ENVIRONMENT AGENCY AUSTRIA umweltbundesamt

Austria's National Air Emission Projections 2012 for 2015, 2020 and 2030

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

Scenario: With Additional Measures

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Project management

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ZUSAMMENFASSUNG

Die österreichischen Emissionsprojektionen für die Luftschadstoffe Schwefeldioxid (SO_2), Stickoxide (NO_x), flüchtige organische Verbindungen ohne Methan (NMVOC) und Ammoniak (NH_3) für das Szenario „mit bestehenden Maßnahmen" wurden zuletzt im Jahr 2011 erstellt (UMWELTBUNDESAMT 2011c, d).

Der vorliegende Bericht erweitert diese bestehenden Emissionsprojektionen um das Szenario „mit zusätzlichen Maßnahmen" und eine erstmalige Abschätzung für den Schadstoff Feinstaub ($PM_{2,5}$). Dadurch werden neben bereits implementierten auch jene Maßnahmen abgebildet, die sich im Planungsstadium befinden und nach Einschätzung der involvierten ExpertInnen eine realistische Chance auf Umsetzung haben sowie bis 2030 emissionswirksam werden.

Das Szenario basiert auf den energiewirtschaftlichen Grundlagendaten von WIFO, Österreichischer Energieagentur, TU Wien und TU Graz, die auch für die Projektionen der Treibhausgas-Emissionsentwicklung herangezogen wurden (UMWELTBUNDESAMT 2011b). Da die verwendeten Grundlagendaten auf der Energiestatistik 2009 (letztes Datenjahr 2008) basieren, sind seitdem erfolgte Aktualisierungen der Energiestatistik nicht berücksichtigt.

In der EU-Richtlinie 2001/81/EG[1] werden für die untersuchten Luftschadstoffe Emissionshöchstmengen ab dem Jahr 2010 festgelegt. Nach der englischen Bezeichnung dieser Obergrenzen (National Emission Ceilings, NEC) ist auch im Deutschen der Begriff „NEC-Richtlinie" und „NEC-Gase" üblich. Artikel 7 in Verbindung mit Annex III der NEC-Richtlinie legt fest, dass für diese Luftschadstoffe Emissionsprojektionen zu erstellen und jährlich zu aktualisieren sind. Dabei kommen die Verfahren zur Anwendung, die im Rahmen des UNECE-Übereinkommens über weiträumige grenzüberschreitende Luftverunreinigung (Convention on Long-Range Transboundary Air Pollution, LRTAP-Convention[2] 1979) vereinbart wurden.

Österreich berichtet die Emissionen im Rahmen des UNECE-Übereinkommens anhand der verkauften Treibstoffmenge. Die Emissionsberichterstattung an die Europäische Kommission gemäß NEC-Richtlinie erfolgt auf Basis der verbrauchten Treibstoffmenge. In den folgenden Abschnitten werden die Ergebnisse deshalb in beiden Versionen dargestellt.

Die NEC-RL soll im kommenden Jahr überarbeitet werden. Zusätzlich zu den vier bisher erfassten Luftschadstoffen SO_2, NO_x, NMVOC und NH_3 soll für die primären Emissionen von Feinstaub ($PM_{2,5}$) eine Emissionshöchstmenge festgelegt werden. Ziele für 2020 oder ein späteres Jahr sollen als Relativziele – bezogen auf die Emissionshöchstmenge 2005 – festgelegt werden.

[1] Richtlinie 2001/81/EG des Europäischen Parlaments und des Rates vom 23. Oktober 2001 über nationale Emissionshöchstmengen für bestimmte Luftschadstoffe

[2] http://www.unece.org/env/lrtap/full%20text/1979.CLRTAP.e.pdf

Nationale Gesamtemissionen

Die folgenden Tabellen zeigen die nationalen Gesamtemissionen der Luftschadstoffe für die Jahre 1990, 2005 und 2010 aus der österreichischen Emissionsinventur (UMWELTBUNDESAMT 2012a) sowie die Ergebnisse der Projektionen bis 2030 (Stand: Mai 2012).

Tabelle A umfasst die Emissionen auf Basis der verkauften Treibstoffmenge gemäß dem UNECE-Übereinkommen über weiträumige grenzüberschreitende Luftverunreinigung. Dabei ist zu beachten, dass in Österreich in den letzten Jahren ein beachtlicher Teil der verkauften Treibstoffmenge im Inland getankt, jedoch im Ausland verfahren wurde (preisbedingter Kraftstoffexport im Fahrzeugtank).

Tabelle A: Nationale Gesamtemissionen für 1990 bis 2010 und projizierte Emissionen für 2015, 2020 und 2030 auf Basis der verkauften Treibstoffmengen (CLRTAP-Projektionen) im Szenario „mit zusätzlichen Maßnahmen" (Quelle: Umweltbundesamt).

Luftschadstoff	Emissions-Inventur 2012			projizierte Emissionen		
[kt/a]	1990	2005	2010	2015	2020	2030
NO_x	195,41	236,25	188,79	150,38	131,26	120,25
SO_2	74,54	27,15	18,76	17,44	17,90	19,03
NMVOC	275,98	162,03	132,89	126,25	119,89	110,72
NH_3	65,48	62,70	62,45	61,55	61,47	61,15
$PM_{2,5}$	24,18	22,34	19,83	17,42	15,69	14,91

In Tabelle B werden die nationalen Gesamtemissionen auf Basis der in Österreich verbrauchten Treibstoffmenge ohne preisbedingtem Kraftstoffexport (gemäß Artikel 2 der NEC-Richtlinie) dargestellt. Diese Emissionsmengen (außer $PM_{2,5}$) sind Österreichs offizielle Werte gemäß Artikel 8 (1) der NEC-Richtlinie.

Tabelle B: Nationale Gesamtemissionen für 1990 bis 2010 und projizierte Emissionen für 2015, 2020 und 2030 auf Basis der verbrauchten Treibstoffmengen (NEC-Projektionen) im Szenario „mit zusätzlichen Maßnahmen" (Quelle: Umweltbundesamt).

Luftschadstoff	Emissions-Inventur 2012			projizierte Emissionen		
[kt/a]	1990	2005	2010	2015	2020	2030
NO_x	181,48	167,72	144,00	125,83	115,94	112,70
SO_2	73,71	27,09	18,72	17,40	17,86	18,99
NMVOC	272,94	158,72	131,58	125,67	119,40	110,31
NH_3	65,46	61,97	62,16	61,47	61,38	61,12
$PM_{2,5}$	23,68	20,62	18,96	17,04	15,43	14,77

Gemäß Artikel 2 der NEC-Richtlinie gilt diese für die Emissionen von Schadstoffen im Gebiet der jeweiligen Mitgliedstaaten. Die folgende Tabelle des Jahres 2010 ist den nationalen Emissionshöchstmengen der NEC-Richtlinie gegenübergestellt. Einzig die NO_x-Emissionen lagen 2010 über der nationalen Emissionshöchstmenge der NEC-Richtlinie. Diese Höchstmengen sind als Obergrenze auch in den Folgejahren nach 2010 einzuhalten.

Tabelle C: Nationale Emissionen auf Basis der <u>verbrauchten Treibstoffmengen</u> und Ziele für 2010 gemäß NEC-Richtlinie 2001/81/EC (NEC-Projektionen), (Quelle: Umweltbundesamt).

[kt/a]	Emissionen 2010	Emissionshöchstmenge 2010 (Ziel NEC-RL)
NO_X	144,00	103
SO_2	18,72	39
NMVOC	131,58	159
NH_3	62,16	66

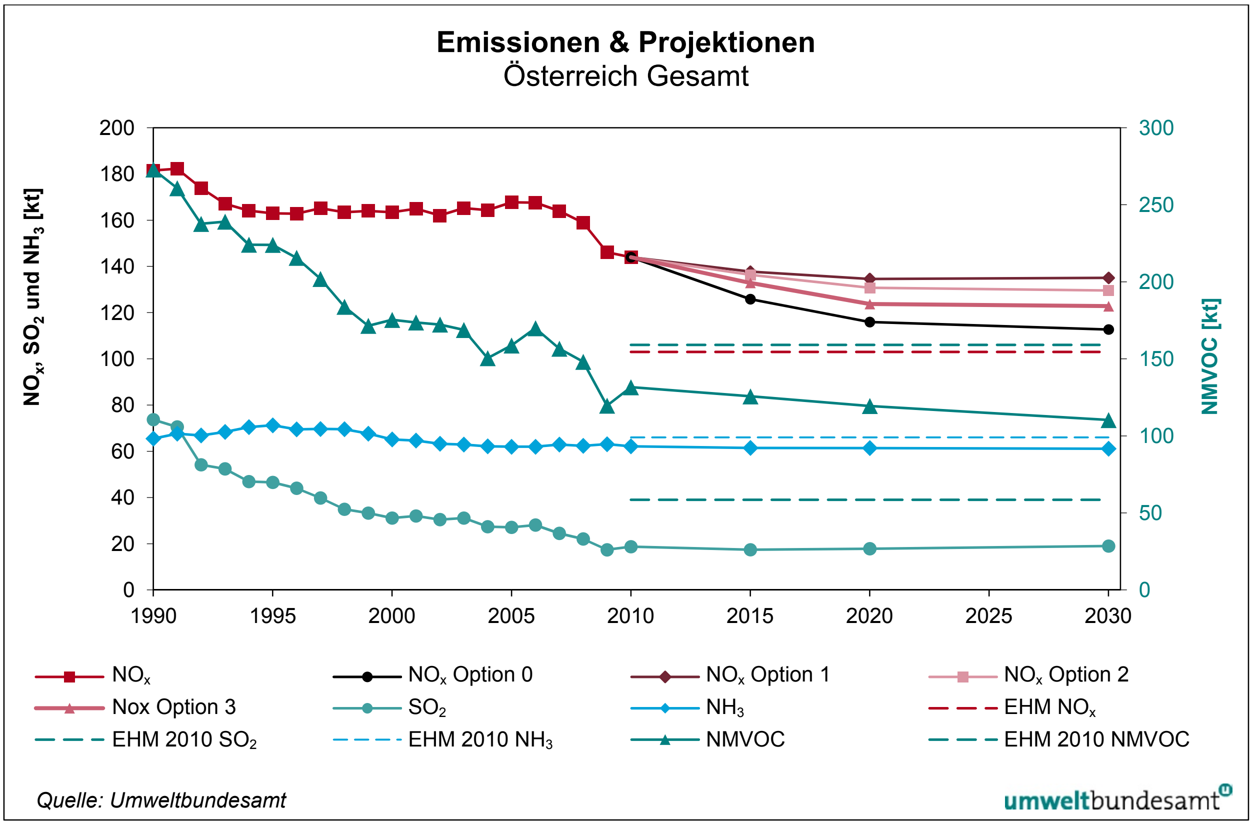

Abbildung A: Historische (1990–2010) und projizierte NEC-Emissionen auf Basis der verbrauchten Treibstoffmengen (2015, 2020 und 2030) sowie Emissionshöchstmengen (EHM) gemäß NEC-Richtlinie 2001/81/EC (2010), (Quelle: Umweltbundesamt).

NO_x-Trend

Die Hauptquelle der nationalen NO_x-Emissionen ist der Sektor Energie mit einem Anteil von mehr als 96 %, wobei der größte Anteil an den Gesamtemissionen im Jahr 2010 auf den Straßenverkehr mit 58 % (inklusive Kraftstoffexport im Fahrzeugtank, d. h. auf Basis des verkauften Treibstoffs) bzw. 45 % (exklusive Kraftstoffexport im Fahrzeugtank) entfällt.

In den letzten Jahren ist ein beachtlicher Teil der verkauften Treibstoffmenge im Inland getankt, jedoch im Ausland verfahren worden (preisbedingter Kraftstoffexport im Fahrzeugtank). Dieser ist für die Zielerreichung der NO_X-Emissionen von maßgeblicher Bedeutung. Die nationalen NO_x-Emissionen betrugen 2010 inklusive Kraftstoffexport im Fahrzeugtank 189 kt und ohne Kraftstoffexport im Fahrzeugtank 144 kt. Österreich berichtet die Emissionen gemäß NEC-Richtlinie auf Basis des verbrauchten Kraftstoffs (ohne Kraftstoffexport im Fahrzeugtank), damit wird die Emissionshöchstmenge von 103 kt/a um rund 41 kt überschritten.

Das Szenario „mit zusätzlichen Maßnahmen" (WAM) zeigt eine Reduktion der Emissionen bis 2030. Hauptverantwortlich hierfür sind die Modernisierung der Flotte sowie die sinkenden spezifischen NO_x-Emissionen von Pkw und schweren Nutzfahrzeugen der neuesten und künftigen Abgasklassen. Letztere werden auf Basis der gesetzlich festgelegten Typprüfgrenzwerte in den Projektionen berücksichtigt. Allerdings sanken in der Vergangenheit die realen Emissionen im Straßenverkehr nicht so stark wie es die auf Typprüfgrenzwerten basierenden Emissionsprojektionen erwarten ließen. Daher wurden im Rahmen der aktuellen Projektionen diesbezüglich vier Alternativszenarien mit unterschiedlichen Annahmen berechnet[3]:

- **Variante 0:** EURO 5 und 6 erfüllen wie geplant die festgelegten Grenzwerte (optimistisch). Diese Variante ist in den Tabellen A und B ausgewiesen.
- **Variante 1: Keine Wirkung EURO 5/6**

  Im Echtzeitbetrieb bleiben EURO 5- und EURO6-Schwerfahrzeuge auf demselben Niveau wie EURO 4-Fahrzeuge (pessimistisch)
- **Variante 2: Geringe Wirkung EURO 6**

  Im Echtzeitbetrieb bleibt EURO 5 auf dem gleichen Niveau wie EURO 4, während EURO 6 um 20 % besser abschneidet als EURO 4
- **Variante 3: Geringe Wirkung EURO 5, höhere Wirkung EURO 6**

  EURO 5 ist um 10 % besser als EURO 4. Das Emissionskontrollsystem von EURO 6 arbeitet die gesamte Zeit über auf der Autobahn (mit 50 % der Fahrleistung) und die Hälfte der Zeit auf dem untergeordneten Straßennetz (mit 23 % der Fahrleistung)

Die Reduktion der Emissionen (exklusive Kraftstoffexport im Fahrzeugtank) bis 2030 variiert je nach gewählter Variante zwischen minus 22 % bis minus 6 %.

