AUSTRIA'S NATIONAL AIR EMISSION PROJECTIONS 2023 FOR 2025 AND 2030

Pollutants: NO_x, SO_2, NMVOC, NH_3 and $PM_{2.5}$
Scenario: With Existing Measures (WEM)

Submission: 15 March 2023 (draft)

REPORT
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CONTENT

1 GENERAL APPROACH

Austrian emission projections of the pollutants nitrogen oxide (NO_x), sulphur dioxide (SO_2), non-methane volatile organic compounds (NMVOC), ammonia (NH_3) and particulate matter ($PM_{2.5}$) for the scenarios "with existing measures" (WEM) were last published in 2021 in a report entitled "Austria's National Air Emission Projections 2021 for 2020, 2025 and 2030" (UMWELTBUNDESAMT 2021).

This year's report provides a fully updated emission projections for the WEM scenario, based on energy balances and on an update of policies and measures (PAMs).

For the submission in March only one scenario "with existing measures" was modelled, which includes all measures implemented by 1 January 2022. Later in the year also a scenario "with additional measures" will be available. This scenario will include planned policies and measures currently being developed under the National Air Pollution Control Programme and the Integrated National Energy and Climate Plan for Austria.

The status of the implementation of measures has been defined at expert level in consultation with the Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology. Information on national policies and measures included in the WEM scenario can be found in Chapter 3.

The air pollutant projections are fully consistent with current GHG emission projections reported under Regulation (EU 2018/1999) on the Governance of the Energy Union and Climate Action (Umweltbundesamt, 2023c).

The report further outlines relevant background information to enable better understanding of the key socio-economic assumptions used in the preparation of the projections. For comparison purposes, emission data from the National Air Emission Inventory of March 2023 (UMWELTBUNDESAMT, 2023b) have been included as well.

1.1 Legal Background

Upon signing the UNECE Gothenburg Protocol to the Convention on Long-Range Transboundary Air Pollution of 1 December 1999[1], the EU agreed on national emission ceilings for nitrogen oxides (NO_x), sulphur dioxide (SO_2), ammonia (NH_3) and non-methane volatile organic compounds (NMVOC) for the year 2010 and, under the amendment in 2012, also on emission ceilings for the year 2020. Austria signed the Gothenburg Protocol but has not ratified it. For this reason, the targets are not binding for Austria. However, the Directive of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants (NEC Directive 2001/81/EC)2 stipulates national emission ceilings for these air pollutants, which are relevant for Austria. The obligation to comply with the ceilings for 2010 has been transposed into national law through the Air Emission Ceilings Act ('Emissionshöchstmengengesetz-Luft')[3]. The revised NEC Directive (EU) 2016/2284 lays down national emission reduction obligations (additionally for the pollutant $PM_{2.5}$) for the years 2020 and 2030 and has been transposed into national law by the Air Emissions Act 2018 (Emissionsgesetz-Luft 2018)[4].

Pursuant to Article 8 (1) of the revised NEC Directive, Member States (MS) shall prepare and biennially update their national emission projections and pursuant to Article 10 (2), MS shall provide their national emission inventories and projections to the Commission and to the European Environment Agency.

According to Article 22 of the revised Guidelines 2022[5] for reporting emission data under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP), Parties should report emissions from road transport on the basis of 'fuel sold' and may voluntarily calculate emissions based on 'fuel used' in the geographical area of the Party. Furthermore, Article 23 states that some parties (including Austria) may choose to use national emission totals calculated on the basis of fuel used as a basis for compliance with their respective emission ceilings.

According to the revised NEC Directive (2016/2284/EU) Article 10 (2), reporting under NEC shall be consistent with reporting to the Secretariat of the LRTAP Convention. Furthermore, Annex IV (Part 1 (4)) states that emissions from road transport shall be calculated and reported on the basis of 'fuel sold'. However,

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[1] Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution to Abate Acidification, Eutrophication and Ground-level Ozone, http://www.unece.org/fileadmin/DAM/env/lrtap/full%20text/Informal_document_no_17_No23_Consolidated_text_checked_DB_10Dec2012_-_YT_-_10.12.2012.pdf

[2] Directive 2001/81/EC of the European Parliament and the Council of 23 October 2001 concerning national emission ceilings for certain pollutants, OJ L309/22, 27 November 2001. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2001:309:0022:0030:EN:PDF

[3] Bundesgesetz über nationale Emissionshöchstmengen für bestimmte Luftschadstoffe (Emissionshöchstmengengesetz-Luft, EG-L), BGBl. I Nr. 34/2003

[4] Bundesgesetz über nationale Emissionsreduktionsverpflichtungen für bestimmte Luftschadstoffe (Emissionsgesetz-Luft 2018 – EG-L 2018), BGBl. I Nr. 75/2018

[5] https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2022/emissions_reporting_guidelines_2023.pdf

MS having the choice to use national emission totals calculated on the basis of 'fuel used' as a basis for compliance under the LRTAP convention may continue to use this option in order to ensure coherence between international and Union law.

Over the last decade, Austria has experienced a considerable amount of fuel exports in vehicle tanks as fuel prices in Austria have been lower than in the neighbouring countries. Most of the fuel was used by heavy-duty vehicles for long-distance transport (inside and outside the EU). This is of relevance for NO_x emissions only.

This report provides emissions projection data based on 'fuel sold' also, for checking compliance with the emissions ceilings of the NEC Directive.

Annex I of the NEC Directive (2001/81/EC) determines national emission ceilings for certain atmospheric pollutants. By the year 2010, Member States had to limit their annual national emissions of these pollutants to an amount not exceeding these emission ceilings. Emissions reduction commitments from 2020 onwards are stated in Annex II of the revised NEC Directive (EU) 2016/2284 (see Table 1).

Table 1: National emission ceilings and emission reduction commitments for Austria according to NEC Directive 2001/81/EC and NEC Directive 2016/2284/EU, respectively.

	from 2010 onwards*	**from 2020 to 2029****	**from 2030 onwards****
Obligation under:	**Directive 2001/81/EC**	**Directive (EU) 2016/2284**	**Directive (EU) 2016/2284**
NO_x	103 kt	37%	69%
SO_2	39 kt	26%	41%
NMVOC	159 kt	21%	36%
NH_3	66 kt	1%	12%
$PM_{2.5}$	-	20%	46%

* *Absolute emissions ceiling in kt per year*

** *Reduction compared with base year 2005 in %*

1.2 Data structure of projections and national inventory

Where reasonable and applicable, emissions were calculated and projected on the basis of the methodologies used in the Austrian Inventory. These are described in Austria's National Inventory Report 2023 (UMWELTBUNDESAMT 2023a).

The Austrian Inventory is based on the SNAP (Selected Nomenclature for sources of Air Pollution) nomenclature and has to be converted into the current reporting format as required under the LRTAP Convention, i.e. the NFR (Nomenclature for Reporting) format. Projections have thus been calculated on the basis of the SNAP nomenclature and subsequently converted into the NFR format. Emissions from energy-related sectors (NFR 1.A) are calculated on the basis of energy scenarios 2023 (HAUSBERGER/SCHWINGSHACKL, 2023 and E-THINK, 2023).

The air pollutant projections are fully consistent with the historical emission data from the Austrian Emission Inventory (submission March 2023) up to the latest available data year 2021.

Emission factors and underlying parameters are described in the methodological sub-chapters 4 of this report.

1.3 Underlying Models

Model calculations are based on custom-made methodologies for the individual sectors.

- Energy forecast (fuel combustion) are based on the National Energy Balance of (Statistik Austria, 2022a) and on an econometric input-output model (MIO-ES), supported by calculations carried out using the bottom-up models:
  - INVERT/EE-Lab (e-think energy research (e-think, 2023): domestic heating and hot water supply.
  - NEMO & GEORG (SCHWINGSHACKL & REXEIS 2022): energy demand and emissions of transport (incl. off-road).
- Forecasts of emissions from industrial processes and solvent emissions are based on Umweltbundesamt expert judgements and on projections for the respective gross value added (NACE code).
- In the agriculture sector the following models were used:
  - For activity data calculation (animal livestock, crop yields, mineral fertilizers, agriculture area) the PASMA model of the Austrian Institute of Economic Research (WIFO & BOKU 2023) was used.
  - For the determination of the economic impact on the overall economy, the PASMA results were transferred into ADAGIO,

WIFO's Input-Output-World Model with econometrically estimated behavioural equations.
   - For emission calculation, the agriculture model of the Austrian GHG inventory was used. Existing measures of agricultural practice projected for Austria were taken into account.
- Projections for waste (expert judgements on waste amounts and waste treatment) were prepared by Umweltbundesamt.

A detailed description of the models is provided in a report entitled "GHG Projections and Assessment of Policies and Measures in Austria 2023", submitted under the Governance Regulation (Regulation (EU) 2018/1999) in 2023 (UMWELTBUNDESAMT 2023c).

The following table presents the main data sources used for the activity data presented in this report, as well as information on the institution carrying out the actual calculations.

1.4 General Socio-economic Assumptions

Data used for general socio-economic assumptions, which form the basis of Austria's emission projections, can be found in Table 2. Methodological assumptions are included in Chapter 4. Further assumptions about key input parameters are included in UMWELTBUNDESAMT (2023c).

Table 2: Key input parameters for emission projections (UMWELTBUNDESAMT 2023c).

Year	Scenario	2020	2021	2025	2030	2035	2040	2050
GDP [billion € 2020]	WEM	381	402	439	466	497	533	599
GDP real growth rate [%]	WEM	-6.5	5.9	1.6	1.1	1.6	1.4	1.1
Population [1 000]	WEM	8 917	8 961	9 114	9 251	9 360	9 470	9 626
Stock of dwellings [1 000]	WEM	3 982	4 008	4 112	4 207	4 295	4 380	4 497
Heating degree days	WEM	3 311	3 301	3 260	3 210	3 160	3 110	3 010
Exchange rate [US$/€]	WEM	1.2	1.2	1.2	1.2	1.2	1.2	1.2
International coal price [€ 2020/GJ]	WEM	1.6	3.7	3.1	3.1	3.1	3.3	3.7
International oil price [€ 2020/GJ]	WEM	6.4	10.5	15.4	15.4	15.4	16.2	19.7
International natural gas price [€ 2020/GJ]	WEM	3.1	15.1	13.2	11.3	11.3	11.3	11.8
CO_2 certificate price [€ 2020/t CO_2]	WEM	24.0	54.0	80.0	80.0	82.0	85.0	160.0

2 MAIN RESULTS

The following table shows Austria´s national total emissions and projections based on 'fuel sold' in accordance with the reporting provisions under the UNECE LRTAP Convention as well as under the NEC Directive 2016/2284/EU. Fuel sold emissions are also the basis for compliance with Austria's emission reduction commitments under Directive 2001/81/EC.

Directive (EU) 2016/2284 sets emission reduction commitments for five air pollutants: nitrogen oxides (NO_x), sulphur dioxide (SO_2), non-methane volatile organic compounds (NMVOC), ammonia (NH_3) and particulate matter ($PM_{2.5}$).

The scenario "with existing measures" results in significant emission reductions by 2030 for all pollutants. The most substantial reduction (about 68%) from 2005 to 2030 is projected for NO_x, provided that the latest and new emission standards for road vehicles meet their specifications under real-world driving conditions.

Emission reductions for the other pollutants are in the range of 37% to 57%; NH_3 emissions, however, are projected to only decrease by 8% (see Table 3).

Table 3: Austrian national total emission trend in kt in comparison with the base year 2005 in % based on fuel sold for the scenario "with existing measures" (Source: Umweltbundesamt).

Pollutant [kt]	Emission inventory 2023					Emission scenario (WEM)	
	1990	2005	2010	2020	2021	2025	2030
NO_x	218.95	247.85	206.02	124.47	122.64	98.65	80.26
		0%	-17%	-50%	-51%	-60%	-68%
SO_2	73.70	25.89	15.99	10.41	10.87	10.95	11.09
		0%	-38%	-60%	-58%	-58%	-57%
NMVOC	334.05	157.17	137.90	110.53	110.83	102.83	98.78
		0%	-12%	-30%	-29%	-35%	-37%
NH_3	69.27	62.70	65.15	65.53	65.85	62.29	57.62
		0%	4%	5%	5%	-1%	-8%
$PM_{2.5}$	27.26	22.75	19.89	13.35	13.94	12.50	12.07
		0%	-13%	-41%	-39%	-45%	-47%

* NO_x and NMVOC emission in the subsector 3 B and 3 D are included in the sums and should not be taken into account for checking compliance with emission reduction commitments.

Compliance with national emission reduction commitments

According to Article 4, paragraph 3, of NEC Directive 2016/2284/EU emission of NO_x and NMVOC from the source categories NFR 3B (manure management) and 3D (agricultural soils) are not accounted for the purpose of complying. The following table meets this requirement.

Regarding the achievement of the 2030 targets, Austria will comply with all pollutants except NH_3 in the "with existing measures" scenario.

Table 4: Austrian national total emissions in kt accounted for the purpose of complying in comparison with the target 2030 and the scenario "with existing measures" (Source: Umweltbundesamt).

Pollutant [kt]	Emission inventory 2023			Emission scenario 2030 (WEM)		Target	Difference to Target
	2005	2020	2021	2025	2030	2030	2030
NO_x	237,1	113,6	111,6	88,1	70,2	73,5	-3,3
NMVOC	118,8	75,1	75,5	70,0	68,9	76,0	-7,2
SO_2	25,9	10,4	10,9	11,0	11,1	15,3	-4,2
NH_3	62,7	65,5	65,8	62,3	57,6	55,2	2,5
$PM_{2.5}$	22,7	13,3	13,9	12,5	2,1	12,3	-0,2

2.1 Nitrogen Oxides NO_x

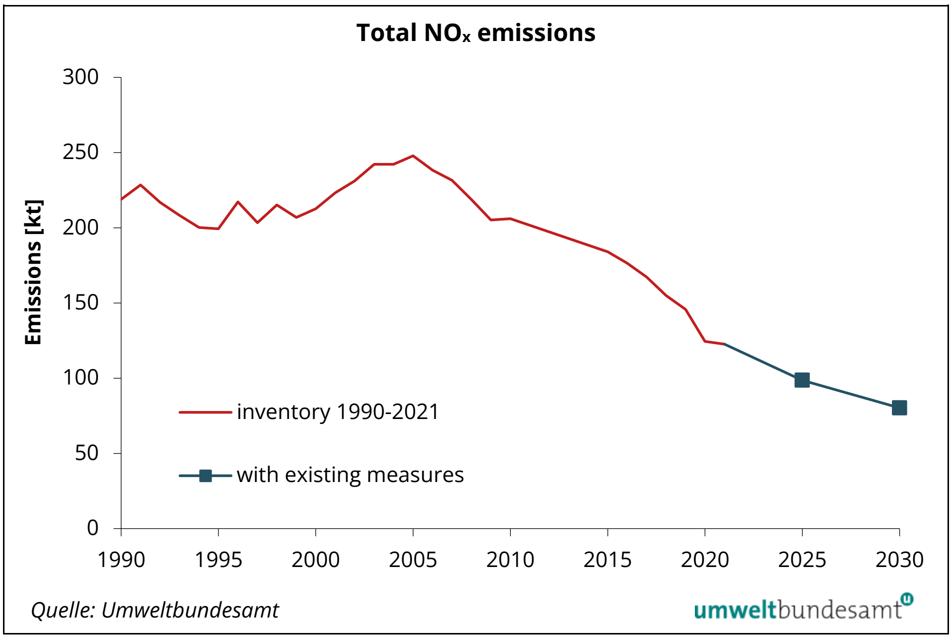
In 1990, Austria's total NO_x emissions amounted to 218.9 kt and in 2021 to 122.6 kt, meaning a decrease of 44.0 % over the period. Since 2005, an emission reduction of about 50.5 % has been achieved.

The main share of Austria's national NO_x emissions is emitted by fuel combustion activities. At 44.4 %, road transportation accounted for the biggest share of Austria's total NO_x emissions in the year 2021. In the years 2003 to 2005, NOx emissions from road traffic peaked and have since then decreased continuously. They have been reduced by 65.0 %. In particular, emissions from heavy duty vehicles (trucks and busses) have fallen due to improvements in exhaust after-treatment technology.

In the scenario "with existing measures" the national total emissions are expected to decrease to 80.3 kt by 2030 (-67.6% compared to 2005).

The main drivers of the NO_x emissions trend over the period to 2030 are expected to be road transport, households and the energy industry. Contrary to the overall trend, emissions from manufacturing industries are expected to remain stable.

Figure 1: Historical (1990 to 2021) and projected NO_x emissions for WEM (2022–2030) of based on fuel sold.



NO_x emissions from road transport (NFR 1.A.3.b.) are projected to decrease by 63.7% (i.e. -34.7 kt) from 2021 to 2030. In particular, heavy duty vehicles are projected to decrease by 78.8%, while emissions from passenger cars will decrease by 57.1%.

This decline is based on the following assumptions:

- vehicle fleet turnover in combination with decreasing specific emission factors for Euro VI (HDV), Euro 6d_temp and EURO 6d (PC)
- It is assumed that from 2025 onwards we will see substantial registrations of new BEVs (battery electric vehicles) over 100.000 cars per year. 2035 will be the first year with 100% BEV registrations in the PC an LDV sector.

