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Key Indicators of Climate Change and the Energy Sector in 2024. Special Topic: Land Use and its Relevance for Food Security

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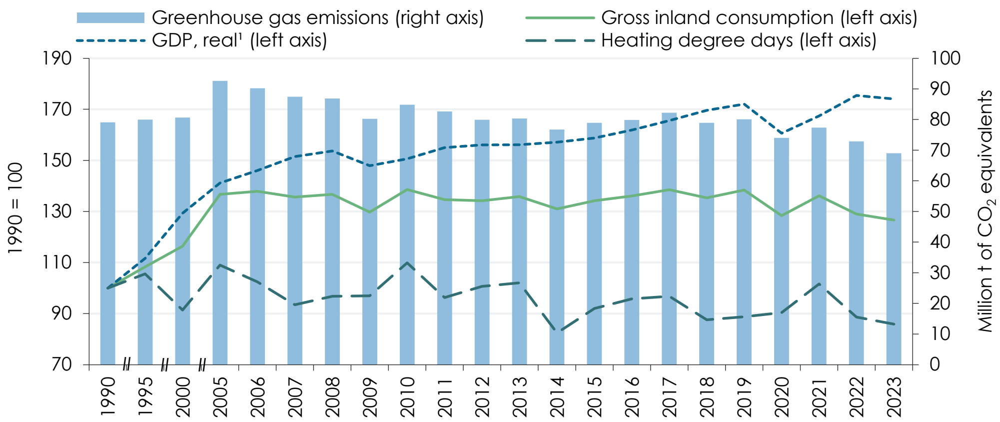
- In 2022, the Austrian economy grew strongly (GDP +4.8 percent in real terms), while both energy consumption (–5.3 percent) and greenhouse gas emissions (–5.8 percent) fell.
- The fall in emissions can be attributed to the rise in energy prices as a result of the war in Ukraine, mild weather, significant expansion of renewable energy technologies, and the increased replacement of heating systems.
- For 2023, the Environment Agency Austria is forecasting a further significant decrease in emissions of 5.3 percent, although GDP has shrunk slightly by –0.8 percent. This implies a continued decline in energy consumption and a switch from natural gas to renewable energy sources.
- Since 1990, the cultivated arable land in Austria has decreased by around 84,600 ha (6 percent) and permanent grassland (including alpine pastures) by as much as 744,400 ha (38 percent). With production remaining roughly the same as last year this jeopardises food security.

Greenhouse gas emissions, energy consumption, gross value added and heating degree days in Austria



"Due to the ongoing expansion of renewable energy production capacities, Austria is expected to be a net exporter of electricity in 2023 for the first time since 2000."

In 2022, gross domestic energy consumption had decoupled from economic development. According to preliminary data, this decoupling did not continue in 2023, as economic output also shrank (source: Environment Agency Austria; Statistics Austria, Energy Balance Austria 1970-2022; WDS – WIFO Data System, Macrobond. 2023: preliminary data from the near-term emission forecast "Nowcast" of the Environment Agency Austria and preliminary Energy Balance Austria 2023. – [1] Reference year 2015).

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September 2024

Key Indicators of Climate Change and the Energy Sector in 2024. Special Topic: Land Use and its Relevance for Food Security

The year 2022 was characterised by a decoupling of economic growth from greenhouse gas emissions. Austria emitted significantly less greenhouse gases than in the previous year (–5.8 percent), although GDP grew substantially (+4.8 percent). This divergence was due to the sharp rise in energy prices following the war in Ukraine, mild weather conditions, the increase in renewable energy technologies, and improvements in the energy efficiency of the capital stock. After 2020, greenhouse gas emissions reached their lowest level since 1990 (72.8 million t CO_2 equivalents). However, much remains to be done to reach Austria's target of climate neutrality by 2040, especially in view of a possible economic upturn in 2025. This year's special feature looks at land use trends and their relevance for food security. Against the backdrop of climate change and together with stagnating yields per hectare and population growth, the steady decline in agricultural land harbours risks to food security.

JEL-Codes: Q15, Q41, Q42, Q43, Q54 • **Keywords:** Climate change, climate policy, energy policy, agricultural production, environmental indicators, land use, food security

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This 17th WIFO report documents and analyses the development of key indicators of climate change and the energy sector in 2022 and – where available – in 2023. It is based on current data on greenhouse gas emissions in Austria (Environment Agency Austria, 2024a, 2024b, 2024c) and energy flows according to the reported energy balances (Statistics Austria, 2023b, 2024c)[1].

The developments in 2022 were largely determined by the Russian war in Ukraine that resulted in an increase in energy prices.

Despite the positive economic development, energy consumption and greenhouse gas emissions in Austria fell significantly compared to the previous year.

The developments in the areas of energy consumption, energy supply and greenhouse gas emissions are analysed below for Austria's total economy and its sectors in relation toits climate policy goals. Against the backdrop of climate change, this year's special topic deals with the importance of land use for food security.

[1] After the editorial deadline, the Environment Agency Austria published an updated near-term forecast of greenhouse gas emissions in Austria. It could no longer be taken into account in this article.

1. Climate and energy indicators

1.1 Gross domestic energy consumption in the EU 27 fell as a result of the war in Ukraine

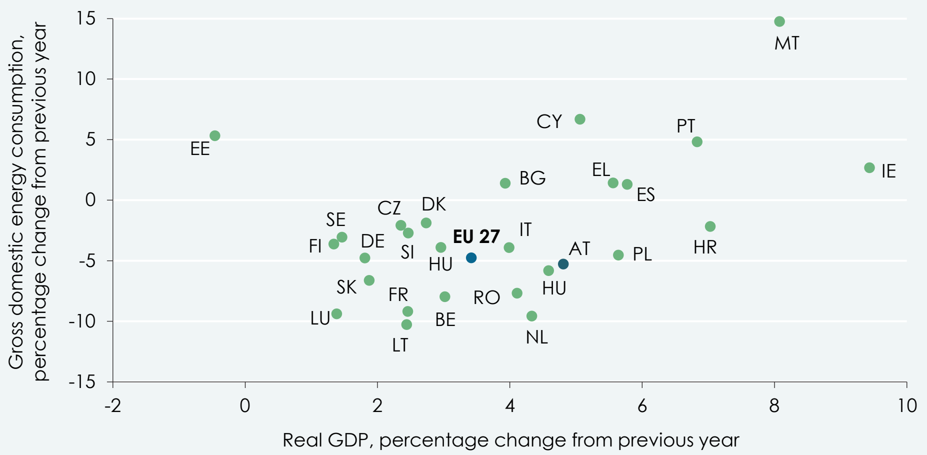
In 2022, GDP in the EU 27 increased by 3.4 percent compared to the previous year. In contrast, energy use fell by 4.7 percent to 56,698 PJ, the second-lowest figure since 1990; only in 2020 had it been lower. The decline was primarily due to the rise in energy prices as a result of the Russian war in Ukraine.

A comparison of the development of the two key figures at country level shows a differentiated picture (Figure 1): economic output rose in 2022 in all EU countries with the exception of Estonia, which was already in recession due to high inflation. Ireland, Malta, Croatia and Portugal recorded strong GDP growth. In contrast, gross domestic energy consumption in 2022 was below the 2021 level in 19 EU countries. The use of fossil fuels fell slightly compared to the previous year, with a 13 percent decline in natural gas. The use of renewable energy sources increased again – at 23 percent, their share of gross final energy consumption in the EU 27 was 1.1 percentage points higher than in 2021.

Despite significant economic growth, energy consumption in the EU 27 fell in 2022 as a result of the war in Ukraine and price increases.

Figure 1: **Development of gross domestic energy consumption in relation to GDP development in the EU countries**

2022



Source: Eurostat.

1.2 Austria: Energy price increases and climate policy measures curbed emissions in 2022

Austria emitted significantly fewer greenhouse gases across all sectors in 2022 than in the previous year (–5.8 percent). Emissions fell to 72.8 million t of CO_2 equivalents (CO_2 emissions: 61.5 million t; Figure 2) due to the drastic increase in energy prices, but also due to mild weather, an increase in the replacement of heating systems and the expansion of renewable energy technologies. Beside 2020, this was the lowest level since 1990.

