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Reports

R-140

AUSTRIAN AIR EMISSION INVENTORY

1994

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Bundesministerium für Umwelt, Jugend und Familie

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PREFACE

This report presents the results of the Austrian 1994 air emission inventory carried out by the Federal Environment Agency - Austria. This inventory includes eight "classic" air pollutants (sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds, methane, carbon monoxide, carbon dioxide, nitrous oxide and ammonia), nine heavy metals (arsenic, cadmium, chromium, copper, mercury, nickel, lead, selenium and zinc) and two groups of persistent organic pollutants (dioxins and polycyclic aromatic hydrocarbons).

In the first part of the report the methodology of the inventory is explained. The second part presents an analysis of emission sources of individual air pollutants as well as results for selected environmental topics such as climate change/ greenhouse gases, acidification, and tropospheric ozone. Also a short description of the methodology applied for data collection is given.

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SUMMARY

For the year 1994 the following emissions of “classic“ air pollutants have been estimated for Austria by the Federal Environment Agency - Austria:

	emission in 1000 tonnes	
sulphur dioxide (SO_2)	54.9	
nitrogen oxides (NO_x)	171.1	
non-methane volatile organic compounds (NMVOC)	456.6	
methane (CH_4)	632.0	
carbon monoxide (CO)	1180.5	
nitrous oxide (N_2O)	13.5	
ammonia (NH_3)	86.8	
carbon dioxide (CO_2)	59.6	million tonnes

In addition emissions of the nine heavy metals

	emission in tonnes
arsenic (As)	3.3
cadmium (Cd)	2.7
chromium (Cr)	6.6
copper (Cu)	9.2
mercury (Hg)	2.2
nickel (Ni)	35.5
lead (Pb)	24.3
selenium (Se)	4.7
zinc (Zn)	208.4

and of the persistent organic pollutants (POPs)

	emission	
dioxins	28.7	g (I-TEQ)
polycyclic aromatic hydrocarbons (PAH)	457.6	tonnes

were estimated.

These results are presented with respect to selected environmental topics

- climate change / greenhouse gases
- acidification
- tropospheric ozone
- toxic organic air pollutants and heavy metals

The results of the Austrian 1994 air emission inventory can be summarised as follows:

- Emissions of greenhouse gases are dominated by the sectors *road transport*, *production processes* and *non-industrial combustion plants*.

- Emissions of acidifying substances are mainly produced by the sectors *road transport* and *agriculture and forestry*.

- The major part of PAH emissions is caused by combustion of fuelwood within the sector *non-industrial combustion plants* .

- Emissions of dioxins are mainly produced by the sectors *non-industrial combustion plants* and *production processes*.

- With regard to five heavy metals the sector *non-industrial combustion plants* is the main emission source.

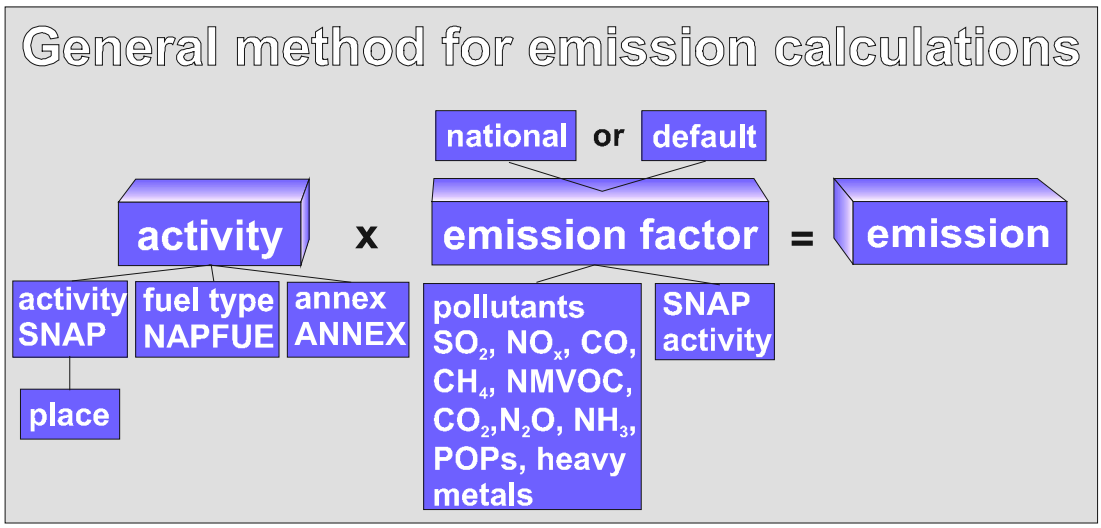
METHODOLOGY

The calculation of emissions was carried out in accordance with the CORINAIR methodology. CORINAIR is an air emission inventory for Europe initiated in 1985 by the European Council of Ministers as part of the CORINE (Coordination d'Information Environmentale) work programme. CORINAIR was then integrated into the work programme of the European Environment Agency and work is co-ordinated by the *European Topic Centre on Air Emissions*.

The objective of CORINAIR is to provide a complete, consistent and transparent emission inventory for Europe.

CORINAIR 94

The CORINAIR inventory is based on national statistical data as for example fuel consumption and production statistics. Moreover in emission calculations emission factors were applied which are specific for the sources according to the SNAP nomenclature[1]. Emission factors and activities (e.g. fuel consumption, production rates etc.) as well as resulting emission calculations are stored in a data base. For the CORINAIR inventory large emitters are registered as point sources. These include e.g. large thermal power plants and waste incineration plants. Adherence to the CORINAIR methodology guarantees increased transparency of the results as well as a standardised registration for all European states.



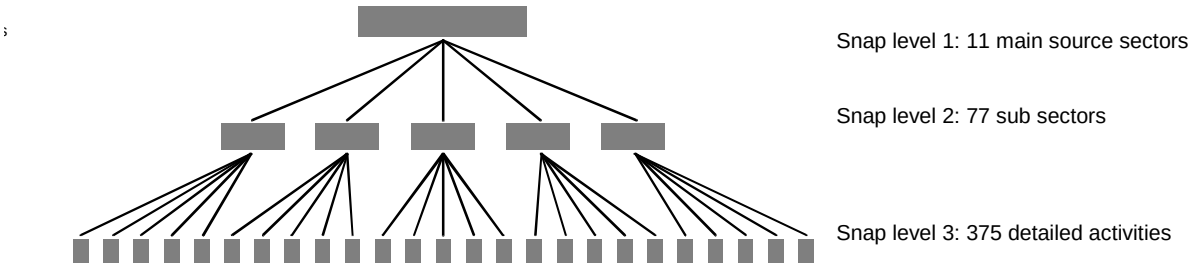
[1] Fontelle J. & Chang, J. (1997): European Topic Centre on Air Emissions. Recommendations for Revised Data System for Air Emission Inventories. Office for Official Publications of the European Communities, Luxemburg.

Classification of emission sources according to CORINAIR

CORINAIR distinguishes between emission sources using the so-called SNAP-code (Selected Nomenclature for Air Pollution). The approximately 400 different sources are grouped in 11 main source sectors (SNAP level 1):

1. *Non-industrial combustion plants*
2. *Combustion in manufacturing industry*
3. *Production processes*
4. *Extraction and distribution of fossil fuels*
5. *Solvent and other product use*
6. *Combustion in energy and transformation industries*
7. *Road transport*
8. *Other mobile sources and machinery*
9. *Waste treatment and disposal*
10. *Agriculture and forestry*
11. *Nature*

The 11 main source sectors are subdivided into 77 sub-sectors (SNAP level 2).
On the lowest level (SNAP level 3) 375 detailed activities of air emission sources are distinguished.



Basically, this report provides information about air pollutant emissions on SNAP level 1. In some cases, though, results are presented in more detail to allow for a more precise assessment of individual emission sources.

Air pollutants

SO_2	SO_2 and SO_3 as SO_2
NO_x	nitrogen oxides ($NO+NO_2$) as NO_2
NMVOC	non-methane volatile organic compounds (not including substances regulated by the Montreal Protocol**)**
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
N_2O	nitrous oxide
NH_3	ammonia
POP	persistent organic pollutants
PAH	sum of polycyclic aromatic hydrocarbons
DIOXIN	sum of polychlorinated dibenzodioxins and -furans as 2,3,7,8-TCDD-equivalents (I-TEQ)
HEAVY METALS	arsenic, cadmium, chromium, copper, mercury, nickel, lead, selenium and zinc

Geographic areas in CORINAIR

The CORINAIR system distinguishes geographic areas in accordance with NUTS[1] levels as defined by EUROSTAT. This report presents emission data on NUTS level 0, which means for the whole of Austria.

Point sources in Austria

In the Austrian 1994 air emission inventory use has been made of the information available at the Federal Environment Agency - Austria on the more than 50 steam boilers.

[1] NUTS: Nomenclature of Territorial Units for Statistics

Emissions of classic air pollutants

This chapter presents the emissions of gaseous air pollutants in Austria for the year 1994. For each pollutant a short description of its main emission sources is given.

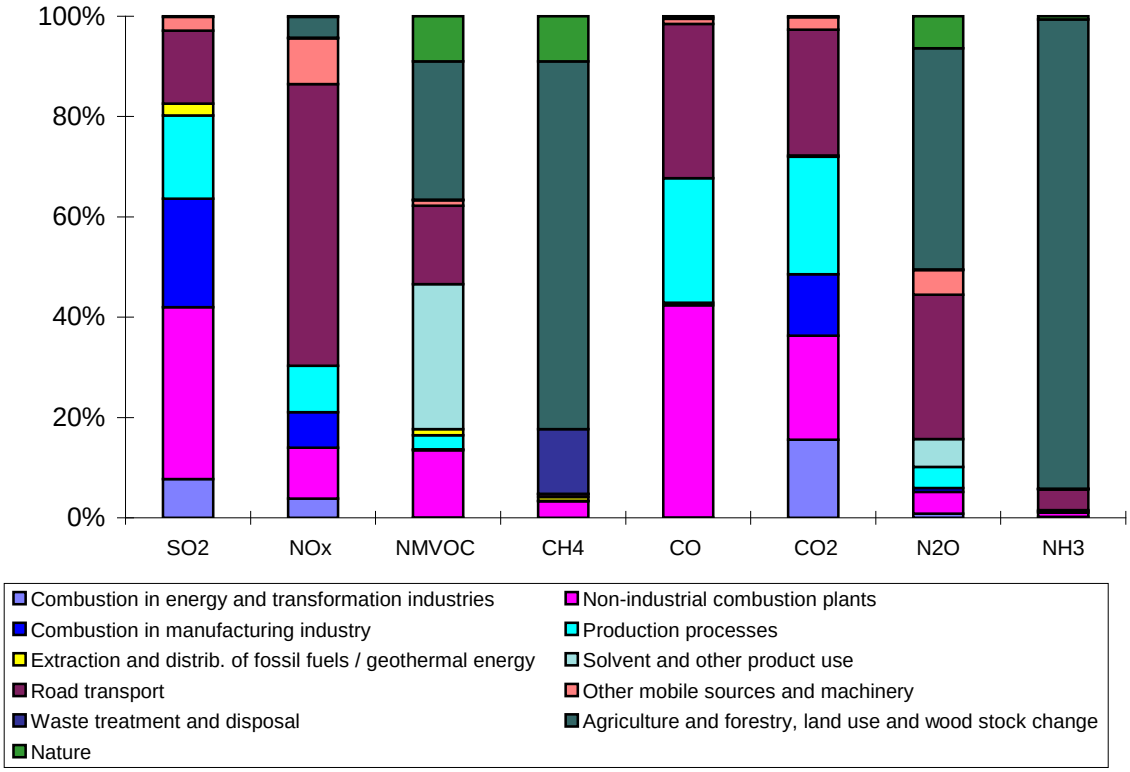
The following table gives a survey of the "classic air pollutants" (SO_2, NO_x, NMVOC, CH_4, CO, CO_2, N_2O, NH_3); their emissions have already been reported in CORINAIR 90. Emissions of the main source sectors are presented as well.

