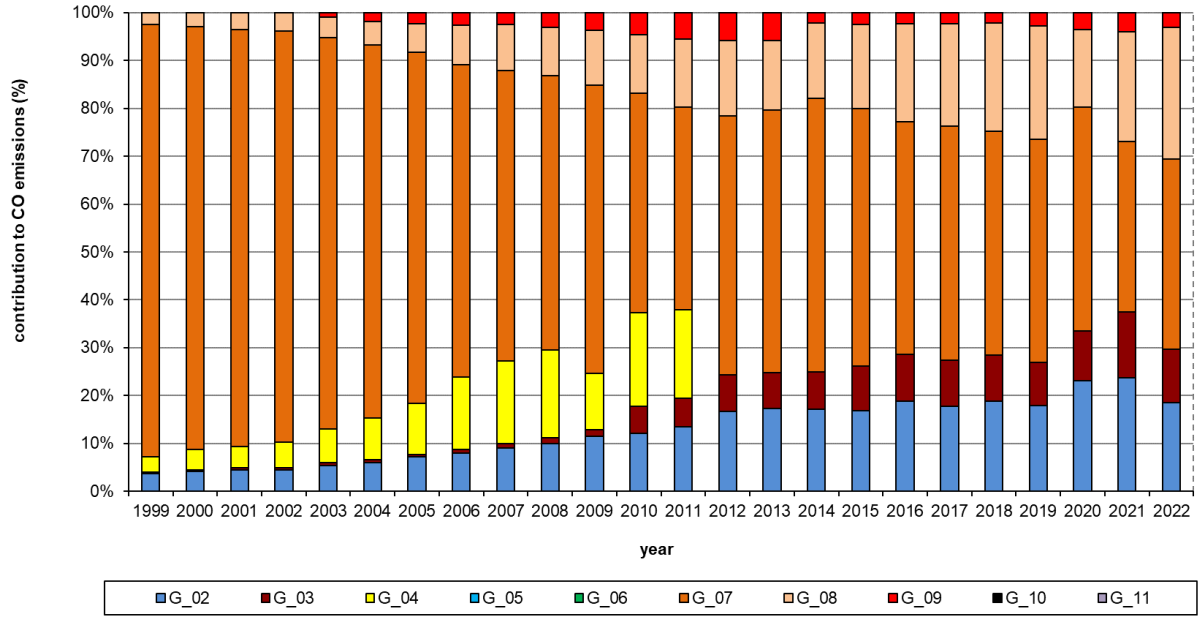


**Figure 16. CO emissions breakdown by SNAP group (%)**

### 2.2.4 Particulate matter

Table 11 to Table 13 and Figure 17 to Figure 19 show the $PM_{2.5}$, $PM_{10}$ and TPM emissions.

Total emissions of particulate matter have decreased from 1999 to 2022 by 75, 71 and 67% for $PM_{2.5}$, $PM_{10}$ and TPM, respectively. It can be seen that groups 07 and 02 presented the largest contribution to total emissions.

