Austria's National Air Emission Projections 2021 for 2020, 2025 and 2030

Pollutants: NO_x, SO_2, NMVOC, NH_3 and $PM_{2.5}$

umweltbundesamt
ENVIRONMENT AGENCY AUSTRIA

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Scenario: With Existing Measures (WEM)
With Additional Measures (WAM)
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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 2019 in a report entitled "Austria's National Air Emission Projections 2019 for 2020, 2025 and 2030" (UMWELTBUNDESAMT 2019).

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

Two scenarios were modelled: "with existing measures" includes all measures implemented by 1 January 2018; "with additional measures" includes 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 (BMNT 2019a, b). Information on national policies and measures included in the scenarios can be found in Chapter 3.

Additional measures to meet the current 2030 target as well as the enhanced ambition for 2030 are currently under discussion and could therefore not be included in the scenarios. Furthermore, the effect of the current health crisis (COVID-19 pandemic) has not been considered in the scenario analysis, as final data for 2020 was not available when the report was prepared and further short-term impacts of the crisis itself are still unclear. Both issues will be addressed in the forthcoming submission in 2023.

Furthermore, to consider fuel exports in vehicle tanks, we have evaluated the fuel options 'fuel sold' and 'fuel used'.

The air pollutant projections are fully consistent with current GHG emission projections under the EU Monitoring Regulation (UMWELTBUNDESAMT 2021c).

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 2021 (UMWELTBUNDESAMT 2021a) 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 further 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 2014[5] for reporting emission data under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP), Parties shall 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

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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 http://ceip.at/fileadmin/inhalte/emep/2014_Guidelines/ece.eb.air.125_ADVANCE_VERSION_reporting_guidelines_2013.pdf

transport shall be calculated and reported on the basis of 'fuel sold'. However, 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.

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

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.

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 2021 (UMWELTBUNDESAMT 2021a).

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 2019 (AEA 2018, HAUSBERGER & SCHWINGSHACKL 2018, TU WIEN & ZEU 2018, WIFO 2018).

The air pollutant projections are fully consistent with the historical emission data from the Austrian Emission Inventory (submission March 2021) up to the latest available data year 2019.

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. Emissions from fuel combustion and industrial processes are based on the National Energy Balance of Statistics Austria (2019) and on an econometric input-output model (DYNK) of the Austrian Institute of Economic Research (WIFO 2018), supported by calculations carried out using the bottom-up models TIMES (Austrian Energy Agency, AEA 2018), INVERT/EE-Lab (Energy Economics Group of the Technical University of Vienna and the Zentrum für Energiewirtschaft und Umwelt (e-think), TU Wien & ZEU 2018) and NEMO & GEORG (Graz University of Technology, TU Graz 2018).

The agricultural scenario is based on the PASMA model of the Austrian Institute of Economic Research (WIFO & BOKU 2018). Projections for solvents und waste 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", submitted under the Monitoring Mechanism Regulation (MMR) in 2021 (UMWELTBUNDESAMT 2021c).

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.

Table 2: Main data sources for activity data and emission values.

Sector	Data Sources for Activity Data	Emission Calculation
Energy	National Energy Balance of Statistics Austria, macro-economic model DYNK of the Austrian Institute of Economic Research (WIFO), bottom-up models TIMES (AEA), INVERT/EE-Lab (Vienna University of Technology, Zentrum für Energiewirtschaft und Umwelt (e-think)) as well as NEMO & GEORG (Graz University of Technology)	Umweltbundesamt (energy providers, manufacturing industries, residential and commercial sector, parts of the transport sector) Graz University of Technology (transport sector)
Industry	Austrian Institute of Economic Research (macroeconomic model DYNK) Solvents: as above, expert judgements,VOC Directive	Umweltbundesamt
Agriculture	Austrian Institute of Economic Research (agriculture model PASMA) (WIFO & BOKU 2018).	Umweltbundesamt
Waste	Landfill database, 'EDM' (national database on waste amounts, deposited and treated) Federal Waste Management Plan Expert judgement by Umweltbundesamt on waste amounts expected to be pre-treated in mechanical-biological treatment plants population scenarios (STATISTIK AUSTRIA 2018c)	Umweltbundesamt

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 3. Methodological assumptions are included in Chapter 4. Further assumptions about key input parameters are included in UMWELTBUNDESAMT (2021c).

Table 3: Key input parameters for emission projections (UMWELTBUNDESAMT 2021c).

Year	Scenario	2017	2020	2025	2030
GDP [billion € 2016]	WEM	361	386	414	444
GDP real growth rate [%]	WEM	3.1	1.8	1.4	1.4
GDP [billion € 2016]	WAM	361	375	404	434
GDP real growth rate [%]	WAM	3.1	1.7	1.5	1.4
Population [1 000]	both	8 797	8 942	9 158	9 331
Stock of dwellings [1 000]	both	3 831	3 992	4 126	4 230
Heating degree days	both	3 224	3 204	3 171	3 118
Exchange rate [US$/€]	both	1.2	1.2	1.2	1.2
International coal price [€ 2016/GJ]	both	3.0	2.6	3.2	3.8
International oil price [€ 2016/GJ]	both	8.2	13.9	15.7	17.3
International natural gas price [€ 2016/GJ]	both	5.8	8.9	9.6	10.5
CO_2 certificate price [€ 2016/t CO_2]	both	7.0	15.5	23.3	34.7

2 MAIN RESULTS

The following table shows Austria´s national total emissions according to Austria's inventory and projections based on 'fuel sold' as well as 'fuel used'. Emissions have to be reported based on 'fuel sold' under the UNECE LRTAP Convention as well as under the NEC Directive 2016/2284/EU. With respect to compliance with the emission ceilings for 2010 under Directive 2001/81/EC, Austria reports emissions and projections based on 'fuel used'. When referring to emissions based on 'fuel used', 'fuel exports in the vehicle tank' are not considered. 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 scenarios do not include the impact of the Covid crisis as the data for 2020 could not be fully examined before the deadline for this submission.

The scenario "with existing measures" results in significant emission reductions by 2030 for all pollutants except NH_3. The most substantial reduction (about 65% for 'fuel sold' and 57% for 'fuel used') 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 33% to 53%; NH_3 emissions, however, are projected to increase by 10% (see Table 4).

Table 4: *Austrian national total emission trend in kt in comparison with the base year 2005 in % based on (a) fuel sold and (b) fuel used for the scenario "with existing measures" (Source: Umweltbundesamt).*

Pollutant [kt]	**Emission inventory 2020**				**Emission scenario**			**Type of scenario**
	1990	**2005**	**2010**	**2019**	**2020**	**2025**	**2030**	
NO_x	217.35	247.33	204.45	144.20	137.54	106.65	87.19	fuel sold (WEM)
		0%	-17%	-42%	-44%	-57%	-65%	
	200.40	190.30	168.97	130.66	125.15	99.16	82.02	fuel used (WEM)
		0%	-11%	-31%	-34%	-48%	-57%	
SO_2	73.70	25.93	15.99	10.93	11.94	12.38	12.25	fuel sold (WEM)
		0%	*-38%*	*-58%*	*-54%*	*-52%*	*-53%*	
	72.92	25.88	15.96	10.89	11.91	12.34	12.20	fuel used (WEM)
		0%	*-38%*	*-58%*	*-54%*	*-52%*	*-53%*	
NMVOC	335.54	157.73	137.91	108.59	108.51	105.53	102.91	fuel sold (WEM)
		0%	*-13%*	*-31%*	*-31%*	*-33%*	*-35%*	
	331.03	153.26	135.90	108.01	107.94	105.01	102.42	fuel used (WEM)
		0%	*-11%*	*-30%*	*-30%*	*-31%*	*-33%*	

Pollutant [kt]	Emission inventory 2020				Emission scenario			Type of scenario
	1990	2005	2010	2019	2020	2025	2030	
NH_3	61.84	60.08	62.89	63.82	63.54	64.81	65.91	fuel sold (WEM)
		0%	*5%*	*6%*	*6%*	*8%*	*10%*	
	61.79	59.46	62.39	63.57	63.29	64.53	65.60	fuel used (WEM)
		0%	*5%*	*7%*	*6%*	*9%*	*10%*	
$PM_{2.5}$	27.07	22.56	19.81	14.06	13.96	12.71	11.72	fuel sold (WEM)
		0%	*-12%*	*-38%*	*-38%*	*-44%*	*-48%*	
	26.52	20.97	18.94	13.86	13.78	12.59	11.63	fuel used (WEM)
		0%	*-10%*	*-34%*	*-34%*	*-40%*	*-45%*	

The scenario "with additional measures" results in emission reductions by 2030 for all pollutants until 2030. The most substantial reduction (about 66% for 'fuel sold' and 59% for 'fuel used') in the period 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 0.1% to 52%. (see Table 4).

Table 5: Austrian national total emissions in kt and trend in comparison with the base year 2005 in % based on (a) fuel sold and (b) fuel used for the scenario "with addtional measures" (Source: Umweltbundesamt). NO_x and NMVOC emissions in the subsectors 3 B and 3 D have not been taken into account for checking compliance with the 2020/2030 emission reduction commitments.

Pollutant [kt]	Emission inventory 2020				Emission scenario			Type of scenario
	1990	2005	2010	2019	2020	2025	2030	
NO_x	217.35	247.33	204.45	144.20	136.90	104.49	83.01	fuel sold (WAM)
		0%	-17%	-42%	-45%	-58%	-66%	
	200.40	190.30	168.97	130.66	124.63	97.39	78.34	fuel used (WAM)
		0%	-11%	-31%	-35%	-49%	-59%	
SO_2	73.70	25.93	15.99	10.93	11.98	12.56	12.52	fuel sold (WAM)
		0%	*-38%*	*-58%*	*-54%*	*-52%*	*-52%*	
	72.92	25.88	15.96	10.89	11.94	12.52	12.47	fuel used (WAM)
		0%	*-38%*	*-58%*	*-54%*	*-52%*	*-52%*	
NMVOC	335.54	157.73	137.91	108.59	109.10	105.78	102.27	fuel sold (WAM)
		0%	*-13%*	*-31%*	*-31%*	*-33%*	*-35%*	
	331.03	153.26	135.90	108.01	108.54	105.24	101.70	fuel used (WAM)
		0%	*-11%*	*-30%*	*-29%*	*-31%*	*-34%*	

Pollutant [kt]	Emission inventory 2020				Emission scenario			Type of scenario
	1990	2005	2010	2019	2020	2025	2030	
NH_3	61.84	60.08	62.89	63.82	63.64	62.18	59.75	fuel sold (WAM)
		0%	*5%*	*6%*	*6%*	*3%*	*-1%*	
	61.79	59.46	62.39	63.57	63.38	61.89	59.43	fuel used (WAM)
		0%	*5%*	*7%*	*7%*	*4%*	*0%*	
$PM_{2.5}$	27.07	22.56	19.81	14.06	14.08	12.49	11.72	fuel sold (WAM)
		0%	*-12%*	*-38%*	*-38%*	*-45%*	*-48%*	
	26.52	20.97	18.94	13.86	13.90	12.38	11.64	fuel used (WAM)
		0%	*-10%*	*-34%*	*-34%*	*-41%*	*-45%*	

2.1 Nitrogen Oxides NO_x

In 1990, Austria's total NO_x emissions amounted to 217.4 kt (including fuel exports in the vehicle tank, i.e. based on 'fuel sold'). After an all-time high between 2003 and 2005, emissions have since been following a continuously decreasing trend. In 2019, NO_x emissions amounted to 144.2 kt and were about 33.7% lower than in 1990.

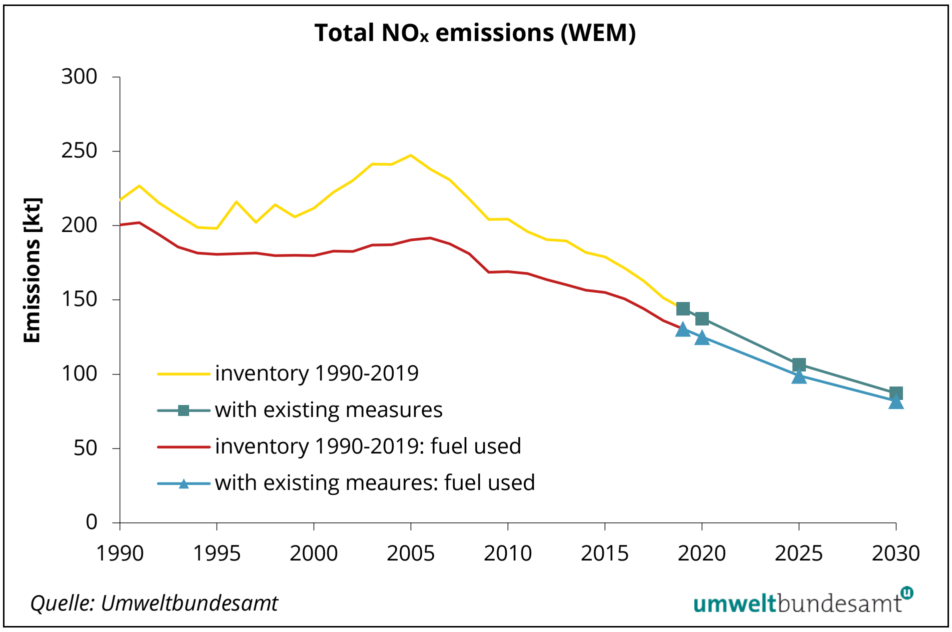
Compared to 2005 levels, emissions in 2019 were about 41.7% lower. When considering inland fuel consumption without 'fuel exports in the vehicle tank', NO_x emissions amounted to only 130.7 kt in 2019, corresponding to a 31.3% decrease since 2005. The gradual replacement of vehicles with new vehicles with lower fuel consumption and lower NO_x emissions (and well-functioning after-treatment devices) contributed to the decreasing trend in the last few years.

The main source of NO_x emissions in Austria (with a share of 92.5% in 2019) is Sector 1.A Fuel Combustion Activities. Within this sector, 1.A.3.b Road transport ('fuel sold') accounts for the highest share (51.7%) of total NO_x emissions. Further major sources are 1.A.2 Industry (17.2%), 1.A.4 Other Sectors (13.2%) and 1.A.1 Energy Industry (7.2%). Sector 3 Agriculture contributes 7.2%.

In the scenario "with existing measures" the national total emissions (including 'fuel export') are expected to decrease to 87.2 kt by 2030 (-64.7% compared to 2005). Without considering 'fuel exports', they are expected to decrease to 82.0 kt by 2030 (–56.1% 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. The decrease in emissions from manufacturing industries is less pronounced.

Figure 1: Historical (1990 to 2019) and projected emissions WEM (2020–2030) of NO_x based on (a) fuel sold and (b) fuel used.



NO_x emissions from road transport (especially cars and heavy-duty vehicles) are projected to decrease by 65.0% (i.e. -48.5 kt) from 2019 to 2030. This decline is based on the following assumptions:

- modernisation of the vehicle fleet in combination with decreasing specific emission factors and introduction of the latest emission classes Euro VI (HDV), Euro 6d_temp and EURO 6d (PC)
- an increased share of e-mobility by 2030 as a substitute for conventionally fuelled cars

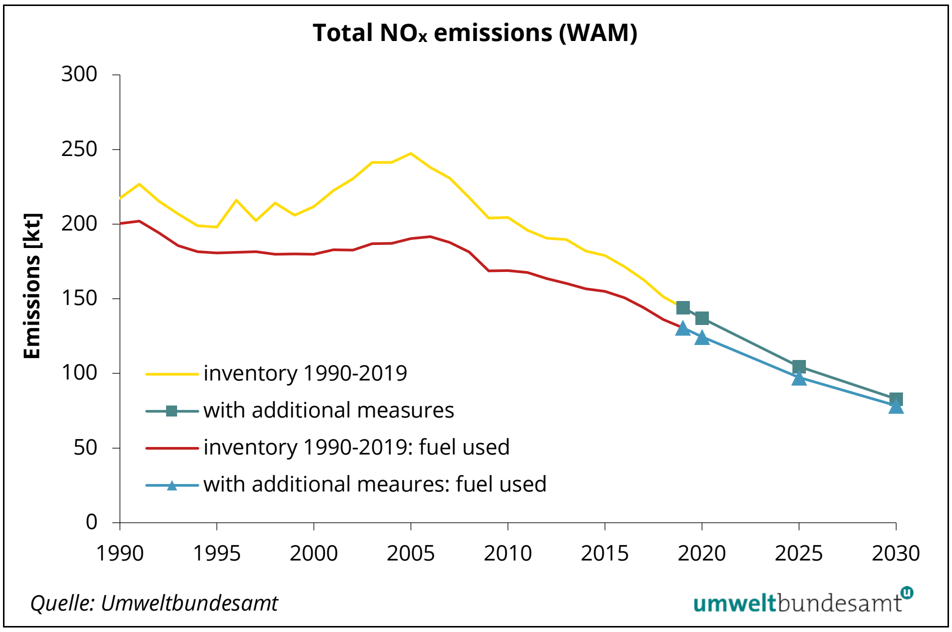
Emissions from 1.A.4. Other Sectors (households, commercial and agriculture) are projected to decrease by 27.2% (i.e. -5.2 kt) from 2019 to 2030. This is mainly due to a modernisation of (and decline in emissions from) non-road mobile machinery (NRMM, so-called off-road vehicles) and a switch to low-emission technology. It is not assumed that there will be a switch from fossil to electric propulsion systems in these categories. Mobile sources in households and agriculture (off-road) show a decrease of 40.5% (-2.7kt) by 2030. Stationary sources are expected to decrease by 19.9% (-2.4 kt) by 2030 because of a decrease in the use of fuel oil, ongoing stock replacement with condensing boilers and the effects of ecodesign provisions for the installation of new heating systems.

Reduced fuel inputs of coal and oil to thermal power stations are responsible for lower emissions in 1.A.1 Energy Industry (-21.5%, i.e. -2.24 kt) by 2030.

Emissions from 1.A.2 Manufacturing Industries and Construction decreased by 27.2% between 2005 and 2019 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.

In the scenario 'with additional measures' the national total emissions (including 'fuel export') are expected to decrease to 83 kt by 2030 (-66.4% compared to 2005). Without considering 'fuel exports', they are expected to decrease to 78.3 kt (–58.8% compared to 2005).