Main source sectors Emission in 1000 tonnes	SO_2	NO_x	NMVOC	CH_4	CO	CO_2 (mio. tonnes)	N_2O	NH_3
Combustion in energy and transformation industries	4.2	6.6	0.2	0.1	0.7	9.3	0.1	0.1
Non-industrial combustion plants	18.8	17.3	61.2	20.8	499.3	12.4	0.6	0.8
Combustion in manufacturing industry	11.9	12.1	1.1	0.5	6.5	7.3	0.1	0.2
Production processes	9.1	15.8	12.7	0.1	292.9	14.0	0.6	0.2
Extraction and distribution of fossil fuels	1.3	0.0	5.7	4.8	0.0	0.1	0.0	0.0
Solvent and other product use	0.0	0.0	131.8	0.0	0.0	0.0	0.8	0.0
Road transport	8.0	96.1	71.5	3.6	363.0	14.9	3.9	3.6
Other mobile sources and machinery	1.5	15.6	4.8	0.2	12.2	1.5	0.7	0.0
Waste treatment and disposal	0.1	0.2	0.7	81.5	4.5	0.1	0.2	0.1
Agriculture and forestry, LUWC[1]	0.0	7.0	125.9	463.4	1.5	(-15.5)*	6.0	81.2
Nature	0.0	0.3	41.0	57.1	0.0	0.0	0.9	0.5
Total **Emission in 1000 tonnes (CO_2 in mio. tonnes)**	**54.9**	**171.1**	**456.6**	**632.0**	**1180.5**	**59.6**	**13.5**	**86.8**

*... LUWC is not included in national emission calculations

[1] LUWC: Land Use and Wood stock Change

Relative contribution of the main source sectors to emissions of the "classic air pollutants" in Austria in 1994



Sulphur dioxide

In Austria in 1994 total SO_2 emission was 54900 tonnes. Of all sources, the sector *non-industrial combustion plants* emitted the largest amount of SO_2 , i.e. 18800 tonnes (33% of the total emissions). This sector comprises on the one hand commercial and institutional plants, on the other hand residential plants. Within the main source sector *non-industrial combustion plants* 2/3 of the SO_2 emissions are produced by residential plants.

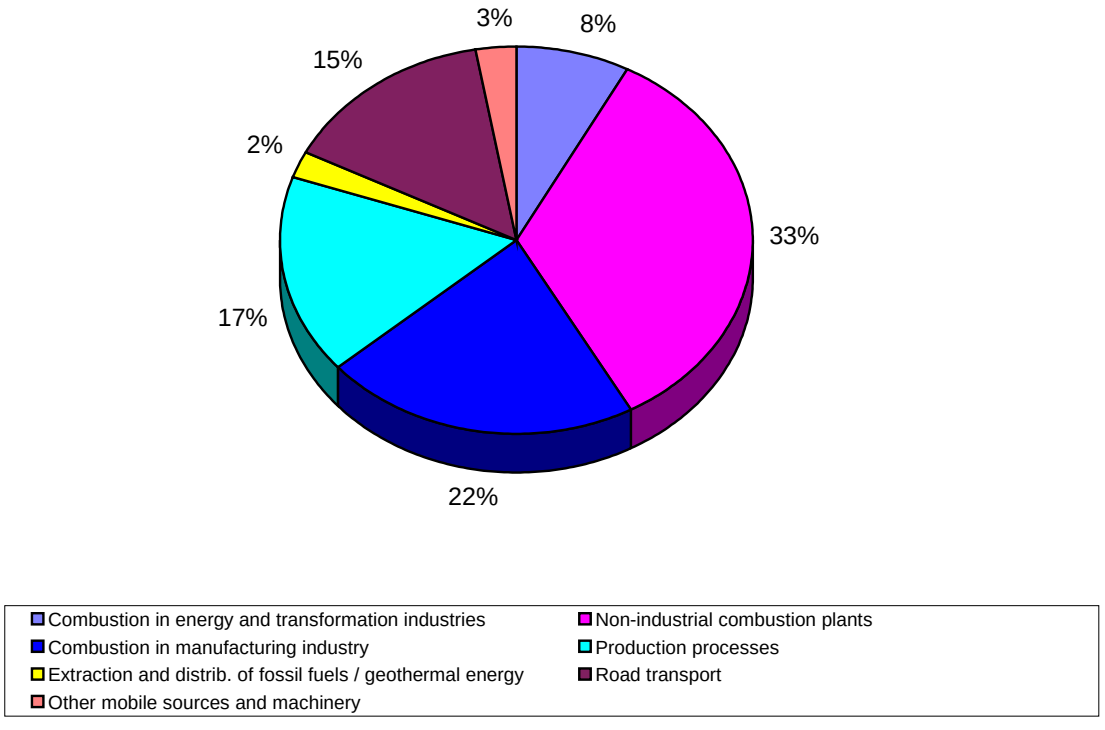
Combustion in manufacturing industry is the second most important main source sector producing 22% of the total emissions (11900 tonnes). *Production processes* cause 17% of the total SO_2 emissions.

Motor vehicles emit about 8000 tonnes of SO_2, of which nearly one half is produced by heavy duty vehicles. Passenger cars produce 3100 tonnes of SO_2 emissions, the share of diesel fuelled passenger cars amounting to 64% of these SO_2 emissions. The group of light duty vehicles emits 900 tonnes of SO_2, of which the greater part is again produced by diesel fuelled vehicles.

Relative contribution of the main source sectors to SO_2 emissions

in Austria in 1994

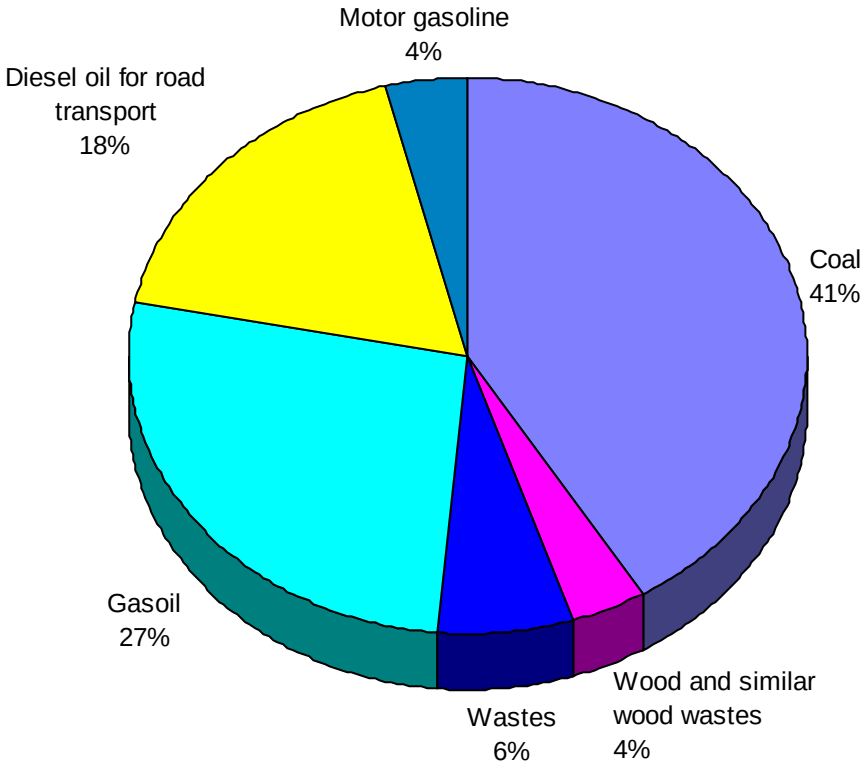
Total SO_2 emissions: 54900 tonnes



Of 54900 tonnes total SO_2 emissions 81% (44600 tonnes) are caused by the use of fuels. The following graph shows the relative share of individual fuel groups in this kind of SO_2 emission.

Relative contribution of individual fuels to fuel-related SO_2 emissions in Austria in 1994

Total SO_2 emissions from fuels: 44600 tonnes



Nitrogen oxides

In Austria nitrogen oxide emissions are clearly dominated by *road transport*. This main source sector produces 96150 tonnes of NO_x, which is 57% of the total emissions. Within the sector *road transport* heavy duty vehicles produce 53% of the NO_x emissions. The majority of the passenger cars is already equipped with catalytic converters, their emissions amounting to 10400 tonnes (11%). Passenger cars without catalytic converters, however, produce 20290 tonnes of nitrogen oxides (21% of the *road transport* emissions). Light duty vehicles emit 7620 tonnes of nitrogen oxides (about 8% of the *road transport* emissions).

The main source sector *other mobile sources and machinery* produces 15600 tonnes of NO_x emissions (9% of the total emissions). This sector includes aviation, navigation, machinery in agriculture etc.