Emissions from 1.A.4. Other Sectors (households, commercial and agriculture) are projected to decrease by 29.0% (i.e. -5.6 kt) from 2021 to 2030. This is mainly due to a modernisation of (and decline in emissions from) non-road mobile machinery (NRMM, so-called off-road vehicles) and a switch to low-emission technology. A switch from fossil to electric propulsion systems in these categories is partly assumed. Mobile sources in households and agriculture (off-road) show a decrease of 37.6% (-2.3kt) by 2030. Stationary sources are expected to decrease by 47.6% (-8.9 kt) by 2030 because of a decrease in the use of gas oil, ongoing stock replacement with condensing boilers and the effects of ecodesign provisions for the installation of new heating systems.

Reduced fuel inputs of gas and oil to thermal power stations and a decrease in oil and gas extraction are responsible for lower emissions in 1.A.1 Energy Industry (-12.9%, i.e. -1.3 kt) by 2030.

Emissions from 1.A.2 Manufacturing Industries and Construction decreased by 27.5% between 2005 and 2021 due to the installation of primary and secondary NO_x abatement measures. More of these measures will be implemented by

2030, but the effect is expected to be offset by an increase of emissions due to economic growth.

Table 5: Austrian national NO_x emissions in kt and trend based on 'fuel sold' (Source: Umweltbundesamt).

NFR	Description	Emission inventory 2023* [kt]					scenario [kt]		Type of scenario
		1990	2005	2010	2020	2021	2025	2030	
	Total	218.95	247.85	206.02	124.47	122.64	98.65	80.26	WEM
1 A 1	Energy Industries	17.78	14.30	12.80	9.93	9.99	8.99	8.70	WEM
1 A 2	Manufacturing Industries and Construction	33.04	33.98	32.15	24.30	24.63	23.97	23.72	WEM
1 A 3 a, c, d, e	Off-Road Transport	4.01	6.03	5.11	2.36	2.76	3.59	3.74	WEM
1 A 3 b	Road Transportation	116.17	155.57	121.32	58.25	54.50	35.77	19.79	WEM
1 A 4	Other Sectors	29.81	26.32	23.65	18.21	19.20	15.19	13.64	WEM
1 A 5	Other	0.07	0.09	0.08	0.05	0.05	0.05	0.05	WEM
1 B	Fugitive Emissions	IE	IE	IE	IE	IE	IE	IE	WEM
2A,B,C, H,I,J,K,L	Industrial Processes	4.24	0.67	0.52	0.46	0.44	0.50	0.50	WEM
2D, 2G	Solvent and Other Product Use	0.03	0.03	0.03	0.02	0.02	0.02	0.02	WEM
3 B	Manure Management	0.67	0.60	0.59	0.58	0.58	0.53	0.45	WEM
3 D	Agricultural Soils	12.97	10.16	9.74	10.26	10.43	10.00	9.59	WEM
3 F, I	Field Burning and other agriculture	0.03	0.02	0.02	0.00	0.00	0.00	0.00	WEM
5	Waste	0.12	0.07	0.03	0.04	0.04	0.04	0.04	WEM

* *Data source: Austrian Emission Inventory 2023 (UMWELTBUNDESAMT 2023b)*

IE … included elsewhere; NA … not applicable; NO … not occurring

2.2 Sulphur Dioxide SO_2

In 2021, SO_2 emissions amounted to 10.9 kt. Since 1990 (73.7 kt), emissions have decreased by 85.2 % and since 2005 by 58.0 %.

This decline is mainly due to a reduction in the sulphur content in mineral oil products and fuels (as prescribed by the Austrian Fuel Ordinance), the installation of desulphurisation units in plants (according to the Clean Air Act for boilers) and an increased use of low-sulphur fuels such as natural gas.

From 2020 to 2021, SO_2 emissions rose by 4.4 % (+0.5 kt), mainly because in the iron and steel industry (1.A.2.a), which accounts for the largest share of SO_2 emissions (43 %), the emissions rose by 7.0 % (+0.3 kt) as a result of increased production of pig iron and steel. Compared to the previous year, SO_2 emissions also increased significantly in the residential (1.A.4.b.1) and commercial/institutional heating sector (1.A.4.a.1) due to higher consumption of heating oil, coal and firewood (cooler weather compared to 2020). In the oil refinery sector (1.A.1.b) a rise of SO_2 emissions could also be observed.

In the scenario 'with existing measures' (WEM) the national total SO_2 emissions are projected to reach 11.1 kt by 2030. Compared to 2005, this is a reduction of – 57.2%. Compared to 2021, however, this means an increase of 2% (i.e.2 kt). A large part of appropriate mitigation measures (e.g. reduction of the sulphur content in liquid fuels, waste gas treatment) have already been implemented. The reduction potential is therefore only minor.

The highest decrease by 2030 is expected in NFR 1.A.4 Other Sectors (- 26.9%; - 0.4 kt) mainly due to a further shift in residential heating from solid and liquid fossil fuels (coal, oil) towards the use of heat pumps, district heat and biomass heating systems in gradually more energy-efficient buildings. Emissions from Manufacturing Industries and Construction (1.A.2) are expected to increase by 10.0% (+ 0.7 kt).

Figure 2: Historical (1990 to 2021) and projected SO_2 emissions for WEM (2022–2030) of based on fuel sold.

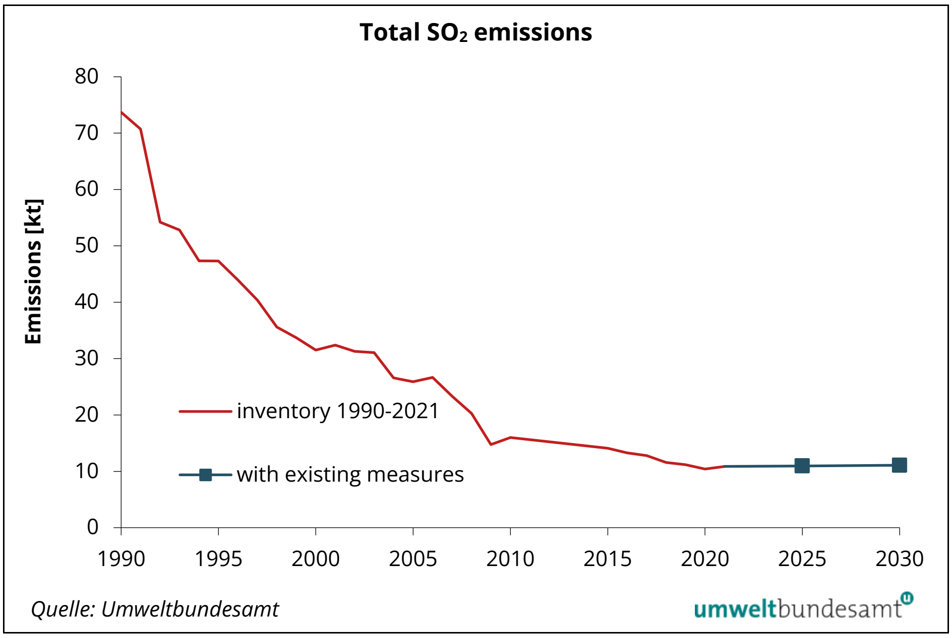


Table 6: Austrian national SO_2 emissions in kt and trend based on 'fuel sold' (Source: Umweltbundesamt).

NFR	Description	Emission inventory 2023* [kt]					scenario [kt]		Type of scenario
		1990	2005	2010	2020	2021	2025	2030	
	Total	73.70	25.89	15.99	10.41	10.87	10.95	11.09	WEM
1 A 1	Energy Industries	14.07	6.71	2.74	1.04	1.14	1.00	0.99	WEM
1 A 2	Manufacturing Industries and Construction	17.83	10.12	9.40	7.26	7.38	7.94	8.12	WEM

NFR	Description	Emission inventory 2023* [kt]					scenario [kt]		Type of scenario
		1990	2005	2010	2020	2021	2025	2030	
1 A 3 a, c, d, e	Off-Road Transport	0.36	0.19	0.18	0.08	0.09	0.13	0.15	WEM
1 A 3 b	Road Transportation	4.77	0.16	0.13	0.12	0.13	0.12	0.11	WEM
1 A 4	Other Sectors	32.66	7.88	2.77	1.27	1.50	1.12	1.10	WEM
1 A 5	Other	0.01	0.01	0.01	0.01	0.01	0.01	0.01	WEM
1 B	Fugitive Emissions	2.00	0.04	0.05	0.02	0.03	0.02	0.01	WEM
2A,B,C, H,I,J,K,L	Industrial Processes	1.93	0.72	0.70	0.58	0.59	0.59	0.59	WEM
2D, 2G	Solvent and Other Product Use	0.00	0.01	0.01	0.00	0.00	0.00	0.00	WEM
3 B	Manure Management	NA	NA	NA	NA	NA	NA	NA	WEM
3 D	Agricultural Soils	NA	NA	NA	NA	NA	NA	NA	WEM
3 F, I	Field Burning and other agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	WEM
5	Waste	0.07	0.06	0.01	0.02	0.02	0.02	0.02	WEM

* *Data source: Austrian Emission Inventory 2023 (UMWELTBUNDESAMT 2023b)*

IE … included elsewhere; NA … not applicable; NO … not occurring

2.3 Non-Methane Volatile Organic Compounds (NMVOCs)

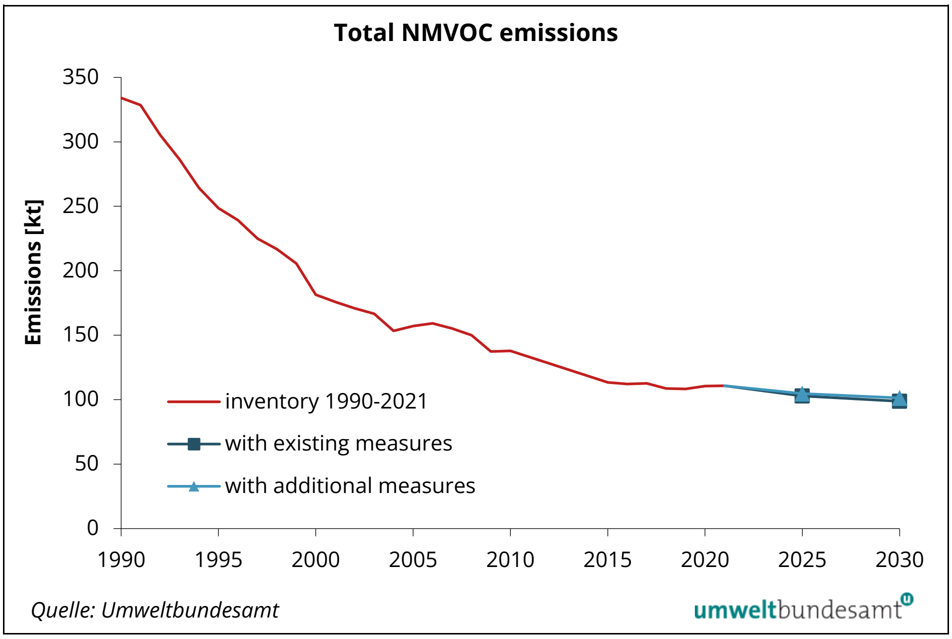
Non-methane volatile organic compounds emissions amounted to 334.1 kt in 1990 and to 110.8 kt in 2021. This corresponds to a reduction of 66.8 %. From 2020 to 2021, NMVOC emissions increased by 0.3 kt (+ 0.3 %).

The largest reductions since 1990 have been achieved in the road transport sector due to an increased use of catalytic converters and diesel cars. Currently the road transport sector (1.A.3.b.) accounts only for a small share (3.4 %) of Austria's total NMVOC emissions.

In 2021, the main sources of NMVOC emissions in Austria are NFR 2.D.3 Solvent Use with a share of 31.1%, the agriculture sector (3) with a share of 31.9 % and the NFR 1.A.4.b.1 Residential stationary heating with 22.7 % of the total NMVOC emissions.

In the scenario 'with existing measures' (WEM) national total NMVOC emissions are expected to decrease to 98.8 kt by 2030 (-37.2% compared to 2005).

Figure 3: Historical (1990 to 2021) and projected NMVOC emissions for WEM (2022–2030) of based on fuel sold.



Total NMVOC emissions are projected to decrease by 10.9% by 2030 (compared to 2021). The largest reduction is expected to be achieved in Sector 1.A.4 (mainly households and commercial), with a decrease of 24.9% (i.e. -7.3 kt) over the period from 2021 to 2030. This is mainly due to a trend towards low emission technologies (heating types) and projected lower emission factors for new boilers in the buildings sector (see also ecodesign requirements in Chapter 4.1.3), as well as a decrease in the use of fuel wood as a source of energy.

Emissions in NFR sector *1.A.3 Road Transport* are projected to fall by 13.2% (i.e. - 0.6 kt) by 2030, in earlier years owing to state-of-art exhaust gas treatment (regulated catalytic converter) and a substantial share of electric vehicles in the long-term causing zero direct emissions.

On the other hand, emissions from 2.D.3 'Solvent Use' are expected to increase by 5.1% by 2030 (i.e.1.8 kt) due to projected economic growth resulting in an increase in solvent use. Emission regulations for the relevant sectors have been enforced at EU level, with some of the legal requirements in Austria being even stricter. The requirements for paints and varnishes were harmonised at EU level, existing regulations do not forsee a further tightening of emission standards. Calculations are based on solvent balances from companies, and linked to economic projections for the respective sub sectors, coupled with expert judgement on the actual increase of solvent use, taking into account the offset due to new technologies.

Emissions from agriculture are projected to decrease by 15.4% (i.e. 5.5 kt) by 2030 compared to 2021, mainly caused by the developments of livestock in Austria.

Table 7: Austrian national NMVOC emissions in kt and trend based on 'fuel sold' (Source: Umweltbundesamt).

NFR	Description	Emission inventory 2023* [kt]					scenario [kt]		Type of scenario
		1990	2005	2010	2020	2021	2025	2030	
	Total	334.05	157.17	137.90	110.53	110.83	102.83	98.78	
1 A 1	Energy Industries	0.32	0.24	0.35	0.30	0.31	0.31	0.31	WEM
1 A 2	Manufacturing Industries and Construction	1.68	2.06	1.94	0.97	0.96	0.89	0.88	WEM
1 A 3 a, c, d, e	Off-Road Transport	1.53	1.79	1.45	0.51	0.62	0.94	0.89	WEM
1 A 3 b	Road Transportation	96.36	20.26	10.11	3.95	3.75	3.50	2.89	WEM
1 A 4	Other Sectors	48.49	33.64	34.79	26.60	29.33	23.13	22.02	WEM
1 A 5	Other	0.01	0.02	0.01	0.01	0.01	0.01	0.01	WEM
1 B	Fugitive Emissions	15.59	3.46	2.57	2.03	2.02	2.16	2.01	WEM
2A,B,C, H,I,J,K,L	Industrial Processes	4.36	3.56	3.72	3.84	3.86	3.47	3.50	WEM
2D, 2G	Solvent and Other Product Use	114.61	53.63	44.99	36.86	34.57	35.55	36.32	WEM
3 B	Manure Management	33.52	26.95	27.03	25.91	26.03	24.60	22.60	WEM
3 D	Agricultural Soils	17.37	11.40	10.82	9.50	9.33	8.23	7.31	WEM
3 F, I	Field Burning and other agriculture	0.06	0.04	0.03	0.00	0.00	0.00	0.00	WEM
5	Waste	0.17	0.12	0.10	0.06	0.06	0.05	0.05	WEM

* *Data source: Austrian Emission Inventory 2023 (UMWELTBUNDESAMT 2023b)*

IE … included elsewhere; NA … not applicable; NO … not occurring

2.4 Ammonia (NH_3)

Ammonia emissions amounted to 65.8 kt in 2021. Since 1990, NH_3 emissions have decreased by 4.9 %, although since 2005 they have increased by 5.0 %.

The main source of NH_3 emissions is the agriculture sector with a share of 94.1 % in 2021. Within the agriculture sector about 51 % of NH_3 emissions result from Manure Management (3.B) and 49 % from Agricultural Soils (3.D).

There was a decrease of 7.0 % in NH_3 emissions from the agriculture sector between 1990 and 2021. This reduction can be mainly explained by decreasing cattle numbers, more efficient feeding and an increased application of low emission spreading techniques (e.g. band spreading, trailing shoe, rapid incorporation of manure).

Agricultural NH_3 emissions mainly arise from animal husbandry and the application of organic and mineral N fertilisers.

Within sector *3.B Manure Management* emissions arise from animal husbandry and the storage of manure. In manure management, cattle accounts for the highest share (63% in 2021). Levels of emissions depend on livestock numbers but also on housing systems and manure treatment (e.g. NH_3 emissions from loose housing systems are considerably higher than those from tied housing systems). Since 2005, NH_3 emissions from agriculture have increased by 7.8%, mainly due to higher emissions from cattle, which are increasingly housed in loose housing systems for animal welfare reasons.

Ammonia emissions from *3.D Agricultural Soils* occur as a result of the application of mineral N fertilisers as well as organic fertilisers (including animal manure, sewage sludge, digestates from biogas plants and compost). Another source of NH_3 emissions is urine and dung deposited on pastures by grazing animals.

In the scenario 'with existing measures' (WEM), national total emissions are expected to decrease to 57.6 kt by 2030 (-8.1% compared to 2005). For the period between 2021 and 2030, NH_3 emissions show a decrease in by 12.5%.

Declining animal numbers and existing measures such as the increased use of low-emissions manure spreading techniques in the agriculture sector are the main reasons for decreased emissions in 2030. National forecasts for the agricultural production in Austria (WIFO & BOKU 2023) show that cattle numbers will decrease by 13% between 2021 and 2030. Pig numbers decreases at a much higher rate because the output price and input cost relations are less favourable. Poultry numbers will decline at a similar rate as the number of pigs until 2030. In accordance with Austria's CAP-SP the share of low-emission spreading techniques will be increased significantly in the coming years (see Chapter 4.5).