Figure 2: Historical (1990 to 2019) and projected NO_x emissions WAM (2020–2030) based on (a) fuel sold and (b) fuel used.



NO_x emissions from road transport (especially cars and heavy-duty vehicles) are projected to decrease by 69.7% (i.e. -52.0 kt) from 2019 to 2030.

Emissions from 1.A.4. Other Sectors (households, commercial and agriculture) are projected to decrease by 27.2% (i.e. -5.2 kt) from 2019 to 2030. Mobile sources in households and agriculture (off-road) show a decrease of 41.1% (i.e. -2.8 kt) by 2030. Stationary sources are expected to decrease by 20.8% (i.e. -2.55 kt) by 2030.

Reduced fuel inputs of coal and oil to thermal power stations and higher consumption of biomass in 1.A.1 Energy Industry results in a decrease of 13.9%, (i.e. -1.44 kt) by 2030.

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

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Type of scenario
		1990	2005	2010	2019	2020	2025	2030	
	Total	217.35	247.33	204.45	144.20	137.54	106.65	87.19	fuel sold (WEM)
		217.35	247.33	204.45	144.20	136.90	104.49	83.01	fuel sold (WAM)
	Total	200.40	190.30	168.97	130.66	125.15	99.16	82.02	fuel used (WEM)

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Type of scenario
		1990	2005	2010	2019	2020	2025	2030	
		200.40	190.30	168.97	130.66	124.63	97.39	78.34	fuel used (WAM)
1 A 1	Energy Industries	17.78	14.30	12.80	10.39	9.63	8.75	8.16	WEM
1 A 1	Energy Industries	17.78	14.30	12.80	10.39	10.29	9.33	8.95	WAM
1 A 2	Manufacturing Industries and Construction	33.04	33.98	32.15	24.75	24.55	25.10	24.52	WEM
1 A 2	Manufacturing Industries and Construction	33.04	33.98	32.15	24.75	24.37	25.11	24.70	WAM
1 A 3 a, c, d, e	Off-Road Transport	3.94	5.93	5.03	4.54	4.12	3.91	3.76	WEM
1 A 3 a, c, d, e	Off-Road Transport	3.94	5.93	5.03	4.54	4.12	3.96	3.91	WAM
1 A 3 b	Road Transportation	116.25	155.61	120.11	74.61	69.70	41.89	26.09	fuel sold (WEM)
		116.25	155.61	120.11	74.61	68.51	39.93	22.58	fuel sold (WAM)
1 A 3 b	Road Transportation	99.29	98.57	84.63	61.07	57.31	34.40	20.93	fuel used (WEM)
		99.29	98.57	84.63	61.07	56.24	32.83	17.91	fuel used (WAM)
1 A 4	Other Sectors	29.85	26.55	23.93	18.98	18.57	16.10	13.82	WEM
1 A 4	Other Sectors	29.85	26.55	23.93	18.98	18.64	16.06	13.66	WAM
1 A 5	Other	0.07	0.09	0.08	0.08	0.08	0.08	0.08	WEM
1 A 5	Other	0.07	0.09	0.08	0.08	0.08	0.07	0.08	WAM
1 B	Fugitive Emissions	IE	IE	IE	IE	IE	IE	IE	WEM
1 B	Fugitive Emissions	IE	IE	IE	IE	IE	IE	IE	WAM
2A,B,C, H,I,J,K,L	Industrial Processes	4.24	0.67	0.52	0.48	0.50	0.50	0.50	WEM
2A,B,C, H,I,J,K,L	Industrial Processes	4.24	0.67	0.52	0.48	0.50	0.50	0.50	WAM
2D, 2G	Solvent and Other Product Use	0.03	0.03	0.03	0.02	0.02	0.02	0.02	WEM
2D, 2G	Solvent and Other Product Use	0.03	0.03	0.03	0.02	0.02	0.02	0.02	WAM
3 B	Manure Management	0.60	0.58	0.56	0.55	0.55	0.53	0.51	WEM
3 B	Manure Management	0.60	0.58	0.56	0.55	0.55	0.52	0.49	WAM
3 D	Agricultural Soils	11.40	9.50	9.18	9.76	9.79	9.73	9.68	WEM
3 D	Agricultural Soils	11.40	9.50	9.18	9.76	9.79	8.95	8.08	WAM
3 F, I	Field Burning and other agriculture	0.05	0.04	0.04	0.02	0.02	0.02	0.02	WEM
3 F, I	Field Burning and other agriculture	0.05	0.04	0.04	0.02	0.02	0.02	0.02	WAM
5	Waste	0.10	0.05	0.02	0.02	0.02	0.02	0.02	WEM

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Type of scenario
		1990	2005	2010	2019	2020	2025	2030	
5	Waste	0.10	0.05	0.02	0.02	0.02	0.02	0.02	WAM

* *Data source: Austrian Emission Inventory 2020 (UMWELTBUNDESAMT 2021b)*

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

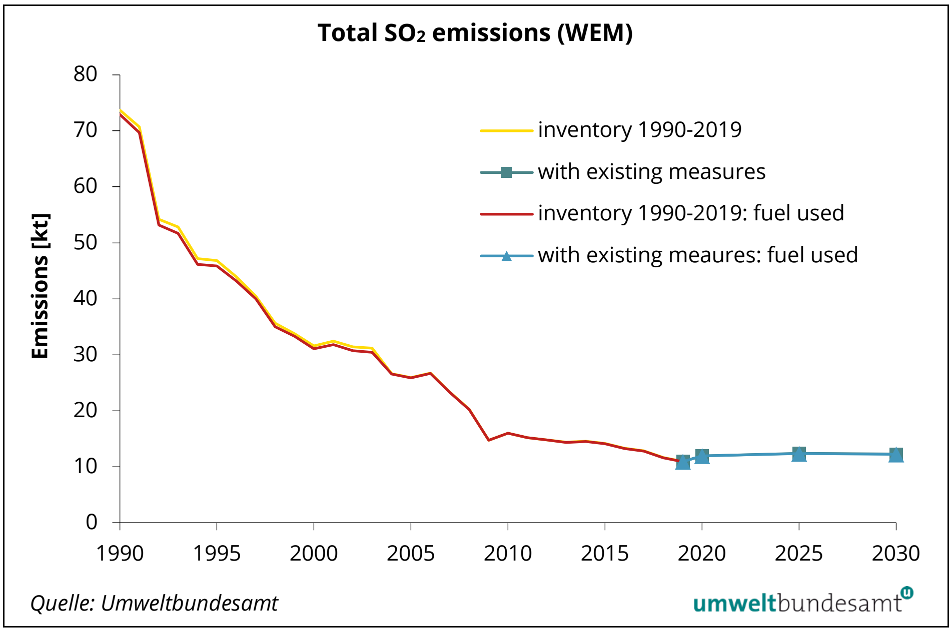
2.2 Sulphur Dioxide SO_2

In 1990, national total SO_2 emissions amounted to 73.7 kt. Since then, emissions have decreased quite steadily. By the year 2019, emissions had decreased by 85.2% compared to 1990 (amounting to 10.9 kt), mainly due to lower emissions from residential heating, combustion in industry and energy industries. A sharp decrease observed in 2008 was due to a further reduction of the sulphur content to 10 ppm in domestic heating oil. In 2019, emissions were about 57.9% lower than in 2005.

The main source of SO_2 emissions in Austria is the NFR Sector 1.A Fuel Combustion Activities with 94.4% in 2019. Within this sector, the main contributors to total SO_2 emissions are 1.A.2 Manufacturing Industries with 66.7% (more than the half of the emissions arise from the iron and steel industry), 1.A.1 Energy Industries with 11.9% and 1.A.4 Other Sectors (residential heating) with 12.9% of the total emissions.

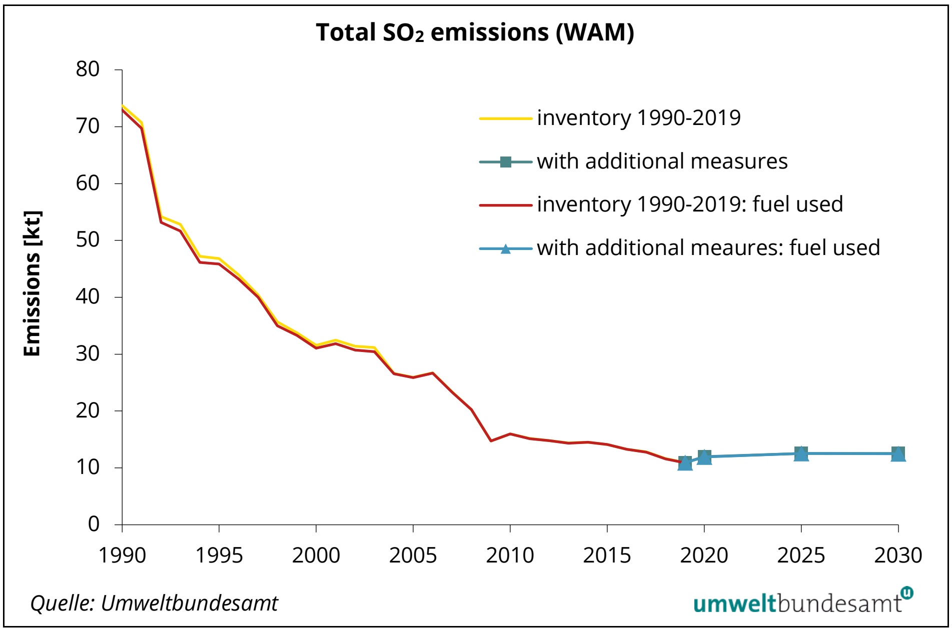
In the scenario 'with existing measures' (WEM) the national total emissions including 'fuel export' are expected to decrease to 12.2 kt by 2030 (–52.8% compared to 2005). Without considering 'fuel exports', they are expected to decrease to 12.2 kt (–52.9% compared to 2005).

Figure 3: Historical (1990 to 2019) and projected SO_2 emissions WEM (2020–2030) based on (a) fuel sold and (b) fuel used.



In the scenario 'with additional measures' (WAM), national total emissions including 'fuel export' are expected to decrease to 12.5 kt by 2030 (–51.7% compared to 2005). Without considering 'fuel exports', they are expected to decrease to 12.5 kt (–51.8% compared to 2005).

Figure 4: Historical (1990 to 2019) and projected SO_2 emissions WAM (2020–2030) based on (a) fuel sold and (b) fuel used.



Total SO_2 emissions are expected to increase slightly over the period from 2019 to 2030. A large part of appropriate mitigation measures (e.g. reduction of the sulphur content in liquid fuels, waste gas treatment) have already been implemented. Therefore, the reduction potential that remains is small.

Minor effects can be expected at the sectoral level over the period from 2019 to 2030: emissions from Energy Industries (1.A.1) are expected to decrease due to less fuel input (WEM: -21.1%, i.e. -0.28 kt ; WAM: -20.9%, i.e.-0.27 kt) and emissions from Other Sectors (1.A.4) are expected to decrease by 2030 (WEM: -29.3%-, i.e.-0.41 kt ; WAM: -25.8%, i.e.-0.36 kt) due to a shift from fossil fuels (oil, coal) to renewables. Emissions from Manufacturing Industries and Construction (1.A.2) are expected to increase (WEM: +27.7%, i.e.2.0 kt WAM: 30.9%, i.e. 2.25 kt).

Table 7: Austrian national SO_2 emissions in kt and trend based on (a) fuel sold and (b) fuel used (Source: Umweltbundesamt).

NFR	**Description**	**Emission inventory 2019* [kt]**				**Emission scenario [kt]**			**Type of scenario**
		1990	**2005**	**2010**	**2019**	**2020**	**2025**	**2030**	
	Total	73.70	25.93	15.99	10.93	11.94	12.38	12.25	fuel sold (WEM)
		73.70	25.93	15.99	10.93	11.98	12.56	12.52	fuel sold (WAM)
	Total	72.92	25.88	15.96	10.89	11.91	12.34	12.20	fuel used (WEM)
		72.92	25.88	15.96	10.89	11.94	12.52	12.47	fuel used (WAM)
1 A 1	Energy Industries	14.07	6.71	2.74	1.30	1.37	1.17	1.03	WEM
1 A 1	Energy Industries	14.07	6.71	2.74	1.30	1.39	1.15	1.03	WAM
1 A 2	Manufacturing Industries and Construction	17.83	10.14	9.40	7.29	8.25	9.11	9.31	WEM
1 A 2	Manufacturing Industries and Construction	17.83	10.14	9.40	7.29	8.25	9.29	9.54	WAM
1 A 3 a, c, d, e	Off-Road transport	0.36	0.18	0.18	0.17	0.15	0.15	0.16	WEM
1 A 3 a, c, d, e	Off-Road transport	0.36	0.18	0.18	0.17	0.14	0.15	0.16	WAM
1 A 3 b	Road Transportation	4.77	0.16	0.13	0.14	0.14	0.15	0.15	fuel sold (WEM)
		4.77	0.16	0.13	0.14	0.14	0.14	0.13	fuel sold (WAM)
1 A 3 b	Road Transportation	3.99	0.11	0.09	0.11	0.11	0.11	0.10	fuel used (WEM)
		3.99	0.11	0.09	0.11	0.11	0.10	0.09	fuel used (WAM)
1 A 4	Other Sectors	32.66	7.91	2.77	1.41	1.39	1.18	1.00	WEM
1 A 4	Other Sectors	32.66	7.91	2.77	1.41	1.43	1.22	1.05	WAM
1 A 5	Other	0.01	0.01	0.01	0.02	0.02	0.02	0.02	WEM
1 A 5	Other	0.01	0.01	0.01	0.02	0.01	0.01	0.02	WAM
1 B	Fugitive Emissions	2.00	0.04	0.05	0.02	0.03	0.02	0.01	WEM

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Type of scenario
		1990	2005	2010	2019	2020	2025	2030	
1 B	Fugitive Emissions	2.00	0.04	0.05	0.02	0.03	0.02	0.01	WAM
2A,B,C, H,I,J,K,L	Industrial Processes	1.93	0.72	0.70	0.56	0.56	0.56	0.56	WEM
2A,B,C, H,I,J,K,L	Industrial Processes	1.93	0.72	0.70	0.56	0.56	0.56	0.56	WAM
2D, 2G	Solvent and Other Product Use	0.00	0.01	0.01	0.00	0.00	0.00	0.01	WEM
2D, 2G	Solvent and Other Product Use	0.00	0.01	0.01	0.00	0.00	0.00	0.01	WAM
3 B	Manure Management	NA	NA	NA	NA	NA	NA	NA	WEM
3 B	Manure Management	NA	NA	NA	NA	NA	NA	NA	WAM
3 D	Agricultural Soils	NA	NA	NA	NA	NA	NA	NA	WEM
3 D	Agricultural Soils	NA	NA	NA	NA	NA	NA	NA	WAM
3 F, I	Field Burning and Other Agriculture	0.01	0.00	0.00	0.00	0.00	0.00	0.00	WEM
3 F, I	Field Burning and Other Agriculture	0.01	0.00	0.00	0.00	0.00	0.00	0.00	WAM
5	Waste	0.07	0.06	0.01	0.01	0.01	0.01	0.01	WEM
5	Waste	0.07	0.06	0.01	0.01	0.01	0.01	0.01	WAM

* *Data source: Austrian Emission Inventory 2020 (UMWELTBUNDESAMT 2021b)*

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

2.3 Non-Methane Volatile Organic Compounds (NMVOCs)

In 1990, Austria's total NMVOC emissions amounted to 335.5 kt. Emissions have decreased steadily since then and by the year 2019 emissions had decreased by 67.6% to 108.6 kt (compared to 1990). In 2019, emissions were about 31.2% lower than in 2005.

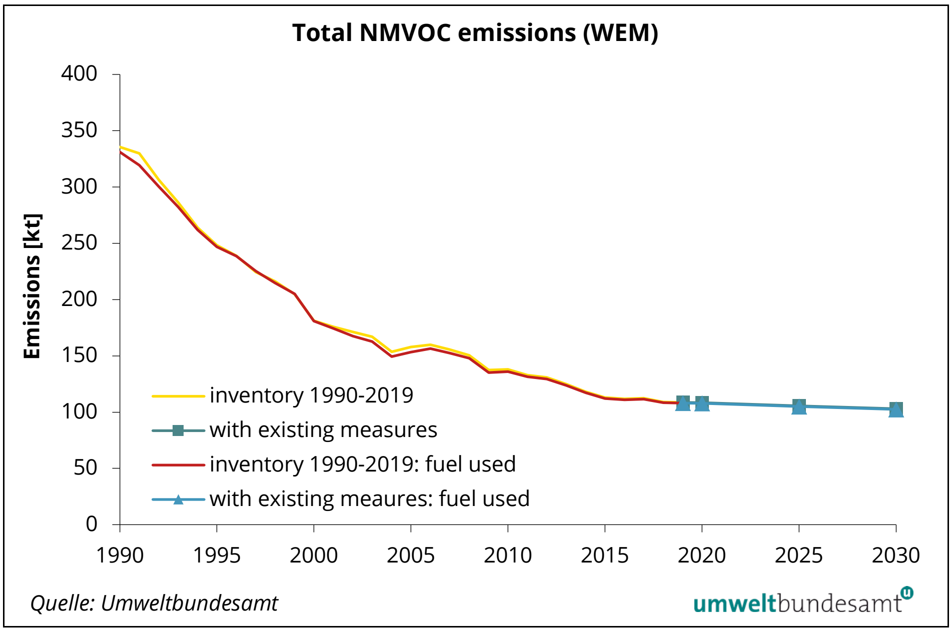
The main reasons for the emission reductions is the implementation of EU Directives relating to the use of solvents (e.g. 'The Paints Directive'), the modernisation of boilers in households and the usage of catalytic converters in petrol (gasoline) cars together with a shift to diesel cars.

The main sources of NMVOC emissions in Austria are NFR 2.D.3 Solvent Use with a share of 29.9% in 2019, 1.A.4 Other Sectors (24.8%) and 3.B Manure Management (24.5%).

In the scenario 'with existing measures' (WEM) national total emissions including 'fuel export' are expected to decrease to 102.9 kt by 2030 (-34.8% compared to

2005). Without considering 'fuel exports', they are expected to decrease to 102.4 kt (-33.2% compared to 2005).

