Greenhouse gas scenarios for Austria

Original article

Greenhouse gas scenarios for Austria: a comparison of different approaches to emission trends

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Abstract

In the present paper, national and externally organized projections of greenhouse gas emissions for Austria were compared to gain insight on the underlying scenario data assumptions. National greenhouse gas emission trends extend until 2030, an assessment of European Union (EU) countries to 2050. In addition, data for 2000 – 2100 was extracted from the global emission database described by the Representative Concentration Pathways (RCP). By identifying trends in these projections, it was possible to produce a) a long-term assessment of national scenarios until 2100, b) an assessment of the ambition level toward national climate strategies, and c) a standardized method to compare trends across countries. By extracting RCP data, Austrian's methane, nitrous oxide and carbon dioxide emissions up to 2100 could be projected for all sources as well as specific sectors. With respect to the RCP scenario emission data, national projections did not seem to employ the mitigation potentials available for the most stringent RCP scenario, RCP2.6. Comparing projections that supported the EU Climate Strategy 2030 with national projections revealed similar trends. Because RCP2.6 is the only scenario consistent with a two degree global warming target, and it is much more ambitious than any of the national or European projections, further measures will be required if Austria is to adequately contribute to this widely accepted policy goal.

Key words: Austria, Emission scenario, EU climate policy, Representative Concentration Pathway, Two-degree target

1. Introduction

Anthropogenic contributions are recognized as key elements of global change (IPCC, 2014). For this reason, approaches to address this potentially central threat to the future perspective of humans must consider greenhouse gas (GHG) emissions. Many approaches plan for the future, thus the preparation of scenarios (i.e., including different, but consistent timelines for future development) seems an appropriate tool to initiate discussions and guide possible actions.

In fact, the climate community has already used scenarios as tools in compiling assessment reports (Nakicenovic and Swart, 2000). Detailed scenarios have also been developed for the Millennium Ecosystem Assessment (MA, 2005), and to better understand the future of environmental issues with relation to nitrogen (Winiwarter et al., 2011).

However, while scenarios have been developed for many purposes with different preconceptions and background assumptions, these may not always be fully transparent. In this paper, we examine several such approaches, highlight differences with regard to presumptions used, and summarize the results of their implementation in Austria. Specifically, we discuss existing scenarios for GHG emissions, and point out the differences and similarities between the respective GHGs carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Projected GHG emission data from scenarios at three different spatial levels (global, European, and national) are compared. In each case we extract Austrian emissions for the full time scale available, extending to 2100 at the maximum. Both country totals and emissions from one specific sector, the sector agriculture, are included in this analysis.

This study does not evaluate the details of the assumptions underlying the respective scenario approaches, but it merely compares the results. We intend to demonstrate that, by highlighting discrepancies and inconsistencies in the outputs of the respective time series, valuable conclusions for policy makers on the relevance of existing plans to mitigate GHG emissions can be drawn.

2. Overview of different scenarios used

Different sets of scenarios, all based on similar industrial sectors and arrangements, but derived largely independently of one another were used. Due to their different purpose, they were developed to cover different spatial extensions and time periods. These scenario sets include: national GHG projections from the Environment Agency Austria (Umweltbundesamt 2013a), the EU-Reference Scenario 2013 (Capros et al., 2013) covering the member countries of the European Union

(EU), and the Representative Concentration Pathways (Masui et al., 2011; Riahi et al., 2011; Thomson et al., 2011; van Vuuren et al., 2011b) as a global approach.

2.1. National scenarios

In accordance with the requirements of the GHG monitoring mechanism (European Commission, 2005), each EU member state is obliged to develop two emission scenarios: with existing measures (WEM) and with additional measures (WAM). WEM scenarios include measures and policies that have already been adopted in the past; WAM scenarios refer to measures and policies that have been planned, but not yet implemented. The Austrian WAM scenario of 2013 (Umweltbundesamt, 2013a) is used here as a basis for modelling the national emission scenario. This scenario is considered to depict an optimistic case for Austria, because it includes all reduction measures which, according to experts' opinions, have a high probability of implementation[1]. The scenario, covering the period up to 2030, includes GHG mitigation measures that were implemented as part of the Austrian Climate Strategy 2007, and includes additionally planned policy measures that are expected to become effective by 2030. To date, little information on national scenarios has been made available for the period beyond 2030. Because historical data is used for 2000, 2005 and 2010, the impact of the recent financial crisis is addressed. The model is based on a national energy scenario (supported by calculations from bottom-up models), an agricultural scenario, and a projection of waste production (Umweltbundesamt, 2013a). Figure 1 depicts the total Austrian GHG emissions from 1990 to 2030. As can be seen, the overall increase in emissions (CO_2-eq.) between the initial and the final year was 0% and 7%, respectively, for the WAM and the WEM scenario.

Figure 1: Total GHG emissions in Austria from 1990 to 2030 according to national scenarios (historic data from Umweltbundesamt, 2012, projections based on Umweltbundesamt, 2013a).

The WEM scenario covers the future emissions expected according to all relevant legislation and policies, i.e., those already implemented as to which Austria has made a commitment (a complete list of all relevant activities can be read in Umweltbundesamt, 2013). Additional mitigation options currently under consideration as part of national policy were also included in the WAM 2013 scenario. All of these measures are in accord with national, European, and international commitments and regulations (Umweltbundesamt, 2013). The primary additional measures relate to economic incentives, EU-regulations, and awareness building (Table 1).

Table 1: Emission reduction measures planned in Austria for further emission mitigation (WAM) (European Environment Agency, 2014; Umweltbundesamt, 2013.)

Projected emission trends, like those provided by Umweltbundesamt, are reported as part of the national obligations of members of the United Nations Framework Convention on Climate Change (UNFCCC) listed in Annex I (developed countries). In their national communications submitted to UNFCCC every four years, all Annex 1 countries report in a similar way on national scenarios with measures and with additional measures. These reports are publicly accessible via the UNFCCC web site[2].

2.2. EU Reference Scenario 2013

The EU Reference Scenario 2013 uses a common approach for all 28 EU member countries, building on results from a number of different models (Capros et al., 2013). The PRIMES model is taken for projections of energy and CO_2 emissions; the combined GLOBIOM-G4M model is used for projecting GHG effects of land-use, land-use change and forestry (LULUCF); the GAINS model, for non-CO_2 emissions projections; and the CAPRI model, for impact assessments related to agriculture and international trade policies. The EU Reference Scenario is then able to depict the consequences arising from current trends, including policies adopted as late as spring 2012, for each of the 28 EU member countries. The core elements of this reference scenario are the development of the European energy system and an analysis of current trends in economic development and population growth. The scenario is based on the latest statistical data taken from EUROSTAT (at the time of modelling: 2010), and has been complemented by member state comments. Current data, as presented in the various projections, now reflects the impact of the 2008 economic crisis on the European Union. The policy measures covered include all binding targets set by the EU regarding emission reductions, energy efficiency, renewable energy quotas, and EU-ETS (EU- emission trading scheme) reform (Capros et al., 2013; European Commission, 2014a; see also a summary presented on the Website of the European Commission[3]). They also take into account the additional input received from member country experts during the consultation process.