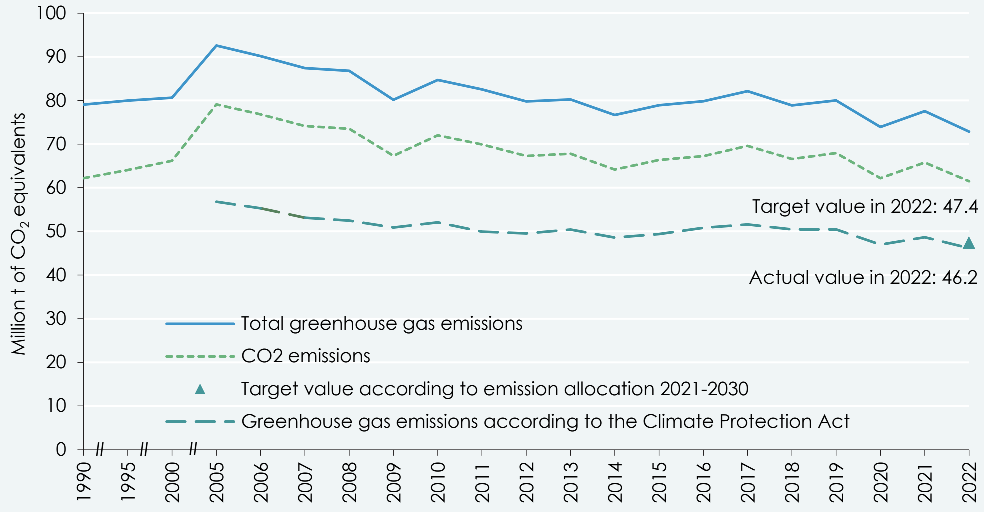
For the sectors outside the EU emissions trading system, national caps apply for the period 2021 to 2030 in accordance with the Effort Sharing Regulation 2018/842/EU (European Commission, 2018a). In 2022, the relevant cap for Austria was 47.4 million t of CO_2 equivalents. At 46.2 million t of CO_2 equivalents, actual emissions were below the target value. Emissions in the emissions trading sector also fell significantly compared to 2021 (–2.1 million t of CO_2 equivalents or –7.2 percent) and amounted to 26.6 million t, of which 7 million t were attributable to energy generation and 19.6 million t to industry. The reduction is primarily due to a decrease in steel production and the use of crude oil in refineries as well as declines in other sectors.

Austria emitted fewer greenhouse gases in 2022 than in the previous year, both in the EU emissions trading system and in the sectors regulated by the Climate Protection Act.

Energy consumption in 2022 was also noticeably lower than in the previous year (–5.3 percent; Figure 3) despite the strong GDP growth of 4.8 percent. Energy-related greenhouse gas emissions fell by 6.6 percent, as in particular the use of natural gas declined due to high energy prices. Process-related emissions fell by 5.7 percent, while non-energy-related emissions from agriculture hardly changed (–0.6 percent) and those from waste management fell by –4.6 percent.

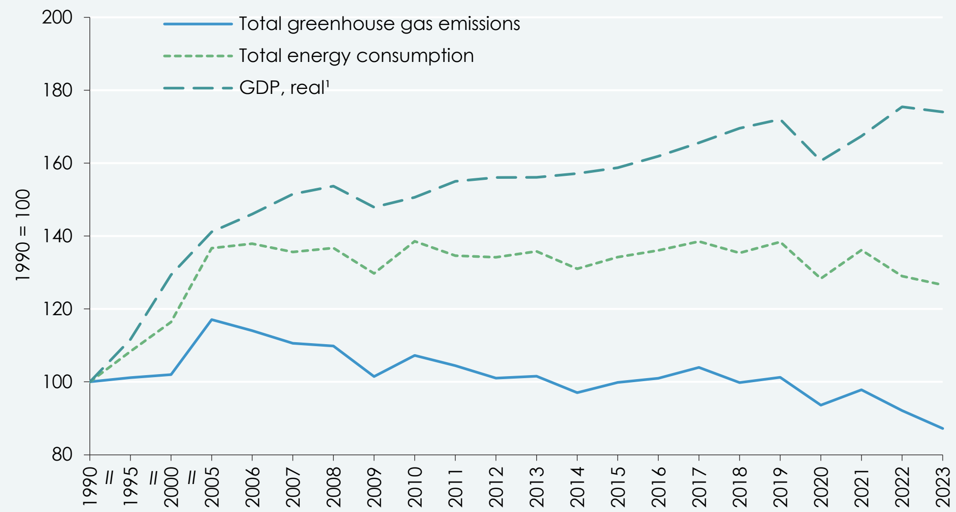
Austria's greenhouse gas emissions fell significantly in 2022 despite strong growth of real GDP.

Figure 2: **Greenhouse gas emissions in Austria and Kyoto target**



Source: Environment Agency Austria.

Figure 3: **Greenhouse gas emissions and economic growth in Austria**



Source: Environment Agency Austria; Statistics Austria, Energy Balance Austria 1970-2022; WDS – WIFO Data System, Macrobond. 2023: preliminary data from the near-term emissions forecast "Nowcast" of the Environment Agency Austria and preliminary Energy Balance Austria 2023. – [1] Reference year 2015.

The Environment Agency Austria (2024b) predicts a further significant decrease in emissions of 5.3 percent in 2023, although GDP only fell slightly by 0.8 percent in 2023. This divergence reflects a continued reduction in energy consumption in Austria and the switch from natural gas to renewable energy sources.

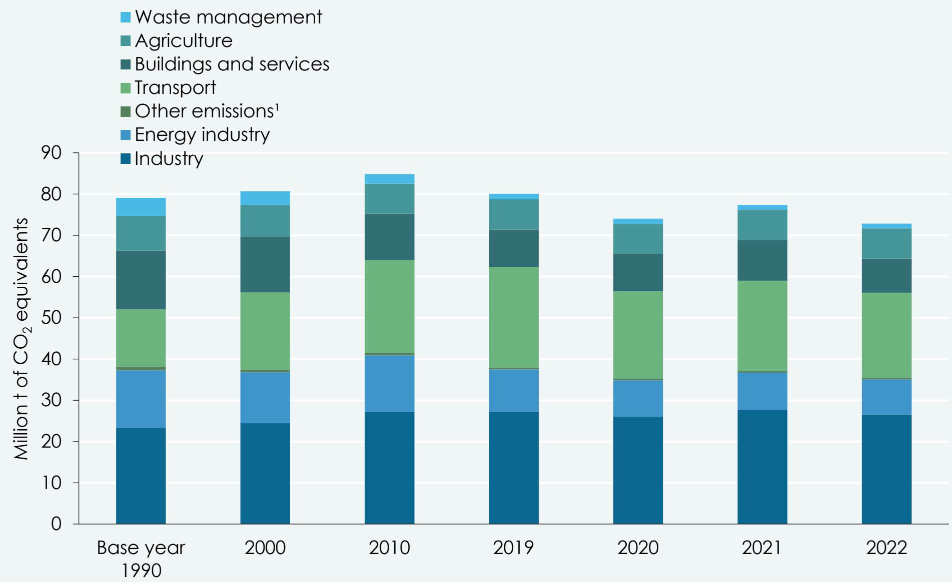
The sectors buildings and services, transportation and others recorded the sharpest declines in emissions in 2022.

1.3 Declining greenhouse gas emissions in all sectors

In 2022, greenhouse gas emissions in Austria decreased in all sectors (Figure 4). In relative terms, emissions from buildings and services declined most strongly (–15.4 percent). Greenhouse gas emissions from the transport sector (–5.5 percent) and the remaining "other emissions" (–5.8 percent) also fell significantly. In absolute terms, emissions in the buildings and service sector also fell most strongly (–1.5 million t of CO_2 equivalents), ahead of the industry and transport sectors, where the reduction in emissions amounted to 1.2 million t of CO_2 equivalents each. Since 1990, an increase in emissions can in particular be observed for transport (+48.5 percent), but also for industry. In contrast, the other sectors were able to reduce their emissions, in some cases significantly (see sections 1.6 and 1.7).