Figure 5: Historical (1990 to 2019) and projected NMVOC emissions WEM (2020–2030) based on (a) fuel sold and (b) fuel used.



Total NMVOC emissions are projected to decrease by 5.2% by 2030 (compared to 2019). The largest reduction is expected to be achieved in Sector 1.A.4 (mainly households and commercial), with a decrease of 20.5% (i.e. -5.5 kt) over the period from 2019 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 3), as well as a decrease in the use of fuelwood as a source of energy.

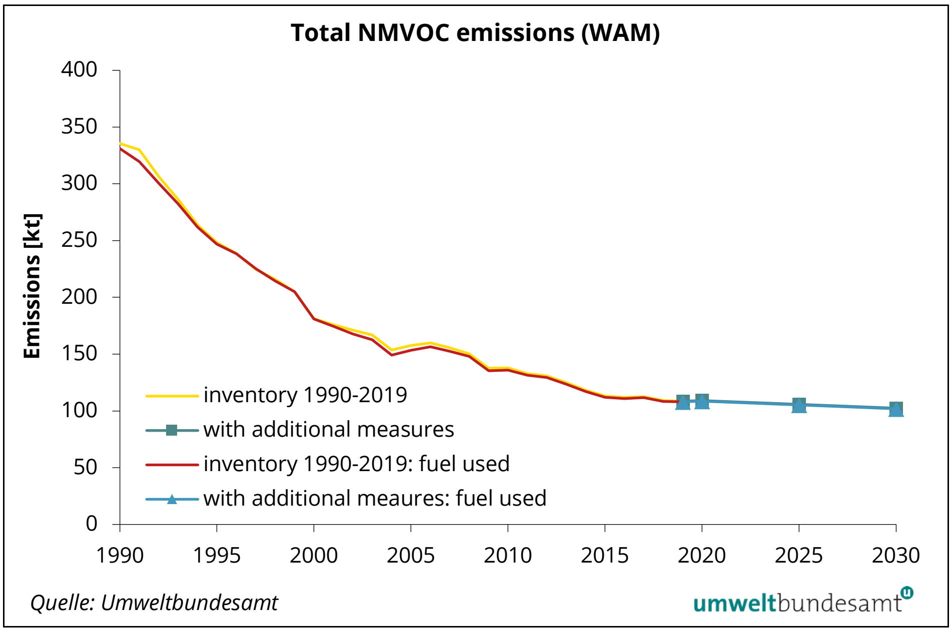
Emissions in the sector Road Transport are projected to fall by 27.5% (i.e. 1.29 kt) by 2030, especially owing to state-of-art exhaust gas treatment (regulated catalytic converter) and an increased share of diesel and electric vehicles.

On the other hand, emissions from 2.D.3 'Solvent Use' are expected to increase by 4.9% by 2030 (i.e.1.59 kt) due to an increase in the consumption of solvents. Emission regulations for the relevant sectors have been enacted at EU level (with some of the legal requirements in Austria being even stricter). The requirements for paints and varnishes have been harmonised at EU level; existing regulations do not provide for a further tightening of emission standards. The model for calculating emissions has been revised: calculations are now based on solvent balances from companies, and linked to economic projections for each NACE code.

Emissions from agriculture are projected to increase by 0.8% (i.e. 0.30 kt) by 2030, mainly caused by the developments of livestock in Austria.

In the scenario "with addtional measures" (WAM) the national total emissions including 'fuel export' are expected to decrease to 102.3 kt by 2030 (-35.2% compared to 2005). Without considering 'fuel exports', they are expected to decrease to 101.7 kt (-33.6% compared to 2005)

Figure 6: Historical (1990 to 2019) and projected emissions WAM (2020–2030) of NMVOC based on (a) fuel sold and (b) fuel used.



NMVOC emissions from agriculture are projected to decrease by 4.8% (i.e. -1.77 kt) over the period to 2030, mainly due to assumed developments of livestock in Austria.

Table 8: Austrian national NMVOC emissions in kt and trend based on (a) fuel sold and (b) fuel used (Source: Umweltbundesamt).

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Type of scenario
		1990	2005	2010	2019	2020	2025	2030	
	Total	335.54	157.73	137.91	108.59	108.51	105.53	102.91	fuel sold (WEM)
		335.54	157.73	137.91	108.59	109.10	105.78	102.27	fuel sold (WAM)
	Total	331.03	153.26	135.90	108.01	107.94	105.01	102.42	fuel used (WEM)
		331.03	153.26	135.90	108.01	108.54	105.24	101.70	fuel used (WAM)
1 A 1	Energy Industries	0.32	0.24	0.35	0.30	0.30	0.30	0.30	WEM
1 A 1	Energy Industries	0.32	0.24	0.35	0.30	0.30	0.30	0.30	WAM
1 A 2	Manufacturing Industries and Construction	1.68	2.06	1.94	1.03	0.90	0.84	0.82	WEM
1 A 2	Manufacturing Industries and Construction	1.68	2.06	1.94	1.03	0.88	0.83	0.82	WAM

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Type of scenario
		1990	2005	2010	2019	2020	2025	2030	
1 A 3 a, c, d, e	Off-Road transport	1.51	1.78	1.44	0.90	0.80	0.72	0.70	WEM
1 A 3 a, c, d, e	Off-Road transport	1.51	1.78	1.44	0.90	0.80	0.73	0.71	WAM
1 A 3 b	Road Transportation	96.37	20.44	10.19	4.70	4.59	3.89	3.41	fuel sold (WEM)
		96.37	20.44	10.19	4.70	4.69	4.12	3.71	fuel sold (WAM)
1 A 3 b	Road Transportation	91.87	15.97	8.18	4.12	4.02	3.38	2.92	fuel used (WEM)
		91.87	15.97	8.18	4.12	4.12	3.57	3.14	fuel used (WAM)
1 A 4	Other Sectors	49.27	33.74	34.80	26.94	27.36	24.32	21.42	WEM
1 A 4	Other Sectors	49.27	33.74	34.80	26.94	27.87	25.15	22.53	WAM
1 A 5	Other	0.01	0.02	0.02	0.02	0.02	0.02	0.02	WEM
1 A 5	Other	0.01	0.02	0.02	0.02	0.02	0.02	0.02	WAM
1 B	Fugitive Emissions	15.49	3.34	2.45	2.23	2.20	2.00	1.82	WEM
1 B	Fugitive Emissions	15.49	3.34	2.45	2.23	2.20	2.00	1.82	WAM
2A,B, C,H,I,J ,K,L	Industrial Processes	4.02	3.04	3.22	3.42	3.43	3.47	3.50	WEM
2A,B, C,H,I,J ,K,L	Industrial Processes	4.02	3.04	3.22	3.42	3.43	3.47	3.50	WAM
2D, 2G	Solvent and Other Product Use	114.52	53.48	44.84	32.48	32.65	33.41	34.07	WEM
2D, 2G	Solvent and Other Product Use	114.52	53.48	44.84	32.48	32.65	33.41	34.07	WAM
3 B	Manure Management	35.42	28.18	27.82	26.60	26.38	26.66	26.95	WEM
3 B	Manure Management	35.42	28.18	27.82	26.60	26.38	26.32	26.00	WAM
3 D	Agricultural Soils	16.71	11.27	10.73	9.90	9.82	9.83	9.85	WEM
3 D	Agricultural Soils	16.71	11.27	10.73	9.90	9.82	9.38	8.73	WAM
3 F, I	Field Burning and Other Agriculture	0.06	0.04	0.03	0.01	0.01	0.01	0.01	WEM
3 F, I	Field Burning and Other Agriculture	0.06	0.04	0.03	0.01	0.01	0.01	0.01	WAM
5	Waste	0.16	0.11	0.08	0.05	0.05	0.04	0.04	WEM
5	Waste	0.16	0.11	0.08	0.05	0.05	0.04	0.04	WAM

* *Data source: Austrian Emission Inventory 2020 (UMWELTBUNDESAMT 2021b)*

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

2.4 Ammonia (NH_3)

In 1990, national total NH_3 emissions amounted to 61.8 kt; emissions slightly increased over the period from 1990 to 2019. In 2019, emissions were 3.2% above 1990 levels, amounting to 63.8 kt.

The main source of ammonia is the agricultural sector, contributing 93.2% of total NH_3 emissions in 2019. Agricultural NH_3 emissions mainly arise from animal husbandry and the application of organic and mineral N fertilisers.

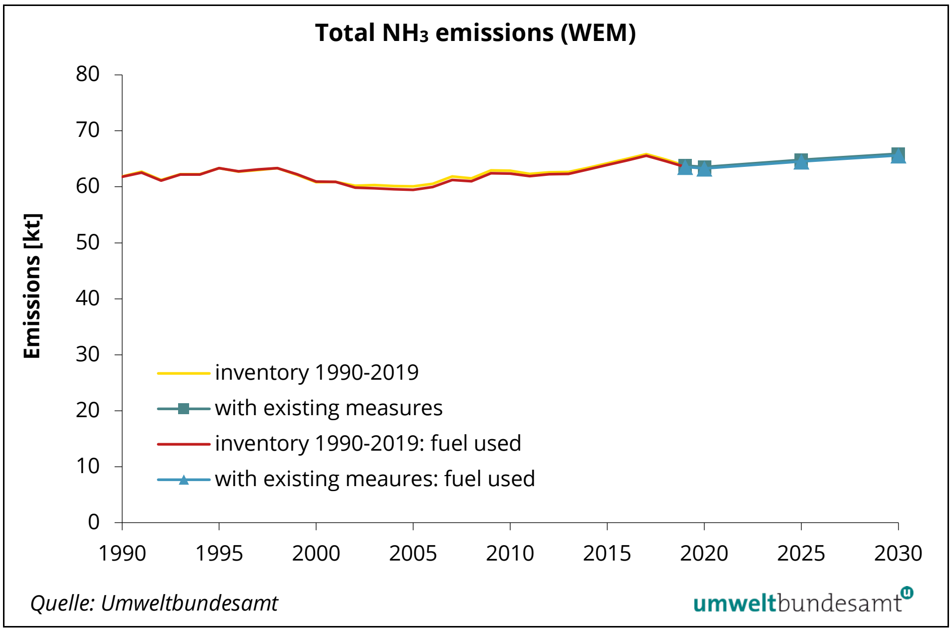
The sub-sector 3.B Manure Management has a share of 45.2% of Austria's total NH_3 emissions in 2019. Emissions arise from animal husbandry and the storage of manure. In manure management, cattle accounts for the highest share (61.2%). Levels of emissions are dependent on livestock numbers but also housing systems and manure treatment (e.g. NH_3 emissions from loose housing systems are considerably higher than those from tied housing systems). Since 1990, emissions from agriculture have increased by 0.5%, mainly due to higher emissions from cattle as a result of an increased use of loose housing systems after 2005 for reasons of animal welfare.

The sub-sector 3.D Agricultural Soils (with a share of 47.9%) has the largest share of national total NH_3 emissions in 2019. These emissions occur as a result of the application of mineral N fertilisers as well as organic fertilisers (including animal manure, sewage sludge, digestate 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 including 'fuel export' are expected to increase to 65.9 kt by 2030 (+9.7% compared to 2005). Without considering 'fuel exports', they are expected to increase to 65.6 kt (+10.3% compared to 2005).

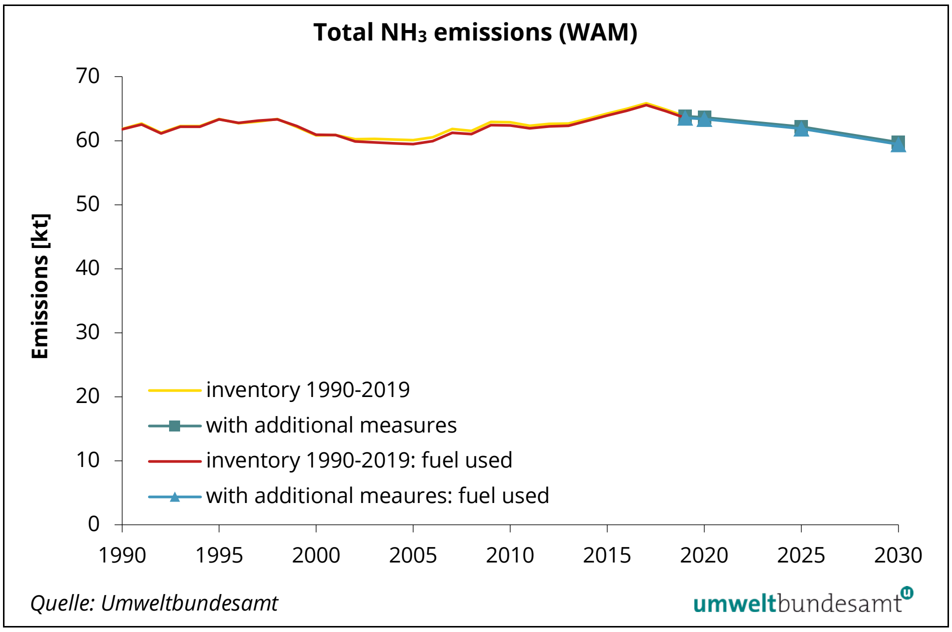
For the period between now and 2030, NH_3 projections show an increase in the WEM scenario (+3.3%). Based on national forecasts for agricultural production in Austria (WIFO & BOKU 2018), animal numbers of dairy cattle are expected to increase (+2.5% compared to 2019). The rise in the number of cattle kept in loose housing systems (to comply with animal welfare regulations) offsets the reduction effects of existing measures, resulting in an increase in emissions of 2.8% (i.e. 0.82 kt) in the sub-sector 3.B *Manure Management.* Furthermore, emissions in sub-sector 3.D *Agricultural Soils* are projected to increase by 3.8% (i.e. 1.16 kt) by 2030 due to increased amounts of animal manure applied to soils.

Figure 7: Historical (1990 to 2019) and projected emissions WEM (2020–2030) of NH_3 based on (a) fuel sold and (b) fuel used.



In the scenario 'with additional measures' (WAM), national total emissions including 'fuel export' are expected to decrease to 59.7 kt by 2030 (-0.6% compared to 2005). Without considering 'fuel exports', they are expected to decrease to 59.4 kt (-0.1%% compared to 2005).

Figure 8: Historical (1990 to 2019) and projected emissions WAM (2020–2030) of NH_3 based on (a) fuel sold and (b) fuel used.



In the scenario WAM for the period between now and 2030, NH_3 emissions are expected to decrease by 6.4%. The main reason for these emission reductions is the implementation of the additional measures listed the Austrian NAPCP and NECP. Measures in herd management, animal feeding, animal husbandry and slurry storage will reduce emissions by 6.0% (i.e. -1.72 kt) in the sub-sector 3.B *Manure Management.* Furthermore, emissions in sub-sector 3.D *Agricultural*

Soils are expected to decrease by 11.2% (i.e. -3.43 kt) by 2030, mainly due to an increased use of emission reducing manure application techniques and a decreased need for mineral N fertilisers.

Table 9: Austrian national NH3 emissions in kt and trend based on (a) fuel sold and (b) fuel used (Source: Umweltbundesamt).

NFR	Description	Emission inventory 2021 [kt]				Emission scenario [kt]			Type of scenario
		1990	2005	2010	2019	2020	2025	2030	
	Total	27.07	22.56	19.81	14.06	13.96	12.71	11.7	fuel sold (WEM)
		27.07	22.56	19.81	14.06	14.08	12.49	11.7	fuel sold (WAM)
	Total	26.52	20.97	18.94	13.86	13.78	12.59	11.6	fuel used (WEM)
		26.52	20.97	18.94	13.86	13.90	12.38	11.6	fuel used (WAM)
1 A 1	Energy Industries	0.85	0.80	1.12	0.93	0.95	0.93	0.90	WEM
1 A 1	Energy Industries	0.85	0.80	1.12	0.93	0.98	0.90	0.91	WAM
1 A 2	Manufacturing Industries and Construction	1.90	1.85	1.52	0.71	0.71	0.79	0.82	WEM
1 A 2	Manufacturing Industries and Construction	1.90	1.85	1.52	0.71	0.71	0.81	0.83	WAM
1 A 3 a, c, d, e	Off-Road Transport	0.70	0.66	0.52	0.42	0.58	0.57	0.55	WEM
1 A 3 a, c, d, e	Off-Road Transport	0.70	0.66	0.52	0.42	0.58	0.57	0.55	WAM
1 A 3 b	Road Transportation	5.70	7.23	4.90	2.47	2.32	1.94	1.83	fuel sold (WEM)
		5.70	7.23	4.90	2.47	2.32	1.59	1.65	fuel sold (WAM)
1 A 3 b	Road Transportation	5.15	5.65	4.03	2.26	2.14	1.83	1.74	fuel used (WEM)
		5.15	5.65	4.03	2.26	2.14	1.17	0.96	fuel used (WAM)
1 A 4	Other Sectors	13.39	9.05	9.18	7.11	7.05	6.11	5.20	WEM
1 A 4	Other Sectors	13.39	9.05	9.18	7.11	7.15	6.25	5.36	WAM
1 A 5	Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	WEM
1 A 5	Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	WAM
1 B	Fugitive Emissions	0.11	0.09	0.07	0.06	0.06	0.05	0.04	WEM
1 B	Fugitive Emissions	0.11	0.09	0.07	0.06	0.06	0.05	0.04	WAM
2A,B,C,H,I,J,K,L	Industrial Processes	3.29	1.83	1.37	1.36	1.25	1.26	1.26	WEM
2A,B,C,H,I,J,K,L	Industrial Processes	3.29	1.83	1.37	1.36	1.25	1.26	1.26	WAM

NFR	Description	Emission inventory 2021 [kt]				Emission scenario [kt]			Type of scenario
		1990	2005	2010	2019	2020	2025	2030	
2D, 2G	Solvent and Other Product Use	0.54	0.49	0.50	0.43	0.44	0.45	0.45	WEM
2D, 2G	Solvent and Other Product Use	0.54	0.49	0.50	0.43	0.44	0.45	0.45	WAM
3 B	Manure Management	0.13	0.11	0.11	0.11	0.11	0.11	0.11	WEM
3 B	Manure Management	0.13	0.11	0.11	0.11	0.11	0.11	0.11	WAM
3 D	Agricultural Soils	0.14	0.15	0.14	0.14	0.13	0.13	0.13	WEM
3 D	Agricultural Soils	0.14	0.15	0.14	0.14	0.13	0.13	0.13	WAM
3 F, I	Field Burning and Other Agriculture	0.09	0.08	0.06	0.02	0.02	0.02	0.02	WEM
3 F, I	Field Burning and Other Agriculture	0.09	0.08	0.06	0.02	0.02	0.02	0.02	WAM
5	Waste	0.23	0.21	0.29	0.29	0.31	0.33	0.38	WEM
5	Waste	0.23	0.21	0.29	0.29	0.31	0.33	0.38	WAM

* *Data source: Austrian Emission Inventory 2020 (UMWELTBUNDESAMT 2021b)*

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

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

National total $PM_{2.5}$ emissions amounted to 27.1 kt in 1990. They have decreased steadily ever since: from 1990 to 2019, emissions (with 'fuel exports') decreased by 48.1% to 14.1 kt. Emissions calculated based on 'fuel used' stood at 26.5 kt in 1990 and decreased to 13.9 kt in 2019 (-47.7%).