2.3. Representative Concentration Pathways

The RCP scenarios were prepared as part of a common effort toward integrated assessment modelling that was undertaken by groups in the US, the European Union, and Japan. The purpose of these scenarios is to produce long-term projections to “explicitly explore the impact of different climate policies [and] [...] allow evaluating the costs and benefits of long-term climate goals” (van Vuuren et al., 2011a, p. 6). The availability of a common set of scenarios that cover global developments while allowing for a reduction to the national level is clearly useful for the scientific community and other stakeholders. Such scenarios allow comparisons to be drawn and important research results to be communicated. The RCPs represent four different emission scenarios that lead to levels of radiative forcing of 2.6, 4.5, 6 and 8.5 W/m², respectively, by the end of the century, covering the globe at a ½ by ¼ degree grid. The scenarios were developed based on the existing literature and with the intent to provide a consistent outlook with reference to climate-related future emissions and the corresponding atmospheric GHG concentrations. The RCPs provide information on all atmospheric trace constituents that have an impact on radiative forcing, cover the period up to 2100, and have been designed to represent different target forcing levels up to that year. They comprise one mitigation scenario (RCP2.6), two stabilization scenarios (RCP4.5, RCP6), and one scenario with high emission projections (RCP8.5). The low radiative forcing scenario assumes levels of 3 W/m² long before 2100, with a subsequent decline. The medium radiative forcing scenarios project a stabilization at 4.5 or 6 W/m² by 2100, with a possible subsequent decline, while the high radiative forcing scenario (close to a no-mitigation case) leads to 8.5 W/m² by 2100, with further increases possible (van Vuuren et al., 2011a).

The RCP2.6 is the only scenario under the International Panel on Climate Change 5th Assessment Report (IPCC AR5) that is consistent with limiting global warming to the two-degree target (see IPCC, 2014; Rogelj et al., 2011). This is a widely accepted aim to limit global warming to a maximum of a global average temperature increase of 2°C above the pre-industrialized conditions. It is clear that emissions would need to decrease drastically in order to reach a level of radiative forcing of 2.6 W/m² by 2100. For example, CO_2 emissions would need to decrease by over 100% (base year 2000) by 2100 to reach a level of around -1 GtC (negative emissions) per year, i.e. CO_2 needs to be sequestered at considerable scale. This is only possible by radically increasing energy efficiency, raising the share of bio energy, and by employing carbon capture and storage technology at the same time to remove even biogenic CO_2 emissions (van Vuuren et al., 2011b).

The RCPs are the first phase in a new process toward developing global climate scenarios, and include a second phase to create socioeconomic storylines, the Shared Socioeconomic Pathways (SSP), which describe a consistent image of a future society that includes climate policy measures (Nakicenovic et al., 2014). Due to the wide variety of such mitigation and adaptation policies, a third dimension, beyond the concentration (RCP) and socioeconomic phases (SSP), is needed. Shared Climate Policy Assumptions (SPAs) are intended to provide a range of consequences from policy measures (Ebi et al., 2014; O'Neill et al., 2014; van Vuuren et al., 2014), in order to depict the effectiveness of climate policy measures, and thus raise understanding and awareness of the uncertainties involved (Moss et al., 2010; Nakicenovic & Swart 2000).

3. Methodology

As a first step, specific emission data for Austria (from the WAM-2013 and EU-Reference scenarios) was gathered from Umweltbundesamt and European Union reports (Capros et. al 2013; Umweltbundesamt, 2011a; 2011b; 2012; 2013a; 2013b).

Secondly, grid data for eight different substances and twelve different industrial sectors, as shown in Table 2, were downloaded from the RCP database[4]. This grid data was provided at a level of spatial resolution of 0.5° x 0.5° for all reactive gases and aerosol compounds in netcdf format. Data for each of the 45 Austrian grid cells were extracted separately and a summation for every ten years (from 2000 until 2100), by sector and substance, was made. This led to a projection that described the aggregated values for every substance by year. Where gridded data was not available, comparable regional totals were used, covering all OECD (Organisation for economic co-operation and development) countries (for all RCPs) or countries in the Western Europe region (WEU) (for the RCP8.5 only: Rao, personal communication, July 17, 2013). Emissions from air transportation and international shipping occurred in part outside country boundaries and were, therefore, not included in any of the data sets (Thomson et al., 2011).

Table 2: 10 industrial sectors and 11 atmospheric trace compounds (based on van Vuuren et al., 2011a)

In a third step, all grid cells having a majority of their area within Austria (between 12.25° - 16.25° East and 46.25° - 48.25° North) were selected, and their respective emissions were added in order to arrive at a representative figure for Austria. Emissions (by species and sector) were normalized with respect to the base year 2000, to allow direct comparison with similarly normalized emission trends for the OECD and WEU regions. Because RCP scenarios include specific national data, differences in terms of sectoral split and regional trends (at OECD and/or WEU level) were to be expected.

Finally, in a fourth step, graphical representations of emission projections across the various scenario levels (i.e., the national level, EU level, and RCP projections) were compared for Austria by GHG species (CO_2, CH_4, and N_2O) and industrial sector[5]. For national and EU scenarios, historical data were used for the years 2000, 2005 and 2010 (Umweltbundesamt, 2012), and scenario data were used for the remaining period (until 2030 and 2050). In contrast, the RCPs use modelled data right from the beginning, except from the initial year of 2000. The same year was also chosen as a reference to guide the future developments of the RCPs, because information on regional and global inventories was available (Granier et al., 2011). Where sectoral split data were insufficient, RCP grid data were replaced by aggregated and comparable data for the OECD and WEU regions. A lack of sufficient grid data also meant that CO_2 and N_2O data in RCP8.5 were only available for the region Western Europe. Thus, although some of the advantages provided by an overarching model were lost, RCPs still allowed an extension of national and European scenarios, and an extrapolation of possible scenario paths up to the year 2100, to be made.

Additionally, the EU Climate Strategy 2030, the EU-Reference scenario for all EU-member states (28), was compared to RCP scenario data for the European region. This comparison provided insights on the potential of the EU Climate Strategy 2030 and allowed it to be seen within a larger global context. This and the other comparisons of national, European and international scenario data depended on publicly available emission data. By using publicly available data, it is possible to perform similar analyses for other Annex I countries where national scenarios are available.

4. Results of different GHGs for Austria and the European Union

4.1. Projections for CH_4 for Austria

Most Austrian CH_4 emissions derive from the agricultural sector, and most particularly from enteric fermentation in cattle and manure treatment. A comparison of various emission scenarios for CH_4 (see Figure 2) showed that the Austrian CH_4 emission levels in the WAM-2013 (labelled as national WAM scenario) scenario were between the expected levels in RCP2.6 and RCP4.5. When comparing the national scenario up to 2030 with the EU Reference Scenario, it can be observed that Austria's national scenario for the period 2025-2030 is slightly more optimistic than anticipated by the European scenario. The differences observed during this period are mainly due to different underlying assumptions with respect to the level of agricultural production and to the fact that the cattle number is expected to remain unchanged in the national scenario (Umweltbundesamt, 2013a). A comparison of national scenario data with projected RCP data revealed that the highest level of agreement was found with respect to RCP4.5.

Figure 2: Trends of Austrian CH_4 emissions in different scenarios: RCP 2.6, RCP 4.5 (grid data), RCP 8.5 (total WEU), national WAM scenario 2013, and EU-Reference Scenario for Austria. Data were derived

from van Vuuren et al. (2011b), Thomson et al. (2011), Rao (personal communication July 17, 2013, based on Riahi et al., 2011), Umweltbundesamt (2013a), and Capros et al. (2013), respectively.

