Interreg
EUROPEAN UNION
Danube Transnational Programme
EcoInn Danube

NATIONAL REPORT ON O&O – AUSTRIA

Project co-funded by European Union funds (ERDF and IPA)
Contact: ecoinn.danube@cvtisr.sk

2017

WP3	Strategy for eco-knowledge
ACTIVITY 3.2	Analysing the environment for ecoinnovation in partner countries
DELIVERABLE 3.2.2	National report on obstacles and opportunities

Project number	DTP1-191-1.1
Title of the project	Eco-innovately connected Danube Region (EcoInn Danube)
Version	Final
Author	ERDF PP12 Economica Institute of Economic Research, Julia Borrmann, Andrea Pitzschke, Kalpana Scholtes-Dash
Country	Austria
Date	2017

NATIONAL REPORT ON OBSTACLES AND OPPORTUNITIES

AUSTRIA

Figures and tables are numbered separately for each chapter

1. ABSTRACT

Austria is a leading country in the EU with respect to the government's financial support for research and development. Despite Austria's strong investment into R&D, government R&D outlays in the areas environment and energy (as a share of GDP) lie below the EU average. These areas thus receive less public R&D support - compared to the size of the economy - than on average in the EU. Nevertheless, Austria is a top performer in the EU in terms of eco-innovation activity, boasting the second highest share of firms introducing innovations with environmental benefits for the end user in the EU and the second highest share of firms introducing innovations with environmental benefits for the firm. Furthermore, patent and publication output in the field is well-above the EU average. Employment and revenue in eco-industries and the circular economy both lie below the EU average. Increasing financial support from the government in the areas environment and energy could be helpful for reaping higher socio-economic benefits from using eco-innovations and for achieving higher resource efficiency.

Having the largest per-capita ecological footprint among all Danube region countries, Austria clearly lives beyond its means. Only with drastic reductions in Greenhouse gas (GHG) emissions will Austria be able to reach the targets agreed to in the Paris Climate Act agreement. Raising the still comparatively low energy costs can set incentives for energy saving as well as for R&D of innovative energy-efficient products and services. Transformation from a throw-away society to the increased use of durable goods can trigger desirable re-orientation of the industrial sector. Austria´s waste recycling rates (packaging, plastics, e-waste etc.) lie within EU average, but -unlike the situation in many Danube region countries, have not developed favorably.

Despite EU-wide efforts (e.g. `Roadmap to a Resource-Efficient Europe´, 2011) towards higher resource productivity in order to decouple economic growth from resource use and its environmental impact, decoupling is not in sight. Austria´s measures taken during the past few years had a disappointingly small effect. With respect to environmental expenditures, Austria´s public sector should catch up with other countries, especially regarding expenditures with the potentially most-sustainable effects, i.e. investments.

We conclude that incentives and sanctions for both industry and households would be useful tools to cut down on material consumption and to improve resource efficiency. However, sanctions for companies must be well-planned (e.g. balanced with incentives) to avoid further increase of the already comparatively high production costs and resultant negative economic impacts as well as migration into countries with lower environmental standards.

2. OVERALL NATIONAL RANKING

Julia Borrmann

This section will provide an overview of the national ranking according to important composite indices on innovation, the "European Innovation Scoreboard - Summary Innovation Index", the "Eco-Innovation Scoreboard" as well as the "Innovation Output Indicator – Composite Score".

European Innovation Scoreboard

The European Innovation Scoreboard ranks the performance of EU Member States' innovation systems using 27 indicators aggregated into a Summary Innovation Index. Austria's score lies 21 percent above the EU average 2010 and 19 percent above the EU average 2016 with respect to the Summary Innovation Index. Austria has managed to improve its innovation performance significantly since 2010 and is currently clustered into the "strong innovators" group.

Given that Austria is the EU country with the highest score in the "strong innovators" group, Austria' ranking can be perceived as being very good, but needs to improve further, in order to leap forward into the group of "innovation leaders". Bringing Austria into the group of European innovation leaders by 2020 is a goal adopted by the Austrian government in the Strategy Plan for Research, Technology and Innovation[1]. The positive trend since 2010 and the strong performance increase compared to last year elicit a positive outlook for Austria, but given that all other EU countries are also trying to improve their innovation performance, relative improvements are difficult to achieve. In comparison to the other Danube Region countries, Austria currently has the second highest score behind Germany.[2]

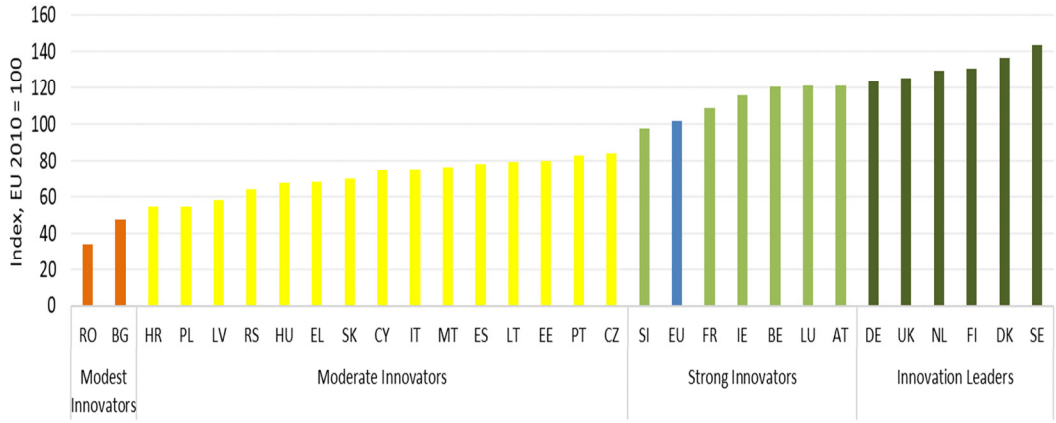


Figure 1: European Innovation Scoreboard – Summary Innovation Index, EU member states and Serbia, 2016 (Source: European Commission)

This research report aims to benchmark Austria's position in the EU and Danube region with regards to innovation in general and eco-innovation in particular. A third benchmark is used in Figure 2, called "strong innovators", showing the three strongest innovators in the Danube Region: Germany, Austria and Slovenia.[3]

[1] See BKA, BMF, BMUKK, BMVIT, BMWFJ and BMWF (2011).

[2] In all diagrams and charts on innovation, the Danube Region average is calculated as an unweighted average using data for Austria (AT), Bulgaria (BG), Croatia (HR), Czech Republic (CZ), Germany (DE), Hungary (HU), Romania (RO), Serbia (RS), Slovenia (SI) and Slovakia (SK), whenever available.

[3] With the exception of Figure 1, the country group "Strong Innovators" is defined in the Danube Region context, as the unweighted average of Germany, Austria and Slovenia, the three Danube Region countries with the highest scores in the Summary Innovation Index 2016 of the European Innovation Scoreboard.

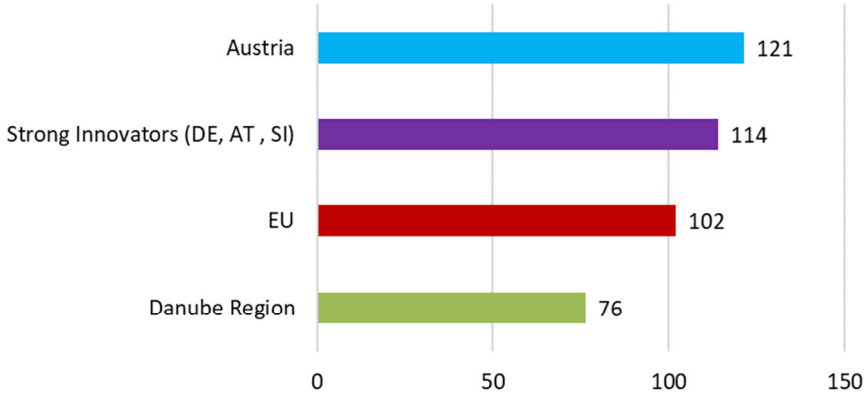


Figure 2: European Innovation Scoreboard - Summary Innovation Index 2016 (EU 2010 = 100), (Source: European Commission)

Austria's performance is far above the EU average with respect to the framework conditions; it is well-endowed with human resources and can build upon attractive research systems with a fair amount of publication output. A substantial amount of money (relative to GDP) is invested into public and business enterprise R&D. Austria is doing well concerning the amount of innovation activities, with a relatively high share of innovating SMEs, an above average amount of patents as well as a relatively large amount of intellectual assets (trademarks and design applications).

Weaknesses are present with respect to the innovation impacts, for example employment in fast-growing firms in innovative sectors and exports from knowledge-intensive services. Austria is a laggard concerning venture capital investment.

Eco-Innovation Scoreboard

The Eco-Innovation Observatory (EIO) devised an index composed of 16 indicators for comparing the eco-innovation performance of a country in comparison with the EU average. The Eco-innovation composite index consists of five components: (1) eco-innovation inputs, (2) eco-innovation activities and (3) eco-innovation outputs, (4) resource efficiency outcomes and (5) socio-economic outcomes.

Austria ranks eighth within the EU-28 in the Eco-Innovation Composite Index 2016 and achieves a score of 104, thus slightly above the EU average of 100. The Eco-Innovation Observatory clustered Austria into the group of the "average eco-innovation performers". Germany is in the lead achieving an index rating of 140, followed by Luxemburg and the three Nordic EU countries Finland, Denmark and Sweden. In comparison to last year, Austria has moved up from the twelfth to the eighth best performing member-state and has managed to improve its score in comparison to 2015 (2015: 101). On a positive note, the upward trend since 2015 can be mentioned as well as the fact that Austria is above the EU average and ranks second - on about the same level as Slovenia - behind Germany in the Danube Region.

Considering that Austria has the image of being very ecologically friendly and active in generating eco-friendly products and services, Austria's performance is lower than would be expected. Austria's heterogeneous performance with regards to the components of the Eco-Innovation Index provide indications as to where weaknesses might exist. Of the sixteen variables included in the Eco-innovation index, Austria lies above the EU average in seven of the indicators and below the EU average in eight indicators; and there is no value available for the indicator "water productivity". Austria does well regarding the categories "eco-innovation activities" and "eco-innovation outputs", but is below the EU

average with respect to “eco-innovation inputs”, “resource efficiency outcomes” and “socio-economic outcomes”.

Focusing on areas, where there is need for improvement according to the Eco-Innovation Index, the following aspects require reflection: Regarding the eco-innovation inputs, Austria surprisingly does not fare too well. Public funding in terms of the government’s environmental and energy R&D appropriations and outlays is (slightly) below the EU average, while green early-stage investments is very low in comparison to the other EU28 member-states. With respect to eco-innovation output, Austria does well regarding patents and publications, but lies below the EU average concerning eco-innovation related media coverage. The relatively low media coverage on eco-innovations may illustrate the need for creating more awareness for this subject. Looking at resource efficiency outcomes, Austria scores well on energy productivity, but lies far below the EU average regarding material productivity and GHG emissions intensity. Regarding the Socio-Economic Outcomes, Austria performs well with respect to the exports of products from eco-industries, but lies below the EU average concerning employment in eco-industries and circular economy and revenue in eco-industries and the circular economy.

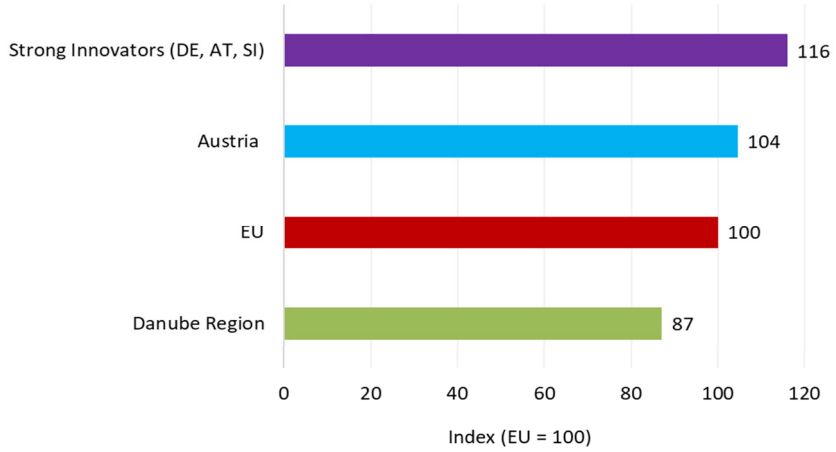


Figure 3: Eco-Innovation Index 2016, Composite Index (Source: Eco-Innovation Observatory)

Innovation Output Indicator

The Innovation Output Indicator was developed by the European Commission to benchmark national innovation policies. It is composed of the following four indicators:

- Patent applications per billion GDP (in PPS)
- Employment in knowledge-intensive activities as a percentage of total employment
- Share of medium and high-tech goods and services in a country’s exports
- Employment in high-growth enterprises in innovative sectors

The most recent Innovation Output Indicator 2016 was calculated with data from 2014. Austria’s innovation output in 2014 was slightly above the EU average, showing a strong catching-up process since 2011. Austria’s score has risen from 95.3 in 2011 to 104.0 in 2014 (EU 2011 = 100).

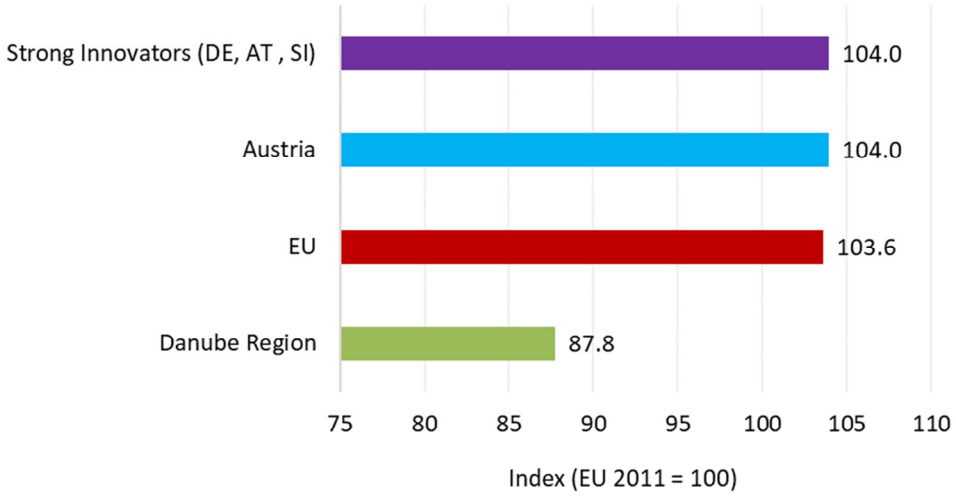


Figure 4: Innovation Output Indicator – Composite IOI Score, Index EU 2011 = 100 (Source: European Commission)

3. INNOVATION

Julia Borrmann

The European Innovation Scoreboard ranks the performance of EU Member States' innovation systems using 27 indicators grouped into the areas: framework conditions, investments, innovation activities and impacts. Austria comes in seventh in the EU and second in the Danube region with a score of 121 in the Summary Innovation Index (EU 2010 = 100). Austria has managed to improve its innovation performance significantly since 2010 reducing the distance to the innovation leaders.

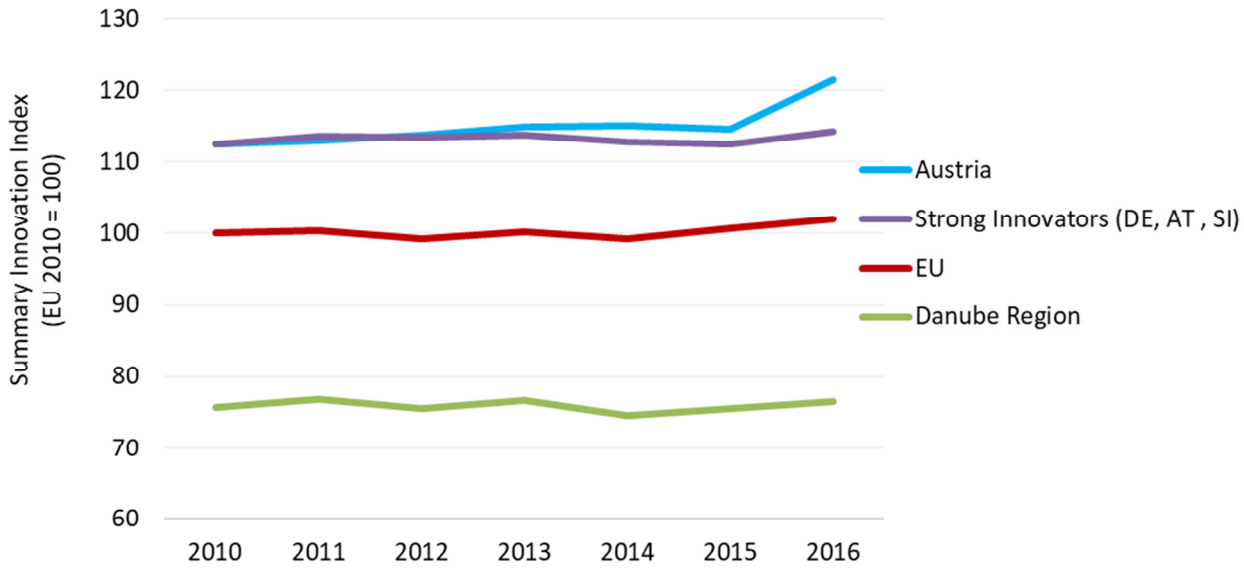


Figure 5: European Innovation Scoreboard - Summary Innovation Index, 2016 (Source: European Commission)
Note: The Member States' performance in 2016 is shown relative to that of the EU average in 2010.

Austria performs well in the three performance groups addressing the framework conditions (i.e. human resources, attractive research systems and innovation-friendly environment), in the three performance groups focusing on innovation activities (i.e. innovators, linkages and intellectual assets) and in the performance group "firm investments". Weaknesses are present with respect to the two performance groups directed at impacts (employment impacts and economic effects), in particular with respect to

employment in fast-growing firms in innovative sectors and exports from knowledge-intensive services. Another weakness can be found in the performance group "finance and support" concerning "venture capital investment", in which Austria is a true laggard.

SUMMARY INNOVATION INDEX	121.5
FRAMEWORK CONDITIONS	
Human resources	138.6
Doctorate graduates	130.7
Tertiary education	142.1
Lifelong learning	144.2
Attractive research systems	157.6
International co-publications	442.7
Most cited publications	116.9
Foreign doctorate students	114.9
Innovation-friendly environment	110.5
Broadband penetration	133.3
Opportunity-driven entrepreneurship	94.4
INVESTMENTS	
Finance and support	95.9
Public R&D expenditure	130.2
Venture capital investment	52.5
Firm investments	165.1
Business R&D expenditure	185.0
Non-R&D innovation expenditure	61.5
Upgrading ICT skills	228.6
INNOVATION ACTIVITIES	
Innovators	122.3
Product / process innovators	124.0
Organisational/marketing innovations	121.3
SMEs innovating in-house	121.6
Linkages	129.8
Innovative SMEs collaborating with others	193.3
Public-private co-publications	127.9
Private co-funding public R&D	79.5
Intellectual assets	139.7
PCT patent applications	115.5
Trademark applications	163.4
Design applications	154.3
IMPACTS	
Employment impacts	78.5
Employment in knowledge-intensive activities	114.1
Employment fast-growing firms in innovative sectors	52.5
Economic effects	82.7
Medium & high-tech product exports	106.6
Knowledge-intensive services exports	54.1
Sales of new-to-market and new-to-firm innovations	87.3

Table 1: European Innovation Scoreboard, Index (EU 2010 = 100), Austria, 2016 (Source: European Commission)
Note: Value above the EU average 2010 are shown in green, values below the EU average 2010 in red.

Selected indicators that are viewed as being particularly interesting are shown for Austria in comparison to the EU average and Danube Region average using diagrams.

Framework Conditions

Eight indicators of the Summary Innovation Index refer to the framework conditions. Austria scores above the EU average concerning the three human resources indicators (doctorate graduates, tertiary education and lifelong learning) and the three indicators measuring the attractiveness of the research systems (publications and foreign doctorate students). Austria has a mixed performance on the two indicators assessing the innovation-friendliness of the environment: Austria's score on broadband penetration is below the current EU-average (but above the EU-average 2010), opportunity-driven entrepreneurship is slightly above the current EU-average (but below the EU-average 2010).[4]

New doctorate graduates

The share of new doctorate graduates reflects the supply of new second-stage tertiary graduates (ISCED 8), i.e. typically Ph.D. graduates. Austria has 1.90 doctorate graduates per 1000 inhabitants aged 25 to 34. This is in line with the EU average (EU: 1.85) and the Danube Region average (DR: 1.88), but below the scores of Slovenia, Germany and Slovakia, the leading countries in the Danube Region. Austria has seen a declining share of new doctorate graduates since 2010, whereas the EU and the Danube Region witnessed an increase in 2012 and a relatively stable development since then. The declining figures in Austria can be explained with the fact that doctorates are viewed as declining in importance for non-academic careers.

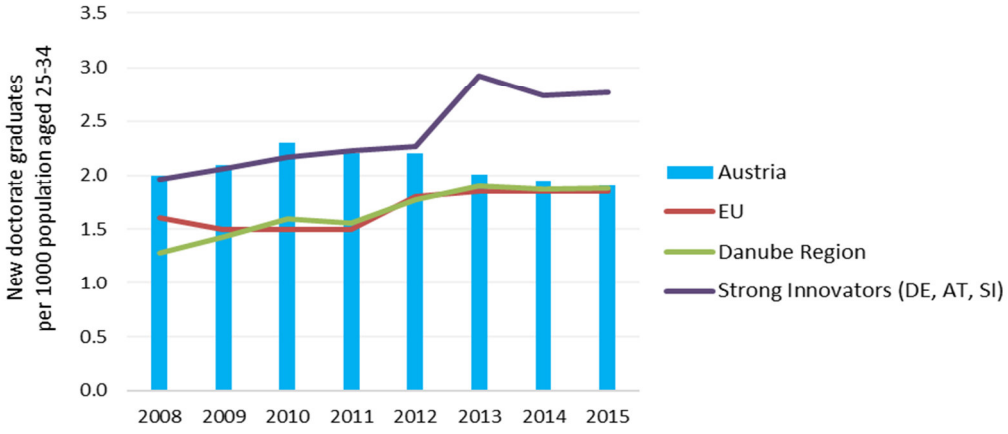


Figure 6: New doctorate graduates per 1000 population aged 25-34 indicator (Source: Eurostat)

OBSTACLE: New doctorate graduates as a share of the population aged 25 to 34 conforms to the EU average, but is far behind leading EU countries such as Slovenia. Furthermore, Austria's share has dropped significantly since the year 2010. In order to ensure a fresh supply of highly skilled human capital, Austria should set measures to make a Ph.D. more attractive, especially in those areas seen as particularly relevant for innovation. Such measures need to go beyond the Ph.D. program, because the decision to enrol in a Ph.D. programme, largely depend upon employment perspectives and research conditions after the completion of the Ph.D.

[4] The indicator broadband penetration is defined as the number of enterprises with a maximum contracted download speed of the fastest fixed internet connection of at least 100 Mb/s as a share of the total number of enterprises. The data source for this indicator is Eurostat and the Community Survey of ICT Usage and E-commerce in Enterprises.

Tertiary education

Nearly forty percent (39.7 percent) of the population aged 25 to 34 in Austria have completed tertiary education. Austria has managed to raise this share from 21 percent in 2010 from a level that was far below the EU average to a value that is slightly above the EU average (EU 2016: 38.2 percent) and significantly above the Danube Region average. This is due to a change in the indicator definition with a reclassification of the graduates of higher vocational education *(Berufsbildende Höhere Schulen)*.

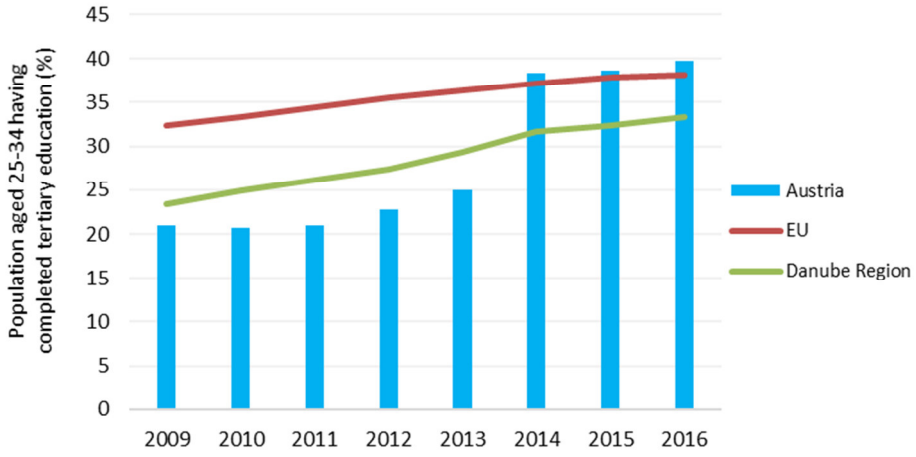


Figure 7: Population aged 25-34 having completed tertiary education, share in percent (Source: European Commission)

OPPORTUNITY: Austria has improved its ranking concerning the share of 25 to 34-year olds having completed tertiary education, due to a change in the definition of tertiary education. More effort is needed to boost the share of highly-trained people significantly above the EU average.

International scientific co-publications

Co-publication output is one way of showing how well research systems function. International scientific co-publications per million population are a proxy for the quality of scientific research. Austria has 1336 scientific publications with at least one co-author based abroad per million population. This is well above the EU average of 494 and the Danube Region average of 596. Austria has managed to significantly increase its international scientific co-publications in the past years, from 890 per million inhabitants in the year 2010. Austria is ahead of all other Danube Region countries.

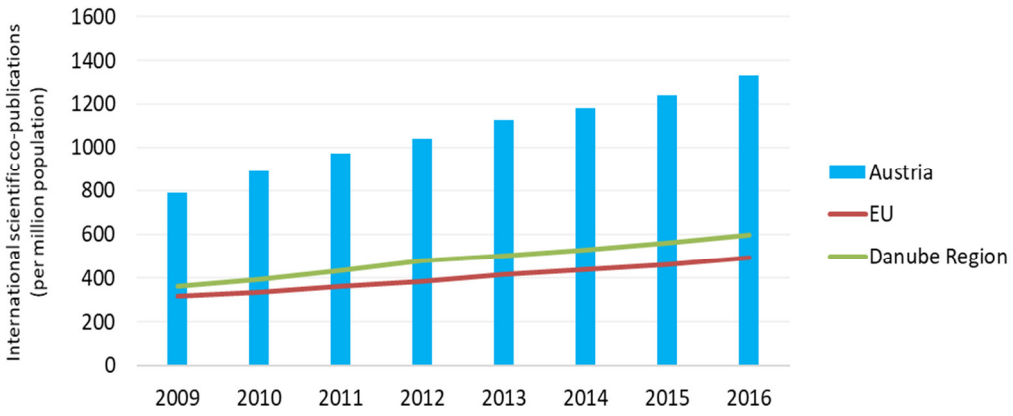


Figure 8: International scientific co-publications (Source: Eurostat, Web of Science)

OPPORTUNITY: In comparison to both the EU-28 and the Danube Region, Austria has a high share of international scientific co-publications. Austria should make sure that the benefits from international research networks become visible in output indicators that other nearer to the market, such as patents and in impact indicators, such as sales, employment and exports. The better the knowledge transfer from (basic) research to product and process innovations, the larger the benefits.

Scientific publications among the top 10% most cited publications

The European Innovation Scoreboard includes a second indicator on the publication output, namely scientific publications among the top 10 percent most cited publications worldwide as a share of the total scientific publications of the particular country. A share of 11.7 percent of all scientific publications of Austria are among the top 10% most cited publications worldwide compared to 10.6 percent on average in the EU and 7.0 in the Danube Region. Austria has seen an increase since 2010 (Austria 2010: 10.5 percent), while the EU average has only risen slightly (EU 2010: 10.3 percent). Europe is the leading Danube Region country with respect to this indicator.

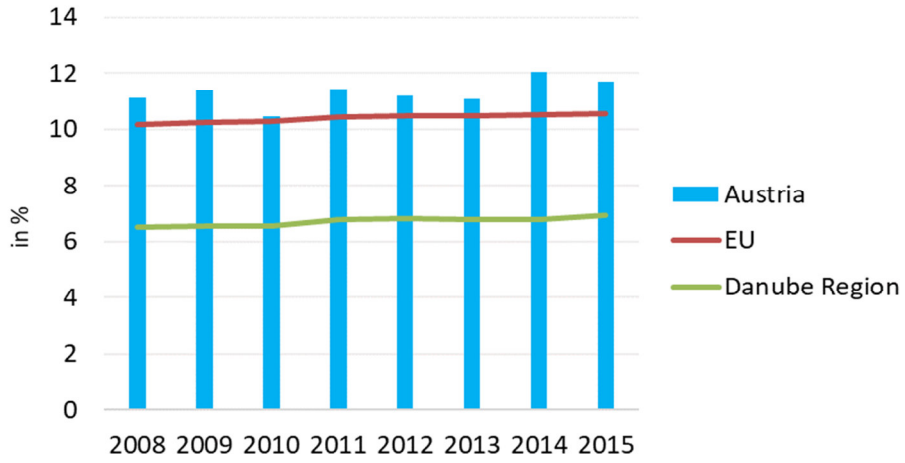


Figure 9: Scientific publications among the top 10% most cited publications worldwide as a share of the total scientific publications of the country (Source: Eurostat, Web of Science, CWTS - Leiden University)

OPPORTUNITY: Austria has a high share of heavily cited scientific co-publications, implying that Austria's scientific research output is of a high quality in comparison to both the EU-28 and the Danube Region. Austria should try to make sure that the research output translates into innovation activities such as patents, new products and processes. Integrating firms into applied research networks is useful for facilitating the process of translating publications into product innovations. Follow-up projects that help getting research results into firms might be useful.

Opportunity-driven entrepreneurship

This index is calculated as the ratio between the share of persons involved in improvement-driven entrepreneurship and the share of persons involved in necessity-driven entrepreneurship. Improvement-driven entrepreneurship includes persons involved in Early-Stage Entrepreneurial Activity, who claim to be driven by opportunity as opposed to finding no other option for work; and who indicate that the main drivers for entrepreneurship are independency and raising the income. Necessity-driven entrepreneurship includes persons involved in Early-Stage Entrepreneurial Activity, who claim to be involved in

entrepreneurship because they have no other option for working. In countries with a higher relative prevalence of improvement-driven opportunity entrepreneurship, the framework conditions for entrepreneurship seem to be favourable. A low score indicates a lack of other employment possibilities.