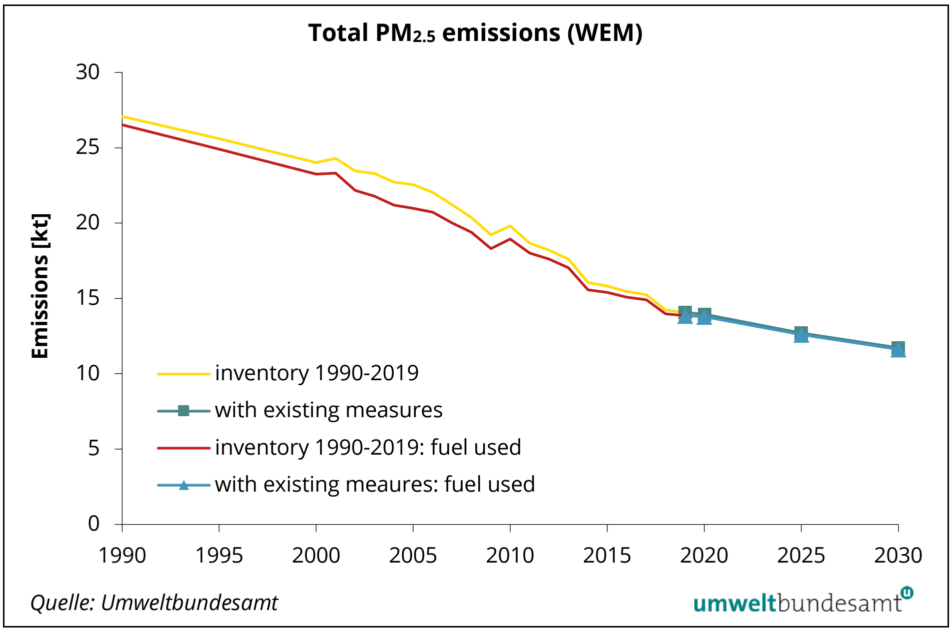
In 2019, $PM_{2.5}$ emissions in Austria mainly arose from combustion activities in the energy sector, which accounted for 82.6% of the national total. Within this sector, 1.A.4 Other Sectors (50.5%), 1.A.3 Transport (20.5%), 1.A.2 Industry (5.1%) are the main contributors to $PM_{2.5}$ emissions. Sector 2 IPPU is responsible for 12.8%.

In Sector 1.A.4 (mainly households and commercial), substantial emission reductions have been achieved as a result of the replacement of old installations with new low emission heating systems, a decrease in the use of fuelwood as a source of energy, the installation of energy-saving combustion plants, by connecting buildings to district heating networks or to other public energy and heating networks.

The reduction in 1.A.3 Transport since 2005 has been due to improvements in drive and exhaust gas after-treatment technologies and tax incentives (fuel consumption-based car registration tax: lower tax rates for diesel passenger cars equipped with particulate filter systems).

In the scenario "with existing measures" (WEM) the national total emissions including 'fuel export' are expected to decrease to 11.7 kt by 2030 (-48.0% compared to 2005). Without considering 'fuel exports', they are expected to decrease to 11.6 kt (-44.6% compared to 2005).

Figure 9: Historical (1990 to 2019) and projected emissions WEM (2020–2030) of $PM_{2.5}$ based on (a) fuel sold and (b) fuel used.



In the WEM scenario, $PM_{2.5}$ emissions of 1A4 Other Sectors are expected to decrease by 26.8% (i.e -1.91 kt) in 2030 compared to 2019. $PM_{2.5}$ emission reductions are mainly due to increased efficiency of buildings and heating systems and a trend away from manually fed fuel wood boilers and ovens. A decreasing energy demand for solid fuel (fuel wood, coal) is also responsible for $PM_{2.5}$ reductions. Furthermore, projected emission factors for new boilers in buildings are lower for future installations (see also ecodesign requirements in Chapter 3).

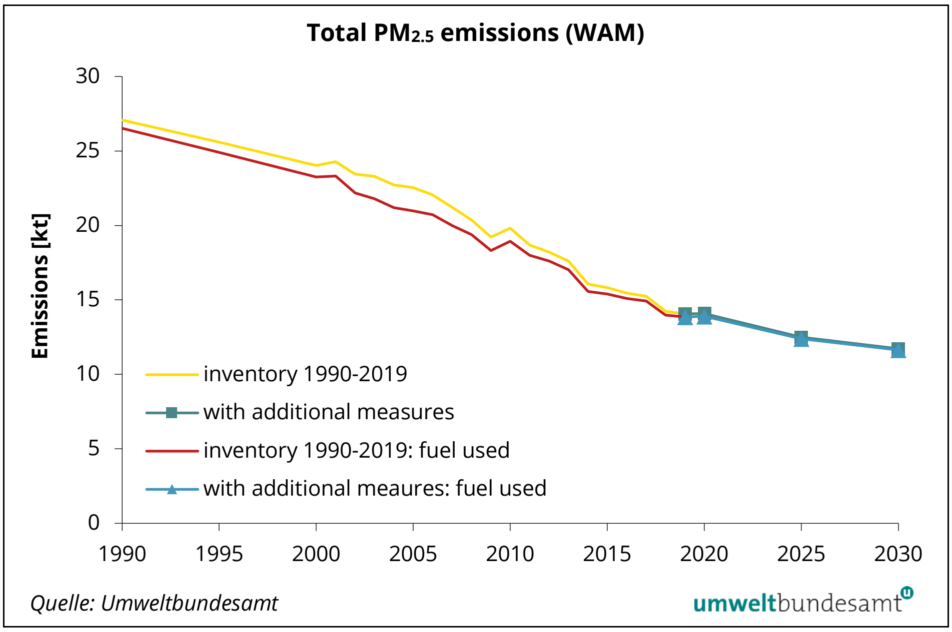
Total $PM_{2.5}$ emissions from the road transport sector (including 'fuel export') are expected to decrease by about 25.8% (i.e. -0.64 kt) compared to 2019. Without considering 'fuel exports', they are expected to decrease by about 23.0% (i.e. -0.52 kt) compared to 2019. Whereas exhaust emissions from cars and trucks are expected to decrease by 2030 (due to a higher penetration of vehicles fitted with filters), 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 a slight decrease in $PM_{2.5}$ emissions has been observed, generally due to a decrease in biomass usage for electricity and heat generation.

Emissions from 1 A 2 Manufacturing Industries and Construction decreased by 61.6% between 2005 and 2019 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.

Mobile sources in industry (off-road) show a 74.5% decrease (i.e. -0.08 kt) by 2030, mainly due to the penetration of industrial off-road machinery fitted with particulate filters.

Figure 10: Historical (1990 to 2019) and projected emissions WAM (2020–2030) of $PM_{2.5}$ based on (a) fuel sold and (b) fuel used.



In the scenario 'with additional measures' (WAM), national total emissions including 'fuel exports' are expected to decrease to 11.7 kt by 2030 (-48.0% compared to 2005). Without considering 'fuel exports', they are expected to decrease to 11.6 kt (-44.5% compared to 2005).

$PM_{2.5}$ emissions from 1A4 Other Sectors are expected to decrease by 24.5% (i.e. -1.74 kt) by 2030 compared to 2019. Total $PM_{2.5}$ emissions from the road transport sector (including 'fuel exports') are expected to decrease by about 33.1% (i.e. -0.82 kt) compared to 2019.

Due to higher inputs of biomass in energy consumption, $PM_{2.5}$ emissions in some combustion related sectors (e.g. 1A2) are slightly higher than in the WEM scenario.

Table 10: Austrian national $PM_{2.5}$ emissions in kt and trend based on (a) fuel sold and (b) fuel used (Source: Umweltbundesamt).

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Type of scenario
		1990	2005	2010	2019	2020	2025	2030	
	Total	27.07	22.56	19.81	14.06	13.96	12.71	11.7	fuel sold (WEM)
		27.07	22.56	19.81	14.06	14.08	12.49	11.7	fuel sold (WAM)
	Total	26.52	20.97	18.94	13.86	13.78	12.59	11.6	fuel used (WEM)
		26.52	20.97	18.94	13.86	13.90	12.38	11.6	fuel used (WAM)
1 A 1	Energy Industries	0.85	0.80	1.12	0.93	0.95	0.93	0.90	WEM
1 A 1	Energy Industries	0.85	0.80	1.12	0.93	0.98	0.90	0.91	WAM
1 A 2	Manufacturing Industries and Construction	1.90	1.85	1.52	0.71	0.71	0.79	0.82	WEM
1 A 2	Manufacturing Industries and Construction	1.90	1.85	1.52	0.71	0.71	0.81	0.83	WAM
1 A 3 a, c, d, e	Off-Road Transport	0.70	0.66	0.52	0.42	0.58	0.57	0.55	WEM
1 A 3 a, c, d, e	Off-Road Transport	0.70	0.66	0.52	0.42	0.58	0.57	0.55	WAM
1 A 3 b	Road Transportation	5.70	7.23	4.90	2.47	2.32	1.94	1.83	fuel sold (WEM)
		5.70	7.23	4.90	2.47	2.32	1.59	1.65	fuel sold (WAM)
1 A 3 b	Road Transportation	5.15	5.65	4.03	2.26	2.14	1.83	1.74	fuel used (WEM)
		5.15	5.65	4.03	2.26	2.14	1.17	0.96	fuel used (WAM)
1 A 4	Other Sectors	13.39	9.05	9.18	7.11	7.05	6.11	5.20	WEM
1 A 4	Other Sectors	13.39	9.05	9.18	7.11	7.15	6.25	5.36	WAM
1 A 5	Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	WEM
1 A 5	Other	0.02	0.02	0.02	0.02	0.02	0.02	0.02	WAM
1 B	Fugitive Emissions	0.11	0.09	0.07	0.06	0.06	0.05	0.04	WEM
1 B	Fugitive Emissions	0.11	0.09	0.07	0.06	0.06	0.05	0.04	WAM
2A,B,C,H, I,J,K,L	Industrial Processes	3.29	1.83	1.37	1.36	1.25	1.26	1.26	WEM
2A,B,C,H, I,J,K,L	Industrial Processes	3.29	1.83	1.37	1.36	1.25	1.26	1.26	WAM
2D, 2G	Solvent and Other Product Use	0.54	0.49	0.50	0.43	0.44	0.45	0.45	WEM
2D, 2G	Solvent and Other Product Use	0.54	0.49	0.50	0.43	0.44	0.45	0.45	WAM

NFR	Description	Emission inventory 2019* [kt]				Emission scenario [kt]			Type of scenario
		1990	2005	2010	2019	2020	2025	2030	
3 B	Manure Management	0.13	0.11	0.11	0.11	0.11	0.11	0.11	WEM
3 B	Manure Management	0.13	0.11	0.11	0.11	0.11	0.11	0.11	WAM
3 D	Agricultural Soils	0.14	0.15	0.14	0.14	0.13	0.13	0.13	WEM
3 D	Agricultural Soils	0.14	0.15	0.14	0.14	0.13	0.13	0.13	WAM
3 F, I	Field Burning and Other Agriculture	0.09	0.08	0.06	0.02	0.02	0.02	0.02	WEM
3 F, I	Field Burning and Other Agriculture	0.09	0.08	0.06	0.02	0.02	0.02	0.02	WAM
5	Waste	0.23	0.21	0.29	0.29	0.31	0.33	0.38	WEM
5	Waste	0.23	0.21	0.29	0.29	0.31	0.33	0.38	WAM

* *Data source: Austrian Emission Inventory 2020 (UMWELTBUNDESAMT 2021b)*

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

3 POLICIES AND MEASURES (PAMS)

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.

Compared to the last submission in 2019, reporting on policies and measures has improved. Additional measures in the WAM scenario are based on the National Climate and Energy Plan and the National Air Pollution Control Programme.

The Austrian air pollutant projections are consistent with current GHG emissions projections under the EU Governance Regulation (UMWELTBUNDESAMT 2021c).

A detailed description of the individual measures for GHGs is provided in a report entitled "GHG Projections and Assessment of Policies and Measures in Austria", submitted under the Governance Regulation (2018/1999) in 2021 (UMWELTBUNDESAMT 2021c).

Measures to reduce GHG emissions and air emission scenarios have been identified. The measures are considered in the scenarios. 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 Green Electricity Act. 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. In addition, financial support for heat and power cogeneration is granted in order to support the efficient use of primary energy for electricity production.

- Further enhancement of renewable energy in power supply and district heating (WAM)
  - A further increase in the share of renewable energy in power supply and district heating, to be achieved by 2030, 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 will be set in the Renewable Energy Expansion Act for increasing the share of wind power, photovoltaics, small hydropower plants and biomass/biogas in electricity generation in the next decade.
  - Investment support for biomass-based district heating systems will continue to be granted via the Domestic Environmental Support Scheme. Funding for this scheme has recently been considerably increased. Additional support will be granted for innovative district heating systems (see PaM Domestic Environmental Support Scheme).

- Further enhancement of energy efficiency in the energy industries (WAM)
  - A further increase in energy efficiency in the energy and manufacturing industries is essential for the achievement of climate and energy goals. Based on EU legislation, Austria adopted an Energy Efficiency Act and

prepared National Energy Efficiency Action Plans in 2014 and 2017 respectively, with quantitative targets for final and primary energy consumption in 2020. The Energy Efficiency Action Plans have since been integrated in the National Energy and Climate Plan. The Austrian National Energy and Climate plan was published at the end of 2019.
  - Furthermore, support through the domestic environmental support scheme in the sector 'non-ETS industry' is expected to be increased (see PaM Domestic Environmental Support Scheme).
  - Financial support for heat and power cogeneration based on fossil fuels will no longer be granted from 2021 onwards.

- Further enhancement of renewables in gas supply (WAM)
  - Austria intends to increase the share of renewables in its final energy demand. As natural gas is the predominant fuel in the sector 'energy industries', it is essential to raise the share of renewable gas in the national gas grid.

3.3 Transport (1.A.3)

- Increase the share of clean 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 of the Action Plan for electric mobility, as well as the e-mobility offensive laid down in the national climate and energy strategy (#mission2030).

- Increase fuel efficiency in road transport (WEM)
  - Supported by the following instruments: fuel tax increase in 2011, greening the truck toll, mobility management and awareness raising – 'klimaaktiv mobil' fuel saving initiative and introduction of speed limits to tackle air quality problems.

- Modal shift to environmentally friendly transport modes (WEM)
  - The objective of this measure is to achieve a shift in the modal split towards environmentally friendly transport modes through the following instruments: mobility management and awareness – 'klimaaktiv mobil' initiative and the promotion of corporate feeder lines for freight transport.

- Further enhancement of fuel efficiency in road transport (WAM)
  - With this measure, the increase of fuel efficiency in road transport is to be expanded and intensified beyond the ambition level of the scenario

WEM. The greatest technology-related contribution to increasing fuel efficiency in road transport can be achieved through the use of electric vehicles, which is due to the comparatively high energy efficiency of the technology itself. The measure therefore focuses on using instruments that intend to directly or indirectly promote the market ramp-up of battery-electric vehicles or vehicles that are powered by hydrogen fuel cells.

- Further modal shift to environmentally friendly transport modes (WAM)
  - With this measure, the modal shift to environmentally friendly transport modes is to be expanded and intensified beyond the ambition level of the scenario WEM. With regard to the ambitious national and international climate targets, a further shift to environmentally friendly transport modes with a lower energy demand is essential. This applies to both passenger transport and freight traffic. In the field of motorised transportation - active mobility is dealt with in PaM N° 15 - public transport and rail-bound freight transport are of particular importance. This PaM therefore includes instruments that focus on expanding the range of public transport services and offering additional capacities for rail-bound freight transport.

- Further enhancement of clean energy sources for transport (WAM)
  - With this measure, the increase in the share of clean energy sources in road transport is to be expanded and intensified beyond the ambition level of the scenario WEM. In this PaM, the target of a 14% share of renewable energy in transport has been implemented in accordance with the EU Directive on the promotion of renewable energy (RES II). It has been assumed that the proportion of renewable energy in transport will increase, primarily due to the increasing market penetration of electric mobility paired with a high share of renewable energy in the electricity mix and a slight increase in the use of sustainably produced biofuels. In 2017, Austria had a share of renewables of around 9.5% in the transport sector. The additional 4.5% (to achieve the minimum target of 14% in 2030) can mainly be generated by increasing the share of e-mobility and with an increased use of biofuels in gasoline and diesel fuels. GHGs affected: CO_2, CH_4, N_2O

- Enhanced consideration of climate mitigation in spatial planning & mobility management
  - The current traffic system is the result of decades of car-centred transport and spatial planning. This and the increasing urban sprawl have complemented each other. Spatial structures only react inertly to external impulses. At the same time, the creation of short distances and the mixing of different uses are key to enabling sustainable, environmentally friendly mobility. In this PaM, ecological spatial planning is promoted and combined with multimodal mobility management. The aim is

to sustainably reduce the need to use private cars, to support multimodal mobility behaviour and thus to optimise energy efficiency in the transport sector.