4.2. Projections for N_2O for Austria

The main source of N_2O emissions was again the agricultural sector, largely as a result of intensive farming techniques, coupled with the high use of nitrogen fertilizers. In Austria, N_2O emissions from agriculture were responsible for about 3/4 of total N_2O emissions (incl. LULUCF). The sharp decline observed between 2000 and 2005 is the result of reduction measures that were undertaken in the chemical industry during this period, and in part also due to a general reduction of emissions from agricultural soils (Umweltbundesamt, 2012). For the period of 2010 to 2030, N_2O emissions are projected to decline in agriculture due to a more efficient use of fertilizers (-0.65 Gg), and also in the energy sector (-0.96 Gg); no significant change is expected in other sectors (Umweltbundesamt, 2013a). National N_2O projections for Austria (labelled as national WAM scenario) (see Figure 3) show a declining trend, but are still above the RCP2.6 projection. As was the case for national CH_4 emissions, N_2O emissions were also projected to follow a low-emission path, i.e., between RCP2.6 and RCP4.5. While the predicted national emissions until 2030 were lower than anticipated in the EU Reference Scenario, there is still room for further reduction. The difference between the expected levels in the national and in the EU Reference scenario can be mostly attributed to the a shift in the latter between 2010 and 2015, where both cattle numbers in general, and the use of mineral fertilizer, in particular, are expected to increase. Other changes are minor over time.

Figure 3: Trends of Austrian N_2O emissions in different scenarios: RCP 2.6 (grid data), RCP 4.5 (total OECD), RCP 8.5 (total WEU), national WAM scenario 2013, EU-Reference Scenario for Austria. Data derive from van Vuuren et al. (2011b), Thomson et al. (2011), Rao (personal communication July 17, 2013, based on Riahi et al., 2011), Umweltbundesamt (2013a), and Capros et al. (2013), respectively.

4.3. Projections for CO_2 for Austria

With regards to the most prominent greenhouse gas, carbon dioxide, the majority of the CO_2 emissions in Austria occur in the industrial, transport and energy sectors. As a result of the increase in transport activity, CO_2 emissions in Austria increased by 16.5% in the period from 1990 to 2010 (Umweltbundesamt, 2012).

The Austrian national WAM scenario (see figure 4) reveals a clear increase in CO_2 between 2000 and 2005. In this scenario, an initial increase due to the economic boom occurring during the period is followed by a sharp decline, which is a result of the economic crisis of 2008. However, looking at projected CO_2 levels for 2030, little difference between the estimates provided by the various scenarios, and no noticeable reduction in CO_2 as compared to 2000, can be seen. Because 2005 is considered the base year for the 20-20-20 targets of the European Union[6] (Bundeskanzleramt, 2014, European Commission, 2012), it is interesting to note that the apparent initial reduction in national CO_2 emissions is only the consequence of the sharp increase of emissions between 2000 and 2005.

There appear to be two distinct stages of the EU Reference Scenario. Before 2015, CO_2 emissions fluctuate, but still exhibit an overall increase. After 2015, a continuous decrease in emissions is observed, with emissions declining rapidly until 2035, and then less rapidly thereafter. Between 2010 and 2025, the EU scenario would appear to be less ambitious in terms of emission reduction than the national scenario. For the period following 2025, the EU data show that further decreases in CO_2 emissions are expected until 2050. According to the EU Climate Strategy 2030 (European Commission, 2013), the European Union is pursuing an overall target reduction in CO_2 emissions of 40% by 2030 (compared to levels in the base year 1990). Because further reduction effort is contained within the EU-Reference Scenario that extends to 2050 (Capros et al., 2013), we would argue that Austria is unlikely to reach EU goals by following the national WAM projections of 2013.

RCP data on Austrian CO_2 emissions are quite revealing. The only historical data in the RCP scenarios are from 2000. A big difference between RCP data and national scenario trends can be observed. It is clear that such a steep increase in emissions during the first five years of this century was not anticipated, and that the steep drop in emissions up to 2010 was due to the global economic crisis. The national scenario is highly consistent with the projected RCP8.5 data for the year 2010, but RCP, for which this is a modelled year, does not reflect the economic boom visible in high emissions in 2005. In addition, the future trends are clearly different, and by 2030 a difference of about 18% emerges. The RCP8.5 trend line shows that, in the absence of additional policy measures, CO_2 emissions in Austria are likely to be considerably higher in 2030. This is also the case for 2100. Until 2030, the emission trends in scenarios RCP4.5 and RCP6 appear to be similar to those shown in the forecast of the national scenario. Given that the emission decrease in 2010 was the result of a major economic crisis, we argue that in the absence of additional climate policy measures national emissions are not likely to drop under the levels projected in RCP4.5 and RCP6. However, because the lowest RCP scenario, RCP2.6, is the only scenario consistent with meeting the widely accepted global warming target of two degrees (see IPCC, 2014; Rogelj et al., 2011), it is obvious that Austrian climate policy will not allow such a goal to be achieved.

In summary, based on the comparison made with the national emission projections, Austrian levels of CO_2 appear to be closer to the modelled RCP4.5 and RCP6 levels than those in RCP2.6. Clearly, with respect to 2030, the levels depicted in the national emission projection are considerably higher than corresponding levels in the European projection. Assuming that the two degree warming target remains politically intact and results in the appropriate policy measures, for example, to achieve a global contract by 2020 and binding targets by 2030, current national plans of greenhouse gas mitigation will probably not be sufficient. An inspection of the Austrian data reveals that, by following the stated emission paths, Austria will not achieve a 30% reduction in CO_2 emissions by 2030, using 2000 as a base year (Figure 4). Furthermore, in order to meet the levels shown in RCP2.6 (and thus achieve its share of meeting the two degree goal), Austria would need to reduce its emissions drastically.

Figure 4: Trends of Austrian CO_2 emissions in different scenarios: RCP 2.6, RCP 4.5, RCP 6.0 (all for total OECD), RCP 8.5 (total WEU), national WAM scenario 2013, EU-Reference Scenario for Austria. Data derive from van Vuuren et al. (2011b), Thomson et al. (2011), Masui et al. (2011), Rao (personal communication July 17, 2013, based on Riahi et al., 2011), Umweltbundesamt (2013a), and Capros et al. (2013), respectively.

4.4. European Climate Strategy 2030

Comparing the EU Climate Strategy 2030 (EU-Reference scenario for all 28 EU-members) with RCP data for the European region gave insights into the potential of this climate strategy. The EU 2030 framework for climate and energy policies proposes several objectives for all member states in order to achieve the European climate goal for 2030. One of these objectives is a reduction of GHG emissions in all member states, as compared to 1990, by 40% (European Commission, 2013). This implies an overall reduction of CO_2 emissions below the level projected in RCP4.5. Until 2030, changes of CO_2 emissions that are expected in the EU-Reference Scenario (Capros et al., 2013) will remain below those of the RCP2.6 projection. This simply reflects the fact that the RCPs do not capture the financial crisis that occurred at the beginning of this century. This could be a chance for European climate policy, assuming that decision makers act quickly enough, to push for lower CO_2 emissions. However, at the moment, the European CO_2 emissions (similar to Austrian CO_2 emission projections) are projected to be above levels expected in the RCP2.6 (for the OECD-region) in 2050. It would appear that not even the most ambitious climate policy will be able to match the levels of the RCP2.6 projection and, thus, implementation of policies consistent with the achievement of the two degree goal seems highly unlikely. Figure 5 shows RCP projections with respect to CO_2 emissions for the OECD-region, as well as for the EU-Reference scenario for all 28 member states.