Die Maßnahme, die die Emissionsreduktion im WAM-Szenario am meisten beeinflusst, ist die sukzessive Erhöhung der Mineralölsteuer. Darüber hinaus sind Maßnahmen zur Steigerung des öffentlichen Personenverkehrs (z. B. Ausbau und Attraktivierung des öffentlichen Verkehrs) sowie zur verstärkten Nutzung der Bahn im Güterverkehr (z. B. Anschlussbahnförderung) trendbestimmend. Des Weiteren ist die Reduktion der NO_x-Emissionen auch auf den zunehmenden Anteil der Elektromobilität bis 2030 zurückzuführen. Im WAM-Szenario wird von einer starken Nachfrage bezüglich Elektromobilität ohne Widerstände der Bevölkerung gegen die neue Technologie ausgegangen.

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[3] Weitere Details sind im "ANNEX 3: Road Transport – special considerations" zu finden.

SO_2-Trend

Die in der NEC-Richtlinie festgesetzte Emissionshöchstmenge für SO_2 von 39 kt/a wird in Österreich bereits seit mehreren Jahren unterschritten. Die Reduktion der SO_2-Emissionen ergab sich in der Vergangenheit hauptsächlich durch die Einführung von Emissionsgrenzwerten in der Energieerzeugung und durch die Reduktion des Schwefelgehaltes in Mineralöl-Produkten. Im Jahr 2010 wurden rund 19 kt SO_2 emittiert, womit die Emissionshöchstmenge der NEC-Richtlinie von 39 kt/a deutlich unterschritten wurde.

Bis 2030 ist mit einem geringen Anstieg der SO_2-Emissionen zu rechnen. Der parallel zum erwarteten Wirtschaftswachstum steigende Trend in der Industrie (1A2) wird durch Reduktionen in der Energieversorgung (1A1) und dem Kleinverbrauch (1A4) durch den weiteren Wechsel zu schwefelärmeren Brennstoffen und erneuerbaren Energieträgern kompensiert.

NMVOC-Trend

Die Hauptquellen der nationalen NMVOC-Emissionen sind der Sektor Lösemittel, der 56 % der Gesamtemissionen verursachte, der Kleinverbrauch mit 25 % und der Straßenverkehr mit 9 % (Datenstand 2012).

Seit 1990 kam es zu einer deutlichen Reduktion der NMVOC-Emissionen in den genannten Sektoren. Im Lösemittelsektor konnten die Reduktionen aufgrund diverser legislativer Instrumente (Lösungsmittelverordnung, HKW-Anlagen-Verordnung sowie VOC-Anlagen-Verordnung) erzielt werden.

Die aktuelle Projektion geht von weiter sinkenden NMVOC-Emissionen bis 2030 aus, hauptsächlich aufgrund von Emissionsminderungen in den Sektoren Kleinverbrauch (Trend zu Zentralheizungssystemen, Rückgang des Stückholzeinsatzes und niedrigere Emissionsfaktoren von Neuanlagen) und Verkehr (Verbesserung der Motorentechnik). Ein leichter Anstieg der Emissionen aus der Verwendung von Lösemitteln bis 2015 ergibt sich aus einem Rebound-Effekt nach der Wirtschaftskrise 2009. Danach wird tendenziell mit leicht sinkenden Lösemittelemissionen gerechnet.

Anhand der vorliegenden Daten wurde die NEC-Emissionshöchstmenge von 159 kt NMVOC im Jahr 2010 deutlich unterschritten.

NH_3-Trend

Die Hauptquelle der NH_3-Emissionen in Österreich ist der Sektor Landwirtschaft mit einem Anteil von rund 93 %. Seit 1990 ist ein leichter Emissionsrückgang (-5 %) zu verzeichnen. Bis 2030 wird mit relativ konstanten NH_3-Emissionen gerechnet.

Im Jahr 2010 wurde die in der NEC-Richtlinie festgesetzte Emissionshöchstmenge von 66 kt/a NH_3 um rd. 3,5 kt unterschritten.

$PM_{2,5}$-Trend

Die primären $PM_{2,5}$-Emissionen stammen hauptsächlich aus Verbrennungsprozessen des Sektors Energie. Mit 42 % im Jahr 2010 nimmt der Sektor Kleinverbrauch (1A4) daran den größten Anteil ein. Hierzu zählen Emissionen aus Heizungsanlagen der Haushalte und Dienstleistungen sowie aus mobilen Geräte des Kleinverbrauchs (Rasenmäher, Traktoren), von Brauchtumsfeuern und der Verwendung von Grillkohle. Reduktionen der $PM_{2,5}$-Emissionen entstehen im Szenario „mit zusätzlichen Maßnahmen" vorwiegend durch die Steigerung der Gebäude- und Heizungseffizienz und durch den Trend weg von manuell beschickten Scheitholz-Kesseln. Insbesondere der verminderte Einsatz von festen Brennstoffen (Scheitholz und Kohle) wird in diesem Sektor bis 2030 zu einer $PM_{2,5}$-Reduktion um 36 % führen.

Im Sektor Verkehr wird $PM_{2,5}$ aus den Motoren, vor allem den Dieselmotoren emittiert; der größte Anteil wird allerdings durch Brems- und Reifenabrieb und durch Aufwirbelung auf der Straße verursacht. Die Maßnahme, die die Emissionsreduktion im WAM am stärksten beeinflusst, ist die sukzessive Erhöhung der Mineralölsteuer.

1 INTRODUCTION

The latest Austrian emission projections for the pollutants sulphur dioxide (SO_2), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC) and ammonia (NH_3) for the scenario "with existing measures" (WEM) were published in 2011 (UMWELTBUNDESAMT 2011c, d).

This report covers the results for the scenario "with additional measures" (WAM) together with a first-time projection for $PM_{2.5}$. Planned policies and measures with a realistic chance of being adopted and implemented in time to influence the emissions by 2030 are thus included in the WAM scenario.

The report further outlines relevant background information in order to enable a quantitative understanding of the key socioeconomic assumptions used in the preparation of the projections.

For the purpose of comparison, emission data from the National Air Emission Inventory as of March 2012 (UMWELTBUNDESAMT 2012a) are included as well.

Legal Background

After the signature of the UNECE Gothenburg Protocol to the Convention on Long-Range Transboundary Air Pollution on 1 December 1999[4], the EU agreed on national emission ceilings for sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3) and non-methane volatile organic compounds (NMVOC) for the year 2010.

Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants ("NEC Directive") stipulates national emission ceilings for these air pollutants[5].

Pursuant to Article 7, Member States are obliged to prepare and annually update national emission inventories and emission projections for 2010.

Pursuant to Art. 8 (1), Member States have to report their emission inventories and projections to the Commission. The obligations have been transposed into national law by the Emission Ceilings Act – Air (*Emissionshöchstmengengesetz-Luft)*[6].

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[4] Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution to abate Acidification, Eutrophication and Ground-level ozone, http://www.unece.org/env/lrtap/full%20text/1999%20Multi.E.Amended.2005.pdf

[5] 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

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

2 EMISSIONS

According to Article 15 of the Guidelines[7] for reporting emission data under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP) 2009 Parties shall report emissions from road transport on the basis of fuel sold to the final consumer and may additionally report emissions based on fuel used in the geographic area of the Party.

According to its Article 2, the NEC Directive (2001/81/EC) covers "emissions in the territory of the Member States". In order to comply with this spatial requirement, Austria's reporting to the European Commission according to the NEC-Directive is based on "fuel used".

In the last few years, Austria has experienced a considerable amount of fuel being exported in vehicle tanks, as fuel prices were cheaper than in the neighbouring countries. Most of these fuels were used in heavy duty vehicles for long-distance traffic (inside and outside the EU), which is of relevance for the NO_X emissions only.

Austria´s emission projections were calculated based on both methods, fuel sold and fuel used. Table 1 shows Austria´s national total emissions and projections under the UNECE LRTAP Convention (based on fuel sold). Table 2 shows Austria´s official projections under Article 8 (1) of the NEC Directive. There, emissions are based on fuel used whereas 'fuel exports in the vehicle tank' are not considered.

A revision of the NEC Directive is planned for 2013. New emission ceilings are likely to be established for the four substances already regulated as well as for primary emissions of $PM_{2.5}$. Emissions of $PM_{2.5}$ are thus included in the following tables and emission projections were calculated for $PM_{2.5}$ as well.

Table 1: Austrian national total emissions for 1990, 2005, 2010 and projected emissions for 2015, 2020, 2030 after implementation of planned policies for Austria (with additional measures) in 1 000 tons per year, i.e. [kt/a], based on fuel sold (CLRTAP-Projections), (Source: Umweltbundesamt).

Pollutants	**Emission Inventory 2012**			**Emission Projection**		
[kt]	**1990**	**2005**	**2010**	**2015**	**2020**	**2030**
NO_x	195.41	236.25	188.79	150.38	131.26	120.25
SO_2	74.45	27.15	18.76	17.44	17.90	19.03
NMVOC	275.98	162.03	132.89	126.25	119.89	110.72
NH_3	65.48	62.70	62.45	61.55	61.47	61.15
$PM_{2.5}$	24.18	22.34	19.83	17.42	15.69	14.91

[7] http://www.ceip.at/fileadmin/inhalte/emep/reporting_2009/Rep_Guidelines_ECE_EB_AIR_97_e.pdf

Table 2: Austrian national total emissions for 1990 to 2010 and projected emissions for 2015, 2020 and 2030 after implementation of planned policies for Austria (with additional measures) in 1 000 tons per year, i.e. [kt/a], based on fuel used (NEC-Projections), (Source: Umweltbundesamt).

Pollutants	**Emission Inventory 2012**			**Emission Projection**		
[kt]	**1990**	**2005**	**2010**	**2015**	**2020**	**2030**
NO_x	181.48	167.72	144.00	125.83	115.94	112.70
SO_2	73.71	27.09	18.72	17.40	17.86	18.99
NMVOC	272.94	158.72	131.58	125.67	119.40	110.31
NH_3	65.46	61.97	62.16	61.47	61.38	61.12
$PM_{2.5}$	23.68	20.62	18.96	17.04	15.43	14.77

Annex I of the NEC Directive determines national emission ceilings for certain atmospheric pollutants. By the year 2010 at the latest, Member States shall limit their annual national emissions of these pollutants to an amount not exceeding the emission ceilings. These emission ceilings shall further not be exceeded at any time thereafter.

The following table compares Austria´s national emissions in 2010 with the emission ceilings according to the NEC Directive.

Table 3: Austria's emissions according to the NEC Directive 2001/81/EC and ceilings for 2010 in 1 000 tonnes per year, i.e. [kt/a], (Source: Umweltbundesamt).

[kt]	**Emissions 2010 'fuel used'**	**Ceilings 2010**
NO_X	144.00	103
SO_2	18.72	39
NMVOC	131.58	159
NH_3	62.16	66

2.1 Nitrogen Oxides NO_x

In 2010, NO_x emissions amounted to 188.8 Gg, or 144 Gg without taking fuel export into consideration. After a significant decrease between 2008 and 2009, caused by the economic crisis, emissions showed a slight increase from 2009 to 2010 (+ 0.9%). Compared to 1990 levels, NO_x emissions (with fuel export, i.e. based on fuel sold) were about 3.4% lower in 2010..

The main sources of Austrian NO_x emissions in 2010 are fuel combustion activities with a share of more than 96%. Road transport including fuel export contributes the highest share (58%) to total NO_x emissions. Road transport without fuel export accounts for 45% of the national total emissions.

Further sources are the manufacturing industries and the construction industry (17%), fuel combustion in households as well as off-road vehicles and other machinery in agriculture and forestry.

The scenario "with additional measures" shows a reduction of NO_x emissions. National total emissions including fuel export are expected to decrease to 120.3 kt by 2030. Without 'fuel export' they are expected to reach 112.7 kt.

The main driving force of NO_x emissions until 2030 will be road transport. NO_x emissions from heavy duty vehicles and cars are projected to decrease. The main reasons for this decline are the modernisation of the vehicle fleet, measured lower specific emissions from cars and heavy duty vehicles of the latest emission class and – based on statutory emission limits – the estimated further decrease of specific emissions from motor vehicles of future emission classes. Another cause is the expected slight increase in the share of e-mobility until 2030, which is assumed to substitute conventionally fuelled cars.