Figure 4: Historical (1990 to 2021) and projected NH_3 emissions for WEM (2022–2030) of based on fuel sold.

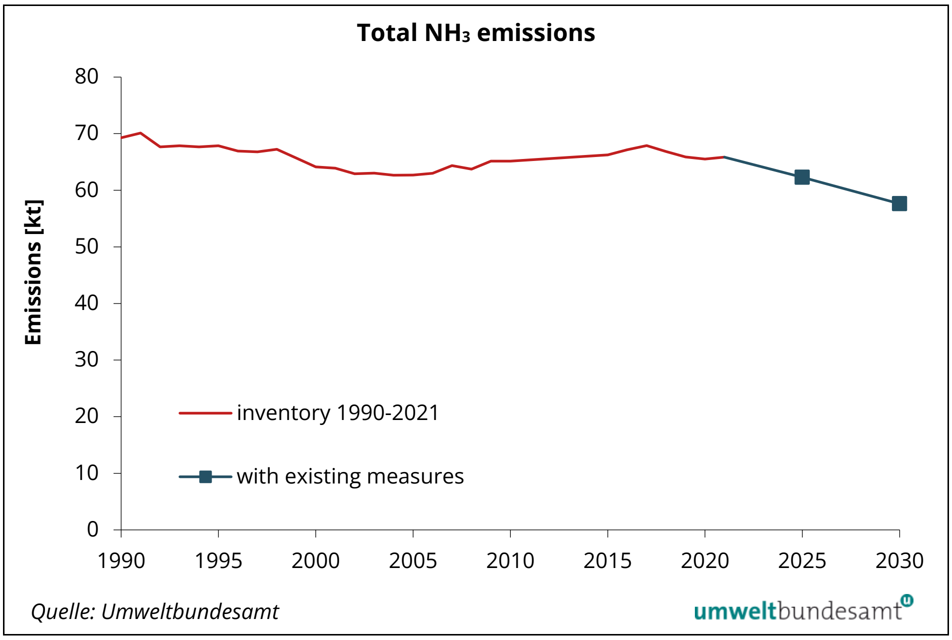


Table 8: Austrian national NH_3 emissions in kt and trend based on 'fuel sold' (Source: Umweltbundesamt).

NFR	Description	Emission inventory 2023* [kt]					scenario [kt]		Type of scenario
		1990	2005	2010	2020	2021	2025	2030	
	Total	69.27	62.70	65.15	65.53	65.85	62.29	57.62	WEM
1 A 1	Energy Industries	0.20	0.31	0.46	0.43	0.44	0.44	0.44	WEM
1 A 2	Manufacturing Industries and Construction	0.33	0.43	0.42	0.39	0.40	0.40	0.40	WEM
1 A 3 a, c, d, e	Off-Road Transport	0.01	0.01	0.01	0.01	0.01	0.02	0.01	WEM
1 A 3 b	Road Transportation	0.80	2.58	1.85	0.89	0.94	1.02	0.95	WEM
1 A 4	Other Sectors	0.63	0.67	0.68	0.60	0.68	0.54	0.55	WEM
1 A 5	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	WEM
1 B	Fugitive Emissions	IE	0.00	0.00	0.00	0.00	0.00	0.00	WEM
2A,B,C, H,I,J,K,L	Industrial Processes	0.27	0.07	0.09	0.10	0.09	0.09	0.09	WEM
2D, 2G	Solvent and Other Product Use	0.07	0.06	0.06	0.06	0.06	0.05	0.05	WEM
3 B	Manure Management	29.66	28.29	29.79	31.26	31.56	30.41	28.07	WEM
3 D	Agricultural Soils	36.91	29.16	30.59	30.56	30.40	28.05	25.79	WEM
3 F, I	Field Burning and other agriculture	0.03	0.02	0.02	0.00	0.00	0.00	0.00	WEM
5	Waste	0.37	1.09	1.17	1.24	1.27	1.26	1.27	WEM

* *Data source: Austrian Emission Inventory 2023 (UMWELTBUNDESAMT 2023b)*

IE … included elsewhere; NA … not applicable; NO … not occurring

2.5 Fine Particulate Matter ($PM_{2.5}$)

Since 1990, $PM_{2.5}$ emissions have decreased by 48.9 %. The decrease since 2005 is estimated at 38.7 %.

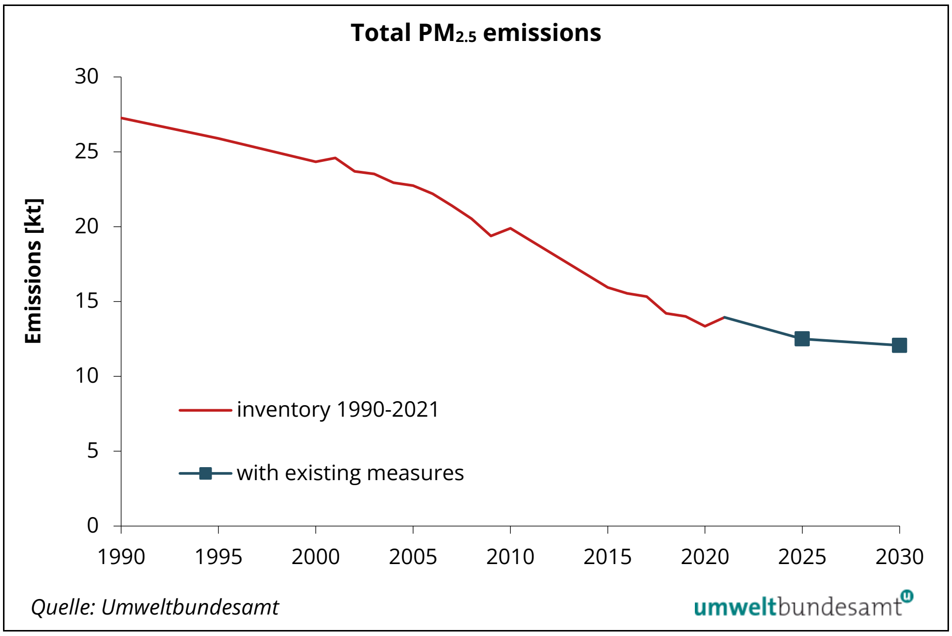
The largest reductions were achieved through reduced coal consumption in households (1.A.4.b.1) and improved vehicle exhaust after-treatment technologies in road transport (1.A.3.b).

From 2020 to 2021, $PM_{2.5}$ emissions increased by 0.6 kt (+4.5 %), due to higher biomass consumption from residential heating (1.A.4.b.1) because of the colder weather and the higher heating demand.

With a share of about 45.1 %, sector 1.A.4.b.1 residential: stationary was the main source of total $PM_{2.5}$ emissions in 2021. The change in emissions between 2020 and 2021 by +9.4 % was due to the increased volume of biomass used for heating because of the colder weather in 2021. To some extent, the overall decreasing trend of 1.A.4.b.1 stationary residential heating since 2005 can also be explained by efficiency improvements through thermal renovation and a switch to modern biomass boilers and stoves (improvements in fuel combustion technologies).

In the scenario "with existing measures" (WEM) the national total emissions are expected to decrease to 12.1 kt by 2030 (- 46.9% compared to 2005).

Figure 5: Historical (1990 to 2021) and projected $PM_{2.5}$ emissions for WEM (2022–2030) of based on fuel sold.



In the WEM scenario, $PM_{2.5}$ emissions of 1.A.4 Other Sectors are expected to decrease by 23.2% (i.e -1.7 kt) in 2030 compared to 2021. $PM_{2.5}$ emission reductions are mainly due to a trend away from manually fed fuel wood boilers and wood stoves. Furthermore, biomass heating systems will be used in gradually more energy-efficient buildings. Thus, a decreasing energy demand for fuel wood (and coal) is responsible for $PM_{2.5}$ reductions. This is also supported by the effects of ecodesign provisions for the installation of new heating systems.

Total $PM_{2.5}$ emissions from the road transport sector (NFR 1.A.3.b) are expected to decrease by about 19.3% (i.e. -0.4 kt) compared to 2021. Whereas exhaust emissions from cars and trucks are expected to decrease by 2030 (due to a higher penetration of vehicles fitted with filters and an increased share of BEVs), emissions from automobile road abrasion and vehicles (tyre, brake wear) are set to increase slightly because of an increase in total vehicle kilometres driven.

In the sector Energy Industries (NFR 1.A.1) a decrease in $PM_{2.5}$ emissions has been observed (-7.1%; 0.1 kt), generally due to a decrease in biomass usage for electricity and heat generation.

Emissions from 1.A.2 Manufacturing Industries and Construction decreased by 65.7% between 2005 and 2021 due to the installation of electrostatic precipitators and bag filters. By 2030, more of these devices will be in use, but the effect will be offset by an increase in emissions due to economic growth.

Table 9: Austrian national $PM_{2.5}$ emissions in kt and trend based on 'fuel sold' (Source: Umweltbundesamt).

NFR	Description	Emission inventory 2023* [kt]					scenario [kt]		Type of scenario
		1990	2005	2010	2020	2021	2025	2030	
	Total	27.26	22.75	19.89	13.35	13.94	12.50	12.07	WEM
1 A 1	Energy Industries	0.85	0.80	1.10	0.96	1.00	0.95	0.93	WEM
1 A 2	Manufacturing Industries and Construction	1.88	1.85	1.52	0.70	0.63	0.71	0.75	WEM
1 A 3 a, c, d, e	Off-Road Transport	0.70	0.66	0.52	0.29	0.31	0.36	0.37	WEM
1 A 3 b	Road Transportation	5.70	7.21	4.89	2.01	1.96	1.73	1.58	WEM
1 A 4	Other Sectors	13.31	9.02	9.15	6.88	7.45	6.01	5.72	WEM
1 A 5	Other	0.02	0.02	0.02	0.01	0.01	0.01	0.01	WEM
1 B	Fugitive Emissions	0.11	0.09	0.07	0.05	0.05	0.05	0.05	WEM
2A,B,C, H,I,J,K,L	Industrial Processes	3.57	2.09	1.53	1.47	1.54	1.72	1.72	WEM
2D, 2G	Solvent and Other Product Use	0.52	0.47	0.48	0.39	0.38	0.38	0.37	WEM
3 B	Manure Management	0.13	0.11	0.11	0.11	0.11	0.11	0.09	WEM
3 D	Agricultural Soils	0.14	0.15	0.14	0.14	0.14	0.13	0.13	WEM
3 F, I	Field Burning and other agriculture	0.07	0.06	0.05	0.00	0.00	0.00	0.00	WEM
5	Waste	0.25	0.23	0.31	0.34	0.34	0.33	0.34	WEM

* *Data source: Austrian Emission Inventory 2023 (UMWELTBUNDESAMT 2023b)*

IE ... included elsewhere; NA ... not applicable; NO ... not occurring

3 POLICIES AND MEASURES (PAMS)

For the submission in March only one scenario "WEM, with existing measures" was modelled, which includes all measures implemented by 1 January 2022. Later in the year also a scenario "with additional measures" will be available. This scenario will include planned policies and measures, which were reported under the National Air Pollution Control Programme and in the Integrated National Energy and Climate Plan for Austria.

For all sectors, reduction measures were identified and emissions projected through specifically designed models. The methodology used for the projections and emission calculations is described in the respective chapters. Consistency between the sector models was ensured by regular expert meetings where potential overlaps and gaps were identified and discussed.

The Austrian air pollutant projections are consistent with current GHG emissions projections under the EU Governance Regulation (EU 2018/1999). A detailed description of the individual measures for GHGs is provided in the report, submitted under the Governance Regulation in 2023 (UMWELTBUNDESAMT 2023c).

Measures to reduce GHG emissions and air emissions have been identified and are considered in the WEM. Measures on GHG emissions and air pollutants strongly interact. They either have impacts across a number of sectors (cross-cutting measures) or they target specific sectors and represent the basis for Austria's air pollutant projections.

3.1 Cross-cutting measures

- EU Emission Trading Scheme (WEM)
    - The system covers CO_2 emissions from large emitters in the industrial sectors, from energy and heat supply to aircraft operators, as well as N_2O emissions from the chemical industry. The EU ETS also has positive side-effects on SO_2 and NO_x in that it encourages operators to upgrade their facilities in order to reduce emissions and increase efficiency.
- Domestic Environmental Support Scheme (WEM)
    - The objective of this funding scheme is to protect the environment and to reduce pressures such as air pollution, greenhouse gas and noise emissions, and waste generation.
- Austrian Climate and Energy Fund (WEM):
    - The main objective of this fund is to provide subsidies for research in – and the implementation of – climate friendly technology, and thus to produce positive side effects on air pollution.

3.2 Energy Industries (1.A.1) and Manufacturing Industries and Construction (1.A.2)

- Increase the share of renewable energy in power supply and district heating (WEM)
  - Increasing the share of renewable energy in power supply and district heating is the main purpose of this policy designed to reduce the impacts of energy systems on the climate. Beyond the traditional use of large-scale hydro-power for electricity generation, quantitative targets have been set for increasing the share of wind power, photovoltaics, small hydropower plants and biomass/biogas in electricity generation in the Renewable Energy Act (Erneuerbare-Ausbau-Gesetz). These targets are to be achieved by fixed feed-in tariffs. Investment support has been granted for biomass-based district heating systems (see PaM Domestic Environmental Support Scheme).

- Increase energy efficiency in energy and manufacturing industries (WEM)
  - An increase in energy efficiency in the energy and manufacturing industries is essential if the growing demand for fuel is to be reduced, along with environmental impacts. Based on EU legislation, Austria implemented an Energy Efficiency Directive (2012/27/EU) and prepared a National Energy Efficiency Action Plan in 2017 with quantitative targets for final and primary energy consumption in 2020.

3.3 Transport (1.A.3)

- Increase the share of renewable energy sources in road transport (WEM)
  - Implementation of the Renewables Directives (2009/28/EC and 2018/2001/ EC) on the promotion of the use of energy from renewable sources and EU CO2 reduction targets for PC, LDV and HDV.

- Increase fuel efficiency in road transport (WEM)
  - Supported by the following instruments: Air quality induced speed limits to tackle local air quality problems and the Eco-Driving initiative of 'klimaaktiv mobil' for fuel saving.
  - Fiscal policy instruments: fuel tax increase in 2011 and greening the truck toll 2010.

- Modal shift in passenger and freight transport
  - The promotion of a modal shift towards active and environmentally friendly transport modes (cycling and walking) is a cornerstone of the 'klimaaktiv mobil' initiative for mobility management and awareness. It is a funding programme for businesses, communities and associations and includes target group-oriented counselling programmes,

  awareness-raising initiatives, partnerships, and training and certification initiatives.
  - The instruments for pushing the share of public transport are the Federal Austrian Railway Framework Plan 2022 – 2027 and nationwide and regional public transport tickets.
  - The instruments to achieve a shift in the modal split towards rail transport and navigation are the Federal Austrian Railway Framework Plan 2022 – 2027, rail freight subsidies and promotion of corporate rail connections for freight transport and the Action Plan Danube until 2022.

3.4 Other Sectors (NFR 1 A 4)

- **Climate Neutral New Buildings (WEM)**
  In the WEM scenario, the full implementation of Directive 2010/31/EU sets the nearly zero-energy building standard for new buildings. High-efficiency alternative heating systems have to be considered, if available. Requirements on the renewable share support the installation of solar appliances. Federal bans on solid and liquid fossil fuel heating systems apply. In the case of subsidies from the Housing Support Scheme ('Wohnbauförderung') additional funding is granted, if stronger standards than the minimum criteria for energy efficiency of the building envelope and for the choice of heating systems are succeeded.
  - OIB Guideline 6 – Energy Savings and Thermal Insulation
  - Oil Boiler Installation Prohibition Act ('Ölkesseleinbauverbotsgesetz – ÖKEVG 2019')
  - Constitutional Art. 15a Agreement on Measures in the Building Sector to reduce Greenhouse Gas Emissions (Federal – State)
  - Funding Programmes to support renewable heating systems and to improve the improve the thermal energy efficiency of the building envelope of new buildings:
    - Domestic Environmental Support Scheme ('Umweltförderung im Inland')
    - Housing Support Scheme ('Wohnbauförderung')
    - Austrian Climate and Energy Fund ('Klima- und Energiefonds')

- **Thermal Improvement of Building Stock (WEM)**
  In the WEM scenario, the full implementation of Directive 2010/31/EU maintains a mandatory energy performance building standard for major renovation. In the case of subsidies from the Housing Support Scheme ('Wohnbauförderung') additional funding is granted, if stronger standards than the minimum criteria for energy efficiency of the building envelope are succeeded. An obligation for having energy performance certificates applies, when renting, leasing or selling buildings.
  - OIB Guideline 6 – Energy Savings and Thermal Insulation

- Constitutional Art. 15a Agreement on Measures in the Building Sector to reduce Greenhouse Gas Emissions (Federal – State)
- Funding Programmes to improve the thermal energy efficiency of the building envelope of existing buildings:
  - Domestic Environmental Support Scheme ('Umweltförderung im Inland')
  - Housing Support Scheme ('Wohnbauförderung')
  - Austrian Climate and Energy Fund ('Klima- und Energiefonds')
  - Building Renovation Initiative for Commercial/Institutional buildings ('Sanierungsoffensive für Betriebe')
  - Building Renovation Initiative for Residential Buildings ('Sanierungsoffensive für Private')
- Act on the Presentation of an Energy Performance Certificate ('Energieausweis-Vorlage-Gesetz 2012 – EAVG 2012')

- **Replacement of Fossil Fuels in Building Stock (WEM)**
  In the WEM scenario, the full implementation of Directive 2010/31/EU maintains that for buildings undergoing replacement of heating systems (alongside or without thermal renovation of the building envelope) high-efficiency alternative systems have to be considered, if available. Requirements on the renewable share support the installation of solar appliances. In the case of subsidies from the Housing Support Scheme ('Wohnbauförderung') additional funding is granted, if stronger standards than the minimum criteria for the choice of heating systems are succeeded. It is assumed, that the focus programme Stepping out of Oil and Gas ('Raus aus Öl und Gas') maintains higher subsidy rates until 2025 for the exchange of fossil fuel heating systems. This bonus phases out until 2040.
  - OIB Guideline 6 – Energy Savings and Thermal Insulation
  - Constitutional Art. 15a Agreement on Measures in the Building Sector to reduce Greenhouse Gas Emissions (Federal – State)
  - District Heating and Cooling Act ('Wärme- und Kälteleitungssausbaugesetz')
  - Funding Programmes for replacement of fossil heating systems to support renewable heating systems in existing buildings:
    - Domestic Environmental Support Scheme ('Umweltförderung im Inland')
    - Housing Support Scheme ('Wohnbauförderung')
    - Austrian Climate and Energy Fund ('Klima- und Energiefonds')
    - Stepping out of Oil and Gas ('Raus aus Öl und Gas') as focus programme of the Building Renovation Initiative for Residential Buildings ('Sanierungsoffensive für Private')

- **Energy Efficiency Measures in Buildings (WEM)**
  An increase in energy efficiency in electricity demand in buildings is a further policy target which is to be achieved by far-reaching instruments at

EU level. Especially the eco-design requirements (Directive 2005/32/EC) for energy-using products and mandatory labelling of household appliances according to their energy consumption (see instrument Energy Labelling of Space and Water Heating Products below), supported by awareness raising measures at national level to inform people of energy efficient products, and advice provided by regional energy agencies are included here. Furthermore, the ecodesign standard emission requirements influence the NO_x, NMVOC and $PM_{2.5}$ emission factors for new installations of heating systems.