**Table 11. $PM_{2.5}$ emissions by SNAP group (t)[1]**

| Year | G_02 | G_03 | G_04 | G_05 | G_06 | G_07 | G_08 | G_09 | G_10 | G_11 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1999** | 602 | 60 | 8.1 | 0 | 0 | 1 343 | 49 | 26 | 4.5 | 0.4 | **2 093** |
| **2000** | 539 | 54 | 9.3 | 0 | 0 | 1 320 | 52 | 33 | 1.9 | 1.1 | **2 010** |
| **2001** | 469 | 47 | 8.1 | 0 | 0 | 1 255 | 52 | 11 | 1.1 | 0.9 | **1 844** |
| **2002** | 411 | 44 | 8.5 | 0 | 0 | 1 242 | 51 | 10 | 1.2 | 0.9 | **1 769** |
| **2003** | 395 | 39 | 9.2 | 0 | 0 | 1 181 | 49 | 20 | 1.2 | 0.9 | **1 696** |
| **2004** | 381 | 24 | 10.3 | 0 | 0 | 1 199 | 50 | 41 | 0.8 | 0.8 | **1 706** |
| **2005** | 371 | 23 | 10.2 | 0 | 0 | 1 147 | 49 | 33 | 0.7 | 0.4 | **1 633** |
| **2006** | 360 | 26 | 12.2 | 0 | 0 | 1 057 | 148 | 25 | 0.7 | 0.6 | **1 630** |
| **2007** | 348 | 25 | 12.3 | 0 | 0 | 951 | 116 | 25 | 0.7 | 0.2 | **1 477** |
| **2008** | 327 | 18 | 11.3 | 0 | 0 | 883 | 91 | 22 | 0.7 | 0.2 | **1 353** |
| **2009** | 315 | 16 | 6.4 | 0 | 0 | 817 | 73 | 20 | 0.7 | 0.2 | **1 248** |
| **2010** | 302 | 12 | 8.7 | 0 | 0 | 705 | 44 | 20 | 0.7 | 0.1 | **1 093** |
| **2011** | 293 | 9 | 7.2 | 0 | 0 | 596 | 44 | 21 | 0.7 | 0.2 | **972** |
| **2012** | 286 | 7 | 0.6 | 0 | 0 | 540 | 51 | 15 | 0.7 | 0.8 | **902** |
| **2013** | 278 | 5 | 0.5 | 0 | 0 | 519 | 41 | 25 | 0.7 | 0.6 | **869** |
| **2014** | 266 | 5 | 0.6 | 0 | 0 | 512 | 35 | 23 | 0.7 | 0.2 | **842** |
| **2015** | 255 | 5 | 0.5 | 0 | 0 | 506 | 38 | 25 | 0.7 | 0.3 | **831** |
| **2016** | 249 | 5 | 0.6 | 0 | 0 | 458 | 50 | 22 | 0.7 | 0.2 | **786** |
| **2017** | 237 | 5 | 0.4 | 0 | 0 | 462 | 57 | 22 | 0.7 | 0.1 | **785** |
| **2018** | 237 | 5 | 0.4 | 0 | 0 | 431 | 64 | 21 | 0.7 | 0.1 | **759** |
| **2019** | 229 | 6 | 0.4 | 0 | 0 | 409 | 61 | 25 | 0.7 | 0.9 | **732** |
| **2020** | 222 | 5 | 0.4 | 0 | 0 | 303 | 46 | 24 | 0.7 | 0.7 | **601** |
| **2021** | 200 | 8 | 0.5 | 0 | 0 | 281 | 50 | 25 | 0.7 | 0.2 | **566** |
| **2022** | 163 | 6 | 0.5 | 0 | 0 | 270 | 53 | 20 | 0.7 | 0.2 | **513** |

*1) G_02: Non-industrial combustion; G_03: Combustion in manufacturing industry; G_04: Production processes; G_05: Extraction and distribution of fossil fuels; G_06: Solvent and other product use; G_07: Road transport; G_08: Non-road transport; G_09: Waste treatment and disposal; G_10: Agriculture; G_11: Other sources and sinks (nature).*