Figure 5: Trends of CO_2 emissions in the European Union by scenario: RCP 2.6, 4.5, 6.0, 8.5 all employ data developed for all of the OECD, and are being compared to the EU28-Reference Scenario. Data derive from van Vuuren et al. (2011b), Thomson et al. (2011), Masui et al. (2011), Riahi et al. (2011), and Capros et al. (2013), respectively.

To provide an initial estimate of the implications of such a climate policy for Austria, we assumed that the 40% reductions of emissions as compared to the 1990 level applied uniformly to all countries. This disregarded the effort sharing agreement of the European Union that allows for some flexibility between member countries in terms of emission reductions, i.e., obligations for some countries may be set lower than that 40% target, and correspondingly higher for other countries. Moreover, we assumed that only the emissions and not the carbon sinks (from the land use, land use change and forestry sectors, LULUCF), which are more difficult to assess in a reliable manner, needed to be covered. Austria had a substantial carbon sink from forest growth in 1990, which essentially ceased to exist (Umweltbundesamt, 2012), will not reappear in the future, and that would make it even more challenging for Austria to meet any target. Because agreements on such details are not available yet, we believe that such conservative background conditions are acceptable to demonstrate the results.

Table 3 shows the level of Austrian GHG emissions (totals, without LULUCF) in the past and compares these absolute values to the respective scenarios (national WAM 2013 scenario, EU-Reference scenario for Austria, RCP2.6 OECD-region data). It is clear that a 40% decrease by 2030, as suggested by the EU Climate strategy's climate goal, exceeds even the low emission scenarios in terms of emission reduction, in both the national scenario and the EU reference scenario. Even the projected GHG emissions of RCP2.6 bring about a 30% reduction only by 2030 (compared to 2000). These results demonstrate that the goals set by the European Climate Strategy are substantial and will require a considerable number of additional mitigation measures to be implemented. These goals, however, do not reflect a legally binding obligation.

Table 3: Comparison of past and present emission levels of Austrian GHG emissions with scenario estimates for 2030 and an indicative interpretation of the proposed EU Climate-strategy 2030 (40% reduction of GHG emissions by 2030, base year 1990).

Different measures can be possible taken to decrease GHG emissions on a national and global level in order to reach the 2°C goal. The RCP2.6 scenario (van Vuuren et al., 2011c) focusses on shifting from fossil fuels to alternative energy production, raising energy efficiency, and creating technological innovations such as carbon capture and storage (CCS). Along with CCS, bioenergy use can result in negative net emissions. The global storage potential of CCS in 2050 is estimated to be about 7000 Mt CO_2 per year (IAE, 2013). On a national level, an increase in energy efficiency and a larger share in alternative energy can play a big role in influencing future CO_2 emissions. Austria may potentially strive toward the 2°C goal by increasing thermal quality of the residential building stock, increasing the use of solar thermal panels for hot water production, and reducing fuel consumption of vehicles and their emissions per km. Those (and other) energy saving measures introduced simultaneously could lead to a mitigation potential in Austria of more than 35 Mt CO_2-eq. in 2050. Furthermore, changes introduced in fuels used in the residential and service sectors, as well as for electricity production, could save 29 Mt CO_2-eq. (considering a best case scenario) (Winiwarter et al., 2009).

4.5. Sectoral details

Careful analysis of the sectors is needed to identify GHG emission sources and, thus, define suitable reduction measures. Focusing on specific industrial sectors provides an opportunity to examine the various possibilities for emission reduction at source level in more detail. In Austria, the industry and transport sectors produce the highest levels of CO_2 emissions (29.6% and 26.3% of national GHG emissions, respectively), and the agriculture sector produces the highest levels of CH_4- and N_2O emissions (combined share of 9.1% of national GHG emissions, data from 2010: Umweltbundesamt, 2012; 2013b).

In the dataset of RCP scenarios, CH_4 and N_2O were available on a grid level to a considerable extent, making it possible to compare data. Because agriculture contributes 75% of total national N_2O emissions and 65% of total national CH_4 emissions, we focussed on this sector. Emissions from agriculture have decreased by 12.9% between 1990 - 2010 due to decreasing livestock numbers and decreasing amounts of N-fertilizers used (Umweltbundesamt, 2012). Several measures targeted at emission reduction have either already been implemented or are currently planned in Austrian agriculture. National estimates assume that the highest reduction potentials can be obtained from fermentation (anaerobic digestion) of liquid manure. This technology would allow methane production from manure to be enhanced, and allow the collection and purification of what is currently released greenhouse gas to make a useful product. The emission reduction potential is projected to be in the region of -149 kt CO_2-eq. by 2020 (European Environment Agency, 2014; Umweltbundesamt, 2013a). A list of further measures is provided in Table 4.

Table 4: Emission reduction measures considered in the Austrian WAM scenario in the agricultural sector (data from: European Energy Agency, 2014; Umweltbundesamt, 2013a)

By comparing the national WAM 2013 scenario for Austria with the European reference scenario for Austria and with RCP2.6 and RCP8.5 data on the grid level (RCP8.5 resolves N_2O data only for the total WEU region), we observed that the emission scenarios for the agricultural sector in Austria did not follow the path of the RCP2.6 projection (Figure 6). It appears as if projections for Austria - those from the Umweltbundesamt and from the European Environment Agency - lie somewhere between the highest and the lowest RCP scenario. Because we do not have access to detailed RCP4.5 and RCP6 data on the grid level, we cannot further narrow down this statement by also including these scenarios in the comparison. Clearly, further emission reduction in this sector (as well as all other sectors) is needed to achieve the two-degree target.

Figure 6: Trends of agricultural GHG emissions in Austria according to different scenarios: RCP 2.6, RCP 8.5 (grid data for CH4, WEU data for N_2O) national-WAM scenario 2013, EU-Reference Scenario for Austria. Data derive from van Vuuren et al. (2011b), Rao (personal communication July 17, 2013, based on Riahi et al., 2011), Umweltbundesamt (2013a), and Capros et al. (2013), respectively.

5. Conclusion

Scenarios can be considered to be consistent descriptions of possible future developments. They are not meant to predict the future, but instead to help reduce infinite possibilities to a more manageable number. The compared scenarios illustrate the effectiveness of climate policy measures in Austria and the European Union. Our results indicate how data from short-term national scenarios can be usefully combined with those from long-term international scenarios. With this method, it is possible to embed national emission scenarios in global research-focused scenarios and compare them with one another. By extracting data from the RCP database, it was possible to project RCP scenarios for a single country, even though not all data were available for all RCP scenarios. The current study was limited to publicly available data and, thus, it was sometimes necessary to use (the spatially less explicit) data presented for the total of all OECD countries instead of the version available on a grid level. Because the present study was merely concerned with analysing trends and not defining absolute numbers, this was considered acceptable.