- Eco-design Ordinance ('Ökodesign-Verordnung 2007 – ODV 2007)
- Energy Labelling of Space and Water Heating Products ('Elektrotechnikgesetz 1992')
- Funding programmes to improve the energy efficiency of existing buildings
- Domestic Environmental Support Scheme ('Umweltförderung im Inland')
- Austrian Climate Protection Initiative ('klimaaktiv'):
  - e5-communities: consultancy for communities to promote climate policies
  - energy saving: education, information and advice for consumers and commercial enterprises to reduce energy consumption
  - renewable energy: provide know-how and support networking for committed companies and associations
- Consultancy service and information campaigns

3.5 Industrial Processes and Product Use (2)

2.D.3 Solvents and other product use

The Austrian Ordinance on Solvents 2005 (BGBl. II Nr. 398/2005) is the implementation of the EU Deco Paints Directive 2004/42/EC: it limits the solvent content in paints and varnishes as well as vehicle refinishing products for reducing VOC emissions.

The Austrian Ordinance on VOC emissions from installations (VOC Anlagen VO BGBl. II Nr. 301/2002) is the implementation of the Industrial Emissions Directive 2010/79/EU regarding industrial activities with relevant solvent use: installations either comply with VOC emission limits, or to work out a reduction plan for VOC emissions. Additionally, all installations with an annual solvent use above a certain threshold are obliged to annually provide a balance on solvent use as well as emissions to authorities.

3.6 Agriculture (3)

Implementation of EU agricultural policies

Agricultural policy according to the CAP Strategic Plan (REGULATION (EU) 2021/2115) as implemented in 2023. This includes the agri-environmental programme and subsidies for investments relevant to air pollution control.

Austria's CAP Strategic Plan (CAP-SP) 2023-2027 was approved in September 2022. Under the Austrian GAP-SP (BML, 2022), a total of 98 interventions are jointly programmed and implemented. For more information please refer to Chapter 4.5).

The implementation of this policy includes e.g. improvements in feeding, the covering of manure storages, low-loss application of manure and biogas slurry, promotion of organic farming, promotion of grazing, reduced usage of mineral fertilisers.

3.7 Waste (5)

- Reduce emissions from waste treatment through further implementation of the Landfill Directive and by avoiding emissions from anaerobic treatment of biogenic waste through covered storage facilities (WEM).

4 METHODOLOGY

4.1 Stationary Fuel Combustion Activities (NFR 1 A)

Total energy demand and production was evaluated on the basis of energy scenarios developed by a consortium of the Centre of Economic Scenario Analysis and Research (CESAR), the Zentrum für Energiewirtschaft (e-think) and the Institute for Thermodynamics and Sustainable Engines at the Graz University of Technology. The scenarios were developed using several models:

- econometric input-output data (MIO-ES)
- domestic heating and domestic hot water supply (INVERT/EE-Lab)
- public electrical power and district heating supply (MIO-ES)
- energy demand and emissions of transport (NEMO & GEORG)

The econometric input-output model MIO-ES combines a private consumption module with an energy and environment module. Important input parameters are energy prices, population and household income (CESAR, 2020). This model was also used to calculate the energy sector.

For modelling energy consumption in domestic heating and domestic hot water supply, the software package INVERT/EE-Lab (E-THINK 2023) was used. INVERT/EE-Lab is based on a stochastic, non-recursive, myopic and economic algorithm, with the objective function to minimise costs. The basic algorithm is based on the principle of the INVERT model. It enables calculation of the energy demand for heating (space heating and hot water) in apartment buildings and in buildings of the public or private service sector while also including the effects of various funding instruments. The main inputs for the calculation are:

- availability of resources
- market penetration of different technologies
- maximum replacement and refurbishment periods
- minimum and maximum lifetime of technical installations
- The results produced by the different models were exchanged and adjusted within several modelling cycles. Umweltbundesamt experts combined the data produced by the different models and included additional calculations for
    - energy inputs for the iron and steel industry,
    - production of electric power and district heating in industry,
    - use of waste as a fuel in power plants and industry,
    - energy input of compressor stations,
    - total energy demand,
    - electricity demand in the transport sector.

This chapter describes the methodology used for emission projections for stationary fuel combustion in the NFR Sectors 1.A.1, 1.A.2 and 1.A.4. The methodology applied for the determination of emission factors is described in the Austrian Inventory Report (UMWELTBUNDESAMT 2023a). Data on energy demand have been split according to the sub-sectors of the Austrian Air Emission Inventory.

4.1.1 Energy Industry (NFR 1 A 1)

This chapter describes the methodology used for emission projections for stationary fuel combustion in the energy and transformation industries.

The model MIO-ES was used which provides fuel-specific activity data on energy industries (i.e. electricity and heat production including waste incineration). The data were multiplied by the same fuel-specific emission factors as those used in the Austrian Inventory.

SO_2, NO_x and $PM_{2.5}$

Projected emissions of SO_2, NO_x and $PM_{2.5}$ were calculated by multiplying projected energy data (UMWELTBUNDESAMT 2023a) by the respective emission factors. The latter were determined based on the Austrian Inventory.

The only refinery operating in Austria installed an SNOX system in November 2007, thereby significantly reducing its emissions of SO_2 and NO_x. As no other changes are expected over the next few years, emission projections have been based on current emission levels.

A detailed description of the methodologies used for Austria's emission projections can be found in the cited literature (UMWELTBUNDESAMT, 2003 a/b/c; BMLFUW, 2004 and UMWELTBUNDESAMT & BMLFUW 2002).

As regards electricity and heat production, it has been assumed that coal and oil-fired plants will shut down by 2020. For gas power plants in the WEM scenario it has been assumed that inputs will slowly decrease in the years to 2050. It has been assumed that there will be no changes of the emission factor for gas plants until 2050.

For installations using solid biomass, emission factors for various plant sizes have been provided in the literature (UMWELTBUNDESAMT, 2007b). Emission factors have not been changed for the time period considered in the WEM scenario.

It has been assumed that the emission factors for waste incineration plants, oil and gas exploration, and for refineries do not change over time.

NMVOC and NH_3

NMVOC and NH_3 emissions are assumed to remain constant at 2021 levels (UMWELTBUNDESAMT 2023b). This simple approach has been chosen because the share of these emissions in the total emissions is less than 1%.

4.1.2 Manufacturing Industry and Combustion (NFR 1 A 2)

This chapter describes the methodology used for emission projections for stationary fuel combustion in the manufacturing industry. A methodological description of emission projections for mobile sources in NFR 1 A 2 is given in Chapter 0.

SO_2 and NO_x

SO_2 and NO_x emissions have been estimated for the NFR Sectors 1.A.2 and 2 grouped together (UMWELTBUNDESAMT, 2003a/c; UMWELTBUNDESAMT, 2007a and UMWELTBUNDESAMT, 2009). The following industrial activities have been identified as major emission sources:

- production in the cement, glass, magnesia, lime and other mineral industries
- iron and steel production
- pulp and paper production
- process emissions from the chemical industry
- wood processing industry
- food industry
- production of non-ferrous metals
- other sectors of the manufacturing industries

Projected emissions were calculated on the basis of trends observed in energy scenarios (UMWELTBUNDESAMT, 2023c) and by incorporating recent data from environmental impact statements on facility expansions and the opening and closing of facilities. For compiling emission projections, emissions factors from the latest inventory and, if available, plant specific data were used.

NMVOC and NH_3

NMVOC and NH_3 emissions from stationary sources are assumed to remain constant at 2021 levels (UMWELTBUNDESAMT, 2023a). This simple approach has been chosen because the share of these emissions in the total emissions is less than 1% for each source.

$PM_{2.5}$

Projected emissions were calculated on the basis of trends observed in energy scenarios (UMWELTBUNDESAMT 2023c) and by incorporating recent data from environmental impact statements on facility expansions and the opening and closing of facilities.

Projections for process emissions from quarries, construction activities and the wood industry are based on extrapolation of past trends.

4.1.3 Other Sectors (NFR 1 A 4)

This chapter describes the methodology used in the WEM scenario and the WAM scenario for emission projections for stationary fuel combustion in the small combustion sector (1 A 4 a Commercial/Institutional, 1 A 4 b Residential (households), and 1 A 4 c Agriculture/Forestry/Fishing. A methodological description of emission projections for mobile sources in NFR 1 A 4 is given in Chapter 4.2.

Activities

A comprehensive model for buildings (INVERT/EE-Lab) has been used to calculate energy consumption for stationary sources separately for the sub-sectors residential and commercial (E-THINK, 2023). Inputs to mobile sources in agriculture were derived with the econometric input-output model MIO-ES. A detailed description of these models can be found in (UMWELTBUNDESAMT, 2023c), e-think, 2023 and (CESAR, 2020).

Emissions

SO_2, NO_x, NMVOC, NH_3 and $PM_{2.5}$ emissions were calculated based on energy demand for stationary sources in sub-sectors 1 A 4 a, 1 A 4 b and 1 A 4 c. A description of the methods and emission factors used for these calculations can be found in the Austrian Informative Inventory Report (UMWELTBUNDESAMT, 2023b).

There are twenty-two technology and fuel dependent main subcategories (heating types) for stationary fuel consumption of category *1.A.4 Other Sectors* as presented in the following table.

Table 10: Heating types of category 1 A 4 Other Sectors – stationary sources (Source: Umweltbundesamt)

No.	Heating type	Fuel
#1	Fuel oil boilers	Light fuel oil, medium fuel oil, heavy fuel oil, diesel, petroleum, other petroleum products
#2	Gas oil stoves	Gas oil
#3	Vapourizing burners	Gas oil
#4	Yellow burners	Gas oil
#5	Blue burners with conventional technology	Gas oil

No.	Heating type	Fuel
#6	Blue burners with low temperature or condensing technology	Gas oil
#7	Natural gas convectors	Natural gas
#8	Atmospheric burners	Natural gas, biogas, sewage sludge gas and landfill gas
#9	Forced-draft natural gas burners	Natural gas, biogas, sewage sludge gas and landfill gas
#10	LPG stoves	Liquefied petroleum gases
#11	LPG boilers	Liquefied petroleum gases
#12	Wood stoves and cooking stoves	Fuel wood
#13	Tiled wood stoves and masonry heaters	Fuel wood
#14	Mixed-fuel wood boilers	Fuel wood
#15	Natural-draft wood boilers	Fuel wood
#16	Forced-draft wood boilers	Fuel wood
#17	Wood chips boilers with conventional technology	Wood waste
#18	Wood chips boilers with oxygen sensor emission control	Wood waste
#19	Pellet stoves	Wood waste
#20	Pellet boilers	Wood waste
#21	Coal stoves	Hard coal and Hard coal briquettes, lignite and brown coal, brown coal briquettes, coke, peat
#22	Coal boilers	Hard coal and Hard coal briquettes, lignite and brown coal, brown coal briquettes, coke, peat, industrial waste

In addition, the whole fuel consumption of charcoal is assumed to be combusted in devices similar to *#12 Wood stoves and cooking stoves* and calculated separately. For each technology, a fuel dependent emission factor is applied.

Additionally, NO_x, NMVOC and $PM_{2.5}$ emission factors have been revised for projected years, based on ecodesign standard emission requirements for the installation of new space heaters and combination heaters[6], water heaters and hot water storage tanks[7], solid fuel local space heaters[8], local space heaters[9] and solid fuel boilers[10]. The ecodesign regulations are assumed to have entered

[6] Commission Regulation (EU) No 813/2013

[7] Commission Regulation (EU) No 814/2013

[8] Commission Regulation (EU) 2015/1185

[9] Commission Regulation (EU) 2015/1188

[10] Commission Regulation (EU) 2015/1189

into force by 1st January 2018 (814/2013, 2015/1188), 26th September 2018 (813/2013), 1st January 2020 (2015/1189) and 1st January 2022 (2015/1185) respectively, gradually replacing existing national emission requirements (Article 15a Agreement).

The adaptation of emission factors to new installations has been based on a comparison of ambition levels between national and EU-wide regulations. The replacement rate has been based on the national emission factor for new installations of the year 2021 (UMWELTBUNDESAMT 2023b) in order to provide conversion factors that reflect the impact of ecodesign policies on new heating systems. Until the ecodesign provisions enter into force, the revised emission factors follow a linear path approximating the full effect of a phased introduction of the ecodesign provisions on manufacturers, distributors and sellers of heating products. This is because market participants may at first have to adapt to the new market environment – as Member States are not allowed to maintain more stringent national requirements during the transition period.

National energy projections display the final energy demand for space heaters and combination heaters, water heaters, solid fuel local space heaters, local space heaters and solid fuel boilers by year of installation.

The share of new installations is expected to shift gradually towards low emission technologies.

Table 11: Share of 1 A 4 heating type in the different fuel categories for new installations 2022–2030 (Source: Umweltbundesamt).

Fuel category	**No.**	**Heating type**	**Share of heating type [% TJ]**		
			1 A 4 a and 1 A 4 b		
			2022	**2025**	**2030**
Fuel oil	#1	Fuel oil boilers	100.0	100.0	100.0
Gas oil	#2	Gas oil stoves	2.0	1.5	0.8
	#3	Vapourizing burners	1.0	0.8	0.4
	#4	Yellow burners	5.0	4.4	3.5
	#5	Blue burners with conventional technology	5.0	4.4	3.5
	#6	Blue burners with low temperature or condensing technology	87.0	88.8	91.9
Gas	#7	Natural gas convectors	5.0	4.2	2.8
	#8	Atmospheric burners	45.0	42.5	38.3
	#9	Forced-draft natural gas burners	50.0	53.3	58.9
LPG	#10	LPG stoves	5.0	3.8	1.9
	#11	LPG boilers	95.0	96.2	98.1
Fuel wood	#12	Wood stoves and cooking stoves	10.0	8.8	6.9
	#13	Tiled wood stoves and masonry heaters	15.0	13.8	11.9
	#14	Mixed-fuel wood boilers	5.0	4.4	3.5
	#15	Natural-draft wood boilers	15.0	14.4	13.5

Fuel category	No.	Heating type	Share of heating type [% TJ]		
			1 A 4 a and 1 A 4 b		
			2022	2025	2030
	#16	Forced-draft wood boilers	55.0	58.5	64.2
Wood chips	#17	Wood chips boilers with conventional technology	5.0	4.4	3.5
	#18	Wood chips boilers with oxygen sensor emission control	95.0	95.6	96.5
Wood pellets	#19	Pellet stoves	10.0	9.4	8.5
	#20	Pellet boilers	90.0	90.6	91.5
Coal	#21	Coal stoves	2.0	1.5	0.8
	#22	Coal boilers	98.0	98.5	99.2

It is assumed that new installations with lower emission factors will be used as substitute for stocks with average 2021 emission characteristics, or increase overall stocks.

Emission factors

NO_x emission factors are assumed to decrease for natural gas and gas oil (due to an increased use of blue burners and forced draft burners with condensing boiler technology).

Besides the shift towards low emission technologies, solid biomass emission factors by heating type (except pellet stoves) are assumed to drop slightly due to minor differences in ambition levels between ecodesign provisions and intermediate national regulations. A noticeable decrease in natural gas emission factors by heating type is expected because of tighter ecodesign requirements.

Additionally, a minor increase in heating oil emission factors by heating type and a noticeable increase in coal emission factors by heating type are expected because of a weakening of existing national regulations.

Overall effects on NO_x emissions highly depend on projected installation rates of new heating systems by heating type and actual fuels used. Table 12 lists the implied NO_x emission factors for projections in the WEM scenario.