Austria has a score of 3.2, which is in line with the EU average of 3.1 and lies far above the Danube Region average of 1.9. Since the year 2010, Austria has however seen a large drop in the relative degree of opportunity-driven entrepreneurship (2010: 8.7), whereas the index scores for the EU (2010: 3.5) and Danube Region (2010: 2.6) have seen a weaker decline in the same time period. Nevertheless, Austria still has the highest score in the Danube Region.

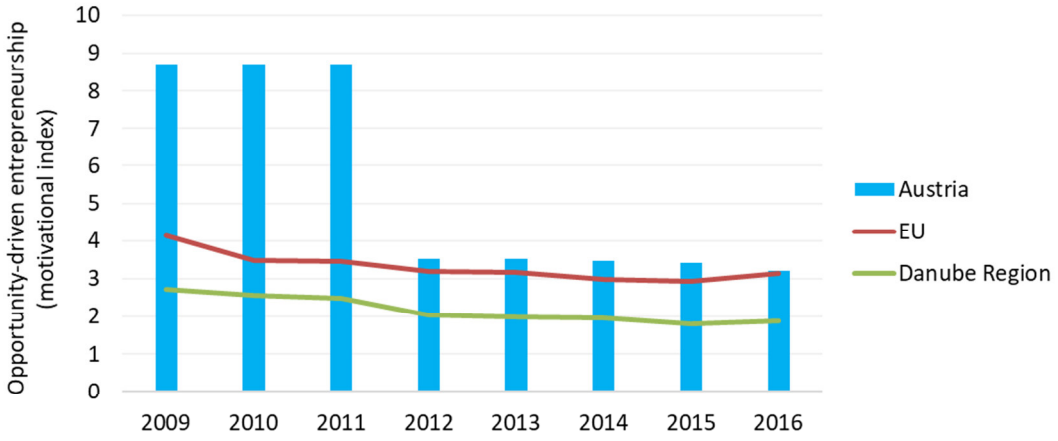


Figure 10: Opportunity-driven Entrepreneurship, Motivational Index, (Source: Global Entrepreneurship Monitor, GEM)
Note: Three-year averages are used.

OBSTACLE: The share of persons involved in improvement-driven entrepreneurship compared to the share of persons involved in necessity driven entrepreneurship is slightly above the EU average and far above the Danube Region average, but significantly behind leading EU countries such as Denmark, Sweden and Finland. Austria should try to improve the conditions for innovation-related entrepreneurial activity.

Investments

Five indicators of the Summary Innovation Index refer to the financial input into innovation. Austria has an above average score in three of the five indicators, i.e. public R&D expenditure, business R&D expenditure and upgrading ICT skills, but lies far below the EU average concerning venture capital investment and non-R&D innovation expenditure.

R&D expenditure in the public sector

In 2015, Austria allocated 0.89 percent of its GDP to fund research and development activities in the public sector, which is comprised of the government and higher education sector. This is significantly above the 0.71 percent share allocated by the European Union average and the Danube Region average of 0.60 percent. Figure 11 shows the R&D expenditure in the public sector in the period from 2008 to 2015.

R&D expenditure in the public sector includes the government sector (GOVERD) and the higher education sector (HERD). Austria's R&D investment in the public sector was already far above the EU average in the

year 2008. While Austria increased its R&D expenditure in the public sector significantly from 0.79 percent of GDP in 2008 to 0.89 percent in 2015, the share of the European Union rose more moderately - from 0.66 to 0.71 percent - during the same period. Austria has the second highest R&D expenditure in the public sector in Danube Region behind Germany (Germany: 0.93 percent of GDP).

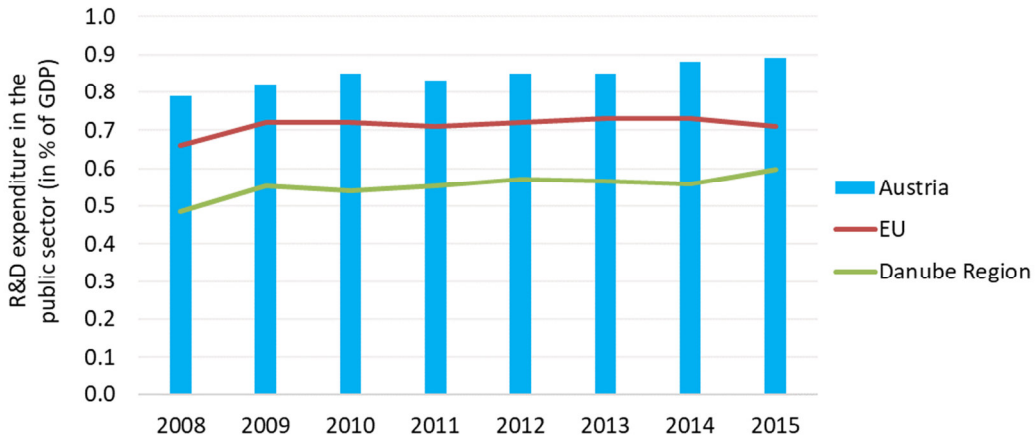


Figure 11: Public R&D expenditure as % of GDP, 2008 – 2015 (Source: Eurostat)

OPPORTUNITY: In comparison to both the EU-28 and the Danube Region, Austria is investing a large share of GDP into R&D activities in the public sector. Austria needs to make sure that it can reap the returns in terms of output and impacts from its relatively well-funded of public R&D. The efficient use of public expenditure on R&D should be ensured. Administration should not take up too large a share of the government's expenditure on R&D.

Venture capital

While public and business funding for R&D is readily available, the amount of venture capital made available to firms is rather low in Austria.[5] Venture capital is defined as private equity capital for investment in companies. Austria's venture capital investment has risen from 0.041 percent of GDP in 2010 to 0.051 percent of GDP in 2015, but is still significantly below the EU average (0.063). The indicator values for the EU average and Danube Region have dropped since 2010. Austria has the third highest score in the Danube Region, behind Hungary and Croatia.

[5] See also AustrianStartups (2017) addressing the Austrian Startup Agenda.

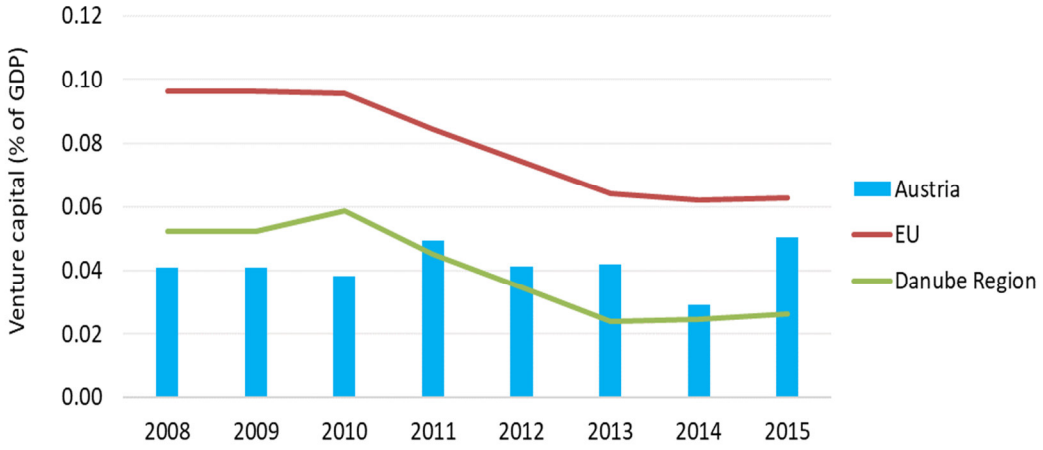


Figure 12: Venture capital (in percent of GDP), 2008 – 2015 (Source: Invest Europe, European Commission)
Note: Three-year averages are used.

OBSTACLE: The share of venture capital as a percentage of GDP is well below the EU average. As venture capital is often the only form of external financing available for young firms using new and risky technologies, too little venture capital can limit the creation of innovative firms and innovative products and processes. Austria should thus try to improve the framework conditions for venture capital being made available in order to boost the creation of new enterprises using or developing new, risky technologies.

R&D expenditure in the business sector

R&D expenditures in the business enterprise sector account for a share equal to 2.18 percent of GDP; the EU average lying at 1.30 percent of GDP in 2015. The R&D expenditure in the Austrian business sector is not only far above the EU average, but is also showing an upwards trend from 1.87 percent of GDP in 2010. Austria currently has the highest R&D expenditures in the business enterprise sector in the Danube Region and the second highest in the EU, behind Sweden.

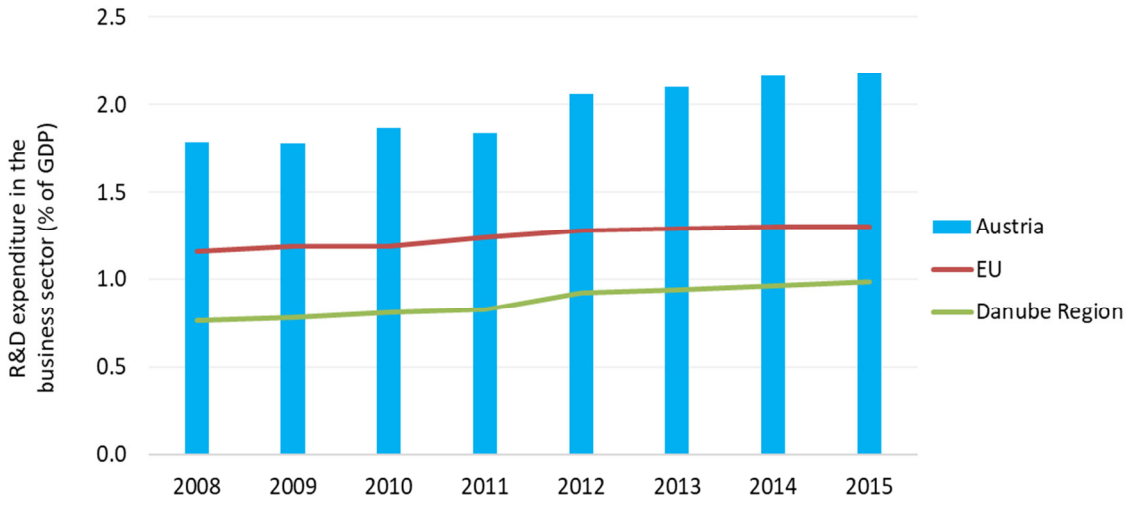


Figure 13: R&D expenditure in the business sector as a share of GDP (BERD), 2008 - 2015 (Source: Eurostat)

OPPORTUNITY: Austria is investing far more into research and development in the private sector than the EU average. It needs to make sure that it can reap the benefits from its investment.

Innovation Activities

Innovation activity is measured using nine indicators with Austria scoring above the EU average on eight of these indicators and below the EU average on one indicator. Austria scores well with respect to the four indicators measuring innovation activity in SMEs, regarding patent, trademark and design applications as well as concerning public-private co-publications per million population, but lies below the EU average in the private co-funding of public R&D expenditures (as a percentage of GDP).

SMEs introducing product or process innovations

A share of 40.7 percent of all SMEs in Austria introduce product or process innovations. This is far above the EU average of 30.9 percent and the Danube Region average of 24.6 percent. In the Danube Region, Austria ranks second behind Germany (41.6), but the leading EU country Belgium is far ahead with a share of 48 percent. Austria's share of SMEs introducing product or process innovations is slightly higher than 2010, after a temporary drop in 2013 and 2014. The values for the EU and for the Danube Region have fallen since 2010.

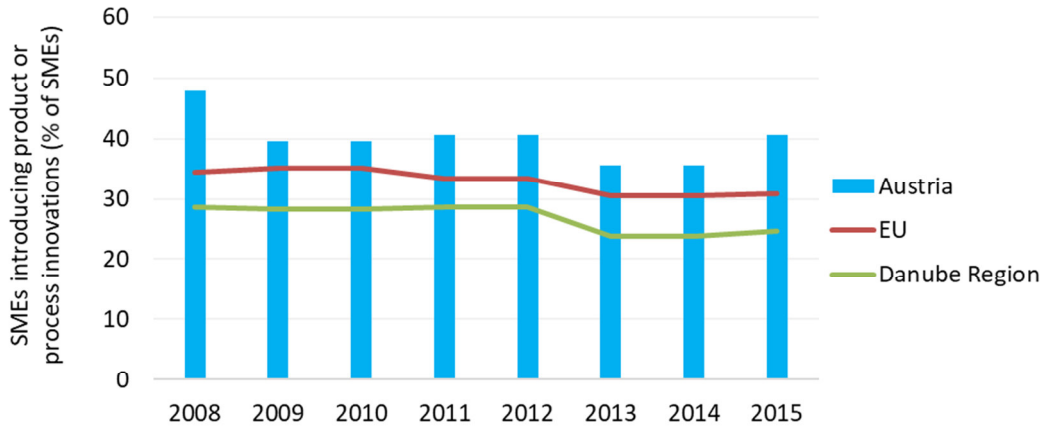


Figure 14: SMEs introducing product or process innovations (in percent of all SMEs), 2008 - 2015 (Source: Eurostat, Community Innovation Survey)

OPPORTUNITY: Austria has an above average share of innovative SMEs as a percentage of all SMEs. This is a positive indication concerning the domestic technological innovation activity. There is however still a lot of room for improvement, if Austria wants to become an innovation leader in the EU with respect to this indicator.

SMEs introducing marketing or organisational innovations

Almost every second SME or 46.1 percent of all SMEs in Austria introduce marketing or organisational innovations. The EU average lies at 34.9 percent, the Danube Region average at 28.3 percent. Whereas the share has increased in the past few years, there has been a decline in the share for the EU and Danube Region average. Austria ranks second in the Danube Region, behind Germany (49.1 percent). Switzerland is

in the lead in Europe with a share of 62.0 percent.

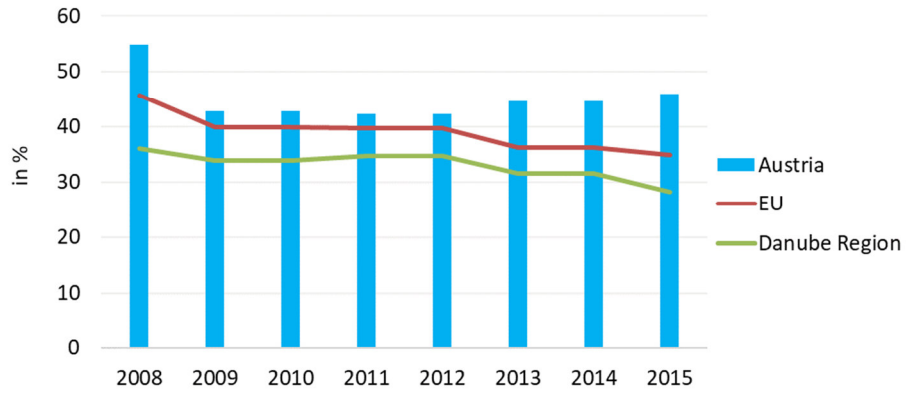


Figure 15: SMEs introducing marketing or organisational innovations (in percent of all SMEs), 2008 - 2015 (Source: Eurostat, Community Innovation Survey)

OPPORTUNITY: Austria has an above average share of SMEs engaging in non-technological forms of innovation with an upwards trend, but should try to increase its share further in order to raise the innovative potential of SMEs even more.

SMEs innovating in-house

More than a third (35.0 percent) of all SMEs in Austria conduct in-house innovation activities compared to 28.8 percent in the EU and 21.6 percent in the Danube Region. Austria has the second highest score in the Danube Region behind Germany (37.9 percent) and ranks seventh in the EU with the EU leading country being Ireland with 41.3 percent. The share of SMEs innovating in-house in Austria is now on about the same level as in the year 2010.

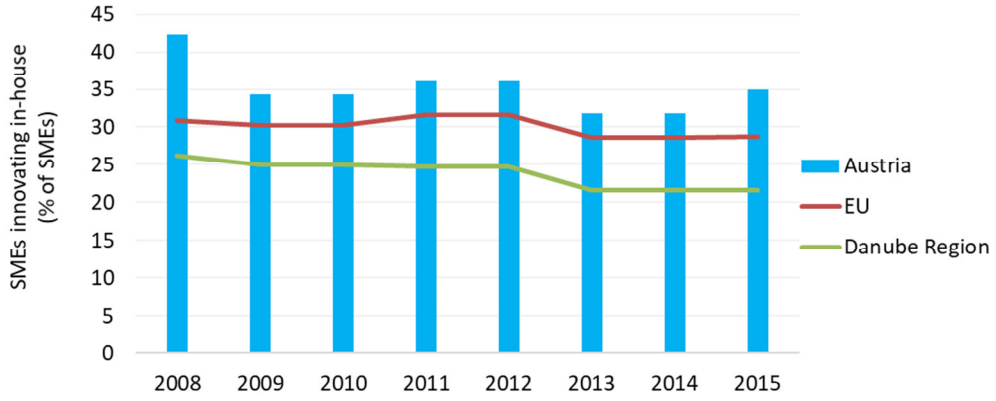


Figure 16: SMEs innovating in-house (in percent of all SMEs), 2008 - 2015 (Source: Eurostat, Community Innovation Survey)

OPPORTUNITY: Austria is doing well with respect to in-house innovation activities by SMEs in comparison to the EU and Danube average, but could try to catch up with EU forerunner countries such as Ireland, by raising the awareness concerning the benefits and possibilities of being active in the field of research. Sponsoring master theses could be a first step for entering the world of R&D for SMEs. Networking activities with research institutions in the proximity of SME locations can help spark more research activities.

Innovative SMEs collaborating with others

About every fifth (or 20 percent) of all SMEs in Austria carry out innovation activities together with other enterprises or institutions. That is both far above the EU average of 11.2 percent and the Danube Region average of 8.9 percent. Austria has the highest value in the Danube Region and is ranked third in the EU with Belgium (28.6 percent) in the lead.

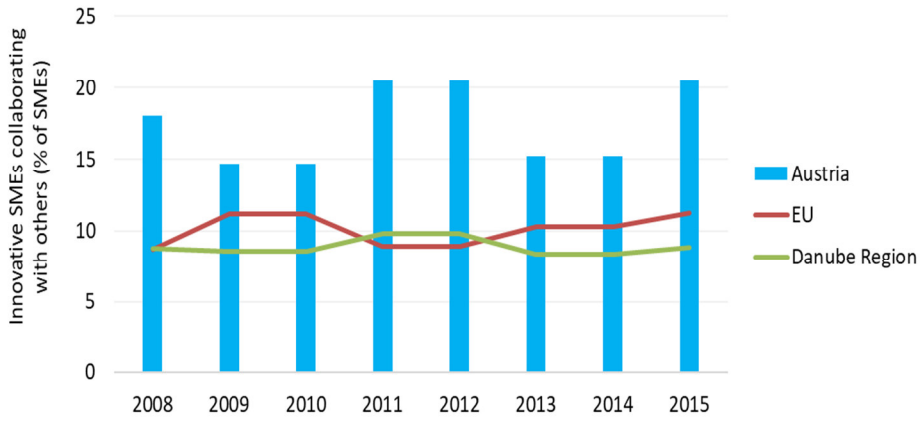


Figure 17: Innovative SMEs collaborating with others (in percent of all SMEs), 2008 - 2015 (Source: Eurostat, Community Innovation Survey)

OPPORTUNITY: Austria has a high share of SMEs engaged in innovation activities with other enterprises or institutions. The SMEs need to make sure that they are able to generate new or improved products and processes from the innovative activities.

PCT patent applications

Austria has 4.9 PCT patent applications per billion GDP (in Purchasing Power Standards). This is a third more than the EU average of 3.7 and more than double the Danube Region average of 2.1. Austria ranks second in the Danube Region behind Germany. Austria's patent output relative to GDP (in PPS) has fluctuated a little in the past years, but is now slightly below the level in 2010. The EU average and the Danube Region average have remained quite stable in the monitored time period.

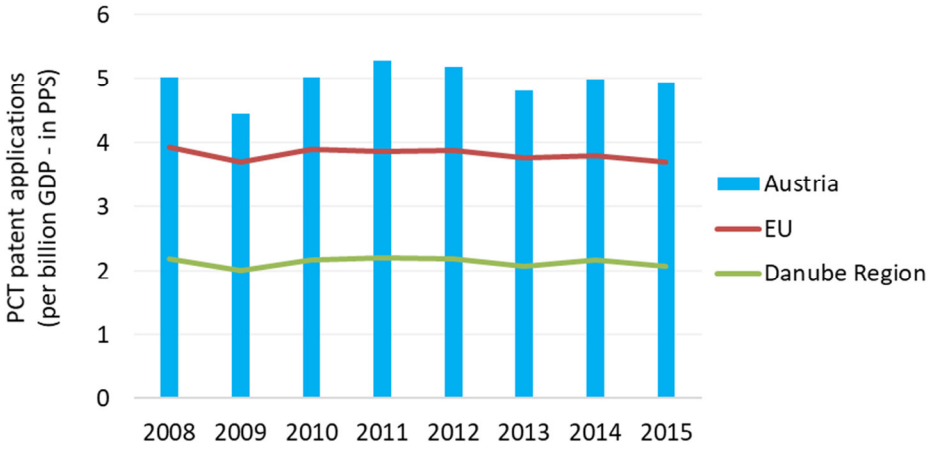


Figure 18: PCT patent applications per billion GDP (in PPS), 2008 – 2015 (Source: European Commission OECD, Eurostat)

OPPORTUNITY: Austria has a high share of PCT patent applications per billion GDP (in PPS) in comparison to the EU average and the Danube Region, but should try to boost its patent output further in order to become an innovation leader in the EU.

Impacts

This indicator category addresses the effect on employment and sales. Looking at the five indicators in this category, Austria has a mixed performance with room for improvement. Austria lies above the EU average regarding the employment share in knowledge-intensive activities and with respect to the export share in medium and high-tech products. Employment in fast-growing firms in innovative sectors and knowledge-intensive service exports lie far below the EU average however. Sales of new-to-market and new-to-firm innovations are also below the EU average.

Employment in Knowledge-Intensive Activities (KIA)

In Austria, employment in knowledge-intensive activities is above the EU and Danube Region average. A share of 14.6 percent of all employees worked in knowledge intensive activities in 2016, whereas the EU average is slightly lower at 14.1 percent and the Danube Region average at 12.2 percent. The share has increased moderately since 2010 in Austria (2010: 14.0 percent), the EU and the Danube Region.

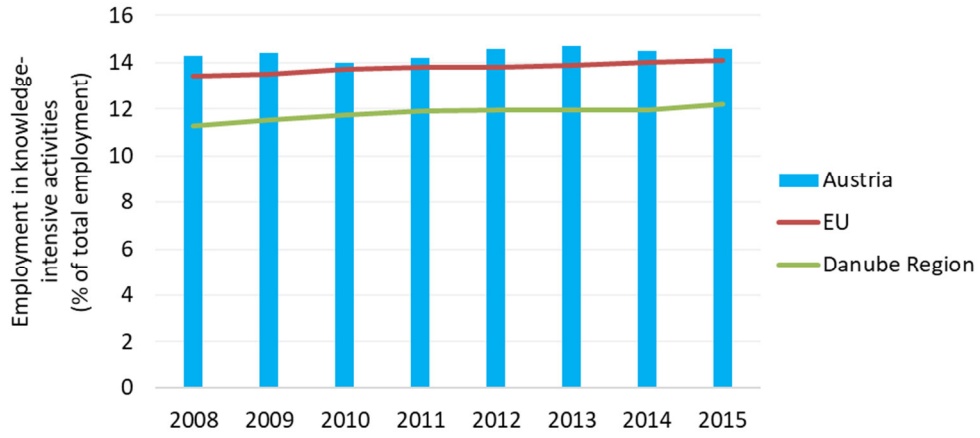


Figure 19: Employment in Knowledge-Intensive Activities (KIA) as a share of total employment (Source: Eurostat)

OBSTACLE: Employment in knowledge-intensive activities as a share of total employment in Austria is slightly above the EU average, but Austria needs to try to make these areas more attractive in order to become an innovation leader.

Exports of medium and high technology products

More than half (57.6 percent) of all products exported from Austria involve medium and high technology products[6]. That is (slightly) above the EU average of 56.2 percent and significantly above the Danube

[6] Medium and high technology exports include exports of the following SITC Rev.3 products: 266, 267, 512, 513, 525, 533, 54, 553, 554, 562, 57, 58, 591, 593, 597, 598, 629, 653, 671, 672, 679, 71, 72, 731, 733, 737, 74, 751, 752, 759, 76, 77, 78, 79, 812, 87, 88 and 891.

Region average of 54.2 percent. Four Danube Region countries, i.e. Hungary, Germany, Slovakia and the Czech Republic have a higher share of medium and high technology exports than Austria. The share of medium and high technology product exports has been increasing steadily in Austria since the year 2012. The EU and the Danube Region have also witnessed a strong upward trend.

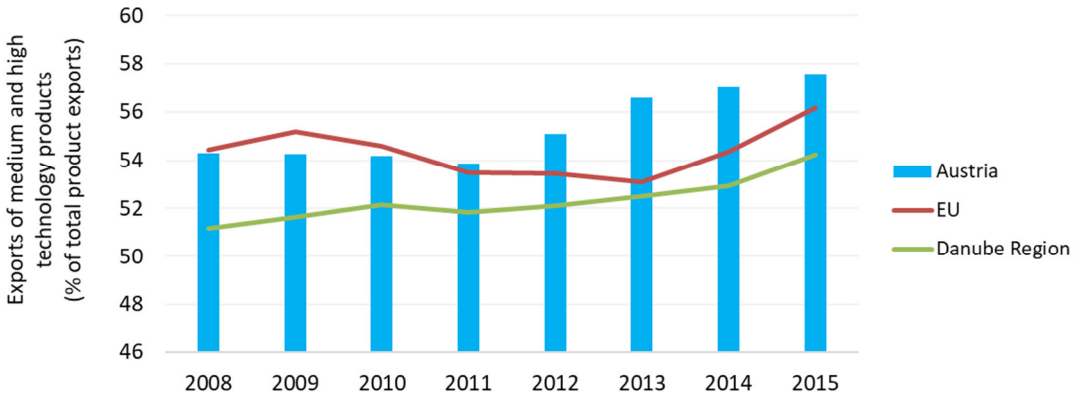


Figure 20: Exports of medium and high technology products, 2008 – 2015 (Source: Eurostat)

OPPORTUNITY: Austria has an above average share of medium and high technology product exports, but should aim to increase this value further.

Knowledge-intensive services exports

Austria has a relatively low share of knowledge-intensive services exports measured as a percentage of total services exports, whereby knowledge-intensive services exports refer to exports in sea transport, air transport, space transport, insurance and pension services, financial services and charges for the use of intellectual property.[7] Whereas about a half (44.4 percent) of all services exports in Austria involve knowledge-intensive services, the EU average lies at 69.3 percent. The Danube Region average share of 42.7 percent is slightly lower than the Austrian share. Over time, i.e. in the past few years, the Austrian share as well as the EU and Danube Region average share have remained relatively stable.

[7] Exports of knowledge-intensive services are defined as the sum of credits in the EBOPS 2010 (Extended Balance of Payments Services Classification) items SC1 (Sea transport), SC2 (Air transport), SC3A (Space transport), SF (Insurance and pension services), SG (Financial services), SH (Charges for the use of intellectual property), SI (Telecommunications, computer, and information services), SJ (Other business services) and SK1 (Audio-visual and related services). Calculations for the indicator are carried out by the European Commission (Joint Research Centre), see European Innovation Scoreboard 2017 - Methodology Report.

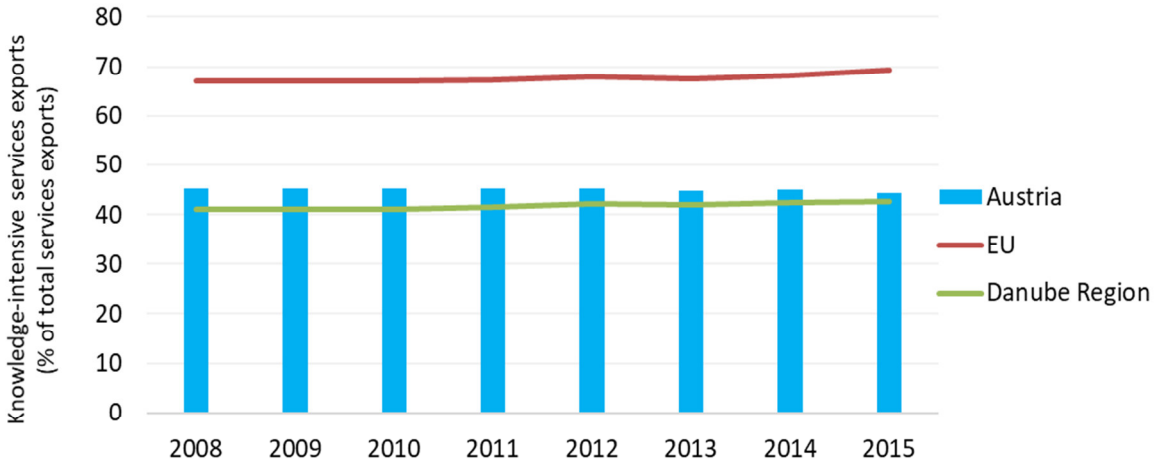


Figure 21: Knowledge-intensive services exports (% of total services exports), 2008 – 2015 (Source: Eurostat)

OBSTACLE: Austria has a relatively low share of knowledge-intensive services exports as a share of total services exports. The strong tourism sector might be a factor contributing to the low relative importance of knowledge-intensive services exports, but nevertheless Austria should try to make conditions for the flourishing of these services and their export more favourable.

Sales of new-to-market and new-to-firm innovations

Less than an eighth (12.0 percent) of the enterprise turnover in Austria comes from sales of new-to-market and new-to-firm innovations. This is below the EU average of 13.4 percent, but above the Danube Region average of 11.2 percent. A number of Danube Region countries, including Slovakia, the Czech Republic, Germany, Hungary, Slovenia and Serbia have higher shares than Austria.