At 36.4 percent or 26.5 million t of CO_2 equivalents, industry was the main source of domestic greenhouse gas emissions in 2022; its share increased by 0.5 percentage points compared to 2021. The transport sector was the second largest emitter at 28.4 percent (20.7 million t of CO_2 equivalents). At 11.6 percent (8.5 million t of CO_2 equivalents), the energy sector's contribution to total emissions in 2022 was higher than that of buildings and services (11.4 percent; 8.3 million t of CO_2 equivalents) for the first time since 2019; agriculture accounted for 10 percent.

Figure 4: **Sources of greenhouse gas emissions in Austria**



Source: Environment Agency Austria. 2023: preliminary data from the emissions near-term forecast "Nowcast" Environment Agency Austria and preliminary Energy Balance for Austria 2023. – [1] Military, fluorinated greenhouse gases, CO_2 transport and storage.

1.4 Significant decoupling of energy consumption and emissions in industry

Although gross industrial value added increased by 4.3 percent in 2022, domestic industry emitted significantly fewer greenhouse gases than in the previous year, as in 2018 and 2020 (–4.4 percent). Nevertheless, its share of total emissions was 4.4 percentage points higher than in 2010. 16 million t of the total 26.6 million t of CO_2 equivalents were attributable to process emissions, which fell by almost 6 percent compared to the previous year, mainly due to lower steel production. Energy consumption in industry increased by 1.1 percent to 319 PJ. This indicates a decoupling of energy consumption and emissions in the industrial sector once the COVID-19 pandemic has been overcome, with emissions intensity falling by 8.4 percent and energy intensity by 3.1 percent in 2022 (Figure 5).

1.5 Decrease in the emissions intensity of the transport sector

Transport-related emissions fell by 5.5 percent to 20.7 million t of CO_2 equivalents in 2022, mainly due to lower road traffic (–1 million t of CO_2 equivalents). Sales of diesel fuel fell, particularly in fuel exports with heavy commercial vehicles, while petrol sales were slightly higher than in 2021 (Environment Agency Austria, 2024a). Nevertheless, transportation's share of total emissions increased by 0.1 percentage point to 28.4 percent. At 340 PJ, final energy consumption in the transport sector was 3.1 percent below the previous year's level. The discrepancy between the development of emissions and final energy consumption is caused by the fact that the consumption data includes international air traffic, while the emission data does not.

In the transport sector, both emission intensity (–9.9 percent) and energy intensity (–7.5 percent) decreased in 2022.

1.6 Greenhouse gas emissions from buildings and services fell due to weather conditions

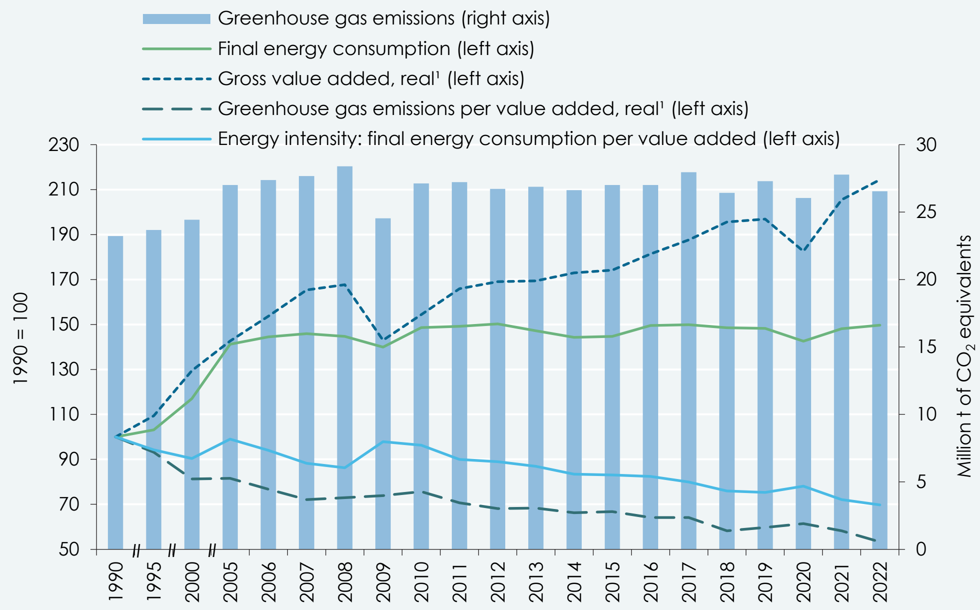
In private households as well as services and agriculture combined (here referred to as buildings and services), both final energy consumption and greenhouse gas emissions decreased significantly in 2022. At 406 PJ, final energy consumption was 54 PJ (12 percent) lower than in the previous year. The majority of the reduction in consumption, namely over 50 PJ, was attributable to

The share of fossil fuels in the energy use of buildings and services decreased in 2022.

space heating, for which significantly less energy was used due to the lower number of heating days (–13 percent). In terms of energy sources, the use of natural gas (–19 PJ), wood fuel (–14 PJ), district heating (–8 PJ) and gas oil for heating purposes (–7 PJ) in particular declined. Growth was only recorded in the areas of ambient and solar heating (+2 PJ; Statistics Austria, 2023c).

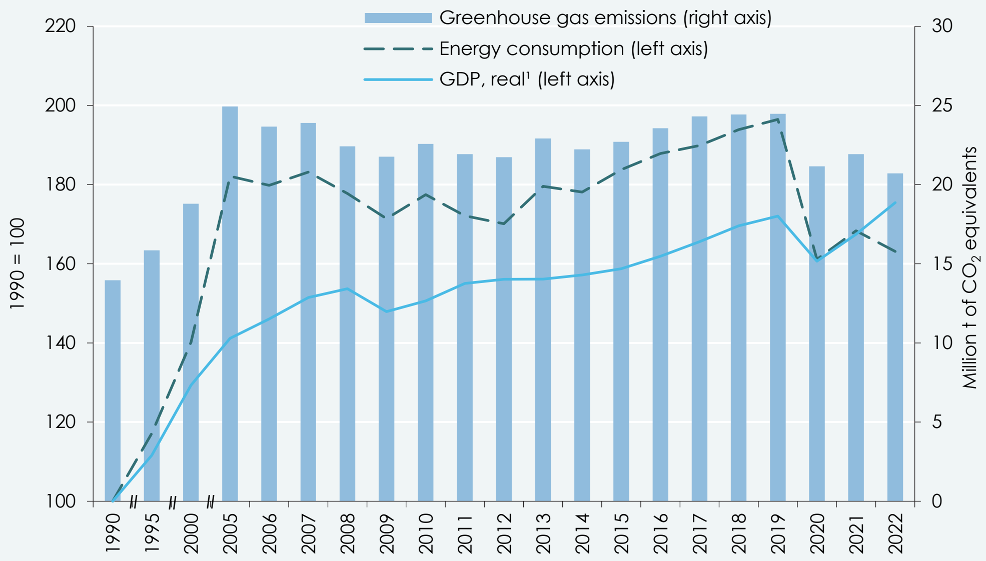
As a result, greenhouse gas emissions from small-scale consumption fell by 15.4 percent (Figure 7) to 8.3 million t of CO_2 equivalents. Emissions per capita (–16.4 percent) fell significantly more than energy consumption and heating degree days (–12 percent and –13 percent respectively). This reflects the decline in the share of fossil fuels in the energy mix by 1.9 percentage points.