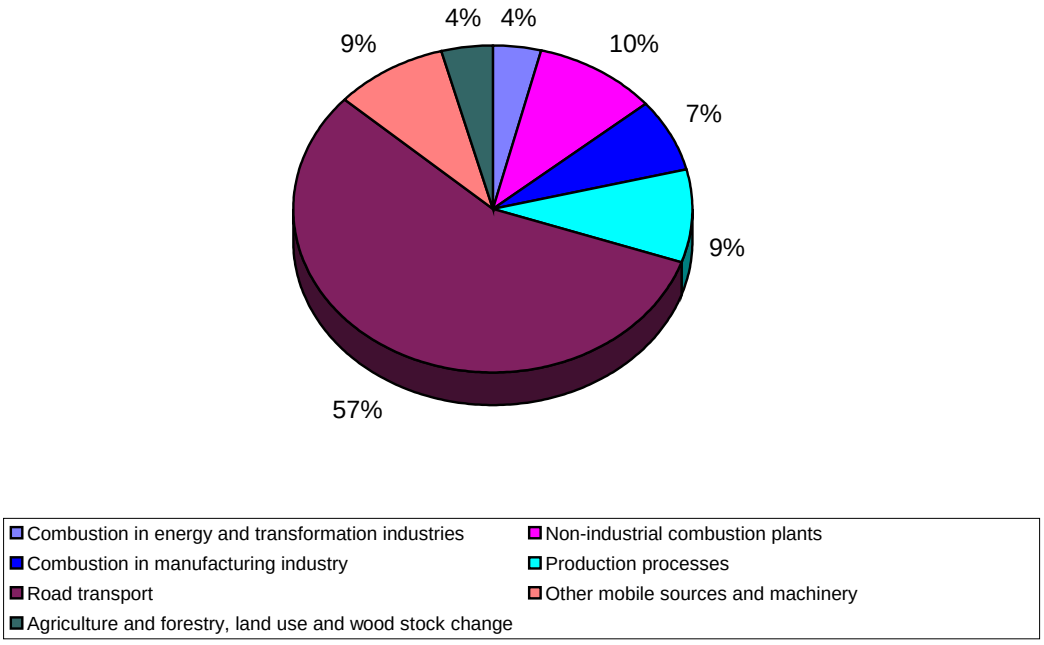
17300 tonnes of NO_x are emitted by the sector *non-industrial combustion plants*, which corresponds to about 10% of the total NO_x emissions. Also with regard to NO_x, this sector is dominated by emissions from residential plants, producing 74% of the NO_x emissions of this sector.

From *production processes* 15850 tonnes of NO_x (9% of the total emissions in Austria) are emitted.

The sector *combustion in manufacturing industry* causes 12100 tonnes of NO_x emissions.

Relative contribution of the main source sectors to NO_x emissions in in Austria in 1994

Total NO_x emissions: 171100 tonnes

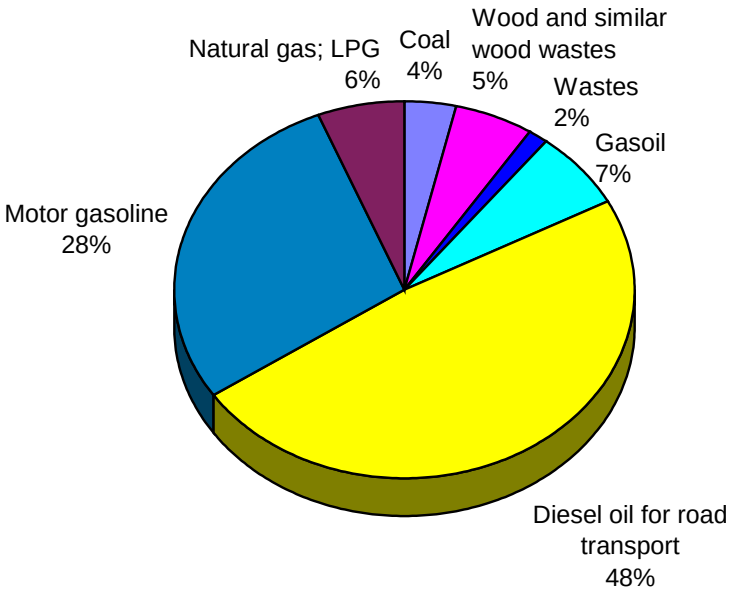


Of 171100 tonnes total NO_x emissions 90% (153600 tonnes) are caused by the use of fuels. The following graph shows the relative share of individual fuel groups in this kind of NO_x emission.

Relative contribution of individual fuels to fuel-related NO_x emissions

in Austria in 1994

Total NO_x emissions from fuels: 153600 tonnes



NMVOC

In 1994 in Austria the main source of emissions of non-methane volatile organic compounds was the sector *solvent use* with 132000 tonnes (28% of the total NMVOC emissions). Production statistics give detailed information about the composition of solvent emissions: the most important substance groups emitted are substances for textile treatment, pesticides, as well as aromatic hydrocarbons and all sorts of dilutions.

The sector *agriculture and forestry* emitted 126000 tonnes of NMVOC. Emissions mostly stem from managed forests[1]. Emission factors for differently used production areas in *agriculture and forestry* and for the sector *nature* are only rough estimates. Thus calculations are much more vague than for other sectors.

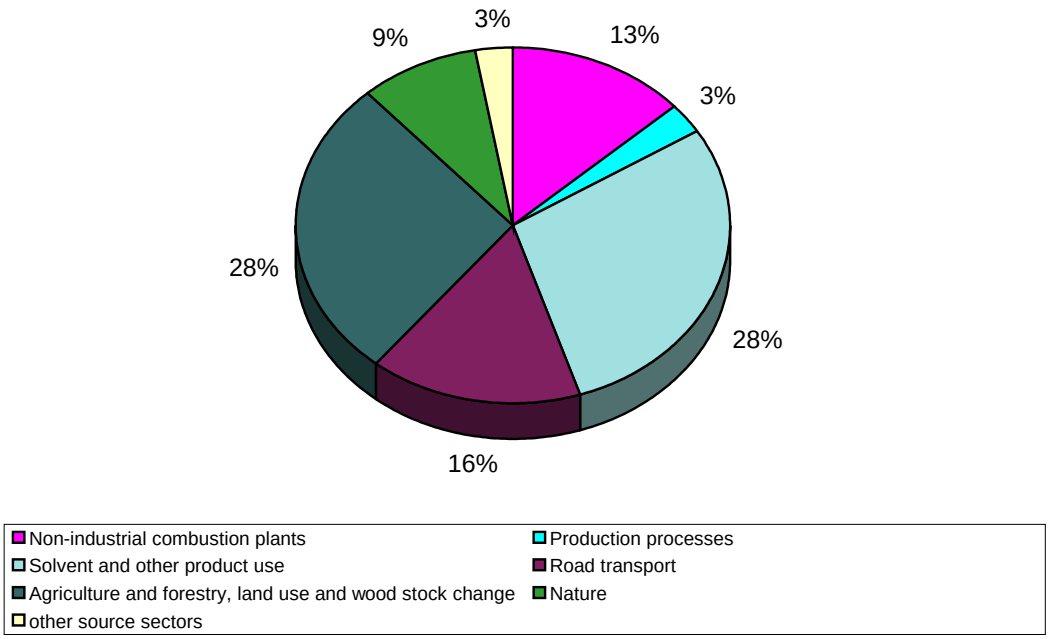
Another 71500 tonnes of NMVOC (16% of the total emissions) were emitted by *road transport*. In the first place gasoline evaporation from vehicles amounting to 27500 tonnes of NMVOC has to be mentioned. Passenger cars have a major share in NMVOC emissions from incomplete combustion of gasoline. As for NO_x NMVOC

[1] The share of managed forests (main source sector *agriculture and forestry*) in the total forest area was taken over from the Austrian Chamber of Agriculture.

emissions from passenger cars equipped with catalytic converters (9980 tonnes) are significantly smaller than those of passenger cars without catalytic converters (18840 tonnes). A considerable amount (10%) of the *road transport* emissions is caused by heavy duty vehicles, which emit 7300 tonnes of NMVOC.

Relative contribution of the main source sectors to NMVOC emissions in Austria in 1994

Total NMVOC emissions: 456600 tonnes

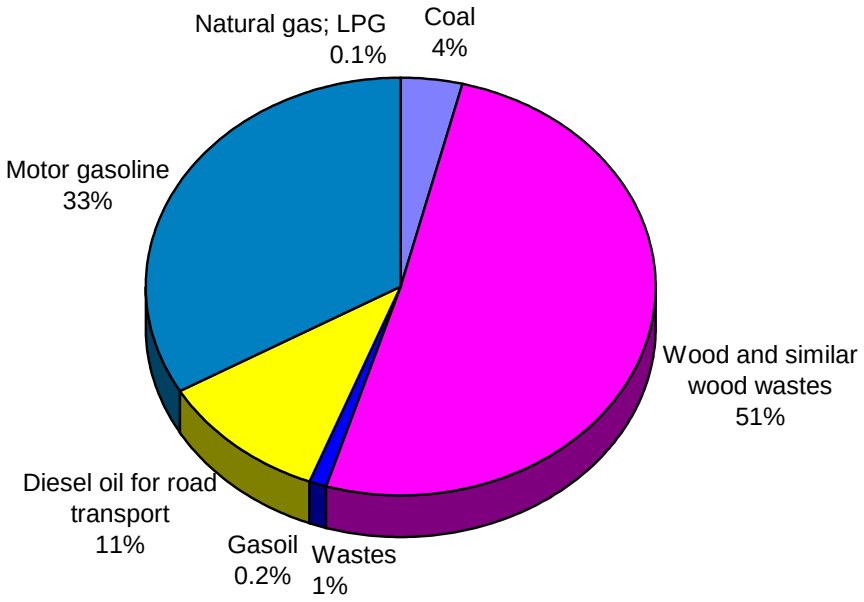


Of 456600 tonnes total NMVOC emissions 25% (111900 tonnes) are caused by the use of fuels. The following graph shows the relative share of individual fuel groups in this kind of NMVOC emission. Petrol evaporation (27500 tonnes) is not included.

Relative contribution of individual fuels to fuel-related NMVOC emissions

in Austria in 1994

Total NMVOC emissions from fuels: 111900 tonnes



Methane

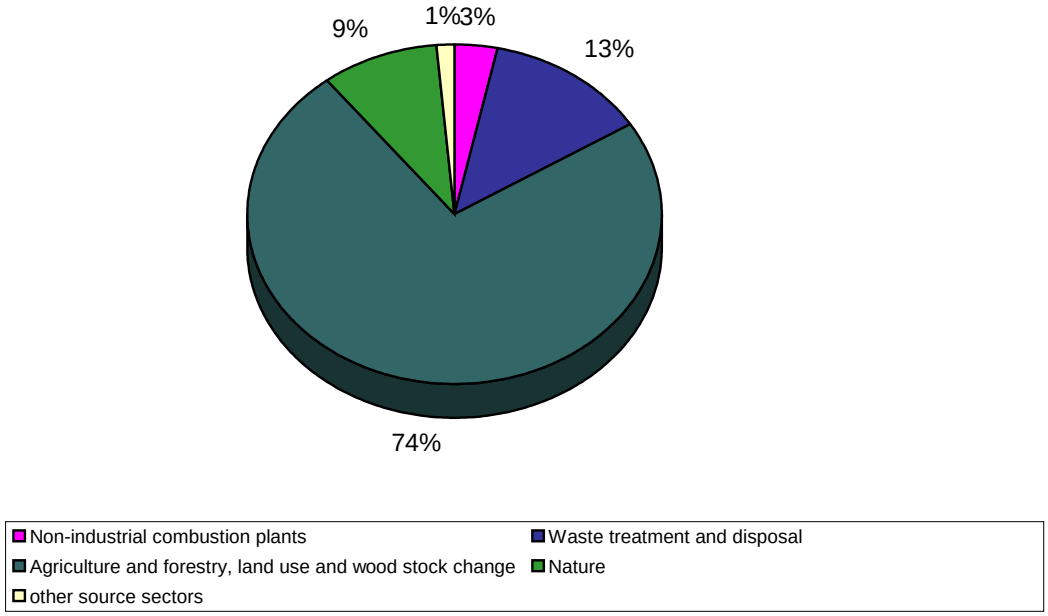
74% or 463400 tonnes of this climatically relevant air pollutant are emitted by the sector *agriculture and forestry*. The major part of emissions from this sector are produced by livestock-breeding and manure storage. Moreover, a considerable part of methane emissions from this sector stems from managed forests. Also with regard to this pollutant emissions from forest and agricultural soils are more vague than other emission data.