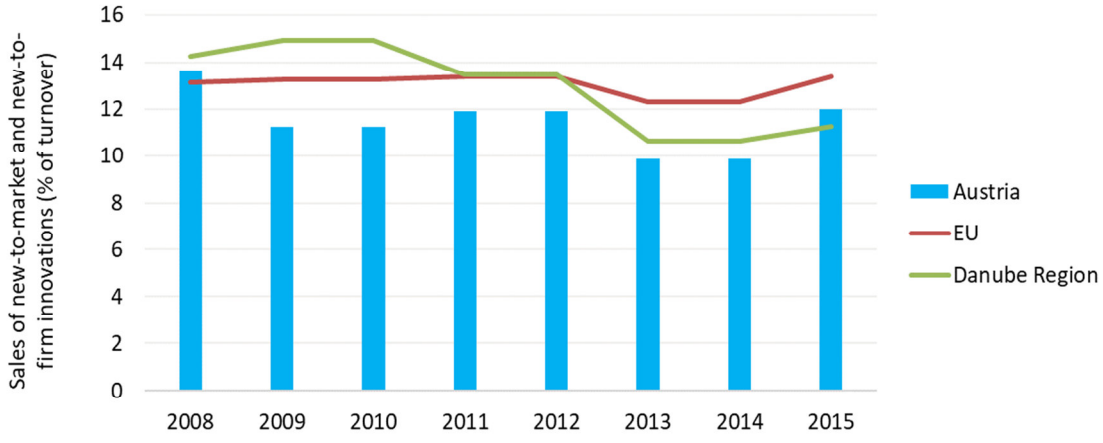


Figure 22: Sales of new-to-market and new-to-firm innovations (% of turnover), 2008 – 2015 (Source: Eurostat, Community Innovation Survey)

OBSTACLE: Austria has a relatively low share of sales from new-to-market and new-to-firm innovations as a percentage of turnover. Austria should try to find out what the causes are and should then eliminate the obstacles for the creation and diffusion of innovative products.

3.1 Eco-Innovation Scoreboard and Eco-Innovation Index

The Eco-Innovation Observatory (EIO) devised an index composed of 16 indicators for comparing the eco-innovation performance of a country in comparison with the EU average.[8] The Eco-innovation composite index consists of five components: (1) eco-innovation inputs, (2) eco-innovation activities and (3) eco-innovation outputs, (4) resource efficiency outcomes and (5) socio-economic outcomes.

Austria ranks eighth in the EU-28 in the Eco-Innovation Composite Index 2016 and achieves a score of 104, thus slightly above the EU average of 100. The Eco-Innovation Observatory clustered Austria into the group of the "average eco-innovation performers", while Germany is in the lead with an index rating of 140, followed by Luxemburg and the three Nordic EU countries Finland, Denmark and Sweden. In comparison to last year, Austria has moved up from the twelfth to the eighth best performing member-state, improving its score since last year (2015: 101). The current score is still far below that achieved in 2010; the previous downturn was however influenced by changes in the composition and calculation of the indicators.

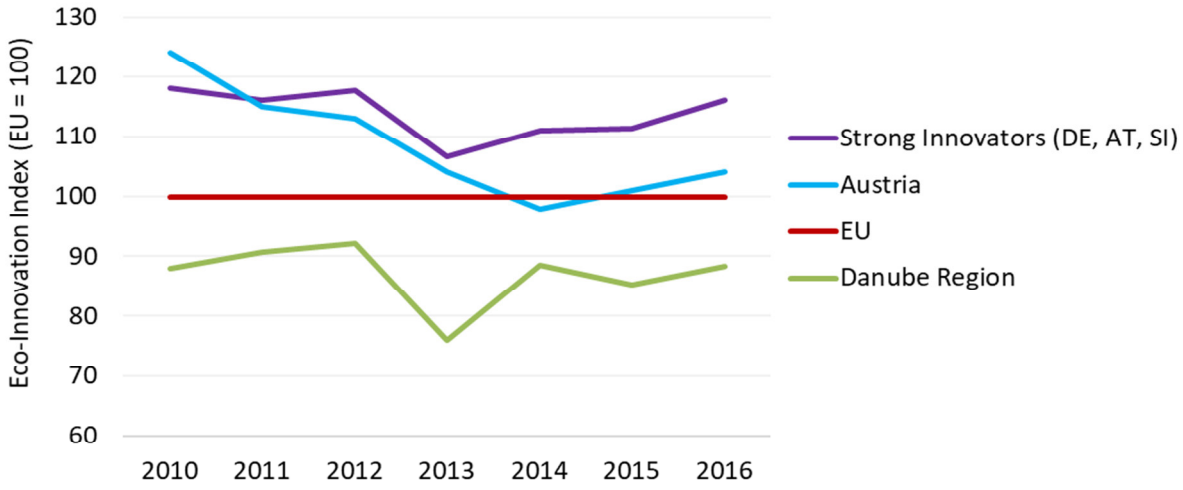


Figure 23: Eco-innovation Index, Austria, 2010 - 2016 (Source: Eco-Innovation Observatory)

Austria scores particularly well in the categories "eco-innovation activities" and "eco-innovation outputs", but is below average with respect to "eco-innovation inputs", "resource efficiency outcomes" and "socio-economic outcomes".

[8] For a more detailed analysis of the Austrian situation concerning eco-innovations see also Bliem et al. (2014) and Frischenschlager (2014).

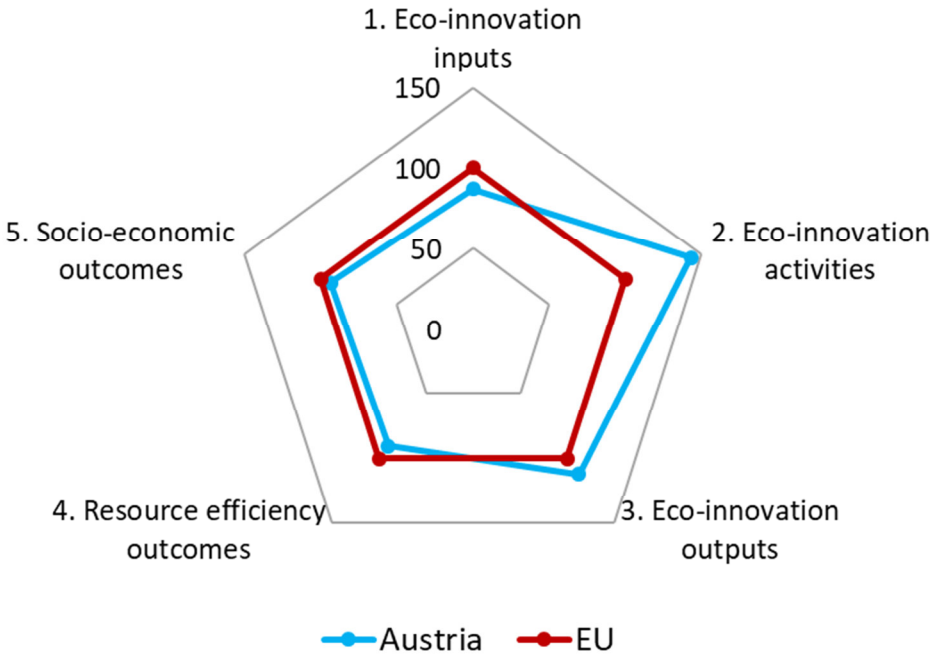


Figure 24: Eco-innovation Index – Thematic Areas, Austria vs. EU average, 2016 (Source: Eco-Innovation Observatory)

Of the sixteen variables included in the Eco-innovation index, Austria lies above the EU average in seven of the indicators and below the EU average in eight indicators; and there is no value available for the indicator "water productivity".

	Index Score
Eco-Innovation Index (Composite Index)	**104**
1. Eco-innovation inputs	**87**
1.1. Governments environmental and energy R&D appropriations and outlays (in % of GDP)	86
1.2. Total R&D personnel and researchers (in % of total employment)	142
1.3. Total value of green early stage investments (in USD per capita)	21
2. Eco-innovation activities	**143**
2.1. Enterprises that introduced an innovation with environ. benefits within the enterprise	152
2.2. Enterprises that introduced an innovation with environmental benefits by the end user	193
2.3. ISO 14001 registered organisations (per mln population)	48
3. Eco-innovation outputs	**112**
3.1. Eco-innovation related patents (per mln population)	134
3.2. Eco-innovation related academic publications (per mln population)	141
3.3. Eco-innovation related media coverage (per numbers of electronic media)	54
4. Resource efficiency outcomes	**93**
4.1. Material productivity (GDP/Domestic Material Consumption)	68
4.2. Water productivity (GDP/total fresh water abstraction)	n/a
4.3. Energy productivity (GDP/gross inland energy consumption)	113
4.4. GHG emissions intensity (CO2e/GDP)	63
5. Socio-economic outcomes	**90**
5.1. Exports of products from eco-industries (in % of total exports)	115
5.2. Employment in eco-industries and circular economy (in % of total employment)	74
5.3. Revenue in eco-industries and circular economy (in % of total revenue)	62

Table 2: Eco-innovation Index, Indicator values for Austria, 2016 (Source: Eco-Innovation Observatory)

Eco-Innovation Inputs

Eco-innovation inputs comprise investments (financial or human resources) aiming to trigger eco-innovation activities. Concerning the Eco-Innovation Input Index, Austria achieves a score of 87, which is below the EU average, but above the Danube Region average. Austria ranks second in the Danube Region, behind Germany, and twelfth in the EU. Austria fell behind in its relative position in the EU, from the ninth rank in 2015.

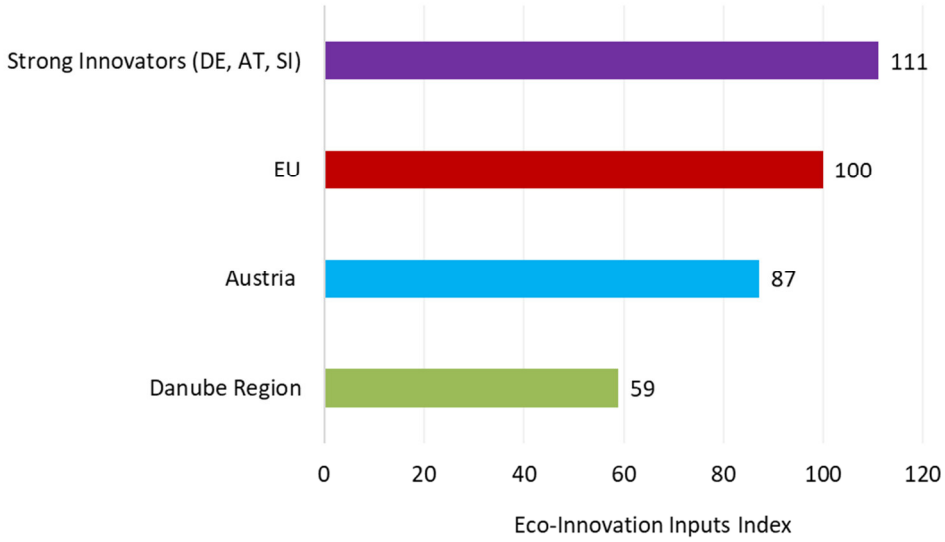


Figure 25: Eco-Innovation Inputs Index 2016 (Source: Eco-Innovation Observatory)

The three indicators in the category eco-innovation inputs are (1) Governments environmental and energy R&D appropriations and outlays (% of GDP), (2) Total R&D personnel and researchers (% of total employment), (3) Total value of green early stage investments (in USD per capita).

The government R&D outlays in the areas environment and energy amount to 0.033 percent of Austrian GDP and thus lie below the EU average of 0.044 percent. Germany, the forerunner in the Danube Region, spends 0.067 percent of GDP on government R&D appropriations and outlays in this area. The second input indicator "employment share of R&D personnel and researchers" is significantly above the EU average, comprising 1.70 percent of the Austrian employees in 2015, whereas the EU average lies at 1.32 percent. Austria has a low value of green early-stage investments in comparison to the other EU28 member states with an index value of 21, thus far below the EU average of 100 and Germany reaching 244. Austria's total amount of green early-stage investments amounted to around 61 Euro per capita in the previous report period, i.e. between 2012 and 2015.[9]

[9] Value for 2012 to 2015 from Eco-Innovation Observatory (2016).

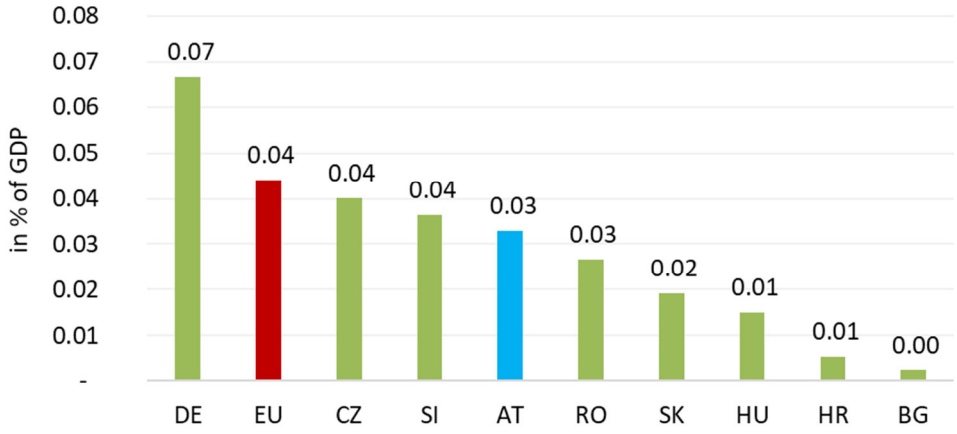


Figure 26: Government's environmental and energy R&D appropriations and outlays, in % of GDP (Source: Eurostat)

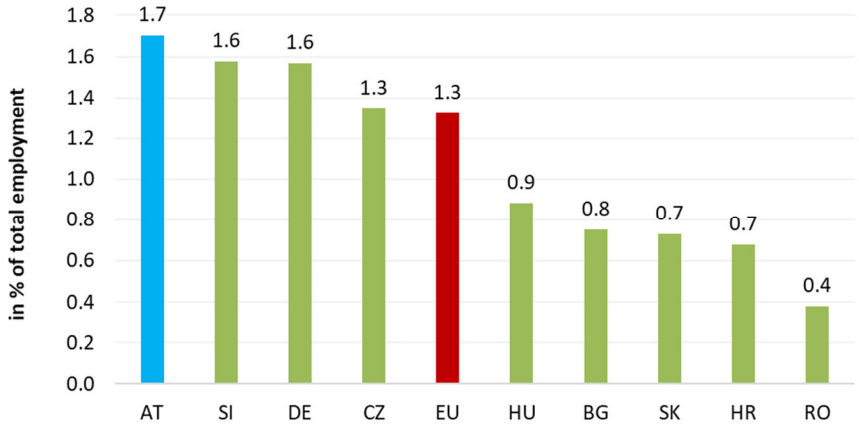


Figure 27: Total R&D personnel and researchers (% of total employment), 2015 (Source: Eurostat)

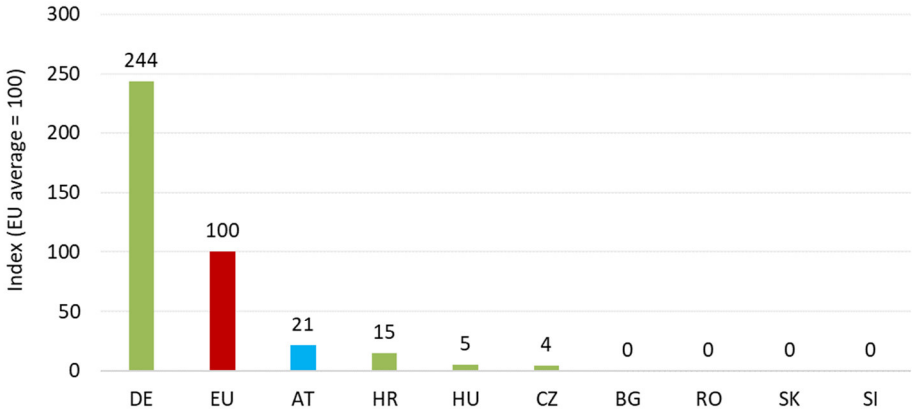


Figure 28: Green early stage investments per capita, 2013 – 2016, Index, EU average = 100 (Source: Cleantech Industries)

OBSTACLE: Austria's performance with regards to the Eco-Innovation Inputs Index is below the EU average, but above the Danube Region average. This is due to a heterogeneous performance with a good score regarding the share of R&D personnel and researchers in percentage of employment, but government R&D outlays in the areas environment and energy that are below the EU average and very low green early-stage investments in comparison to the other EU28 member-states. Austria needs to improve the latter, in order

to score higher on the Eco-Innovation Input Index.

Eco-Innovation Activities

Austria ranks fourth in the EU in 2016 with respect to the Eco-Innovation Activities Index, moving up steeply from rank 12 in 2015 and achieving a score of 143. In the Danube Region, Austria is on second place behind Germany.

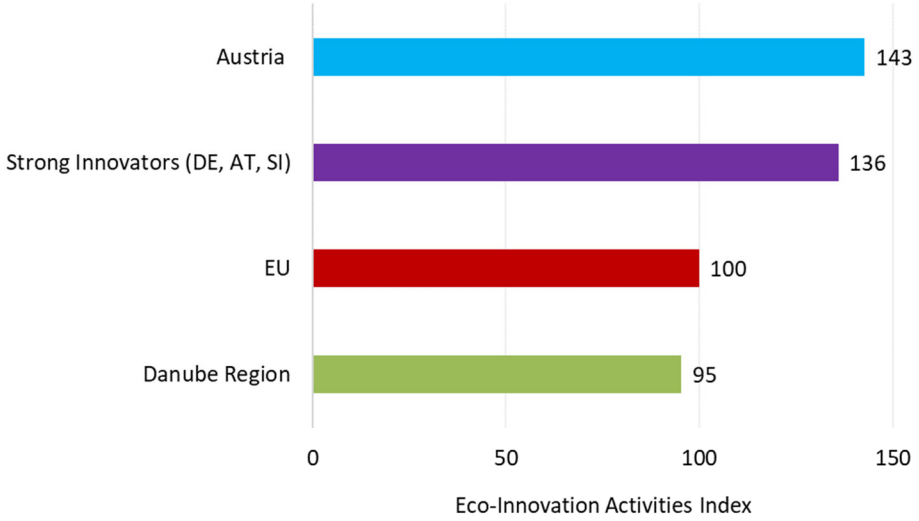


Figure 29: Eco-innovation Activities Index 2016 (Source: Eco-Innovation Observatory)

The Eco-Innovation Activities Index is made up of three indicators: (1) Enterprises that introduced an innovation with environmental benefits obtained within the enterprise (in % of all firms), (2) Enterprises that introduced an innovation with environmental benefits obtained by the end user (in % of all firms) and (3) ISO 14001 registered organisations per million inhabitants. The first two indicators are based on data from the Community Innovation Survey 2014 (CIS 2014) and are shown in Figure 30.[10]

Nearly a third (32 percent) of all Austrian enterprises included in the Community Innovation Survey introduced an innovation with environmental benefits obtained within the enterprise and a quarter of all Austrian enterprises introduced an innovation with environmental benefits obtained by the end user. Austria comes in second in the EU with respect to both CIS indicators, scoring 152 and 193 respectively (with the EU average being 100).

According to the results from the Community Innovation Survey 2014, the most frequently specified benefit from eco-innovations was an energy reduction or reduction of the CO_2-footprint. More than a third (36 percent) of all innovating firms in Austria benefited from energy reductions within the enterprise due to the introduction of eco-innovations. Not only the firms, but also the end consumers benefited from energy reductions. 29 percent of the innovating enterprises in Austria report that their eco-innovations generate environmental benefits in the form of energy reductions through the use or consumption of the product. This is the most frequently named benefit for consumers achieved by the introduction of eco-innovations.

[10] Values for the EU28 are not available, because not all EU member states participated in this component of the survey.

The third indicator for eco-innovation activities addresses the number of ISO 14001 registered organisations relative to the country's population. Austria has far fewer ISO 14001 registered organisations in comparison to the size of its population than the EU average. One reason lies in the fact that Austrian firms and organisations sometimes implement the EU Eco-Management and Audit Scheme (EMAS) system rather than ISO (EIO, 2016); EMAS is however not included in the eco-innovation scoreboard.

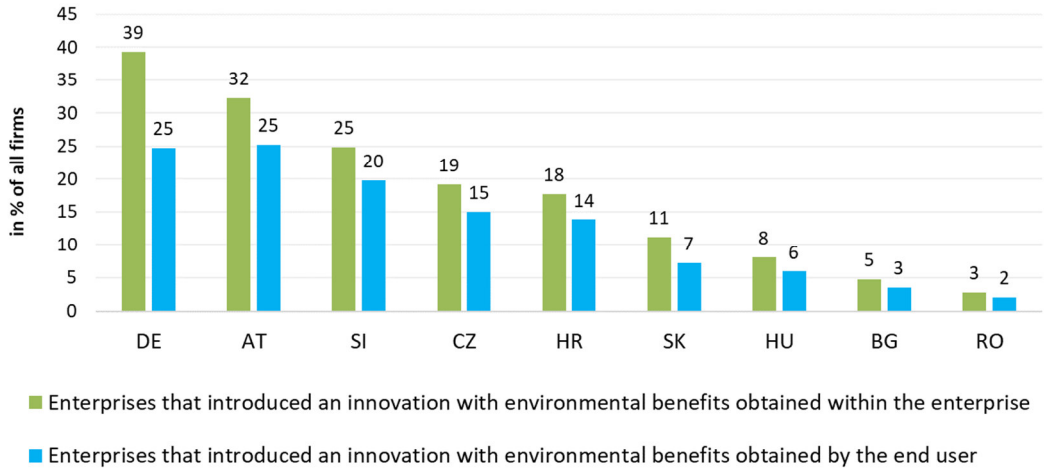


Figure 30: Enterprises that introduced an innovation with environmental benefits obtained within the enterprise and by the end user, in % of all firms, 2014 (Source: Eurostat. CIS)

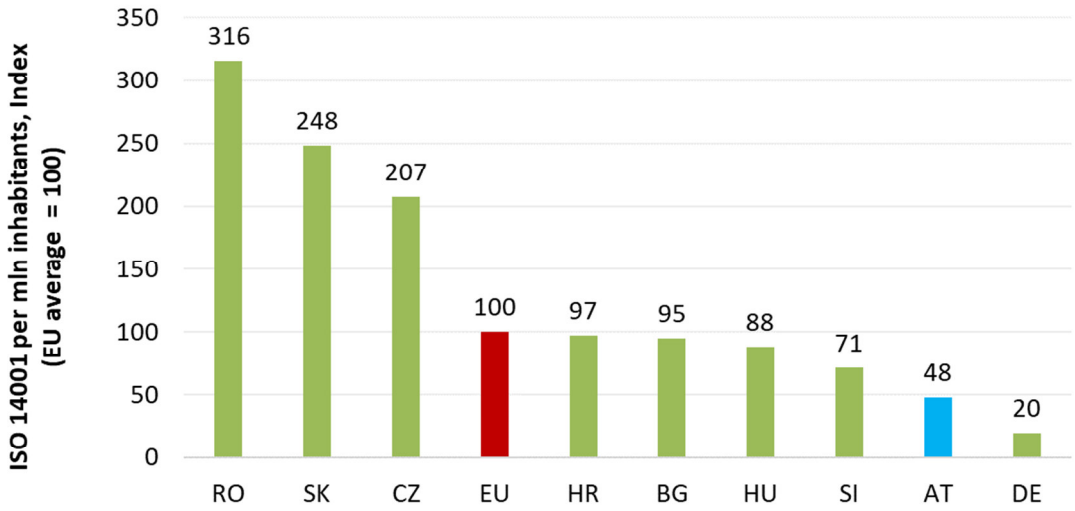


Figure 31: ISO 14001 registered organisations per mln inhabitants, Index EU Average = 100. 2015 (Source: ISO Survey of Certifications)

OPPORTUNITY: Austria has a strength with respect to its eco-innovation activities and its performance is well-above the EU and Danube Region average. Further improvements are possible, if ISO 14001 are increased, however EMAS certification is popular in Austria, so that the indicator selected for the Eco-Innovation Index underestimates Austria's performance.

Eco-Innovation Outputs

Austria ranks twelfth in EU and third in the Danube Region (behind Germany and Slovenia) with respect to the Eco-Innovation Output Index achieving an index score of 134. Austria fell back with regards to its relative position from the fifth rank in the EU in 2015.

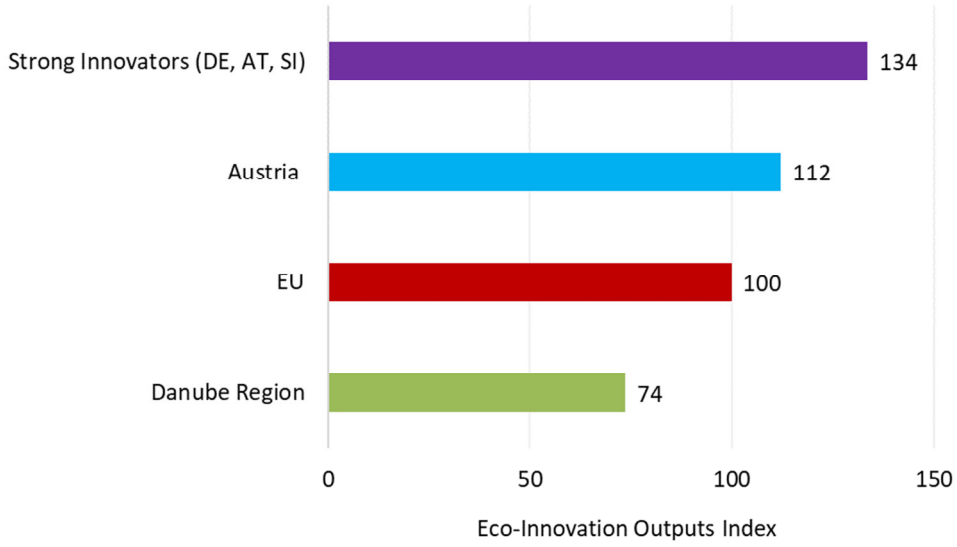


Figure 32: Eco-Innovation Outputs Index 2016 (Source: Eco-Innovation Observatory)

Eco-innovation output consists of three indicators: (1) eco-innovation related patents, (2) eco-innovation related publications and (3) eco-innovation related media coverage. Austria scores well with respect to its eco-innovation related patent and publication output. Austria's index score for the eco-innovation related patent activity is one third above the EU average, ranking Austria sixth in the EU28, behind Germany, Denmark, Sweden, France and Finland as well as second in the Danube Region. Concerning eco-innovation related publications Austria's index score for the publication output per capita is 141 with the EU average at 100. Austria has the tenth highest value in the EU. However, Austria scores well below the EU average with respect to eco-innovation related media coverage. The relatively low media coverage on eco-innovations may illustrate the need for creating more awareness for this subject.

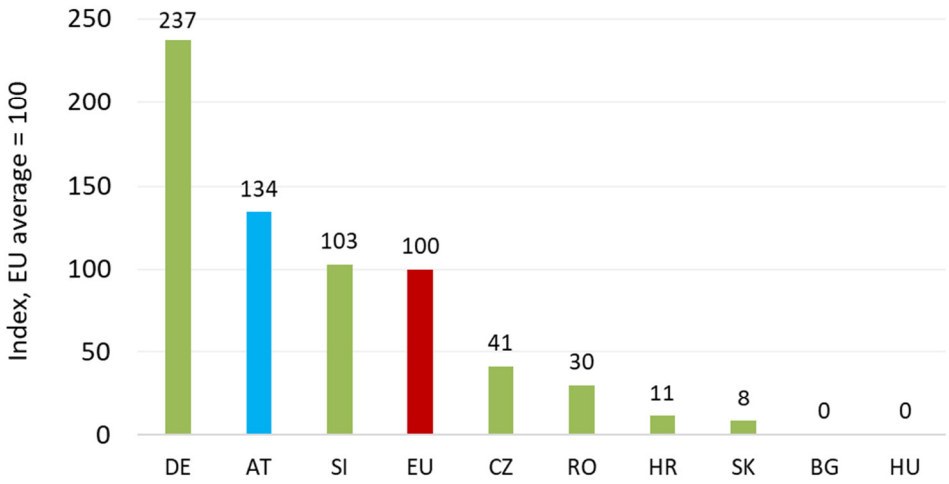


Figure 33: Eco-innovation related patents per capita, Index EU = 100, 2013 (Source: Patstat, Eco-Innovation Observatory)

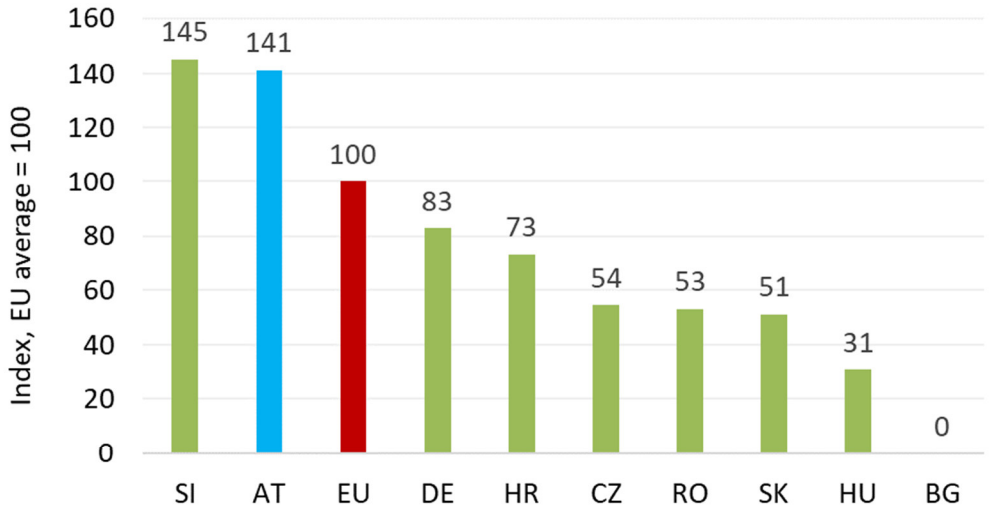


Figure 34: Eco-innovation related publications per capita, Index EU = 100, 2015 (Source: Scopus, Eco-Innovation Observatory)

OPPORTUNITY: Austria scores well regarding the eco-innovation related patents and eco-innovation related publications, but below the EU average regarding the eco-innovation related media coverage. More media coverage on eco-innovations can help create more awareness for this topic.

Resource Efficiency Outcomes Index

Surprisingly, Austria achieves a relatively low score with regards to the Resource Efficiency Outcomes Index. Austria attains an index score of 93, lying both below the EU and Danube Region average, ranking 19th in the EU and fifth in the Danube Region, behind Slovakia, the Czech Republic, Germany and Croatia. Austria has fallen back in its relative position since last year (eleventh rank in the EU in 2015). The Eco-Innovation Output Index is made up of four indicators, whereby only three are available for Austria. Austria scores well on energy productivity, but lies far below the EU average regarding material productivity and GHG emissions intensity.