Figure 5: **Greenhouse gas emissions, energy consumption and gross value added of industry**



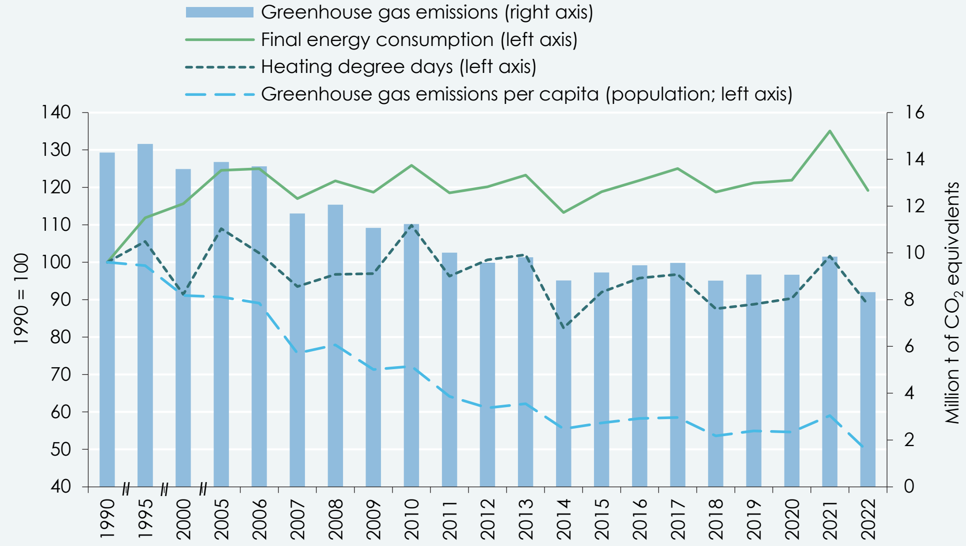
Source: Environment Agency Austria; Statistics Austria, Energy Balance Austria 1970-2022; WDS – WIFO Data System, Macrobond. – [1] Manufacturing including mining, at basic prices, reference year 2015.

Figure 6: **Greenhouse gas emissions and energy consumption of the transport sector and growth of real GDP in Austria**



Source: Environment Agency Austria; Statistics Austria, Energy Balance Austria 1970-2022. – [1] Reference year 2015.

Figure 7: **Greenhouse gas emissions and energy consumption of private households, services and agriculture and number of heating degree days**



Source: Environment Agency Austria; Statistics Austria, Energy Balance Austria 1970-2022; WDS – WIFO Data System, Macrobond.

1.7 Slightly higher greenhouse gas emissions from public electricity and district heating generation

Following a slight decrease in the previous year, greenhouse gas emissions from the public provision of electricity and district heating[2] rose slightly in 2022 (+2.2 percent). However, the energy used for this purpose fell by 3.1 percent. On the one hand, this was due to the lower electricity demand and the weather-related lower demand for district heating, but on the other hand also to the significant decline in electricity generation from hydropower (–14 PJ or –10 percent). Since 2000, the only years in which Austria generated less electricity from hydropower than in 2022 were 2003 and 2011. This shortfall was offset by electricity imports (+4.2 PJ) and electricity from renewables (wind power and photovoltaics +5.5 PJ) as well as fossil fuels (oil +0.4 PJ, natural gas +0.06 PJ). This was associated with an increase in greenhouse gas emissions, which caused the emission intensity of public electricity and district heating provision to grow significantly by +5.5 percent (Figure 8).

1.8 Austria to be a net exporter of electricity in 2023 for the first time since 2000

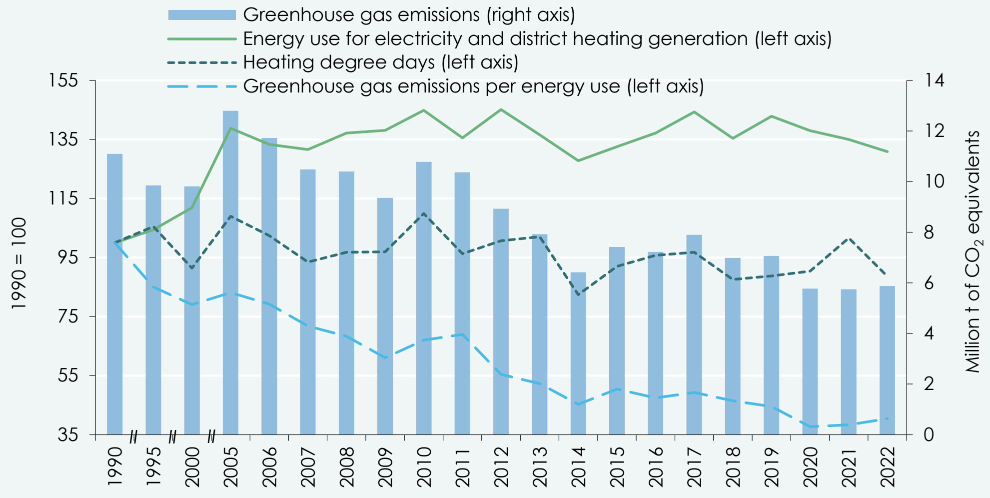
After the brief increase in 2021, Austria's energy consumption fell again in the two following years (–5.3 and –1.9 percent; according to the preliminary energy balance). The forecast value for 2023 of 1,332 PJ implies a continuation of the downward trend, which was driven by the ongoing economic downturn on the one hand and a decline in electricity imports and gas consumption on the other. Despite the stabilisation of the price of natural gas, gas consumption in 2023 shrank by 14.5 percent compared to the level of 1994. In addition to the weak business cycle, the causes include the replacement of gas heating systems, a reduction in electricity generation and lower energy demand for space heating due to the mild winter. Following the ongoing expansion of renewable energy production capacities, Austria is likely to have been a net exporter of electricity in 2023 for the first time since 2000. The balance was 258 PJ.

In 2023, the subdued business cycle resulted in the lowest gross domestic consumption since 2002.

In terms of volume, energy consumption from fossil sources is likely to have fallen by a total of 4.8 percent in 2023, while that from renewable sources is expected to have increased by 11.3 percent (49 PJ). This means that the share of fossil energy in total consumption fell by 1.9 percentage points to just under 62 percent. Despite this positive development, there is still a great need for action to achieve the Austrian goal of climate neutrality by 2040 and the European climate targets, even against the backdrop of a possible economic upturn in 2025.

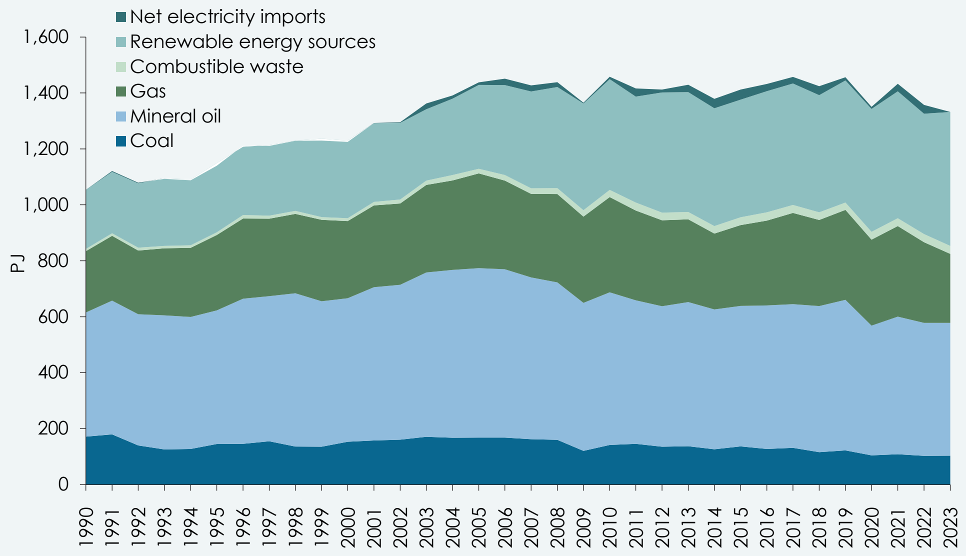
[2] The values and figures in this chapter are not comparable with the previous year's contribution. From this year onwards, only the emissions and conversion input of public energy supply companies for the provision of electricity and district heating are presented. Until last year's report, the data on energy input also included independent energy generation plants and emissions from the refinery.

Figure 8: **Greenhouse gas emissions and energy use for electricity and district heating generation by energy supply companies**



Source: Environment Agency Austria; Statistics Austria, Energy Balance Austria 1970-2022; WDS – WIFO Data System, Macrobond.

Figure 9: **Gross domestic consumption by energy source in Austria**



Source: Statistics Austria, Energy Balance Austria 1970-2022. 2023: preliminary Energy Balance Austria 2023.