About 13% of the total methane-emissions (81500 tonnes) are caused by the sector *waste treatment and disposal*. Within this sector emissions mainly stem from landfills and from the application of sewage sludge.

Fuel-related sources are of minor importance with regard to the total methane emissions. Combustion processes (main source sectors 1 to 3) emit 21300 tonnes of methane of which 95% are produced by residential plants.

Relative contribution of the main source sectors to methane emissions in Austria in 1994

Total methane emissions: 632000 tonnes



Carbon monoxide

Regarding carbon monoxide emissions only three sectors are of importance. They produce 98% of the 1180500 tonnes total carbon monoxide emissions.

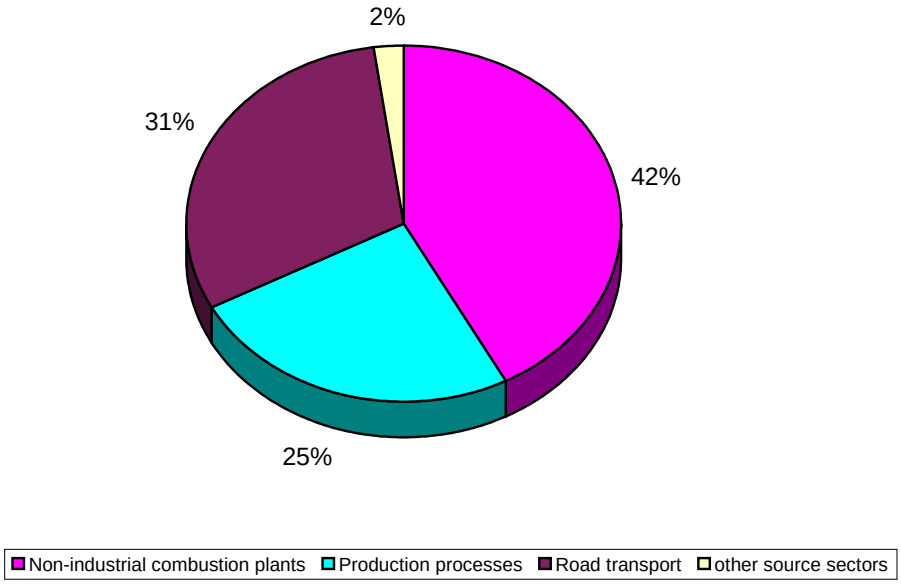
The sector *non-industrial combustion plants* emits 499300 tonnes of carbon monoxide (42% of the total emissions). The main emission sources within this sector are residential plants producing 425200 tonnes of CO, which is about 36% of the total emissions in Austria.

Road transport emits 31% (363000 tonnes) of the total carbon monoxide emissions. The major part (86%) of the emissions from *road transport* is caused by passenger cars. Passenger cars with catalytic converters emit 140900 tonnes, passenger cars without catalytic converters 164000 tonnes of carbon monoxide.

The third sector, which is important with regard to carbon monoxide emissions is the sector *production processes*, producing 25% (292900 tonnes) of the total emissions. Especially the iron and steel industry, from which 270700 tonnes of carbon monoxide are emitted, has a major share in these emissions.

Relative contribution of the main source sectors to CO emissions in Austria in 1994

Total CO emissions: 1180500 tonnes

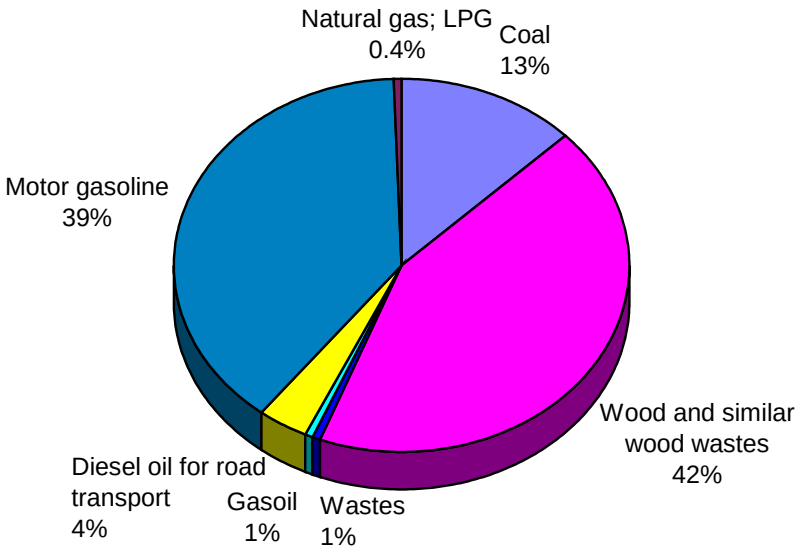


Of 1180500 tonnes total CO emissions 75% (882600 tonnes) are caused by the use of fuels. The following graph shows the relative share of individual fuel groups in this kind of CO emission.

Relative contribution of individual fuels to fuel-related CO emissions

in Austria in 1994

Total CO emissions from fuels: 882600 tonnes



Carbon dioxide

In Austria 59.6 million tonnes of carbon dioxide were emitted in 1994. The sectors *combustion in manufacturing industry* and *production processes* produce 21.2 million tonnes of CO_2 (35% of the total emissions).

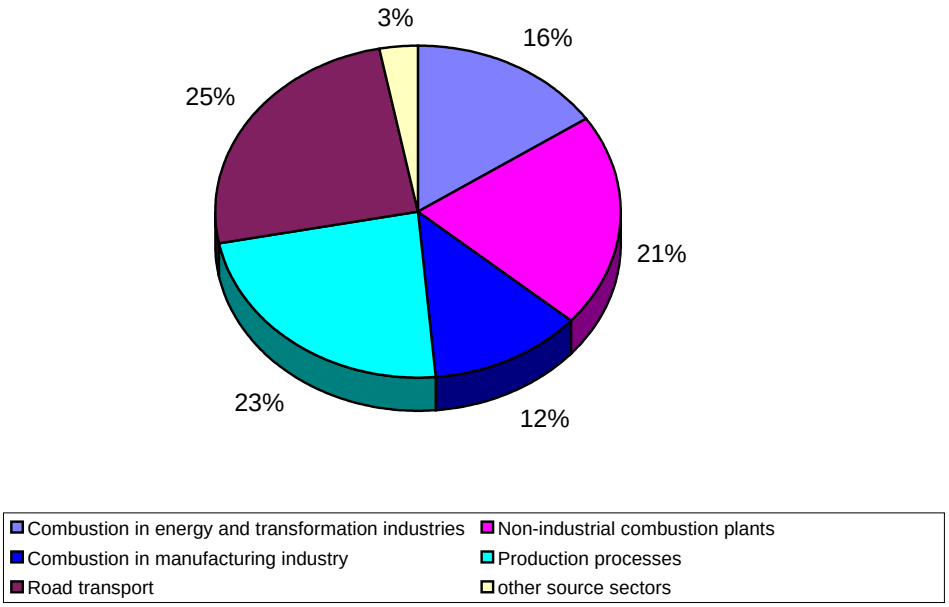
25% of the total CO_2 emissions are caused by *road transport* in Austria. Within the sector *road transport* in the first place passenger cars are of importance emitting 9.1 million tonnes of CO_2 (61% of the emissions from *road transport*). Heavy duty vehicles emit 4.3 million tonnes of CO_2 (29% of the emissions from *road transport*).

The sector *non-industrial combustion plants* emits 12.4 million tonnes of CO_2 and thus has a relative share of about 21% in the total emissions.

The sector *combustion in energy and transformation industries* emits 9.3 million tonnes of carbon dioxide (16% of the total CO_2 emissions).

Relative contribution of the main source sectors to CO_2 emissions in Austria in 1994

Total CO_2 emissions: 59.6 million tonnes



For a detailed discussion of carbon dioxide emissions: see UBA Info 9/96.

In Austria 5.4 million tonnes of wood and 2.3 million tonnes of biogenic fuels were used in 1994. In accordance with IPCC[1] guidelines, the CO_2 emissions of about 12.6 million tonnes resulting from the combustion of biogenic fuels are not included in the Austrian total CO_2 emissions.

Nitrous oxide

In Austria emissions of nitrous oxide are clearly dominated by the sector *agriculture and forestry*, which produces 44% of 13500 tonnes total emissions. Within this sector emissions mainly stem from fertilised cultivated areas. High nitrogen input into soil increases bacterial activity. Denitrification and nitrification processes lead to emissions of volatile nitrogen compounds (N_2O, but also NO_x). For these emissions from soils only rough estimates were available, thus data for this sector are less reliable than those for other sectors.

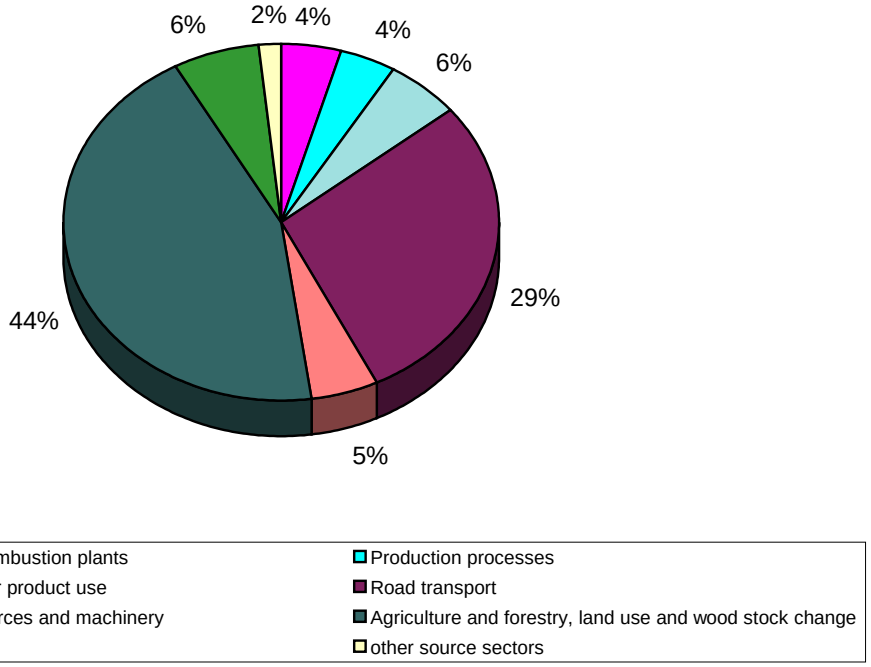
[1] IPCC: Intergovernmental panel on climate change

Road transport produces about 3900 tonnes of N_2O, which is 29% of the total emissions. Within this sector more than 50% of the emissions are emitted by heavy duty vehicles and about 40% by passenger cars.