Our results highlighted potential mitigation opportunities in Austria and the EU and, in a broader sense, allowed us to address global mitigation strategies. The research showed discrepancies in climate strategies that require consideration in future climate policies. A particular focus was placed on RCP2.6 because this is the only IPCC scenario consistent with the widely accepted global warming target of 2°C, which also determines the targets set out in the European Climate strategy for 2030. While the national methane and nitrous oxide emission projections for Austria (including additional measures identified as having high probability of implementation) and the EU reference scenario for Austria show similar reduction potentials, these projections were more similar to those of RCP4.5 than RCP2.6. The same also held for projections of national CO_2 emission scenarios. RCP2.6, and especially the non-binding goals of the EU climate strategy, will require further reduction in GHG emissions beyond the officially provided scenarios. Although the EU Climate Policy 2030 is an ongoing political process for which the decision of burden sharing has not yet been set, it can be argued that these official scenarios seem to be inconsistent with limiting global warming to the target value of 2°C above a pre-industrial situation. Our comparison between the European outlooks on GHGs with the 2°C target of the IPCC AR5 clearly indicates that more action from the international community is needed.

The results of this study represent a benchmark for Austrian climate efforts and allow comparisons to be drawn with international scenarios. While the main focus here was Austria, we suggest that the described method can be applied to any of the countries for which comparable national GHG emission scenarios are available (mainly Annex I countries). Using a similar approach, it is possible to compare countries' climate policies with one another, although such projections from other countries were not addressed here. This makes it possible to place long-term national scenarios in an international, and therefore comparable, context and show their discrepancies and similarities to RCP scenarios. Policy makers providing recommendations for future climate policies (on both Austrian and European levels) must consider the fact that, at the moment, the respective contributions to the 2°C goal are not realistically achievable targets (in Austria or the EU). The results of our study will inform national policy makers and enable them to raise more awareness. If such national comparisons also for other countries consistently demonstrate that targets are not being met, more stringent requirements need to be devised for global mitigation efforts.

Further studies will focus on mitigation measures and storylines necessary to achieve the 2°C goal on a national and European level. These mitigation storylines (Shared Socioeconomic Pathways) have already been published for greater regions, but not for individual nations. Our next step will be to provide an analysis that can help policy makers address climate change on a national level.

Endnotes

[1] A WAMplus scenario was developed by the Umweltbundesamt and will be incorporated in an updated version of the national emission scenarios in 2015.

[2] http://unfccc.int/national_reports/annex_i_natcom/submitted_natcom/items/7742.php (accessed November 16, 2014)

[3] http://ec.europa.eu/clima/policies/2030/index_en.htm (accessed July 3, 2014)

[4] http://tntcat.iiasa.ac.at:8787/RcpDb/ (accessed July 3, 2014)

[5] There are challenges in comparing sectors as sectoral splits are not completely identical. In order to counteract this problem, in some cases aggregated data from the OECD and WEU regions were used instead of grid data (see Höhne et al., 2013).

[6] Austria is seeking to reduce CO_2 emission by 16% (with respect to the base year 2005) for non-ETS sectors (Bundeskanzleramt, 2014, European Commission, 2012).

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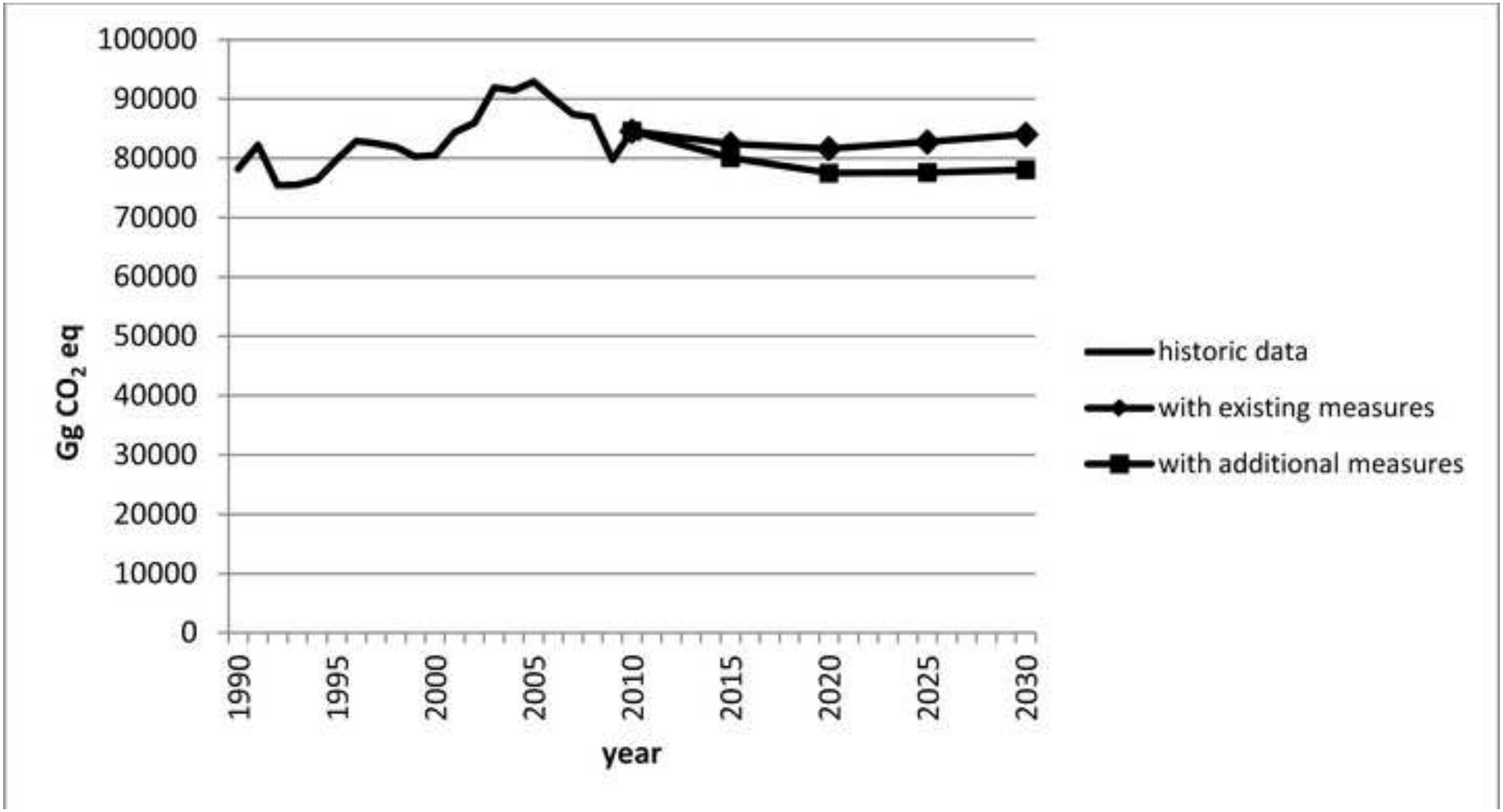
line figure 1