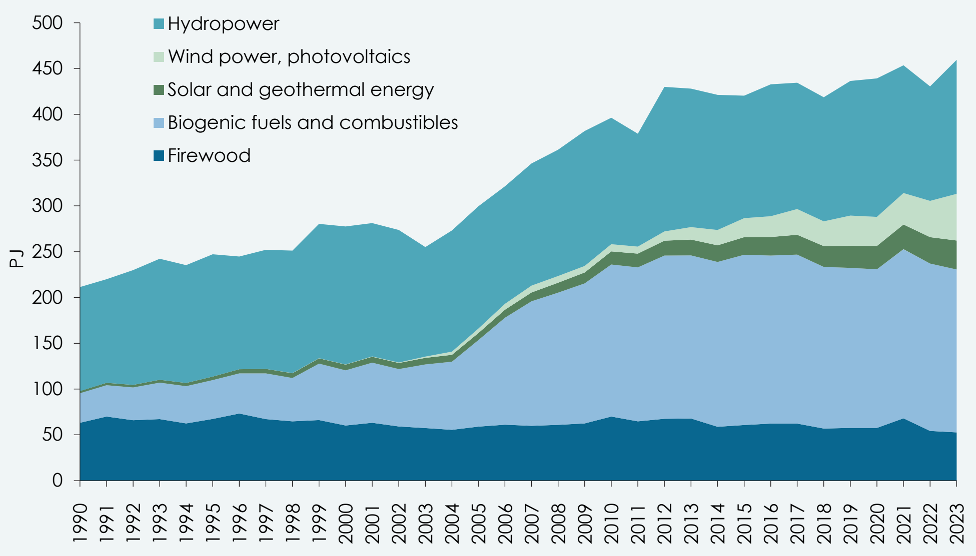
The shares of wind power and photovoltaics as well as solar and geothermal energy in total consumption increased sharply in 2023.

1.9 Share of renewable energy sources increases

According to preliminary data, the share of renewable energy in total consumption rose by 4.3 percentage points to just under 36 percent in 2023. Biogenic fuels and combustibles remained the most important renewable energy sources in 2023 with a share of 37 percent, ahead of hydropower with 31 percent and wood fuel with 11 percent.

The increased endeavour to become independent of fossil fuels is reflected in the high growth rates of solar and geothermal energy (+9.7 percent) as well as wind power and photovoltaics (+28 percent). They underline the ongoing trend towards decarbonisation. In the long term, however, the average annual growth of renewable energy sources has slowed from 3.6 percent (2000-2010) to 1.1 percent (2013-2023).

Figure 10: **Gross domestic consumption of renewable energy sources**



Source: Statistics Austria, Energy Balance Austria 1970-2022. 2023: preliminary Energy Balance Austria 2023.

1.10 Improved foreign energy trade balance

At 17.5 billion €, the value of energy imports in 2023 was around a third lower than in the previous year, reflecting the decline in energy prices. Expenditure on imported electricity (–52 percent) and heating oil (–53 percent) fell the most. In addition to price changes, the lower expenditure is due to the decline in import volumes (–127 PJ or –11 percent). The import volume of heating oil in particular collapsed (–94 percent). The amount of imported electricity fell by 52 percent and the amount of imported natural gas by 32 percent, not least due to the high storage levels at the beginning of 2023 (Table 1).

The need for energy imports is associated with high financial outflows to energy exporting countries. These are still significantly higher than before the energy crisis. In particular, Austria is still highly dependent on Russian natural gas imports. A diversification of supply sources, the rapid expansion of renewable energy sources and the utilisation of efficiency potential play an important role in becoming less dependent on foreign suppliers.

Energy exports increased by around 12 percent in terms of volume to 225 PJ in 2023. However, this growth was not reflected in revenues, which fell by almost 6 percent. As mentioned above, Austria was again a net exporter of electricity in 2023, after being a net importer for the previous 20 years.

The energy trade balance remained negative in 2023 in value (–11.1 billion €), but was around 8 billion € better than in the previous year. The quantity balance was 151 PJ lower.

Austria's income from electricity exports was almost twice as high as expenditure on electricity imports in 2023.

1.11 Higher energy expenditure for housing

Energy expenditure for housing rose by 8 percent in 2022 despite mild weather and lower consumption.

The average energy expenditure of private households for housing in 2022 (last available year) was around 8 percent higher than in the previous year. Monthly expenditure per household increased from an average of 132 € to 143 €. This moderate increase compared to the consumer price index is unlikely to fully reflect the actual expenditure on electricity and gas due to the delay in invoicing. The mild winter of 2022 and energy savings had a dampening effect, resulting in lower consumption by private households of around 15 percent. Gas consumption was almost 18 percent lower than in 2021, while district heating consumption was down 15 percent. Demand for electricity also decreased (–9 percent).

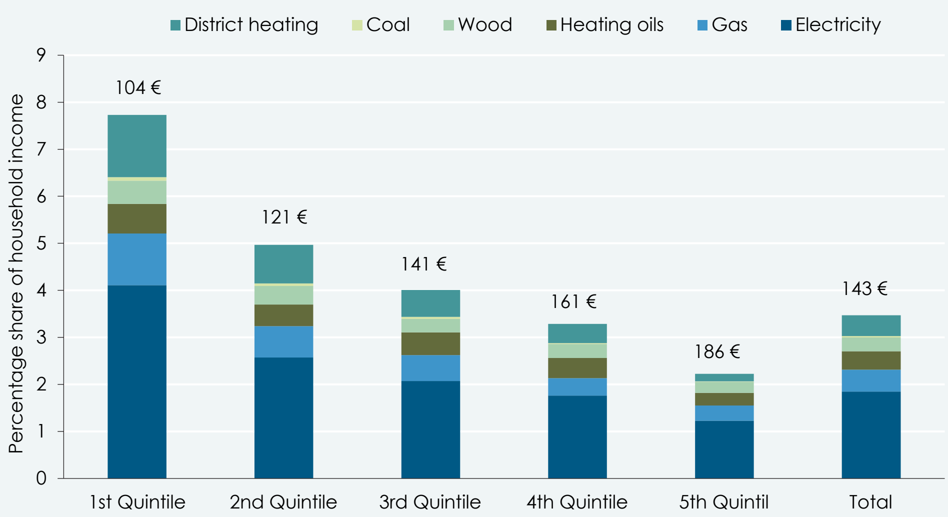
The share of household income spent on energy rose on average by 0.2 percentage points to 3.5 percent in 2022. The lowest income quintile shows a significantly higher increase, from 6.9 to 7.7 percent. Lower-income households would particularly benefit from investments that reduce energy consumption in the medium and long term.

Table 1: **Foreign trade in energy sources**

	Exports				Imports				Balance			
	2015	2021	2022	2023	2015	2021	2022	2023	2015	2021	2022	2023
	Million €											
Coal	2	2	2	25	475	501	1,352	1,064	– 473	– 499	– 1,350	– 1,039
Crude oil	0	0	0	0	3,097	3,434	3,647	4,437	– 3,097	– 3,434	– 3,647	– 4,437
Heating oil	121	0	0	0	33	22	87	41	+ 88	– 22	– 87	– 41
Petrol	477	596	555	638	499	396	1,043	685	– 23	+ 201	– 488	– 46
Diesel fuel	478	792	717	859	2,177	2,927	6,168	4,093	– 1,699	– 2,136	– 5,450	– 3,234
Natural gas	315	438	1,017	720	2,701	4,131	9,207	5,027	– 2,387	– 3,693	– 8,191	– 4,307
Power	857	1,620	4,507	4,159	1,103	1,935	4,574	2,181	– 246	– 315	– 67	+ 1,978
Total	2,249	3,448	6,798	6,401	10,085	13,346	26,079	17,527	– 7,836	– 9,898	–19,281	–11,126
	PJ											
Coal	0.3	0.0	0.0	0.0	119.4	108.0	103.0	105.2	– 119.1	– 108.0	– 103.0	– 105.2
Crude oil	0.0	0.0	0.0	0.0	344.6	321.6	218.3	321.6	– 344.6	– 321.6	– 218.3	– 321.6
Heating oil	21.6	15.4	11.2	16.3	0.5	1.3	1.6	0.1	+ 21.1	+ 14.0	+ 9.6	+ 16.3
Petrol	38.6	39.0	23.6	0.8	33.3	22.5	32.4	28.5	+ 5.3	+ 16.5	– 8.9	– 27.7
Diesel fuel	34.0	48.6	25.1	36.6	155.6	167.7	190.1	153.2	– 121.6	– 119.1	– 165.0	– 116.6
Natural gas[1]	49.4	69.8	69.8	72.1	454.4	524.6	524.6	359.6	– 405.0	– 454.9	– 454.9	– 287.4
Power	69.6	68.0	71.6	98.8	105.8	95.2	102.9	77.6	– 36.2	– 27.2	– 31.3	+ 21.2
Total	213.4	240.8	201.2	224.7	1,213.6	1,241.0	1,173.0	1,045.8	– 1,000.2	– 1,000.1	– 971.8	– 821.1