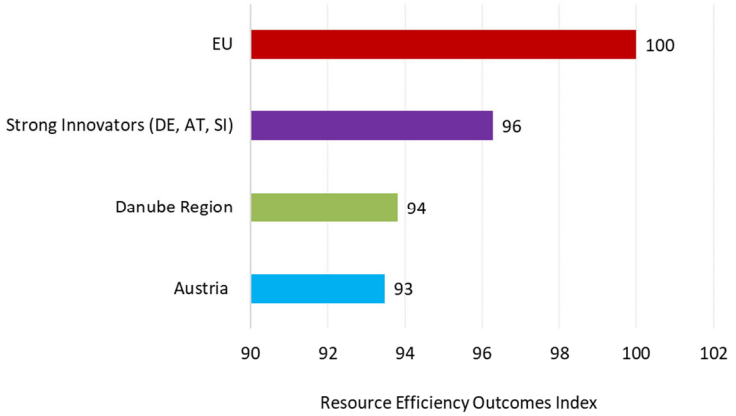


Figure 35: Resource Efficiency Outcomes Index 2016 (Source: Eco-Innovation Observatory)

OBSTACLE: Austria would need to improve its material productivity and GHG emissions intensity in order to score better overall regarding the resource efficiency.

Socio-Economic Outcomes Index

Austria's performance is both below the EU and Danube Region average with respect to the Socio-Economic Outcomes Index. Achieving an index score of 90, Austria ranks 14th in the EU and eighth in the Danube Region, behind Slovakia, the Czech Republic, Germany, Hungary, Slovenia, Romania and Croatia. In comparison to last year, Austria managed to move up (2015: rank 21 in the EU). The index is made up of three indicators; Austria performs well with respect to the exports of products from eco-industries, but lies below the EU average concerning employment in eco-industries and circular economy and revenue in eco-industries and the circular economy.

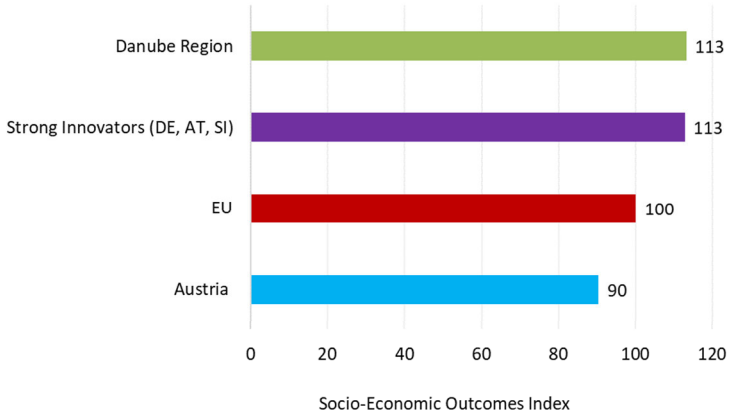


Figure 36: Socio-Economic Outcomes Index 2016 (Source: Eco-Innovation Observatory)

OBSTACLE: Austria's performance with regards to the Socio-Economic Outcomes Index is both below the EU and below the Danube Region average. lies below the EU average. Austria would need to improve its performance regarding employment in eco-industries and circular economy as well as regarding the revenue in eco-industries and the circular economy in order to improve its overall performance regarding the socio-economic outcomes.

3.2 Innovation Output Indicator

The Innovation Output Indicator developed by the European Commission to benchmark national innovation policies is composed of the following four indicators:

- Patent applications per billion GDP (in PPS)
- Employment in knowledge-intensive activities as a percentage of total employment
- Share of medium and high-tech goods and services in a country's exports
- Employment in high-growth enterprises in innovative sectors as a percentage of total employment

The most recent Innovation Output Indicator 2016 was calculated with data for 2014. Austria's innovation output in 2014 conforms to the EU average, showing a strong catching-up process since 2011. Austria's score has risen from 95.3 in 2011 to 104.0 in 2014.

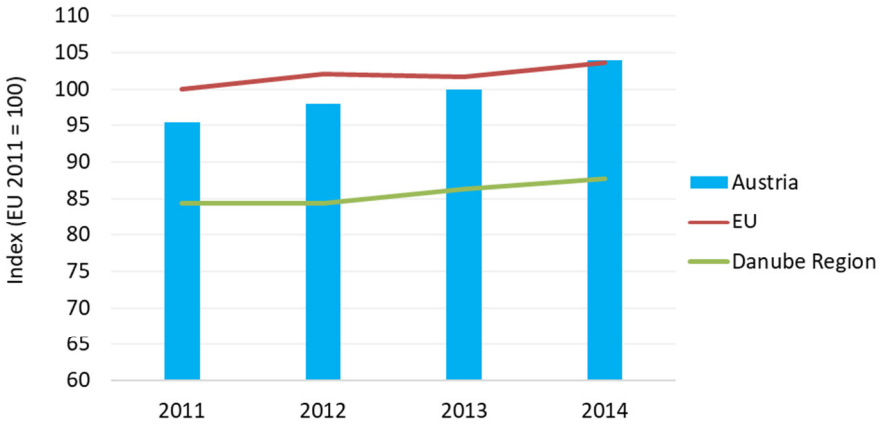


Figure 37: Innovation Output Indicator – Composite IOI Score, Index EU 2011 = 100 (Source: European Commission)

Austria has a mixed performance concerning the four indicators included in the Innovation Output Indicator. It does well in comparison to the EU average with respect to its patent output, which is nearly a third higher than the EU average and more than double as high as in the Danube Region average. Employment in knowledge-intensive activities as a percentage of total employment in Austria is slightly above the EU average and significantly above the Danube Region average. The share of medium and high-tech goods and services in a country's exports is below the EU average, but above the Danube Region average. This result is driven by a very low share of knowledge-intensive service exports in total service exports in Austria compared to the EU average according to the data for 2014. Employment in high-growth enterprises in innovative sectors is above the EU average according to the indicator definition for the Innovation Output Indicator.[11]

OBSTACLE: Austria is in line with the EU average regarding the Innovation Output Indicator. The result is based upon a heterogenous performance regarding the four indicators included in the index. While Austria is strong regarding its patent output, it needs to strengthen its share of knowledge-intensive services in the service exports.

3.3 Research and Innovation Observatory – Key Indicators

The European Commission provides innovation indicators on its Research and Innovation Observatory. Selected indicators that are viewed as being of particular interest are shown below.

Scientists and engineers as a share of the active population

Austria has a lower share of scientists and engineers as a percentage of the active population than the EU average, but witnessed a strong increase since 2011. The share of scientists and engineers in the active population increased from 3.5 percent in 2010 to 6.1 percent in 2016 in Austria. It still lies below the EU average of 7.0 percent in 2016 however. Slovenia and Germany are the leading countries in the Danube Region with a share equal to 7.6 and 7.5 percent respectively; the Danube Region average is at 5.8 percent.

[11] Vertesy and Deiss (2016), Figure 13, p. 24.

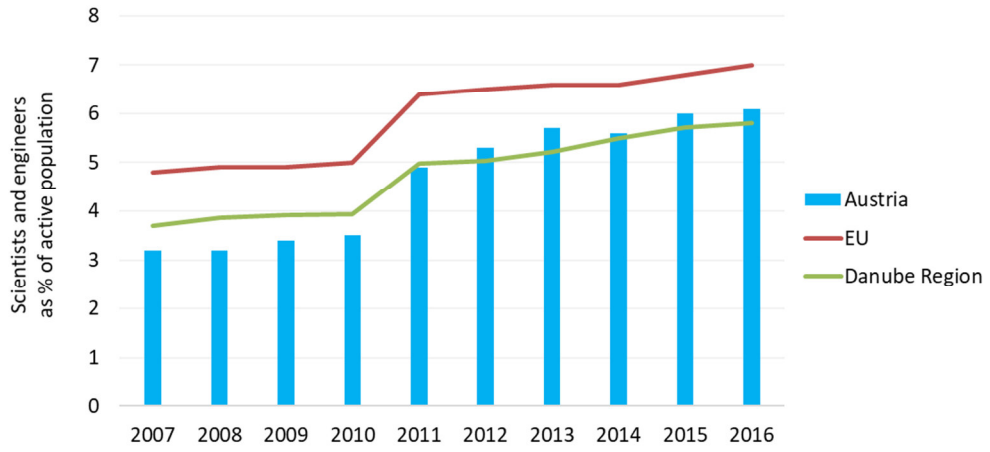


Figure 38: Scientists and engineers as % of active population (Eurostat)

OBSTACLE: Austria has a relatively low share of scientists and engineers in its active population. Due to the importance of human resources in these fields, Austria misses out on opportunities to boost its innovation and technological output. Austria should try to ensure that young people are drawn into these fields by providing the necessary skills in schools and universities as well as ensuring attractive research environments for scientists and researchers.

R&D expenditure as a share of GDP (GERD)

Austria has R&D expenditures equal to 3.07 percent of GDP. This is far above the EU average and higher than in all other Danube Region countries with Austria ranking second in the EU behind Sweden and fifth in the world, behind Israel, South Korea, Japan and Sweden, making Austria a leading country in terms of the financial input into innovation. Austria has been increasing its R&D expenditures continuously in the past fifteen years: The R&D intensity was equal to 1.89 percent of GDP in the year 2000, rose to 2.38 percent in 2005, 2.74 percent in 2010 and is now on an all-time high. Austria and the EU started off with a similar R&D intensity in the year 2000 (EU: 1.77 percent), but the EU had a much flatter trend in the past fifteen years. The EU average R&D intensity was 2.03 percent in 2015.

More than every seventh euro or 70.8 percent of Austria's R&D expenditure goes into R&D that is performed by the business enterprise sector. The higher education sector performs R&D amounting to a quarter (24.3 percent) of Austria's total R&D expenditure. The share of the government sector is equal to 4.4 percent of total R&D and the private non-profit sector is responsible for 0.4 percent of R&D. In comparison to the EU average, Austria has a far higher share of R&D performed by the business enterprise sector (Austria: 71 percent, EU: 64 percent), while the opposite is true for the share of R&D by the government sector (Austria: 4 percent, EU: 12 percent). The share of the higher education sector is about equal to the EU average (Austria: 24 percent, EU: 23 percent).

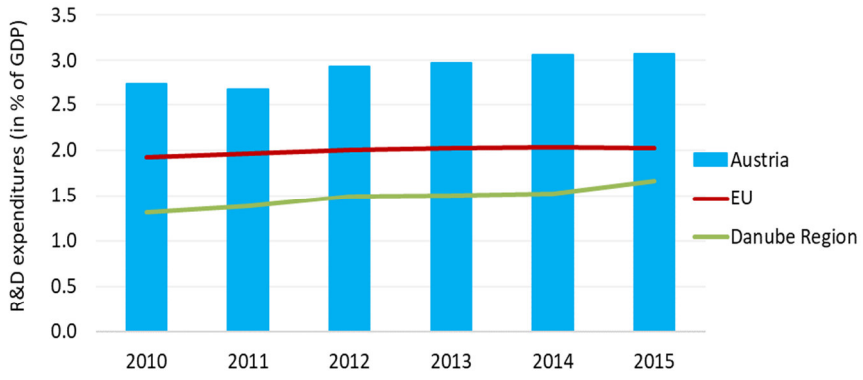


Figure 39: R&D expenditure (GERD) as a percentage of GDP, (Source: Eurostat)

OPPORTUNITY: Austria's R&D intensity is exceptionally high. Austria needs to make sure that the money is well invested without spending too much on administration and bureaucracy.

Government budget appropriations or outlays on R&D (GBOARD)

Austria invests 1.56 percent of general government expenditure into R&D. This is above the EU average of 1.38 percent (value for 2015) and the Danube Region average of 1.17 percent. Germany is the only Danube Region country with a higher value than Austria. Austria's share has risen from 1.45 percent in 2010, while the EU share has fallen slightly in the same time period.

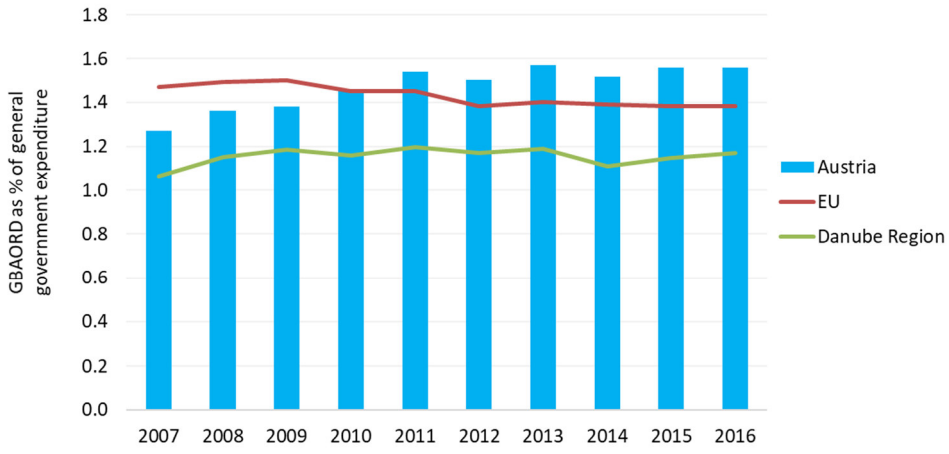


Figure 40: Government budget appropriations or outlays on R&D as % of general government expenditure (Eurostat)
Note: No value for the EU28 available for 2016 yet. The EU28 value for 2015 was used as a best estimate for 2016.

OPPORTUNITY: Austria's public sector invests more into R&D than on average in the EU and Danube Region. It is important to make sure that the money is well invested, so that innovation output rises accordingly.

Turnover from innovation

The turnover from innovation as a share of total turnover was collected in the Community Innovation Survey from 2004 to 2012 on a biennial basis. A share of 13.3 percent of total turnover in the industry

sector in 2012 in Austria resulted from innovation activities. The EU average for the year 2012 was 16.9 percent, the Danube Region average 14.0 was percent, both higher than in Austria. In the service sector, the share of turnover from innovation as a percentage of total turnover was 6.6 percent in Austria compared to 8.7 percent as the EU average and 6.0 percent as the Danube Region average.

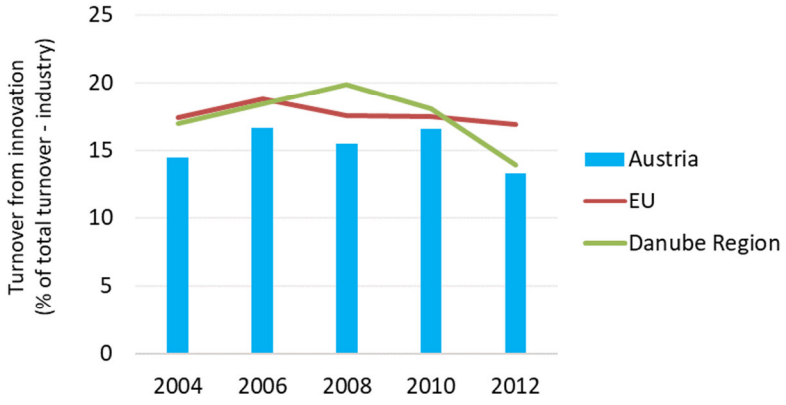


Figure 41: Turnover from innovation as a share of total turnover, industry sector (Source: Eurostat, Community Innovation Survey)

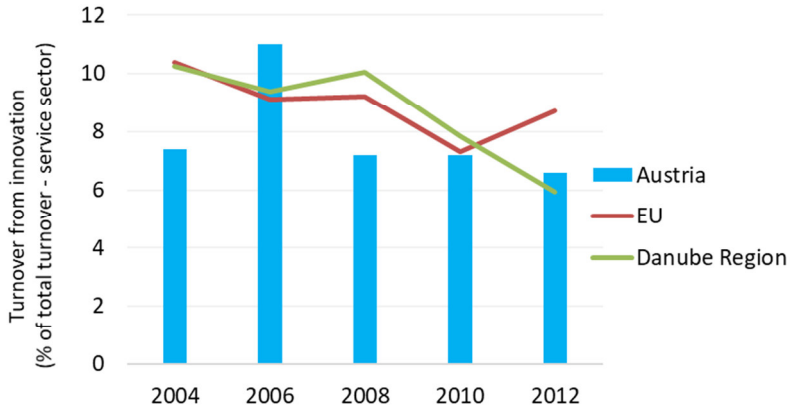


Figure 42: Turnover from innovation as a share of total turnover, service sector (Source: Eurostat, Community Innovation Survey)

OBSTACLE: Austria's turnover from innovation is significantly below the EU average. Reasons should be found why innovation outcomes are so low despite the high R&D intensity.

Employment in medium-high and high-tech manufacturing

Employment in medium-high and high-tech manufacturing as a share of total employment is equal to 6.0 percent in Austria. This is well below the European Union average of 11.6 percent and also below the Danube Region average of 8.2 percent. Austria has seen an upward trend with respect to this indicator since 2008 (2008: 5.0 percent), but a mild downturn compared to last year (2015: 6.2 percent).

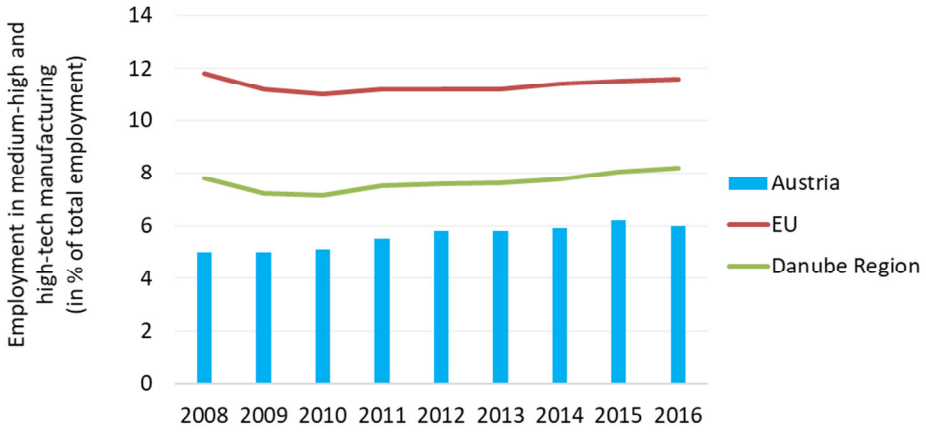


Figure 43: Employment in medium-high and high-tech manufacturing as share in total employment (Source: Eurostat)

OBSTACLE: The low level of employment in knowledge-intensive activities in manufacturing might partly be attributed to the fact that Austria's industry structure is medium-tech with an above average share of medium low-technology manufacturing. However, the classification into high or low-technology sectors causes some firms using high-technology but part of a sector that is in the low-technology segment to be missed. Nonetheless, Austria would benefit from moving more strongly into knowledge-intensive manufacturing activities. This would also help trigger more eco-innovative products and services.

REFERENCES

- Austrian Startups (2017), "Austrian Startup Agenda", Vienna.
- BKA, BMF, BMUKK, BMVIT, BMWFJ and BMWF (2011), "Der Weg zum Innovation Leader: Potenziale ausschöpfen, Dynamik steigern, Zukunft schaffen, Strategie der Bundesregierung für Forschung, Technologie und Innovation" (Federal government's strategy for research, technology and innovation).
- Bliem M., Aigner-Walder B., Brandl B., Gassler H., Grussmann S., Klinglmair A., Miess M., Paterson I., Rodiga-Laßnig P., Schmelzer S. (2014), "Das Potenzial von Öko-Innovationen für den Standort Österreich", IHS - Institute for Advanced Studies, Vienna.
- Eco-Innovation Observatory (2016), "Eco-innovation in Austria", EIO Country Profile 2014 – 2015: Austria, Eco-Innovation Observatory.
- European Commission, Joint Research Centre (2017), "European Innovation Scoreboard 2017 – Methodology Report".
- European Commission (2013), "An analysis of national research systems (I): A Composite Indicator for Scientific and Technological Research Excellence", Joint Research Centre Scientific and Policy Reports.
- Frischenschlager, H. (2014), "Öko-Innovation und Forschung - Betrachtung des Zeithorizontes anhand von drei ausgewählten Öko-Innovationen", Environment Agency Austria (Umweltbundesamt), Vienna.
- Vertesy, Daniel and Richard Deiss (2016), "The Innovation Output Indicator 2016", JRC Technical Papers.

4. ENERGY

Kalpana Scholtes-Dash

***Efficiency**: an improvement in energy efficiency at all stages of the provision and use of energy (e.g. new and refurbished buildings, sustainable mobility, implementation of energy management systems, spatial planning, etc.)*

***Renewable energy**: focus on hydro power (including pump storage), wind power, biomass and photovoltaic*

***Security of supply**: to be increased and aimed at the highest possible degree of cost effectiveness (e.g. district heating and cooling, new transmission networks, diversification of supply sources and routes, gas*

4.1 General overview of energy sector

The main objective of Austrian Energy Strategy is to attain a sustainable energy system that ensures security of supply, environmental compatibility, cost effectiveness, social compatibility and competitiveness as well as to implementing EU Climate and Energy Policy 202020.

Austria's energy policy rests on three pillars[1]

In 2014, a new federal law on energy efficiency was passed in Austria, which will stay in force till 2020. The objective of this law is to implement energy efficiency Directive 2012/27/EU. The law aims to reduce Austrian final energy consumption to 25,078.82 thousand tons of oil equivalent (Ktoe) (1050Petajoul) in 2020. Some of the measures that are being implemented to reach this target are: [2]

- Obligatory energy efficiency measures for energy suppliers: Energy suppliers selling 25 GWh or more will have to implement energy saving measures between 2015 and 2020 to ensure energy savings of 0.6% of their energy sales to the final customer in the previous year.
- Energy management in companies: Companies employing 249 or more persons will have to implement either an energy management guideline (ISO16001 or ISO 50001), or an environmental management guideline (ISO 14000). In addition, they have to have external energy audit every four years.
- Renovation of Federal buildings: energy saving measures are to be implemented in all buildings owned and used by the federal state between 2014 and 2020 leading to a projected saving of 48.2GWh during this period.

Austria depends on imports to meet almost 60% of its energy demand. Oil accounted for 47% of the total import of energy, and 36% of gross final consumption of energy in 2015, followed by renewable resources which supplied 33%., Renewable sources account for 74% domestic production; the contribution of bioenergy and waste have started gaining importance in Austria contributing more than 20% of the primary energy supply in Austria.

The Austrian Energy Strategy was developed and finalized by a broad group of representatives from various ministries, NGOs, federal provinces and Special interest groups. Taking into consideration the fact that the Austrian

[1] Energy Strategy Austria, Federal Ministry of Economy, Family and Youth
[2] Energy efficiency trends and policies in Austria, Austrian Energy Agency, 2015

energy policy aims to address economic growth, environmental protection and security of energy supply in a balanced manner, the target set by the Austrian Energy Strategy for 2020 are as follows:

- Increase in energy efficiency by 20%;
- Increase the share of renewable energy to 34%.

4.2 Energy Intensity of the Economy

Energy efficiency policies, play a key role in reducing the energy consumption. In recent years, the global economy has shown a certain decoupling of GDP and energy consumption, that is, the GDP has grown at a faster rate than final energy consumption, thus reducing the energy intensity of economies. Energy intensity is defined as the energy required to produce 1000 euro of GDP. The energy intensity in Austria is lower than the average energy intensity in both EU and in the Danube region. Energy intensity in Austria decreased by 11% between 2006 and 2015 from 119.4 kg of oil equivalent per 1000-euro GDP to 106.4 kg of oil equivalent per 1000-euro GDP. (figure1)

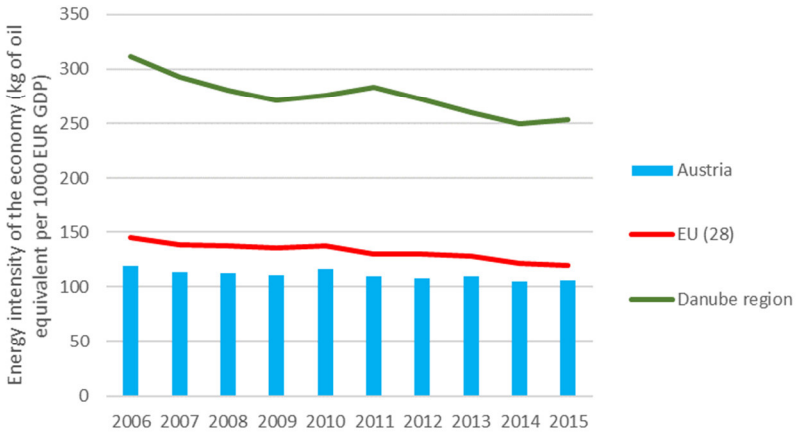


Figure 1 Energy Intensity between2006-2015 (kg of oil equivalent for 1000 Euro GDP) (Source: Eurostat)

It was pointed out in a study by the International energy Agency, the decoupling of GDP growth and energy consumption can mainly be achieved by efficiency improvements.[3] Structural changes have resulted in lower energy intensive industry and services that has contributed to efficiency improvements, and thus, reduced final energy consumption.

4.3 Energy Dependence

Another method of measuring increased energy efficiency is the rate of reduction of energy dependence, that is, the extent to which a country depends on imports to meet its energy requirements. Energy dependence in Austria in 2015, at 61%, is higher than the EU average of 54% and the Danube region average of 43%. However, energy dependence in Austria has decreased from 73% in 2006 to 61% in 2015. That is a decline of 12 percentage points as opposed to a slight increase in the dependence rate of the EU and a decline of 6 percentage points in the Danube region. (Figure 2)

[3] Energy efficiency indicators, International Energy Agency

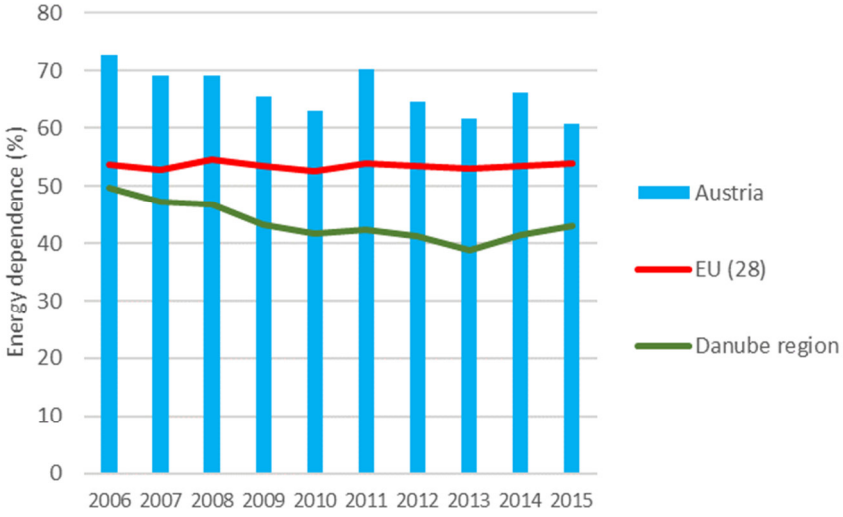


Figure 2 Energy dependence ratio (%) (Source: Eurostat)

Obstacles and Opportunities: The energy intensity of Austria is lower than the other Danube region partners. However, the rate reduction in the Danube region and the EU during the 2006 to 2015 was 19% and 17% respectively as opposed to Austria where it was 11% in the same period. (119.4 kg of oil equivalent per 1000-euro GDP to 106.4 kg of oil equivalent per 1000-euro GDP. (Figure1)). It must be noted here that the industry sector that dominates in energy consumption includes steel industry which is highly energy intensive, and road transport includes a heavy rate of transit transportation.

Austria depends heavily on imported energy to meet its energy needs; the energy policy recognises the need to diversify the source of imports as well as to increase domestic production of renewable energy. The dependence ration has declined at relatively faster rate in Austria than the partners in the EU and Danube region.

4.4 Energy Prices

4.4.1. Electricity Prices

For medium size household consumers in Austria, the price of electricity has increased by 4% between 1st semester 2009 and 2nd semester 2015. Even though, the basic base price has decreased by 10%, the taxes and levies have gone up from 38% of final price in 1st semester 2009 to 60% of final price in 2nd semester 2015. This can be interpreted as a policy measure to reduce final consumption by encouraging households to use energy in more efficient manner. Austria has the second highest tax rate on medium level household consumers (Germany at the highest). (Figure 3)

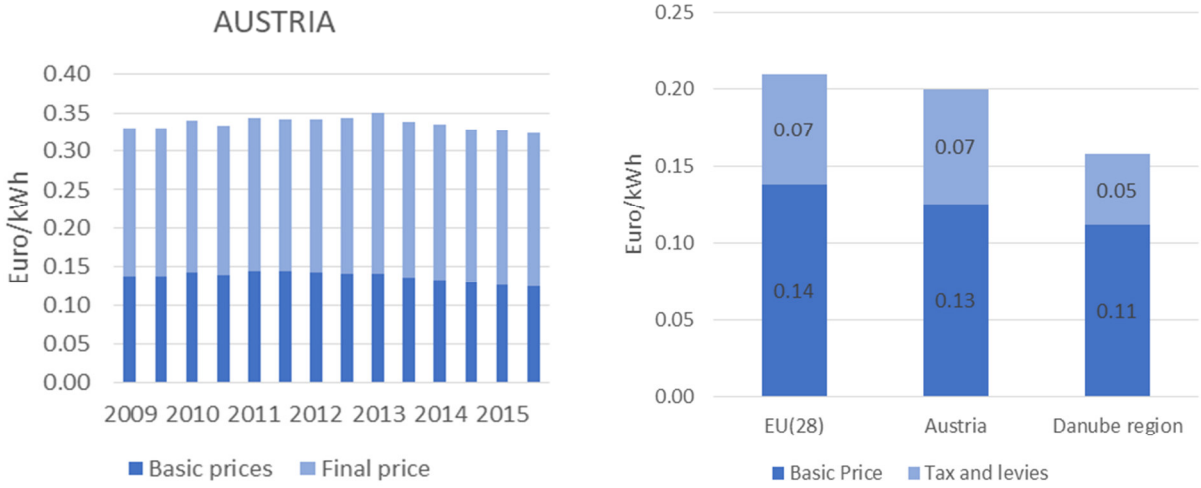


Figure 3 Electricity price for households (2 500 kWh < Consumption < 5 000 kWh) Euro/ kWh (Source Eurostat)

However, if the prices are expressed in terms of Purchasing Power Standard[4], electricity prices are rather low in Austria, Germany being the most expensive in the Danube region with an average price of 0.28PPS/kWh in 2015 as against 0.18 PPS/kWh in Austria during the same time. The average price for EU 28 and the Danube region stood at 0.21PPS/kWh and 0.22 PPS/kWh in 2015.