Fuel-related sources are of secondary importance with regard to this pollutant. From combustion plants and production processes 1370 tonnes of N_2O are emitted, which is 10% of the total emissions in Austria.

Relative contribution of the main source sectors to N_2O emissions in Austria in 1994

Total N_2O emissions: 13500 tonnes



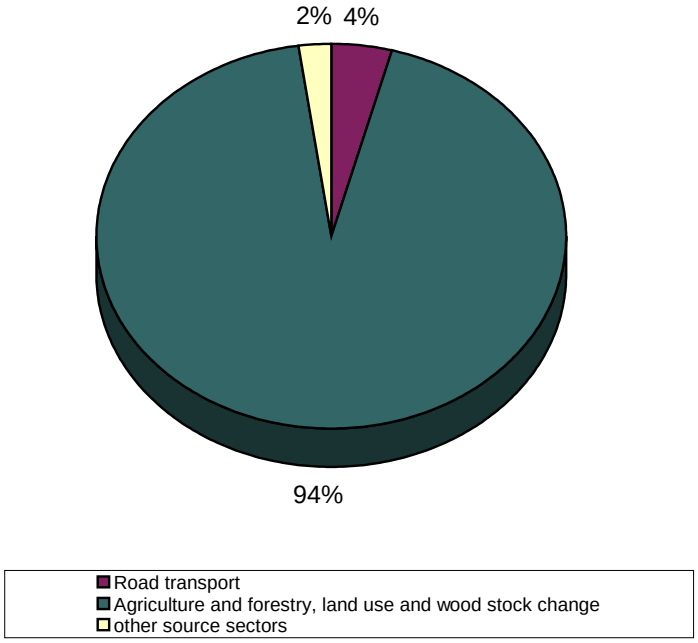
Ammonia

Of 86800 tonnes total NH_3 emissions 94% are produced by the sector *agriculture and forestry*. The greatest part of ammonia emissions is caused by storage of manure (more than 94% of the emissions within this sector), whereas emissions from fertilised cultivated areas are comparatively low.

Another 3600 tonnes of ammonia (4% of the total emissions) are emitted by *road transport*, within this sector mostly emissions of passenger cars are of importance.

Relative contribution of the main source sectors to NH_3 emissions in Austria in 1994

Total NH_3 emissions: 86800 tonnes



SELECTED ENVIRONMENTAL TOPICS

SELECTED GREENHOUSE GASES AND THEIR EFFECT ON THE ENVIRONMENT

Anthropogenic emissions of the greenhouse gases carbon dioxide, methane and nitrous oxide can be expressed as CO_2-equivalents in order to present their relative contribution to the greenhouse effect. Emission data of individual pollutants are multiplied with a conversion factor taking into account different global warming potentials (see the following table). The unit of one CO_2-equivalent (Ceq[1]) equals the global warming potential (GWP) of thousand tonnes of CO_2. In accordance with the UN-FCCC reporting guidelines global warming potentials for a period of 100 years were applied for conversion. The GWP values used are taken from the "Climate Change 1995" report of the Intergovernmental Panel on Climate Change (IPCC).

In the emission inventory CORINAIR 94 emissions of chlorofluorocarbons are not included and thus they are not considered in the shares of the individual sectors in greenhouse gas emissions. Also CO_2 emissions from the use of biomass are not included.

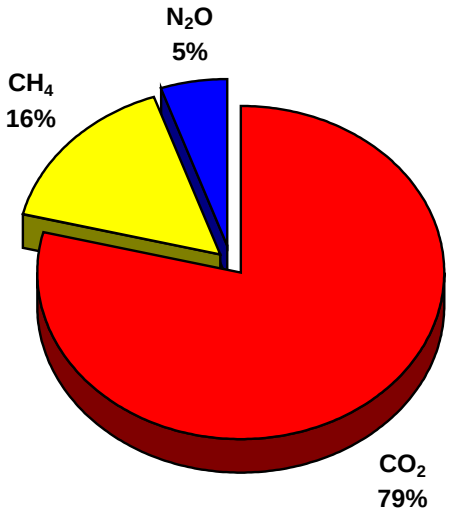
Substance	CO_2	CH_4	N_2O	total	share of single
Conversion factor (GWP value/100 yrs)	1	21	310	Ceq	sectors (%)
Combustion in energy and transformation industries	**9 278**	**2**	**36**	**9 316**	**12.3**
Non-industrial combustion plants	**12 378**	**436**	**181**	**12 995**	**17.2**
Combustion in manufacturing industry	**7 282**	**10**	**31**	**7 324**	**9.7**
Production processes	**13 966**	**2**	**176**	**14 143**	**18.7**
Extraction and distribution of fossil fuels	**148**	**101**	**0**	**249**	**0.3**
Solvent and other product use	**0**	**0**	**233**	**233**	**0.3**
Road transport	**14 931**	**76**	**1 207**	**16 213**	**21.4**
Other mobile sources and machinery	**1 497**	**5**	**206**	**1 709**	**2.3**
Waste treatment and disposal	**115**	**1 711**	**4**	**1 829**	**2.4**
Agriculture and forestry	**0**	**9 732**	**1 849**	**11 581**	**15.3**
TOTAL	**59 595**	**12 075**	**3 923**	**75 593**	

[1] Ceq: Carbon dioxide equivalents, IPCC

Total emissions of greenhouse gases (CFCs not included) amount to an equivalent of 75590 kilotonnes of carbon dioxide (Ceq.). About 78.8% stem from CO_2-, nearly 16% from methane- and 5.2% from N_2O - emissions.

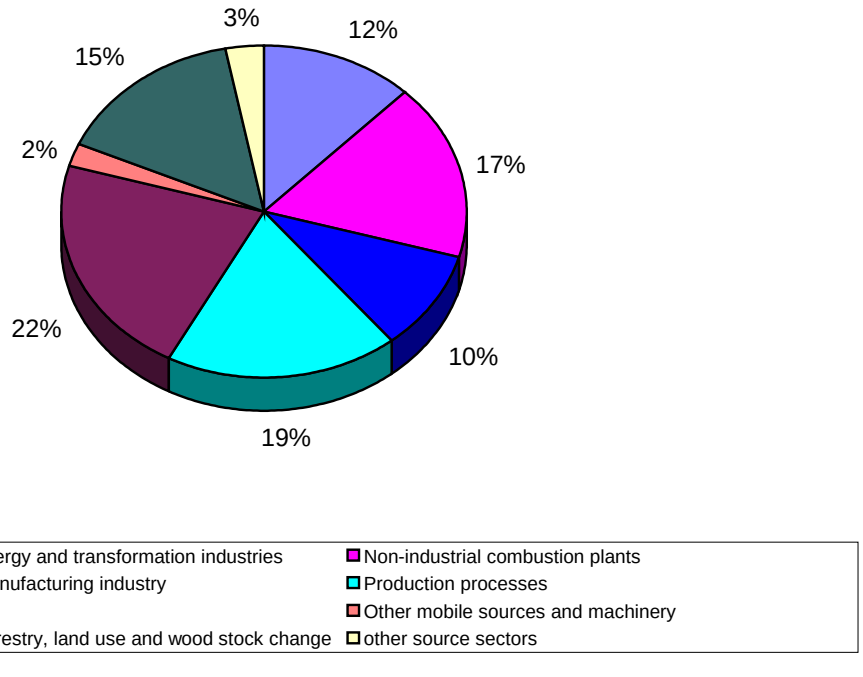
Relative contribution of individual pollutants to the total anthropogenic emissions of greenhouse gases in Austria in 1994

Total emissions: 75590 Ceq



Relative contribution of the main source sectors to the total anthropogenic emissions of greenhouse gases in Austria in 1994

Total emissions: 75590 Ceq



The following sectors have an important relative share in the Ceq total:

- *road transport* (because of CO_2- and N_2O-emissions)
- *production processes* (because of CO_2 emissions)
- *non-industrial combustion plants* (because of CO_2 emissions from combustion processes)
- *combustion in energy and transformation industries* (because of CO_2 emissions from combustion processes)
- *combustion in manufacturing industry* (because of CO_2 emissions from combustion processes)
- *agriculture and forestry* (because of CH_4 emissions from livestock breeding and N_2O-emissions from fertilised cultivated areas)

ACIDIFICATION

Emissions of SO_2, NO_x and NH_3 can cause acidification of water bodies and soils. The input of acidifying substances is effected by deposition of air pollutants and their atmospheric conversion products. Imports of acidifying air pollutants are not included in the following.

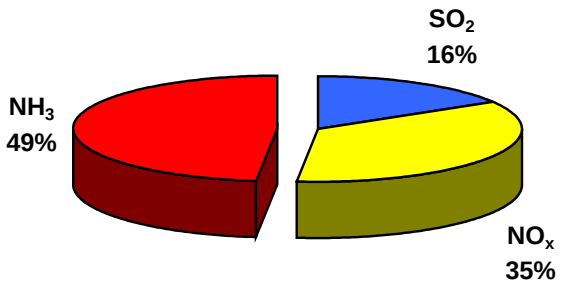
Emissions of acidifying air pollutants can be expressed as acidification equivalents (Aeq[1]). In the following table emission data (in tonnes per year) are multiplied with conversion factors. Thus a comparison of the effects on the environment of individual pollutants is possible.

Substance	SO_2	NO_x	NH_3	total	share of single
Conversion factor	**0.0313**	**0.0217**	**0.0588**	Aeq	sectors (%)
Combustion in energy and transformation industries	**133**	**143**	**9**	**284**	**2.7**
Non-industrial combustion plants	**589**	**375**	**45**	**1 009**	**9.6**
Combustion in manufacturing industry	**371**	**263**	**12**	**646**	**6.1**
Production processes	**285**	**344**	**13**	**642**	**6.1**
Extraction and distribution of fossil fuels	**40**	**0**	**0**	**40**	**0.4**
Solvent and other product use	**0**	**0**	**0**	**0**	**0.0**
Road transport	**250**	**2 086**	**213**	**2 549**	**24.2**
Other mobile sources	**48**	**338**	**3**	**389**	**3.7**
Waste treatment and disposal	**2**	**5**	**3**	**10**	**0.1**
Agriculture and forestry	**0**	**152**	**4 774**	**4 927**	**46.8**
Nature	**0**	**6**	**31**	**37**	**0.4**
TOTAL	**1 717**	**3 713**	**5 103**	**10 533**	

With 49% ammonia has the greatest share in the total of 10500 acidification equivalents. NO_x emissions make up about 35% of the total equivalents, SO_2 emissions amount to 1717 Aeq which is a share of 16% in the total emissions.