**Table 12. $PM_{10}$ emissions by SNAP group (t)[1]**

| Year | G_02 | G_03 | G_04 | G_05 | G_06 | G_07 | G_08 | G_09 | G_10 | G_11 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1999** | 627 | 63 | 15 | 0 | 0 | 1 574 | 49 | 26 | 8.3 | 0.4 | **2 363** |
| **2000** | 562 | 58 | 16 | 0 | 0 | 1 554 | 52 | 33 | 5.5 | 1.3 | **2 281** |
| **2001** | 490 | 50 | 15 | 0 | 0 | 1 493 | 52 | 11 | 4.6 | 1.1 | **2 116** |
| **2002** | 428 | 47 | 15 | 0 | 0 | 1 495 | 51 | 10 | 4.7 | 1.0 | **2 051** |
| **2003** | 411 | 41 | 16 | 0 | 0 | 1 431 | 50 | 20 | 4.9 | 1.1 | **1 974** |
| **2004** | 397 | 24 | 18 | 0 | 0 | 1 458 | 50 | 41 | 4.3 | 1.0 | **1 992** |
| **2005** | 385 | 23 | 16 | 0 | 0 | 1 408 | 49 | 33 | 4.2 | 0.5 | **1 919** |
| **2006** | 374 | 26 | 18 | 0 | 0 | 1 311 | 149 | 25 | 4.1 | 0.7 | **1 909** |
| **2007** | 361 | 25 | 21 | 0 | 0 | 1 192 | 116 | 25 | 4.2 | 0.3 | **1 745** |
| **2008** | 339 | 18 | 19 | 0 | 0 | 1 116 | 91 | 22 | 4.2 | 0.2 | **1 611** |
| **2009** | 325 | 16 | 14 | 0 | 0 | 1 042 | 73 | 20 | 4.1 | 0.2 | **1 495** |
| **2010** | 310 | 12 | 15 | 0 | 0 | 934 | 44 | 21 | 4.1 | 0.1 | **1 341** |
| **2011** | 301 | 9 | 13 | 0 | 0 | 818 | 44 | 21 | 4.1 | 0.3 | **1 211** |
| **2012** | 294 | 7 | 4 | 0 | 0 | 752 | 52 | 15 | 4.1 | 1.0 | **1 129** |
| **2013** | 285 | 5 | 4 | 0 | 0 | 721 | 41 | 25 | 4.1 | 0.7 | **1 085** |
| **2014** | 273 | 5 | 5 | 0 | 0 | 714 | 36 | 23 | 4.1 | 0.2 | **1 058** |
| **2015** | 262 | 5 | 4 | 0 | 0 | 719 | 38 | 25 | 4.1 | 0.4 | **1 057** |
| **2016** | 255 | 5 | 6 | 0 | 0 | 671 | 50 | 23 | 4.1 | 0.3 | **1 014** |
| **2017** | 243 | 5 | 3 | 0 | 0 | 677 | 57 | 23 | 4.1 | 0.2 | **1 011** |
| **2018** | 242 | 5 | 3 | 0 | 0 | 642 | 65 | 21 | 4.1 | 0.1 | **982** |
| **2019** | 233 | 6 | 4 | 0 | 0 | 617 | 61 | 26 | 4.1 | 1.1 | **952** |
| **2020** | 226 | 5 | 4 | 0 | 0 | 457 | 46 | 25 | 4.1 | 0.8 | **767** |
| **2021** | 210 | 8 | 4 | 0 | 0 | 451 | 50 | 25 | 4.1 | 0.3 | **752** |
| **2022** | 170 | 6 | 3 | 0 | 0 | 425 | 53 | 20 | 4.1 | 0.3 | **681** |

*1) G_02: Non-industrial combustion; G_03: Combustion in manufacturing industry; G_04: Production processes; G_05: Extraction and distribution of fossil fuels; G_06: Solvent and other product use; G_07: Road transport; G_08: Non-road transport; G_09: Waste treatment and disposal; G_10: Agriculture; G_11: Other sources and sinks (nature).*