3.4 Other Sectors (NFR 1 A 4)

- Increased energy efficiency of buildings (WEM)
  - Improvement of building standards according to OIB Guideline 6 – Energy saving and thermal insulation, 2015 edition (OIB-330.6-009/15)
  - Implementation of the national plan according to Art. 9 (3) of Directive 2010/31/EU, 2014 edition (OIB-330.6-014/14-012)
  - National and funding programmes for thermal renovation and energy efficiency of buildings
  - Building renovation initiative for private buildings to improve their energy performance ('renovation cheques')
  - Building renovation initiative for commercial and industrial buildings to improve their energy performance
  - Implementation of the Recast of the Energy Performance of Buildings Directive (including the Energy Certification Providing Act)

- Increased share of renewable energy in space heating (WEM)
  - Stepping up the replacement of heating systems
  - Implementation of the District Heating and Cooling Act
  - Providing subsidies for wood fuel heating systems and solar heating systems

- Increased energy efficiency in residential electricity demand (WEM)
  - Implementation of ecodesign requirements (Directive 2006/32/EC) for energy using products
  - Implementation of the Energy Efficiency Directive (2012/27/EU) and energy labelling for household appliances

- Further enhancement of energy efficiency of buildings (WAM)
  - Tightening of building standards according to OIB Guideline 6 – Energy saving and thermal insulation, draft 2018 edition (OIB-330.6-038/18)
  - Implementation of the national plan according to Art. 9(3) of 2010/31/EU, 2018 edition (OIB-330.6-005/18)

- Replacement of fossil fuels with renewable energy sources (WAM)
  - Restrictions on fossil fuel heating systems in new buildings
  - Restrictions on fossil fuel oil heating systems in existing building

  - Concerted replacement of old fossil fuel oil heating systems
  - Restricted access to natural gas networks for heating purposes

3.5 Industrial Processes and Product Use (2)

- Decrease in emissions from F gases and other product use (WEM)
  - The Austrian Ordinance on VOC emissions further includes guidelines for the reduction of emissions. A ddecrease in emissions from solvent and other product use is to be achieved through the implementation of the Solvents Ordinance, the aim of which is to reduce VOC emissions from paints and varnishes, and through the limitation of VOC emissions from the use of organic solvents in industrial installations. The implementation of EU legislation targeting the reduction of F gas emissions also falls within the scope of this sector, but is not relevant for air pollution
  - Emissions of volatile organic compounds from the use of organic solvents in certain industrial installations and commercial enterprises fall within the scope of the Industrial Emissions Directive. Operators are obliged to comply with regulations concerning emission limits. For this reason, regular measurements and reporting are necessary. An annual report on solvent use has to be submitted to the district authorities.

In the scenario the Deco Paints Directive (Directive 2004/42/EC) has been fully implemented, as well as Commission Directive 2010/79/EU on the adaptation to technical progress of Annex III to Directive 2004/42/EC on the limitation of emissions of volatile organic compounds.

3.6 Agriculture (3)

Existing measures (Air Pollutants and GHG emissions)

- The implementation of EU agricultural policies in Austria (WEM) puts *inter alia* a focus on environmentally sound farming practices in Austria's mostly small agricultural holdings. The instruments that have been taken into account in the current WEM scenario are listed below:
- Programme for rural development 2014–2020 (WEM):
  - The Austrian Agri-environmental Programme allocates funding for specific actions for the period 2014–2020.
  - The implementation of this policy includes e.g. improved feeding, covering of manure storage, low-loss application of manure and biogas slurry, promotion of organic farming, promotion of grazing, reduced usage of mineral fertilisers.

- CAP - Common Agricultural Policy (WEM):
  - Implementation of the CAP 2013 reform (in particular the abolition of sugar quota and suckling cow premiums)
  - Internal convergence of direct payments ('regional premium' scheme instead of historical payments)
  - Land is maintained in good agricultural and ecological condition ('cross compliance' and requirements met for 'greening', in particular the crop rotation requirement)
  - Programme for rural development 2014–2020 (see above). Assumed to be maintained over the entire projection period

Additional measures (air pollutants and GHG emissions)

Livestock and feeding management (WAM)

Activity data:

Projected activity data are the same as the activity data used in the WEM scenario (WIFO & BOKU 2018), except for cattle. For cattle, in accordance with Austria's NECP, it has been assumed that, due to the following additional measures, animal numbers will no longer increase from 2025 onwards:

- Site-adapted, area-based livestock farming while maintaining animal welfare (maximum/moderate livestock densities)
- Trend towards a healthier diet for the human population with high quality foods
- Food waste reduction (strategy "Food is precious")
- Breeding progress resulting in lower animal numbers

Reduction of nitrogen excretion:

By optimising livestock feed rations and feed quality, less excess nitrogen is fed, resulting in lower reactive nitrogen emissions (NH_3, N_2O, NO_x, N_2) along the entire farmyard manure management chain.

According to Austria's NAPCP and NECP, the following animal feed-related instruments intend to reduce the nitrogen excretion rates for cattle (with the exception of dairy cows), pigs and chicken by 5% by 2030 compared to the WEM scenario.

- Further improvements of the feeding quality of cattle
- Adapting feed to animal requirements (e.g. multiphase feeding);
- Awareness raising (education and advisory services);
- Promoting marketing opportunities for older cattle - longer use and lower mortality means lower emissions, but requires that meat from older cattle can be sold on the market (e.g. fattening of older cattle/cows).
- Progress in breeding (digestibility, lifetime performance);

Promotion of grazing:

Grazing animals excrete faeces and urine separately. Faster infiltration of urea into the soil reduces ammonia emissions. Grazing also means that less nitrogen is used in cattle feed. In addition, grazing is particularly beneficial from an animal welfare perspective.

The following instruments listed in Austria's NAPCP and NECP are intended to increase grazing of dairy & suckling cows by 30% by 2030.

- Further development and expansion of animal grazing within the framework of the agri-environmental programme ÖPUL, e.g. through a gradual extension of the grazing period.
- Awareness raising (education and advisory services).

Instruments listed under "Livestock and feeding management" are included in NAPCP measure 1 (see Table 11).

Reduction of N losses along the entire farmyard manure chain (WAM)

Additional instruments listed in Austria's NAPCP will further reduce losses of N species emissions (NH_3, N_2O, NO_x, N_2) along the entire farmyard manure management chain.

- Low-emission design
  - of cattle buildings and cow barns (floors with rubber lips +50% by 2030)
  - of pig houses (partially slatted floor +30% by 2030)
  - of chicken houses (manure removal +50% by 2030)
- Increase the use of covers for manure (cattle slurry) storage by +5%, for pig slurry by +10% by 2030
- The share of slurry treated in biogas plants is to be significantly increased (to 30% of Austria's total manure volume) by 2030, in accordance with Austria's NECP.
- Significant increase in the use of emission reducing cattle and pig slurry application techniques (40% of cattle slurry, 40–60% of pig slurry)

The instruments listed under "Reduction of N losses along the entire farmyard manure management chain" are included in NAPCP measure 2, 3 and 4 (see Table 11).

Reducing emissions from the use of mineral fertilisers (WAM)

It is assumed that the use of mineral fertilisers will be further reduced *by* improving nitrogen management in farming (see above) or by introducing a premium for reduced use. The Austrian Agri-environmental Programme ÖPUL already includes some effective instruments for this purpose, which will be further developed or expanded.

- Improvement of demand-oriented dosage through fertiliser planning, soil testing and increased awareness raising (building on existing training and advisory services). Reduction of losses in mineral and organic fertiliser management and increased nitrogen efficiency;

- Legal regulations within the framework of the Nitrate Action Programme;
- Reduced use of urea: direct incorporation, if possible, or conversion to other fertilisers or use of fertilisers with inhibitors. Promotion of advisory services;
- Further development and expansion of the ÖPUL measures, which contribute to a reduced use of nitrogen mineral fertilisers, e.g. complete renunciation of mineral fertilisers, organic farming;
- Nitrogen fixation through cultivation of leguminous plants, reducing the need to use mineral fertilisers;
- Reduction of soil erosion and nitrogen losses (e.g. catch crops, environmentally sound crop rotations, mulch and direct sowing);
- Reduction in the amount of fertilisers used, e.g. through specific measures in areas with increased pollution or risk situations.

According to Austria's NAPCP and NECP, additional instruments in areas of improved N management will reduce the amount of mineral fertilisers used by 20% by 2030 compared to the scenario "with existing measures".

Instruments listed under "Reducing emissions from the use of mineral fertilizsrs" are included in NAPCP measure 5 (see Table 11).

Table 11: WAM Measures according to the National Air Pollution Control Programme

No	Name and brief description of an individual strategy/measure or a strategy/measure package:
1	Livestock and feeding management
2	Low-emission animal housing systems
3	Low-emission manure storage systems
4	Low-emission manure spreading techniques
5	Reducing emissions from the use 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 Environment Agency Austria (Umweltbundesamt), the Austrian Institute of Economic Research ('Wirtschaftsforschungsinstitut', WIFO), the Centre of Economic Scenario Analysis and Research (CESAR), the Austrian Energy Agency, the Energy Economics Group of the Vienna University of Technology, the Zentrum für Energiewirtschaft (e-think) and the Institute for Internal Combustion Engines and Thermodynamics at the Graz University of Technology. The scenarios were developed using several models:

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

In addition, several parameters were calculated endogenously, e.g. pipeline compressors and industrial autoproducers.

The econometric input-output model DYNK combines a private consumption module with an energy and environment module. Important input parameters are energy prices, population and household income (WIFO 2018).

For projecting electricity and district heat generation, a model based on TIMES was used. The model has been adapted especially for Austria. It is based on available capacities for all types of power plants, combined with energy prices and the demand for electricity and district heating (taken from the INVERT/ EE-Lab model). Subsidies (e.g. granted under the Green Electricity Act) and fees (e.g. emission allowances) also constitute important input parameters (AEA 2018).

For modelling energy consumption in domestic heating and domestic hot water supply, the software package INVERT/EE-Lab (TU WIEN & ZEU 2018) 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 2019a). 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.

A model based on TIMES 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 2019b) by the respective emission factors. The latter were determined for power plants and waste incineration facilities on a plant-specific basis for each fuel type, taking into account expansions, the commissioning of new plants and the closing of existing facilities.

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 2003a, 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 2025. 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.

For the WAM scenario, the same methodology was used. Only energy input is different in the WAM scenario.

NMVOC and NH_3

NMVOC and NH_3 emissions are assumed to remain constant at 2019 levels (UMWELTBUNDESAMT 2021b). 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 4.2.1.

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 2017) 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.

For the WAM scenario, the same methodology was used. Only energy input is different in the WAM scenario.

NMVOC and NH_3

NMVOC and NH_3 emissions from stationary sources are assumed to remain constant at 2019 levels (UMWELTBUNDESAMT 2021b). 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 2017) 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.

For the WAM scenario, the same methodology was used. Only energy input is different in the WAM scenario.

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 4.2.1.

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 (TU WIEN & ZEU 2018). Inputs to mobile sources in agriculture were taken from the macro-economic DYNK model. A detailed description of these models can be found in UMWELTBUNDESAMT (2017) TU WIEN & ZEU (2018) and WIFO (2018).

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 2021b).

Twenty-two technology- and fuel-dependent main sub-categories (heating types) have been considered. They are presented in the following table:

Table 12: 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	Vapourising burners	Gas oil
#4	Yellow burners	Gas oil
#5	Blue burners with conventional technology	Gas oil
#6	Blue burners with low temperature or condensing technology	Gas oil
#7	Natural gas convectors	Natural gas
#8	Atmospheric burners	Natural gas, sewage sludge gas, biogas and landfill gas
#9	Forced-draft natural gas burners	Natural gas, sewage sludge gas, biogas and landfill gas
#10	LPG stoves	LPG and gas works gas
#11	LPG boilers	LPG and gas works gas
#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

For charcoal, total fuel consumption is calculated separately, as charcoal is assumed to be combusted in devices similar to wood stoves and cooking stoves.

For each technology fuel-dependent emission factors are applied.

Additionally, NO_x, NMVOC and $PM_{2.5}$ emission factors have been revised for future 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 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 2018 (UMWELTBUNDESAMT 2019b) 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 13: Share of 1 A 4 heating type in the different fuel categories for new installations 2019–2050 (Source: Umweltbundesamt).

Fuel category	No.	Heating type	Share of heating type [% TJ]			
			1 A 4 a 1 A 4 c	1 A 4 a 1 A 4 c	1 A 4 b	1 A 4 b
			2019	2050	2019	2050
Fuel oil	#1	Fuel oil boilers	100%	100%	100%	100%
Gas oil	#2	Gas oil stoves	3%	2%	3%	1%
	#3	Vapourising burners	2%	:	2%	:
	#4	Yellow burners	20%	3%	10%	1%
	#5	Blue burners using conventional technology	15%	5%	15%	3%
	#6	Blue burners using low temperature or condensing technology	60%	90%	70%	95%

[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

Fuel category	No.	Heating type	Share of heating type [% TJ]			
			1 A 4 a 1 A 4 c	1 A 4 a 1 A 4 c	1 A 4 b	1 A 4 b
			2019	2050	2019	2050
Gas	#7	Natural gas convectors	10%	10%	10%	5%
	#8	Atmospheric burners	60%	10%	30%	10%
	#9	Forced draft natural gas burners	30%	80%	60%	85%
LPG	#10	LPG stoves	10%	10%	5%	5%
	#11	LPG boilers	90%	90%	95%	95%
Fuel wood	#12	Wood stoves and cooking stoves	12%	6%	4%	1%
	#13	Tiled wood stoves and masonry heaters	20%	10%	8%	5%
	#14	Mixed-fuel wood boilers	3%	:	3%	:
	#15	Natural draft wood boilers	15%	4%	25%	4%
	#16	Forced draft wood boilers	50%	80%	60%	90%
Wood chips	#17	Wood chips boilers with conventional technology	20%	5%	15%	5%
	#18	Wood chips boilers with oxygen sensor emission control	80%	95%	85%	95%
Wood pellets	#19	Pellet stoves	10%	5%	5%	3%
	#20	Pellet boilers	90%	95%	95%	97%
Coal	#21	Coal stoves	5%	1%	5%	1%
	#22	Coal boilers	95%	99%	95%	99%

It is assumed that new installations with lower emission factors will be used as substitute for stocks with average 2018 emission characteristics, or increase overall stocks.

Emission factors

NO_x emission factors are assumed to decrease for natural gas and heating 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 are assumed to drop slightly due to minor differences in ambition levels between ecodesign provisions and intermediate national regulations. Additionally, a minor increase in heating oil emission factors and a noticeable increase in natural gas and coal emission factors are expected because of a weakening of existing national regulations.

Table 14 lists the implied NO_x emission factors for projections in the WEM scenario.

Table 14: Implied NO_x emission factors in the WEM scenario for coal, fuel wood, wood chips, wood pellets, heating oil, LPG and natural gas (Source: Umweltbundesamt).

in kg/TJ	2018	2020	2025	2030	2035	2040
			1 A 4 a and 1 A 4 c			
Coal	100.0	100.0	100.0	100.0	100.0	100.0
Fuel wood	81.1	81.4	82.3	83.8	85.4	86.0
Wood chips	82.9	80.7	76.1	71.1	66.8	64.1
Wood pellets	60.0	58.3	55.2	52.6	50.5	49.3
Heating oil	36.4	36.3	36.1	35.8	35.4	35.2
LPG	48.7	48.4	47.6	46.5	45.4	45.1
Natural gas	47.0	47.1	47.7	47.9	47.8	47.6
			1 A 4 b			
Coal	90.4	90.4	90.4	90.4	90.4	90.4
Fuel wood	103.4	102.7	100.0	96.2	91.7	88.4
Wood chips	83.2	80.8	76.5	71.2	66.1	63.6
Wood pellets	60.0	58.6	56.5	53.9	51.5	50.1
Heating oil	35.6	35.5	35.4	35.3	35.0	34.7
LPG	44.9	44.9	44.8	44.7	44.6	44.4
Natural gas	40.6	40.5	40.3	40.1	39.7	39.2

Table 15 lists the implied NO_x emission factors for projections in the WAM scenario.

Table 15: Implied NO_x emission factors in the WAM scenario for coal, fuel wood, wood chips, wood pellets, heating oil, LPG and natural gas (Source: Umweltbundesamt).

in kg/TJ	2018	2020	2025	2030	2035	2040
			1 A 4 a and 1 A 4 c			
Coal	100.0	100.0	100.0	100.0	100.0	100.0
Fuel wood	81.1	81.5	82.7	84.4	85.9	86.1
Wood chips	82.9	80.6	75.3	69.9	65.9	64.1
Wood pellets	60.0	58.4	55.1	52.4	50.3	49.3
Heating oil	36.4	36.3	36.2	36.1	35.8	35.7
LPG	48.7	48.4	47.9	47.4	45.9	45.8
Natural gas	47.0	47.2	47.7	47.9	47.7	47.6
			1 A 4 b			
Coal	90.4	90.4	90.4	90.4	90.4	90.4
Fuel wood	103.4	102.5	99.5	95.2	90.7	88.2
Wood chips	83.2	80.6	75.9	70.3	65.3	63.6
Wood pellets	60.0	58.4	55.8	53.0	50.7	50.1
Heating oil	35.6	35.6	35.5	35.5	35.4	35.2
LPG	44.9	44.9	44.9	44.8	44.7	44.6
Natural gas	40.6	40.5	40.3	40.1	39.7	39.3

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.

Table 16 lists the implied NMVOC emission factors for projections in the WEM scenario.

Table 16: implied NMVOC emission factors in the WEM scenario for coal, fuel wood, wood chips, wood pellets, heating oil, LPG and natural gas (Source: Umweltbundesamt).

in kg/TJ	2017	2020	2025	2030	2035	2040
1 A 4 a and 1 A 4 c						
Coal	0.5	0.5	0.5	0.5	0.5	0.5
Fuel wood	347.9	348.7	350.5	353.5	356.0	356.3
Wood chips	116.2	115.0	112.7	108.5	103.3	97.9
Wood pellets	33.0	32.1	30.4	29.0	27.8	27.1
Heating oil	0.5	0.5	0.5	0.4	0.4	0.4
LPG	1.5	1.4	1.3	1.0	0.8	0.7
Natural gas	0.7	0.7	0.6	0.6	0.6	0.5
1 A 4 b						
Coal	295.6	295.6	295.6	295.6	295.6	295.6
Fuel wood	397.4	394.6	385.2	372.2	357.1	346.3
Wood chips	120.2	117.2	111.9	104.3	96.3	91.4
Wood pellets	32.8	32.0	30.9	29.5	28.2	27.4
Heating oil	0.5	0.5	0.5	0.4	0.4	0.3
LPG	0.7	0.7	0.7	0.6	0.6	0.6
Natural gas	0.5	0.5	0.5	0.5	0.5	0.4

Table 17 lists the implied NMVOC emission factors for projections in the WAM scenario.