Table 12: Implied NO_x emission factors in the WEM scenario for coal, oil, natural gas, fuel wood, wood chips and wood pellets (Source: Umweltbundesamt).

in kg/TJ	2021	2025	2030
	1 A 4 a 1		
Coal	100.0	100.0	100.0
Oil	33.4	33.4	33.2
Natural gas	41.8	37.9	36.8
Fuel wood	80.8	81.4	82.2
Wood chips	82.4	81.7	81.2
Wood pellets	60.0	59.8	59.7
	1 A 4 b 1		

in kg/TJ	2021	2025	2030
Coal	94.5	94.5	94.5
Oil	34.0	34.0	33.8
Natural gas	35.5	35.0	34.1
Fuel wood	100.6	99.4	97.5
Wood chips	82.5	81.9	81.4
Wood pellets	60.0	60.1	60.1

NMVOC emission factors are assumed to decrease for solid biomass and coal from 2018 onwards due to existing national regulations imposing standard Organic Gaseous Compounds (OGC) emission thresholds on new installations and subsequent ecodesign requirements, which will be less stringent for solid fuel local space heaters. The ecodesign provisions have almost no effect on the NMVOC emission factors for natural gas and heating oil. For all fuels, the impact of the assumed shift towards low emission technologies in newly installed heating systems is noticeable.

Overall effects on NMVOC emissions highly depend on projected installation rates of new heating systems by heating type and actual fuels used. Table 13 lists the implied NMVOC emission factors for projections in the WEM scenario.

Table 13: Implied NMVOC emission factors in the WEM scenario for coal, oil, natural gas, fuel wood, wood chips and wood pellets (Source: Umweltbundesamt).

in kg/TJ	2021	2025	2030
	1 A 4 a 1		
Coal	0.54	0.54	0.54
Oil	0.44	0.44	0.41
Natural gas	0.56	0.55	0.53
Fuel wood	344.4	339.9	330.9
Wood chips	108.9	95.1	83.9
Wood pellets	32.9	30.6	29.1
	1 A 4 b 1		
Coal	299.3	299.3	299.3
Oil	0.45	0.44	0.42
Natural gas	0.55	0.54	0.52
Fuel wood	389.3	384.2	374.6
Wood chips	111.4	97.5	88.1
Wood pellets	32.7	31.2	30.2

$PM_{2.5}$ emission factors are assumed to decrease for solid biomass and coal due to the ecodesign requirements which – in general – outreach existing national regulations for standard $PM_{2.5}$ emission thresholds. For both fossil fuels and biomass a shift towards low emission technologies in new installations of heating systems shows.

Overall effects on $PM_{2.5}$ emissions highly depend on projected installation rates of new heating systems by heating type and actual fuels used. Table 14, lists the implied $PM_{2.5}$ emission factors for projections in the WEM scenario.

Table 14: implied $PM_{2.5}$ emission factors in the WEM scenario for coal, oil, natural gas, fuel wood, wood chips and wood pellets (Source: Umweltbundesamt).

in kg/TJ	2021	2025	2030
	1 A 4 a 1		
Coal	44.0	44.0	44.0
Oil	1.7	1.7	1.6
Natural gas	0.5	0.5	0.4
Fuel wood	81.2	79.5	76.1
Wood chips	47.1	44.5	42.3
Wood pellets	15.8	15.8	15.8
	1 A 4 b 1		
Coal	89.6	89.6	89.6
Oil	1.7	1.7	1.6
Natural gas	0.5	0.4	0.4
Fuel wood	82.3	80.3	76.9
Wood chips	47.4	44.8	43.0
Wood pellets	15.5	15.5	15.5

All heating type dependent emission factors for 1 A 4 c Agriculture/Forestry/Fishing were set constant at the level of the latest national emission inventory (UMWELTBUNDESAMT, 2023b).

NFR 1 A 4 a 1 Bonfire & Open Fire Pits, 1 A 4 b 1 Barbecue

In addition to emissions from boilers and stoves, this sector includes emissions from bonfires and open fire pits as well as from barbecues. Projected $PM_{2.5}$ emissions have been estimated by extrapolating from 2021 emissions using projected population statistics (STATISTIK AUSTRIA, 2022a).

4.2 Mobile Fuel Combustion Activities (NFR 1 A)

This chapter describes the methodology used for estimating emissions from the NFR Sector 1 A 3 Transport and from mobile sources under NFR 1 A 2 g, 1 A 4 and 1 A 5.

The scenario comprises different approaches in each CRF source category.

1 A 3 a – Aviation

Projections for energy consumption in the aviation sector are based on expert judgement in line with the Austrian aviation industry. The energy demand for aviation fuels (kerosene and different types of SAF (sustainable aviation fuels)) have been estimated taking into account national long-term GDP forecasts, fleet turnover with more energy-efficient planes and higher load capacities as well as assessments of national airport and airline experts regarding the capacities on the ground and in the air.

- Major driving forces:
  - Traffic growth in aviation is closely linked to GDP growth, which could not be stopped by economic downturns, terrorist attacks, extreme weather or even "great recessions" like in 2008-2009. Even after COVID-19 triggered flight restrictions and the brutal invasion war in the Ukraine resulting in closed airspaces, air traffic is steadily recovering aiming at pre-pandemic levels.

1 A 3 b - Road Transport

The calculation of transport emissions is based on two models:

- **NEMO – Emission model Road Transport**
  From the 2015 submission onwards, projections for the time series up to 2040 have been based on NEMO (Network Emission Model, DIPPOLD et al. 2012, HAUSBERGER et al. 2015a, 2015b; SCHWINGSHACKL/REXEIS 2022). Energy consumption and emissions of the different vehicle categories are calculated by multiplying the yearly road performance per vehicle category (km/vehicle and year) by the specific energy use (g/km) and by the emission factors in g/km. NEMO models the road performance and emissions per vehicle size, age and motor type based on dynamic vehicle specific drop out- and road performance functions. To determine fuel consumption and emissions of domestic road transport, vehicle stock and total annual road performance (mileage driven per year) of the vehicle categories should be recorded as precisely as possible by national statistics. Vehicle registrations are being updated yearly.
  It is fully capable of depicting the upcoming variety of possible combinations of propulsion systems (internal combustion engine, hybrid, plug-in hybrid, electric propulsion, fuel cell …) and alternative fuels (CNG, biogas, FAME, ethanol, GTL, BTL, H2 …).

  In addition, NEMO has been designed so that it is suitable for all the main application fields in the simulation of energy consumption and emission output using a road-section based model approach. As there is as yet no complete road network for Austria on a high resolution spatial level, the old methodology based on a categorisation of traffic activities into 'urban', 'rural' and 'motorway' has been applied with the NEMO model. For more details see the chapter on methodology in 3.2.12.2. Road Transport of Austria's National Inventory Report 2023 (Umweltbundesamt, 2023a/b).

- **KEX Tool**
  The KEX tool is used in projections to map the future development of domestic fuel demand in road transport as a function of GDP, population and fuel prices, and to calculate the quantities of fuel exported in motor

vehicles abroad in the future. The KEX tool has been developed for estimating the change in domestic fuel demand and the export of fuels in motor vehicles (MOLITOR et al. 2004, MOLITOR et al. 2009). As independent variables, the KEX tool uses GDP, population, export quotas and domestic and foreign gasoline and diesel prices. Whereas the NEMO model calculates domestic fuel consumption, the KEX tool estimates the amount of fuel purchased in Austria and used abroad. The KEX tool includes a very simplified statistical tool, while NEMO includes predefined technologies for new vehicle registrations, their market penetration and the effects on consumption and emissions.
For more details see the chapter on methodology in 3.2.12.2. Road Transport of Austria's National Inventory Report 2023 (UMWELTBUNDESAMT 2023).

- Major driving forces:
  - Development of international (wholesale) fuel import prices of crude oil as well as
  - Fuel price differences between Austria and neighbouring countries due to different taxation

1 A 2 f, 1 A 3 c, 1 A 3 d, 1 A 4 b, 1 A 4 c, 1 A 5 – Mobile sources

The calculation of transport emissions is based on a model:

- **GEORG - Emission model Off-Road**

  Energy consumption and emissions of Non-road mobile machintery (NRMM) or off-road in Austria are calculated using the GEORG model (Grazer Emissionsmodel für Off Road Geräte) (HAUSBERGER 2000). GEORG has a fleet model part which simulates the actual age and size distribution of non-road mobile machinery (NRMM) stock via age- and size-dependent drop-out rates (i.e. the probability that a vehicle will have been scrapped by the following year). Using this approach, the number of vehicles in each mobile source category is calculated according to the year of the vehicles' first registration and their propulsion systems (gasoline 4-stroke, gasoline 2-stroke, diesel > 80 kW, diesel < 80 kW).

  For more details see the chapter on methodology in 3.2.13.2 Other sectors – mobile combustion of Austria's National Inventory Report 2023 (UMWELTBUNDESAMT 2023b).

- Major driving forces:
  - Operating hours of machines and vehicles - dependent on GDP and production index in the industry sector; demand for passenger and freight transport in the railway sector; weather extremes and resulting harvests and wood production in the agriculture and forestry sector; household income in the household sector; demand for passenger and freight transport on the Danube for navigation.
  - Share of electrification or alternative non-fossil combustion fuels in new registrations.

Special Considerations for $PM_{2.5}$

NFR 1 A 3 b vii Road Transport - Automobile road abrasion

Projected $PM_{2.5}$ emissions from road abrasion and tyre and brake wear have been modelled with NEMO according to the development of total mileage per vehicle category per year (SCHWINGSHACKL/REXEIS 2022).

NFR 1 A 3 c Railways - Abrasion and brake wear

$PM_{2.5}$ emissions from rail abrasion and rail brake wear have been extrapolated from 2021 emissions.

NFR 1 A 5 b - Military mobile machinery

Ground operations: $PM_{2.5}$ emissions from ground operations of military vehicles have been extrapolated from 2021 emissions and projected fuel consumption.

Aviation operations: $PM_{2.5}$ emissions from military aviation operations have been extrapolated from 2021 emissions.

4.2.1 Emission factors WEM

NO_x – Emission factors

As NO_x is the most important air pollutant in the transport sector, the underlying emission factors for NO_x which have been used for the projections across the different EURO classifications are presented in more detail in the following. The test cycles used for calculating the emissions factors for the HBEFA (Handbook of Emission Factors in Road Transport) always represent real-world driving conditions.

PC, LDV, HDV according to HBEFA VersionV4.2

According to the latest amendments to European legislation[11] where the nomenclature for emission classes has been changed to Euro 6a/b and Euro 6d_temp and Euro 6d there were no changes in the WEM scenario. A detailed analysis of the current HBEFA Version V4.2 can be found in a technical study by INFRAS (2022).

Since the Euro 6d-TEMP stage, vehicle emissions must be tested on the road, in addition to laboratory testing. The RDE test is performed during vehicle operation using a portable emissions monitoring system (PEMS).

The following tables show the assumed phase-in periods for each emission standard and vehicle category for all new vehicle registrations. EURO 7 has not been considered yet, because the new EU regulation is still under discussion.

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[11] Regulation (EC) No. 692/2008 on type-approval of motor vehicles (WLTP implementation pending) plus two RDE (real drive emission) packages – Regulation (EC) 2016/427 and 2016/646. Regulation 2017/1154, Regulation 2018/1832

Table 15: Phase-in periods for EURO -classes for new registrations (passenger cars and light duty vehicles), (Source: Umweltbundesamt).

PC/LDV	WEM	
	from	until
EURO 4	2005	2008
EURO 5	2009	2013
EURO 6a/b	2014	2018
EURO 6d_temp	2018	
EURO 6d	2020	
EURO 7	Not considered yet	

Table 16: Phase-in periods for EURO -classes for new registrations (heavy duty vehicles), (Source: Umweltbundesamt).

HDV	WEM	
	from	until
EURO 4	2006	2008
EURO 5	2009	2013
EURO 6	2014	

4.2.1.1 Details on NO_x emission factors

The tables below show the emission factors used for Austria's emission projections 2023, by vehicle category (HBEFA Version V4.2).

Table 17: Comparison of NO_x emission factors for petrol passenger cars (PC), (Source: Umweltbundesamt).

NO_x Passenger Cars Petrol	NEMO HBEFA V4.2
PRE ECE	1.89
G-Kat 87-90	1.24
EURO 1	1.21
EURO 2	0.56
EURO 3	0.20
EURO 4	0.13
EURO 5	0.06
EURO 6a/b	0.06
EURO 6c	0.03
EURO 6d_temp	0.04
EURO 6d	0.04

Table 18: Comparison of NO_x emission factors for diesel passenger cars (PC), (Source: Umweltbundesamt).

NO_x Passenger Cars Diesel	NEMO HBEFA V4.2
EURO 1	0.81
EURO 2	1.07
EURO 3	1.39
EURO 4	0.99
EURO 5	0.96
EURO 6a/b	0.57
EURO 6c	0.29
EURO 6d_temp	0.07
EURO 6d	0.06

Table 19: Comparison of NO_x emission factors for diesel light duty vehicles (LDVs), (Source: Umweltbundesamt).

NO_x Light Duty Vehicles Diesel	NEMO HBEFA V4.2
EURO 1	1.65
EURO 2	1.42
EURO 3	2.09
EURO 4	1.86
EURO 5	1.66
EURO 6a/b	0.71
EURO 6c	0.51
EURO 6d_temp	0.12
EURO 6d	0.10

Table 20: Comparison of NO_x emission factors for heavy duty vehicles (HDVs), (Source: Umweltbundesamt).

NO_x Heavy duty vehicles Diesel	NEMO HBEFA V4.2
Pre EURO	16.19
Euro-I	10.18
Euro-II	10.57
Euro-III	8.58
Euro-IV EGR	6.75
Euro-IV SCR	3.56
Euro-V EGR	7.90
Euro-V SCR	3.56
Euro-VI-ABC	0.83
Euro-VI-DE	0.34

4.2.2 Other Transportation – Pipeline Compressors (NFR 1 A 3 e)

The projected energy demand for pipeline transport up to 2030 is based on expert judgements and historical trends. For transport in pipelines, no changes in emission factors have been assumed.

4.3 Fugitive Emissions (NFR 1 B)

SO_2 and NMVOC

SO_2 and NMVOC emission projections are based on average emission/activity data ratios for the period 2017–2021, as well as on projected activity data such as natural gas exploration, natural gas consumption and gasoline consumption according to the energy scenario (UMWELTBUNDESAMT, 2023c). The length of the gas distribution network has been extrapolated until 2024 using the average yearly growth rate between 2017–2021 (75 km/year) and will stay constant afterwards.

Emission reduction measures such as vapour recovery units at fuel depots and service stations had already been implemented in 2003 and no further reductions are expected due to additional measures. However, NMVOC emissions from gasoline evaporation will decrease due to lower gasoline consumption/fueling.

Emissions from solid fuel transformation (coke ovens) are included in 1 A 2 a.

Coal production ended in 2005.

A detailed description of the methodology used for emission estimates can be found in the Austrian Informative Inventory Report (UMWELTBUNDESAMT 2023b).

NO_x and NH_3

NH_3 emissions are not relevant for this category. According to the Austrian air emission inventory, NO_x emissions from flaring in oil refineries are included in category 1 A 1 b.

$PM_{2.5}$

$PM_{2.5}$ emissions from coal handling and storage (1 B 1 a) were calculated based on coal consumption projections (UMWELTBUNDESAMT 2023c), using the same emission factors as in Austria's national air emissions inventory.

4.4 Industrial Processes (NFR 2)

4.4.1 Industrial Processes (NFR 2 A/B/C/I)

The forecast for developments in the industrial processes sector has been based on macro-economic data for the individual sub-sectors, taking into account known predictions about expansions, startup of new installations and the decommissioning of old facilities.

SO_2, NO_x and $PM_{2.5}$

SO_2, NO_x and $PM_{2.5}$ emissions that are not listed below are reported together with energy-related emissions under 1 A 2 g Other.

$PM_{2.5}$ emissions from quarries and similar activities are based on the latest national inventory and are assumed to remain constant over time. Emissions from the chemical industry are based on developments of sulphuric acid production (SO_2), nitric acid and ammonia production (NO_x) and fertiliser production (NO_x and $PM_{2.5}$). Emissions from metal production are based on the national inventory and environmental reports of Austrian enterprises. Emissions are expected to remain constant. $PM_{2.5}$ emissions from wood processing are assumed to remain constant at the level specified in the national inventory.

NMVOC and NH_3

NH_3 emissions are assumed to remain constant at 2021 levels (UMWELTBUNDESAMT 2023b) in most sub-sectors. This simple approach has been chosen because the share of NH_3 emissions in the total emissions is very small.

For NMVOC emissions in the sub-sector 2.H 'Other Processes' a more detailed approach has been used for the projections. Whereas emissions from sources such as wine, beer and spirits are projected to stay constant, emissions from the category bread have been extrapolated according to the population scenario.

4.4.2 Solvent and Other Product Use (NFR 2 D/G)

NFR 2 D / NMVOCs

Emission projections are calculated in the same level of detail as the inventory: for every sub category considered in the inventory, activity data is held constant in the future (e.g. where technological innovation offsets an increase in use), correlated with economic growth (particularly where it correlated in previous years) or correlated with population growth (particularly for the domestic sector), and for some subsectors, expert judgment was applied.