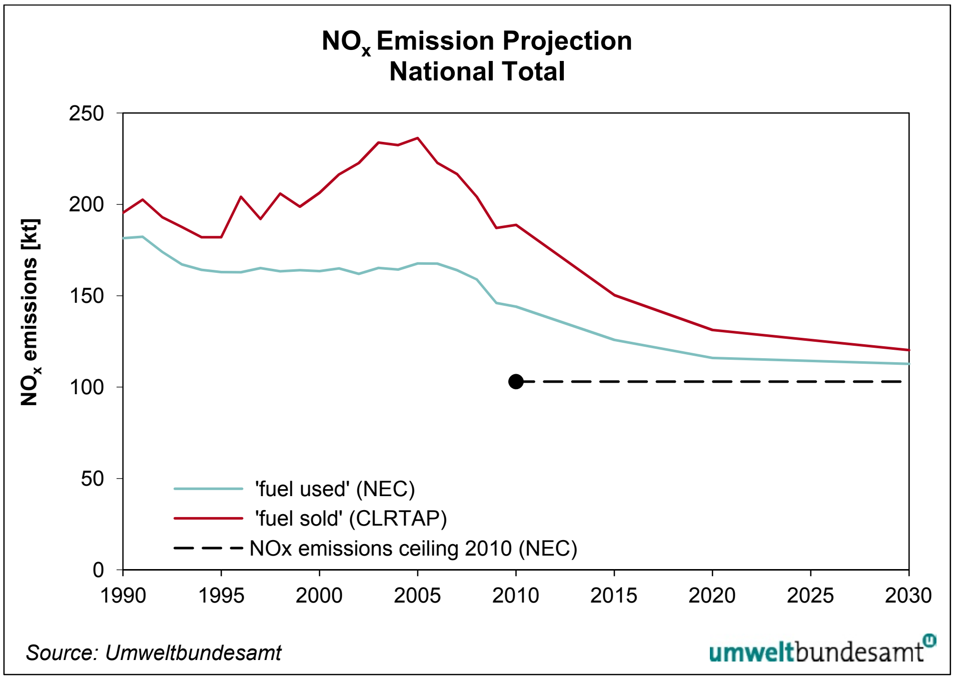

Figure 1: Historical (1990 to 2010) and projected emissions (2015, 2020 and 2030) of NO_X in comparison to the national emission ceiling (2010).

The calculations of transport emissions in the WAM scenario are based on the same general key factors (GDP, population or economic export rate) as in the WEM (with existing measures) scenario. Since road transport is the main source of NOx emissions, the underlying assumptions are described in the following:

a. **Increased fuel tax:** Increasing the fuel tax aims at a reduction of individual motorised transport and a shift towards public transport. Moreover, it shall help to reduce emissions from fuel export.
b. **Modal split development:** The performance of passenger transport and heavy duty vehicles has constantly increased since 1990. Transport-relevant measures were included in the WAM scenario, leading to a decrease in individual motorised transport and an increase in public transport.
c. Freight rail transport will increase slightly, whereas light duty vehicles, navigation and aviation will remain constant on a low level. Moreover,the WAM scenario assumes a shift from road to rail transport.

d. **Electric mobility:** The development of e-mobility up to 2030 has been estimated on the basis of a study (UMWELTBUNDESAMT 2010b). The estimated scenarios are based on ideal political, economic, technical and market conditions for the introduction of electric vehicles. Based on this study, the stock of electric cars (EVs) and plug-in hybrid electric vehicles (PHEVs) is estimated to amount to 210 000 cars in the WAM scenario (in 2020). In 2009, the stock of electric vehicles amounted to 223 units (STATISTIK AUSTRIA 2010a). The WAM scenario assumes that all additional measures (Action Programme "Electro Mobility") are implemented successfully and that there is hardly any resistance in the population to adaptations to the new technology.

e. **Vehicle type approval limit values versus real life emissions:** Real life emissions from road transport have not decreased as much as projected emissions (on the basis of vehicle type approval limit values) in the past. The projections for road transport are based on the assumption that the specified limit values of future technologies are almost reached. Nonetheless, the reduction of NO_x emission levels of vehicles with diesel engines in real world driving situations was clearly lower than the specified limit values in the past. Therefore, additional variations of NO_x emissions of heavy duty vehicles to the WAM scenario were created[8]:

   - **Option 0: EURO 5/6 as planned**

     EURO 5 and 6 meet the specified limit values as planned (optimistic – best case). This option is shown in Tables 1 and 2.

   - **Option 1: No impact EURO 5/6**

     In real world operation, EURO 5 and 6 heavy duty vehicles stay at the same level as EURO 4 vehicles (pessimistic)

   - **Option 2: Low impact EURO 6**

     In real world operation, EURO 5 stays at the same level as EURO 4, whereas EURO 6 is 20% better than EURO 4

   - **Option 3: Low impact EURO 5, higher impact EURO 6**

     EURO 5 is 10% better than EURO 4; the EURO 6 emission control system works the whole time on highways (with 50% of the driving performance) and half the time on the subordinate road network (with 23% of the driving performance)

[8] Further details can be found in ANNEX 3: Road Transport – special considerations.

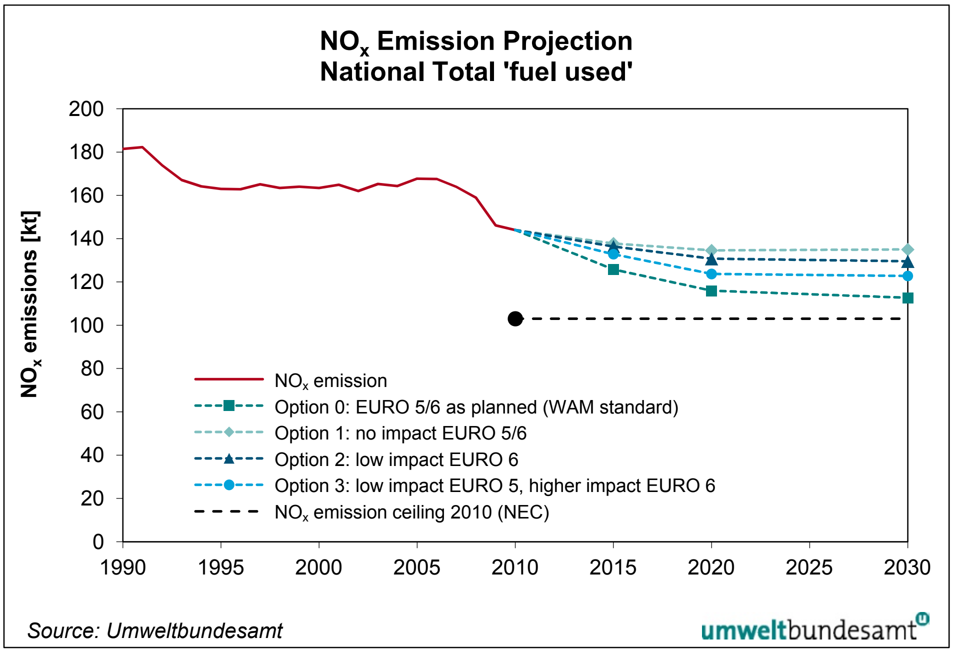

Figure 2: Historical (1990 to 2010) and projected emissions (2015, 2020 and 2030) of NO_x without fuel export in the vehicle tank (i.e. "fuel used") in comparison to the national emission ceiling (2010).

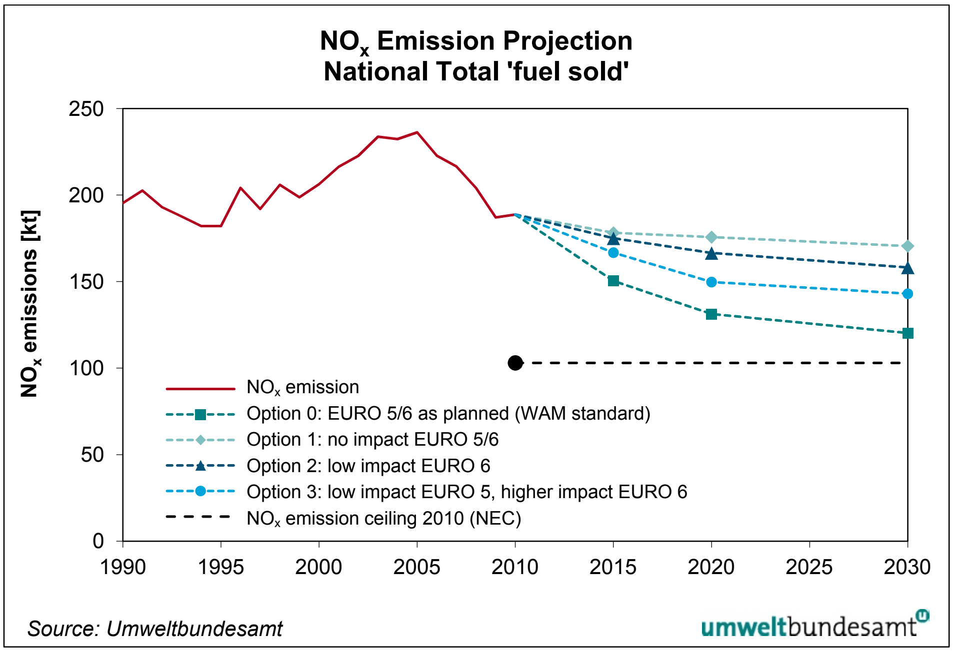

Figure 3: Historical (1990 to 2010) and projected emissions (2015, 2020 and 2030) of NO_X including fuel export in the vehicle tank (i.e. "fuel sold") in comparison to the national emission ceiling (2010).

Table 4: Austria's NO_x emission projection.

	NEC Gas Source Categories	NO_x [kt]					
		1990*	**2005***	**2010***	**2015**	**2020**	**2030**
National Total (fuel sold)	**Option 0: EURO 5/6 as planned**	**195.41**	**236.25**	**188.79**	**150.38**	**131.26**	**120.25**
	Option 1: No impact EURO 5/6				***178.20***	***175.73***	***170.56***
	Option 2: Low impact EURO 6				***175.04***	***166.53***	***158.20***
	Option 3: Low impact EURO 5, higher impact EURO 6				***166.76***	***149.78***	***143.01***
National Total (fuel used)	**Option 0: EURO 5/6 as planned**	**181.48**	**167.72**	**144.00**	**125.83**	**115.94**	**112.70**
	Option 1: No impact EURO 5/6				***137.74***	***134.58***	***135.03***
	Option 2: Low impact EURO 6				***136.39***	***130.73***	***129.54***
	Option 3: Low impact EURO 5, higher impact EURO 6				***132.84***	***123.71***	***122.80***
1 A 1	Energy industries	17.74	15.09	13.83	10.43	10.25	8.64
1 A 2	Manufacturing industries and construction	32.97	33.24	31.81	35.59	38.33	44.90
1 A 3 a,c,d,e	Non-road transport	3.30	4.70	4.33	5.28	5.83	7.19
1 A 3 b Road Transport (fuel sold)	Option 0: EURO 5/6 as planned	102.27	148.91	108.77	71.03	50.31	34.57
	Option 1: No impact EURO 5/6				98.84	94.79	84.88
	Option 2: Low impact EURO 6				95.68	85.59	72.52
	Option 3: Low impact EURO 5, higher impact EURO 6				87.41	68.83	57.34
1 A 3 b Road Transport (fuel used)	Option 0: EURO 5/6 as planned	88.33	80.38	63.98	46.47	35.00	27.02
	Option 1: No impact EURO 5/6				58.38	53.63	49.35
	Option 2: Low impact EURO 6				57.03	49.78	43.86
	Option 3: Low impact EURO 5, higher impact EURO 6				53.49	42.76	37.12
1 A 4	Other sectors	27.66	26.77	22.89	20.51	18.94	17.28
1 A 5	Other	0.07	0.09	0.08	0.08	0.09	0.10
1 B	Fugitive emissions	IE	IE	IE	IE	IE	IE
2	Industrial processes	4.80	1.75	1.50	1.69	1.70	1.75
3	Solvent and other product use	NA	NA	NA	NA	NA	NA
4	Agriculture	6.51	5.65	5.58	5.73	5.76	5.78
4 B	Manure management	5.09	4.59	4.63	4.63	4.67	4.88
4 D	Agricultural soils	1.35	0.99	0.87	1.03	1.02	0.84
4 F,G	Field burning and other agriculture	0.07	0.07	0.07	0.06	0.06	0.06
6	Waste	0.10	0.05	0.01	0.05	0.05	0.05

** Data source: Austrian Emission Inventory 2012 (UMWELTBUNDESAMT 2012a)*

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

2.2 Sulphur Dioxide SO_2

SO_2 emissions have decreased quite steadily since 1990 and were reduced by 75% by the year 2010, which was mainly due to lower emissions from residential heating, combustion in energy and manufacturing industries. The main reasons for this development are the implementation of emission limits in the power generation sector and the reduction of the sulphur content in mineral oil products.

The economic crisis caused a significant emission reduction in 2009, which was partly counterbalanced by a rebound of the economy in 2010.

The main sources of SO_2 emissions in Austria are fuel combustion activities with a share of 92% in 2010,. Within this category, manufacturing industries and construction contribute the most to total SO_2 emissions (58%). Energy industries and other sectors have a share of 17% and 15% of national total emissions, respectively. Only a slight increase in SO_2 emissions (+1.5%) is expected until 2030. Emissions from manufacturing industries and construction are expected to increase (+39%), mainly due to increasing GDP projections. In contrast, emissions from energy industries and other sectors are expected to decrease (-60%) by 2030 due to the shift from fossil fuels to renewable fuels in both categories.