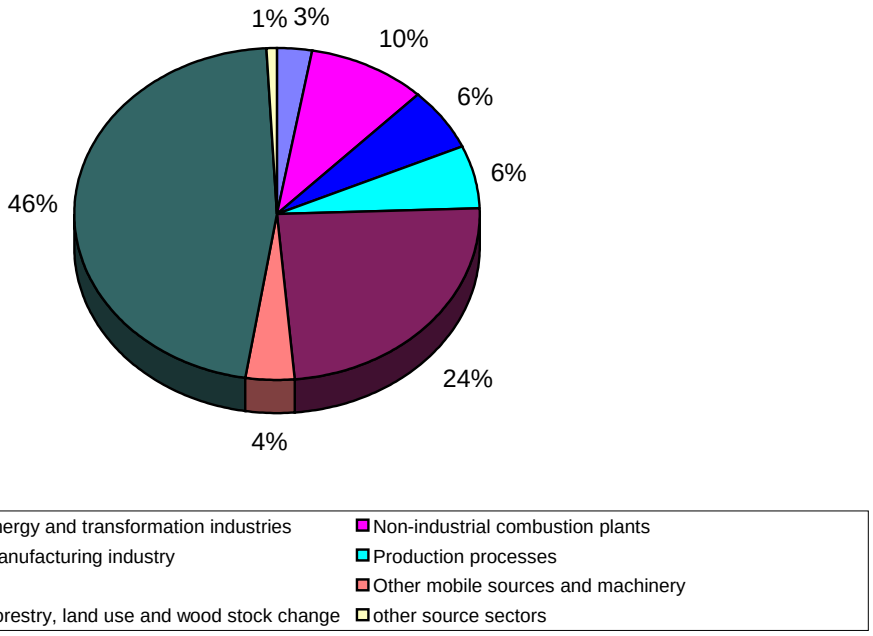
[1] Aeq: Acid equivalents: proportional to mass percent of H^+-ions

Relative contribution of individual pollutants to acidification in Austria in 1994
Total emissions: 10500 Aeq



Relative contribution of the main source sectors to acidification in Austria in 1994

Total emissions: 10500 Aeq



The following sectors have important relative shares in the equivalent total:

- *agriculture and forestry* (because of NH_3 emissions from manure storage)
- *road transport* (because of NO_x emissions)
- *non-industrial combustion plants* (because of SO_2 emissions from combustion processes)
- *combustion in manufacturing industry* and *production processes* (because of NO_x- and SO_2 emissions)

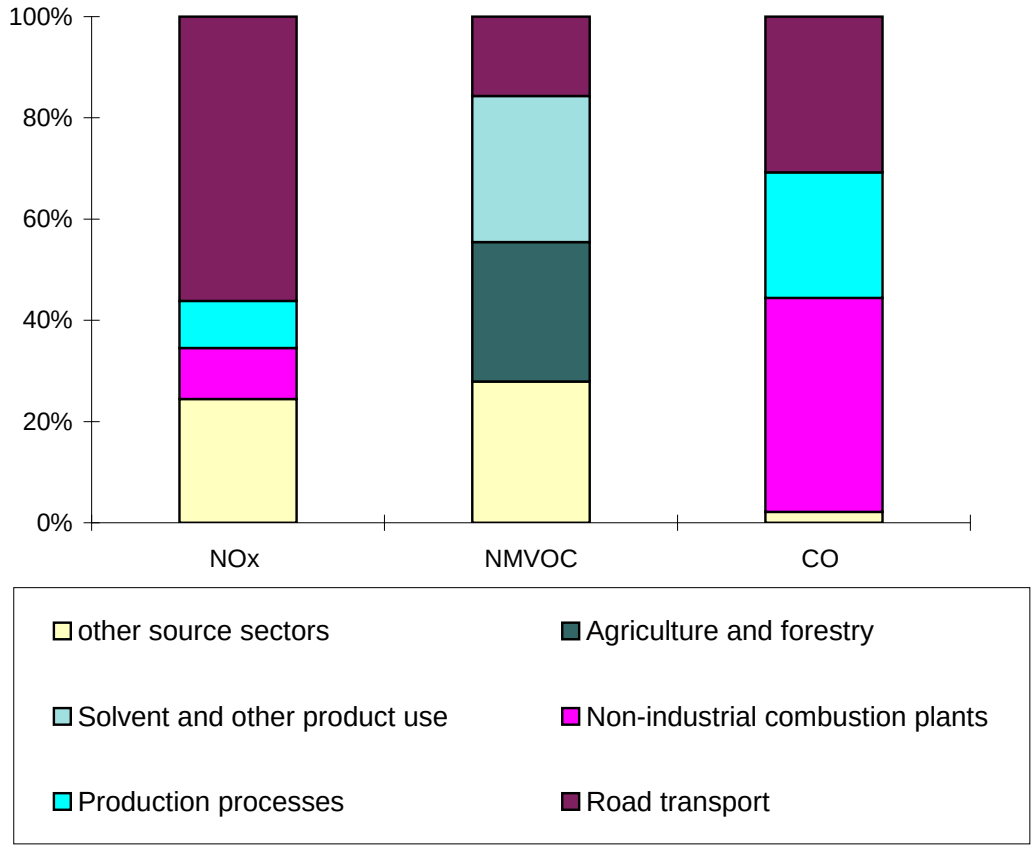
TROPOSPHERIC OZONE

For the formation of tropospheric ozone emissions of the pollutants NO_x and NMVOC as ozone precursors are of high importance. Since, compared to NMVOC, carbon monoxide shows a slower chemical reaction in air it is less important to the local formation of ozone. Also methane has hardly any influence on the local formation of ozone, though, from the global point of view, it is an important ozone precursor as well.

The following graph shows the contribution of the three most important main source sectors to the total emissions of ozone precursors.

Emitters of ozone precursors

in Austria in 1994



With regard to all three ozone precursor substances *road transport* is one of the three main emission sources. The sectors *production processes* and *non-industrial combustion plants* have a nearly equal share with regard to NO_x emissions. The main sources of NMVOC-emissions apart from *road transport* are the sectors *solvent and other product use* and *agriculture and forestry*. High emissions from the sector *agriculture and forestry* can be explained by emissions of biogenic VOC from forest areas.

TOXIC ORGANIC AIR POLLUTANTS AND HEAVY METALS

In the Austrian 1994 air emission inventory emissions of the humantoxic substance class persistent organic pollutants (POPs) and emissions of humantoxic and ecotoxic heavy metals were registered for the first time.

POPs

The group persistent organic pollutants registered in CORINAIR comprises on the one hand polycyclic aromatic hydrocarbons (PAHs) and on the other hand the substance class polychlorinated dibenzodioxins (PCDD) and -furans (PCDF).

PAHs

Polycyclic aromatic hydrocarbons are in the first place a product of incomplete combustion processes. This class of organic compounds comprises a great number of individual substances. Emission data in this emission inventory are aggregated data of individual substances. One of the best known compounds of this group is benzo(a)pyrene.

PCDD and PCDF

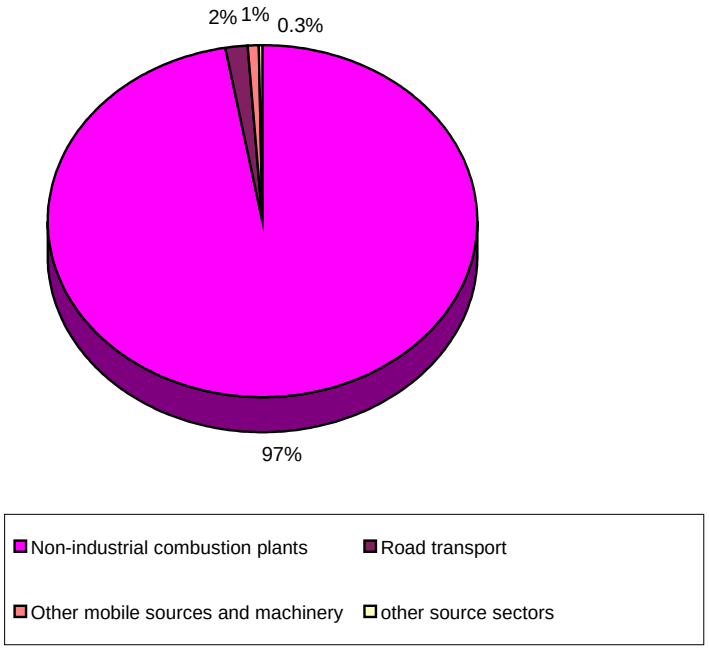
Like the class of PAHs, this substance class also comprises many individual substances. In order to make an estimation of the total toxicity, emissions of individual substances are expressed as 2,3,7,8-tetrachlordibenzodioxin-toxicity-equivalents (I-TEQ) .

	PAH **kg**	dioxin **mg [I-TEQ]**
Combustion in energy and transformation industries	88	0
Non-industrial combustion plants	444 990	16 670
Combustion in manufacturing industry	270	1 500
Production processes	930	10 360
Extraction and distribution of fossil fuels	0	0
Solvent and other product use	0	0
Road transport	7 488	0
Other mobile sources and machinery	3 837	0
Waste treatment and disposal	10	179
Agriculture and forestry	0	0
Nature	0	24
TOTAL	457 612	28 733

In Austria a total of about 458 tonnes of polycyclic aromatic hydrocarbons and 28.7 g I-TEQ are emitted. From the distribution within sectors it is obvious that with regard to both pollutants a few sectors account for the major part of the emissions.