**Table 13. TPM emissions by SNAP group (t)[1]**

| Year | G_02 | G_03 | G_04 | G_05 | G_06 | G_07 | G_08 | G_09 | G_10 | G_11 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1999** | 647 | 71 | 50 | 0 | 0 | 1 811 | 50 | 26 | 13 | 0.7 | **2 668** |
| **2000** | 580 | 64 | 52 | 0 | 0 | 1 797 | 53 | 33 | 10 | 2.0 | **2 591** |
| **2001** | 506 | 55 | 48 | 0 | 0 | 1 740 | 53 | 11 | 8 | 1.7 | **2 422** |
| **2002** | 442 | 52 | 49 | 0 | 0 | 1 756 | 52 | 10 | 8 | 1.6 | **2 370** |
| **2003** | 423 | 45 | 49 | 0 | 0 | 1 688 | 51 | 20 | 9 | 1.7 | **2 286** |
| **2004** | 408 | 24 | 54 | 0 | 0 | 1 725 | 51 | 41 | 8 | 1.5 | **2 313** |
| **2005** | 397 | 23 | 44 | 0 | 0 | 1 680 | 50 | 33 | 7 | 0.8 | **2 234** |
| **2006** | 385 | 26 | 45 | 0 | 0 | 1 574 | 149 | 26 | 7 | 1.1 | **2 212** |
| **2007** | 371 | 25 | 65 | 0 | 0 | 1 439 | 117 | 25 | 7 | 0.5 | **2 048** |
| **2008** | 348 | 18 | 60 | 0 | 0 | 1 355 | 92 | 22 | 6 | 0.3 | **1 902** |
| **2009** | 334 | 16 | 50 | 0 | 0 | 1 274 | 74 | 20 | 6 | 0.3 | **1 775** |
| **2010** | 318 | 12 | 44 | 0 | 0 | 1 161 | 45 | 21 | 7 | 0.1 | **1 609** |
| **2011** | 308 | 9 | 43 | 0 | 0 | 1 035 | 45 | 21 | 6 | 0.4 | **1 469** |
| **2012** | 301 | 7 | 21 | 0 | 0 | 962 | 52 | 16 | 6 | 1.5 | **1 367** |
| **2013** | 292 | 5 | 19 | 0 | 0 | 922 | 41 | 25 | 7 | 1.2 | **1 312** |
| **2014** | 279 | 5 | 26 | 0 | 0 | 916 | 36 | 23 | 6 | 0.4 | **1 292** |
| **2015** | 268 | 5 | 20 | 0 | 0 | 937 | 39 | 25 | 7 | 0.6 | **1 301** |
| **2016** | 261 | 5 | 35 | 0 | 0 | 890 | 51 | 23 | 7 | 0.4 | **1 272** |
| **2017** | 249 | 5 | 18 | 0 | 0 | 899 | 57 | 23 | 7 | 0.3 | **1 257** |
| **2018** | 247 | 5 | 20 | 0 | 0 | 860 | 65 | 21 | 7 | 0.1 | **1 225** |
| **2019** | 239 | 6 | 22 | 0 | 0 | 836 | 61 | 26 | 7 | 1.7 | **1 198** |
| **2020** | 231 | 5 | 22 | 0 | 0 | 619 | 46 | 25 | 7 | 1.3 | **955** |
| **2021** | 214 | 8 | 20 | 0 | 0 | 630 | 50 | 25 | 7 | 0.4 | **955** |
| **2022** | 173 | 6 | 14 | 0 | 0 | 599 | 53 | 20 | 7 | 0.4 | **873** |

*1) G_02: Non-industrial combustion; G_03: Combustion in manufacturing industry; G_04: Production processes; G_05: Extraction and distribution of fossil fuels; G_06: Solvent and other product use; G_07: Road transport; G_08: Non-road transport; G_09: Waste treatment and disposal; G_10: Agriculture; G_11: Other sources and sinks (nature).*