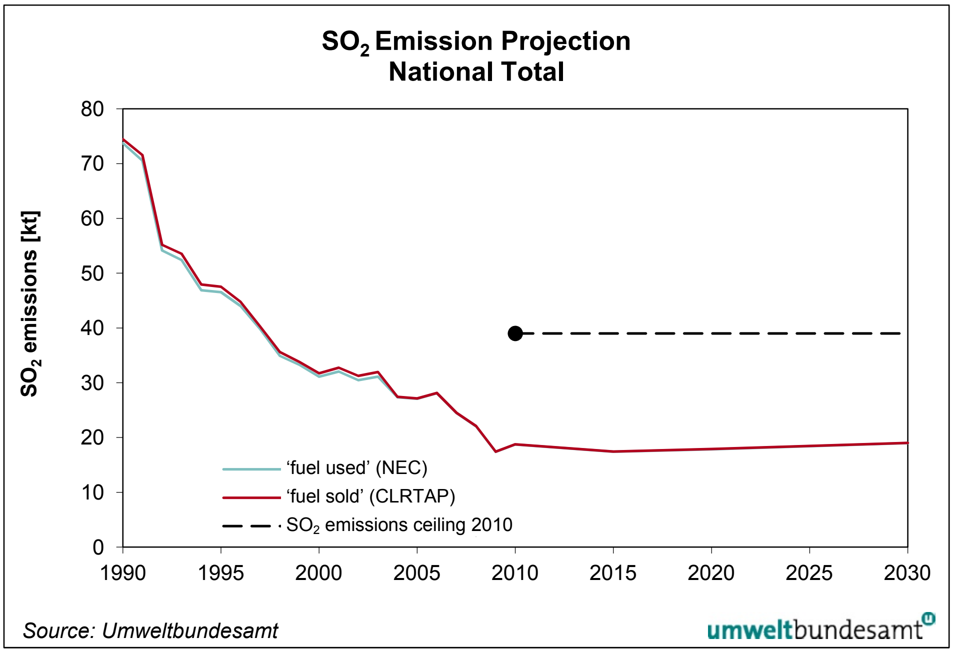

Figure 4: Historical (1990 to 2010) and projected emissions (2015, 2020 and 2030) of SO_2 in comparison to the national emissions ceiling (2010).

Table 5: Austria's SO_2 emission projection (Source: Umweltbundesamt).

	NEC Gas Source Categories	**SO_2 [kt]**					
		1990*	**2005***	**2010***	**2015**	**2020**	**2030**
	National Total (fuel sold)	**74.45**	**27.15**	**18.76**	**17.44**	**17.90**	**19.03**
	National Total (fuel used)	**73.71**	**27.09**	**18.72**	**17.40**	**17.86**	**18.99**
1 A 1	Energy industries	14.04	6.88	3.24	1.79	1.74	1.28
1 A 2	Manufacturing industries and construction	17.97	10.71	10.85	11.67	12.73	15.05
1 A 3 b	Road transport (fuel sold)	4.86	0.16	0.13	0.12	0.12	0.10
1 A 3 b	Road transport (fuel used)	4.12	0.10	0.09	0.08	0.08	0.07
1 A 3 a,c,d,e	Non-road transport	0.33	0.17	0.17	0.18	0.19	0.21
1 A 4	Other sectors	32.94	7.80	2.90	2.49	1.94	1.23
1 A 5	Other	0.01	0.01	0.01	0.02	0.02	0.02
1 B	Fugitive emissions	2.00	0.13	0.23	0.12	0.11	0.09
2	Industrial processes	2.22	1.22	1.21	0.99	0.99	0.99
3	Solvent and other product use	NA	NA	NA	NA	NA	NA
4	Agriculture	0.00	0.00	0.00	0.00	0.00	0.00
4 B	Manure management	NA	NA	NA	NA	NA	NA
4 D	Agricultural soils	NA	NA	NA	NA	NA	NA
4 F,G	Field burning and other agriculture	0.00	0.00	0.00	0.00	0.00	0.00
6	Waste	0.07	0.06	0.01	0.06	0.06	0.06

** Data source: Austrian Emission Inventory 2012 (UMWELTBUNDESAMT 2012a)*

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

2.3 Non-Methane Volatile Organic Compounds (NMVOCs)

Emissions of non-methane volatile organic compounds show a considerable reduction from 1990 to 2010 (– 52%). In the WAM scenario, a reduction of 17% from 2010 to 2030 is expected.

The main sources of NMVOC emissions in Austria are solvent and other product use with a share of more than 56%, and fuel combustion activities with a share of 38%.

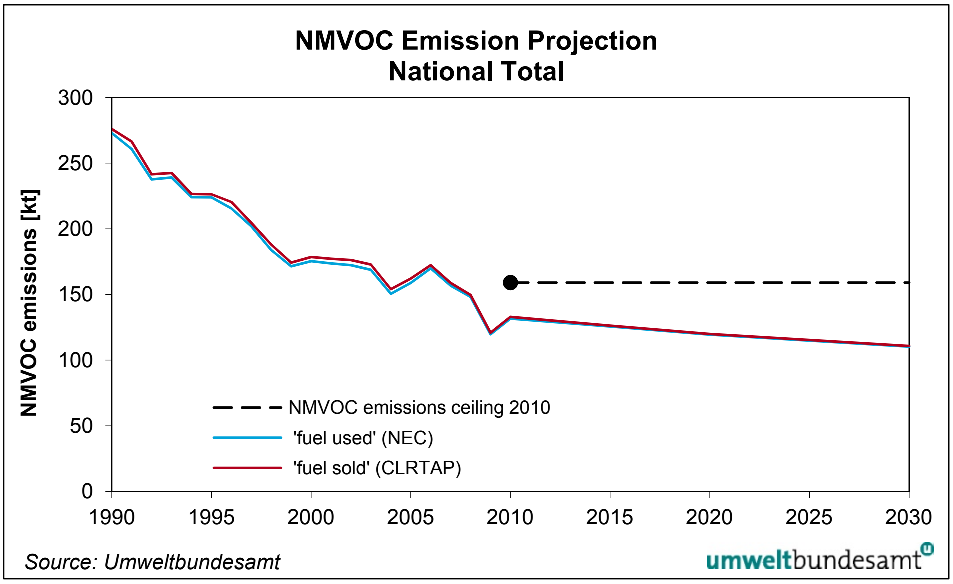

Figure 5: Historical (1990 to 2010) and projected emissions (2015, 2020 and 2030) of NMVOC in comparison to the national emissions ceiling (2010).

NMVOC emissions are projected to decrease until 2030. Improvements of engine technology for mobile sources, a trend towards central heating and lower emission factors of new boilers in the residential sector as well as a decrease in the use of log wood as energy source will lead to an emission reduction.

In the category solvent and other product use, emissions are expected to increase until 2015 due to a rebound effect after the 2009 economic crisis. Thereafter, the scenario shows a slight decrease caused by the reduced consumption of solvents. There are no additional measures planned for solvents.

Table 6: Austria's NMVOC emission projection (Source: Umweltbundesamt).

	NEC Gas Source Categories	**NMVOC [kt]**					
		1990*	**2005***	**2010***	**2015**	**2020**	**2030**
	National Total (fuel sold)	**275.98**	**162.03**	**132.89**	**126.25**	**119.89**	**110.72**
	National Total (fuel used)	**272.94**	**158.72**	**131.58**	**125.67**	**119.40**	**110.31**
1 A 1	Energy industries	0.42	0.57	0.80	0.80	0.80	0.80
1 A 2	Manufacturing industries and construction	1.74	2.12	2.40	2.45	2.52	2.71
1 A 3 b	Road transport (fuel sold)	71.78	21.78	12.44	8.94	7.18	5.52
1 A 3 b	Road transport (fuel used)	68.74	18.47	11.13	8.36	6.68	5.11
1 A 3 a,c,d,e	Non-road transport	1.09	1.14	1.03	1.10	1.10	1.11
1 A 4	Other sectors	61.28	37.69	33.57	25.50	23.03	19.72
1 A 5	Other	0.01	0.02	0.02	0.02	0.02	0.02
1 B	Fugitive emissions	12.13	2.86	1.98	2.16	2.07	1.97
2	Industrial processes	11.10	4.71	4.73	4.73	4.73	4.73
3	Solvent and other product use	114.43	89.20	74.09	78.66	76.57	72.39
4	Agriculture	1.85	1.86	1.78	1.84	1.85	1.73
4 B	Manure management	NA	NA	NA	NA	NA	NA
4 D	Agricultural soils	NA	NA	NA	NA	NA	NA
4 F,G	Field burning and other agriculture	1.85	1.86	1.78	1.84	1.85	1.73
6	Waste	0.16	0.09	0.06	0.05	0.03	0.02

* *Data source: Austrian Emission Inventory 2012 (UMWELTBUNDESAMT 2012a)*

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

2.4 Ammonia (NH_3)

Emissions of NH_3 have slightly decreased since 1990. The main source of ammonia is the agricultural sector, contributing 93% to total NH_3 emissions in 2010.

Agricultural NH_3 emissions result from animal husbandry, the storage of manure as well as the application of organic manure.The emission trend closely follows the development of the Austrian livestock, so NH_3 emissions from agriculture are expected to show a constant trend in line with constant livestock numbers.

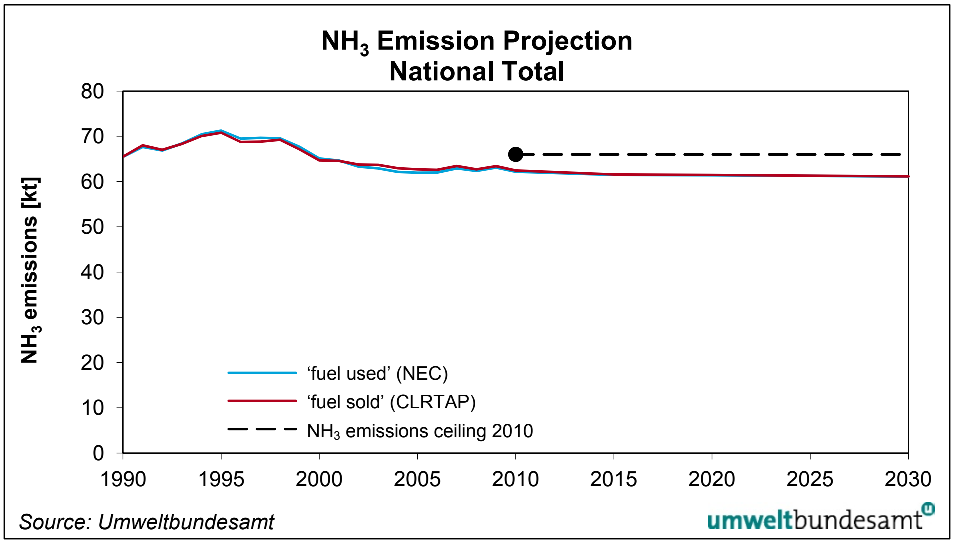

Figure 6: Historical (1990 to 2010) and projected emissions (2015, 2020 and 2030) of NH_3 in comparison to the national emissions ceiling (2010–2030).

Table 7: Austria's NH_3 emission projection (Source: Umweltbundesamt).

	NEC Gas Source Categories	NH₃ [kt]					
		1990*	**2005***	**2010***	**2015**	**2020**	**2030**
	National Total (fuel sold)	**65.48**	**62.70**	**62.45**	**61.55**	**61.47**	**61.15**
	National Total (fuel used)	**65.46**	**61.97**	**62.16**	**61.47**	**61.38**	**61.12**
1 A 1	Energy industries	0.20	0.31	0.46	0.46	0.46	0.46
1 A 2	Manufacturing industries and construction	0.35	0.44	0.41	0.41	0.41	0.41
1 A 3 b	Road transport (fuel sold)	2.87	3.02	1.27	0.73	0.59	0.40
1 A 3 b	Road transport (fuel used)	2.86	2.28	0.98	0.65	0.50	0.36
1 A 3 a,c,d,e	Non-road transport	0.01	0.01	0.01	0.01	0.01	0.01
1 A 4	Other sectors	0.63	0.71	0.68	0.62	0.60	0.55
1 A 5	Other	0.00	0.00	0.00	0.02	0.02	0.02
1 B	Fugitive emissions	IE	IE	IE	IE	IE	IE
2	Industrial processes	0.27	0.07	0.09	0.09	0.09	0.09
3	Solvent and other product use	NA	NA	NA	NA	NA	NA
4	Agriculture	60.80	56.86	58.22	57.75	58.12	58.13
4 B	Manure management	55.21	51.63	52.46	52.24	52.67	53.43
4 D	Agricultural soils	5.12	4.68	5.14	4.98	4.93	4.23
4 F,G	Field burning and other agriculture	0.47	0.54	0.62	0.53	0.53	0.47
6	Waste	0.36	1.29	1.30	1.46	1.17	1.09

* *Data source: Austrian Emission Inventory 2012 (UMWELTBUNDESAMT 2012a)*

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 24 Gg in 1990 and have decreased steadily ever since: From 1990 to 2010, emissions were reduced by 18% (to 20 Gg).. In 2010, $PM_{2.5}$ emissions in Austria mainly arose from combustion activities in the energy sector with a share of 84% in national total emissions. The WAM scenario projects a decrease of 22% between 2010 and 2030.

Emissions of fine particulate matter resulted to a large extent from power plants with flue gas cleaning systems, which filter larger particles. The reduction of $PM_{2.5}$ emissions is generally due to the installation of flue gas collection and modern flue gas cleaning technologies in several branches.

The sub category 1A4 other sectors is the largest source of $PM_{2.5}$ with a share of 42% in national total emissions. The $PM_{2.5}$ emissions of this sub category decrease in the WAM scenario by 36% until 2030. Other sectors include fuel combustion in commercial and institutional buildings and households as well as off-road vehicles and other machinery in the area of agriculture and forestry. Emission reductions of $PM_{2.5}$ are mainly due to an increase in efficiency of buildings and heating systems and to the trend against manual feeding log boilers. The decreasing energy demand for solid fuels (log wood, coal) leads to a $PM_{2.5}$ reduction of about 36% until 2030. The main assumptions in the WAM scenario include a faster increase in the renovation rate and a reduced demand for energy in the subsectors residential and commercial

The sub-category road transport has a share of 20%. The largest source within this category is automobile road abrasion, which increases slightly even by 2030. Total $PM_{2.5}$ emissions of the sub category road transport are expected to decrease by about 52%. The main measure in the WAM scenario responsible for the decrease in emissions is the increase of the Austrian fuel tax. The relevant assumptions are described in chapter 2.1.