Table 17: implied NMVOC emission factors in the WAM scenario for coal, fuel wood, wood chips, wood pellets, heating oil, LPG and natural gas (Source: Umweltbundesamt).

in kg/TJ	2017	2020	2025	2030	2035	2040
1 A 4 a and 1 A 4 c						
Coal	295.6	295.6	295.6	295.6	295.6	295.6
Fuel wood	397.4	394.2	383.6	368.8	353.7	345.7
Wood chips	120.2	116.9	111.1	103.1	95.0	91.5
Wood pellets	32.8	31.9	30.5	29.0	27.8	27.4
Heating oil	0.5	0.5	0.5	0.5	0.4	0.4
LPG	0.5	0.5	0.5	0.5	0.5	0.4
Natural gas	0.7	0.7	0.7	0.7	0.7	0.6
1 A 4 b						
Coal	266.0	265.4	257.4	238.9	201.6	202.3
Fuel wood	397.3	394.0	383.5	368.8	353.7	345.7
Wood chips	119.7	116.7	111.2	103.9	96.4	92.9
Wood pellets	32.8	31.9	30.5	29.0	27.7	27.4
Heating oil	0.5	0.5	0.5	0.5	0.4	0.4
LPG	0.8	0.8	0.8	0.8	0.7	0.7
Natural gas	0.6	0.6	0.5	0.5	0.5	0.5

$PM_{2.5}$ 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.

Table 18, lists the implied $PM_{2.5}$ emission factors for projections in the WEM scenario.

Table 18: implied $PM_{2.5}$ emission factors in the WEM scenario for coal, fuel wood, wood chips, wood pellets, heating oil, LPG and natural gas (Source: Umweltbundesamt).

in kg/TJ	2017	2020	2025	2030	2035	2040
1 A 4 a and 1 A 4 c						
Coal	44.0	44.0	44.0	44.0	44.0	44.0
Fuel wood	81.6	80.8	78.2	72.6	65.4	60.3
Wood chips	47.9	46.7	44.4	41.6	39.2	37.5
Wood pellets	15.9	15.4	14.7	14.0	13.4	13.1
Heating oil	1.8	1.8	1.7	1.6	1.6	1.5
LPG	1.3	1.3	1.1	0.9	0.7	0.6
Natural gas	0.6	0.6	0.5	0.5	0.5	0.4
1 A 4 b						
Coal	86.0	86.0	86.0	86.0	86.0	86.0
Fuel wood	86.7	85.0	79.4	71.5	62.4	55.8
Wood chips	48.3	46.9	44.5	41.4	38.4	36.9

in kg/TJ	2017	2020	2025	2030	2035	2040
Wood pellets	15.6	15.2	14.7	14.1	13.5	13.1
Heating oil	1.8	1.8	1.7	1.6	1.5	1.4
LPG	0.6	0.6	0.6	0.5	0.5	0.5
Natural gas	0.4	0.4	0.4	0.4	0.4	0.4

Table 19 lists the implied $PM_{2.5}$ emission factors for projections in the WEM scenario.

Table 19: implied $PM_{2.5}$ emission factors in the WAM scenario for coal, fuel wood, wood chips, wood pellets, heating oil, LPG and natural gas (Source: Umweltbundesamt).

in kg/TJ	2017	2020	2025	2030	2035	2040
1 A 4 a and 1 A 4 c						
Coal	44.0	44.0	44.0	44.0	44.0	44.0
Fuel wood	81.6	80.5	77.0	70.8	63.7	59.8
Wood chips	47.9	47.0	44.1	41.1	38.8	37.6
Wood pellets	15.9	15.6	14.7	14.0	13.4	13.1
Heating oil	1.8	1.8	1.8	1.7	1.6	1.6
LPG	1.3	1.3	1.2	1.1	0.8	0.7
Natural gas	0.6	0.6	0.5	0.5	0.5	0.4
1 A 4 b						
Coal	86.0	86.0	86.0	86.0	86.0	86.0
Fuel wood	86.7	84.7	78.4	69.5	60.4	55.4
Wood chips	48.3	47.2	44.3	41.1	38.1	37.0
Wood pellets	15.6	15.3	14.6	13.9	13.3	13.1
Heating oil	1.8	1.8	1.7	1.7	1.7	1.6
LPG	0.6	0.6	0.6	0.6	0.5	0.5
Natural gas	0.4	0.4	0.4	0.4	0.4	0.4

NFR 1 A 4 a i Bonfire & Open Fire Pits, 1 A 4 b i 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 2018 emissions using projected population statistics (STATISTIK AUSTRIA 2018c).

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.

4.2.1 Aviation (NFR 1 A 3 a)

For projections of energy consumption in the aviation sector, an econometric input-output DYNK model of the Austrian Institute of Economic Research (WIFO 2018) was used. Within the framework of an energy demand scenario for the different NACE sectors in Austria, the energy demand for aviation gasoline and kerosene was estimated. In monetary terms, the demand for flight services is indirectly dependent on the population (via consumption in total, employed persons), relative prices (not the tickets per se, but prices for "flight services") and their trends (in the consumption patterns).

- Major driving forces:
  - Flight movements and distances (dependent on international (whole-sale) fuel import prices of crude oil, taxes/profit margins on fossil fuels, → fuel price, GDP, ...)

4.2.2 Road and Off-road Transport (NFR 1 A 3 b-d, 1 A 2 g, 1 A 4 b-c, 1 A 5)

4.2.3 Methodology (WEM & WAM)

The calculation of transport emissions is based on different models:

NEMO – Emission model road (CRF Source Category 1 A 3 b)

- From 2015 onwards, projections have been based on NEMO, the Network Emission Model (DIPPOLD/REXEIS/HAUSBERGER 2012; HAUSBERGER/SCHWINGSHACKL/REXEIS 2015a, b, 2018). It combines a detailed calculation of the fleet composition with a simulation of energy consumption and emission output on a vehicle level. 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 in such a way 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, a methodology categorising traffic activities into 'urban', 'rural' and 'motorway' has been applied with the NEMO model.

- Major drivers of emissions:
  - Vehicle kilometres (dependent on GDP, fuel price, population, degree of motorisation, …)
- For more details see 3.2.12.2. Road Transport of Austria's National Inventory Report 2020 (UMWELTBUNDESAMT 2021a).

KEX Tool (CRF Source Category 1 A 3 b)

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 future quantities of fuel exported by motor vehicles from Austria to other countries. The KEX tool was developed for estimating changes in domestic fuel demand and fuel exports 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.

- Major drivers of emissions:
  - development of international (wholesale) fuel import prices of crude oil
  - fuel price differences between Austria and neighbouring countries
- For more details see 3.2.12.2. Road Transport of Austria's National Inventory Report 2019 (UMWELTBUNDESAMT 2021a).

GEORG – Emission model off-road
(CRF Source Category 1 A 2 f, 1 A 3 c, 1 A 3 d, 1 A 4 b, 1 A 4 c, 1 A 5)

- Energy consumption and off-road emissions in Austria are calculated using the GEORG model (Grazer Emissionsmodel für Off Road Geräte) (PISCHINGER 2000). The GEORG model consists of a fleet model part which simulates the actual age and size distribution of non-road mobile machinery (NRMM) stock using age- and size-dependent drop-out rates (i.e. the probability that a vehicle will have been scrapped by the following year). This approach is used to calculate the number of vehicles in each mobile source category, according to the year of the vehicles' first registration and according to their propulsion system (gasoline 4-stroke, gasoline 2-stroke, diesel > 80 kW, diesel < 80 kW).
- Major drivers of emissions:
  - Operating hours of machines (dependent on GDP, harvest, wood production, …)
- For more details see 3.2.13.2 Other Sectors – mobile combustion of Austria's National Inventory Report 2019, (UMWELTBUNDESAMT 2021a).

Special Considerations for $PM_{2.5}$:

NFR 1 A 3 b vii R.T., Automobile road abrasion

Projected $PM_{2.5}$ emissions from road abrasion and tyre and brake wear have been estimated in a manner that is consistent with Austria's Air Emission Inventory (UMWELTBUNDESAMT 2019b). Projected passenger car and heavy duty vehicle kilometres are multiplied by emission factors (HAUSBERGER & SCHWINGSHACKL 2018).

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 2017 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 2017 emissions and projected fuel consumption.

Aviation operations: $PM_{2.5}$ emissions from military aviation operations have been extrapolated from 2017 emissions.

4.2.4 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.

Passenger cars (PC) according to 'HBEFA3.3_draft'

According to the latest amendments to European legislation[11], the nomenclature for emission classes in PC EURO 6 has been changed to Euro 6a/b. Euro 6c has become Euro 6d_temp (in HBEFA 6d1) and Euro 6d is a new emission class which is consistent with HBEFA Euro 6d2.

EURO 6a/b

The emission behaviour of individual vehicles was assessed by taking into account the shares of vehicle models produced and included in the European registration statistics. In the NEMO model based on HBEFA V3.3_draft, only the emission factors for ambient conditions at 20°C are used. For HBEFA V3.3 (final

[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.

version, not implemented yet), additional correction factors which take the influence of ambient temperature (ca. +25-30% for Austria) into account are under development.

EURO 6d

From a set of current EURO 6 measurement data, 6 vehicles which already meet the final RDE (real driving emissions) standards (EURO6d final) were selected. These vehicles were used to produce the EURO 6d emission factors.

EURO 6d-temp

Emission factors for the interim emission standard ("EURO 6d_temp") were generated by weighting the emission intensity of EURO 6a/b and EURO 6d. The weighting factors were defined in relation to the conformity factors for RDE legislation.

Light duty vehicles (LDVs)

Not updated (as LDVs were not part of the HBEFA3.3_draft update). Nevertheless, available measurement data indicate that the real world emission factors for LDVs for EURO 5 and EURO 6 are higher than those provided in HBEFA3.2. This will be updated in HBEFA4. Therefore, in the current scenario, emissions are probably underestimated.

Heavy duty vehicles (HDVs)

Not updated (not part of the HBEFA 3.3_draft update).

A detailed description of all underlying assumptions can be found in a technical study by TU Graz (HAUSBERGER & SCHWINGSHACKL 2017).

The following tables show the assumed phase-in periods for each emission standard and vehicle category for all new vehicle registrations:

Table 20: 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	

Table 21: 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	2030

4.2.4.1 Details on NO_x emission factors

The tables below show the emission factors used for Austria's emission projections 2019, by vehicle category. They are consistent with those used for Austria's projections 2017.

Table 22: Comparison of NO_x emission factors for diesel passenger cars (PC), (Source: Umweltbundesamt).

NO_x	NEMO HBEFA V.3.3_draft[12]
PRE ECE	1.014
ECE15/01	1.014
ECE15/02	1.014
ECE15/03	1.014
ECE15/04	1.014
US 83	0.748
Legal Act A	0.770
EURO 2	0.815
EURO 3	0.857
EURO 4	0.567
EU4+DPF	0.567
EURO 5	0.695
EURO 6a/b	0.421
EURO 6d_temp	0.197
EURO 6d	0.127

[12] HBEFA 3.3_draft incl. the latest measurement results for updates on NO_x emissions factors; excl. the influence of ambient temperature on the NO_x emission level of diesel vehicles. Current measurements from the roller test stand show that some brands and models have a significantly higher NO_x output at ambient temperatures of around 0° C compared to the standard temperature of 23° C. This effect can be due to, among other things, reducing or switching off the exhaust gas recirculation. This is expected to increase corresponding emission levels by an additional 25 % to 30 % in the next HBEFA version.

Table 23: Comparison of NO_x emission factors for diesel light duty vehicles (LDVs), (Source: Umweltbundesamt).

NO_x	NEMO HBEFA V.3.3_draft
PRE ECE	1.78
ECE15/01	1.78
ECE15/02	1.78
ECE15/03	1.78
ECE15/04	1.78
US 83	1.56
Gesetz A	1.59
EURO 2	1.41
EURO 3	1.14
EURO 4	0.93
EURO 5	0.86
EURO 6	0.30
EURO 6c	0.16

* *Emission factors for LDVs were not updated in the HBEFA 3.3_draft version.*

Table 24: Comparison of NO_x emission factors for heavy duty vehicles (HDVs), (Source: Umweltbundesamt).

NO_x	NEMO HBEFA V.3.3_draft
1980s	14.11
Euro-I	9.67
Euro-II	9.84
Euro-III	7.73
Euro-IV EGR	5.40
Euro-IV SCR	3.11
Euro-V EGR	3.97
Euro-V SCR	2.02
Euro-VI 2014–2015	0.30
Euro-VI 2050	0.19

4.2.5 Emission factors WAM

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

EURO 6a/b

The emission behaviour of all single vehicles was assessed by taking into account the shares of the vehicle models produced and included in the European registration statistics. In the NEMO model, based on HBEFA 3.3, correction factors for passenger cars are implemented that reflect the influence of ambient temperature (in Austria +25–30%).

EURO 6d

From a set of current EURO 6 measurement data, 6 vehicles which already meet the final RDE (real driving emissions) provisions (EURO 6d final) were selected. These vehicles were used to produce the EURO 6d emission factors.

EURO 6d-temp

Emission factors for the emission standard ("EURO 6d_temp") were generated by weighting the emission intensity of EURO 6a/b and EURO 6d. The weighting factors were defined in relation to the conformity factors for RDE legislation.

Light duty vehicles (LDVs)

Not updated (as LDVs were not part of the HBEFA 3.3_draft update). Nevertheless, available measurement data indicate that the real-world emission factors for LDVs for EURO 5 and EURO 6 are higher than those provided in HBEFA 3.2. This will be updated in HBEFA 4. Therefore, in the current scenario, emissions are probably underestimated.

Heavy duty vehicles (HDVs)

Not updated (not part of the HBEFA 3.3_draft update).

The following tables show the assumed phase-in periods for each emission standard and vehicle category for all new vehicle registrations:

Table 25: Phase-in periods for EURO-classes for new registrations (passenger cars and light duty vehicles), (Source: Umweltbundesamt).

PC/LDV	WAM	
	from	**until**
EURO 4	2005	2008
EURO 5	2009	2013
EURO 6a/b	2014	2018
EURO 6d_temp	2018	
EURO 6d	2020	

Table 26: Phase-ion periods for EURO-classes for new registrations (heavy duty vehicles), (Source: Umweltbundesamt).

HDV	WAM	
	from	**until**
EURO 4	2006	2008
EURO 5	2009	2013
EURO 6	2014	2030

4.2.5.1 Details on NO_x emission factors

The tables below show the emission factors used for WAM projections, by vehicle category.

Table 27: Comparison of NO_x emission factors for diesel passenger cars (PC), (Source: Umweltbundesamt).

NO_x	HBEFA 3.3
EURO 0	0.760
EURO 1	0.702
EURO 2	0.750
EURO 3	0.799
EURO 4	0.657
EURO 5	0.861
EURO 6	0.483
EURO 6 d	0,156

Table 28: Comparison of NO_x emission factors for diesel light duty vehicles (LDVs), (Source: Umweltbundesamt).

NO_x	HBEFA 3.3
EURO 0	1.73
EURO 1	1.56
EURO 2	1.39
EURO 3	1.12
EURO 4	0.90
EURO 5	0.86
EURO 6	0.28

* *Emission factors for LDV were not updated in the HBEFA Version 3.3.*

Table 29: Comparison of NO_x emission factors for heavy duty vehicles (HDVs), (Source: Umweltbundesamt).

NO_x	HBEFA 3.3
Euro-0	8.99
Euro-I	6.40
Euro-II	7.39
Euro-III	6.08
Euro-IV	3.97
Euro-V	2.94
Euro-VI	0.37

4.2.6 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 2015–2019, as well as on projected activity data such as natural gas exploration, natural gas consumption and gasoline consumption according to the energy scenario (UMWELTBUNDESAMT 2019c). The length of the gas distribution network has been extrapolated using the average yearly growth rate between 2015–2019 (218 km/year).

Emission reduction measures such as vapour recovery units at fuel depots and service stations had already been implemented in 2003. No further reductions are expected.

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 2021b).

NO_x and NH_3

NH_3 emissions are not relevant in 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) have been calculated on the basis of projections for coal consumption (UMWELTBUNDESAMT 2019c), using the same emission factors as those in Austria's National Air Emissions Inventory.

The methodology is the same for the WEM and WAM scenario. There are differences in gasoline consumption and, therefore, different NMVOC emissions from gasoline distribution.

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 (WIFO 2018), 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.

There is no difference between WEM and WAM.

NMVOC and NH_3

NH_3 emissions are assumed to remain constant at 2019 levels (UMWELTBUNDESAMT 2021b) 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)

NMVOCs

Methodology of the Austrian Air Emission Inventory

Emission projections for 2019–2030 are calculated based on the emissions of the latest inventory year, and assuming a correlation with either population growth for sectors based on domestic use of solvents or economic growth in the other sub-sectors. In some cases, a constant development has been assumed (e.g. where technological innovation offsets an increase in use – see below for more details).

Source data for the Austrian Air Emissions Inventory are obtained from surveys (WINDSPERGER et al. 2002a, 2002b, 2004; WINDSPERGER & SCHMID-STEJSKAL 2008, WINDSPERGER et al, 2018) as well as import-export statistics (foreign trade balance) and production statistics provided by Statistik Austria, as well as from data reported under the VOC Directive.

In order to determine the quantity of solvents used for the various applications in Austria, a bottom-up and a top-down approach were combined. The top-down approach provided the total quantities of solvents used in Austria, whereas the amounts of solvents used in different applications and the solvent emission factors were calculated on the basis of the bottom-up approach. Emissions reported under the VOC Directive were used for all those sectors where this was possible (taking into account the number of employees in the relevant sector to extrapolate emissions, to thus include installations that are below the threshold for reporting). By combining the results from the bottom-up and the top-down approach, the quantities of solvents used per year were determined, and the solvent emissions from different applications calculated. This approach was finalised for Austria's National Air Emissions Inventory 2018 (UMWELTBUNDESAMT 2019b) and updated and refined in 2020 (based on the year 2019).