Correlated with economic growth of the relevant economic sector (either fully correlated or "partially": only a share obtained by expert judgement is correlated, the remains are set constant):

- Car repairing
- Construction and building (partially)
- Wood coating

- Other industrial paint application (partially)
- Electronic components manufacturing
- Pharmaceutical products manufacturing
- Fat, edible and non edible oil extraction

Set constant:

- Manufacture of automobiles
- Coil coating
- Metal degreasing
- Other industrial cleaning
- Rubber processing
- Paints manufacture
- Inks manufacture
- Adhesives
- Other manufacturing
- Printing industry
- Preservation of woods

Correlated with population growth:

- Dry cleaning
- Domestic solvent use
- Domestic use of pharmaceutical products

Expert judgement:

- Textile finishing
- Other (deicing and cement industry VOC use)

As EFs have decreased in the previous decade (due to measures under the VOC Directive), it has been assumed that the directive is fully implemented and no further emission reductions driven by it are to be expected, thus EFs are set to the latest value.

NFR 2 G/ NOx, SO2 NH_3 and $PM_{2.5}$

Emissions arise from product use, namely tobacco smoke and fireworks. Emissions from fireworks were set constant to the mean activity of the past 5 years. For tobacco use, the downward trend in emissions over the last years was assumed to continue for the next ten years, and then emissions remain constant.

4.5 Agriculture (NFR 3)

This chapter gives an overview of the European and Austrian farming policy, provides information on basic economic and technological assumptions and describes the methodologies used for the sectoral scenarios by 2040.

Emissions projections are provided for sources of ammonia (NH_3), nitric oxide (NO_x), non-methane volatile organic compounds (NMVOC), sulphur dioxide (SO_2) and particulate matter ($PM_{2.5}$).

Emission calculations are based on the methodologies used in the Austrian Air Emissions Inventory. The report "Austria's Informative Inventory Report 2023" (UMWELTBUNDESAMT 2023b) includes a comprehensive description of the methodologies used.

The EU CAP strategic plan

The Common Agricultural Policy (CAP) is a European Union policy with a long tradition, embedded in the EU's framework for action, such as the goal of a climate-neutral Europe in 2050.

By the end of 2021 Austria submitted its CAP Strategic Plan (CAP-SP) 2023-2027. The plan was approved in September 2022. It includes interventions that enable participants to receive direct payments (former 1st pillar of the CAP), and measures financed by the EAFRD (former 2nd pillar of the CAP). In addition, sector programmes (fruit and vegetables, bees, wine, hops) were implemented. Since the CAP period started with a delay of three years, we assume that the programme will continue until 2030. In the Austrian CAP-SP (BML, 2022), a total of 98 interventions, based on 45 needs, are jointly programmed and implemented. According to the intervention logic, the climate-relevant interventions are assigned to objective 4 (climate) by corresponding relevant outcome indicators. Compared to the previous CAP period (2014-2020 which was extended until 2022) both climate mitigation and climate change adaptation measures have gained more weight compared to other measures. However, the volume of funds has not changed significantly.

Main results

Cattle numbers: WEM projections indicate that the cattle numbers will decrease by 13% between 2021 and 2030. After 2030, the number continues to decline, but at a lower rate. This is because only the output and input prices and technical coefficients change. No further increment in investment costs was assumed. In its latest outlook on agricultural markets, the European Commission also anticipates lower beef production and a declining number of dairy cows at EU level.

Pig numbers: The number of pigs decreases at a much higher rate because the output price and input cost relations are less favourable. In its most recent outlook on agricultural markets, the European Commission expects lower production of pork as well at EU level.

Poultry numbers: The number of poultry declines at a similar rate as the number of pigs until 2030. After 2030, the number of poultry decreases at a lower rate. The modelled development of the poultry population is in contrast to the observed trends. The reason lies in the international competition for poultry meat and eggs and the comparatively high production costs in Austria.

Fertilizer application: Model results indicate that mineral fertilizer application onagricultural land will increase. Reason is the nutrient deficit due to the declining animal livestock. The lower amount of organic fertilizer will be compensated by higher sales of mineral fertilizers.

Scenario 'with existing measures' (WEM)

The scenario is based on price projections of OECD/FAO (OECD-FAO 2022) for the EU, existing farm policies and the legal framework of regulations (see Chapter 3).

Activity data

Scenario WEM

PASMA (WIFO & BOKU 2023) provides the basic activity data for the WEM scenario.

The PASMA Model

The Positive Agricultural Sector Model Austria (PASMA), developed by the Austrian Institute of Economic Research (WIFO), maximises sectoral farm welfare and is calibrated on the basis of historical activities in arable farming, forestry, livestock breeding and agro-tourism. The method of Positive Mathematical Programming (PMP) assumes a profit-maximising equilibrium (e.g. marginal revenue equals marginal cost) in the base run and derives the coefficients of a non-linear objective function based on observed levels of production activities (WIFO & BOKU 2023).

Assumptions on prices, yields and production

PASMA price projections are based on assumptions about the development of key indicators on global agricultural commodity and food markets (OECD & FAO, 2022). Forecasts on key economic indicators are based on Kaniovski et al. (2021) and energy prices are consistent with those assumed for the energy sector.

Several sources of market data are available which can be used as a basis of price projections. All prices but energy prices were derived from OECD-FAO outlooks on agricultural markets (OECD-FAO 2022). A comparison of this OECD-forecasts with projections of the European Commission (European Commission, 2022) shows that international bodies have very similar assumptions about the future development of key economic indicators. Due to the type of farm sector model used in this analysis, assumptions on the Austrian economic context (e.g., GDP growth, population dynamics) are not required directly. However, they are included in the exogenous price assumptions (mainly the consumer price index). Other driving forces (prices, technology, constraints) are referenced in of the following sections.

No OECD-FAO forecasts are available for the period after 2031. Therefore, the assumption was made that prices will follow the previous development from this year onwards for most activities. Price estimates of farm outputs are specific for the Austrian market situation. The observed price wedge between Austrian and EU markets was assumed to prevail in the future.

Within this project a detailed set of assumptions on technical coefficients, yields and productivity was developed in a stakeholder process, including the expertise of farm production experts from the Austrian Chamber of Agriculture, the Austrian Agency for Health and Food Security (AGES) and participants of three meetings of the project board established for this study.
Results can be summarised as follows: productivity in livestock farming, particularly in milk production, will increase in the coming years, but at a slower pace than in the past. With regard to crop yields, the consensus was that climate change is likely to lower country averages after 2030. One outcome of the discussions was that the expected yields of crops were lowered after 2030 and that the cost of stables for livestock would be significantly more expensive than in 2020. To assume higher prices is justified by the fact that compliance with environmental legislation will make investments more expensive. For more information please refer to (WIFO & BOKU 2023).

4.5.1 Manure Management (3.B)

This source category includes emissions occurring during the housing and storage of livestock manure.

Scenario WEM

Feed intake and N excretion

Feed intake parameters and N excretion values are the same as applied in Austria's Air Emission Inventory (UMWELTBUNDESAMT 2023b). Austria-specific N excretion values for dairy cows were calculated on the basis of projected milk yields (+14% from 2020 to 2040).

Manure Management Systems (MMS)

Data on MMS distribution are based on a comprehensive analysis of Austria's agricultural practices in 2017 (PÖLLINGER et al. 2018).

In the distribution of manure management systems a continued trend towards loose housing systems has been assumed. Additionally, the trend towards liquid manure systems was taken into account.

Based on information from the CAP Strategic Plan the share of dairy and suckling cows kept on pasture was increased slightly by 10% until 2030 and kept constant thereafter.

Other assumptions on agricultural practice, such as for the storage of farm manure or the share of farm manure treated in biogas plants, correspond to those of the OLI.

4.5.2 Agricultural Soils (3.D)

This source category includes emissions from anthropogenic N inputs to agricultural soils.

Scenario WEM

Inorganic N-fertilizers

Projected data on mineral fertiliser application data have been taken from (WIFO & BOKU 2023).

Animal manure applied to soils

Based on projections in Austria's CAP Strategic Plan the share of low-emission spreading techniques has been increased for the application of cattle manure to 32.3% and the application of pig manure to 75.7% until 2027. Values were kept constant thereafter.

For solid-liquid separation available data according to the CAP Strategic Plan were used (5.2% in 2027) and extrapolated thereafter.

4.5.3 Field Burning of Agricultural Residues (3.F)

In Austria, a federal law restricts the burning of agricultural residues on open fields. Residue burning is only permitted occasionally and on a very small scale. For the latest inventory year 2021, no field burning occurred in Austria at all ("NO"). Our assumption is that there will be no burning also in the projected years.

4.5.4 PM emissions from agriculture

Particle Emissions from Animal Husbandry

Particle emissions from this source are primarily associated with dietary manipulation of forage; a smaller part arises from dispersed excrement and litter. Estimates are related to Austrian livestock projections. To maintain consistency with Austria's Air Emission Inventory (UMWELTBUNDESAMT 2023b), emission factors from the RAINS model (LÜKEWILLE et al. 2001) were used.

Particle Emissions from Field Operations

Emissions of particulate matter from field operations are linked to the use of machinery on agricultural soils. They are considered in connection with the farmed area. For the projections, the same methodology (EMEP/EEA 2019, Tier

1) as in Austria's Annual Air Emission Inventory (UMWELTBUNDESAMT 2023b) was used. Activity data on the projected cropland and grassland area were obtained from PASMA (WIFO & BOKU 2023).

Particle Emissions from Bulk Material Handling

Because this source is of minor importance, $PM_{2.5}$ emissions have been extrapolated using the inventory values from 2021 onwards.

4.5.5 Uncertainties

Emission projections are fraught with a range of uncertainties. These uncertainties have to be kept in mind when considering the results of this analysis:

- **Model uncertainty:** The first uncertainty factor is related to the type of model. The PASMA model (WIFO & BOKU 2023) is static by design and adjustments to future situations are calculated in discrete steps which are based on exogenous assumptions (prices, costs, technical coefficients) and model-endogenous coefficients (marginal costs) based on observations in the reference period. Investment costs are not considered in the model as it is based on gross margin calculations. The model assumes a swift adaptation of land uses and management and an efficient use of resources. In practice, such adaptations may be over-optimistic because farmers are not able or willing to adjust in the way the model suggests.
- **Market uncertainty:** A comparison of past OECD-FAO projections and the observed outcomes suggests that there is a considerable difference between them. The range of such uncertainties is discussed in more detail in the OECD-FAO report (2022).
- **Policy uncertainty:** Policies affect the decisions of farmers and other market participants in various ways. The range of policies is not limited to agricultural policies alone: energy policies affect energy prices and thus input costs; urban planning regimes affect decisions about developments in residential and commercial areas, which have an impact on the availability of agricultural land.

4.5.6 Sensitivity analysis

In the sensitivity analysis, the focus was placed on investment costs, as these are subject to a high degree of uncertainty. Several variants of investment costs were used and compared in the PASMA model. The final assumptions for the cost increase were determined according to the stakeholder dialogue assuming higher construction costs than observed in the past. As a result, animal husbandry became more expensive whereas other activities like e.g. plant production became more profitable for farmers.
Overall, the PASMA results for Austria in 2030 are in line with the expectations of the OECD (OECD-FAO 2022) and the European Union (EC, 2022). However, the

development of milk production in Austria deviates from the generally expected developments due to the comparative advantage of dairy production in Austria compared to other countries.

4.6 Waste (NFR 5)

4.6.1 Waste Disposal on Land (NFR 5.A)

NMVOC and NH_3 emissions from solid waste disposal are calculated based on their respective content in the emitted landfill gas (taking gas recovery into account). For NMVOCs, a concentration of 300 mg/m³ and for NH_3 a concentration of 10 mg/m³ in the landfill gas is assumed.

For the calculation of landfill gas (mainly methane (CH_4)) arising from solid waste disposal on land the IPCC[12], a Tier 2 (First Order Decay) method is applied, taking into account historical data on deposited waste. According to this method, the degradable organic component (DOC) of waste decays throughout a few decades (IPCC 2006). The Tier 2 method is recommended for the calculation of landfill emissions at national level; it consists of two equations: one for calculating the amount of methane generated, based on the amount of accumulated degradable organic carbon at landfills in a particular year, and one for calculating the methane actually emitted after subtracting the recovered and the oxidised methane.

More detailed information on the methodology (as well as on the parameters applied) can be found in Austria's Informative Inventory Report (UMWELT-BUNDESAMT 2023b).

Projections of landfill gas emissions are calculated on the basis of predictable future trends in waste management as a result of the implementation of legal provisions at federal government level. As stipulated in the Landfill Ordinance, only pre-treated waste has been deposited in landfills since 2009. Consequently, only the following landfill fractions have been taken into account for the projections:

1. Residues and stabilised waste arising from the mechanical and/or biological treatment of waste; this fraction is expected to develop in accordance with assumptions made for projected emissions from MBT plants.
2. Some minor amounts of sludge, construction waste and paper with a low TOC content (below the threshold for TOC disposal).

On the basis of the assumptions made, projected activity data were calculated as shown below:

[12] Intergovernmental Panel on Climate Change

Table 21: Past trend (1990–2020) and scenarios (2025–2050) for "Residual waste" and "Non-residual waste" activity data (Source: Umweltbundesamt).

Year	Residual Waste [kt/a]	Non-residual Waste [kt/a]	Total Waste [kt/a]
1990	1 996	649	2 644
2000	1 052	827	1 879
2005	242	390	631
2010	0.0	245	245
2015	0.0	132	132
2020	0.0	166	166
2025	0.0	190	190
2030	0.0	190	190
2035	0.0	190	190
2040	0.0	190	190
2045	0.0	190	190
2050	0.0	190	190

$PM_{2.5}$ from Waste Disposal on Land (NRF 5.A)

Emissions from this category arise from the handling of dusty waste at landfill sites.

For the calculation of $PM_{2.5}$ emissions, only specific waste types are taken into account. The largest fraction is mineral waste (in particular excavated soil), contributing 97% (2021) of the total waste used for $PM_{2.5}$ calculations. Moreover, slags, dust and ashes from thermal waste treatment and combustion plants, as well as residues from iron and steel production (slags dust, rubble) and some construction wastes are taken into account. Solidified or stabilised wastes are not considered.

Emissions are calculated by multiplying the waste amount by an emission factor (the same as the one used for the Austrian Air Emission Inventory, see UMWELTBUNDESAMT (2023b).

Table 22: Past trend (1998–2020) and scenarios (2025–2050) for dusty waste activity data in kt (Source: Umweltbundesamt).

	1998	2000	2010	2020	2030	2040	2050
Total dusty waste amount	4 381	5 028	10 782	28 833	30 838	33 667	36 497

For the projections of activity data, it has been assumed that the amount of the deposited waste types considered will increase annually by 1% of the amount landfilled in 2021.

4.6.2 Biological Treatment of Waste – Composting (NFR 5.B.1)

NH_3 Emissions are calculated separately for

- waste treated in mechanical-biological treatment (MBT) plants and
- waste treated in composting plants as well as home-composted biogenic waste,

multiplying the respective emission factors by the waste amounts.

The emission factors used for the projections are the same as those described in Austria's Informative Inventory Report (UMWELTBUNDESAMT 2023b).

Composting plants, home composting

Home-composted waste amounts are assumed to increase with population growth (STATISTIK AUSTRIA 2022b). About 50% of the amount of the waste treated in composting plants is expected to remain constant at 2021 levels (tree loppings and wood used as structural material in the composting process), while the other 50% is expected to increase with population growth (organic waste collected from households).

Mechanical-biological treatment plants

As regards the amounts of waste undergoing mechanical-biological treatment (MBT) in Austria, it is assumed that they will remain at the mean level of 2009 – 2021.

Table 23: Past trend and scenario for composting activity data.

[kt waste treated]	1990	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Composted organic waste	418	1 467	1 689	1 834	2 019	2 227	2 335	2 365	2 393	2 417	2 434	2 452
Mechanical-biologically treated waste	345	254	623	551	439	462	458	458	458	458	458	458

4.6.3 Anaerobic treatment of agricultural feedstock (NFR 5.B.2)

NH_3 emissions from anaerobic digestion (manure and energy crops) are reported under category 5.B.2.

For further information on the methodology used see Chapter 4.5 on the agriculture sector.

4.6.4 Waste Incineration (NFR 5.C)

Because of the small contribution of pollutants from this source (NO_x, SO_2, NMVOC, NH_3) to the national total emissions (less than 1%), 2019 emission levels have been used for the forecast. A detailed description of the methodology used for estimating emission of these pollutants can be found in the Austrian Informative Inventory Report 2023 (UMWELTBUNDESAMT 2023b).

4.6.5 Wastewater Treatment (NFR 5.D)

This category includes NMVOC emissions from the treatment of domestic wastewater (5.D.1), i.e. wastewater of domestic origin as well as commercial and industrial wastewater treated together with domestic wastewater in municipal wastewater treatment plants. In addition, NMVOC from industrial on-site treatment (5.D.2) is considered from this submission onwards (refer to UMWELTBUNDESAMT 2023b).

Emissions were calculated following a Tier 1 approach by multiplying the wastewater amounts by the emission factor taken from the EMEP/EEA 2019 Guidebook (15 mg/m^3 of wastewater). Most recent data on volumes of wastewater treated were taken from the Electronic Emission Register of Surface Water Bodies ('Emissionsregister – Oberflächenwasserkörper' – 'EMREG-OW'[13]).

Treated domestic wastewater amounts are expected to increase with population growth. The volume of industrial wastewater treated on site is expected to remain on the level of 2021. The emission factor remains the same for the whole time series.

Table 24: Past trend (1990–2020) and scenarios (2025–2050) for wastewater volumes in Million m^3.

	1990	2000	2010	2020	2030	2040	2050
Domestic wastewater treated (municipal and domestic wastewater treatment plants, cesspools)	640	996	1 112	1 077	1 105	1 139	1 163
Industrial wastewater treated on-site	340	382	446	434	432	432	432

4.6.6 Other Waste Handling (NRF 5.E)

In this category $PM_{2.5}$ emissions from vehicle fires, fires at detached houses, apartment buildings and industrial buildings are covered.