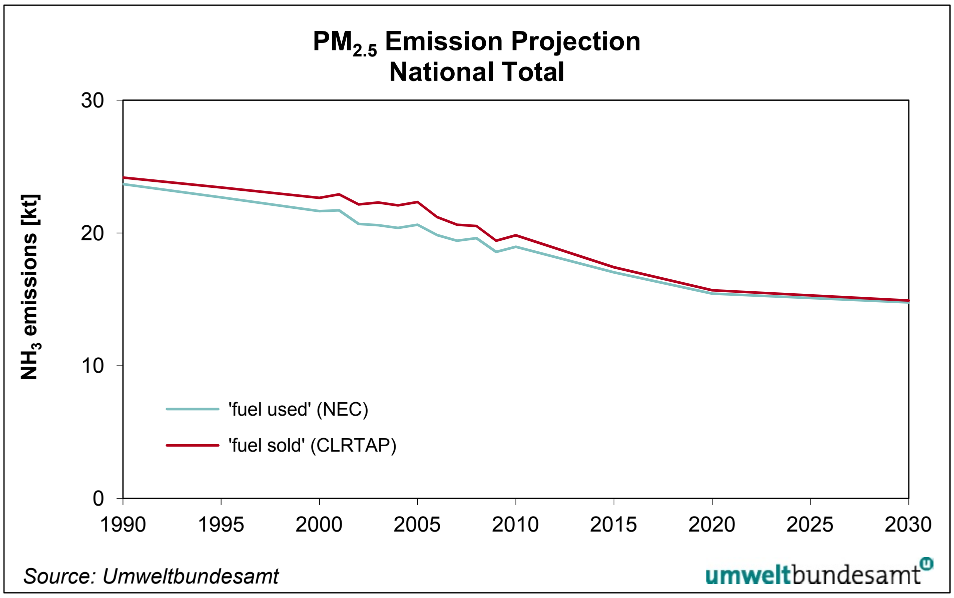

Figure 7: Historical (1990 to 2010) and projected emissions (2015, 2020 and 2030) of $PM_{2.5}$

Table 8: Austria's $PM_{2.5}$ emission projection (Source: Umweltbundesamt).

	NEC Gas Source Categories	**$PM_{2.5}$ [kt]**					
		1990*	**2005***	**2010***	**2015**	**2020**	**2030**
	National Total (fuel sold)	24.18	22.34	19.83	17.42	15.69	14.91
	National Total (fuel used)	23.68	20.62	18.96	17.04	15.43	14.77
1 A 1	Energy industries	0.83	0.80	1.15	1.12	1.14	0.72
1 A 2	Manufacturing industries and construction	2.08	2.21	2.51	2.57	2.64	3.16
1 A 3 b	Road transport (fuel sold)	3.69	6.01	3.99	2.57	2.07	1.90
1 A 3 b	Road transport (fuel used)	3.19	4.29	3.13	2.19	1.81	1.75
1 A 3 a,c,d,e	Non-road transport	0.73	0.68	0.60	0.62	0.58	0.50
1 A 4	Other sectors	11.67	8.92	8.34	7.15	5.87	5.34
1 A 5	Other	0.02	0.02	0.02	0.02	0.02	0.02
1 B	Fugitive emissions	0.09	0.09	0.07	0.07	0.07	0.05
2	Industrial processes	3.24	1.83	1.39	1.57	1.57	1.57
3	Solvent and other product use	0.41	0.44	0.44	0.45	0.46	0.48
4	Agriculture	1.40	1.32	1.29	1.26	1.25	1.16
4 B	Animal husbandry and manure management	IE	IE	IE	IE	IE	IE
4 D	Plant production and agricultural soils	1.14	1.11	1.09	1.05	1.04	0.95
4 F,G	Field burning and other agriculture	0.26	0.21	0.20	0.20	0.20	0.20
6	Waste	0.02	0.03	0.03	0.03	0.03	0.03

** Data source: Austrian Emission Inventory 2012 (UMWELTBUNDESAMT 2012a)*

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

3 SOURCES OF DATA

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 and on a macro-economic model (DEIO) of the Austrian Institute of Economic Research (WIFO 2011), supported by calculations carried out with the bottom-up models TIMES (AEA 2011), ERNSTL (TU WIEN 2011) and GLOBEMI & GEORG (HAUSBERGER 2011).

Projections for agriculture were calculated by the Austrian Institute of Economic Research (SINABELL ET AL. 2011a) in cooperation with Umweltbundesamt. Projections for solvents und waste were modelled by Umweltbundesamt.

A detailed description of the models is provided in a report titled "GHG Projections and Assessment of Policies and Measures in Austria", submitted to the European Commission and the European Environment Agency (UMWELTBUNDESAMT 2011a).

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

Table 9: Main data sources for activity data and emission values (Source: Umweltbundesamt).

Sector	Data Sources for Activity Data	Emission Calculation
Energy	National Energy Balance of Statistics Austria, macro-economic model of the Austrian Institute of Economic Research (WIFO), bottom-up models TIMES (AEA), ERNSTL (Vienna University of Technology) as well as GLOBEMI & GEORG (Graz University of Technology)	Umweltbundesamt (energy providers, manufacturing industries, residential and commercial sector, parts of transport sector) Graz University of Technology (transport sector)
Industry	Austrian Institute of Economic Research (macroeconomic model DEIO)	Umweltbundesamt
Solvent	Statistics Austria	Umweltbundesamt
Agriculture	Austrian Institute of Economic Research (agriculture model PASMA) (SINABELL et al. 2011a)	Umweltbundesamt
Waste	Historical values: Landfill database, EDM (solid waste deposited) Projected values: expert judgement on future amounts of solid waste expected to be disposed on landfills (based on recent and expected developments)	Umweltbundesamt

4 METHODOLOGY

4.1 General Approach

Where reasonable and applicable, emissions were calculated and projected on the basis of the methodology used in the Austrian Inventory. The Austrian Inventory is based on the SNAP (Selected Nomenclature for sources of Air Pollution) nomenclature and has to be transformed into the current reporting format as required under the LRTAP convention, the NFR (Nomenclature For Reporting) format. Projections were thus also calculated on the basis of the SNAP nomenclature and subsequently transformed into the NFR format.

For all sectors, reduction measures were identified and emissions projected by specifically designed models. The methodology used for the projections of the key driving forces and emission calculations is described in the respective chapters. Consistency between sector models was ensured by regular expert meetings, which addressed overlaps and possible gaps.

The scenario "with additional measures" (WAM) includes planned policies and measures with a realistic chance of being adopted and implemented in time to influence the emissions. All additional measures have been defined at expert level in consultation with the Federal Ministry of Agriculture, Forestry, Environment and Water Management.

Emissions from energy-related sectors (NFR 1.A) are calculated on the basis of energy scenarios as of 2011 (UMWELTBUNDESAMT 2011b).

4.2 General Socio-economic Assumptions

Data used for general socio-economic assumptions, which form the basis of the Austrian emission projections, can be found in Table 8. Further assumptions for key input parameters can be found in UMWELTBUNDESAMT 2011a.

Table 10: Key input parameters of emission projections (Source: Umweltbundesamt).

Year	2010	2015	2020	2025	2030
GDP [billion € 2008]	279.78	305.92	339.70	376.66	420.41
Population [1 000]	8 388	8 556	8 726	8 877	9 021
Stock of dwellings [1 000]	3 662	3 851	4 042	4 227	4 401
International coal prices [€/GJ]	5.71	7.18	8.61	10.40	12.56
International oil prices [€/GJ]	10.41	13.09	15.70	18.97	22.91
International gas prices [€/GJ]	8.33	10.47	12.56	15.17	18.33

4.3 Stationary Fuel Combustion Activities (NFR 1 A)

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.

A model based on TIMES was used, which provides fuel-specific activity data for energy industries (i.e. electricity and heat production including waste incineration). These data were multiplied by the same established fuel-specific emission factors, which were used in the Austrian Inventory. Emission factors for unspecified fuels (e.g. for refinery fuel gas, refinery coke) or waste (e.g. municipal solid waste, hazardous waste) were derived from plant-specific data.

The methodology applied for the determination of emission factors is described in the Austrian Inventory Report (UMWELTBUNDESAMT 2012a).

As regards the only refinery operated in Austria, the installation of a SNOX plant in November 2007 has significantly reduced emissions of SO_2 and NO_x. Since no other changes are expected in the next few years, emission projections have been based on current emission levels.

For oil and gas exploration and storage, the historical trends of the past have been prolonged.

Figures on energy demand have been split up into the sub-sectors of the Austrian air emission inventory.

4.3.1 Energy Industry (NFR 1 A 1)

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

SO_2, NO_x and $PM_{2.5}$

The projected emissions of SO_2, NO_x and $PM_{2.5}$ were calculated by multiplying projected energy data (UMWELTBUNDESAMT 2011b) 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, commissioning of new plants and the closing down of existing facilities.

For $PM_{2.5}$, plant-specific emission factors for TSP have been converted to $PM_{2.5}$ by the ratio used in the Austrian Air Emission Inventory.

A detailed description of the methodologies used can be found in the cited literature (UMWELTBUNDESAMT 2003a, b, c, BMLFUW 2004 and UMWELTBUNDESAMT & BMLFUW 2002).

NMVOC and NH_3

NMVOC and NH_3 emissions are assumed to remain constant at 2010 levels (UMWELTBUNDESAMT 2012a). This simple approach has been chosen because their share in total emissions is less than 1%.

4.3.2 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 5.4.

SO_2 and NO_x

For the estimation of SO_2 and NO_x, both sectors NFR 1 A 2 and 2 have been assessed together (UMWELTBUNDESAMT 2003a, c, UMWELTBUNDESAMT 2007 and UMWELTBUNDESAMT 2009). The following industrial sectors have been identified as the major emission sources:

- production in the cement, glass, magnesia, lime and other mineral industry,
- 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.

The projected emissions were calculated by applying the trend of energy consumption (UMWELTBUNDESAMT 2011b) and by incorporating recent data from environmental impact statements on facility expansions and the opening and closing down of facilities.

NMVOC and NH_3

The NMVOC and NH_3 emissions from stationary sources are assumed to remain constant at 2010 levels (UMWELTBUNDESAMT 2012a). This simple approach has been chosen because their share in total emissions is less than 2%.

$PM_{2.5}$

The projected emissions were calculated by applying the trend of energy consumption (UMWELTBUNDESAMT 2011b) and by incorporating recent data from environmental impact statements on facility expansions and the opening and closing down of facilities.

For process emissions from quarries, construction and the wood industry, the historical trends of the past have been prolonged.

NFR 1 A 2 f i Other Mobile in Industry – Soil Abrasion

This category includes emissions from soil abrasion of industrial off-road mobile machinery, mainly from the construction sector.

Projected $PM_{2.5}$ emissions have been estimated in a manner consistent with the Air Emission Inventory (UMWELTBUNDESAMT 2012a). The machinery operating hours are multiplied by a constant emission factor. Activity data is consistent with the activity data used for the calculation of exhaust emissions.

4.3.3 Other Sectors (NFR 1 A 4)

This chapter describes the methodology used 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 4.4.

Activities

A comprehensive model for buildings (ERNSTL) is used to calculate the energy consumption of stationary sources separately for the sub-sectors residential and commercial. The input for the sector agriculture stems from the macro-economic model DEIO. A detailed description of these models can be found in UMWELTBUNDESAMT 2011a, TU WIEN 2011 and WIFO 2011.

Emissions

SO_2, NO_x, NMVOC, NH_3 and $PM_{2.5}$ emissions were calculated based on the energy demand for stationary sources in the subsectors 1 A 4 a, 1 A 4 b and 1 A 4 c. A comprehensive description of the methods and emission factors used for these calculations can be found in the Austrian Informative Inventory Report (UMWELTBUNDESAMT 2012a).

Separate emission factors have been used for:

- Fuel type (e.g. coal, natural gas, heating and other oil, residual fuel oil, LPG, wood log & wood briquettes, wood chips and wood pellets).
- Heating type (central heating, heating systems for apartments and stoves).
- Different technologies (e.g. new biomass boilers – wood gasification, condensing gas and heating oil boilers).

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

Next to emissions from boilers and stoves, this sector includes emissions from bonfires and open fire pits as well as from barbecueing. Projected $PM_{2.5}$ emissions have been estimated by extrapolating 2010 emissions with projected population statistics.

NFR 1 A 4 c ii Off-road Vehicles and Other Machinery – Soil Abrasion

This category includes emissions from soil abrasion of agricultural off-road mobile machinery such as tractors and mowers.

Projected $PM_{2.5}$ emissions have been estimated in a manner consistent with the air emission inventory (UMWELTBUNDESAMT 2012a). The machinery operating hours are multiplied by a constant emission factor. Activity data is consistent with the activity data used for the calculation of exhaust emissions.

4.4 Mobile Fuel Combustion Activities (NFR 1 A)

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

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

The calculation of transport emissions is based on different models. The following input parameters are used for road/off-road emission projections:

- **Transport demand model**

  The transport demand data used here (which is the basis for emission modelling) is the result of calculations and forecasts made by a team of experts, who also compiled the Austrian "Environmental Balance of Transport" 2006/2008. The Environmental Balance of Transport is a multidisciplinary inter-modal analysis of transport demand in Austria since 1950 and its impact on the environment, human health and climate.