Projections

The trend in the quantity of solvents (substances) and solvent-containing products, i.e. the relationship between imports and exports and the production of solvents, was based on activity data (solvent use) in the different sub-categories (SNAPs). These were related to economic growth (where the SNAPs had been linked to NACE codes), or population growth (in the domestic sector). Economic growth was taken into account when a correlation between historic activity data and growth could be determined and for some cases expert judgement was used.

Emission factors for substances linked to the different SNAPs are based on plant specific data. These emission factors were calculated from solvent balances obtained from companies. For emissions caused by products only the solvent contained in the product counts as activity. Over the last few years, the calculation model has been fundamentally revised and the information on the solvent content of products has been updated.

As EFs have decreased in the last few years (due to measures under the VOC Directive), a conservative approach has been adopted, which means that no further measures will be implemented and the EFs are therefore assumed to remain constant.

Most of the demand for solvents arises from the paint and coatings industry, pharmaceutical products manufacturing, households (cleaners, disinfectants, personal care products) and the printing industry. Besides the paints used in the sub-sector "Construction and buildings", most consumer products are decorated or protected with paint or coatings. Furthermore, solvents are used in many industrial cleaning applications such as cleaning for maintenance purposes and cleaning in the manufacturing process. Solvents are also used for the cleaning of high-precision mechanical parts such as ball bearings.

The emission scenarios to 2030 show emissions from car manufacturing, car repairing, construction and buildings, wood coating, degreasing, rubber processing, and manufacturing of pharmaceuticals, based on economic growth data (via the respective NACE codes) and including assumptions for emissions from coil coating, paints, inks and glue manufacturing, adhesives and other manufacturing, as well as printing, which are expected to remain constant. For other industrial paint applications, metal degreasing, textile finishing, preservation of wood, and application of glues and adhesives, expert judgement was used based on BAT documents and trends over the last few years and on an understanding of the key drivers in the relevant sectors. Domestic solvent use was based on population growth.

NO_x, SO_2 and NH_3

According to the Austrian inventory, any NO_x, SO_2 and NH_3 emissions occurring in Austria do not originate from solvent use. All these emissions are caused by product use. NO_x, SO_2 and NH_3 emissions from product use (i.e. tobacco smoke and fireworks) were calculated by multiplying emissions of the latest inventory year (2019; submission 2021) by the projected number of inhabitants (population) in Austria in 2030 (STATISTIK AUSTRIA 2018c).

$PM_{2.5}$

$PM_{2.5}$ emissions from product use (i.e. tobacco smoke and fireworks) were calculated by multiplying emissions of the latest inventory year (2019; submission 2021) by the projected number of inhabitants (population) in Austria until 2030 (STATISTIK AUSTRIA 2018c).

4.5 Agriculture (NFR 3)

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 2021" (UMWELTBUNDESAMT 2021b) includes a comprehensive description of the methodologies used.

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 crops, forestry, livestock, and farm tourism activities. The Positive Mathematical Programming (PMP) method assumes a profit-maximising equilibrium (e.g. marginal revenue equals marginal cost) in the base run and derives coefficients of a non-linear objective function on the basis of observed levels of production activities (WIFO & BOKU 2018).

Economic assumptions

Apart from the milk price projections, all estimates are derived from OECD-FAO agricultural market outlooks (OECD-FAO 2018). Estimates for the coming period were made on the basis of previously observed wedges – or gaps – in prices between the EU and Austria.

Milk prices in Austria are slightly higher than in most other EU countries (e.g. AMA 2018). Other exogenous economic assumptions (e.g. GDP or population size) are not necessary for Austria; they are embedded in exogenous price assumptions. Other driving forces are prices, technology and constraints.

Other assumptions

- Increase in milk yield per cow (+4.6% from 2020 to 2030)
- Loss of agricultural land following the long-term trend

Main results

Cattle numbers are expected to increase slightly.The Rural Development Programme and the alpine farming premium scheme provide favourable conditions for extensive cattle production. The availability of grassland and relatively high beef prices, together with moderate levels of projected milk yields per cow, make cattle farming attractive.

Decreasing prices for pork are expected to lead to falling numbers of pigs. This result is in line with expectations of pig production experts, who predict a decline in production mainly due to limitations in production facilities. OECD/FAO projections indicate low prices for pork as well.

According to the model results, poultry production will decrease. Relatively high feed costs (mainly soya meal) make the production of poultry meat in Austria less profitable. Furthermore, poultry and egg producers in Austria have to cope with considerably higher costs compared to producers in other countries.

The sale of mineral nutrients is likely to decline slightly. This result is consistent with a long-term trend but not consistent with observations of more recent sales data. The model assumes that manure is a well-suited substitute for mineral fertiliser with cheap trade options within NUTS-3 regions and that therefore a smaller amount of mineral fertiliser will be needed.

Scenario 'with existing measures' (WEM)

The scenario is based on price projections of OECD/FAO (OECD-FAO 2018) for the EU, existing farm policies and the legal framework of regulations (see Chapter 3).

Scenario "with additional measures" (WAM)

The WAM scenario takes into account the additional agricultural policy measures provided for in the National Air Pollution Control Programme and the Integrated National Energy and Climate Plan (BMNT 2019a,b). For a detailed description of the measures considered, see Chapter 3.

Activity data

Scenario WEM

PASMA (WIFO & BOKU 2018) provides the basic activity data for the WEM scenario. To increase consistency between the inventory and the projections, projected activity data for animal livestock, mineral N fertiliser and milk yields of dairy cows were adjusted to the latest inventory time series available.

Scenario WAM

Projected activity data are the same as those used in the WEM scenario (WIFO & BOKU 2018), except for cattle. For cattle, it is assumed that due to additional measures, livestock numbers will no longer increase from 2025 onwards (see Chapter 3).

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

The feed intake parameters and N excretion values applied here are the same as those applied in Austria's Air Emission Inventory (UMWELTBUNDESAMT 2021b). Austria-specific N excretion values for dairy cows were calculated on the basis of projected milk yields (+4.6% from 2020 to 2030).

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).

For 2030, the share of cattle kept in tie stall housing systems was adjusted downwards by 25% (due to provisions on animal welfare). This share varies according to specific sub-categories of cattle; in 2017 it was between 13 and 37% (PÖLLINGER et al. 2018). The shares of liquid and solid waste within the tie stall housing systems are expected to remain unchanged – at the same level as in the national inventory.

Taking into account the trend towards liquid systems, the share of loose housing systems/liquid in 2030 has been increased.

Scenario WAM

Feed intake and N excretion

WAM includes additional measures on animal feeding (e.g. improved feed quality according to animal requirements and adapted to local conditions) resulting in a slight decrease in nitrogen excretion for cattle (with the exception of dairy cows), pigs and chicken in 2030 compared to the WEM scenario. For more details see Chapter 3.

Manure Management Systems (MMS)

The scenario WAM includes the following additional measures:

- Additional measures for animal housings and manure storage as listed in the Austrian NAPCP;
- Increased grazing of dairy & suckling cows by 2030;
- Increased share of Austria's total manure amount treated in biogas plants by 2030.

For more details see Chapter 3.

4.5.2 Agricultural Soils (3.D)

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

Scenario WEM

Projected mineral fertiliser application data have been taken from (WIFO & BOKU 2018). To increase consistency between the inventory data and the projections, projected volumes of mineral fertiliser were adjusted to the latest inventory time series available.

Scenario WAM

The scenario WAM includes the following additional measures:

- Measures for low-loss slurry application listed in the National Air Pollution Control Programme leading to lower NH_3 emissions during application on soils;
- Forced sustainable N management leading to a reduction in mineral fertiliser use by 2030 (compared to the scenario "with existing measures").

For more details see Chapter 3.

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.

Thus, we applied a simple approach using the 2020 fraction of burnt agricultural residues for both scenarios.

4.5.4 PM emissions from agriculture

For PM emissions, there are no specific additional measures in the WAM scenario. Slight differences in emission levels are due to the different cattle numbers in the two scenarios.

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 2021b), 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 Tier 1) as in Austria's Annual Air Emission Inventory (UMWELTBUNDESAMT 2021b) was used.

Activity data on the projected cropland and grassland area were obtained from PASMA (WIFO & BOKU 2018).

Particle Emissions from Bulk Material Handling

Because this source is of minor importance, $PM_{2.5}$ emissions have been extrapolated using inventory values from 2017 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 the model. The model is static by design and adjustments to future situations are calculated in discrete steps that are based on exogenous assumptions (prices, costs, technical coefficients) and model-endogenous coefficients (marginal costs) which are 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 overoptimistic because farmers are not able or willing to adjust as 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 OECDFAO report (2018).
- **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

Three sensitivity scenarios were performed in the framework of (WIFO & BOKU 2018). The results of sensitivity analysis (in comparison to the scenario WEM) are summarised as follows:

Sensitivity Scenario 1

Underlying assumptions: milk prices decrease by 20% and pork prices increase by 20%.

As expected, the response of production to changing (relative) prices is significant. In sensitivity scenario 1, the number of cows remains more or less unchanged compared to the reference period and the number of pigs increases significantly. The results show that the relative prices for livestock categories are very important for the model results.

Sensitivity Scenario 2

Underlying assumptions: market prices remain constant.

As expected, the changes in production are not as strong as in WEM, although very similar. The number of dairy cows increases but not as much as in WEM. The agricultural area does not decline as much, indicating the important role of price changes - variable cost relations, particularly with respect to mineral fertilizers.

Sensitivity Scenario 3

Underlying assumptions: higher prices for mineral fertilisers

As expected, the amount of commercial fertiliser is reduced compared to WEM (by three percentage points). Such a small reaction is consistent with empirical findings on price elasticities for mineral fertiliser, which are very small. Even significantly higher prices induce only a small change.

All assumptions and results were shown to a panel of agricultural experts in Austria. All arguments put forward by the experts were well founded and plausible. For more details see (WIFO & BOKU 2018).

4.6 Waste (NFR 5)

NMVOCs and NH_3 from 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[13], 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 (UMWELTBUNDESAMT 2021x).

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:

[13] Intergovernmental Panel on Climate Change

Table 30: Past trend (1990–2015) and scenarios (2020–2040) 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	160	160
2025	0.0	160	160
2030	0.0	160	160

A detailed description of the methodology used for the calculation of landfill gas emissions can be found in Austria's National Inventory Report (UMWELTBUNDESAMT 2021a).

$PM_{2.5}$ 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% (2019) 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 (2021a).

Table 31: Past trend (1998–2015) and scenarios (2020–2040) for dusty waste activity data (Source: Umweltbundesamt).

[kt waste handled at landfills]	1998	2000	2005	2010	2015	2020	2025	2030
Total dusty waste amount	4 381	5 028	10 502	10 782	25 149	33 112	34 752	36 391

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 2019.

NH_3 from Biological Treatment of Waste – Composting (NFR 5.B.1)

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 2021a).

Composting plants, home composting

Home-composted waste amounts are assumed to increase with population growth (STATISTIK AUSTRIA 2018c). About 50% of the amount of the waste treated in composting plants is expected to remain constant at 2019 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 same level as in 2019. The impact of the BREF document for waste treatments issued in 2018 on the activities of existing MBT plants will be small.

Table 32: Past trend and scenario for composting activity data.

[kt waste treated]	1990	2000	2005	2010	2015	2020	2025	2030
Composted organic waste	418	1 467	2 375	2 523	2 718	2 916	2 954	2 986
Mechanically-biologically treated waste	345	254	623	551	439	430	430	430

NH_3 from 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.

NO_x, SO_2, NMVOC and NH_3 from Waste Incineration (NFR 5.C)

Because of the small contribution of these pollutants 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 2021 (UMWELTBUNDESAMT 2021b).

NMVOC from Wastewater Treatment (NFR 5.D)

This category includes NMVOC emissions from domestic wastewater handling (5.D.1), wastewater of domestic origin as well as commercial and industrial wastewater treated together with domestic wastewater in municipal wastewater treatment plants.

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 in municipal wastewater treatment plants were taken from the Electronic Emission Register of Surface Water Bodies ('Emissionsregister – Oberflächenwasserkörper' – 'EMREG-OW'[14]).

In the activity data projections, treated wastewater amounts are expected to increase with population growth. The emission factor remains the same for the whole time series.

Table 33: Past trend (1990–2015) and scenarios (2020–2040) for wastewater volumes.

[Million m^3 wastewater treated]	1990	2000	2005	2010	2015	2020	2025	2030
Domestic wastewater treated (municipal and domestic wastewater treatment plants, cesspools)	640	996	1 038	1 112	1 039	1 095	1 115	1 132

$PM_{2.5}$ from Other Waste Handling (NRF 5.E)

Emissions from this category arise from vehicle fires, fires at detached and undetached houses, apartment buildings and industrial buildings.

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 activity data projections, a mean value of the number of fires reported in the period 1990–2019 was assumed to extrapolate the projections. Population growth was taken into consideration. The emission factor remains the same for the whole time series.

[14] 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).

Table 34: Number of fires: past trend (1990–2015) and scenarios (2020–2040) .

[number of fires]	**1990**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Car fires	1 586	1 682	1 759	1 727	1 584	1 698	1 846	2 172
Fires at buildings (industrial buildings, detached/ undetached houses, apartments)	2 995	3 066	2 617	3 545	3 674	3 151	3 424	4 030

5 RECALCULATIONS: CHANGES WITH RESPECT TO SUBMISSION 2019

The changes made to the projections since the previous submission of emission projections of air pollutants in 2019 (UMWELTBUNDESAMT 2019c) 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 last time a scenario with additional measures was submitted was in 2015. There were several methodical changes to the inventory (e.g. EMEP/EEA Guidebook 2016) in the submissions 2017 and 2019. These recalculations are not discussed in this report. For further information on the recalculations of the inventory see 'sector specific recalculations' in Austria's National Inventory Report 2017 and Austria's National Inventory Report 2019.

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

Table 35: Comparison of projections 2019 and 2021 in the WEM scenario based on fuel sold – national totals (in kt), (Source: Umweltbundesamt).

Total	**2005**	**2010**	**2019**	**2020**	**2025**	**2030**
			Projections 2019			
NO_x	238	183	133	127	99	84
SO_2	25	16	14	14	13	13
NMVOC	156	137	121	120	116	112
NH_3	63	66	69	69	71	72
$PM_{2.5}$	22	19	15	15	13	12
			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

Total	2005	2010	2019	2020	2025	2030
			Difference 2021/2019			
NO_x	9	21	11	11	7	3
SO_2	0	0	-3	-2	-1	-1
NMVOC	2	1	-13	-12	-11	-9
NH_3	-3	-3	-6	-6	-6	-6
$PM_{2.5}$	0	1	-1	-1	-1	0

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

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

Table 36: Major changes between projections 2019 and 2021 for Sectors 1A1, 1A2 and 2 (in kt), (Source: Umweltbundesamt).

Pollutant	Sector (CRF)	2005	2010	2019	2020	2025	2030
NO_x	1 A 1 – Energy industries	-0.1	-0.3	0.5	0.0	0.3	0.3
	1 A 2 – Manufacturing Industries and Construction	-0.1	-0.1	-3.2	-3.2	-1.6	-1.9
	2 – Industrial Processes	0.0	0.0	0.0	0.0	0.0	0.0
SO_2	1 A 1 – Energy industries	0.0	0.0	0.0	0.1	0.1	0.1
	1 A 2 – Manufacturing Industries and Construction	-0.2	-0.3	-2.8	-1.9	-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	-0.2	-0.2	-0.4	-0.4	-0.4	-0.4
	2 – Industrial Processes	0.0	0.0	0.1	0.0	0.0	0.0
NMVOC	1 A 1 – Energy industries	0.0	0.0	-0.1	-0.1	-0.1	-0.1
	1 A 2 – Manufacturing Industries and Construction	0.3	0.5	-0.1	-0.2	-0.2	-0.2
	2 – Industrial Processes	-1.4	-1.4	-4.7	-4.7	-4.8	-4.9
	2 D – Solvents	-1.4	-1.4	-4.7	-4.7	-4.9	-4.9

Revisions up to the year 2019 are mainly due to updates of the national energy balance. For the 2019 projections the energy balance with data up to 2017 was used, whereas for the 2021 projections the energy balance with data up to 2019 was used. Hence, the energy demand and thus the emissions have changed in the current projections.

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.

Based on a new study on emissions from the wood industry (IÖ 2018), the biomass emission factors for other industries have been adapted in the national inventory and therefore updated for the projections accordingly.

Based on plant-specific data from the glass industry, emission factors have been adapted in the national inventory and therefore updated for the projections accordingly.

2 D – Solvents and other product use

An update of bottom-up data was based on information for 2019. All district authorities were contacted and requested to provide solvent balances available from companies that are obliged to report under the IED directive. This led to an estimated return rate of approximately 85% of all solvent balances, which was higher than during the previous bottom-up survey for the year 2015. In the course of updating the model for 2019, the allocation of the companies to the different categories was re-evaluated. By scaling up companies (in sectors where not all companies are obliged to report) according to economic sectors, allocation has been improved and now follows the economic rather than the technical activity a company pursues (e.g. a company producing printed cardboards is now allocated to cardboard production and no longer to the printing sector).

These above changes were implemented consistently for 2015 and 2019. The improved allocation is also more consistent with the approach for 2000. Data between 2001 and 2015, and 2015 and 2019 were interpolated as before. This led to changes in the allocation of AD and emissions in each NFR category and therefore also the EF/category for all years from 2001 onwards.

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

5.1.2 Transport (1 A 3)

Table 37: Major changes between projections 2019 and 2021 for Sector 1A3, in kt (fuel sold), (Source: Umweltbundesamt).