Emissions were calculated following a Tier 2 approach, multiplying the number of fires per category by the emission factor taken from the EMEP/EEA 2019 Guidebook.

$$Emissions = AD * EF$$

AD *activity data (number of fires)*
EF *emission factor*

For the projection of car fires and apartment fires the population growth (STATISTIK AUSTRIA 2022b) was taken for extrapolation. Regarding detached houses and industrial buildings a mean value of the number of fires reported

[13] BGBl. II Nr. 29/2009: Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über ein elektronisches Register zur Erfassung aller wesentlichen Belastungen von Oberflächenwasserkörpern durch Emissionen von Stoffen aus Punktquellen (EmRegV-OW).

for 2004-2021 was used to project the number of future fires. The emission factor remains the same for the whole time series.

Table 25: Number of fires: past trend (1990–2020) and scenarios (2020–2050).

	1990	2000	2010	2020	2030	2040	2050
Car fires	1 586	1 682	1 727	1 696	1 875	1 934	1 974
Accidental fires at buildings	2 995	3 066	3 545	3 306	3 362	3 390	3 410

5 RECALCULATIONS: CHANGES WITH RESPECT TO SUBMISSION 2021

The changes made to the projections since the previous submission of emission projections of air pollutants in 2021 (UMWELTBUNDESAMT 2021) are presented in this chapter. In general, there are five main factors influencing these changes:

1. Changes in base data (e.g. GHG inventory, energy balance).
2. A switch to the new EMEP/EEA Guidebook 2019, which entailed methodical changes and partly considerable sectoral recalculations (e.g. for the agriculture sector) of the inventory and of emission projections, as the methods had to be applied consistently for calculating past trends and emission scenarios.
3. Changes in assumptions for activity scenarios. These changes can be triggered by revised economic or technical scenarios, the inclusion of additional policies and measures, and revisions of policies or measures which become necessary because of amendments to legislation.
4. Update on new emission factors (e.g. in the transport sector).
5. Changes in the models used for activity or emission scenarios.

The following tables show a comparison of past trends in the WEM scenarios for national emission totals.

Table 26: Comparison of projections 2021 and 2023 in the WEM scenario based on fuel sold – national totals (in kt), (Source: Umweltbundesamt).

Total	2005	2010	2020	2021	2025	2030
			Projections 2021			
NO_x	247	204	144	138	107	87
SO_2	26	16	11	12	12	12
NMVOC	158	138	109	109	106	103
NH_3	60	63	64	64	65	66
$PM_{2.5}$	23	20	14	14	13	12
			Projections 2023			
NO_x	248	206	124	123	99	80
SO_2	26	16	10	11	11	11
NMVOC	157	138	111	111	103	99
NH_3	63	65	66	66	62	58
$PM_{2.5}$	23	20	13	14	13	12
			Difference 2023/2021			
NO_x	+1	+2	-13	-8	-8	-7
SO_2	+0	+0	-2	-1	-1	-1
NMVOC	-1	0	2	+5	-3	-4
NH_3	+3	+2	+2	+2	-3	-8
$PM_{2.5}$	0	0	-1	0	0	0

For further information on the recalculations of the inventory see 'sector specific recalculations' in Austria's National Inventory Report 2023 and Austria's National Inventory Report 2023.

In the following chapters the main changes per sector are discussed in detail.

5.1 Energy Industry (NFR 1 A 1), Manufacturing Industry and Combustion (NFR 1 A 2) and Industrial Processes (NFR 2)

Table 27: Major changes between projections 2021 and 2023 for Sectors 1A1, 1A2 and 2 (in kt), (Source: Umweltbundesamt).

Pollutant	Sector (CRF)	2005	2010	2020	2021	2025	2030
NO_x	1 A 1 – Energy industries	0.0	0.0	0.3	0.7	0.2	0.5
	1 A 2 – Manufacturing Industries and Construction	0.0	0.0	-0.2	-0.3	-1.1	-0.8
	2 – Industrial Processes	0.0	0.0	0.0	-0.1	0.0	0.0
SO_2	1 A 1 – Energy industries	0.0	0.0	-0.3	-0.2	-0.2	0.0
	1 A 2 – Manufacturing Industries and Construction	0.0	0.0	-1.0	-1.3	-1.2	-1.2
	2 – Industrial Processes	0.0	0.0	0.0	0.0	0.0	0.0
$PM_{2.5}$	1 A 1 – Energy industries	0.0	0.0	0.0	0.0	0.0	0.0
	1 A 2 – Manufacturing Industries and Construction	0.0	0.0	0.0	-0.1	-0.1	-0.1
	2 – Industrial Processes	0.2	0.1	0.2	0.3	0.4	0.4
NMVOC	1 A 1 – Energy industries	0.0	0.0	0.0	0.0	0.0	0.0
	1 A 2 – Manufacturing Industries and Construction	0.0	0.0	0.1	0.1	0.1	0.1
	2 – Industrial Processes	0.7	0.7	4.6	4.3	2.1	2.2
	2 D – Solvents	0.1	0.1	4.2	3.9	2.1	2.2

Revisions up to the year 2021 are mainly due to updates of the national energy balance. For the 2021 projections the energy balance with data up to 2019 was used, whereas for the 2023 projections the energy balance with data up to 2021 was used. A significant decrease in energy consumption was caused by the COVID-crisis in 2020 to 2022. Thus industrial emissions have decreased. In the energy industries the decommissioning of coal based plants took place sooner than expected, therefore emissions of SO_2 are lower than previously. However, demand of power and district heating increases more than in previous scenarios thus emissions of NOx (coming from biomass plants) are higher.

Emission factors have been adapted mainly to take account of the effect of measures but partly also to incorporate the recalculations of the latest inventory.

2 D – Solvents and other product use

Recalculations for the year 2020 onwards were mainly due to new reports from installations that became available and were included in the inventory. Additionally, information on activity data of Road Paving with Asphalt for the whole time series was updated in the inventory.

As SNAPs were better aligned with economic sectors, the projections were also updated and based on updated assumptions for the economic sectors in question.

5.2 Transport (1 A 3)

Table 28: Major changes between projections 2021 and 2023 for Sector 1A3, in kt (fuel sold), (Source: Umweltbundesamt).

Pollutant	Sector (CRF)	2005	2010	2020	2021	2025	2030
NO_x	1 A 3 – Transport	0.1	1.3	-13.2	-10.4	-6.4	-6.3
	1 A 3 a – Civil Aviation	0.0	0.0	-0.8	-0.6	0.1	0.3
	1 A 3 b 1 – Passenger cars	0.5	0.1	-12.2	-10.0	-4.0	-2.8
	1 A 3 b 2 – Light duty vehicles	0.0	0.0	-0.8	-0.7	-1.1	-1.2
	1 A 3 b 3 – Heavy duty vehicles	-0.6	1.1	1.6	1.7	-1.0	-2.2
	1 A 3 b 4 – Mopeds & Motorcycles	0.0	0.0	0.0	-0.1	0.0	-0.1
	1 A 3 c – Railways	0.0	0.0	-0.1	-0.1	0.0	-0.1
	1 A 3 d – Navigation	0.0	0.0	-0.8	-0.4	-0.3	-0.2
	1 A 3 e – Pipeline compressors	0.1	0.1	-0.1	-0.2	-0.1	-0.1
NMVOC	1 A 3 – Transport	-0.2	-0.1	-0.9	-0.8	-0.2	-0.3
	1 A 3 a – Civil Aviation	0.0	0.0	-0.1	-0.1	0.0	0.0
	1 A 3 b 1 – Passenger cars	0.0	0.0	-0.6	-0.6	-0.4	-0.6
	1 A 3 b 2 – Light duty vehicles	0.0	0.0	0.0	0.0	0.0	0.0
	1 A 3 b 3 – Heavy duty vehicles	-0.1	0.0	0.0	0.0	0.0	0.1
	1 A 3 b 4 – Mopeds & Motorcycles	0.0	0.0	0.0	-0.1	-0.1	-0.1
	1 A 3 c – Railways	0.0	0.0	0.0	0.0	0.0	0.0
	1 A 3 d – Navigation	0.0	0.0	-0.2	-0.1	0.2	0.2
	1 A 3 e – Pipeline compressors	0.0	0.0	0.0	0.0	0.0	0.0

For the year 2020 the difference between the 2021 and 2023 projections is due to the slump in activities caused by the pandemia. The 2021 submission for the transport sector included a modelling result which was already estimated before 2020. The differences in the years 2025 to 2040 are due to a revision of the share of BEVs in new car registrations and following the reduced amount of fossil fuels needed, which was much more conservative in the old projection.

5.3 Other Sectors (NFR 1 A 4)

Table 29: Major changes between projections 2021 and 2023 for Sector 1A4 in kt (Source: Umweltbundesamt).

Pollutant	Sector (NFR)	2005	2010	2020	2021	2025	2030
NO_x	1 A 4 – Other Sectors	-0.2	-0.3	-0.4	1.2	-0.9	-0.2
	1 A 4 a 1 – Commercial/Institutional: Stationary	-0.1	0.0	-0.1	0.1	-0.1	-0.1
	1 A 4 b 1 – Residential: stationary	-0.2	-0.2	-0.3	1.1	-0.6	0.2
	1 A 4 c 1 – Agriculture/Forestry/Fishing: Stationary	0.0	0.0	0.0	0.0	-0.1	0.0
NMVOC	1 A 4 – Other Sectors	-0.1	0.0	-0.8	2.7	-1.2	0.6
	1 A 4 a 1 – Commercial/Institutional: Stationary	0.0	0.0	0.1	0.1	0.2	0.2
	1 A 4 b 1 – Residential: stationary	-0.1	0.0	-0.4	2.8	-0.7	1.0
	1 A 4 c 1 – Agriculture/Forestry/Fishing: Stationary	0.0	0.0	0.0	0.2	-0.1	0.0
$PM_{2.5}$	1 A 4 – Other Sectors	0.0	0.0	-0.2	0.6	-0.1	0.5
	1 A 4 a 1 – Commercial/Institutional: Stationary	0.0	0.0	0.0	0.0	0.1	0.1
	1 A 4 b 1 – Residential: stationary	0.0	0.0	-0.2	0.5	-0.1	0.5
	1 A 4 c 1 – Agriculture/Forestry/Fishing: Stationary	0.0	0.0	0.0	0.0	0.0	0.0

In the 2023 submission, NEC emissions have been subject to significant changes, compared to the 2021 submission, to both the inventory and the projected years starting from 2021, for several reasons:

- Minor revision of the national energy balances for former inventory years 2005 and 2010 for mobile sources of NFR 1 A 4.
- The recalculation in the years 2005, 2010 and 2020 is predominantly due to the revision of the energy demand model for space heating. Minor changes in air pollutant emissions of NFR 1 A 4 a 1 and NFR 1 A 4 b 1 occur because of updated heating stock data and newly allocated shares of combustion technologies per energy carrier (updated energy demand model for space heating). In particular, lower NO_x emissions occur because of higher shares of new technologies, which are considered with lower NO_x emissions than conventional equipment (see UMWELTBUNDESAMT, 2023b for further details):
  - New Blue burners with low temperature or condensing technology (heating type #6),
  - New forced-draft natural gas boilers (heating type #9),
  - Advanced mixed-fuel wood boilers (heating type #14).
- Updates in the NMVOC inventory for mobile sources of 1 A 4 b 2 in the years 2020 and 2021 and in corresponding projected years 2025 and 2030 contribute to changes of NFR 1 A 4 against the 2021 submission.
- The difference in the year 2021 is due to emerging trends in activity data (energy consumption) for the inventory data year, in particular higher fuel consumption of biomass because of a more intense heating period.

- The INVERT/EE-Lab model for NFR 1 A 4 a 1 and 1 4 A b 1 was updated with recent statistical data on building stock and thermal building quality. The model was recalibrated against the new energy balance.

5.4 Agriculture (NFR 3)

Table 30: Major changes between projections 2021 and 2023 for Sector 3 (in kt), (Source: Umweltbundesamt).

Pollutant	Sector (NFR)	2005	2010	2020	2021	2025	2030
NH_3	3 – Agriculture	3.0	2.7	2.7	2.5	-1.9	-7.6
	3 B 1 a	0.2	0.2	0.3	0.4	0.2	-0.1
	3 B 1 b	1.1	1.2	1.6	1.8	1.2	0.2
	3 B 4 e	0.0	0.0	0.0	0.0	-0.1	-0.5
	3 B 3	0.7	0.5	0.2	0.2	-0.2	-0.7
	3 B 4 g	0.0	0.0	0.3	0.3	0.3	0.0
	3 D	1.1	0.8	0.2	-0.1	-3.1	-6.0
NO_x	3 – Agriculture	0.7	0.6	0.5	0.7	0.3	-0.2
	3 D	0.7	0.6	0.5	0.7	0.3	-0.1
NMVOC	3 – Agriculture	-1.1	-0.7	-0.8	-0.9	-3.7	-6.9
	3 B	-1.2	-0.8	-0.5	-0.4	-2.1	-4.4

Activity data projections:

Emission calculations are based on projected activity data obtained from the PASMA model (WIFO & BOKU 2023). Since the last study (WIFO & BOKU 2018) the PASMA model was updated on the basis of a new inventory time series (1990-2020), new legal and economic conditions affecting prices, costs, and technical coefficients in the sectoral agriculture projections.

Within the 2022 inventory submission, Austrian revised its agriculture inventory substantially. New updated and representative values for nitrogen and energy intake, excretion of nitrogen (Nex) and volatile solids (VSex) based on a new country specific study (HÖRTENHUBER et al. 2022, HÖRTENHUBER et al. 2023) have been included into the inventory. The application of improved methodologies taking into account detailed data on animal feeding, resulted in increased NH_3 and NO_x emissions, especially in the first years of the time series. Improvements of the enteric CH_4 emission calculations in Austria's greenhouse gas inventory led to lower NMVOC emissions for the entire time series. Detailed information on the inventory revision of the 2022 submission can be found in Austria's Informative Inventory Report 2022 (UMWELTBUNDESAMT 2022a) and in Austrira's National Inventory Report 2022 (UMWELTBUNDESAMT 2022b).

The new WEM scenario considers the CAP strategic plan for the first time putting more emphasis on reducing air pollutants and greenhouse gas emissions. Furthermore, energy prices are estimated to be significantly higher as well as the cost of investments are increasing at a higher rate, mainly because of improved animal welfare standards and the price surge observed.

5.5 Waste (NFR 5)

Table 31: Major changes between projections 2021 and 2023 for Sector 5 (in kt), (Source: Umweltbundesamt).

Pollutant	Sector (CRF)	2005	2010	2020	2021	2025	2030
NH_3	5 – Waste	-0.35	-0.39	-0.41	-0.38	-0.40	-0.40

Compared to the 2021 projections, major revisions were carried out for category 5.B Biological Waste Treatment. Amounts of home composted waste (part of 5.B.1) were re-estimated applying a new methodology developed for the Federal Waste Management Plan 2023[14] delivering a more plausible result than previously estimated. This was done in view of a future reporting obligation regarding home-composted quantities to the European Commission (In the future home composting is to be included in the AT recycling rate for municipal waste).

Only minor revisions were reported for the categories 5.A and 5.D as new data became available for the annual inventory (deposited amounts, wastewater volumes, connection rate 2020), slightly changing the basis for extrapolation.

Moreover NMVOC emissions from industrial on-site wastewater treatment were estimated for the first time, slightly increasing emissions from 5.D wastewater treatment.

[14] https://www.bmk.gv.at/themen/klima_umwelt/abfall/aws/bundes_awp/bawp2023.html

6 REFERENCES

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2004): Nationaler Zuteilungsplan für Österreich gemäß § 11 EZG, Wien.

BMNT – Federal Ministry of Sustainability and Tourism (2019a): Integrierter nationaler Energie- und Klimaplan für Österreich, Wien. https://www.bmk.gv.at/themen/klima_umwelt/klimaschutz/nat_klimapolitik/energie_klimaplan.html

BMNT – Federal Ministry of Sustainability and Tourism (2019b): Nationales Luftreinhalteprogramm 2019 gemäß § 6 Emissionsgesetz-Luft 2018. Bundesministerium für Nachhaltigkeit und Tourismus, Wien 2019

BML – Federal Ministry of Agriculture, Forestry, Regions and Water Management (2022): GAP-Strategieplan Bericht 2021. Selbstverlag, BML, Wien 2022.

DIPPOLD, M., REXEIS, M., HAUSBERGER, S. (2012): NEMO – A Universal and Flexible Model for Assessment of Emissions on Road Networks. 19th International Conference "Transport and Air Pollution", 26. – 27.11.2012, Thessaloniki.

EC - EUROPÄISCHE KOMMISSION (2022): EU agricultural outlook for markets, income and environment, 2022-2032 [online]. Verfügbar unter: https://ec.europa.eu/info/food-farmingfisheries/farming/facts-and-figures/markets/outlook/medium-term_en#latestissue

CESAR (2020): MIO-ES: A Macroeconomic Input-Output Model with Integrated Energy System. Centre of Economic Scenario Analysis and Resarch (CESAR). Wien. Online verfügbar unter https://www.cesarecon.at/wp-content/uploads/2020/10/MIOES_Manual_Public_FINAL.pdf, zuletzt geprüft am 08.03.2023.

E-Think (2023) Zentrum für Energiewirtschaft und Umwelt (e-think): Energieszenarien. WEM Szenario: Ergebnisse. Publikation in Vorbereitung.