  Transport volumes for road and rail are based on an amalgamation as well as an analytical synthesis of official background statistics relevant for travel and freight transport demand by Statistics Austria. Available information such as population data, motorisation rates, vehicle fleet sizes, economic and income development statistics was used. Transport volumes for all other modes (i.e. inland waterways, local buses and trams) were derived from data collected by official Austrian bodies such as Statistics Austria, the Austrian Federal Ministry of Economy, Family and Youth (BMWFJ) or the Austrian Federal Ministry of Agriculture and Forestry, Environment and Water Management.

- **GLOBEMI - Emission model road (NFR *1 A 3 b*)**

  For the calculation of road emissions, the GLOBEMI model is used (HAUSBERGER 1998, HAUSBERGER 2010, HAUSBERGER 2011). GLOBEMI has been developed for the calculation of emission inventories in larger areas. Input parameters are, amongst others, the vehicle stock of each category (cars, light duty vehicles, …) split into layers according to the propulsion system (SI, CI, …), engine volume or vehicle mass, the emission factors for the vehicles according to the year of their first registration, and the number of passengers per vehicle and tonnes of payload per vehicle. Furthermore, the model delivers **an assumption regarding the fuel export effect.**

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

  The energy consumption and off-road emissions in Austria are calculated with the model GEORG (**G**razer **E**missionsmodell für **O**ff **R**oad **G**eräte) (PISCHINGER 2000, HAUSBERGER & MACHER 2008). The GEORG model has a fleet model part, which simulates the actual age and size distribution of the vehicle stock via age- and size-dependent drop-out rates (probability that a vehicle will be scrapped by the next year). With this approach, the stock of each category of mobile sources is calculated based on the year of the vehicle's first registration and the propulsion system (gasoline 4-stroke, gasoline 2-stroke, diesel > 80 kW, diesel < 80 kW).

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 brake wear have been estimated in a manner consistent with the air emission inventory (UMWELTBUNDESAMT 2012a). Projected passenger car and heavy duty vehicle kilometres (HAUSBERGER 2011) are multiplied by emission factors.

- **NFR 1 A 3 c Railways abrasion and brake wear**

  $PM_{2.5}$ emissions from rail abrasion and rail brake wear have been extrapolated with 2010 emissions.

- **NFR 1 A 5 b Military mobile machinery**

  Ground operations: $PM_{2.5}$ emissions for the military sector (ground operations) have been extrapolated by means of 2010 emissions and projected fuel consumption.

  Aviation operations: Based on the forecast (WIFO 2011) for the aviation sector, the average annual growth rate of energy consumption up to 2030 is transferred to the military aviation sector and corresponding emission factors are used for calculating $PM_{2.5}$.

  Soil abrasion: This category includes emissions from soil abrasion of military mobile machinery. Projected $PM_{2.5}$ emissions have been estimated in a manner consistent with the air emission inventory (UMWELTBUNDESAMT 2012a). The machinery operating hours are multiplied by a constant emission factor. Activity data is consistent with activity data used for the calculation of exhaust emissions.

While calculating the NO_x emissions for the emission projections it turned out that the reduction of the NO_x-emission levels of vehicles with diesel engines in real world driving situations was clearly lower than originally expected. Therefore, NO_x emission factors for passenger cars EURO 5 and EURO 6 have been raised in contrast to the initial WAM scenario. It was further recognized, that the NO_x emission levels for EURO 5 and EURO 6 of heavy duty vehicles (HDV) were estimated too optimistically. Therefore, NO_x emission factors for HDV EURO 5 and EURO 6 were adapted. Further details can be found in ANNEX 3: Road Transport – Special Considerations.

4.4.2 Aviation (NFR 1 A 3 a)

The projection of energy consumption in the aviation sector up to 2030 is based on a forecast for jet fuel by the Austrian Institute of Economic Research (WIFO 2011).

$PM_{2.5}$ emissions have been extrapolated by means of 2010 emissions and projected fuel consumption.

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

The projection of energy demand for pipeline transport up to 2030 is based on expert judgments obtained during several interviews with Austrian pipeline operators.

4.5 Fugitive Emissions (NFR 1 B)

SO_2 and NMVOC

SO_2 and NMVOC emission projections for fugitive emissions are based on emission/activity data ratios for 2004–2008, as well as on projected activity data such as natural gas and crude oil exploration, and natural gas and gasoline consumption according to (WIFO 2011). Emission reduction measures such as the introduction of vapour recovery units at depots and service stations were already implemented in 2003, and no further reductions are expected.

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

Coal production was abandoned in 2005.

A detailed description of the methodology for emission estimations can be found in the Austrian Informative Inventory Report 2010 (UMWELTBUNDESAMT 2012a).

NO_x and NH_3

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

$PM_{2.5}$

1 B 1 a coal handling: $PM_{2.5}$ emissions from coal handling and storage have been extrapolated by means of 2010 emissions and projected coal consumption (WIFO 2011).

4.6 Industrial Processes (NFR 2)

The forecast for developments in industrial production has been based on macro-economic data for the sub-sectors (UMWELTBUNDESAMT 2011b), taking into account known predictions about expansions in iron and steel production, the opening of new installations and the decommissioning of old facilities for sulphuric acid production.

NO_x and NMVOC emissions from 2 D 1 Pulp and Paper are reported together with energy-related emissions under 1 A 2 f Other.

SO_2, NO_x and $PM_{2.5}$

The methodology used for calculating SO_2, NO_x and $PM_{2.5}$ is described in Chapter 4.3.2.

NMVOC and NH_3

NMVOC and NH_3 emissions were assumed to remain constant at the levels of 2008 (UMWELTBUNDESAMT 2012a). This simple approach has been chosen because their share in total emissions is less than 3%.

4.7 Solvent and Other Product Use (NFR 3)

NMVOCs

Emission projections for 2011 until 2030 are calculated by multiplying emissions of the latest inventory year (2010; submission 2012) by the extrapolation of the trend (2000–2010) of the activity data in each subsector.

The basis for the data of the Austrian air emission inventory (OLI) 2012 (data basis 2010) has been provided by surveys (WINDSPERGER et al. 2002a, 2002b, 2004; WINDSPERGER & SCHMID-STEJSKAL 2008) as well as import-export statistics (foreign trade balance) and production statistics provided by Statistics Austria.

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 shares of solvents used in different applications and the solvent emission factors were calculated on the basis of the bottom-up approach. By linking the results of the bottom-up and the top-down approach, the quantities of solvents used per year and the solvent emissions of the different applications were obtained.

The quantity (saldo) of solvents (substances) and solvent containing products which are imported and exported, are extrapolated by the trend of 2000–2010. The production of solvents is assumed as a constant value (as of 2010). It is further assumed that the prospected error/deviation by extrapolation and constant values is comparatively small compared to the total associated uncertainty.

The emission factors used for the forecast were the same as in 2010, as the positive impact of enforced laws and regulations in Austria is expected to be only minimal in subsequent years. Emission factors are calculated by solvent use per substance category at NACE-level-4 for all industrial sectors, and are based on information from surveys in households and industry as well as structural business statistics.

NO_x, SO_2 and NH_3

According to the Austrian inventory, there is no occurrence of NO_x, SO_2 and NH_3 emissions from solvent use.

$PM_{2.5}$

Emission projections for $PM_{2.5}$ are calculated by multiplying the emission factor of the latest inventory year (2010; submission 2012) by the number of inhabitants (population) until 2030 (provided by Statistics Austria).

The basis for the emission factor (data basis 2010, Austrian air emission inventory (OLI) 2012) has been provided by a survey (WINIWARTER, W. et. al. 2007).

4.8 Agriculture (NFR 4)

Agricultural activities and emissions are projected for sources of ammonia (NH_3), nitric oxide (NO_X), non-methane volatile organic compounds (NMVOC), sulphur dioxide (SO_2) and particulate matter ($PM_{2.5}$).

4.8.1 Methodology

Emissions are calculated on the basis of the methodology used for the Austrian air emission inventory. A comprehensive description can be found in the Austrian Informative Inventory Report (IIR) 2012 (UMWELTBUNDESAMT 2012a).

Input parameters for activity data projections have been obtained from the Positive Agricultural Sector Model Austria (PASMA), developed by the Austrian Institute of Economic Research (WIFO) (SINABELL et al. 2011a).

The model maximises sectoral farm welfare and is calibrated on the basis of historical crop, forestry, livestock, and farm tourism activities by using the method of Positive Mathematical Programming (PMP). This method assumes a profit-maximizing 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.

Economic Assumptions

Several assumptions, basically on input prices, were made to run the model described above. Prices were derived from OECD-FAO outlooks on agricultural markets (OECD-FAO 2010). Other exogenous economic assumptions for Austria (like the GDP or population size) are not explicitly essential for the model used in this analysis, as the partial equilibrium model of the agricultural sector mainly depends on input and output prices. Input prices were assumed to be consistent with available forecasts for the Austrian energy sector (UMWELTBUNDESAMT 2011b). Since production is driven by resource availability, prices and technological development, and since Austrian agriculture is an integrated part of the common market, carry-over effects from European demand patterns are noticeable and determine the results.

The forecast period in this study lasts until 2030. OECD-FAO forecasts are not available for the period beyond 2019, so it is assumed, that prices will follow the inherent trend after 2019.

Technological Progress

Information on storage facilities on Austrian farms was obtained from the Austrian farm survey of 1999. Other assumptions, in particular on technical progress in plant and animal production are based on (SINABELL & SCHMID 2005). Deviating from this source, estimates of increasing milk yields per dairy cow have been somewhat reduced according to the estimates discussed in an expert panel in January 2011.

Policy Measures

The following policy measures were considered:

- Slightly more efficient use of mineral fertiliser (efficiency of N from manure increases by 12,5%).
- Further stimulation of organic farming by granting higher subsidies than for the implementation of an agro-environmental measure with lower environmental benefits (technically speaking, funds of UBAG measures from the Austrian agro-environmental programme are shifted to organic farming).
- Energy crop production on 10 000 hectares.
- Abolition of the premium for suckler cows.

4.8.2 Activity Data

This chapter gives an overview of the PASMA scenario results.

Livestock projections - scenario "with additional measures" (WAM)

- The number of cattle is slightly decreasing while the number of dairy cows practically stays the same. The most plausible reasons are that the slight expansion of organic farming lowers the output and that the expansion of bioenergy crops limits the production of fodder and therefore makes livestock production less competitive.
- The number of suckling cows is lower than in the baseline scenario. This is based on the assumption that the premium for suckling cows will be abolished. According to our results, suckling cow production will prevail in several regions even under such detrimental conditions. This can be explained by the fact that sufficient low-cost grassland is available and investments in more productive activities are not likely to be economical in these regions.
- More land will be used for crop production and the production situation will be better for organic farming; more land will be designated to legumes.
- The size of land designated to bioenergy short-rotation poplar will be 10 000 hectares assuming that policies to boost bioenergy production will be in place.
- The output of crops (mainly cereals and corn) will increase, the reason being that the policy scenario assumes that the agro-environmental measure "UBAG" will be abolished and that premiums will be shifted to organic farming. As a consequence, organic farming will be slightly more attractive, although production will become more intensive on the remaining acreage and thus compensate the output-decreasing effect of organic farming.

4.8.3 Emission Calculation

Emissions are calculated on the basis of the revised methodology of the Austrian inventory 2010, which includes new management options and new emission factors (AMON & HÖRTENHUBER 2008).

N Excretion Values

The feed intake parameters applied here are the same as those applied in the national air emission inventory (UMWELTBUNDESAMT 2012a). Austria-specific N excretion values of dairy cows have been calculated on the basis of projected milk yields.

Animal Waste Management Systems

The projected animal waste management system (AWMS) distribution corresponds to the AWMS data used in the 2010 inventory. The data is based on a comprehensive investigation of Austria's agricultural practices in 2005 (AMON et al. 2007).

A comprehensive description of the methodologies used for emission calculations can be found in 'Austria's Informative Inventory Report 2012' (UMWELTBUNDESAMT 2012a).

$PM_{2.5}$ Emissions from Field Operations

Emissions of particulate matter from field operations are linked to the usage of machines on agricultural soils. They are considered in relationship with the treated areas.

Activity data

Agricultural land use data applied to the calculation of particle emissions have been obtained from the Positive Agricultural Sector Model Austria (PASMA), developed by the Austrian Institute of Economic Research (WIFO) (SINABELL et al. 2011a).

Due to the limited number of measurements, a separate parameterisation of different field crops as well as a different treatment of cropland and grassland activities was not possible for the calculation of PM emissions. Thus, the sum of projected cropland and grassland area (excluding extensive mountain pastures) was used as activity data.

Emission factors

For the estimation of emissions from field operations, an emission factor of 5kg/ha PM_{10} has been applied (ÖTTL & FUNK 2007). PM emissions occurring from harvesting have been calculated using an emission factor of 5 kg/ha PM_{10} (HINZ & VAN DER HOEK 2006). Both emission factors are based on measurements carried out directly on the field (two meters above soil and on the harvester). Following Hinz, only a small part of the particle emissions stays in the atmosphere under wet conditions. For the projections, a value of 10% has been applied. For the share of operations under dry conditions, a factor of 0.1 has been assumed.

The following fractions have been used for conversion:

$PM_{2.5}$ ....TSP * 10%

PM_{10}............TSP * 45%

PM Emissions from Bulk Material Handling

Due to the minor importance of this source, the $PM_{2.5}$ emissions were extrapolated from 2010 inventory values.

Particle Emissions from Animal Husbandry

Particle emissions from this source are primarily connected with the manipulation of forage, and a smaller part arises from dispersed excrements and litter. Wet vegetation and mineral particles of soil are assumed to be negligible, so particle emissions from free-range animals are not included.