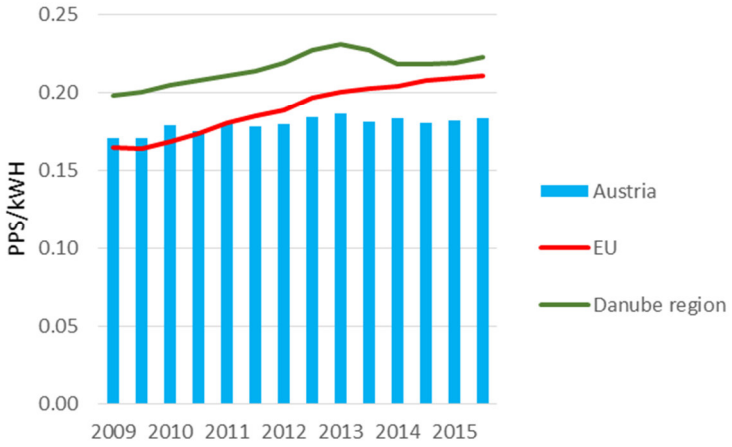


Figure 4 Electricity price for households Band (2 500 kWh < Consumption < 5 000 kWh) per kWh in Purchasing Power Standard (Source: Eurostat)*

Industry accounts for one third of final electricity consumption in Austria. The price of Electricity in Austria for industrial use is one of the lowest in the Danube region. Electricity price for industrial consumption in Austria has declined by 9.6% from 2009 levels (figure5). However, this decline is less than the change in the basic price of electricity which decreased by almost 25% during the same period as a result of an increase in tax and levies from 44% to 73%. (Figure 5)

[4] Purchasing power standard(PPS) is an artificial common reference currency that eliminates price level differences between countries. One unit of PPS can by the same volume of goods and services in all countries.

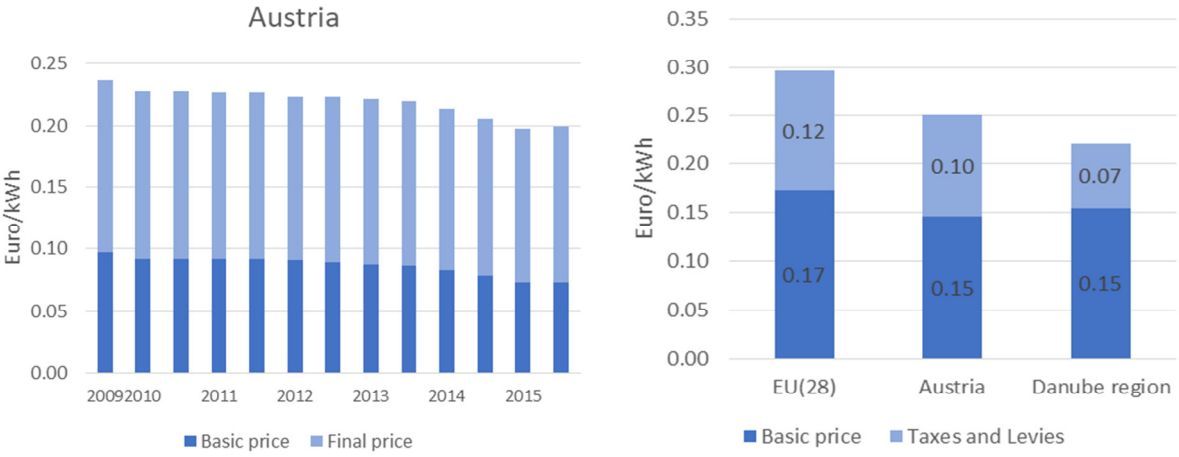


Figure 5 Electricity price for industrial use in Austria 500 MWh < 2 000 MWh, Euro/kWh (Source: Eurostat)

In PPP terms, the price for electricity, in Austria, for industrial consumption stands at the lowest level (0.23PPS/kWh) in the Danube region. The average price in the Danube region in PPS terms id 0.35/kWh. (Figure 6)

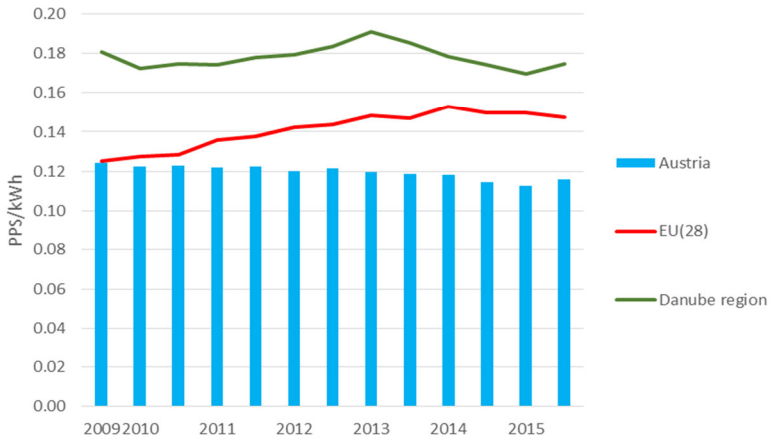


Figure 6 Electricity price for industrial use (500 MWh < 2 000 MWh) per kWh in Purchasing Power Standard (Source Eurostat)*

4.4.2. Gas prices

Average gas prices in 2015 for household use (for consumption between 20GJ and 200 GJ) was highest in Austria, at 0.072 euro/kWh. Average price in the Danube region and EU (28) was 0.049 euro//kWh and 0.68 euro /kWh respectively. Taxes and levies make up for almost one third of the final price in Austria. The basic price of electricity has increased by 10% and final price has increased by 9% during the above period, though there was a drop during 2009 and 2010 in the aftermath of global financial crisis. Following a steep increase between 2010 and 2012, the price of gas for household consumers has been decreasing till second half of 2015.

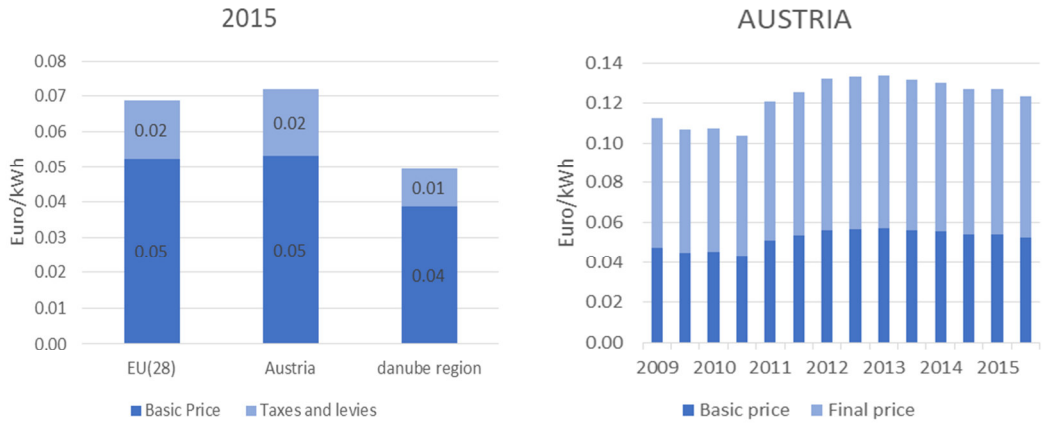


Figure 7 Gas price for households in Austria (20 GJ < Consumption < 200 GJ) Euro/per kWh (Source: Eurostat)

Even though the price of electricity for household use is higher than the EU average and the Danube region average, in PPS terms it id slightly below EU average and around 11% lower than the average price in the Danube region. (Figure 8)

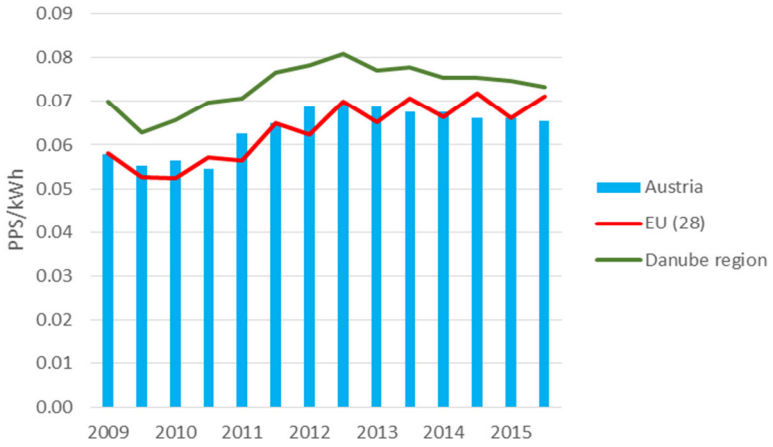


Figure 8 Gas price for household use (20 GJ < Consumption < 200 GJ) per kWh in Purchasing Power Standard (Source: Eurostat)*

In 2015, the average price without taxes and levies for the industrial consumers stood at 0.03 euro across EU and Danube region. Highest tax rate was registered in Romania where the taxes were at 78% of the basic price, followed by Austria with tax rate at 59%. (Figure 9)

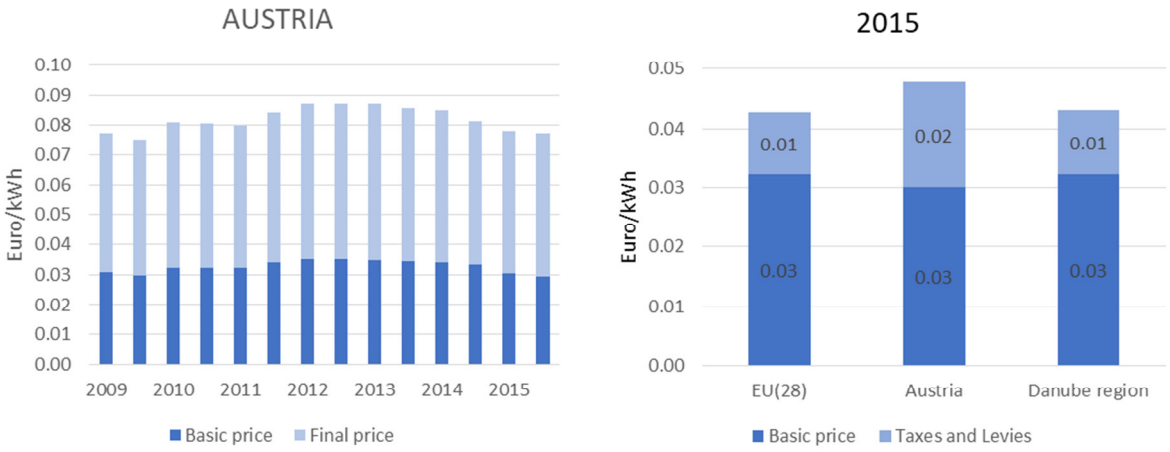


Figure 9 Structure of gas price for industrial use (20 GJ < Consumption < 200 GJ) per kWh in Euro (Source: Eurostat)*

In contrast to the prices for industrial consumers in Austria expressed in terms of euro, the price in PPS terms is the lowest in the Danube region. (Figure 10)

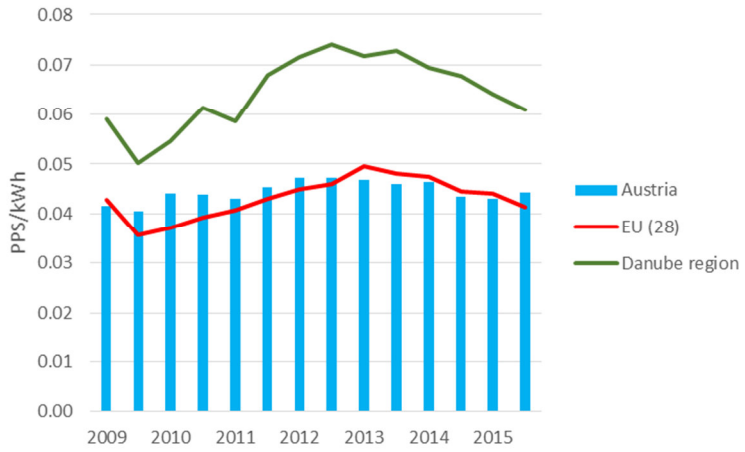


Figure 10 Comparative gas prices for industrial use (20 GJ < Consumption < 200 GJ) per kWh in PPS (Source: Eurostat)

4.5 National Energy Sector

4.5.1 Primary Energy Production

In 2015, 36% of the total energy of Austria was produced locally, up from 29% in 2006. The increase in primary production of energy in Austria was achieved mainly by an increase in production of renewable energy.

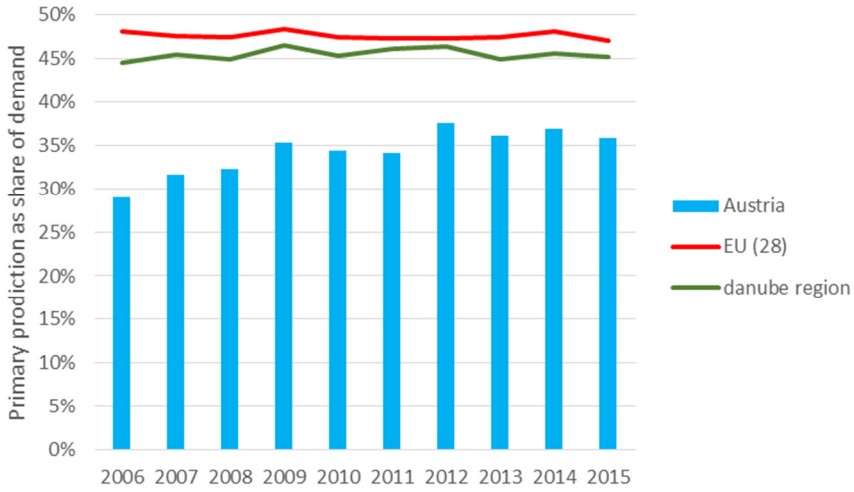


Figure 11 Primary production as share of demand (Source: Eurostat)

Production of energy from renewable sources increased from 7Mtoe[5] in 2006 to 9.3Mtoe in 2015. Share of natural gas and petroleum product as source of primary energy production declined by 30% and 13% respectively between 2006 and 2015. The growth in biofuels and waste as source of energy has been remarkable, its contribution to domestic energy production increasing from 38% in 2006 to 50% in 2015. (Figure 12)

[5]Mtoe: Million tons of oil equivalent

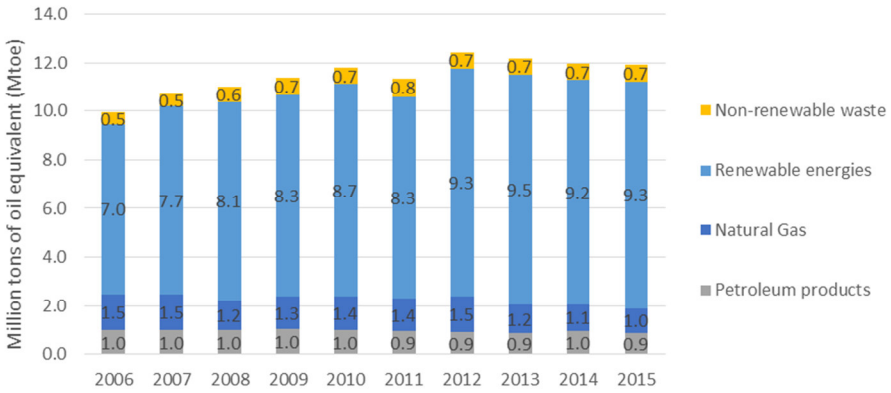


Figure 12 Primary energy production by source, 2006-2015 (Source: Eurostat)

Renewable energy source occupies an important role in Austria. As compared to EU (28) and Danube region, where renewable energy accounts for 27% and 25% respectively, Austria derives 78% of domestic energy production from renewable sources. (Figure 13)

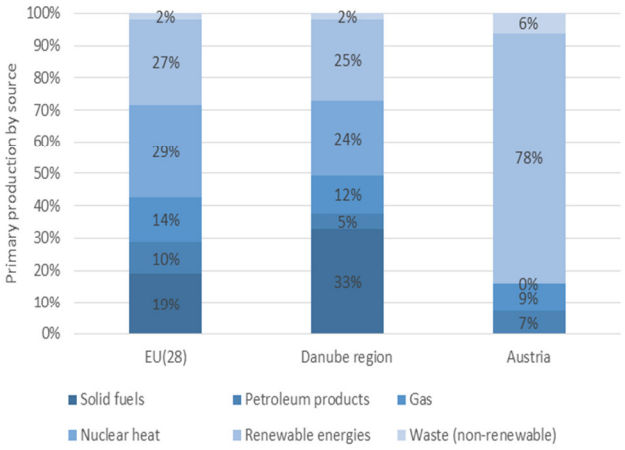


Figure 13 Share of resource in primary production (Source: Eurostat)

Detailed share of various sources in primary energy production in Austria is given in Figure 14. 48% energy produced in Austria is from biofuels and waste (5.7Mtoe), up from 38% in 2006 (3.8Mtoe). Hydro power accounted for 27% (3.2Mtoe) of energy production source in 2015 registering a decline of 4 percentage points from 31% in 2006. However, in absolute terms energy production from hydropower increased by 3% between 2006 and 2015.

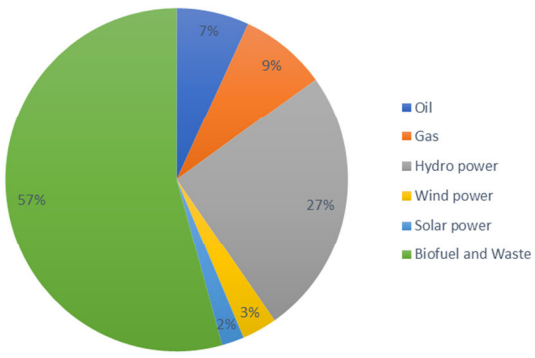


Figure 14 Primary energy production by source, Austria 2015 (Source: Eurostat)

4.5.2 Gross Inland Consumption

During 2015, total primary energy supply in Austria was 33.25Mtoe, 3% less than the level 34.26Mtoe in 2006. After the sharp decline in consumption amounting to almost 6% in 2009, there was an initial increase in 2010 which has tapered out steadily. The supply from renewable sources has increased by 31% from 7.4Mtoe to 9.7Mtoe, whereas petroleum products and natural gas as sources of energy have declined by 16% and 9% respectively during the same period.

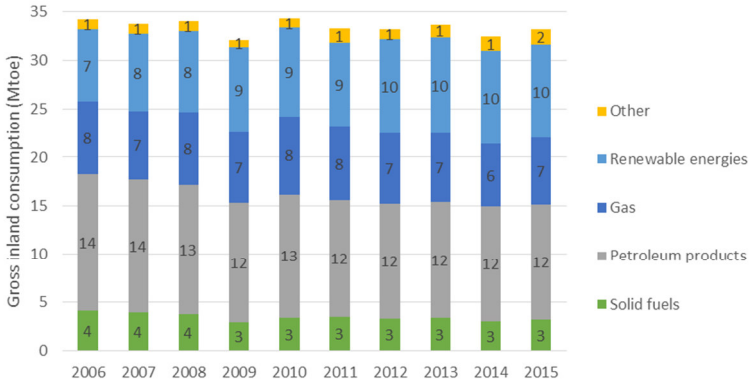


Figure 15 Supply of energy for inland consumption by source in Mtoe(Source: Eurostat)

In 2015, the petroleum products held the biggest share in all three cases, 34% in EU-28, 28% in Danube region and 36% in Austria. However, in contrast to the former two where natural gas (EU (28), 22%), and solid fuel (Danube region, 26%) were the second largest source of energy, in Austria renewable energies accounted for the second highest share at 29% of the total gross inland consumption.

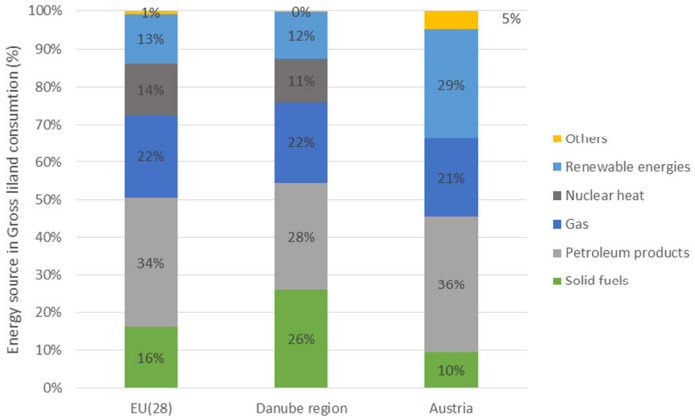


Figure 16 Gross inland consumption according to sources 2015(Source: Eurostat)

In Austria, per capita gross consumption of energy, at 3.9 tons of oil equivalent in 2015 was higher than that of the EU-28 as well the Danube region. In the EU and the Danube region it was 3.2 and 2.9 tons of oil equivalent respectively. The per-capita grass consumption of energy has declined by 7% between 2006 and 2015 in Austria as opposed to 14% and 13% in the EU and the Danube region respectively. (Figure 17)

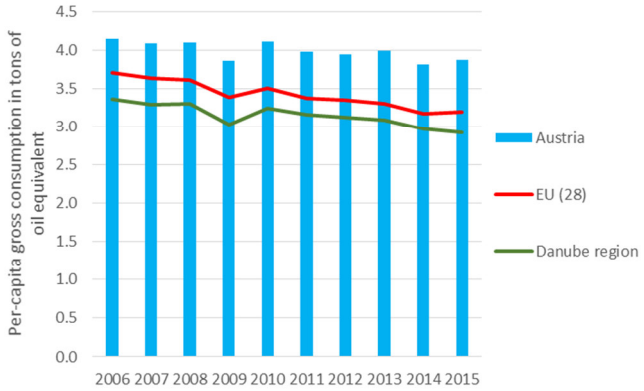


Figure 17 Per-capita gross consumption in tons of oil equivalent (Source: Eurostat)

4.5.3 Total Final Consumption -TFC (Source of energy)

Total final energy consumption in Austria in 2015 was 27.4Mtoe, 1.5% less than in 2006. After reaching its peak in 2010 (28.2Mtoe), the TFC has shown rather small variations between 2010 and 2015. The largest share was held by petroleum products accounting for more than one third (9.8Mtoe) of the TFC. The share of petroleum products in final energy consumption has declined from 41% in 2006 to 36% in 2015. On the other hand, share of renewable energies has increased from 10.6% in 2006 to 14% in 2014. Since 2006, there has been 14% decrease in use of petroleum products, and 4% decrease in use of gas as source of final energy consumption. (Figure 18).

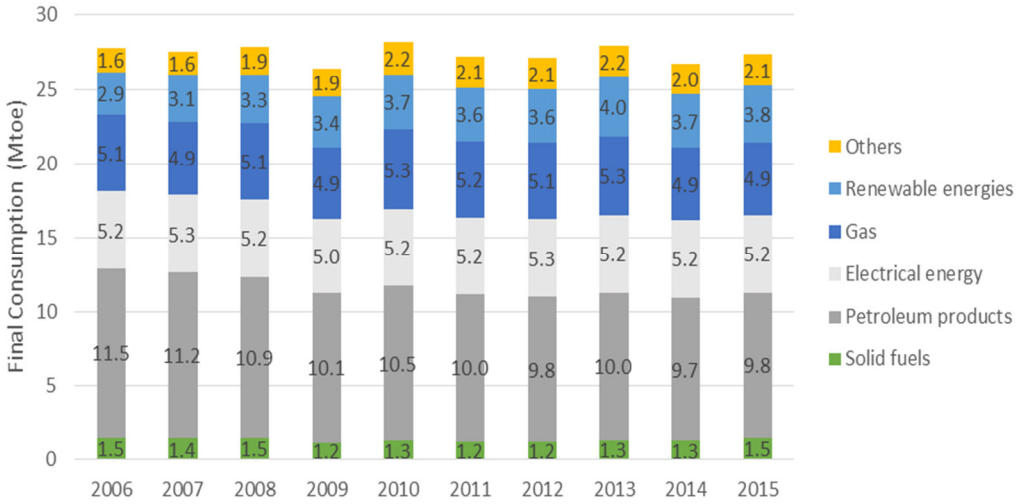


Figure 18 Final energy consumption in Austria according to source (in Mtoe) (Source: Eurostat)

The structure of TFC according to source varies across nations. Share of renewable energies is the highest in Austria at 14% of final energy consumption as compared to 8% in the EU-28 and 8.5% in the Danube region (Figure 19). However, it must be underlined here that the electric energy, and derived heat[6] have a very high renewable source content, but are not included in this diagram under renewable source.

[6] Electrical energy from hydro, solar and wind energy, and derived heat from heat generation plants using renewable energy.

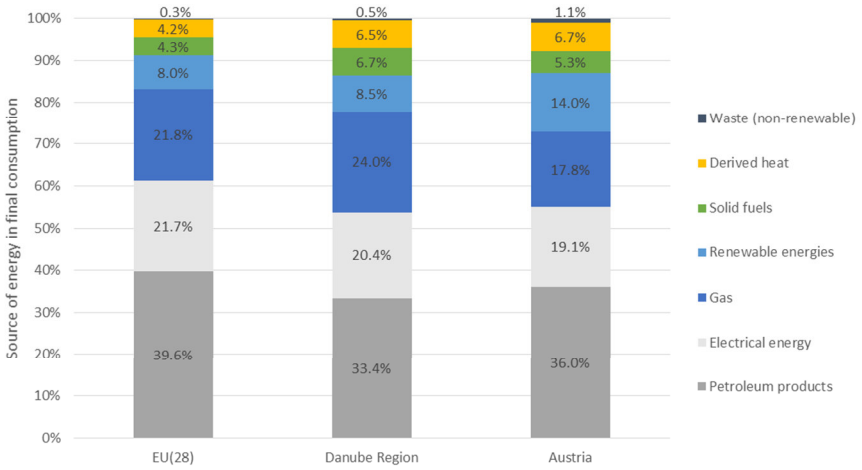


Figure 19 Structure of final energy consumption according to source in 2015 (Source: Eurostat)[7]

Per capita final consumption of energy is the highest in Austria among the Danube region countries at 3.2 tons of oil equivalent as opposed to an EU-28 average of 2.1 and Danube region average of 1.9. It should be noted here that there has been a 5% decrease in final per capita energy consumption in Austria between 2006 and 2015.

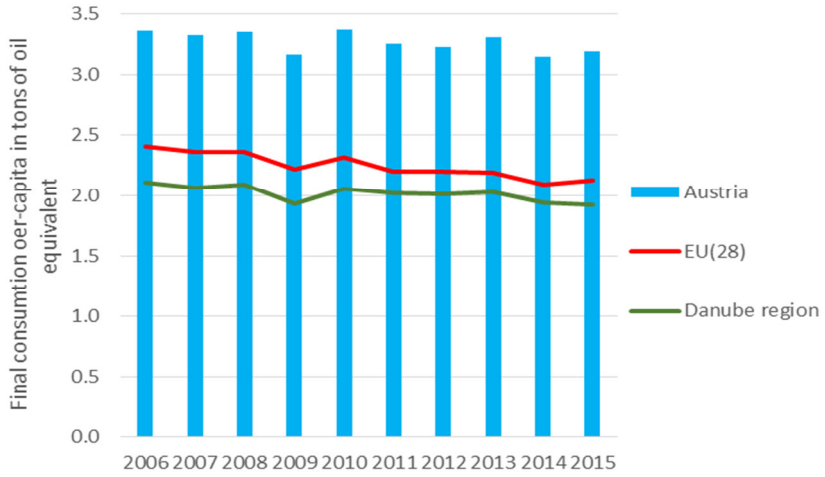


Figure 20 Per capita final consumption in 2015 in tons of oil equivalent. (Source: Eurostat)

4.5.4 Final consumption (Sectors)

Nearly two third of Austria's TFC of energy can be attributed to industry and transport. Industry sector's consumption of energy has gone up by one percentage point, from 32% to 33% of total final consumption of energy between 2006 and 2015. On the other hand, the share of industry in TFC has reduced by 2 and 3 percentage points in the EU and in the Danube region respectively during the same period.

[7] The renewable energy source in this case does not include the renewables used in electricity production, in generation of heat and the proportion of bio fuels and waste in the solid fuels.

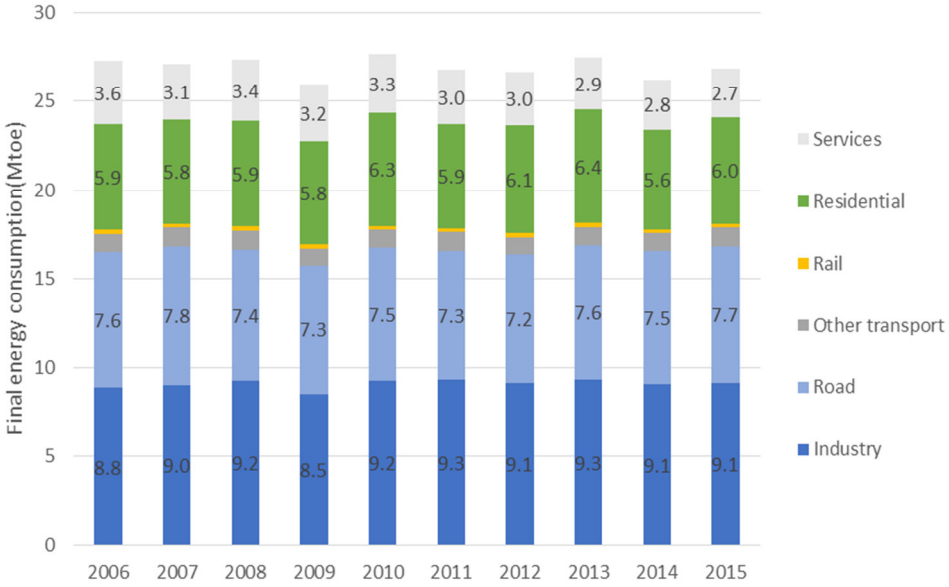


Figure 21 Share of final energy consumption in Austria (Source: Eurostat)

The road transport accounts for almost 90% of energy consumed in the transport sector in 2015. Oil represents 86% fuel used in this sector in 2015 down from 91% in 2006, while renewable energy and bio fuels accounted for 7.2% and 6.5% respectively, almost twice the share in 2006.