Source: Statistics Austria, Energy Balance Austria 1970-2022, preliminary Energy Balance Austria 2023, Foreign Trade Statistics; WDS – WIFO Data System. – [1] Natural gas transit through Austria is no longer shown in the current energy balance. The values for the import and export of natural gas are taken from the foreign trade statistics and include transit.

Figure 11: **Share of energy expenditure for housing in household income in 2022**



Source: EU-SILC.

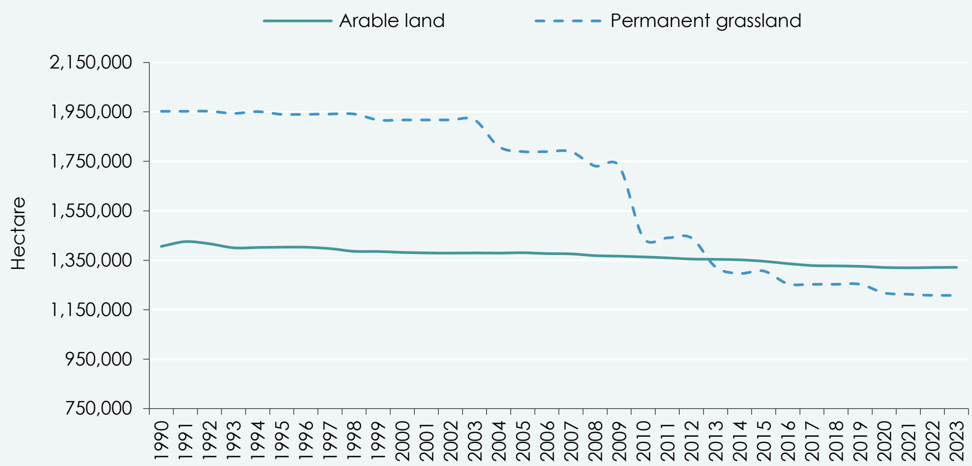
2. Agricultural production and nitrogen balance in Austria

Agriculture and forestry are more dependent on the environment and the use of natural resources than almost any other sector. In addition to its central role in food security through the production of food and animal feed, agriculture provides numerous ecosystem services. For example, it contributes to climate stability (Meyer et al., 2023) and the preservation of biodiversity by building up carbon stocks in standing biomass and soils.

In 2023, around 31 percent (2,596,000 ha) of Austria's land area was used for agriculture. Of this, 1,322,800 ha (51 percent) was arable land and 1,208,400 ha (46.5 percent) was permanent grassland. The remainder was made up of permanent crops and private gardens. Since 1990, the cultivated arable land in Austria has decreased by around 84,600 ha (6 percent) and the area of permanent grassland (including alpine pastures) by as much as 744,400 ha (38 percent;

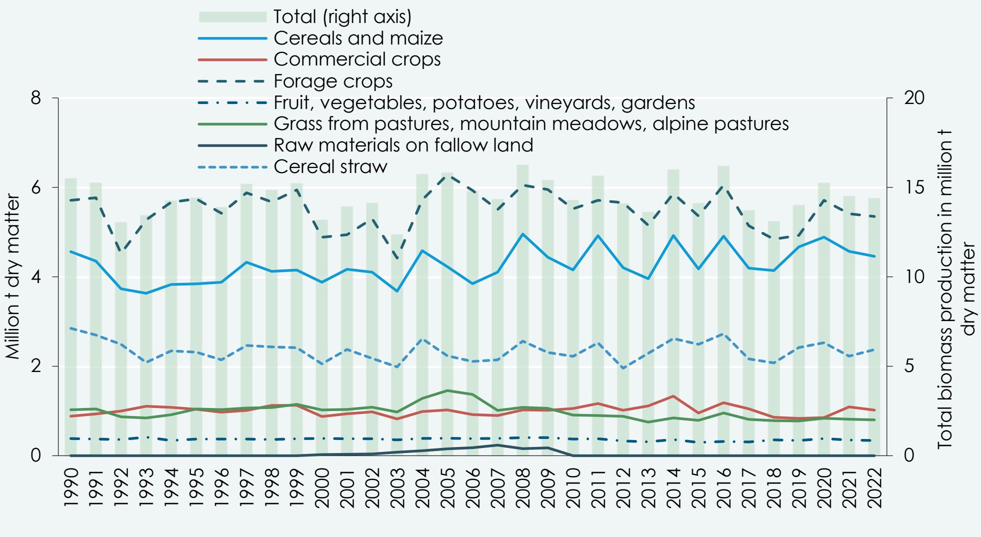
Figure 12). Per capita, the available agricultural area for food production was 2,844 m², which means that it was around a third smaller compared to 1990 (4,505 m²).

Figure 12: **Agricultural land use**



Source: Austrian Central Statistical Office (1992); Statistics Austria (2022a); Statistics Austria, Cultivation on arable land – field crop and permanent pasture production, various years https://www.statistik.at/statistiken/land-und-forstwirtschaft/pflanzenbau/ackerbau-dauergruenland); Statistics Austria, Agricultural structure survey – land use, various years https://www.statistik.at/statistiken/land-und-forstwirtschaft/betriebsstruktur/bodennutzung); STATcube from Statistics Austria, Field crop production from 1970; STATcube from Statistics Austria, Agricultural structure survey 2020 – land use.

Figure 13: **Production of economically usable biomass by agriculture in Austria**



Source: WIFO calculations based on Buchgraber et al. (2003); DLG feed value table; Resch (2007). Straw is a by-product of grain production (excluding maize); a standardised grain/straw ratio of 1:0.9 is assumed. Loss factors for the feed industry according to Buchgraber et al. (2003), supply balances according to Statistics Austria (2024b).

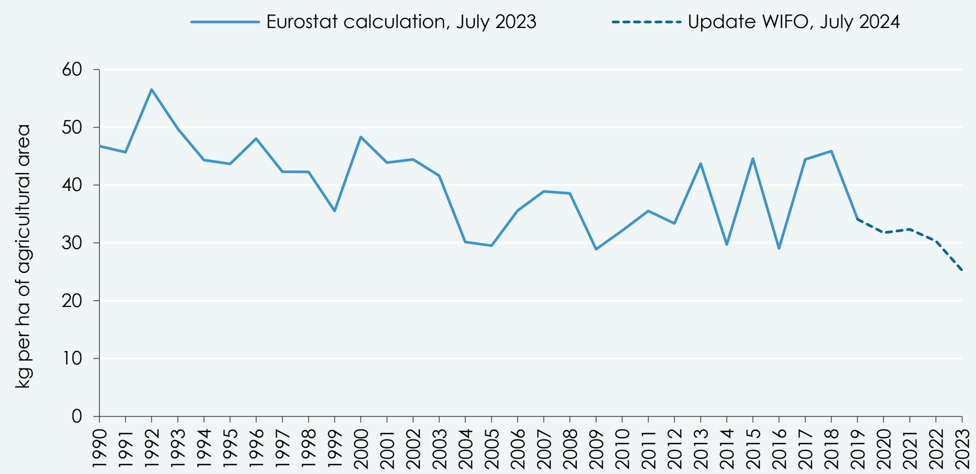
The production of biomass on arable land does not follow the declining trend in arable land due to slightly increasing yields per hectare. However, agricultural biomass production has been stagnating for decades (Figure 13), with considerable annual fluctuations, mainly due to weather conditions. This is particularly problematic in face of the increasing demand from a growing population (Statistics Austria, 2023a). If dietary behaviour remains unchanged, domestic agriculture will less and less contribute to food security, resulting in an increased dependency on imports.