The estimations of particle emissions from animal husbandry are related to the Austrian livestock projections.

Activity data

Livestock numbers: PASMA scenario results have been taken (SINABELL et al. 2011a).

Emission factors

Due to the lack of more reliable and up-to-date data, the emission factors of the RAINS model (LÜKEWILLE et al. 2001) have been used.

Following (KLIMONT et al. 2002), the share of PM_{10} in TSP is assumed to be 45%, and the share of $PM_{2.5}$ in TSP is assumed to be 10%.

A more detailed description of the methodologies used for $PM_{2.5}$ emission calculations can be found in 'Austria's Informative Inventory Report 2012' (UMWELTBUNDESAMT 2012a).

4.9 Waste (NFR 6)

NMVOCs and NH_3 from Waste Disposal

NMVOC and NH_3 emissions are calculated based on their respective content in the emitted landfill gas (after consideration of gas recovery). For NMVOCs, a concentration of 300 vol.%, and for NH_3 a concentration of 10 vol.% in the landfill gas is assumed.

For the calculation of emissions arising from solid waste disposal on land, the IPCC (Intergovernmental Panel on Climate Change) Tier 2 method – a method recommended for the calculation of landfill emissions on national level – is applied, consisting of two equations: firstly, calculating the amount of methane accumulated up to the year of the inventory; secondly, calculating the emitted methane after subtracting the recovered and oxidised methane amounts. Country-specific parameters are used (e.g. the recovered landfill gas) if available. More detailed information as well as the parameters themselves can be found in Austria's National Inventory Report (UMWELTBUNDESAMT 2012b).

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 (Landfill Ordinance, Ordinance on the mechanical biological treatment of waste, which is currently in preparation). Under the Landfill Ordinance, only pre-treated waste is allowed to be deposited since 2009. Consequently, only the following landfill fractions have been taken into account for the projections:

(1) Residues (stabilised waste) from the mechanical biological treatment of residual wastes; this fraction is expected to decrease.

(2) The landfill fraction from the mechanical treatment of waste.

A detailed description of the methodology used for the calculation of projections of CH_4 emissions can be found in Austria's projection of greenhouse gases, submitted to the European Commission under the EU Monitoring Mechanism (UMWELTBUNDESAMT 2011a).

NO_x, SO_2, NMVOC and NH_3 from Waste Incineration

Due to the low contribution of these pollutants to national total emissions (below 1% for all gases), the 2008 emission levels have been applied to this forecast. A detailed description of the methodology used for emission estimations can be found in the Austrian Informative Inventory Report 2012 (UMWELTBUNDESAMT 2012a).

NH_3 Emissions from Mechanical-biological Treatment and Composting of Waste

Emissions are calculated separately for

- Waste treated in mechanical-biological treatment plants and
- Composted waste

by multiplying the respective emission factors by the waste amounts. For the projections, the same emission factors were used as those in the annual inventory (UMWELTBUNDESAMT 2012a, UMWELTBUNDESAMT 2012b).

With regard to the activity data on composted waste, it is assumed that the amount of bio-waste collected separately and home composting will increase/decrease according to demographic developments over the forecast period. Municipal garden and park waste is expected to remain constant.

With regard to the amount of waste treated in mechanical-biological treatment plants in Austria, the following assumptions have been made:

- Until 2015, the amounts of waste treated in mechanical-biological treatment plants will remain the same (as in 2009), as no further facilities are planned.
- From 2015 onwards, the amounts of waste treated in mechanical-biological treatment plants are expected to decrease, as it is assumed that plants will close down in view of stricter regulations on waste air purification.
- In 2020, only 25% of the amounts currently treated will be subject to mechanical-biological treatment. By 2030, no waste is expected to be treated in this way anymore. At the same time, other treatment methods such as dry stabilisation will probably gain importance.

$PM_{2.5}$

For the calculation of $PM_{2.5}$ emissions, only specific waste types are considered such as residues from iron and steel production (slags, dusts), clinker, dust and ashes from thermal waste treatment and combustion plants, as well as some mineral and construction waste.

Emissions are calculated by multiplying the waste amount by an emission factor (the same as used for the Austrian air emission inventory). For the projection of waste amounts, differentiated assumptions have been made for the single fractions: Metallurgic waste (clinker, dusts, etc.) and mineral waste are assumed to develop in accordance with the respective projected gross value added in the respective economic sector (ÖNACE 27 Manufacture of basic metals, ÖNACE 45 Construction). For the projection of residues from thermal treatment and combustion plants, projected energy data (waste as fuel) has been used as an indicator (UMWELTBUNDESAMT 2011b). For all other wastes historical values have been taken (for extrapolation).

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ANNEX 1: NATIONAL PROJECTION ACTIVITY DATA

Table 11: Assumptions on general economic parameters (Source: Umweltbundesamt).

	Unit	2010	2015	2020	2030
1. Gross Domestic Product	Value (billion €)	279.78	305.92	339.70	420.41
2. Population	Thousand people	8 388	8 556	8 726	9 021
3. International coal prices	€ per GJ	5.71	7.18	8.61	12.56
4. International oil prices	€ per GJ	10.41	13.09	15.70	22.91
5. International gas prices	€ per GJ	8.33	10.47	12.56	18.33

Table 12: Assumptions for the energy sector – with additional measures (Source: Umweltbundesamt).

	Unit	2010	2015	2020	2030
Total gross inland consumption					
1. – Oil (fossil)	Petajoule (PJ)	549	495	467	412
2. – Gas (fossil)	Petajoule (PJ)	337	325	332	360
3. – Coal	Petajoule (PJ)	350	380	416	427
4. – Biomass without liquid biofuels (e.g. wood)	Petajoule (PJ)	IE	IE	IE	IE
5. – Liquid biofuels (e.g. bio-oils)	Petajoule (PJ)	IE	IE	IE	IE
6. – Solar	Petajoule (PJ)	IE	IE	IE	IE
7. – Other renewable (wind, geothermal etc)	Petajoule (PJ)	351	380	417	428
Total electricity production by fuel type					
8. – Oil (fossil)	GWh	1 474	1 051	1 051	-
9. – Gas (fossil)	GWh	12 994	9 236	7 505	16 402
10. – Coal	GWh	1 474	1 051	1 051	-
11. – Renewable	GWh	42 246	45 589	49 086	48 790

Table 13: Assumptions for the industry sector (Source: Umweltbundesamt).

	Unit	2010	2015	2020	2030
12. – Growth of the industrial sector in GDP	growth rate (%) per year				
Metals	%	0.04	0.04	0.04	0.04
Mineral industries	%	1.56	1.56	1.56	1.56
Paper and print	%	– 0.20	– 0.20	– 0.20	– 0.20
Chemistry	%	2.17	2.17	2.17	2.17
Others	%	2.08	2.08	2.08	2.08

Table 14: Assumptions for the transport sector (fuel sold; incl. fuel export), (Source: Umweltbundesamt).

		Unit	2010	2015	2020	2030
15.	Passenger person kilometres	million km	81 030	88 745	97 916	127 530
16.	Growth of freight tonne kilometres	million tonne	145 379	132 502	150 383	151 706

Table 15: Assumptions for buildings (residential and commercial or tertiary sector), (Source: Umweltbundesamt).

		Unit	2010	2015	2020	2030
21.	Number of dwellings (permanently occupied)	1 000	3 662	3 851	4 042	4 401

Table 16: Assumptions for the agriculture sector (Source: Umweltbundesamt).

		Unit	2010	2015	2020	2030
23.	Beef cattle	1 000 heads	1 481	1 468	1 456	1 469
24.	Dairy cows	1 000 heads	533	539	545	542
25.	Sheep	1 000 heads	311	305	300	292
26.	Pigs	1 000 heads	2 965	2 928	2 905	2 796
27.	Poultry	1 000 heads	12 551	12 443	12 346	11 665
28.	Mineral fertiliser	t N	104 095	104 764	103 680	85 366

Table 17: Assumptions for the waste sector (Source: Umweltbundesamt).

		Unit	2010	2015	2020	2030
31.	Municipal solid waste disposed to landfills	tonnes	0	0	0	0
33.	Municipal solid waste disposed composted*	tonnes	148 000	148 000	37 000	0

* *residues from biological and mechanical-biological treatment plants - disposed of at landfills (no biogenic waste is landfilled directly)*

ANNEX 2: ADDITIONAL KEY INPUT PARAMETERS

Residential, Commercial & Other Sectors

Table 18: Underlying energy price development for projections– residential and commercial sectors in cent/kWh (Source: Umweltbundesamt).

Residential sector		**2010**	**2015**	**2020**	**2025**	**2030**
Coal	cent/kWh	3.68	3.59	3.98	4.25	4.54
Wood log and wood briquettes	cent/kWh	3.56	3.64	3.75	3.88	4.02
Wood chips	cent/kWh	3.08	3.15	3.24	3.36	3.48
Wood pellets	cent/kWh	4.46	4.56	4.7	4.86	5.03
Natural gas	cent/kWh	7.09	7.32	7.68	8.1	8.56
Heating and other gas oil (HEL 2007)	cent/kWh	7.88	8.23	8.77	9.41	10.1
Distr. heat Vienna	cent/kWh	4.15	4.25	4.41	4.59	4.78
Distr. heat other	cent/kWh	5.37	5.5	5.7	5.93	6.18
Distr. heat biomass	cent/kWh	4.77	4.89	5.06	5.27	5.49
Commercial sector		**2010**	**2015**	**2020**	**2025**	**2030**
Coal	cent/kWh	3.07	2.99	3.32	3.54	3.78
Wood log and wood briquettes	cent/kWh	2.97	3.03	3.13	3.23	3.35
Wood chips	cent/kWh	2.57	2.63	2.7	2.8	2.9
Wood pellets	cent/kWh	3.72	3.8	3.92	4.05	4.19
Natural gas	cent/kWh	5.91	6.1	6.4	6.75	7.13
Heating and other gas oil (HEL 2007)	cent/kWh	6.57	6.86	7.31	7.84	8.42
Distr. heat Vienna	cent/kWh	3.46	3.54	3.68	3.83	3.98
Distr. heat other	cent/kWh	4.48	4.58	4.75	4.94	5.15
Distr. heat biomass	cent/kWh	3.98	4.08	4.22	4.39	4.58

Table 19: Assumptions on subsidy rates in percent – with additional measures (Source: Umweltbundesamt).

Subsidy rates [%]	**2010**	**2015**	**2020**	**2025**	**2030**
Wood log and wood briquettes	35	35	35	35	35
Wood chips	38	38	38	38	38
Wood pellets	38	38	38	38	38
Distr. heat Vienna	15	15	15	15	15
Distr. heat other	15	15	15	15	15
Distr. heat biomass	23	23	23	23	23
Solar thermal	33–38	33–38	33–38	33–38	33–38
Renovation measures (insulation and window)	40	40	40	40	40

Table 20: Assumptions on the number and size of buildings, and the number of permanently occupied dwellings – with additional measures.

Number of buildings		**2010**	**2015**	**2020**	**2025**	**2030**
Residential buildings with one or two apartments	number	1 480 340	1 528 027	1 569 913	1 601 558	1 626 402
Residential buildings with more than two apartments	number	196 468	202 839	208 437	212 671	215 999
Commercial buildings	number	149 790	162 400	176 118	184 171	192 606
Size of buidlings		**2010**	**2015**	**2020**	**2025**	**2030**
Residential buildings with one or two appartments	million m² gross floor area	250	258	265	271	275
Residential buildings with more than two apartments	million m² gross floor area	162	168	174	178	181
Commercial buildings	million m³ gross floor volume	164	177	191	200	209
Number of permanently occupied dwellings		**2010**	**2015**	**2020**	**2025**	**2030**
Residential buildings with one or two apartments	number in 1 000	1 747	1 801	1 848	1 883	1 910
Residential buildings with more than two apartments	number in 1 000	1 915	2 050	2 194	2 344	2 491

Agriculture

Table 21: Assumptions on macro-economic variables in the European Union, 2010–2019 (Source: OECD-FAO 2010; UMWELTBUNDESAMT 2011b).

		2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Real GDP	%	1.0	1.8	2.3	2.2	2.2	2.2	2.2	1.7	1.7	1.7
Price deflator	%	0.5	0.6	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Population	%	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
GDP deflator	%	0.5	0.6	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0
World oil price	USD/ barrel	80.0	82.7	85.7	88.8	92.1	95.4	98.9	102.5	106.2	110.1

Prices were derived from OECD-FAO outlooks on agricultural markets (see OECD-FAO 2010). Projections of the EU Commission (CEC 2010) show very similar assumptions about future developments of key economic indicators.

ANNEX 3: ROAD TRANSPORT – SPECIAL CONSIDERATIONS

HISTORICAL VIEW

Emission factors for passenger cars (PC), light duty vehicles, mopeds and motorcycles used in the Austrian transport model (GLOBEMI; Hausberger) are based on HBEFA 1.2 (implemented in 1999), HBEFA 2.1 (implemented in 2004), ARTEMIS (implemented in 2007) and HBEFA 3.1 (implemented in 2010) (see Figure 8). Emission factors for heavy duty vehicles (HDV) used in the Austrian transport model (GLOBEMI; Hausberger) are based on HBEFA 1.2 (implemented in 1999), HBEFA 2.1 and HBEFA 3.1 (implemented in 2010) (see Figure 9).