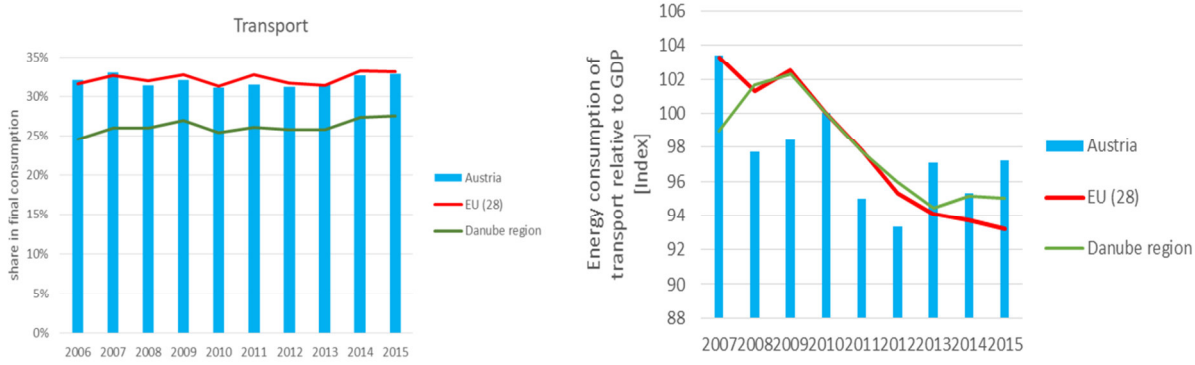


Figure 22 Share of transport in total final consumption and relative to GDP (Source: Eurostat)

The industry sector accounted for 33% of the TFC in 2015, making it the largest consumer of energy in Austria, and this is higher that the share in the EU as well as the Danube region. Gas and electricity make up for the most of the energy source in the sector consisting of 33% and 26% of the total respectively. Biofuels contribute 16% of the sector's energy needs whereas, renewable energy and oil make up for 12% each.

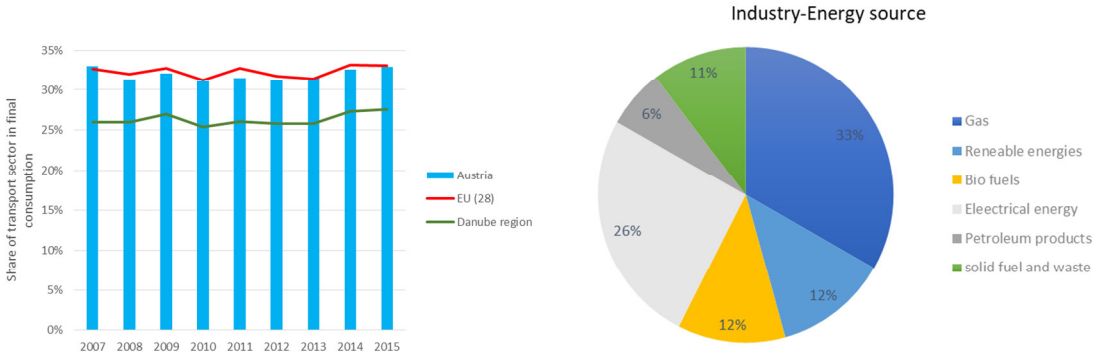


Figure 23 Share of industry in total final energy consumption and the energy mix in the sector (Source: Eurostat)

Residential sector accounted for 22% of TFC in 2015. Out of 5.9 Mtoe of energy consumed for residential sector, 24% is accounted for by electrical energy, oil 16%, gas15% and 26% biofuels. Per capita consumption of electricity in residential sector in Austria is consistently higher than the EU and the Danube region average. (Figure 24) The indicator is defined as the quantity of electricity consumed by households. Household consumption covers all use of electricity for space and water heating and all electrical appliances.

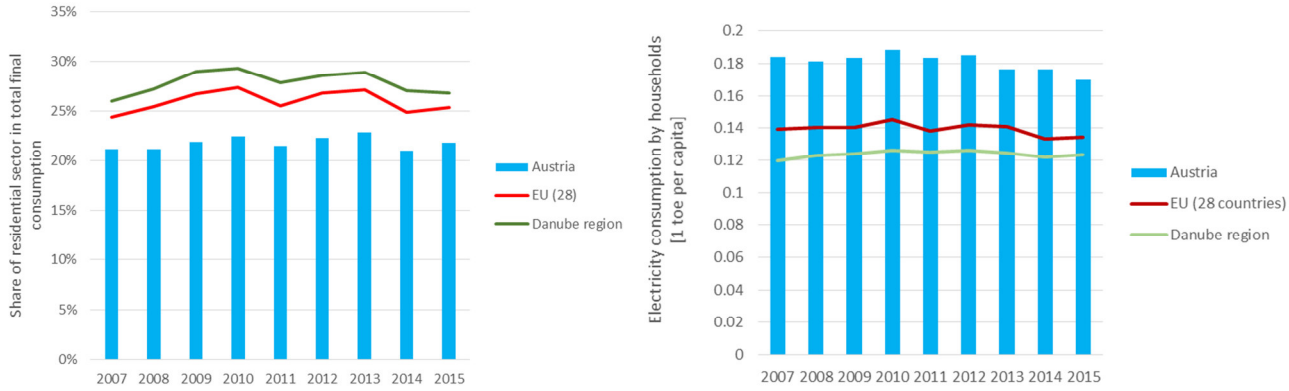


Figure 24 Residential sector in TFC (Source: Eurostat)

Service sector accounted for 10% of the TFC, nearly 40% of the final consumption in this sector is fulfilled by electrical energy. Share of gas and oil in this sector has declined from 46% in 2006 to 26% in 2015.

Obstacles and Opportunities

The main factor of concern in Austria seems to be the high level of per-capita consumption of energy. It may be pointed out that there may be three factors contributing to this:

1. Low price of energy;
2. High share of steel sector in industry which is known to be energy intensive;
3. The road transport in Austria contains significant amount of transit transport.

However, it must be noted here that despite the high per-capita consumption, the energy intensity in Austria is among the lowest in the EU(28) and the Danube region.

4.6 Imports

Austria depends heavily on imported energy. Energy imports in 2015 was 29.5Mtoe, 3% lower than 2006 levels. Total energy import in Austria has declined from 30.4 million tons of oil equivalent in 2006 to 29. 5 million tons of oil equivalent in 2015 (figure 24). The most substantial decrease was achieved in case of solid fuels (27%), followed by petroleum products (9.4%). On the other hand, renewable energy imports of Austria increased by 25.6% from 2.5% of the energy import in 2006 to 3.2% in 2015.

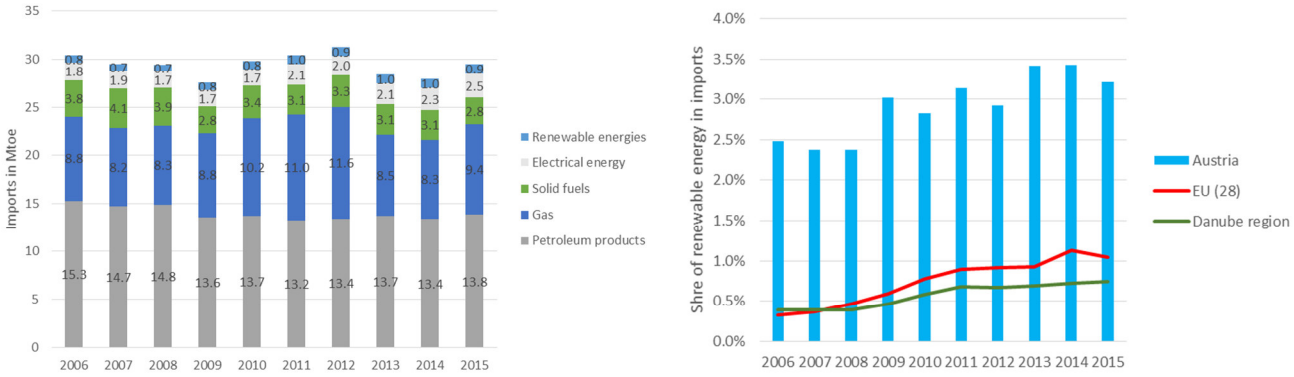


Figure 25 Source of energy imports in Austria in Mtoe(source: Eurostat)

4.7 Renewable Energy

Renewable energy contributed almost 11Mtoe to gross final consumption, in 2015, that is 33% of total, up from 25.4% in 2016. Most of the renewable energy in Austria is derived from biofuel and waste accounting for 21.3%. (Figure 26) The 2020 target for Austria is to meet 34% of its energy requirements from renewable sources.

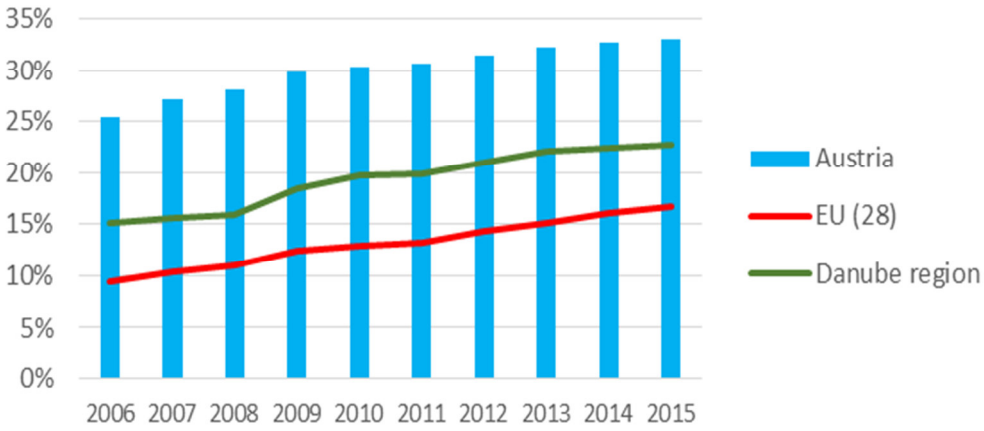


Figure 26 Share of renewable energy in gross final consumption (%)

The share of renewable energy in transport is the highest (11.4%) in the EU and Danube region. This share has seen nearly 4 percentage point increase during 2006 to 2015. (Figure 27)

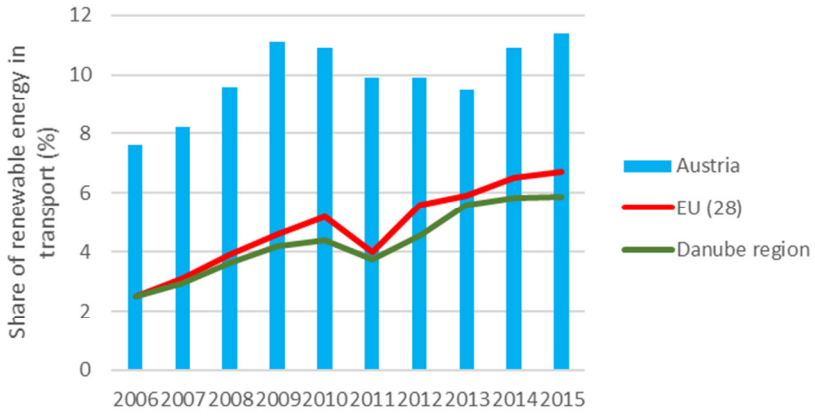


Figure 27 Share of renewable energy in transport (%) (Source: Eurostat)

Similarly, in case of secondary energy generation, such as electricity and heating and cooling energy, Austria leads in its usage of renewable energy. (Figure 28)

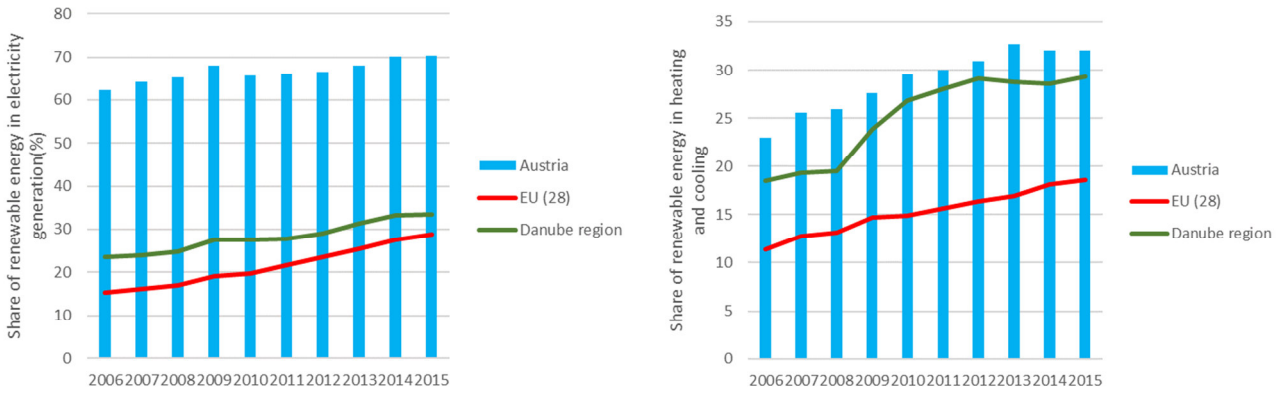


Figure 28 Share of renewable sources in total energy generations (source: Eurostat)

More than 70% of energy uses to produce electricity and 32% of energy used for heating and cooling in Austria are accounted for by renewable energy sources. The importance of renewable energy in heating and cooling has increased at a fast rate in the Danube region as a whole (11%) and in Austria by 9%.

Obstacles and Opportunities

Austria is one of the leading countries in the global drive towards expansion of renewable energy sources. All renewable electricity generation technologies are eligible for the Austrian feed-in tariff. (ÖSG 2012 and related regulations). Additionally, small PV installations with a maximum capacity of 5 kW, can avail of Government subsidy. Construction of small and medium-sized hydro-electric power stations are also subsidised by investment grants.

4.8 Energy Efficiency Indicators

4.8.1 Greenhouse gas emissions intensity of energy consumption

The greenhouse gas intensity of energy consumption is an index that measures the ratio between energy-related greenhouse gas emissions (carbon dioxide, methane and nitrous oxide) and gross inland energy

consumption.[8] This index indicates that the greenhouse gas emissions related to energy consumption have declined by 10 % in Austria as opposed to 8% and 9% in EU (28) and the Danube region respectively. However, there was a slight increase in this index (1.2%) in 2014-15. (Figure 29)

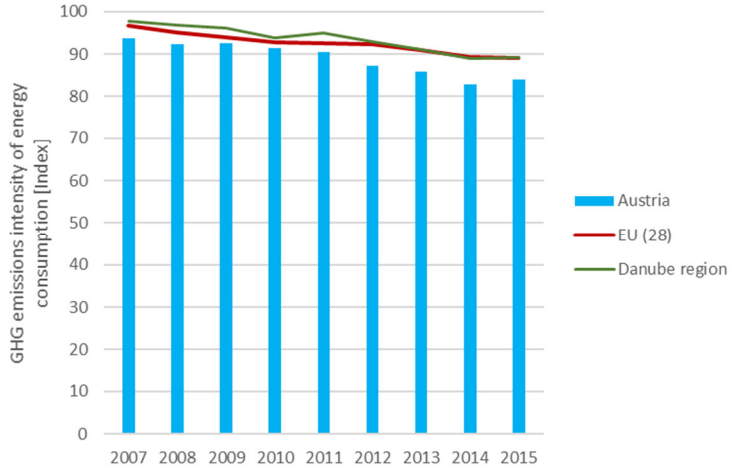


Figure 29 Greenhouse gas emission index of gross inland energy consumption (Source: Eurostat)

4.8.2 Combined heat and power generation% of gross electricity generation

Combined heat and power (CHP) or cogeneration technology reduces the need for additional fuel combustion for the generation of heat and thus helps reduce the associated harmful impact on environment. (Figure 30)

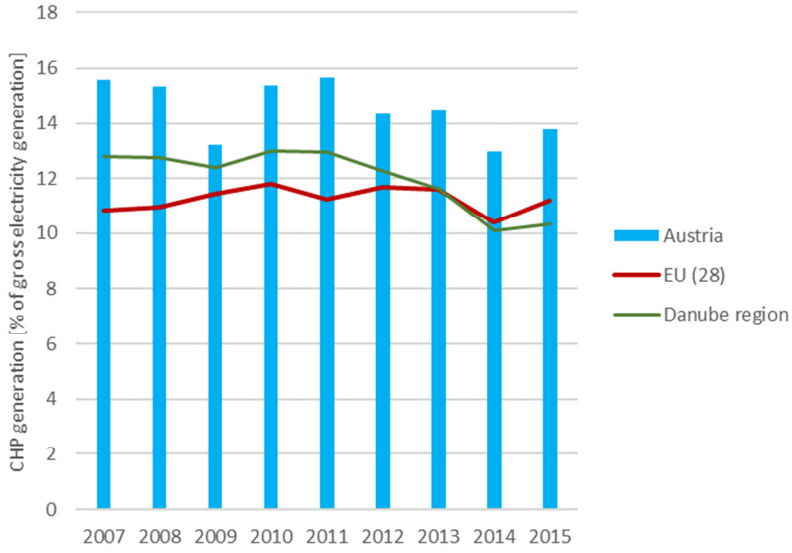


Figure 30: Combined heat and power generation % of gross electricity generation[9] (Source: Eurostat)

4.8.3 Energy Productivity

This indicator measures ratio between gross domestic product (GDP) by the gross inland consumption of energy. Energy productivity in Austria is the highest in the Danube region. However, energy productivity growth has been rather slow (7%) as compared to 11% in the Danube region. (Figure 31)

[8] Eurostat definition

[9] Slovakia not included in the Danube region average shares seem too high as compared to other national data.

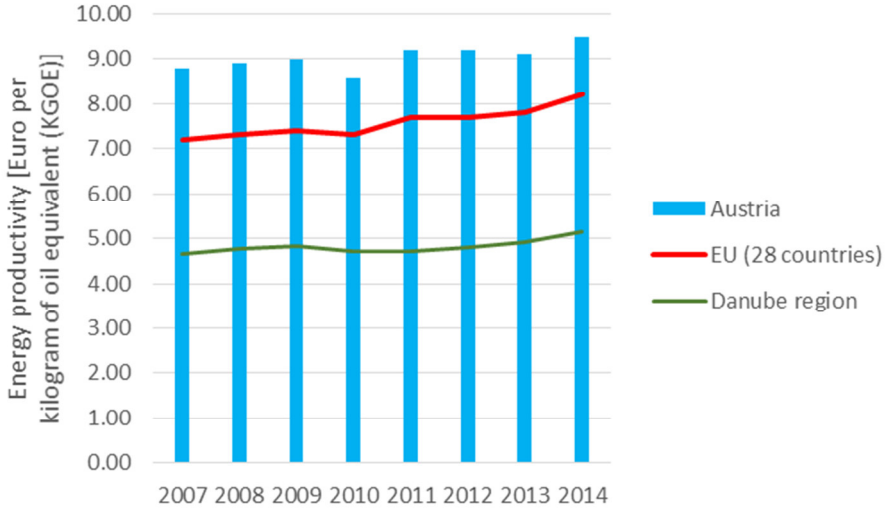


Figure 31 Energy productivity (Euro/Kgoe) (Source: Eurostat)

4.8.4 Energy consumption of transport relative to GDP

This indicator is the ratio between the energy consumption of transport and GDP (chain-linked volumes, at 2010 exchange rates). The energy consumed by all types of transport with the exception of maritime and pipeline transport.[10] This index demonstrates that the energy usage in transport relative to GDP is almost similar across the regions is declining rather slowly over time

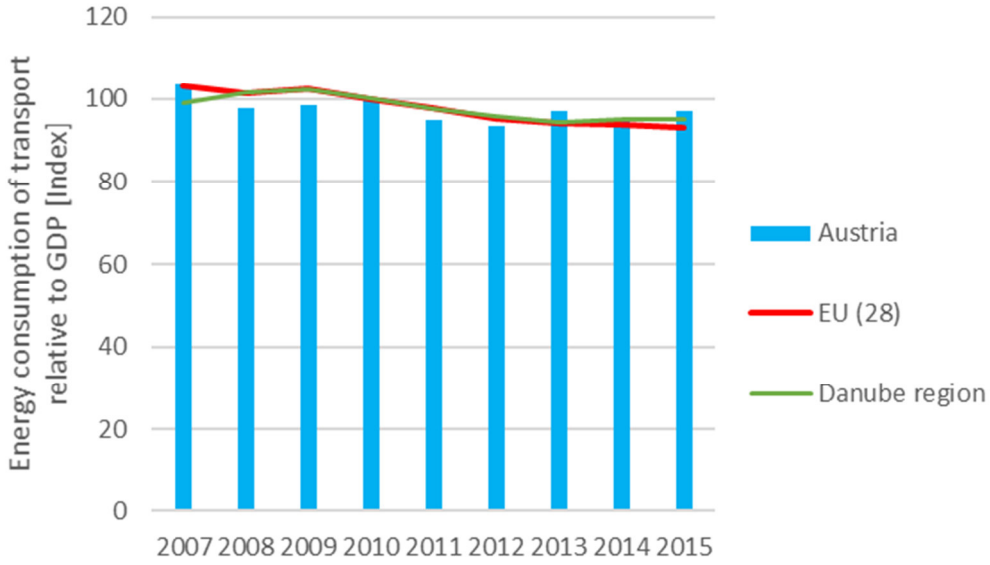


Figure 32 Energy consumption of transport relative to GDP (2010 as base year, value 100)

4.9 National energy policy

Austria, though leading in energy efficiency and environmental indicators, still has a relatively high per-capita consumption of energy as compared to EU and Danube region averages. In order to fulfil the commitments to the energy efficiency Directive 2012/27/EU, on 1 January 2016, the Energy Efficiency Guidelines Regulation (Energieeffizienz-Richtlinienverordnung) entered into force. These regulations specify the duties of the national energy efficiency monitoring body and have outlined over 100 possible

[10] Eurostat definition

methods for documenting, reporting, assessing and classifying energy efficiency measures. More than 40 Austrian organisations at the federal as well as state or municipal levels offer energy efficiency information services for consumers. The Klimaaktiv, Austrian government's climate change information and grant programme, was established in order to support the implementation of Climate Change Strategy. It is overseen by the Ministry of the Environment, and managed by the Austrian Energy Agency. A few policy measures taken under the programme are:

- Tax reform: zero-CO2 passenger cars and company cars are eligible for VAT discounts from 1st January 2016
- Establishment of a housing investment bank (WBIB-G) to support housing construction of energy efficient dwellings, and the Act on non-profit housing, entered into force on 1 January 2016.
- Refurbishing of public buildings to reduce energy consumption

In order to increase sustainability of energy consumption there are a few key policy instruments that are being implemented nationwide:

- On September 23rd, 2009, the federal parliament passed an extensive amendment to the Austrian Green Electricity Act (Ökostromgesetz) with longer support periods for wind and solar plants, adjusted feed-in tariffs. These changes are aimed at increased capacity building specifically in wind and hydro power and biomass plants.
- National support policy the Environmental Support Act (Umwelförderungsgesetz) promotes use of renewable energy mainly in the form of investment grants. These grants are aimed at addressing support levels for commercial entities, non-profit organizations, public institutions and utilities engaged in renewable energy production. Private households receive investment grants at the provincial level.
- The Resource Efficiency Action Plan (REAP), devised in 2012 promotes information and awareness raising activities on sustainable energy production and use; provides energy advice to private households, public bodies and companies; carries out media campaigns for better understanding among public.
- Green Electricity Act 2012 has ensured an increase in public funding of green electricity production to up to 50 million euros. This is designed to increase the share of electricity consumption generated by renewable energy sources to 85% by the year 2020.

With the above measures and additional policy framework. Austria aims to achieve it 2020 goals and be a global leader in sustainable and secure energy supply while ensuring economic growth.

5. ENVIRONMENTAL PROTECTION

Andrea Pitzschke

5.1 Environmental Challenges

Land use, infrastructure and ecological footprint

Austria has a wealth of natural resources. Only with adequate environmental protection will the country be able to preserve these resources and maintain a high living standard for coming generations. Many lakes and rivers have drinking water quality. Approximately 16 % of the total national territory (83.872 km^2) comprise nature reserves; there are six officially recognised National Parks (2.8 % of territory). Owing to a generally strict legislation on environmental issues, contamination with industry pollutants, heavy metals and chemical deposits from mining activities in Austria is less pronounced than in most other Danube region (DR) countries. Austria has a strong infrastructure, concentrated in and around main conurbations. Area of permanent settlement (data: 2015) occupy 32.584 km^2 (38 %) of the national territory. The proportion of road surfaces (total: 2052 km2) within that area ranges from 5.2 % in Upper Austria to 19 % in Vienna[1]. Effects of soil sealing-related depletion of natural flood retention areas are becoming increasingly apparent. For building, maintenance and renewal of its infrastructure Austria exploits large amounts of material and energy resources. A comparison of per-capita ecological footprint (6.1 global hectares) vs. biocapacity (3.0 gha) clearly reveals: Austria lives beyond its means (figure 1).

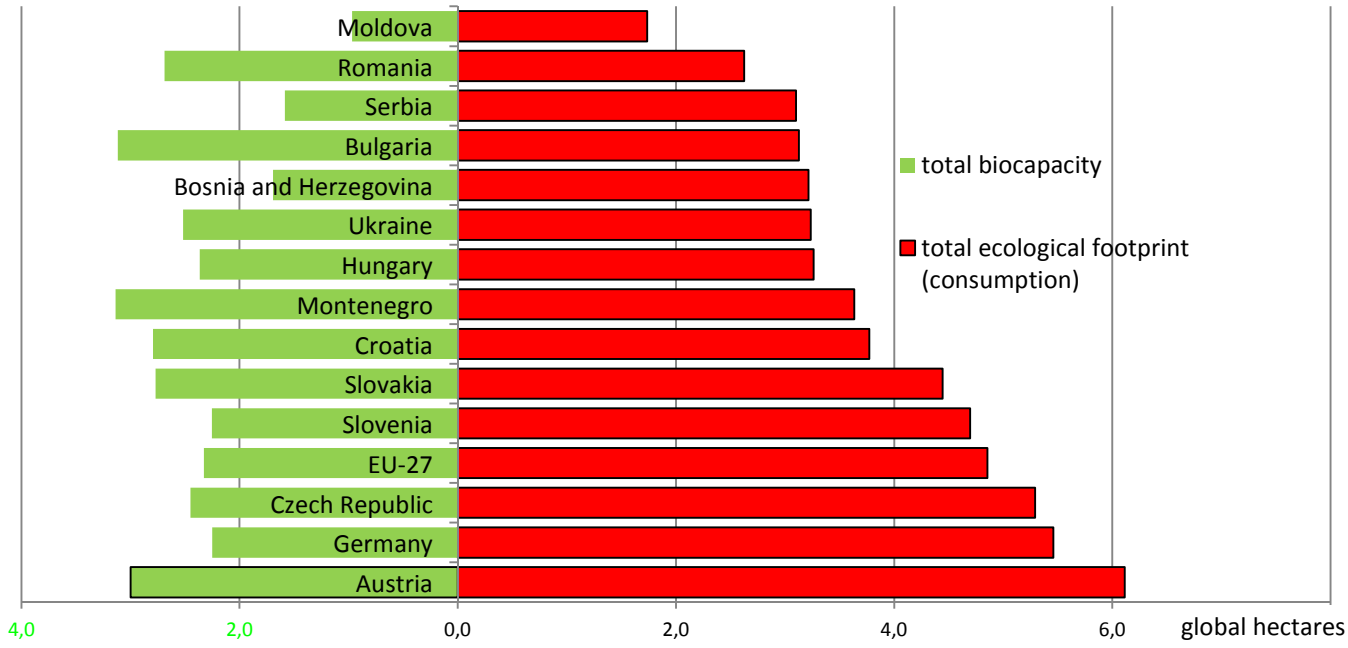


Figure 1 Per-capita ecological footprint vs. biocapacity in selected countries, 2013 (data source: Global Footprint Network)[2]

As would be expected, high-income countries show generally larger footprints (emphasizing the need to

[1] https://www.bmvit.gv.at/service/publikationen/verkehr/strasse/downloads/statistik_strasseverkehr2016.pdf

[2] The **Ecological Footprint** is a measure of the biologically productive surface a population or human activity requires to produce (**biocapacity**) all the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management practices. This includes producing renewable resources, accommodating urban infrastructure and roads, and breaking down or absorbing waste products, particularly carbon dioxide emissions from fossil fuel. Current Ecological Footprint Accounts use **global hectares** as a measurement unit, which makes data and results globally comparable (www.footprintnetwork.org). The difference between ecological footprint and biocapacity (biocapacity deficit) serves calculating a nation-specific "world overshoot day" or "how many earths would be needed if the entire world population behaved like a particular nation"

decouple economic growth from resource consumption). Among Danube region countries, Austria is the inglorious frontrunner. Noteworthy, Bulgaria and Romania present the only (fully or almost) deficit-free countries (0.0 or -0.1 gha/capita) in the Danube region. Cross-country variations in total ecological footprints (comprising six categories, figure 2) primarily arise from differences in carbon footprints.