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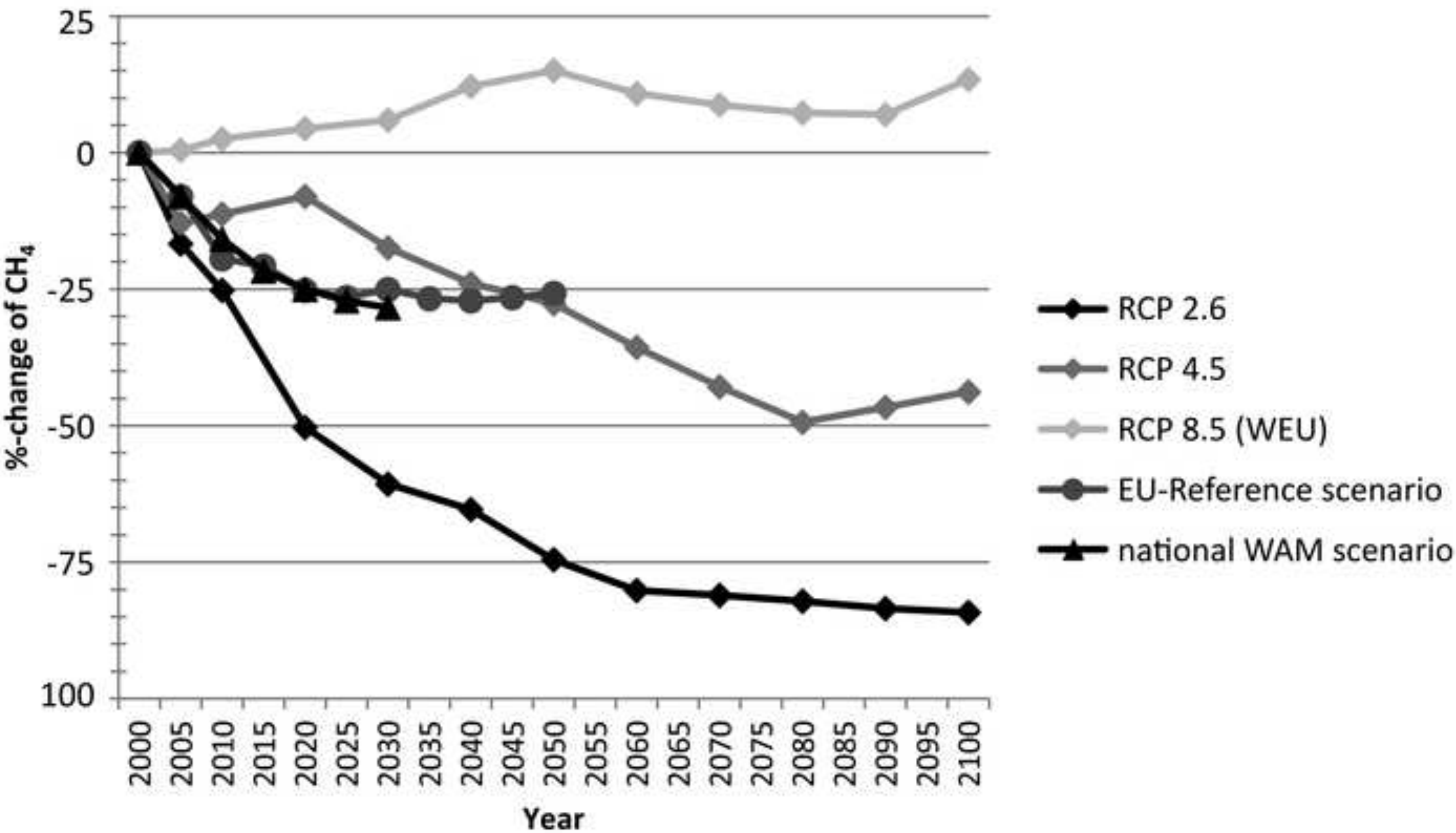

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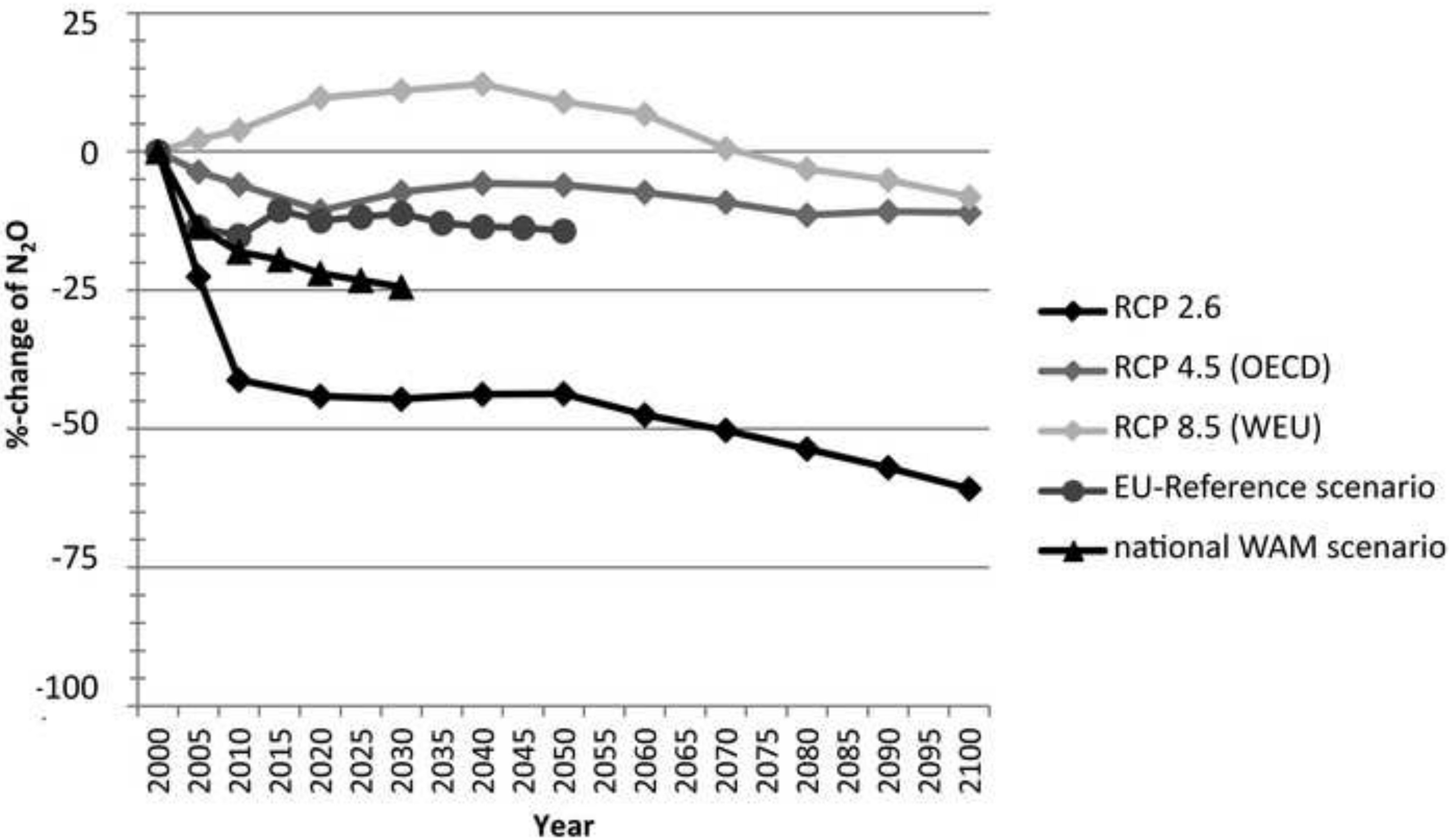