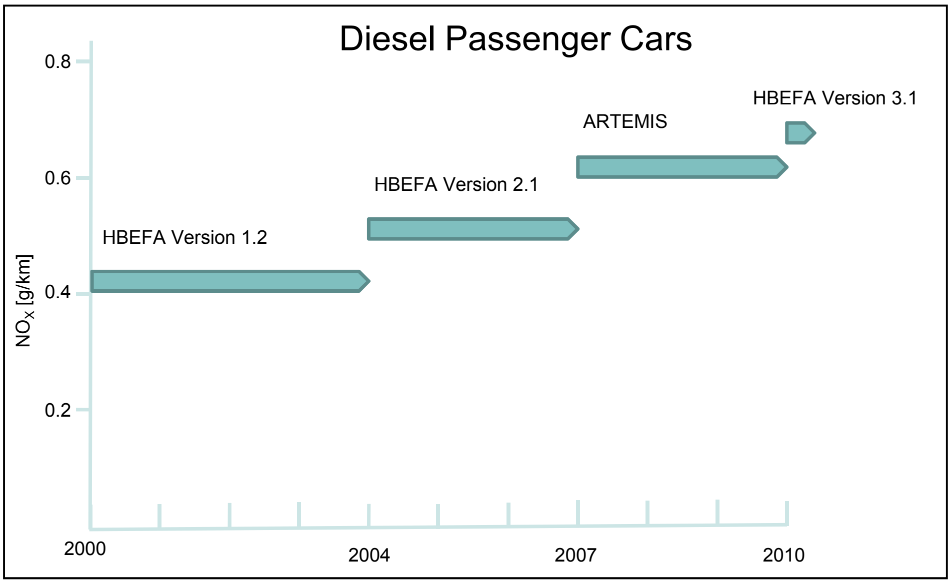

Figure 8: Average NO_X emissions per vehicle-km for PC in HBEFA 1.2; HBEFA 2.1; ARTEMIS; HBEFA 3.1.

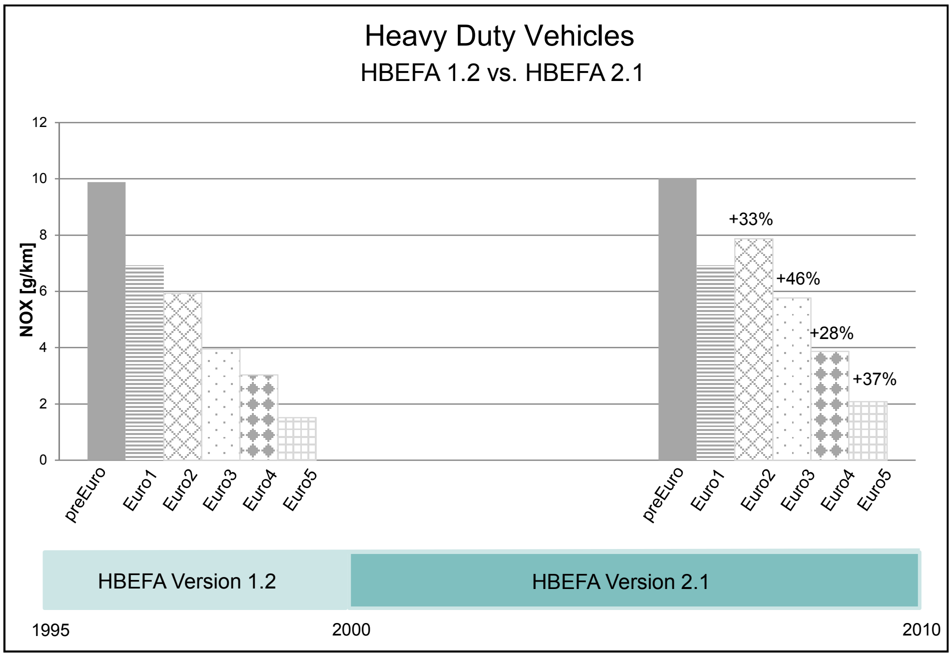

Figure 9: Average NO_x emissions for HDV per vehicle-km in HBEFA 1.2; HBEFA 2.1.

In the course of the measurements for the creation of HBEFA 2.1, ARTEMIS and HBEFA 3.1 it was recognized, that the reduction of the NOx emission levels of vehicles with diesel engines in real world driving situations was clearly lower than originally expected (see Figure 9).

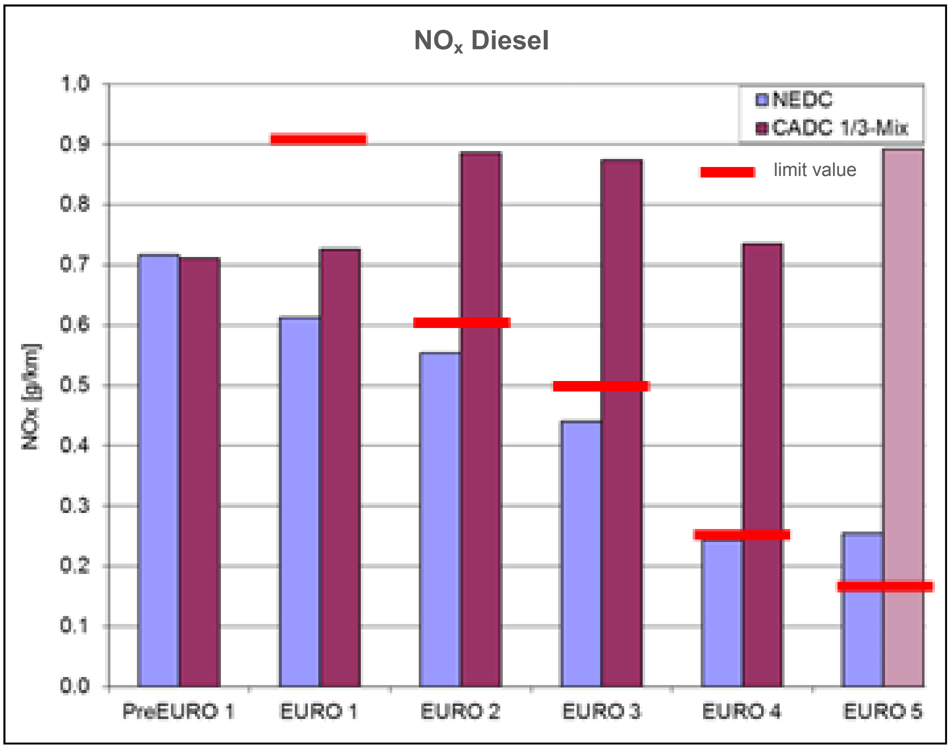

Figure 10: Average NO_x emissions per legislation class (NEDC-CADC)

The most noticeable rise in NO_x emissions was mainly observed with the adoption of the ARTEMIS emission factors in the 2007 inventory. In ARTEMIS a new set of real world driving cycles was developed for passenger cars, light goods vehicles and motorcycles (CADC, Common ARTEMIS Driving Cycle). This CADC results in clearly different emission factors for most exhaust gas components compared to the former cycles (HBEFA cycles). Some studies on driving behavior indicate that modern vehicles are rather driven with speed patterns similar to the CADC. The older driving cycles from the HBEFA were recorded in 1990 and the vehicles used in 1990 were certainly different in terms of engine power and vehicle agility. This may explain that the HBEFA cycles show lower driving dynamics, which for several combinations of vehicles and exhaust gas components results in significant lower emission levels compared to the CADC.

As opposed to the general expectations regarding emission legislation limit values, , emission reduction due to EU emission legislation has not shown effective lowering of emissions when it comes to comparison with real world emission factors deviated from real-world driving patterns.

CURRENT PROJECTIONS – HEAVY DUTY VEHICLES (HDV)

Special Issues for HDV

Higher emission levels than during the test cycle: Before a truck is taken into operation, it is tested according to a certain standard - the statutory test cycle for the respective truck type. This process examines whether the exhaust of the truck complies with legal limits. Measurements of the Technical University of Graz showed that under real driving conditions, the emissions of nitrogen oxide are much higher than previously thought. This is, amongst other factors, mainly due to the specific programming of the engine management.

Low fuel consumption increases nitrogen oxides: For reasons of engine technology, a reduction of nitrogen oxides can lead to increased fuel consumption. Conversely, low fuel consumption increases NO_x emissions. To comply with the legislation requires limits for nitrogen oxides. Therefore, the electronic control of engines is set to comply with the limits for nitrogen oxides during the vehicle emission test procedure. For road driving, however, the engine management of HDV concentrates on minimising fuel consumption. Under real driving conditions, this resulted in a smaller decrease in nitrogen oxides than expected.

Primarily newer vehicles are affected: Nitrogen oxide emissions of more recent vehicles were particularly underestimated. Over the past years, the limits have become much stricter. In contrast, nitrogen oxide emissions of heavy-duty vehicles have hardly changed for many driving situations, especially in urban areas. Thus, under real driving conditions NO_x emissions are in some cases significantly above typing limits!

Assumptions for HDV

Calculations of emission projections are based on the assumption that the specified limit values of future technologies are almost reached. Emission factors are periodically checked for compliance with these limits and updated by measurements on the test bench and using portable measuring systems.

EURO 4 technology showed (like EURO 2 and 3) that the assumptions on a reduction caused by the Euro limit legislation were not met under real world driving conditions. The same applies to the EURO 5 technology, although measurement data are not available in a statistically representative volume in order to integrate data into the transport emission modeling. Currently, the first EURO 6 vehicles are available on the market; data on emissions under real conditions is therefore not very strong – yet.

In the scenario "With Additional Measures", it was assumed that the real world emissions for EURO 5 and 6 meet the specified limit values (BEST CASE). The initial value for "1 A 3 b iii, Road Transport, Heavy Duty Vehicles" in the WAM scenario stood at 23.4 Gg NO_x for fuel sold and at 9.8 Gg NO_x for fuel used in 2020.

From a present-day perspective, it seems that these emission factors cannot be met in real world operation again. Therefore, we added the following three variations of NO_x emissions of heavy duty vehicles to the WAM scenario in 2020:

- **Option 1: No impact EURO 5/6**

  In real world operation, EURO 5 and 6 heavy duty vehicles stay at the same level as EURO 4 vehicles

- **Option 2: Low impact EURO 6**

  In real world operation, EURO 5 stays at the same level as EURO 4, whereas EURO 6 performs 20% better than EURO 4

- **Option 3: Low impact EURO 5, higher impact EURO 6**

  EURO 5 is 10% better than EURO 4; the EURO 6 emission control system works the whole time on highways (with 50% of the driving performance) and half the time on the subordinate road network (with 23% of the driving performance)

Table 22 NO_x emissions of road transport (HDV) for different scenarios and fuel sold/fuel used (Source: Umweltbundesamt).

	Fuel sold			**Fuel used**		
NO_x emissions abs. [Gg]	**Option 1** No impact EURO5/6	**Option 2** Low impact EURO 6	**Option 3** Higher impact EURO 6	**Option 1** No impact EURO5/6	**Option 2** Low impact EURO 6	**Option 3** Higher impact EURO 6
EURO 0	0.32	0.32	0.32	0.13	0.13	0.13
EURO 1	0.11	0.11	0.11	0.05	0.05	0.05
EURO 2	1.32	1.32	1.32	0.55	0.55	0.55
EURO 3	3.22	3.22	3.22	1.35	1.35	1.35
EURO 4	3.44	3.44	3.44	1.44	1.44	1.44
EURO 5	13.46	13.46	12.11	5.64	5.64	5.08
EURO 6	46.00	36.80	21.40	19.28	15.42	8.97
SUM	**67.87**	**58.67**	**41.92**	**28.44**	**24.59**	**17.57**

CURRENT PROJECTIONS – PASSENGERS CARS (PC)

Assumptions for PC

In previous scenarios it was assumed that the real world NO_x emissions for EURO 5 and 6 show a steadily decreasing trend (decrease of emission factors proportional to limit values for type approval). With that assumption for the current WAM scenario emissions of "1 A 3 b i, Road Transport, Passenger Cars" would have been 14.5 Gg NO_x for fuel sold and 13.4 Gg NO_x for fuel used.

From a present-day perspective, it seems that these emission factors cannot be met in real world operation. Therefore we decided to assume EURO 5 NO_x emissions to be 21% higher than EURO 4. EURO 6 NO_x emissions stay at the same level as EURO 4.

The assumptions for EURO 5 are based on information by automotive technology experts who refer to the latest available measurements of passenger cars on the chassis dyno (results not published yet). The assumptions concerning EURO 6 are based on expert judgements.

The value for "1 A 3 b i, Road Transport, Passenger Cars" in the final WAM scenario with the PC EURO 5/6 variation amounts to 23.4 Gg NO_x for fuel sold and 21.7 Gg NO_x in 2020.

An additional uncertainty factor regarding NO_x emission projections in the transport sector is the unknown future fleet penetration (PC) with "positive ignition direct injecting engines". Due to their higher fuel economy, these engine types may be introduced by the manufacturers onto the market in larger quantities in order to meet CO_2 emission legislation (443/2009). Emission factors are currently not empirically proven, but due to the capability of the lean combustion operation of this engine type, NO_x emissions may become an issue in real world driving modes.

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The report „Austria's National Air Emission Projections 2012 for 2015, 2020 and 2030" covers projections for the the pollutants sulphur dioxide (SO_2), nitrogen oxides (NO_x), Non-Methane Volatile Organic Compounds (NMVOC) and Ammonia (NH_3) as well as a first-time projection for $PM_{2.5}$. In the scenario used (with additional measures) planned policies and measures with a realistic chance of being adopted and implemented in time to influence emissions by 2030 are included. The projections for NO_x show a remarkable potential for reduction of emissions until 2030. For SO_2 no further significant reductions are expected. NMVOC and Ammonia emissions will decrease after 2010. A comparison with the national emission ceiling for 2010 shows compliance for the pollutants SO_2, NMVOC and NH_3. The NO_x emissions are expected to exceed the emission ceiling considerably.

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