Relative contribution of the main source sectors to PAH emissions in Austria in 1994

Total PAH emissions: 458 tonnes

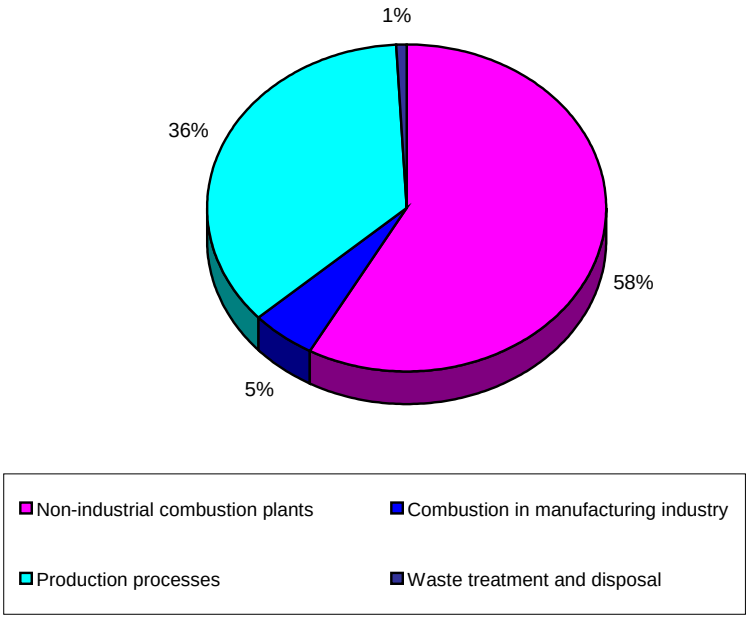


- The sector *non-industrial combustion plants* produces more than 97% of the total PAH emissions. Within this sector residential plants producing 350 tonnes of PAHs are the main emission sources in Austria. 97% (or 340 tonnes) of the PAHs emitted by residential plants are produced by combustion of fuelwood, which covers about 35% of the residential energy demand.
- *Road transport* emits about 7.5 tonnes of PAHs (1.6% of the total emissions).
- The third most important main source sector is *other mobile sources and machinery* producing an annual total of 3.8 tonnes, which is 0.8% of the total emissions.
- The contribution of all other main source sectors to the total PAH emissions amounts to 0.3% (1.3 tonnes), here in the first place *production processes* are of importance.

Total emissions of PCDD and PCDF equal 28.7 g 2,3,7,8-TCDD equivalent.

Relative contribution of the main source sectors to dioxin emissions in Austria in 1994

Total dioxin emissions: 28.7 g I-TEQ

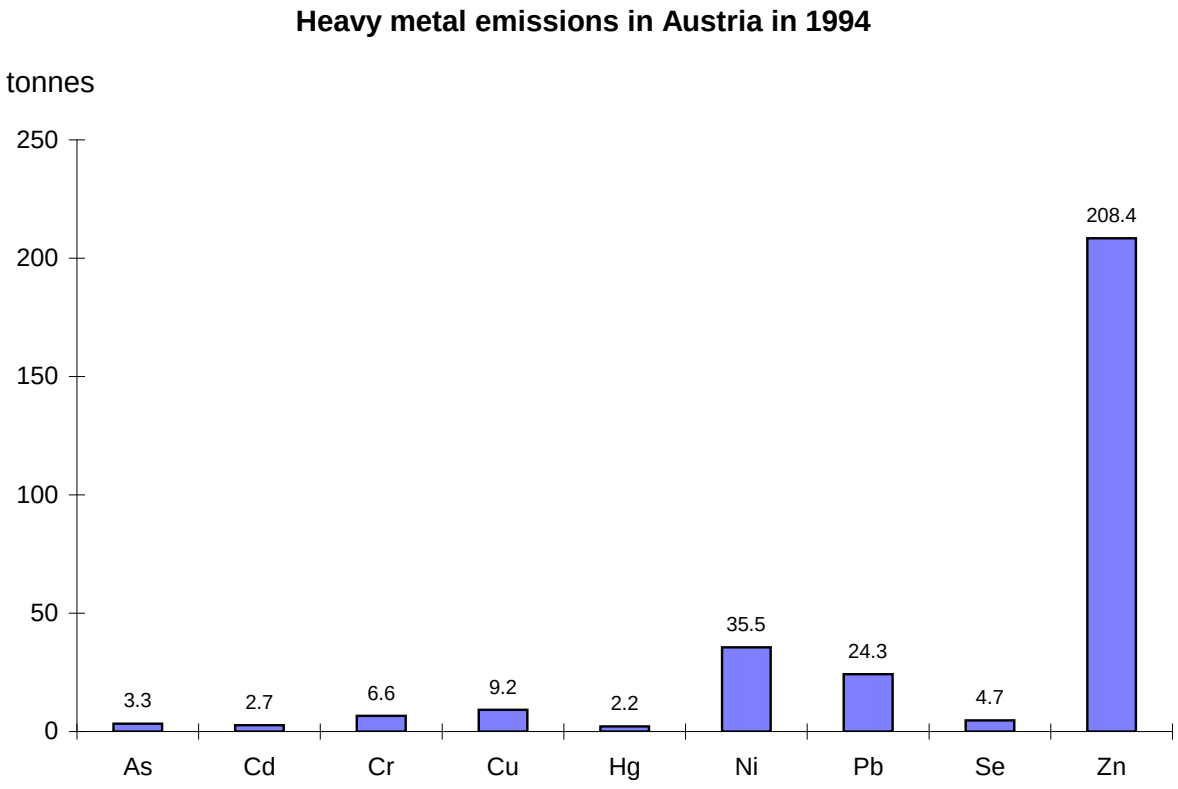


- The sector *non-industrial combustion plants* emits 16.7 g I-TEQ (58% of the total dioxin emissions). About 91% of these dioxin emissions are produced by combustion of fuelwood.
  Within this sector the relative contribution of residential plants amounts to more than 49% of the dioxin emissions. Combustion plants in *agriculture and forestry* have a nearly equal share producing 7.7 g dioxin emissions (46% of the main source sector *non-industrial combustion plants*).
- About one third of the annual dioxin emissions is caused by the sector *production processes*, which emits 10.4 g per year. Most of all sinter plants producing dioxin emissions of 8.0 g I-TEQ are of great importance. From secondary aluminium production another 1.8 g I-TEQ are emitted.

- From *combustion in manufacturing industry* 1.46 g 2,3,7,8-TCDD-equivalent are released into the environment. Within this sector more than 91% of the dioxin emissions are caused by combustion of waste, wood and similar wood wastes. Most of all wood and similar wood wastes, which cover only about 5.7% of the energy demand, produce at their combustion 0.83 g I-TEQ (56.7% of the total emissions within this sector).
- From incineration plants for municipal waste 0.05 g I-TEQ are emitted.
- From cremation dioxin emissions of 0.1 g I-TEQ are caused.

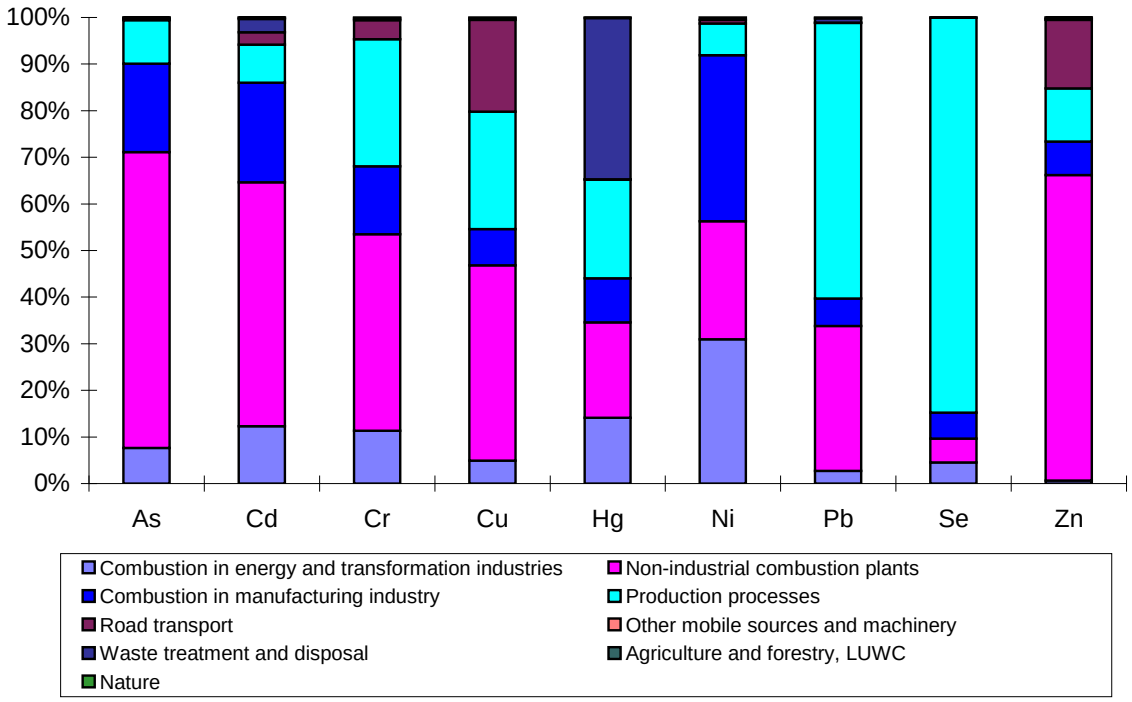
HEAVY METALS

For CORINAIR 94 emissions of nine heavy metals were registered. Total emissions of the different heavy metals and relative contributions of individual sectors can be seen in the two following graphs.



Regarding heavy metal emissions the widely differing human- and ecotoxic effects of the individual heavy metals have to be borne in mind.

Relative contribution of the main source sectors to heavy metal emissions in Austria in 1994



As In the 3.3 tonnes total arsenic emissions the sector *non-industrial combustion plants* has a share of more than 63% (2.1 tonnes).

The sector *combustion in manufacturing industry* emits 0.6 tonnes and the sector *production processes* produces another 0.3 tonnes of arsenic. Thus industry has a relative share of more than 28% in the total arsenic emissions.

Cd In Austria 2.7 tonnes of cadmium are emitted. The sector *non-industrial combustion plants*, which emits 1.4 tonnes, has a share of more than one half in the total emissions.

The sectors *combustion in manufacturing industry* and *production processes* emit 0.6, respectively 0.2 tonnes of cadmium. The share of emissions from these sectors amounts to 29.4% of the total cadmium emissions.

The sector *combustion in energy and transformation industries*, which emits 0.3 tonnes of cadmium, causes more than 12% of the total emissions of this heavy metal.

Cr With regard to 6.6 tonnes chromium emissions the sectors *non-industrial combustion plants*, *combustion in manufacturing industry* and *production processes* have a share of about 42% (2.8 tonnes of Cr). From the sector *combustion in manufacturing industry* 0.97 tonnes of chromium (14.6%) are emitted, from the sector *production processes* 1.8 tonnes (27.3% of the total emissions). The highest

emissions within the sector *production processes* are caused by the iron and steel industry.

The use of fuels in the sector *combustion in energy and transformation industries* causes chromium emissions of 0.75 tonnes, which is 11.3% of the total emissions.

Cu Also with regard to copper emissions the sector *non-industrial combustion plants* has with 42.2% the greatest share in 9.2 tonnes total emissions.

About a quarter of the copper emissions (2.3 tonnes) is caused by *production processes*. Most of all emissions from the iron- and steel industry are of great importance.