Sufficient availability of nutrients (nitrogen, phosphorus and potassium) is of central importance for soil fertility and the production

The steady decline in agricultural land is jeopardising food security in the face of stagnating yields per hectare and population growth.

of biomass, which serves as food, animal feed and raw materials for industrial applications. With the removal of harvested crops, nutrients are removed from the soil and their replacement with fertilisers is a prerequisite for high crop yields. Easily soluble mineral or organic fertilisers (e.g., farm manure, compost) are used by agriculture for this purpose. However, intensive fertilisation has a negative impact on the environment. Nutrients that are not absorbed by plants can enter the groundwater and surface waters or – particularly in the case of nitrogen fertilisers – are released into the atmosphere in gaseous form.

Figure 14: **Nitrogen balance**



Source: Eurostat, Gross Nutrient Balance 1990-2019 (data retrieved on 18. 8. 2023, data status 21. 7. 2023); WIFO calculations. Until 2012, the data was determined by the Environment Agency Austria using the OECD method. The Eurostat and OECD methods differ with regard to the areas and sources covered (e.g., atmospheric deposition). Explanatory notes are provided by Kletzan-Slamanig et al. (2014).

Nitrogen (fertilisation) is necessary to ensure high yields in the long term, but is also a significant source of emissions.

The nitrogen balance according to the method developed by the OECD and modified by Eurostat (Figure 14; OECD & Eurostat, 2007) accounts for the synthesis of atmospheric nitrogen via the root system of some plants and atmospheric deposition in addition to fertiliser inputs. The sum of nutrient inputs is compared with the removal by the harvested crop. If the balance is positive, more nitrogen has been added to the agricultural cycle than has been removed. As the balance surplus increases, so does the risk of undesirable inputs into groundwater or greenhouse gas emissions. A reduction in mineral fertiliser inputs is positive for the environment and often also associated with economic advantages.

Overall, the amount of nitrogen fertiliser applied in Austria has been slightly decreasing since 1990. On the one hand, the annual fluctuations are due to the unpredictable nutrient requirements of crops at the time of fertilisation. On the other hand, the statistics record the quantities sold on the market and not the quantities actually applied.

3. Special topic: The importance of land use for food security

3.1 Introduction

In view of climate change, changing land use harbours enormous potential, but also conflicts of interest.

The term land use refers to the management and transformation of natural spaces and ecosystems into built and artificial areas such as fields, pastures, forests, settlements and transport infrastructure. Land use, which includes human actions, activities and interventions to change or maintain the existing land cover, plays a central role in policy making with regard to climate protection, biodiversity conservation and sustainable development (Jandl et al., 2024). The land use sector (Land Use, Land Use Change and Forestry – LULUCF) harbours considerable potential for carbon sequestration and emission reduction and thus for achieving climate targets (European Commission, 2018b). Agricultural land use is in turn crucial for food security.

Like biodiversity, terrestrial ecosystems are affected by climate change to varying degrees and are vulnerable to extreme weather events. Sustainable land use can support the reduction of negative climate change impacts, especially extreme weather events such as heavy rainfall, heat and drought, on ecosystems and social welfare. Depending on land use and climate change, terrestrial ecosystems act as sources or sinks for greenhouse gases.

Changes in land use can make significantly contribute to reducing emissions, but their influence is limited and affected by conflicting objectives and interests, e.g., between food production, energy production, urban development and nature conservation.

A current example of short-term land use conflicts between nature conservation and agriculture is the resistance to the EU regulation on nature restoration (2022/0195(COD)). Nature conservation objectives such as the rewetting of peatlands (Schröck et al., 2022) or the creation of flowering field margins are pitted against security of supply in agricultural production. Nature conservation is criticised because, ceteris paribus, it reduces the agricultural area. However, research findings indicate that measures to restore natural resources have a significant positive impact on food production in the long term and therefore favour food security (Liquete et al., 2022). Short-term conflicts of use can therefore be resolved in synergies in the medium to long term. There is also an urgent need for action to restore natural habitats in cities, not least in terms of land use.

This year's special topic deals with land use in agricultural production and its importance for food security in Austria.

3.2 Development of cultivated agricultural area

Agricultural land and forests characterise land cover in the EU 27 with 38 and 37 percent respectively (Eurostat, 2021, 2023). At the same time, Europe is one of the most intensively utilised land masses in the world. With the growth of cities and infrastructure, land consumption is also steadily increasing (European Environment Agency, 2023). It refers to the loss of biologically productive soils through soil sealing, i.e., the covering of land with a layer impermeable to water and air for the construction of settlements, businesses and infrastructure, and through intensive use for recreational use (e.g., parks, sports facilities), as well as landfills and extraction sites (e.g., gravel ponds). As surveys for Austria show, land consumption in the years 2019 to 2021 averaged 41 km² per year or 11 ha per day (Environment Agency Austria, 2023). This often affects arable land, grassland or forest areas, which are then no longer available for agricultural production and can no longer fulfil ecosystem services, such as the provision of food, water and other resources as well as their function as carbon sinks. Among other things, this jeopardises food security.

Against this background, WIFO analysed the effects of the decline in arable land in the period from 1999 to 2020 on food security as part of a study for Austria (Arnold et al., 2023) and identified starting points for curbing land consumption. The procedure and results of the study are outlined below.

3.3 Data basis and methodology

The Farm Structure Survey is carried out in Austria every ten years as a census and is one of the most important data sources for tracking changes in agricultural land use. The data from the 1999 and 2020 Farm Structure Survey (Statistics Austria, 2001, 2022a) were used for this purpose and analysed at municipal level. Not all crops produced on arable land are suitable for human consumption. For the analysis, fodder crops (e.g., silage maize, alfalfa) were replaced by a crop mix suitable for human consumption observed at the municipal level. The total crop yield in tonnes for the years 1999 and 2020 was estimated by multiplying it by the average yields per hectare for the years 2020 to 2022 (Statistics Austria, 2020, 2021, 2022b).

In order to determine the food supply potential of the domestic agricultural sector, an common measure was calculated for the various crops using the measure of the "grain equivalents" (GE; Schulze Mönking & Klapp, 2010). The calculation was carried out using GE coefficients which indicate how suitable an agricultural commodity is for feeding people. 1 GE corresponds to the nutritional value of 100 kg of barley.

In Austria, land consumption in the years 2019 to 2021 averaged 11 hectares per day. This often resulted in the loss of biologically productive and ecologically valuable arable land, grassland and woodland.

The supply balance (Statistics Austria, 2024a) and current population statistics (Statistics Austria, 2023a) can be used to calculate how much of a particular agricultural commodity Austrians consume per capita per year. If the quantities consumed are also converted into grain equivalents, using GE coefficients, it is possible to draw conclusions about the supply performance of the Austrian agricultural sector with and without loss of arable land in the years 1999 to 2020. Based on the observed product mix of agricultural goods consumed in Austria in 2020, 10.4 GE were required to feed one person for one year.