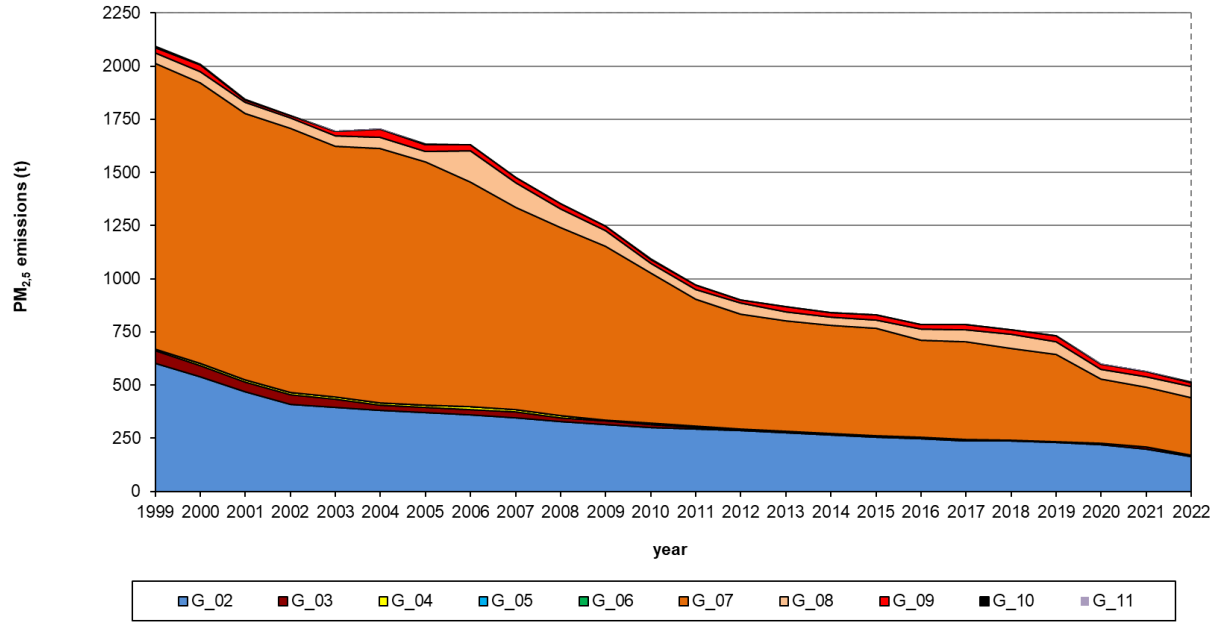


**Figure 17. $PM_{2.5}$ emissions trend by SNAP group (t)**

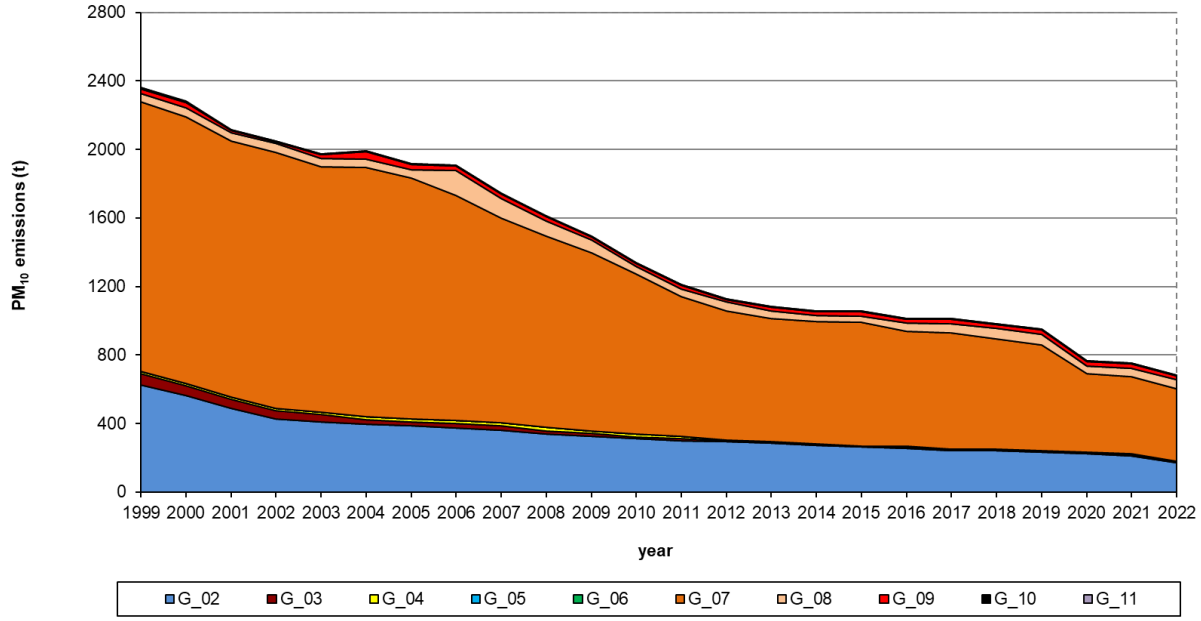


**Figure 18. $PM_{10}$ emissions trend by SNAP group (t)**

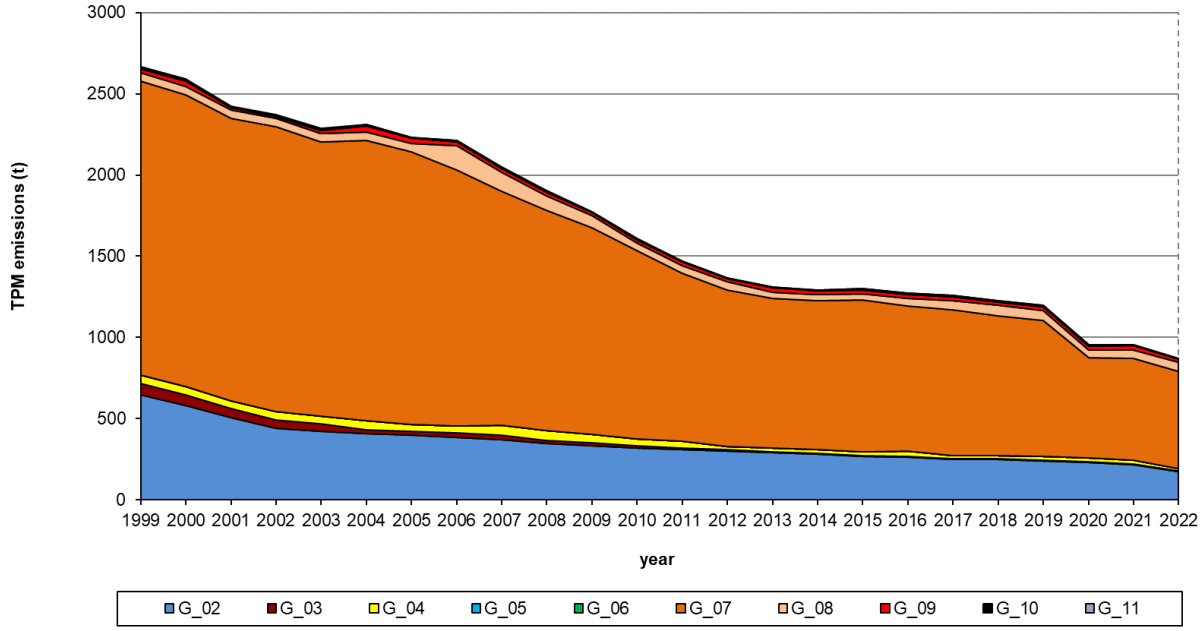


**Figure 19. TPM emissions trend by SNAP group (t)**

Because of its higher impact on human health, the following analysis will be focused on $PM_{2.5}$ emissions. Figure 20 shows the relative contribution of each activity group to $PM_{2.5}$ emissions in Madrid. “Road transport” is the most emitting sector, accounting for 53% of total emissions in 2022. It can be seen that the $PM_{2.5}$ emissions of group 02 represent 32% of total emissions in 2022, even though its emissions decreased since 1999. As for the rest of groups, only SNAP 08 presented a contribution of 10% in 2022, the others being virtually irrelevant.