Pollutant	Sector (CRF)	2005	2010	2019	2020	2025	2030
NO_x	1 A 3 – Transport	9.2	20.7	15.1	15.2	9.7	5.3
	1 A 3 a – Civil Aviation	0.0	0.0	0.4	0.0	0.0	0.0
	1 A 3 b 1 – Passenger cars	10.5	18.7	11.7	12.3	8.1	4.6
	1 A 3 b 2 – Light duty vehicles	2.4	3.8	4.2	3.9	2.4	1.5
	1 A 3 b 3 – Heavy duty vehicles	-4.6	-2.5	-1.5	-1.3	-1.0	-1.0
	1 A 3 b 4 – Mopeds & Motorcycles	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3
	1 A 3 c – Railways	0.0	0.0	-0.2	-0.2	-0.2	-0.1
	1 A 3 d – Navigation	1.0	0.9	0.9	0.9	0.8	0.7
	1 A 3 e – Pipeline compressors	0.0	0.0	-0.2	-0.1	-0.1	-0.1

Pollutant	Sector (CRF)	2005	2010	2019	2020	2025	2030
NMVOC	1 A 3 – Transport	0.2	-1.7	-2.7	-2.6	-2.2	-1.9
	1 A 3 a – Civil Aviation	0.0	0.0	0.0	0.0	0.0	0.0
	1 A 3 b 1 – Passenger cars	1.6	0.1	-1.3	-1.1	-1.0	-0.9
	1 A 3 b 2 – Light duty vehicles	-0.2	-0.2	-0.1	-0.1	0.0	0.0
	1 A 3 b 3 – Heavy duty vehicles	-0.1	-0.2	-0.2	-0.1	-0.1	-0.1
	1 A 3 b 4 – Mopeds & Motorcycles	-1.7	-1.6	-1.1	-1.1	-0.9	-0.8
	1 A 3 c – Railways	0.0	0.0	0.0	0.0	0.0	0.0
	1 A 3 d – Navigation	0.5	0.4	0.2	0.1	0.1	0.1
	1 A 3 e – Pipeline compressors	0.0	0.0	0.0	0.0	0.0	0.0

Domestic activity data (fuel consumption/mileage) has been updated with new specific mileage per vehicle category. For the first time, data from periodic road-worthiness testing has been evaluated resulting in new age-related mileage data. This affects the categories PC, LDV and MC.

Due to the dieselgate scandal and mandatory Euro 6d_temp PEMS emission measurements, large amounts of new measurement data have become available. New findings, such as the influence of ambient temperature on the functional efficiency of NO_x exhaust after-treatment systems (such as SCR), the aging conditions of such systems, new improved traffic situations combined with revised dynamic parameters, have led to an increase in in emissions in each vehicle category.

5.1.3 Other Sectors (NFR 1 A 4)

Table 38: Major changes between projections 2019 and 2021 for Sector 1A4 in kt (Source: Umweltbundesamt).

Pollutant	Sector (NFR)	2005	2010	2015	2020	2025	2030
NO_x	1 A 4 – Other Sectors	+ 0.4	+ 0.9	+ 0.1	– 0.3	– 0.2	– 0.2
	1 A 4 a 1– Commercial/Institutional: Stationary	– 0.1	– 0.2	– 0.1	– 0.2	– 0.2	– 0.3
	1 A 4 b 1 – Residential: stationary	+ 0.4	+ 1.1	+ 0.2	+ 0.1	+ 0.1	+ 0.2
	1 A 4 c 1 – Agriculture/Forestry/Fishing: Stationary	+ 0.2	+ 0.1	+ 0.0	– 0.1	– 0.1	– 0.1
NMVOC	1 A 4 – Other Sectors	+ 2.6	+ 3.6	– 0.4	– 2.5	– 1.3	+ 0.1
	1 A 4 a 1– Commercial/Institutional: Stationary	– 0.2	– 0.6	– 0.4	– 1.1	– 0.9	– 0.7
	1 A 4 b 1 – Residential: stationary	+ 2.4	+ 4.3	+ 0.7	– 0.6	+ 0.1	+ 0.9
	1 A 4 c 1 – Agriculture/Forestry/Fishing: Stationary	+ 0.4	– 0.2	– 0.6	– 0.8	– 0.5	– 0.1
$PM_{2.5}$	1 A 4 – Other Sectors	+ 0.2	+ 0.4	– 0.4	– 0.4	– 0.4	– 1.3
	1 A 4 a 1– Commercial/Institutional: Stationary	– 0.0	– 0.1	– 0.0	– 0.2	– 0.2	– 0.2
	1 A 4 b 1 – Residential: stationary	+ 0.2	+ 0.5	– 0.3	– 0.5	– 0.3	– 0.1
	1 A 4 c 1 – Agriculture/Forestry/Fishing: Stationary	+ 0.1	+ 0.0	– 0.0	– 0.1	– 0.1	– 0.1

In the 2021 submission, NEC emissions have been subject to significant changes, compared to the 2019 submission, to both the inventory and the projected years starting from 2020, for several reasons:

- Major revision of the national energy balances
- The change in the years 2005, 2010 and 2015 is due to emerging trends in activity data (energy consumption) for recent inventory data years, in particular biomass use for heating (+11% in the year 2005, +25% in 2010 and +15% in 2015 against the 2019 projections) which form the basis for the projections (and the model calibration).
- Revision of the energy demand model for space heating
- The module 'Heating type by technology' was updated with a new approach based on recent market data and expert consultation (on the sale of fuel technology). This information was used for re-modelling the heating stock and turnover based on two studies, resulting in revised consumption data for each type of heating, which is relevant to NEC air pollutant emissions. Additionally, the mixed-fuel wood boiler stock was subdivided into two categories (advanced and conventional). Advanced technology is associated with (slightly) lower NO_x, NMVOC and $PM_{2.5}$ emissions than conventional equipment. See IIR 2020 for further details on changes in methodology (UMWELTBUNDESAMT 2021b).
- Recalibration of the results of the INVERT/EE-Lab from the 2019 submission
- The INVERT/EE-Lab model has not been updated since the last submission; however, the results for heating energy demand have been recalibrated against the fuel mix emerging from the latest activity data (change in biomass use).

5.1.4 Agriculture (NFR 3)

Table 39: Major changes between projections 2019 and 2021 for Sector 3 (in kt), (Source: Umweltbundesamt).

Pollutant	Sector (NFR)	2005	2010	2019	2020	2025	2030
NH_3	3 – Agriculture	-2.7	-3.0	-5.4	-5.8	-5.6	-5.5
	3 B 1 a	0.0	0.0	-0.3	-0.3	-0.4	-0.4
	3 B 1 b	-0.2	-0.3	-0.7	-1.0	-1.0	-1.0
	3 B 4 e	-0.1	-0.1	-0.1	0.0	0.0	0.0
	3 B 3	0.0	0.0	0.0	0.1	0.1	0.1
	3 B 4 g	-0.9	-0.9	-0.7	-0.6	-0.5	-0.5
	3 D	-1.4	-1.6	-3.6	-4.0	-3.8	-3.8
NO_x	3 – Agriculture	0.0	0.0	-0.8	-0.9	-0.9	-0.9
	3 D	0.1	0.1	-0.8	-0.9	-0.9	-0.9
NMVOC	3 – Agriculture	-0.5	-0.4	-1.3	-1.9	-1.9	-1.9
	3 B	-0.1	0.0	-0.8	-1.2	-1.2	-1.2

Activity data projections:

Projections of animal livestock, average milk yields of dairy cows and mineral N fertiliser amounts are based on (WIFO & BOKU 2018). In order to increase consistency between inventory data and projections, projected activity data were adjusted to the latest inventory time series available.

Methodological changes to the Austrian Air Emission Inventory:

The main reason for the revision to **NH_3 emissions from manure management** is the implementation of the new EMEP/EEA Guidebook 2019 in Austria's air emission inventory. The 2019 version of the Guidebook provides updated NH_3 emission factors for housing and storage for the livestock categories layers and broilers, as well as sheep and other animals. Also, the calculation method has been revised. It is based on the fraction of TAN that is immobilised in organic matter (f_{imm}) when manure is managed as a litter-based solid and the litter is straw. According to (EEA 2019), this immobilisation greatly reduces the potential for NH_3-N emissions arising during storage and after application.

Revised **NH_3 emissions from inorganic N fertilisers** are mainly due to the implementation of new information on rapid incorporation of urea into the soil, resulting in lower NH_3 emissions and the implementation of a new emission factor for N stabilised fertilisers.

NO_x emissions are calculated using a mass-flow approach based on the concept of a flow of TAN through the manure management system according to the EMEP/EEA GB 2019. Although there were no changes in the methodology for NO_x, the revisions in the ammonia inventory had an impact on NO_x estimates.

The **NMVOC emission calculations** according to the 2019 EMEP/EEA Tier 2 methodology are strongly linked to the compilation of the ammonia emissions inventory. Therefore, the revisions to the ammonia inventory also had an impact on the NMVOC emissions.

5.1.5 Waste (NFR 5)

Table 40: Major changes between projections 2019 and 2021 for Sector 5 (in kt), (Source: Umweltbundesamt).

Pollutant	Sector (CRF)	2005	2010	2019	2020	2025	2030
NH_3	5 – Waste	-0.01	-0.01	0.02	0.02	0.02	0.02

Revisions compared to the 2019 projections are mainly due to methodological changes in sub-category 5.A Solid Waste Disposal on Land, in response to an issue raised during the comprehensive ESD Review in 2020 affecting the amount of landfill gas formed. In addition, the method for extrapolating the amount of landfill gas collected was improved based on more detailed data available at the level of the federal provinces.

There are further revisions to sub-category 5.D Wastewater treatment due to the availability of new data on wastewater volumes 2018 and on the percentage of the population connected to a sewer system (2018).

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7 ANNEX: NATIONAL PROJECTION ACTIVITY DATA

Table 41: Assumptions about general economic parameters with existing measures (Source: Umweltbundesamt).

	Unit	2019	2020	2025	2030
1. Gross Domestic Product	Value (billion €)	366	386	414	444
2. Population	Thousand people	8 895	8 942	9 158	9 331
3. International coal prices	€/GJ	3	3	3	4
4. International oil prices	€/GJ	13	14	16	17
5. International gas prices	€/GJ	9	9	10	10

Table 42: Assumptions about general economic parameters with additional measures (Source: Umweltbundesamt).

	Unit	2019	2020	2025	2030
1. Gross Domestic Product	Value (billion €)	361	375	404	434
2. Population	Thousand people	8 895	8 942	9 158	9 331
3. International coal prices	€/GJ	3	3	3	4
4. International oil prices	€/GJ	13	14	16	17
5. International gas prices	€/GJ	9	9	10	10

Table 43: Assumptions for the energy sector – with existing measures (Source: Umweltbundesamt).

	Unit	2019	2020	2025	2030
Total gross inland consumption*					
1. – Oil (fossil)	Petajoule (PJ)	541	539	539	526
2. – Gas (fossil)	Petajoule (PJ)	321	297	285	280
3. – Coal	Petajoule (PJ)	119	125	112	106
4. – Biomass without liquid biofuels (e.g. wood)	Petajoule (PJ)	230	222	222	222
5. – Liquid biofuels (e.g. bio-oils)	Petajoule (PJ)	21	22	24	32
6. – Solar*	Petajoule (PJ)	14	14	19	24
7. – Other renewable (wind, geothermal etc)	Petajoule (PJ)	168	188	196	201
Total electricity production by fuel type*					
8. – Oil (fossil)	GWh	693	200	207	212
9. – Gas (fossil)	GWh	11 569	8 645	7 454	7 015
10. – Coal	GWh	3 414	4 197	2 959	2 209
11. – Renewable	GWh	54 393	56 020	57 984	59 762

* *Solar thermal and PV*

Table 44: Assumptions for the energy sector – with additional measures (Source: Umweltbundesamt).

	Unit	2017	2020	2025	2030
Total gross inland consumption*					
1. – Oil (fossil)	Petajoule (PJ)	541	534	503	465
2. – Gas (fossil)	Petajoule (PJ)	321	294	275	255
3. – Coal	Petajoule (PJ)	119	124	110	103
4. – Biomass without liquid biofuels (e.g. wood)	Petajoule (PJ)	230	231	240	258
5. – Liquid biofuels (e.g. bio-oils)	Petajoule (PJ)	21	25	34	36
6. – Solar*	Petajoule (PJ)	14	14	35	52
7. – Other renewable (wind, geothermal etc)	Petajoule (PJ)	168	189	213	238
Total electricity production by fuel type*					
8. – Oil (fossil)	GWh	693	190	195	196
9. – Gas (fossil)	GWh	11 569	8 483	7 436	6 987
10. – Coal	GWh	3 414	4 180	2 920	2 149
11. – Renewable	GWh	54 393	56 782	67 792	78 448

* *Solar thermal and PV*

Table 45: Assumptions for the industry sector – with existing measures (Source: Umweltbundesamt).

	Unit	2019	2020	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	%	3.2%	2.8%	1.3%	1.1%
Pulp & Paper	%	4.0%	4.2%	2.6%	2.6%
Non-metallic Minerals	%	2.8%	2.3%	1.6%	1.5%
Chemical Industry	%	4.3%	4.6%	3.0%	3.1%
Machine Construction	%	3.6%	4.3%	2.7%	2.7%
Vehicle Construction	%	3.3%	4.0%	2.2%	2.3%
Food and Drink	%	3.0%	3.3%	2.1%	2.2%
Other Industry	%	3.5%	5.1%	4.3%	2.1%

Table 46: Assumptions for the industry sector – with addtional measures (Source: Umweltbundesamt).

	Unit	2019	2020	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	%	3.2%	2.8%	1.3%	1.1%
Pulp & Paper	%	4.0%	4.2%	2.6%	2.6%
Non-metallic Minerals	%	2.8%	2.3%	1.6%	1.5%
Chemical Industry	%	4.3%	4.6%	3.0%	3.1%
Machine Construction	%	3.6%	4.3%	2.7%	2.7%
Vehicle Construction	%	3.3%	4.0%	2.2%	2.3%
Food and Drink	%	3.0%	3.3%	2.1%	2.2%
Other Industry	%	3.5%	5.1%	4.3%	2.1%

Table 47: Assumptions for the transport sector – with existing measures (Source: Umweltbundesamt).

	Unit	2019	2020	2025	2030
15.Passenger person kilometres*	million km	118 469	119 288	123 563	127 847
16.Growth of freight tonne kilometres*	million tonne-km	80 184	81 654	88 730	95 094
17.Fleet turnover assumptions (vehicle replacement)					
17a.Passenger cars**	% of new vehicles per year	7%	6%	6%	6%
17b.Light duty vehicles**	% of new vehicles per year	10%	9%	8%	8%
17c.Heavy trucks**	% of new vehicles per year	9%	10%	8%	8%

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

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

Table 48: Assumptions for the transport sector – with additional measures (Source: Umweltbundesamt).

	Unit	2019	2020	2025	2030
15.Passenger person kilometres*	million km	118 469	120 260	120 603	122 987
16.Growth of freight tonne kilometres*	million tonne-km	80 184	83 246	88 672	93 666
17.Fleet turnover assumptions (vehicle replacement)					
17a.Passenger cars**	% of new vehicles per year	7%	6%	6%	6%
17b.Light duty vehicles**	% of new vehicles per year	10%	9%	8%	8%
17c.Heavy trucks**	% of new vehicles per year	9%	10%	8%	8%

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

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

Table 49: Assumptions for buildings residential and commercial or tertiary sector– with existing measures, (Source: Umweltbundesamt).

	Unit	2019	2020	2025	2030
20a.The rate of change of floor space for tertiary buildings *	%	0.89%	0.88%	0.88%	0.81%
20b.The rate of change of floor space for dwellings*	%	0.94%	0.93%	0.65%	0.55%
21a.The number of dwellings in the tertiary sector**	Number	195 736	197 365	205 663	213 751
21a.The number of dwellings in the tertiary sector**	Number	3 959 729	3 992 168	4 126 423	4 229 832

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

** *Number of permanently occupied dwellings*

Table 50: Assumptions for buildings residential and commercial or tertiary sector– with additional measures, (Source: Umweltbundesamt).

	Unit	2019	2020	2025	2030
20a.The rate of change of floor space for tertiary buildings *	%	0.89%	0.88%	0.88%	0.81%
20b.The rate of change of floor space for dwellings*	%	0.94%	0.93%	0.65%	0.55%
21a.The number of dwellings in the tertiary sector**	Number	195 736	197 365	205 662	213 750
21a.The number of dwellings in the tertiary sector**	Number	3 959 729	3 992 168	4 126 423	4 229 832

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

** *Number of permanently occupied dwellings*

Table 51: Assumptions for the agriculture sector with existing measures (Source: Umweltbundesamt).

	Unit	2019	2020	2025	2030
23.Beef cattle	1 000 heads	1 355	1 328	1 339	1 350
24.Dairy cows	1 000 heads	524	522	530	537
25.Sheep	1 000 heads	403	408	409	410
26.Pigs	1 000 heads	2 773	2 818	2 792	2 767
27.Poultry	1 000 heads	17 461	17 461	16 798	16 135
28.Synthetic fertiliser	kt N	106	107	104	102

Table 52: Assumptions for the agriculture sector – with additional measures (Source: Umweltbundesamt).

	Unit	2019	2020	2025	2030
23.Beef cattle	1 000 heads	1 355	1 328	1 339	1 339
24.Dairy cows	1 000 heads	524	522	530	530
25.Sheep	1 000 heads	403	408	409	410
26.Pigs	1 000 heads	2 773	2 818	2 792	2 767
27.Poultry	1 000 heads	17 461	17 461	16 798	16 135
28.Synthetic fertiliser	kt N	106	107	94	82

Table 53: Assumptions for the waste sector– with existing measures (Source: Umweltbundesamt).

	Unit	2017	2020	2025	2030
31.Municipal solid waste disposed of in landfills*	tonnes	166 659	160 361	160 361	160 361

* *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.*

Table 54: Assumptions for the waste sector– with additional measures (Source: Umweltbundesamt).

	Unit	2017	2020	2025	2030
31.Municipal solid waste disposed of in landfills*	tonnes	166 659	160 361	160 361	160 361

* *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.*

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This report covers the results for projections of the air pollutants sulphur dioxide (SO_2), nitrogen dioxide (NO_x), non-methane volatile organic compounds (NMVOCs), ammonia (NH_3) and particulate matter ($PM_{2.5}$) under the scenarios "with existing measures" (WEM) and "with additional measures" (WAM). It updates previous projections for air pollutants from 2019 (REP-0689).

The results for the WEM and WAM scenarios show significant emission reductions (based on fuel used) from 2005 to 2030 for all pollutants except NH_3. The most substantial reduction - about 65 % (WEM) and about 66 % (WAM) - is projected for the pollutant NO_x. Emission reductions for the other pollutants except NH_3 range from 35 % to 53% in the WEM scenario and from 35 % to 52 % in the WAM scenario. NH_3 emissions are projected to increase by 10 % in the WEM scenario and to decrease by 1 % in the WAM scenario.

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