The sector *road transport* emits 1.8 tonnes of copper. Heavy metal emissions of this sector are mainly due to the wear of brakes and tyres.

Hg More than one third of 2.18 tonnes total mercury emissions are produced by waste incineration plants.

From *production processes* 0.46 tonnes of this heavy metal are emitted. Also the sector *non-industrial combustion plants* has with about 20% an important share in the total mercury emissions.

Ni The nickel emissions of 35.5 tonnes in 1994 are in the first place caused by the combustion of fuels. The sector *combustion in manufacturing industry* produces 12.6 tonnes (36% of the total emissions) and thus has the greatest share in emissions of this heavy metal.

Other important emission sources of nickel are the sectors *combustion in energy and transformation industries* and *non-industrial combustion plants* with a share of 31%, respectively 25% in the total emissions.

Pb From the sector *production processes* 14.4 tonnes of lead (59% of 24.3 tonnes total emissions) are emitted. Within this sector most of all 8.9 tonnes of lead emissions from the iron and steel industry are of importance. From the production of non-ferrous metals 2.8 tonnes of lead are emitted (19% of the emissions from the sector *production processes*). Processes in the glass industry cause another 2.6 tonnes of lead emissions.

The sector *non-industrial combustion plants* has a relative share of 31% (7.6 tonnes) in the total lead emissions. Most of all lead emissions of 6.3 tonnes from residential plants are of importance.

Due to a ban of leaded petrol emissions of this heavy metal from *road transport* have decreased to 0.05% of the total emissions.

Se In Austria 4.7 tonnes of selenium are emitted. *Production processes* cause nearly 85% (3.99 tonnes) of the selenium emissions. Within this sector the main emission source is the glass industry producing 3.9 tonnes of selenium emissions, which is 98% of the emissions from this sector.

15% of the emissions (0.72 tonnes of Se) stem from combustion processes with a nearly equal share of the three sectors *combustion in energy and transformation industries*, *non-industrial combustion plants* and *combustion in manufacturing industry*.

Zn In Austria zinc emissions amount to 208 tonnes of which 137 tonnes (65.6%) are caused by the sector *non-industrial combustion plants*.

The second most important zinc-emitter in Austria is *road transport*, producing 30.6 tonnes (nearly 15% of the total emissions). Zinc emissions from road-transport are mostly due to the wear of brakes and tyres.

From *production processes* 23.7 tonnes of zinc (11.4% of the total emissions) are emitted. Within this sector the major part of the emissions is caused by processes in the iron and steel industry.

The following table shows the relative share of combustion processes (summarised data of the main source sectors *combustion in energy and transformation industries*, *non-industrial combustion plants* and *combustion in manufacturing industry*) in the total emissions of the individual heavy metals.

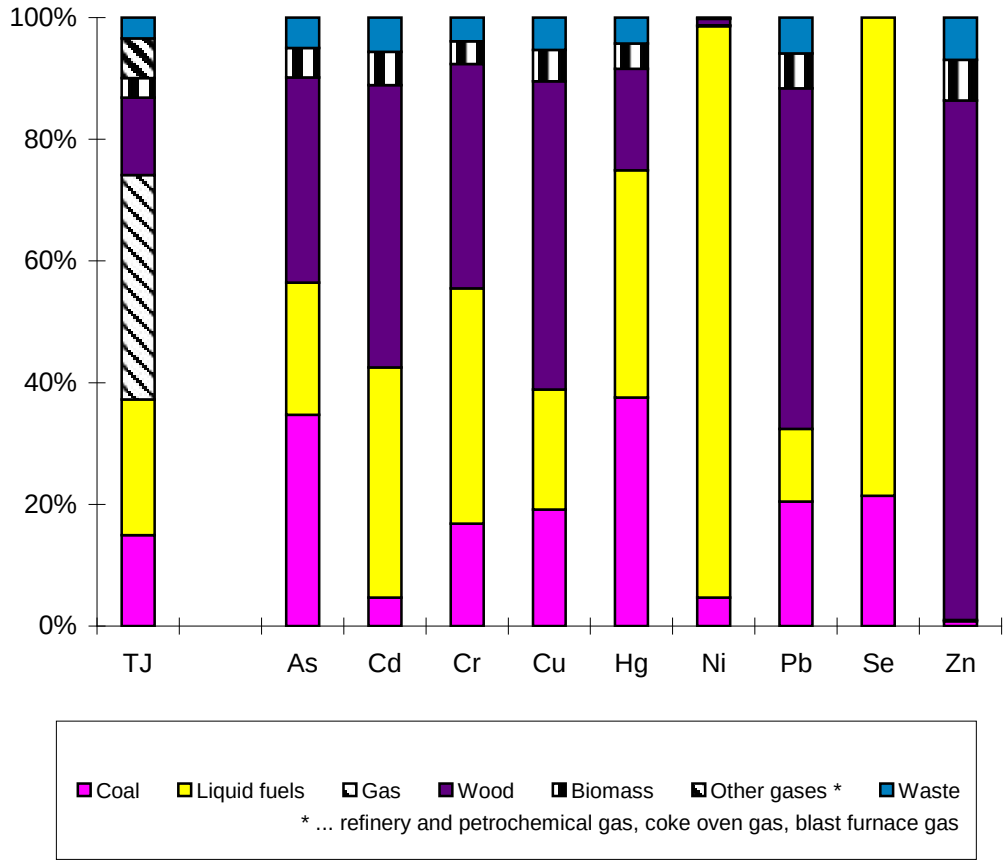
Kg heavy metal	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
total emissions	3 264	2 717	6 626	9 238	2 177	35 534	24 293	4 707	208 374
fuel-related sources	2 940	2 337	4 512	5 046	959	32 664	9 646	717	152 971
share of the fuel-related sources	90.1%	86.0%	68.1%	54.6%	44.0%	91.9%	39.7%	15.2%	73.4%

It can be seen that with regard to the heavy metals arsenic, cadmium, chromium, copper, nickel and zinc the relative share of fuel-related sources in the total emissions is higher than 50%.

The following graph shows the share of individual fuels in the coverage of the energy demand and their share in heavy metal emissions.

Relative share of individual fuels in the coverage of the energy demand and their share in fuel-related heavy metal emissions

in Austria in 1994



By combustion of coal about 15% of the energy demand of combustion processes, which amounts to 656300 TJ, is covered. Most of all, this fuel is of great importance with regard to arsenic- and mercury emissions which have a share of 35%, respectively 38% in fuel-related emissions. Liquid fuels contribute substantially to fuel-related nickel- (94%) and selenium emissions (79%). The combustion of liquid fuels is also of considerable importance with regard to emissions of the other heavy metals with the exception of zinc.

Gaseous fuels, which cover 44% of the energy demand, do not cause emissions of these nine heavy metals.

By combustion of fuelwood about 13% of the energy demand is covered. This fuel is mainly used within the sector *non-industrial combustion plants*. Combustion of fuelwood is of decisive importance with regard to emissions of six heavy metals; combustion of wood and similar wood wastes dominates the emissions of zinc, lead, copper and cadmium and has a share of 34%, respectively 37% in emissions of the heavy metals arsenic and chromium. Calculations of the emissions of fuelwood are

based on internationally applied emission factors, which are rather high and should be subject to a critical review.

Biofuels and organic waste cover each about 3% of the energy demand. Their share in the heavy metal emissions lies within a range of 4% to 7%, except for nickel and selenium, which have a relative share of <0.2%.

Data collection

Compared to earlier emission calculations CORINAIR 94 was improved with regard to several aspects:

Completeness of information

For CORINAIR 94 for many sectors an entirely new calculation of emissions was carried out, e.g. of emissions from the sector *solvent and other product use* (see UBA-Info 6-96) and of emissions from *non-industrial combustion plants* (see UBA-Info 11-95). Also for the calculation of emissions from *road transport* (see UBA-Info 7/8-96) and air traffic new calculation models were applied. For *combustion in energy and transformation industries* for the first time data from the database on steam boilers of the Federal Environment Agency - Austria were available.

Moreover data on a wider range of pollutants are part of CORINAIR 94. Apart from SO_2, NO_x, CO, NMVOC, CH_4, N_2O and NH_3 also nine heavy metals and POPs[1] were included in this emission inventory.

Also from industry new data were available because of co-operation with the Austrian Chamber of Commerce. A compilation of emission data of individual industry sectors from the *Austrian Chamber of Commerce* and the *Federation of Austrian Industry* were included in CORINAIR 94. (Emissionserhebung einzelner Industriebereiche für 1993, Forschungsinstitut für Chemie und Umwelt; A. Windsperger, Ch. Turi und St. Steinlechner).

Emissions data of the Schwechat refinery were conveyed to the Federal Environment Agency - Austria by OMV (A. Virag).

Emissions of air pollutants from Austria′s iron and steel industry were calculated by VOEST (Austrian Iron and Steel Industries; J. Sigmund).

Calculation of emissions from *road transport* was carried out by the Institut für Verbrennungskraftmaschinen und Thermodynamik, TU Graz (Institute for Internal Combustion Engines and Thermodynamics; R. Pischinger, St. Hausberger).

Calculation of emissions of heavy metals was carried out by the "Österreichisches Forschungszentrum Seibersdorf" (Austrian Research Centre Seibersdorf; R. Orthofer).

[1] Persistent organic pollutants

The dioxin emission inventory was set up by "FTU-Forschungsgesellschaft Technischer Umweltschutz GmbH" (C. Hübner).

The PAH emission inventory was worked out by "DI Scheidl Umweltanalytik GmbH" (F. Twrdik, K. Scheidl).

Detailed information

CORINAIR 94 makes a detailed distinction between air emission sources using the so-called SNAP-code (Selected Nomenclature for Air Pollution).

This nomenclature is applied Europe-wide and distinguishes between more than 400 different activities. It forms the basis of the so far most detailed assessment in Austria. For comparison in CORINAIR 90 on Snap Level 3 only 257 activities were distinguished.

Comparability of information

The CORINAIR inventory is carried out by almost all European countries. Standardised methodology allows for a comparison of data collected in different countries.

Transparency of information

For this inventory apart from the calculation of emissions also underlying data were stored in a database. Thus calculations become transparent.

The Federal Environment Agency - Austria will publish a second report as part of the Austrian Air Emission Inventory 1994 which will include all basic data used in this inventory (emission factors, data on fuel consumption and production) and moreover emission data of the individual SNAPs.

Possibility of extension

The integration of the Austrian pollutant emission data in a European database makes additional information from international projects easier accessible. Emission factors can be compared to those applied in the neighbouring countries.

The methodology underlying CORINAIR 90 differs widely from CORINAIR 94, thus comparability of emissions is limited. Until the end of 1997 the Federal Environment Agency - Austria will therefore calculate emission data for the years 1990 to 1995 in accordance with the CORINAIR 94 format. Only the existence of a consistent time series will allow for an exact interpretation of emission trends.