3.4 Calculation of the potential total crop yield with and without land consumption

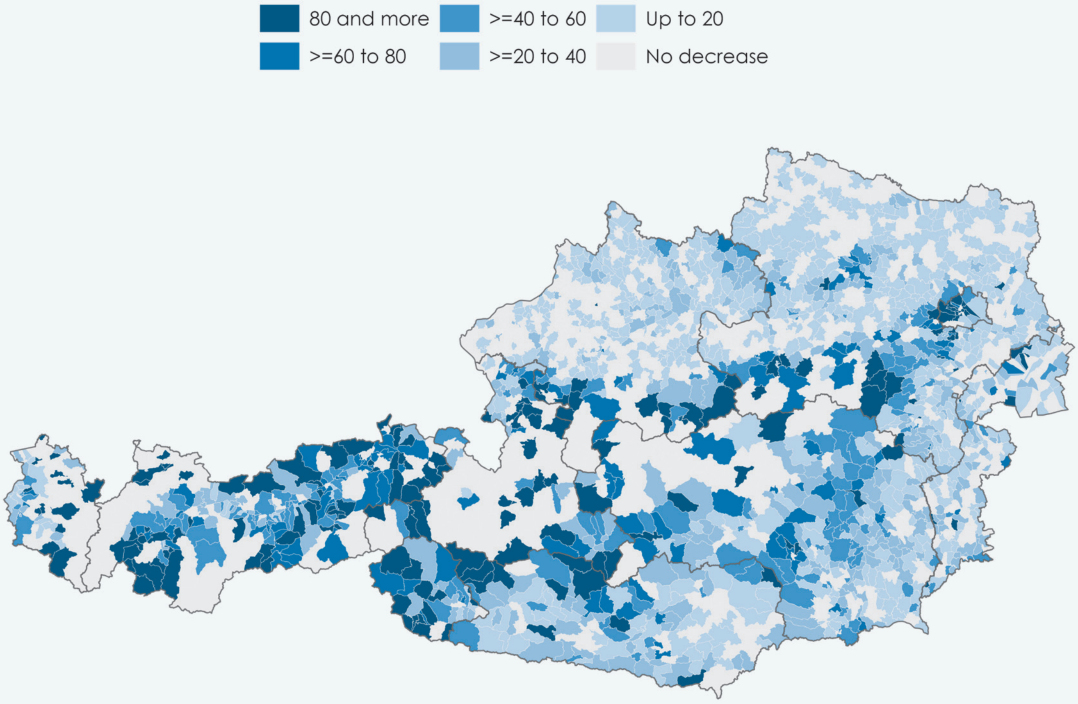
In 2020, arable land was cultivated in 92.5 percent of all municipalities in Austria, totalling around 1,322,900 ha. The area under cultivation has shrunk by a total of 72,362 ha (5.2 percent) since 1999, which is around 1.7 times the area of Vienna[3]. Figure 15 illustrates the extent of the decline by municipality.

Between 1999 and 2020, the arable land available for food production in Austria shrank by around 72,400 hectares, meaning that the potential yield fell by 13.7 percent.

[3] As the recording criteria for farms reporting land have changed slightly between the two Farm Structure Surveys in 1999 and 2020, the change in arable land area indicated is not exact.

Figure 15: **Decrease in cultivated arable land in Austria**

1999-2020, in percent



Source: WIFO calculations based on the Agricultural Structure Survey 1999 and 2020 (Statistics Austria, 2001, 2022a).

Table 2: **Crop yield and grain equivalents produced with and without loss of arable land**

	Crop yield	Grain equivalents	People fed[1]	Annual average population
	Million t		Million	
1999				7.99
2020				8.92
Without loss of space	13.78	95.39	9.17	
With loss of space	11.90	90.26	8.68	
Absolute change	– 1.88	– 5.13	– 0.49	+ 0.93
Percentage change	– 13.7	– 5.4	– 5.4	+ 11.6

Source: WIFO calculations based on the Agricultural Structure Surveys 1999 and 2020 (Statistics Austria, 2001, 2022a), Statistics Austria (2023a) and Schulze Mönking and Klapp (2010). – [1] With a requirement of 10.4 grain units per person per year.

The total potential yield of crops suitable for human nutrition was 11.9 million t in 2020. If the cultivated arable land had not shrunk since 1999, the potential crop yield would have been 13.7 percent (around 1.9 million t) higher. Converted to the number of grain equivalents produced and the number of people who could be fed by the arable crops produced, the decline amounts to around 5.4 percent (Table 2). The fact that it is significantly lower than 13.7 percent in grain equivalents is because the composition of crop types changed during the period under review. For example, crops with a high yield but low value for human nutrition (a low GE coefficient), such as sugar beet, have lost a disproportionate amount of weight.

3.5 Implications for food security

The results of the study show a significant long-term decline in arable land available for food production. However, agricultural goods are not used exclusively for human consumption, but also as animal feed and industrial raw materials. In addition, Austria has favourable conditions for the cultivation of permanent grassland, which can be used to produce animal feed. In 2020, around 1.2 million hectares of permanent grassland were cultivated (Statistics Austria, 2022a). Future analyses of food security should therefore also take into account the proportion of arable land and permanent grassland that is used to produce feed for livestock production.

Grain units are an easy-to-understand measure of supply performance, but do not take into account differences in product quality. For example, they do not differentiate between organically and conventionally produced products. Moreover, other important aspects such as a balanced supply of energy, protein and essential amino and fatty acids are also not accounted for. This aspect should also be addressed in future analyses.

In addition to land consumption, population growth and climate change also pose key challenges for future food security (Meyer & Sinabell, 2022). On the one hand, population growth will result in an increased demand for food. Forecasts assume that Austria's population will increase to 9.87 million by 2050 (main variant of Statistics Austria, 2023a). On the other hand, rising temperatures, changes in precipitation, more frequent extreme weather events and the decreasing availability of fresh water will have a negative impact on the crop growth and yields (Szalay et al., 2021). Since the yields per hectare of important crops have been stagnating for years and international studies (e. g., Zabel et al., 2021) even consider a potential decline in yields by the middle of the century, supply gaps cannot be compensated for by increases in productivity alone. Rather, it must be avoided that the area available for agricultural production continues to decrease.

3.6 Role of spatial planning and tax policy in reducing land consumption

In Austria, general responsibility (in terms of legislation and implementation) in the area of spatial planning and organisation falls within the remit of the federal provinces. Accordingly, there are nine different spatial planning acts, which form the binding basis for spatial planning and zoning by the municipalities. The responsible use of land is one of the main tasks of spatial planning. To this end, various utilisation requirements must be weighed up.

Three interrelated impact dimensions can be distinguished with regard to the goal of limiting land consumption through construction measures and settlement development. Firstly, avoidance by limiting the conversion of undeveloped land (grassland) into building land, secondly, recycling by incentivising the use of vacant residential and commercial buildings, and thirdly, intensification through using land already designated as building land and existing buildings (densification).

Spatial planning measures implemented by the federal provinces in terms of the economical use of land can be divided into four thematic categories:

- Legal requirements are regulatory measures defining the type of land.
- Fiscal instruments include tax and expenditure instruments, e.g., the infrastructure levy on undeveloped building land and vacancy and second home levies (discussed in detail in Arnold et al., 2023, 14f).
- Planning support is provided by measures to improve the information situation and monitor the impact of established practices, e.g., through spatial development concepts and ongoing monitoring.
- Awareness-raising measures, training programmes (e.g., soil protection) for the population and participatory and cooperative planning procedures support education and promote participation.

3.7 Conclusions

In Austria, urban sprawl particularly drives land consumption. Urban sprawl is associated with a particularly high demand for roads and other infrastructure (Brenner et al., 2024; Haberl et al., 2023; Dallhammer et al., 2021). In some rural regions, the sealed area of 1,500 m² per capita is already six times as large as in densely built-up urban areas (Dallhammer et al., 2021). Urban sprawl is also problematic from an economic perspective, as the creation and maintenance of infrastructure is associated with high costs. Moreover, it impedes the provision of nationwide public transport services, which would be a key step towards achieving socio-ecological transformation (cf. Egger et al., 2024).

The Austrian tax system contains numerous taxes and duties as well as special tax regulations that (can) influence land use and land consumption both positively and negatively (see Arnold et al., 2023). A reform of existing regulations that promote land consumption would be just as appropriate as innovative tax approaches to control land use in a way that protects the soil.

To date, no statistics are available that show how much arable land, grassland or forest is converted into settlement and infrastructure areas or used for other purposes. The newly introduced land monitoring programme (Austrian Conference on Spatial Planning, 2024) should provide this information regularly in future and thus support evidence-based decision-making. There is a need for research on the development and testing of land use strategies and scenarios with regard to different objectives. For example, the effects of land use on food security, emissions from the land use sector (LULUCF), the development of biodiversity and other ecosystem services should be analysed.

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