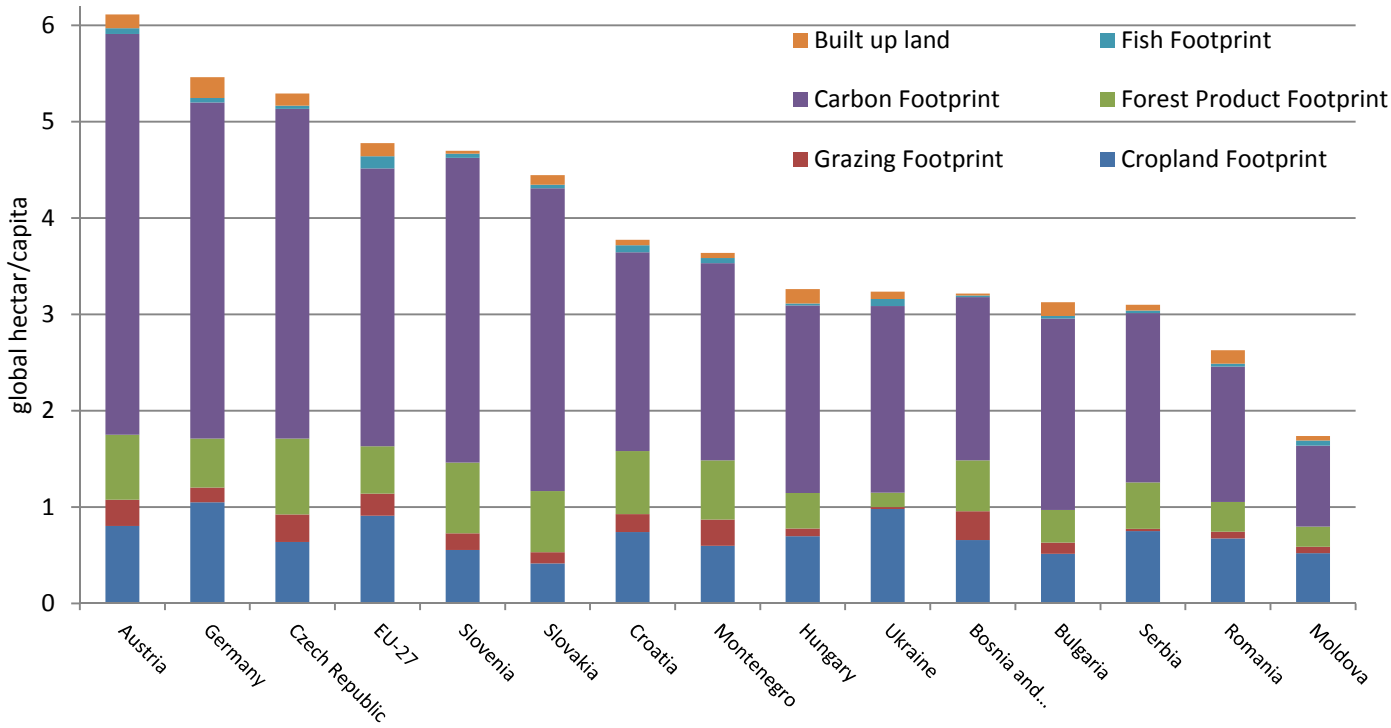


Figure 2: Ecological footprint composition in Danube region countries_2013 (source: data source: Global Footprint Network)[3]

National amounts of CO_2 equivalent emissions (accounting for a country´s `carbon footprint´) comprise fossil fuels and cement production emissions incurring on-site (territorial emissions) as well as emission attributable to outsourced production of imported goods (emission transfers). For Austria, these two components make up 70-80 % and 20-30 % of total consumption emissions, respectively (figure 3). CO_2 equivalent emissions in 2014 are almost identical to those of 1990. A sharp transient drop in territorial emissions, most likely due to economic crisis-related production decline, can be noted. (The economic crisis, in that respect, was an environmental benefit.) With respect to greenhouse gas (GHG) emission developments (figure 4), Austria, EU and DR countries show similar profiles: Emissions decreased from 2010-2014 (by 14 % in Austria) and are now on a worrying raise again. Austria´s per capita GHG emissions lie slightly above EU average and markedly above that of DR countries.

[3] The **cropland Footprint** includes crop products allocated to livestock and aquaculture feed mixes, and those used for fibers and materials. The **forest product footprint** is calculated based on the amount of lumber, pulp, timber products, and fuel wood consumed by a population on a yearly basis. The **fishing grounds footprint** is calculated based on estimates of the maximum sustainable catch for a variety of fish. The **grazing land Footprint** is calculated by comparing the amount of livestock feed available in a country with the amount of feed required for all livestock in that year, with the remainder of feed demand assumed to come from grazing land. The **built-up land footprint** is calculated based on the area of land covered by human infrastructure: transportation, housing, and industrial structures. Built-up land may occupy what would previously have been cropland. The **carbon footprint** represents the area of forest land required to sequester CO_2 emissions associated with fossil fuel use. (more details see www.footprintnetwork.org)

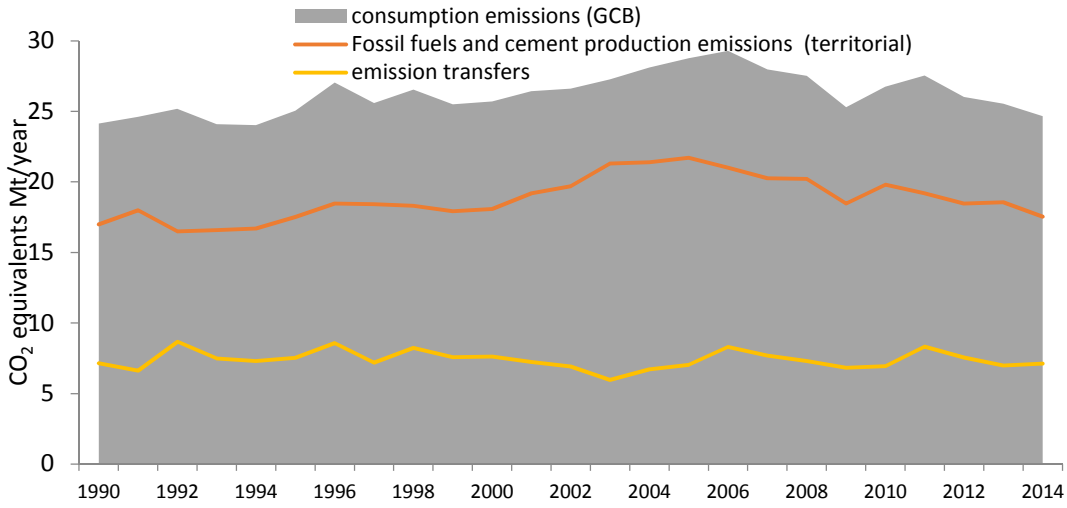


Figure 3: Carbon emissions in Austria: territorial emissions and emission transfer in 1990-2014 (Source: [4]).

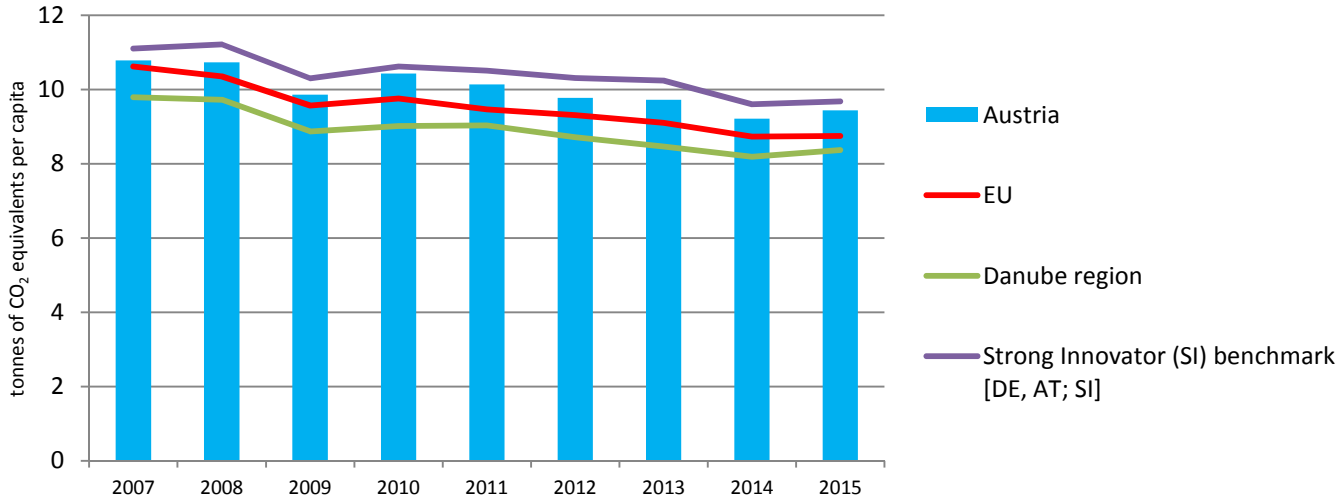


Figure 4: Greenhouse gas emission per capita (source: Eurostat)

OBSTACLES: Austria lives beyond its means. The ultimate objective, a zero biocapacity deficit, can only be reached upon drastic reductions in fossil fuel use. Austria, as a first step, should head for lowering its biocapacity deficit to EU average (-2.5 gha/capita), which can be achieved by reducing the ecological footprint to that of Germany. As re-emphasised also during the United Nations Framework Convention on Climate Change, 23rd Conference of the Parties (COP23) in Bonn, November 2017, Austria will fail to meet the Paris Climate Act agreement targets unless it radically reduces GHG emissions. There is an urgent need for truly effective actions, as otherwise restricting global warming to the 2 °C limit will remain illusory.

OPPORTUNITIES: Lower Austria (and Baden-Württemberg (D) as the only representatives of DR countries) disclosed their region-wide GHG emissions in an international report[5] , documenting achievements and tasks such as that `Lower Austria reached its ambitious 100 % renewable electricity target in 2015, but still has a target of 50 % renewable energy in the total energy mix by 2020´. Such transparency can create a

[4] Data sources: Updated from Peters, GP, Minx, JC, Weber, CL and Edenhofer, O 2011. Growth in emission transfers via international trade from 1990 to 2008. Proceedings of the National Academy of Sciences 108, 8903-8908. http://www.pnas.org/content/108/21/8903.abstract; UNFCCC (June 2016) and Boden, T.A., G. Marland, and R.J. Andres. 2016. Global, Regional, and National Fossil-Fuel CO2 Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. doi 10.3334/CDIAC/00001_V2016

[5] https://www.theclimategroup.org/sites/default/files/downloads/compact_report_2016_0.pdf

desirable contest and give incentives for followers. The Austrian Climate Change Research Network CCCA[6], as a national coordinating body for promotion of climate research, pursues to strengthen multidisciplinary approaches, knowledge and science transfer in order to advise politics and society. Cooperation of the CCCA´s growing pool of experts with those of other DR countries can boost mutual progress.

Environmental challenges: Overview

Austria faces diverse environmental challenges, many of which are home-made and/or related to climate change (outlined in detail in the BMLFUW annual report "Klimaschutzbericht"). Consequences of anthropogenic greenhouse gas emissions have long been recognized and are particularly evident in alpine regions. The following table lists some obvious and less well-known challenges, some of which will be described in more detail in subsequent report sections.

Challenge or harmful activity	Consequence	Danger	Suggested solution
Climate change	glacier melting; drought, heat	river hydrology disturbances; harvest loss, need for energy-demanding irrigation systems, rural depopulation	Landscape protection, new agricultural concepts, alternative drought-resistant crops, mixed cultivation
Land sealing	water cannot drain away	Flooding→harvest loss, erosion, building damages	Spatial decision support tool [7] Restrict/reduce land sealing, limit urban sprawl, use permeable alternatives[8]
Monocultures, pesticide usage (private&agri-culture)	biodiversity loss	natural heritage irrevocably lost	Targeted re-introduction and cultivation of endangered species, Bio-control instead of chemical pesticides, use-on-demand, public awareness raising
Excessive heating and air conditioning of buildings	high energy demand	GHG emissions, Waste of energy	Insulation with non-toxic sustainable materials incl. vertical greening Full transparency on energy consumption to initiate saving-contests between households.
Excessive consumerism	excessive material use, industry pollutions	resource exhaustion, waste accumulation	Recycling, module-systems, compatible repair components, awareness raising for `sufficiency´ and alternative (non-material) `rewards´
Lubricants from motors, turbines, vehicles	Uncontrolled release into environment	accumulation of non-degradable, toxic substances	Bio-degradable alternatives
Invasive plants (neophytes)	Outcompete/displace native species, biodiversity loss	natural heritage loss, ecosystem imbalance, landscapes lose individual character, allergies	Controlled large-scale uproot actions and subsequent re-planting with native species
Excessive outdoor lighting, 24h	Light pollution, energy wastage	pollinator disturbance (Knop *et al.*, 2017), insect death[9] ecosystem imbalance, harvest loss	Reduce lightning number, duration and intensity, raise public awareness

Table 1: (non-exhaustive list of) environmental challenges relevant for Austria and most DR countries

Glacier melting and land erosion

As an alpine country Austria faces accelerated glacier melting and thinning. Global warming-derived

[6] http://www.ccca.ac.at/en/home/
[7] http://www.giscame.com/giscame/english.html
[8] http://ec.europa.eu/environment/soil/pdf/SoilSealing-Brochure_en.pdf
[9] https://www.cbd.int/doc/world/at/at-nr-05-en.pdf

changes in river hydrology and morphology are projected to be the greatest of any hydrological system, with profound impacts on the natural environment (Milner *et al.*, 2017). Equally alarming, roughly 7.2 tons per hectare are lost due to erosion each year, resulting in EU-wide mean annual soil loss rates of almost 4 % (Panagos *et al.*, 2015). As can be recognized from the heat map (figure 5), several Danube region countries including Austria are considerably affected.

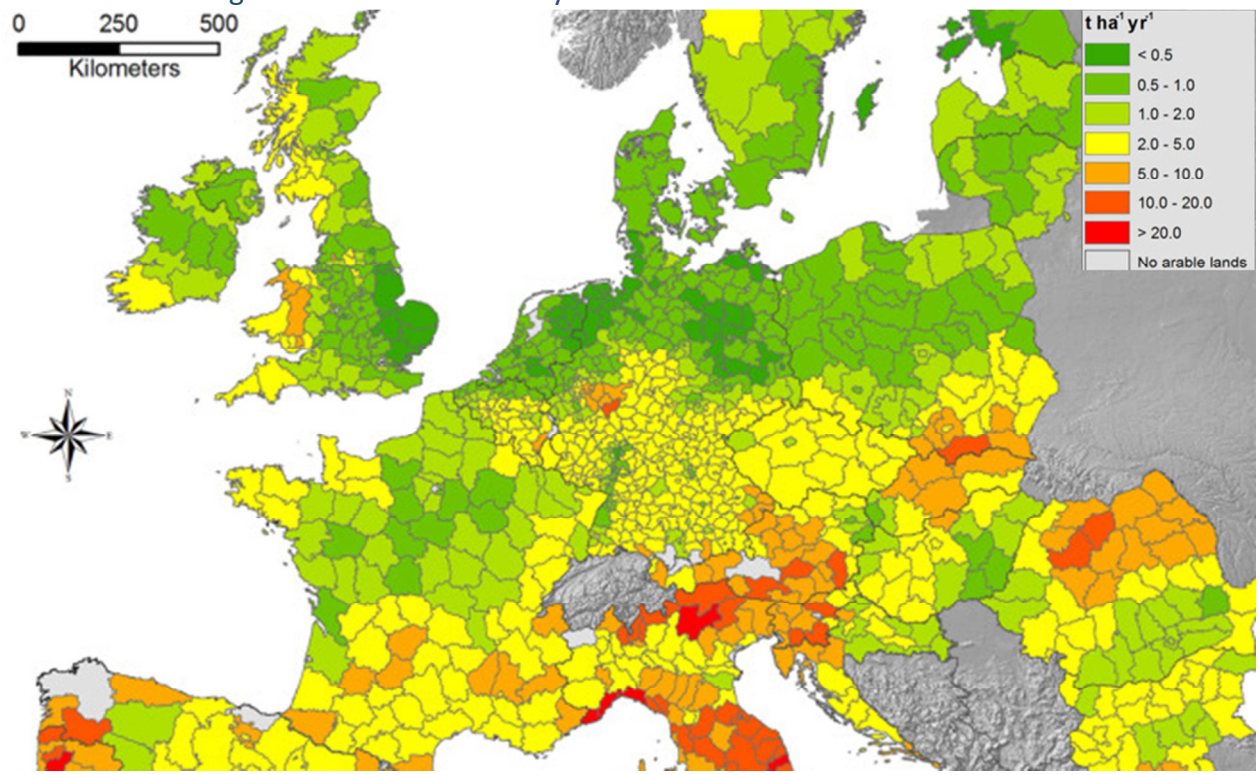


Figure 5: EU-wide soil loss of arable land. Modified from: (Panagos et al., 2015)

A pilot study (Lorenz *et al.*, 2013) demonstrated that integration of innovative crop sequences related to bio-energy production or organic farming and different soil tillage, soil management and soil protection techniques are effective means to restrict soil erosion. The impact of alternative agricultural land use strategies on soil erosion risk and ecosystem services provision can be computed by GISCAME (GIS= geographic information system, CA = cellular automaton, ME = multi criteria evaluation), a spatial decision support tool[10].

OPPORTUNITY: DR countries can capitalize from existent state-of-the-art tools to stop land erosion. It is `just´ a matter of coordination and practical implementation

Agriculture

Progressive climate change and the associated increase in abundance and severity of extreme weather conditions seriously impact agricultural production. Styria, Austria´s main fruit-growing area, faces hail or late-spring frost at an increasing frequency/intensity. Throughout the country (agricultural land 1414ha; OECD2015), prolonged heat and/or drought periods lower crop harvest yields. Owing to lack of prospects, many farmers abandon their land (rural depopulation). As in most DR countries, maize (primarily for feed), wheat and rapeseed dominate cultivated land. Rapid re-orientation is needed, as monoculture farming is taking its toll, causing e.g.: decline in biodiversity of flora and fauna, nitrate pollution of water due to over-fertilization (manure), soil erosion (short rooted crops), flooding (fields of maize hardly retain water), changes in pollinator fitness and behaviour (e.g. annual rhythm of bees disturbed by flower scarcity in

[10] http://www.giscame.com/giscame/english.html

summer and late-flowering rapeseed).

As a major source of greenhouse gases, agriculture contributes to climate change which in turn restricts agricultural productivity. To maintain high levels of harvest yields, (energy-costly) fertilizers and (biodiversity-repressing) pesticides are being used, thus closing the vicious circle.

The Upper Austrian environmental secretary Rudi Anschober recently demanded a Europe-wide ban on glyphosate[11], the most widely applied herbicide, approved by the EU in 2002, re-approved now until 2022. Evidence, also from Austrian researchers, for negative impacts of glyphosate on environment and health is growing (Schutte *et al.*, 2017; Van Hoesel *et al.*, 2017). France plans to fully renounce glyphosate as soon as alternatives emerge, but no later than 2020.

Lifestock emissions

Agricultural production for livestock feed, i.e. not for direct human food, requires substantially more space and water, and generates substantially more GHG emissions. Despite general public awareness on health and health risks, meat consumption in Austria (currently 103 kg/capita) exceeds that of any other European country. Lifestock – as sources for enteric fermentation gas– and synthetic fertilizers and manure account for the bulk of Austria´s agricultural emissions (figure 6, left).

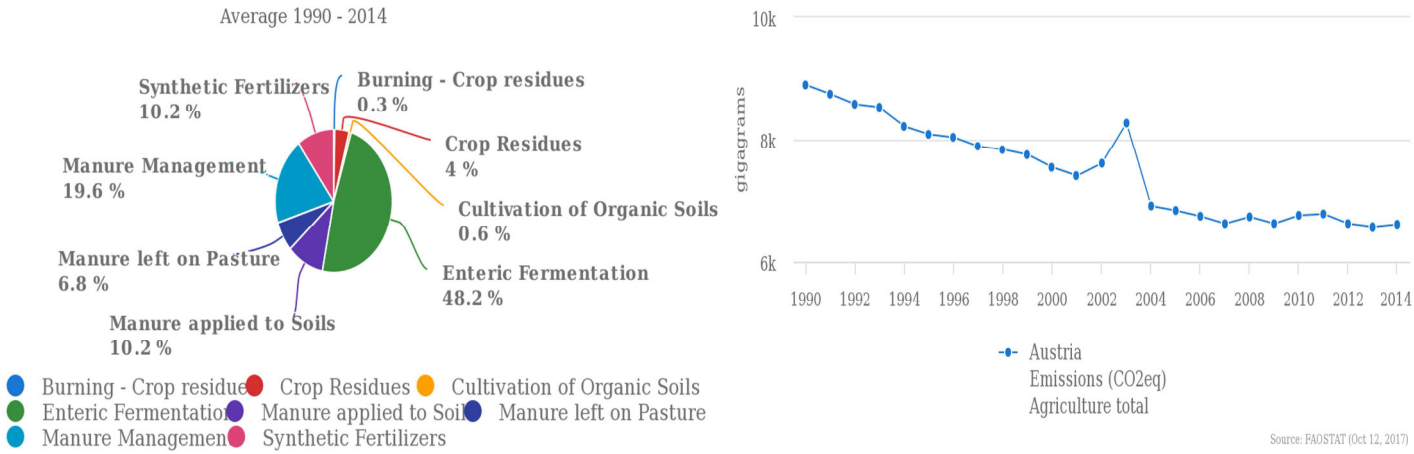


Figure 6: CO_2 equivalent emissions in Austrian agriculture; by sector (left) and as time course[12]

As a result of major reductions in lifestock numbers around 1990-2000 agriculture-derived emissions declined. However, due to subsequent lifestock number stabilisation, the desirable trend ceased (figure 6, right). Steady improvements in technology and farm management allowed maintaining high agricultural productivity but their overall effect on CO_2 equivalent emissions remains marginal.

OPPORTUNITIES: Eco-innovative solutions for weed management encompass e.g. mobile devices that i) recognize and remove weeds or ii) enable release of (preferably organic) herbicides on-demand. Similar precision farming concepts are also applicable to irrigation and pathogen protection. The basics for such strategies exist (Aune *et al.*, 2017; Balafoutis *et al.*, 2017).

Austria has strong intellectual capacity, which should be merged with entrepreneurial spirit to develop new perspectives for small-scale and organic farming. Arche Noah[13], an NGO dedicated to preserving and distributing `forgotten´ genetic resources (intra- and inter-species variety) can provide seeding material for innovative agricultural concepts. Austrian geologic and climate conditions would allow for `material

[11] https://www.land-oberoesterreich.gv.at/Mediendateien/LK/PKAnschober11102017Internet.pdf.
[12] chart source: http://www.fao.org/faostat/en/#country/11
[13] https://www.arche-noah.at/

farming´, an attractive alternative to energy- and chemical-consuming production.
The only effective means towards a more sustainable agriculture is a marked reduction in lifestock numbers and thus, meat and dairy product consumption. (Even a moderate) change in consumer will bring improvements. If all Austrians converted from a current average diet to a vegetarian or vegan diet, agricultural emission would drop dramatically (10.5 to 2 Mio tons CO_2/year), as would land need, manure production and associated nitrate influx into soil and ground water. Incentives could be given through higher pricing of meat and dairy products. With a share of currently app. 20 %, organic farming in Austria shows a growing, above-average importance in agriculture. Strict regulations define product qualification for the `Bio´ label, for which consumers are willing to pay more. Continuation of this desirable trend and respective pilot actions / knowledge transfer to farmers in other DR countries should be encouraged and supported. Intensified exchange of know-how between farmers would be beneficial both from an economic and ecologic perspective.

Invasive species

Invasive plant species represent an underestimated danger to ecosystems and human health, as they multiply explosively, displace native species and release potential allergens. For instance Ambrosia (`ragweed´)-derived allergens (Rasmussen *et al.*, 2017) affect an estimated population of 618.000 Austrians (11 % population in Eastern Austria) (Hemmer et al., 2010). The burden on the health care system is considerable, given the direct and indirect costs caused by non-treated allergy sufferers in the EU (2400 Euro per capita per year) (Zuberbier *et al.*, 2014). Ragweed, Malaysian Balsam, Japanese Knotweed and other invasive neophytes spread widely in the Danube region. Individual countermeasures taken at the local level (professional guided uproot actions) are insufficient to combat invasive plant spreading within and across countries. In 2017, Austrian researchers implemented an online system which projects current national occurrence and developmental stage of ragweed on a regularly updated map. Citizens can both monitor and report data[14].
OPPORTUNITIES: Above-mentioned online system could be expanded to all DR countries; and be adapted to monitor other invasive species besides ragweed. Austria has the relevant know-how to create international inventories (Karrer *et al.*, 2015). With respective coordination among cooperating municipalities it should be feasible to combine native species removal with biomass energy generation. Noteworthy, high biomass yields can be expected given the fast growth and often high lipid (i.e. energy) content of those plants.

Air quality, pollutants, lubricants

Air pollutants pose a health and environmental risk. For this reason EU legislation has established health-based standards and objectives for a number of pollutants such as nitrogen oxides and particulate matters[15]. Although Austria takes various, regularly revised emissions-reducing measures[16] (e.g. regulations for construction sites, traffic and heating (coal-heating prohibited), air pollutant concentrations remain worryingly high. Several traffic- and industry-intensive `hot spots´ frequently exceed the EU guidance value of nitrogen oxides (50 µg/qm). For Graz (last update 14Nov 2017) this applied to 35 days in 2017[17]. Of special concern are air-borne particulate matters (PM), designated by the WHO as group I carcinogens. There is no save level of PM exposure, inhaled fine particles damage lung and other organs

[14] https://www.ragweedfinder.at/Home/Info
[15] http://ec.europa.eu/environment/air/quality/standards.htm
[16] http://www.ullisima.at/downloads/massnahmenpaket-3.pdf
[17] http://www.umweltbundesamt.at/umweltsituation/luft/luftguete_aktuell/ueberschreitungen/

(Schulze *et al.*, 2017). As of 1.1.2015, the limit value (EU commission directive) for combustion-derived PM2.5 was set to 25 µg/qm. Development of population exposure to PM2.5 in Vienna and other Danube region capitals during 1998-2015 shows no discernable trend. Instead, PM levels considerably fluctuate over time, and overall profiles of individual capitals resemble each other. (Noteworthy, PM profiles do not correlate with oil price development; not shown). PM2.5 pollution in Austria (whole country) lay between 14 and 17 µg/m^3 during the observation period (1998-2015); Vienna expectedly shows higher pollution levels (17-23 µg/m^3), approaching those of the EU-defined limit value. The fact that none of the observed countries and metropolises exhibits a consistent decline in PM2.5 concentrations indicates lack of a more effective policy and/or PM-limiting innovation. Noteworthy, a recent study has demonstrated that elevated concentrations of PM2.5 and traffic-related air pollution within metropolitan areas, in ranges commonly encountered worldwide, are associated with cardiovascular disease development (Kaufman *et al.*, 2016). The (still comparatively high) PM2.5 limit of 25µg/m^3 should therefore only be an intermittent one. Recently raised health concerns on other traffic-/combustion-derived pollutants, ultrafine particles (UFPs) (Chen *et al.*, 2016) clearly call for preventive measurements. To tackle the problem of air pollution, the EU hold a transnational forum (Nov 2017), including also experts from Austria[18].

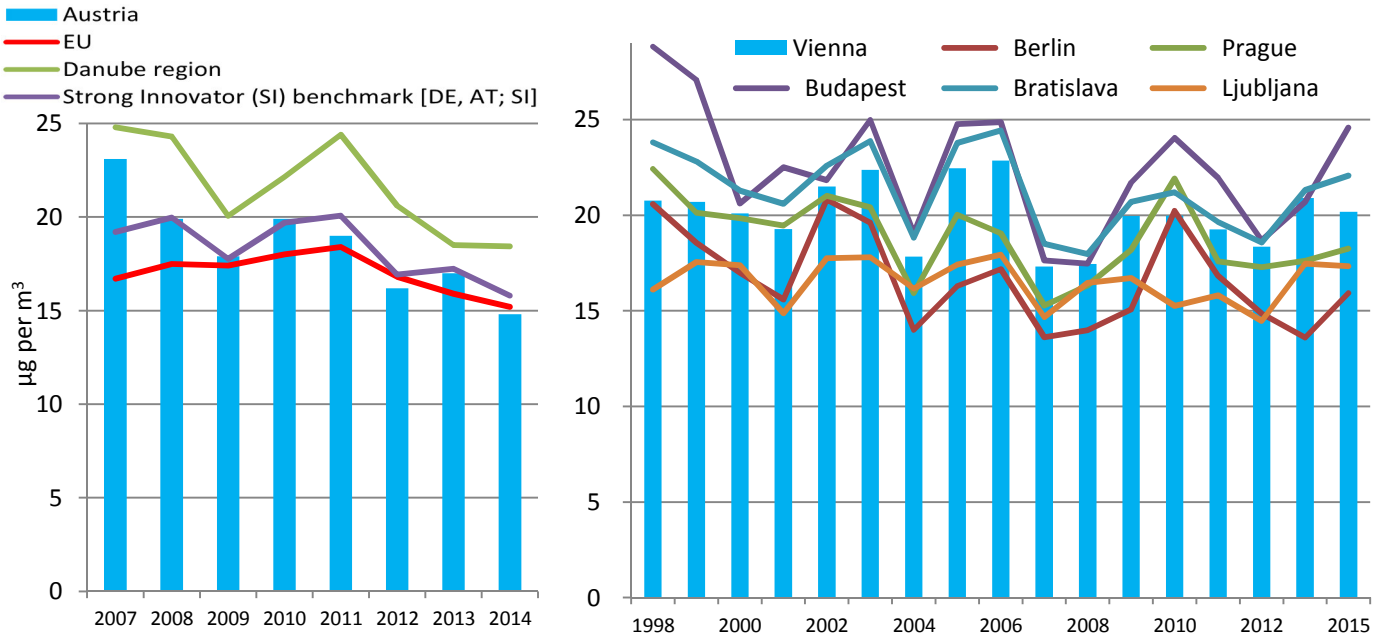


Figure 7: Urban population exposure to air pollution by particulate matter <2.5µm; national comparison 2007-2014 (Source: Eurostat), and comparison of selected DR capitals 1998-2015 (source: OECD)

OBSTACLES and OPPORTUNITIES: Austria, like all DR countries, must take all possible efforts to lower emission levels of health-threatening PMs. Recent measures in Graz (car sharing, bicycle rental network, tight coordination with public transport) have proven effective. Austria should consider ban of diesel vehicles (main source of PMs) from city centers, as implemented by the `C40 cities´ network[19], and give incentives for car sharing and electric vehicles. Laggard cities like Innsbruck could `learn´ from Graz. To avoid falling behind current protection standards, Austria should join the C40 cities network (DR countries currently only represented by Munich and Heidelberg) to unite forces towards improving urban environment. Austria is among the 19 nations of the `Powering Past Coal Alliance´ that was launched at the UN climate summit in Bonn on 16Nov 2017. European countries besides Austria (Belgium, Denmark, Finland, France, Italy, Luxembourg, Netherlands, Portugal, Switzerland, UK), i.e. no other DR country, gave

[18] http://ec.europa.eu/environment/air/clean_air/forum.htm
[19] http://www.c40.org/cities

that commitment to quickly phasing out coal. The current alliance aims to grow to 50 member states by COP24. Austria should use this OPPORTUNITY to take a leader role and encourage DR countries to join.

Lubricants

While lubricants improve fuel economy and vehicle efficiency they also contribute to engine exhaust emissions. Besides vehicles, industry machines and wind turbines (almost 1200 wind turbines in Austria[20]) are major emitters of petrol-based lubricants whose uncontrolled disposal and accumulation threatens soil and aquatic life. Therefore, scientists search for biodegradable alternatives (Jadhav *et al.*, 2017). Microbiological alternatives, which would evade energy-intensive production steps, seem a realistic option (Economica, unpublished).