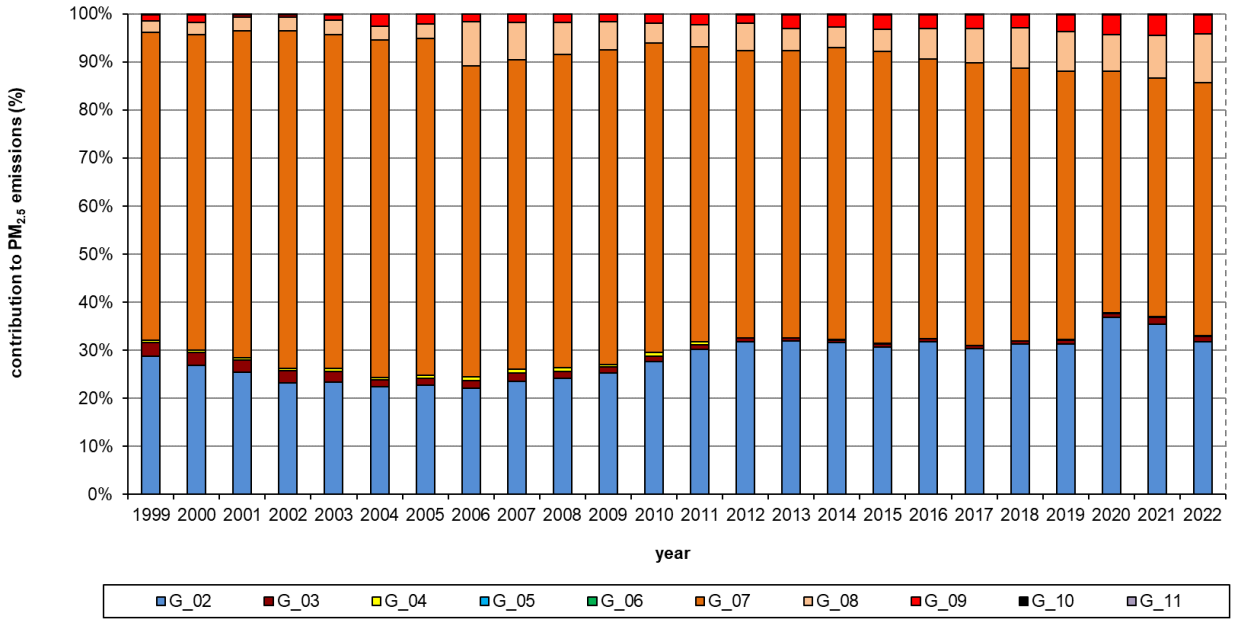


**Figure 20. $PM_{2.5}$ emissions breakdown by SNAP group (%)**

# APPENDIX I. Emissions of Black Carbon (BC)

Table A1 shows the BC emissions by SNAP group. BC has been estimated as a fraction of the $PM_{2.5}$ emissions for each of the emitting activities, according to the reference guidelines currently available for the preparation of emission inventories (EMEP / EEA).

**Table A1. BC emissions by SNAP group (t)[1]**

| Year | G_02 | G_03 | G_04 | G_05 | G_06 | G_07 | G_08 | G_09 | G_10 | G_11 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1999** | 175 | 33 | 0.04 | 0 | 0 | 870 | 26 | 1.04 | 0.341 | 0.032 | **1 105** |
| **2000** | 149 | 30 | 0.04 | 0 | 0 | 850 | 28 | 1.40 | 0.106 | 0.095 | **1 058** |
| **2001** | 127 | 26 | 0.04 | 0 | 0 | 799 | 28 | 0.45 | 0.032 | 0.082 | **980** |
| **2002** | 115 | 24 | 0.04 | 0 | 0 | 795 | 28 | 0.35 | 0.039 | 0.077 | **962** |
| **2003** | 112 | 21 | 0.04 | 0 | 0 | 749 | 28 | 0.67 | 0.031 | 0.079 | **911** |
| **2004** | 107 | 13 | 0.04 | 0 | 0 | 757 | 28 | 0.79 | 0.004 | 0.072 | **905** |
| **2005** | 106 | 12 | 0.04 | 0 | 0 | 718 | 28 | 0.49 | 0.004 | 0.037 | **865** |
| **2006** | 103 | 14 | 0.05 | 0 | 0 | 656 | 90 | 0.23 | 0.004 | 0.052 | **863** |
| **2007** | 99 | 13 | 0.05 | 0 | 0 | 584 | 71 | 0.22 | 0.003 | 0.022 | **768** |
| **2008** | 95 | 9 | 0.05 | 0 | 0 | 539 | 56 | 0.16 | 0.003 | 0.016 | **700** |
| **2009** | 94 | 9 | 0.03 | 0 | 0 | 493 | 45 | 0.10 | 0.002 | 0.015 | **641** |
| **2010** | 93 | 6 | 0.04 | 0 | 0 | 405 | 27 | 0.08 | 0.003 | 0.005 | **531** |
| **2011** | 90 | 5 | 0.03 | 0 | 0 | 325 | 27 | 0.06 | 0.003 | 0.019 | **446** |
| **2012** | 86 | 4 | 0.00 | 0 | 0 | 290 | 31 | 0.06 | 0.003 | 0.073 | **412** |
| **2013** | 83 | 2 | 0.00 | 0 | 0 | 280 | 25 | 0.04 | 0.004 | 0.055 | **390** |
| **2014** | 80 | 2 | 0.01 | 0 | 0 | 275 | 21 | 0.02 | 0.002 | 0.018 | **378** |
| **2015** | 78 | 2 | 0.00 | 0 | 0 | 261 | 23 | 0.02 | 0.002 | 0.027 | **364** |
| **2016** | 76 | 2 | 0.01 | 0 | 0 | 221 | 30 | 0.02 | 0.002 | 0.020 | **329** |
| **2017** | 73 | 2 | 0.00 | 0 | 0 | 223 | 34 | 0.02 | 0.002 | 0.012 | **333** |
| **2018** | 72 | 2 | 0.01 | 0 | 0 | 198 | 39 | 0.02 | 0.002 | 0.005 | **311** |
| **2019** | 70 | 3 | 0.01 | 0 | 0 | 182 | 37 | 0.10 | 0.003 | 0.083 | **292** |
| **2020** | 68 | 2 | 0.01 | 0 | 0 | 135 | 28 | 0.08 | 0.003 | 0.060 | **233** |
| **2021** | 61 | 4 | 0.00 | 0 | 0 | 105 | 30 | 0.02 | 0.002 | 0.021 | **201** |
| **2022** | 51 | 3 | 0.00 | 0 | 0 | 105 | 32 | 0.03 | 0.002 | 0.021 | **190** |