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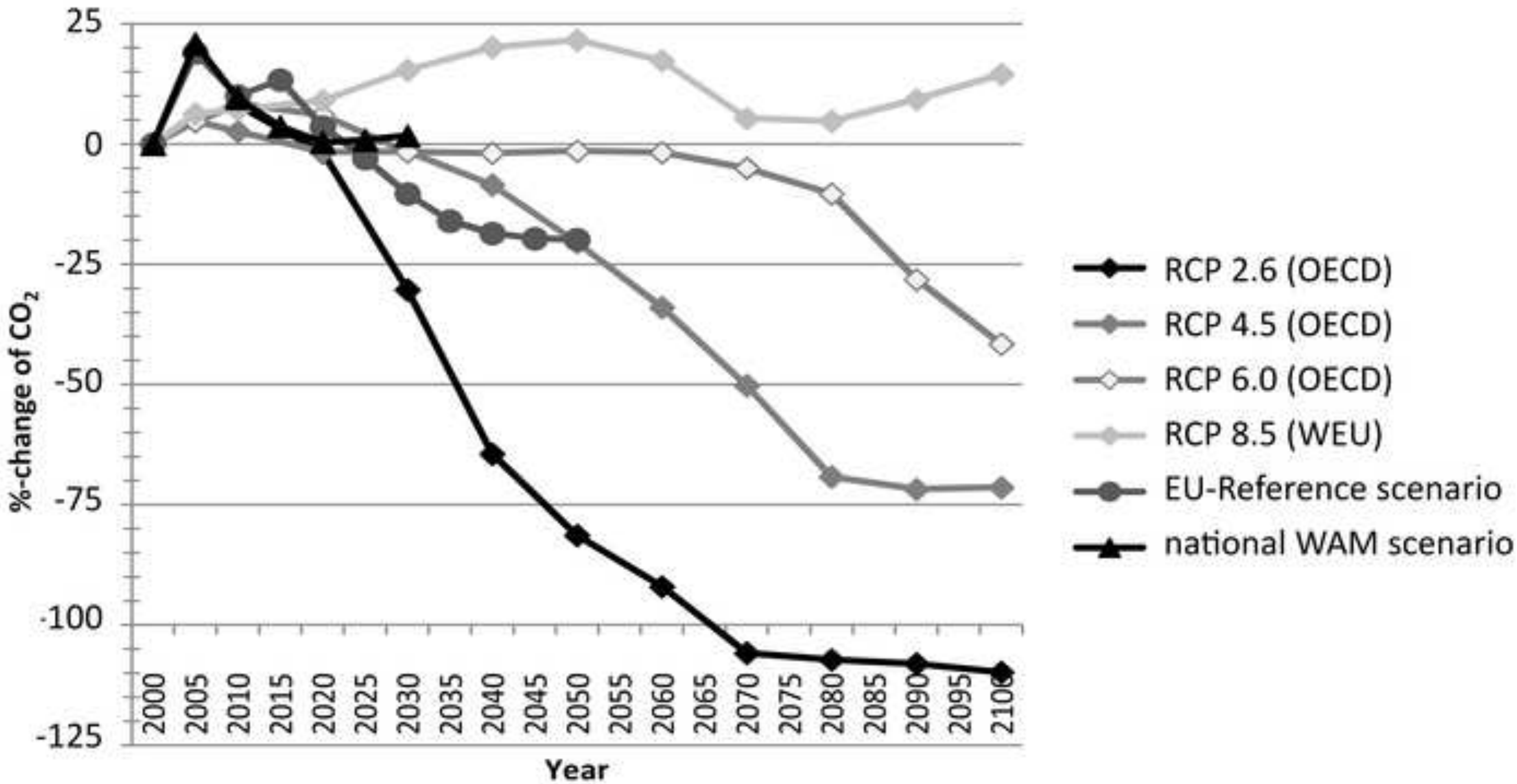

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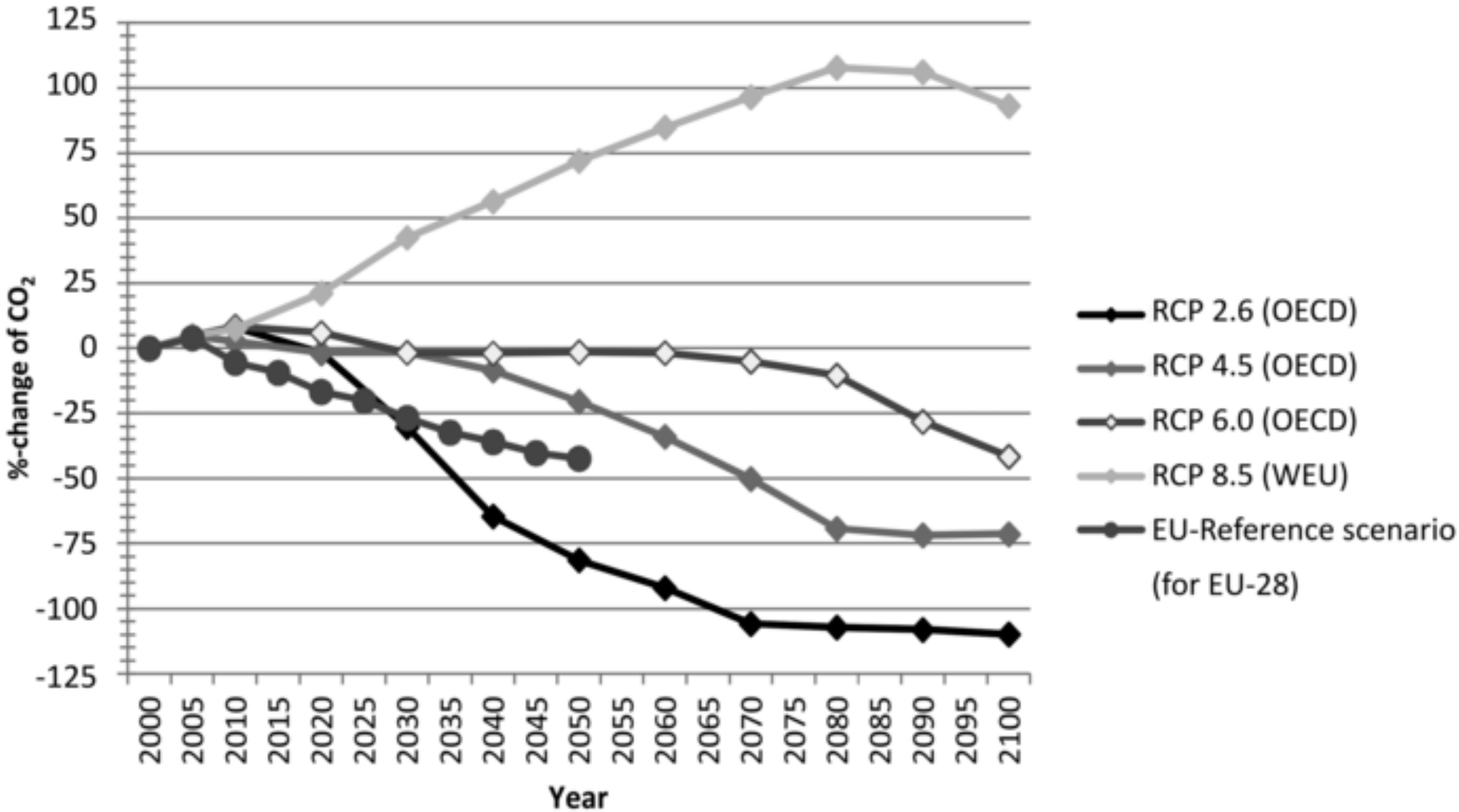