HAUSBERGER, S. (2000): Emissionen des Off-Road Verkehrs im Bundesgebiet Österreich für die Bezugsjahre 1990 bis 1999. Institut für Verbrennungskraftmaschinen und Thermodynamik TU Graz, Graz 2000.

HAUSBERGER, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015a): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2013. FVT – Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH, erstellt im Auftrag der Umweltbundesamt GmbH. Graz 2015.

HAUSBERGER, S.; SCHWINGSHACKL, M. & REXEIS, M. (2015b): NEMO Methodenbericht im Rahmen des Projekts NEMO4U. FVT – Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH, erstellt im Auftrag der Umweltbundesamt GmbH, Graz 2015. Not published yet.

HAUSBERGER, S.; SCHWINGSHACKL (2023): Monitoring Mechanism 2022 und Szenario Transition – Verkehr. ITNA – Institut für Thermodynamik und nachhaltige Antriebe, im Auftrag des BMK, Graz, 2023. Not published yet.

HÖRTENHUBER, S., GRÖßBACHER, V., WEISSENSTEINER, R., ZOLLITSCH, W. (2022): Minderungspotenziale zu Treibhausgas- und Luftschadstoff-Emissionen aus der Nutztierhaltung unter besonderer Berücksichtigung ernährungsbezogener Faktoren (MiNutE). Wien: Universität für Bodenkultur.

HÖRTENHUBER, S.J.; GRÖßBACHER, V.; SCHANZ, L.; ZOLLITSCH, W.J. (2023): Implementing IPCC 2019 Guidelines into a National Inventory: Impacts of Key Changes in Austrian Cattle and Pig Farming. Sustainability 2023, 15, 4814. https://doi.org/10.3390/su15064814

Kaniovski, S., Url Th., Hofer H., Garstenauer V. (2021): A Long-run Macroeconomic Model of the Austrian Economy (ALMM 2.0). New Results (2021). Report of the Austrian Institute of Economic Research.

LÜKEWILLE, A.; BERTOK, I.; AMANN, M.; COFALA, J.; GYARFAS, F.; HEYES, C.; KARVOSENOJA, N.; KLIMONT, Z. & SCHOEPP, W. (2001): A Framework to Estimate the Potential and Costs for the Control of Fine Particulate Emissions in Europe. Interim Report IR-01-023, IIASA, Laxenburg.

OECD-FAO (2022): Agricultural Outlook 2023–2031. OECD & Food and Agriculture Organization of the United Nations. Paris.

MOLITOR, R.; HAUSBERGER, S. et. al (2004): Abschätzung der Auswirkungen des Tanktourismus auf den Kraftstoffverbrauch und die Entwicklung der CO_2-Emissionen in Österreich, Bericht im Auftrag von Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Trafico, Wien 2004.

MOLITOR, R.; HAUSBERGER, S. et. al (2009): Abschätzung der Auswirkungen des Export im Kraftstofftank auf den Kraftstoffabsatz und die Entwicklung der CO_2 und Luftschadstoffemissionen in Österreich – Aktualisierung 2007 und Prognose 2030; im Auftrag des Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft; Bundesministerium für Verkehr, Innovation und Technologie; Graz-Wien; 2009 (not published).

PÖLLINGER et al. (2018): Erhebung zum Wirtschaftsdüngermanagement aus der landwirtschaftlichen Tierhaltung in Österreich. Surveys on manure management from agricultural livstock farmings in Austria. Abschlussbericht TIHALO II. Projekt Nr./Wissenschaftliche Tätigkeit Nr. 3662. PÖLLINGER, A.; BRETTSCHUH, S.; LACKNER, L.; STICKLER, Y.; ZENTNER, A.; HBLFA Raumberg Gumpenstein & Bundesanstalt für Agrarwirtschaft, Wien. Bundesministerium für Nachhaltigkeit und Tourismus (BMNT), Wien 2018.

SCHWINGSHACKL, M. & REXEIS, M. (2022): Straßenverkehrsemissionen und Emissionen sonstiger mobiler Quellen Österreichs für die Jahre 1990 bis 2021. ITNA – Institut für Thermodynamik und nachhaltige Antriebe, im Auftrag des BMK. Graz 2022.

STATISTIK AUSTRIA (2022a): Energiebilanzen 1970-2021. Wien.

STATISTIK AUSTRIA (2022b): Bevölkerungsprognose 2022. Erstellt am 20.12.2022, Wien. Vorausberechnete Bevölkerungsstruktur für Österreich 2021-2080 laut Hauptvariante. https://www.statistik.at/statistiken/bevoelkerung-und-soziales/bevoelkerung/demographische-prognosen/bevoelkerungsprognosen-fuer-oesterreich-und-die-bundeslaender

UMWELTBUNDESAMT & BMLFUW (2002): State of the Art for Waste Incineration Plants. Schriftenreihe, Bd. 24/2002. BMLFUW, Wien.

UMWELTBUNDESAMT (2003a): Böhmer, S.; Wiesenberger, H.; Krutzler, T.; Szednyj, I.; Poupa, S. & Schindler, I.: NO_x -Emissionen: Minderungspotenziale in ausgewählten Sektoren und Szenarien 2010. Berichte, Bd. BE-233. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2003b): Böhmer, S; Schindler, I.; Szednyj, I. & Winter, B.: Stand der Technik bei kalorischen Kraftwerken und Referenzanlagen in Österreich. Monographien, Bd. M-162. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2003c): Wiesenberger, H.; Böhmer, S; Szednyj, I; Krutzler, T.; Poupa, S. & Schindler, I.: Abschätzung der SOx-Emissionen im Jahr 2010 für Energie (SNAP 01) und Industrie (SNAP 03, 04). Berichte, Bd. BE-232. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2007a): Szednyj, I. & Brandhuber, D.; Stand der Technik zur Kalk-, Gips- und Magnesiaherstellung. Reports, Bd. REP-0128. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2007b): Böhmer, S.; Fröhlich, M.; Köther, T.; Krutzler, T.; Nagl, C.; Pölz, W.; Poupa, S.; Rigler, E.; Storch, A. & Thanner, G.: Aktualisierung von Emissionsfaktoren als Grundlage für den Anhang des Energieberichts. Reports, Bd. REP-0075. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2009): Gallauner, T. & Böhmer, S.; Stand der Technik bei Öl- und Gasraffinerien – Referenzanlagen in Österreich. Reports, Bd. REP-0245. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2021): Anderl, M.; Haider, S.; Krutzler, T.; Lampert, C.; Pazdernik, K.; Poupa, S.; Purzner, M.; Schieder, W.; Schodl, B.; Titz, M., Wieser, M. & Zechmeister, A. Austria's National Air Emission Projections 2021 for 2020, 2025 and 2030, Bd. REP-0769. Umweltbundesamt, Wien.

UMWELTBUNDESAMT, 2022a. Pazdernik, K., M. Anderl, A. Friedrich, M. Gangl, M. Kriech, V. Kuschel, C. Lampert, N. Mandl, B. Matthews, S. Mayer, E. Moldaschl, S. Poupa, M. Purzner, A. Rockenschaub, W. Schieder, C. Schmid, G. Schmidt, B. Schodl, E. Schwaiger, B. Schwarzl, G. Stranner, P. Weiss, M. Wieser und A. Zechmeister: Austria's National Inventory Report 2022. Submission under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol. Reports, Bd. REP-0811. Umweltbundesamt, Wien.

UMWELTBUNDESAMT, 2022b. Mayer, M. Anderl, C. Brendle, M. Gangl, C. Lampert, N. Mandl, K. Pazdernik, S. Poupa, M. Purzner, D. Reiterer, W. Schieder, G. Schmidt, B. Schodl, G. Stranner, M. Wieser, R. Wankmüller, R und A. Zechmeister: Austria's Informative Inventory Report 2022. Submission under the UNECE Convention on Long-range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants. Reports, Bd. REP-0809. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2023a): Anderl, M.; Colson, J.; Gangl, M.; Kuschel, V.; Makoschitz, L.; Matthews, B.; Mayer, M.; Mayer, S.; Moldaschl, E.; Pazdernik, K.; Poupa, S.; Purzner, M.; Roll, M.; Rockenschaub A.K.; Schieder, W.; Schmidt, G.; Schodl, B.; Schwaiger, E.; Schwarzl, B.; Stranner, G.; Weiss, P.; Wieser, M. & Zechmeister, A.: Austria's National Inventory Report 2023 – Submission under the United Nations Framework Convention of Climate Change. Reports, DRAFT. Umweltbundesamt, Wien.

UMWELTBUNDESAMT (2023b): Mayer, S.; Anderl, M.; Brendle, C.; Colson, J.; Gangl, M.; Makoschitz, L.; Pazdernik, K.; Poupa, S.; Purzner, M.; Roll, M.; Schieder, W.; Stranner, G.; Schmidt, G.; Wankmüller, R.; Wieser, M. & Zechmeister, A.: Austria's Informative Inventory (IIR) 2023. Submission under the UNECE Convention on Long-range Transboundary Air Pollution. Reports, Draft. Umweltbundesamt, Vienna, 2023

UMWELTBUNDESAMT (2023c): Zechmeister, A.; Anderl, M.; Gössl, M.;Mayer, M. Mayer, S.; Heinfellner, H.; Krutzler, T.; Pazdernik, K.; Perl, D.; Purzner; M.; Poupa, S.; Schieder, W., Schmid, C.; Schodl, B.; Stanner, G.; Staudner, M.; Wiesenberger, H.; Weiss, P & Wieser, M.: GHG Projections and Assessment of Policies and Measures in Austria. Reports, Draft. Umweltbundesamt, Vienna, 2023. Not published yet.

WIFO & BOKU (2018): Sinabell, F.; Schönhart, M. & Schmid, E.: Austrian Agriculture 2020–2050. Scenarios and sensitivity analyses on land use, production, livestock and production systems. Wirtschaftsforschungsinstitut (WIFO) und Universität für Bodenkultur (BOKU), Vienna.

WIFO & BOKU (2023): Sinabell, F.; Falkner, K.; Streicher, G; Schönhart, M. & Schmid, E.: Austrian Agriculture 2030–2040-2050. Scenarios with existing (WEM) and additional (WAM) policy measures. Wirtschaftsforschungsinstitut (WIFO) und Universität für Bodenkultur (BOKU), Vienna.

Legislation

Agreement according to 15a B-VG between the federal government and the federal provinces on 'Maßnahmen im Gebäudesektor zum Zweck der Reduktion des Ausstoßes an Treibhausgasen' (Federal Law Gazette II No. 251/2009, last amendment: Federal Law Gazette II No. 213/2017).

Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (recast) (Text with EEA relevance).

Commission Regulation (EU) No 813/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for space heaters and combination heaters.

Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks.

Commission Regulation (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel local space heaters.

Commission Regulation (EU) 2015/1188 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for local space heaters.

Commission Regulation (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel boilers.

Constitutional Article 15a Agreement between the federal government and the federal provinces concerning placing on the market of small scale combustion equipment respectively the inspection of heating equipment and block heat and power plants (amended by federal provinces individually with ordinance or law).

Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directive 96/57/EC and 2000/55/EC of the European Parliament and of the council (Eco Design Directive) (*No longer in force, Date of end of validity: 19/11/2009)*.

Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services.

Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast).

Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (Text with EEA relevance).Federal Law Gazette I No. 106/1993 Bundesgesetz über Sicherheitsmaßnahmen, Normalisierung und Typisierung auf dem Gebiete der Elektrotechnik (Elektrotechnikgesetz 1992 – ETG 1992), zuletzt geändert durch BGBl. I Nr. 204/2022.

Federal Law Gazette I No. 113/2008 i.d.F. BGBl. I Nr. 150/2021: Wärme- und Kälteleitungsausbaugesetz und Änderung des Energie-Regulierungsbehördengesetzes.

Federal Law Gazette I No. 27/2012: Bundesgesetz über die Pflicht zur Vorlage eines Energieausweises beim Verkauf und bei der In-Bestand-Gabe von Gebäuden und Nutzungsobjekten (Energieausweis-Vorlage-Gesetz 2012 – EAVG 2012).

Federal Law Gazette II No. 126/2007 i.d.F. BGBl. II Nr. 187/2011: Verordnung des Bundesministers für Wirtschaft und Arbeit zur Schaffung eines Rahmens für die Festlegung von Anforderungen an die umweltgerechte Gestaltung energieverbrauchsrelevanter Produkte (Ökodesign-Verordnung 2007 – ODV 2007).

Federal Law Gazette I No. 6/2020 Bundesgesetz über die Unzulässigkeit der Aufstellung und des Einbaus von Heizkesseln von Zentralheizungsanlagen für flüssige fossile oder für feste fossile Brennstoffe in Neubauten (Ölkesseleinbauverbotsgesetz – ÖKEVG 2019).

OIB guideline 6 – Energy savings and thermal insulation. OIB-330.6-026/19. Austrian Institute for Constructional Engineering. Edition April 2019.

ANNEX: NATIONAL PROJECTION ACTIVITY DATA

Table 32: Assumptions about general economic parameters with existing measures (Source: Umweltbundesamt).

	Unit	2020	2021	2025	2030
1. Gross Domestic Product	Value (billion €)	381	402	439	466
2. Population	Thousand people	8917	8961	9114	9251
3. International coal prices	€(2020)/GJ	2	4	3	3
4. International oil prices	€(2020)/GJ	6	10	15	15
5. International gas prices	€(2020)/GJ	3	15	13	11

Table 33: Assumptions for the energy sector – with existing measures (Source: Umweltbundesamt).

	Unit	2020	2021	2025	2030
Total gross inland consumption*					
1. – Oil (fossil)	Petajoule (PJ)	464	494	493	466
2. – Gas (fossil)	Petajoule (PJ)	306	324	297	265
3. – Coal	Petajoule (PJ)	105	108	107	106
4. – Biomass without liquid biofuels (e.g. wood)	Petajoule (PJ)	226	228	227	237
5. – Liquid biofuels (e.g. bio-oils)	Petajoule (PJ)	18	19	18	17
6. – Solar*	Petajoule (PJ)	12	12	34	59
7. – Other renewable (wind, geothermal etc)	Petajoule (PJ)	166	166	217	252
Total electricity production by fuel type*					
8. – Oil (fossil)	GWh	504	529	492	523
9. – Gas (fossil)	GWh	9804	10403	9049	4721
10. – Coal	GWh	2323	2068	1970	1985
11. – Renewable	GWh	55614	53108	68500	83400

* *Solar thermal and PV*

Table 34: Assumptions for the industry sector – with existing measures (Source: Umweltbundesamt).

	Unit	2020	2021	2025	2030
12.The share of the industrial sector in GDP and growth rate (e.g. iron & steel, other metals, cement, coke production, pulp and paper, petroleum refining)	growth rate (%) per year				
Metal Industry	%	-9.5%	12.5%	2.9%	2.0%
Pulp & Paper	%	-9.7%	11.7%	3.0%	2.1%
Non-metallic Minerals	%	-6.6%	8.5%	1.3%	1.1%
Chemical Industry	%	-10.0%	11.7%	3.0%	2.0%
Machine Construction	%	-9.5%	11.5%	2.6%	1.6%

Vehicle Construction	%	-10.2%	11.8%	3.0%	2.0%
Food and Drink	%	-6.5%	7.6%	2.7%	1.7%
Other Industry	%	-4.5%	6.5%	1.6%	1.2%

Table 35: Assumptions for the transport sector – with existing measures (Source: Umweltbundesamt).

	Unit	2020	2021	2025	2030
15.Passenger person kilometres*	million km	96 187	93 600	116 959	122 537
16.Growth of freight tonne kilometres*	million tonne-km	86 730	80 304	89 761	95 970
17.Fleet turnover assumptions (vehicle replacement)					
17a.Passenger cars**	% of new vehicles per year	4%	4%	6%	6%
17b.Light duty vehicles**	% of new vehicles per year	8%	12%	8%	8%
17c.Heavy trucks**	% of new vehicles per year	12%	14%	13%	13%

* *excl. fuel export, excl. int. aviation/navigation*

** *new registrations compared to fleet stock in previous year in %*

Table 36: Assumptions for buildings residential and commercial or tertiary sector– with existing measures, (Source: Umweltbundesamt).

	Unit	2020	2021	2025	2030
20a.The rate of change of floor space for tertiary buildings *	%	0.80%	0.80%	0.80%	0.80%
20b.The rate of change of floor space for dwellings*	%	1.23%	1.11%	0.96%	0.91%
21a.The number of dwellings in the tertiary sector	Number	154841	156072	161097	167605
21b. The number of employees in the tertiary sector	Number	NE	NE	NE	NE
21c. The number of dwellings in the residential sector**	Number	0.80%	0.80%	0.80%	0.80%

* *Ratio of conditioned floor area in commercial buildings between given year and previous year*

** *Number of permanently occupied dwellings*

Table 37: Assumptions for the agriculture sector with existing measures (Source: Umweltbundesamt).

	Unit	2020	2021	2025	2030
23.Beef cattle	1 000 heads	1 331	1 344	1 261	1 156

24.Dairy cows	1 000 heads	525	526	500	474
25.Sheep	1 000 heads	394	402	362	269
26.Pigs	1 000 heads	2 496	2 479	2 272	2 063
27.Poultry	1 000 heads	19 750	19 750	18 904	16 283
28.Synthetic fertiliser	kt N	107	111	109	111

Table 38: Assumptions for the waste sector– with existing measures (Source: Umweltbundesamt).

	Unit	2020	2021	2025	2030
31.Municipal solid waste disposed of in landfills*	tonnes	165 576	197 067	163 991	163 991

* *The unit 'tonne of MSW' comprises all wastes disposed of in mass landfills. It includes mainly pre-treated MSW as the disposal of untreated MSW has been prohibited in Austria since 2009.*