*1) G_02: Non-industrial combustion; G_03: Combustion in manufacturing industry; G_04: Production processes; G_05: Extraction and distribution of fossil fuels; G_06: Solvent and other product use; G_07: Road transport; G_08: Non-road transport; G_09: Waste treatment and disposal; G_10: Agriculture; G_11: Other sources and sinks (nature).*

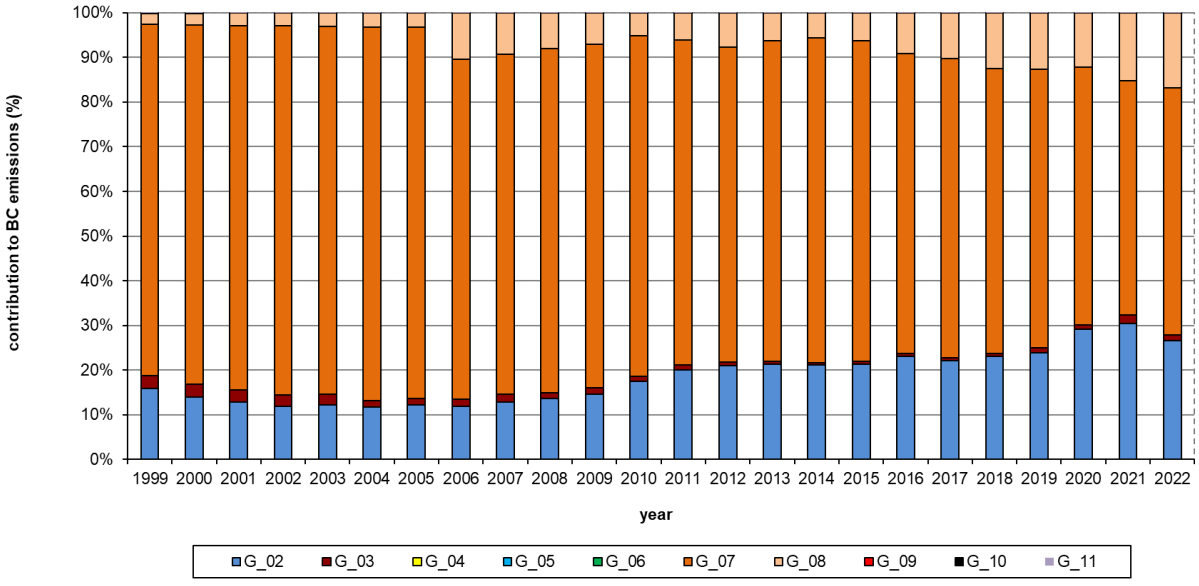


**Figure A1. BC emissions breakdown by SNAP group (%)**