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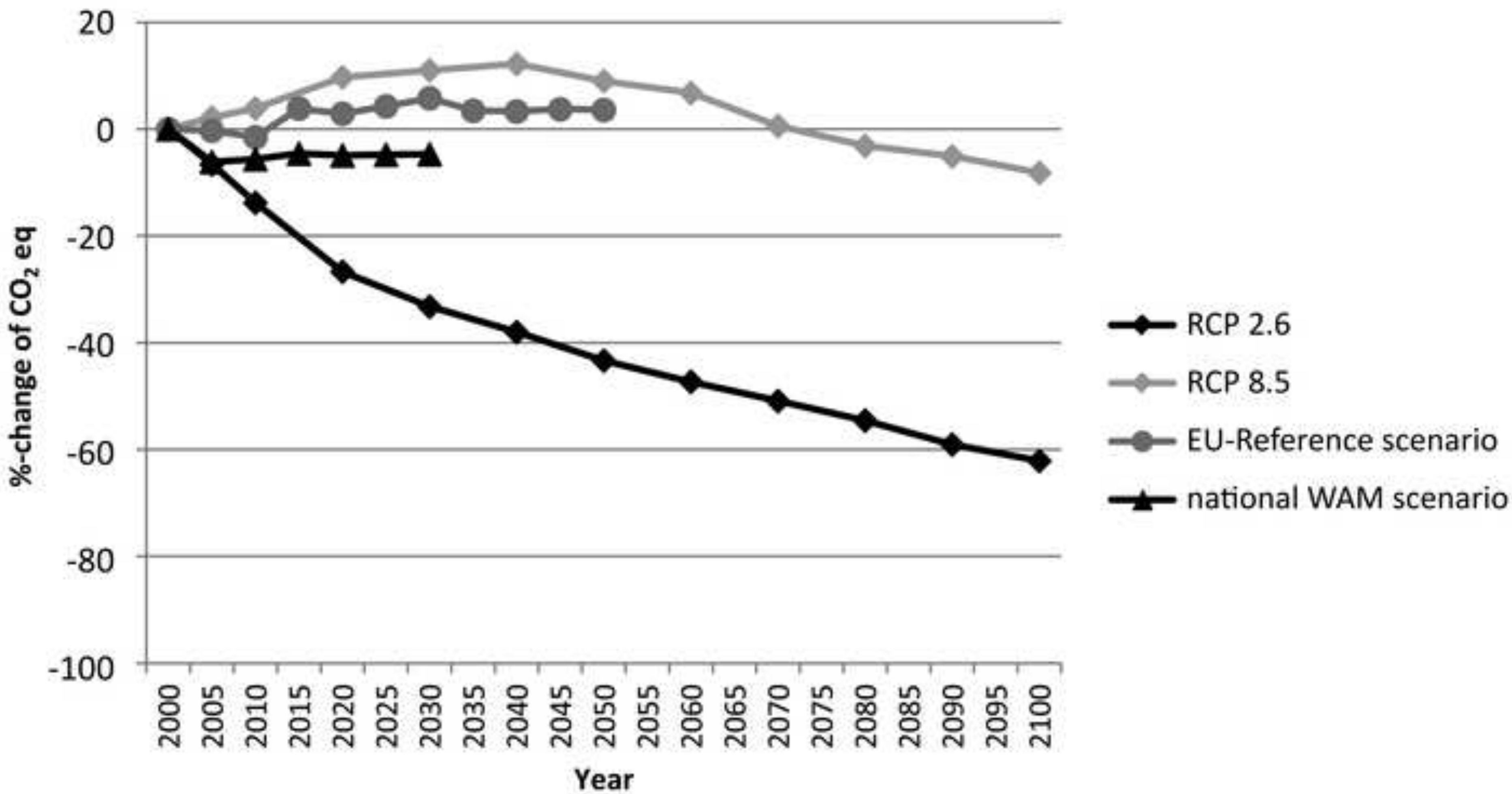

table 1

	Measures						Total GHG savings by 2020 in kt CO_2-eq.
Economic incentives	Greening the truck toll	Fuel tax increase in 2011	Further greening of the consumption tax (NoVA)	Fuel tax increase in 2015 and 2019	Change of heating systems	Domestic Environmental Support Scheme	
	400	1200*	300	2100*	707	250	4957
EU-regulations	EU-Emissions Trading Scheme	Green electricity act 2012 and feed-in tariff ordinance	Energy Efficiency Act (draft)	Promotion of biofuels	Thermal insulation of existing buildings	Common Agricultural Policy (CAP)	
	n.d.	421	150	2100*	426	n.d.	3097
Awareness building	Mobility management and awareness						
	500						500
						other measures	74
						Emission reduction potential in kt CO_2-eq.	8628

* refers to all fuel sold in Austria

table 2

Source sectors of the RCP set		Atmospheric Trace compounds considered		
agr	agriculture (agricultural soil emissions, other agriculture	NOx	Nitrogen oxides	
awb	agricultural waste burning	CO	Carbon oxide	
dom	domestic (residential and commercial buildings	NH_3	Ammonia	
ene	electric power plants, energy conversion, extraction and distribution	NMVOC	Non-Methane Volatile Organic Compound	
ind	industry (combustion and process emissions	SO_2	Sulfur dioxide	
tra	other transport (surface transport)	BC	Black carbon	
wst	waste (landfill, waste water, non-energy incineration)	OC	Organic carbon	
lcf	forest burning (not included in RCP2.6 - NO data)	CH_4	Methane	
sav	savannah burning	NO	Nitric oxide	Only in RCP2.6
slv	Solvents	CO_2	Carbon dioxide	Only in RCP2.6
		N_2O	Nitrous oxide	Only in RCP2.6

table 3

GHG emissions in Austria in (without LULUCF):	Gg CO_2-eq.	Comments:
1990 - Austrian Inventory Report	78162	Historical data
2000 - Austrian Inventory Report	80470	Historical data
2030 - AUT WAM 2013 scenario	78064	Reduction of 3.1% (base year 2000) Reduction of 0.01% (base year 1990)
2030 - EU-Reference Scenario	74900	Reduction of 7.2% (base year 2000) Reduction of 4.2% (base year 1990)
2030 - RCP2.6 OECD-region data	54521	Reduction of 32.25% (base year 2000) Reduction of 30.25% (base year 1990)
EU goal by 2030 (40% red. of 1990) (Assumption: 40% in every country)	46897	

table 4

Measures (for WAM-scenario)	Total GHG savings by 2020 in kt CO_2-eq.
Emission reduction from mechanical biological treatment plants*	n.d.
Coverage of slurry storages	3
Fermentation of liquid manure	149
ÖPUL measures that lead to a reduction in the use of mineral fertilizers	48
Sustainable N management	21
Adapted feeding (in phases) for pigs in order to reduce N_2O/NH_3-emissions	4
Decoupling of premiums for suckling cows	2
Promotion of grazing for cows and suckling cows	1
Emission reduction potential in kt CO_2-eq.	**228**

* this measure is already included the WEM-scenario for Austria