5.2 Resource Efficiency, Waste and Recycling

Domestic material consumption and resource productivity

As (co-)reflected by the ecological footprint (figures 1-3), domestic material consumption in Austria lies markedly above EU- and DR countries average. Austria has made no recognizable efforts to improve its ranking (figure 8, left). The situation is similarly worrying for the indicator `resource productivity´. Overall, Austria uses too much material, in an insufficiently economic manner (figure 8, right).

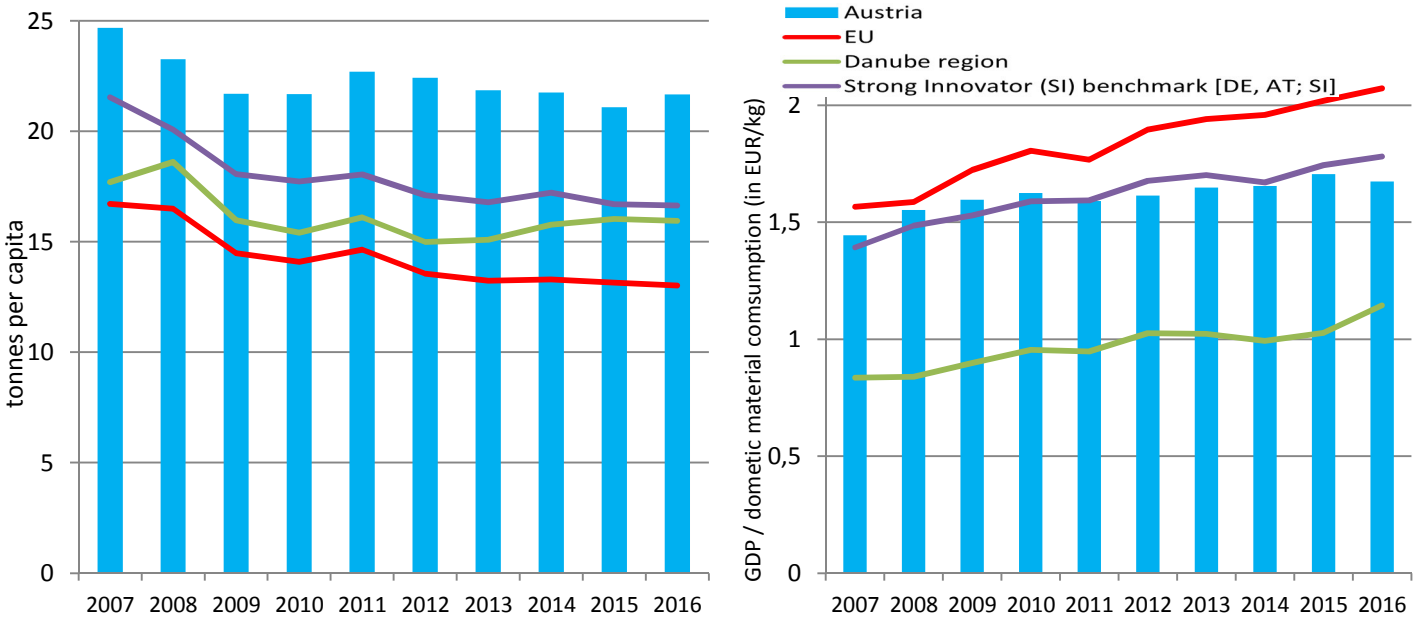


Figure 8: Domestic material consumption (left) and Resource productivity (chain linked volumes) (right); source: Eurostat)

OBSTACLES and OPPORTUNITIES: Incentives and sanctions should be given to cut down material consumption and to improve resource productivity. Public awareness for a more sufficient lifestyle, for sharing of devices etc. is a knowingly effective means. Resource productivity can be enhanced through consistent implementation of circular economy concepts. National success stories do exist, e.g.[21].

Waste and waste management

In 2014, Austrian households generated 4170 Mio tons of waste (table 2). The current waste separation system selectively collects metal/tins, glass, paper, plastics, biological residues and `general waste´. For households, recycling is purely voluntary. A growing number of enterprises deal with collection and

[20] https://www.igwindkraft.at/?xmlval_ID_KEY[0]=1047
[21] www.alchemia-nova.net

conversion of (primarily non-biological) `waste´ into raw materials for new products. `Green waste´ from households, gastronomy, gardening and horticulture, however, at best end up in biomass power plants for energy production, although there would be smarter exploitation strategies (Alamar *et al.*, 2018).

waste (thousand tonnes)	2004	2006	2008	2010	2012	2014
waste generated by households	3,441041	3,711839	3,819277	4,622626	4,020113	4,170023
waste generated by all NACE2 economic activities	49,579909	50,574764	52,489489	42,176953	44,024976	51,698275

Table 2: Waste generated by Austrian households and by NACE2 economic activities (source: Eurostat)

The updated national waste management plan, due every 6 years, (recent issue 2017)[22] sets guidelines for waste classification and disposal. Cross-country comparison of recycling rates of municipal waste indicates effectiveness of the national strategy. Here, Austria performs better than EU- and DR countries average (figure 9). However, whereas other countries continuously improved their municipal waste recycling rates, those of Austria experienced a decline since 2008 and stagnation since 2011. Notably, the national waste management plan seemingly caused no fundamental changes in waste recycling (Otherwise one would expect a rhythmic improvement after each 6-year-period.) Austria could learn from Slovenia whose municipal waste recycling rates have been growing at an impressive speed (table 3).

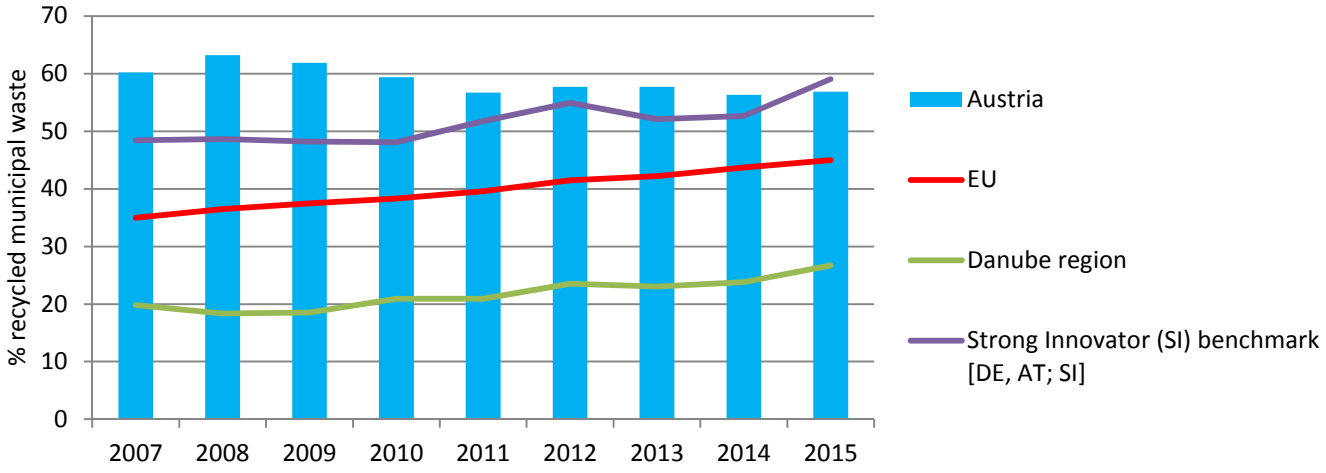


Figure 9: Recycling rates of municipal waste (source: EUROSTAT)

recycling rate (%)	2007	2008	2009	2010	2011	2012	2013	2014	2015
Austria	60,20	63,20	61,90	59,40	56,70	57,70	57,70	56,30	56,90
Slovenia	21,90	18,90	19,60	22,40	35,60	41,90	34,80	36,00	54,10

Table 3: Municipal waste recycling rate development in Austria vs. best-performing DR country Slovenia (source: Eurostat)

OPPORTUNITIES: Overall, present recycling activities only lead to material *down*-cycling. Stricter application of circular economy concepts would largely increase resource efficiency and have an overall positive impact on the environment. Re-feeding `waste´ products at the highest energetic value possible back into the cycle saves energy, material and processing-related emissions. As exemplarily demonstrated by a pilot project[23], smart solutions can be profitable at the economic, ecologic and social level. Several universities pursue `upcycling´ concepts, which call for implementation through venturesome enterprises. Making separation of waste mandatory, both for households and enterprises, would certainly improve recycling rates and save waste-processing energy. Possible incentives for waste separation include higher pricing for residual waste disposal and transparent contents between municipalities for the lowest per-capita waste amounts. In the gastronomy sector refining of waste categories, e.g. `fat/lipid waste´, `fibers´

[22] https://www.bmlfuw.gv.at/greentec/bundes-abfallwirtschaftsplan.html
[23] http://www.interreg-danube.eu/news-and-events/project-news/1097

etc. would provide cleaner starting materials for value-added product. Old frying oil, for instance, can serve as substrate for bacterial production of biodegradable lubricants. A current Interreg project (with BOKU (University of Natural Resources) Austria as lead partner) explores ways for food waste reduction[24].

Packaging material / and -recycling

The beverage industry still primarily fills liquids into plastic bottles or metal cans. Unlike e.g. Germany, Austria has no mandatory deposit-and-return system, giving little incentive to customers for ecologically favorable glass re-fillables. Most supermarket chains have voluntarily stopped to distribute plastic carrier bags (whose natural degradation time is 400 years). Maize-based bags are debatable[25]. Although largely banned from cashier zones, thin plastic bags (vegetable etc.) are still freely available; only being renounced by a minority of environmental-conscious consumers. The environmental ministry publishes annual reports on voluntarily participating chain stores and their progress in plastic bag reduction[26]. Recycling rates for packaging waste in Austria have remained constant over the last decade, matching EU average values. Modest innovator DR countries are catching up (figure 10).

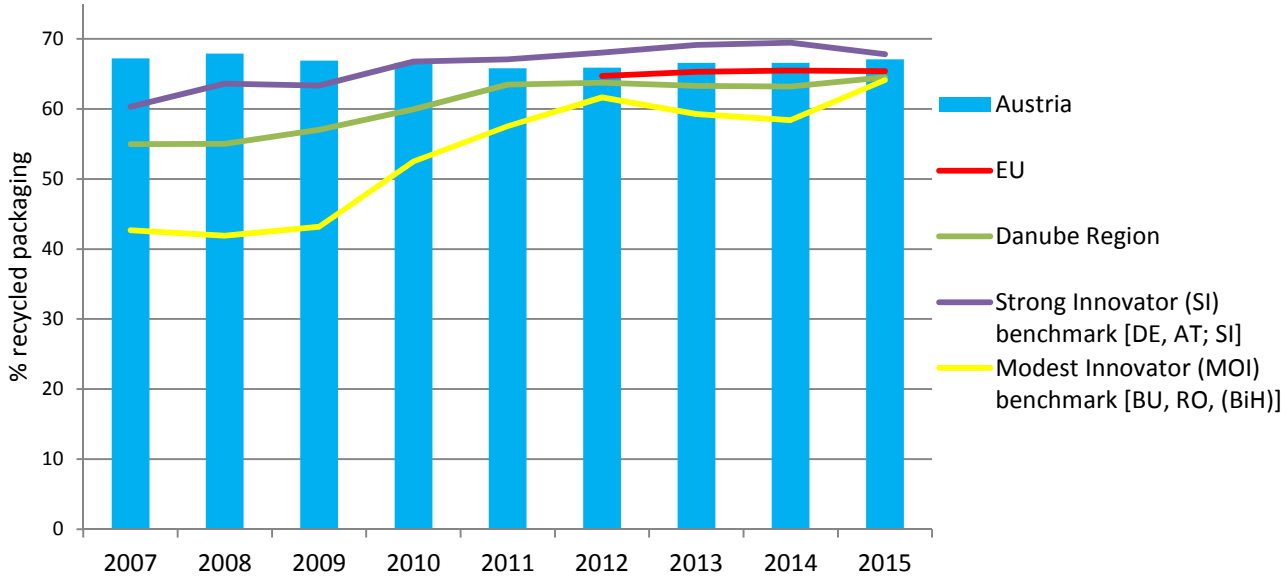


Figure 10: Recycling rates of packaging waste (source: Eurostat)

OPPORTUNITIES: Stores could explore voluntary plastic bag ban as a green marketing opportunity. Higher pricing is a known effective means to change customer behavior. Transparency in all respects can help cut down on packaging material waste. Appropriate actions include: Highlight problems such as plastics particles accumulation in soil, animals, food chain; publically pursuable between-store-contests in plastics minimizing. An intensive exchange of knowhow and technologies seems advisable in order to explore synergies and thus maximize packaging waste recycling in the entire Danube region.

Electronic waste

Large amounts of electronic waste arise each year due to breakdown of devices or replacement by a more modern version. Given that e-waste represents a source of non-degradable, highly valuable robust materials, recycling rates in Austria (40 %) appear disappointingly small.

[24] http://www.interreg-central.eu/Content.Node/STREFOWA.html
[25] http://www.ecology.com/2011/11/01/paper-plastic-corn/
[26] https://www.bmlfuw.gv.at/greentec/pfiadtdisackerl/pfiatdisackerl.html

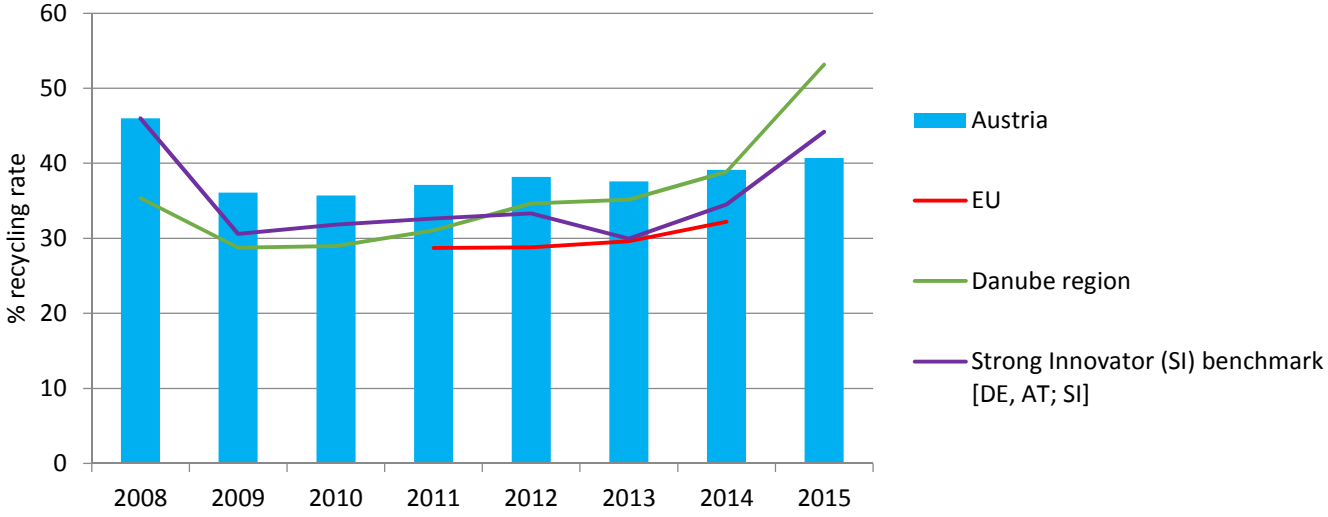


Figure 11: Recycling rates of e-waste *(`collection rate´ multiplied by the `reuse and recycling rate´ of electrical and electronic equipment); EU: limited data availability* ***(source: Eurostat)***

Recycling rate of e-waste, %	2008	2009	2010	2011	2012	2013	2014	2015
Austria	46	36,1	35,7	37,1	38,2	37,6	39,1	40,7
Bulgaria	:	:	40,8	49,4	62,4	60,2	68,3	96,5

Table 4: Recycling rates of e-waste in Austria and the best-performing DR country Bulgaria (source: Eurostat)

OBSTACLES and OPPORTUNITIES: Theoretically, for restoring or improving equipment functionality only the broken or outdated parts would have to be replaced. However, current design, lack of module-style built-up and incompatibility within and between brands make repairs almost impossible. Re-orientation, both for consumers and industry, is needed. This does not only apply to electronic devices but to product choice and product design in general. All DR countries can learn from Bulgaria, which achieved remarkable (96.5 %) e-waste recycling rates (table 4). An Austrian NGO initiative for mobile phone recycling[27] deserves DR-wide attention because disassembling of mobile phone components[28] is both ecologically and economically expedient.

5.3. Environmental Legislation

Since compilation of an exhaustive list and detailed description of environmental legislation would be beyond the scope of the present report, the following paragraphs provide general and some topical information, relevant examples (national and EU legislation) and links for further reading.

EU legislation: Resources, Waste, Recycling

Current directives regarding e.g. resource efficiency, environmental protection and health are accessible through the European Environment Agency portal[29] .

EU countries are obliged to follow common environmental policies[30], encompassing e.g. guidelines on air quality, waste management, nature and biodiversity. European environment policy until 2020 will be guided by the 7th Environment Action Programme (EAP), which also gives long-term directions for >2050.

[27] http://www.janegoodall.at/projekte/handyrecycling/
[28] http://www.janegoodall.at/wp-content/uploads/2013/03/JGI-A-Handyrecycling-Anatomie-eines-Handys.pdf
[29] https://www.eea.europa.eu/soer
[30] http://ec.europa.eu/environment/index_en.htm#

Central topic of the programme is `Living well, within the limits of our planet´ [31]. Noteworthy, EcoInn project goals directly match one overall objective of the EPA, i.e. to `turn the Union into a resource-efficient, green, and competitive low-carbon economy´.

The EAP´s `circular economy package´[32] comprises a number of measures and legislative proposals. With the ultimate objective, sustainable growth and the transition towards a circular economy, the package addresses 6 issues:

1. Higher resource efficiency for a greener and more competitive economy.
2. The `Eco-innovation action plan[33]´ fosters a wide variety of resource efficiency-improving processes, products and services, aiming at enabling green growth and the transition towards a more circular economy.
3. Raw Materials use in a way that does not deplete the planet's resources.
4. Production: Countries agree to promoting greener products and supporting greener companies and organisations.
5. Consumption: Transparent information shall enable consumers to make greener choices.
6. Waste prevention and management

Upon signing the 2030 Agenda (in 2015) Austria agreed to 17 sustainable Development Goals (listed below) and 169 targets[34].

Agenda 2013_Sustainable Development goals

1. End poverty in all its forms everywhere
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3. Ensure healthy lives and promote well-being for all at all ages
4. Ensure inclusive and equitable quality education and promote lifelong learning OPPORTUNITIES for all
5. Achieve gender equality and empower all women and girls
6. Ensure availability and sustainable management of water and sanitation for all
7. Ensure access to affordable, reliable, sustainable and modern energy for all
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10. Reduce inequality within and among countries
11. Make cities and human settlements inclusive, safe, resilient and sustainable
12. Ensure sustainable consumption and production patterns
13. Take urgent action to combat climate change and its impacts
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

EU Climate policies

- By signing the **Paris Climate Agreement** Austria has committed itself to set targets, plan and regularly report on its contribution towards mitigating climate change. The annual national report was published in November 2017[35].
- As one of the **Aarhus Convention** member states (since 2003) Austria has committed itself to collect and publish data on environmental protection. The environmental impact assessment act (2005) was implemented to assess planned projects for their direct and indirect effects on the environment.

[31] http://ec.europa.eu/environment/pubs/pdf/factsheets/7eap/en.pdf
[32] http://ec.europa.eu/environment/green-growth/index_en.htm
[33] https://ec.europa.eu/environment/ecoap/
[34] https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf
[35] http://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0622.pdf

Austria, along with 35 other countries, signed the `Protocol on Pollutant Release and Transfer Registers` (PRTR, 2003) within the framework of the Aarhus Convention. PRTRs shall make data on particularly hazardous pollutants publically accessible[36]. For Austria, the national PRTR database[37] furthermore informs on large industrial and waste treatment facilities. Current data on air quality, pollutant concentration etc., collected at 174 stations throughout the country, are publicly available[38]. Monthly and annual reports as well as prognoses can be accessed from this site, which also directs to data from other European countries.

- Austria acceded to the **Agreement of Cancun**. In the `Cancun Declaration on Mainstreaming the Conservation and Sustainable Use of Biodiversity for Well-being´ (Dec 2016), partner countries commit to `work at all levels within our Governments and across all sectors to mainstream biodiversity, establishing effective institutional, legislative and regulatory frameworks, and incorporating an inclusive economic, social, and cultural approach with full respect for nature and human rights, tailored to national needs and circumstances and in line with other relevant international agreements´ through a number of actions[39].
- **Convention on natural biodiversity** (CBD): In Austria´s 5th report (2014) to the CBD[40], providing an overview on governmental and non-governmental activities on biodiversity, certain deviations from the Aichi Biodiversity Targets became apparent. Despite clear improvement in biodiversity protection and restoration, some Aichi2020 biodiversity targets will be difficult to achieve. One defined target is to increase `Proportion of biodiversity related funding in percent of the public development cooperation (ODA) by 2020+´. Funding dedication to eco-innovative projects would be a rewarding investment.
- **Invasive species**. In January 2015 the **EU regulation No. 1143/2014** on the prevention and management of the introduction and spread of invasive alien species´ came into force. It applies to the (2017 updated) EU list comprising 23 neophytes and 26 neozoa[41] and prohibits their intentional introduction, exchange, cultivation and release. Furthermore, EU member states are obliged to remove and prevent spreading of those species. (see also: (Carboneras *et al.*, 2013; Genovesi *et al.*, 2015)
- As participating country of the **Marrakech climate change conference**, Austria agreed on the `action proclamation for our climate and sustainable development´[42]. As of Oct 2017, the life tracker documenting participating countries` commitment to action[43] reported a total of 12549 entries, to which Austria contributed 71 so far (comparison Bosnia&Herzegowina: 30; Serbia: 2; Germany: 364). For instance, the Austrian Post AG commited itself to `Reduce $CO_2$ emissions from vehicle fleet, buildings, and partner companies by 20 % from 2010 to 2015 through building infrastructure optimization, renewable energy purchases, electric vehicles, and solar power installations´. Four further companies voluntarily target to `use an internal carbon prize´. Several Austrian companies and cities committed themselves to `reducing CO2 emissions´ to varying extent, over varying periods. However, Austria made no commitment in the sector `agriculture´ (currently 16 entries).

National legislation

Austria renounces nuclear energy and co-funds research of the International Atomic Energy Agency´s EURATOM program whose aim is creation of a nuclear-free central Europe.

Environmental protection measurements in Austria are taken at three levels: federal authorities, province

[36] http://www.partizipation.at/pollutant_release.html
[37] http://www5.umweltbundesamt.at/PRTR-web/state.do?stateId=APP_START&txid=1d51f886241b3f300b1bf3e778c91e64235d7001
[38] http://www.umweltbundesamt.at/umweltsituation/luft/luftguete_aktuell/
[39] https://www.cbd.int/doc/meetings/cop/cop-13/official/cop-13-24-en.pdf
[40] https://www.cbd.int/doc/world/at/at-nr-05-en.pdf
[41] www.neobiota-austria.at
[42] https://unfccc.int/files/meetings/marrakech_nov_2016/application/pdf/marrakech_action_proclamation.pdf
[43] http://climateaction.unfccc.int/total-commitment-themes?themeid=0&theme=&open=yes&Country=75

governments and municipalities. Regulations for e.g. waste management, air pollution, herbicide and fertilizer use are comparatively strict, similar to those in e.g. Germany and Switzerland[44].

The environmental ministry provides publically accessible data on national and regional environmental issues and initiatives with respective background knowledge and current legislation; but also provides navigation tools for companies, e.g.[45]. Ambient air quality laws (IG-L and EG-L, incorporating recent EU guidelines) define pollutant monitoring, concentration limits, and protective measurements. Industrial and waste combustion plants must obey statuary limit values defined by the EG-K [46]. The updated national waste management plan, due every 6 years, (recent issue 2017[47]) defines guidelines for waste classification and disposal.

There are two national programmes aiming at a more sustainable agriculture and land use, the Austrian Rural Development Programme the Austrian Agri-Environmental Programme (ÖPUL)[48]. In the latter, conserving Biodiversity is a key issue. The programmes define actions to meet Common agricultural policy and to achieve biodiversity targets.

OBSTACLES and OPPORTUNITIES: At the relevant place, sections above include several positive examples as well as critical comments regarding legislation. In its `Roadmap to a Resource-Efficient Europe´[49] the EU outlined, in 2011 already, ways towards higher resource productivity in order to decouple economic growth from resource use and its environmental impact[50]. However, decoupling is not in sight, as comprehensively demonstrated in a recent study (Peters *et al.*, 2017). Many of the time series charts and tables in the here-presented report reveal that measures taken since 2011 had a disappointingly small effect. Austria does intensify efforts to increase the proportion of renewable energy sources. In its annual report the `Erneuerbare Energien Österreich`, a cluster organization in the field of renewables, provides facts on status quo, reveals weaknesses and outlines the next steps[51]. Furthermore, the environmental ministry compiles information on recent success stories, legislation, actions and issued certificates related to e.g. waste management on dedicated websites[52]. In their diversity these news can give impetus to further green inventions and green cooperative initiatives. Small-scale initiatives and actions, if in sufficient number, can have a substantial cumulative effect on the environment. They should therefore be supported in any respect, e.g. through financial incentives, consulting services, lowering bureaucratic hurdles).

5.4 Environmental Tax

An environmental tax is a tax whose base is a physical unit of something that has a proven, specific negative impact on the environment (Eurostat, 2017). European statistics divide environmental taxes into four categories: energy, pollution, resource and transport taxes.
In Austria, total environmental taxes have steadily grown in the last decade, from 6500 Mio € in 2006 to 8200 Mio € in 2015. Energy and transport taxes make the largest contribution. While resource taxes have doubled since 2006, pollution taxes show a slight decline. In 2015, resource and pollution taxes constituted only 0.26 % (55.69 Mio €) and 0.68 % (21.56 Mio €) of total environmental taxes, respectively.

[44] http://www.austria.org/environmental-protection/
[45] https://www.bmlfuw.gv.at/greentec/chemikalien/reach.html
[46] https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10011027
[47] https://www.bmlfuw.gv.at/greentec/bundes-abfallwirtschaftsplan.html
[48] https://www.bmlfuw.gv.at/english/agriculture/Rural-development.html
[49] http://ec.europa.eu/environment/resource_efficiency/about/roadmap/index_en.htm
[50] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0571&from=EN
[51] http://www.erneuerbare-energie.at/archiv-pressemitteilungen/
[52] https://www.bmlfuw.gv.at/greentec.html

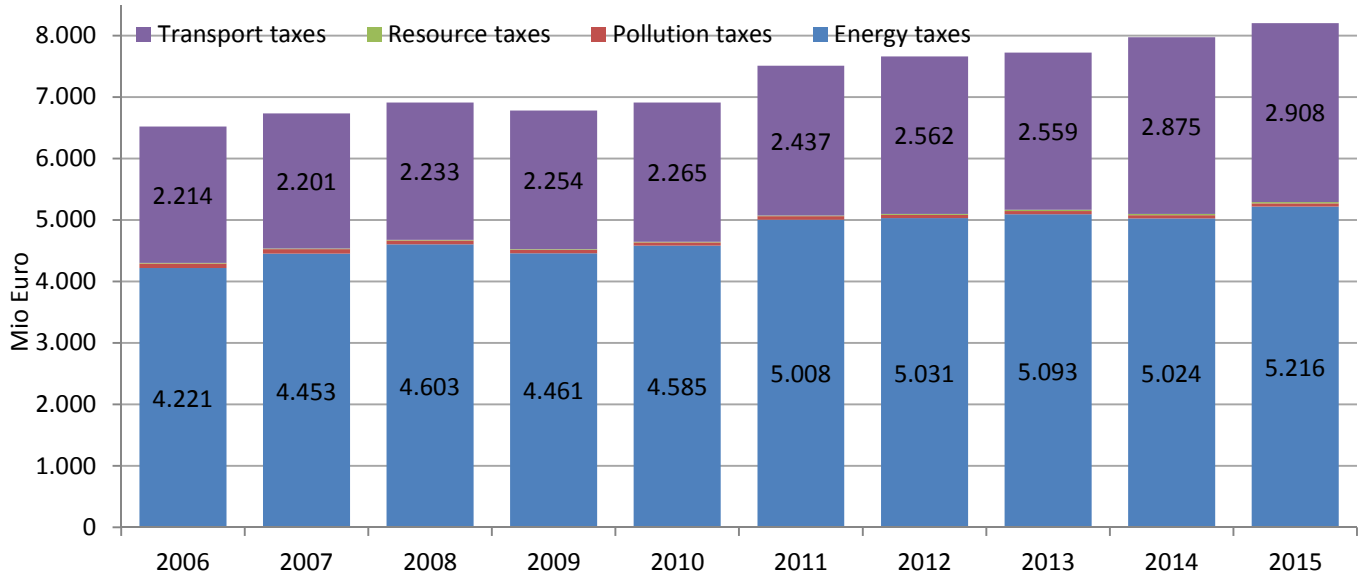


Figure 12: Austria, environmental taxes and their composition (source: Eurostat)

The share of environmental taxes on total tax and social contribution revenues has hardly changed during the last decade (table 5).

Share env. tax (%)	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total environmental taxes	***5,86***	***5,71***	***5,55***	***5,61***	***5,57***	***5,76***	***5,65***	***5,49***	***5,51***	***5,43***
Energy taxes	3,8	3,77	3,7	3,69	3,7	3,84	3,71	3,62	3,47	3,45
Pollution taxes	0,06	0,06	0,05	0,05	0,04	0,04	0,04	0,04	0,04	0,04
Resource taxes	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Transport taxes	1,99	1,86	1,79	1,86	1,83	1,87	1,89	1,82	1,99	1,93

Table 5: Austria, environmental taxes as percentage of total revenues from taxes and social contributions (source: Eurostat). *Heat-map Colour coding according to figure 12.*

In terms of national environmental tax revenues (as % of GDP) Austria falls within EU average (figure 13). There are marked differences between countries with respect both to environmental tax/GDP ratio (table 6) and distribution between tax categories. Austria has comparatively high revenues from transport but low revenues from energy taxes. The opposite holds true for Serbia, which in addition has the highest (GDP-related) environmental tax revenues of all compared countries (table 6).

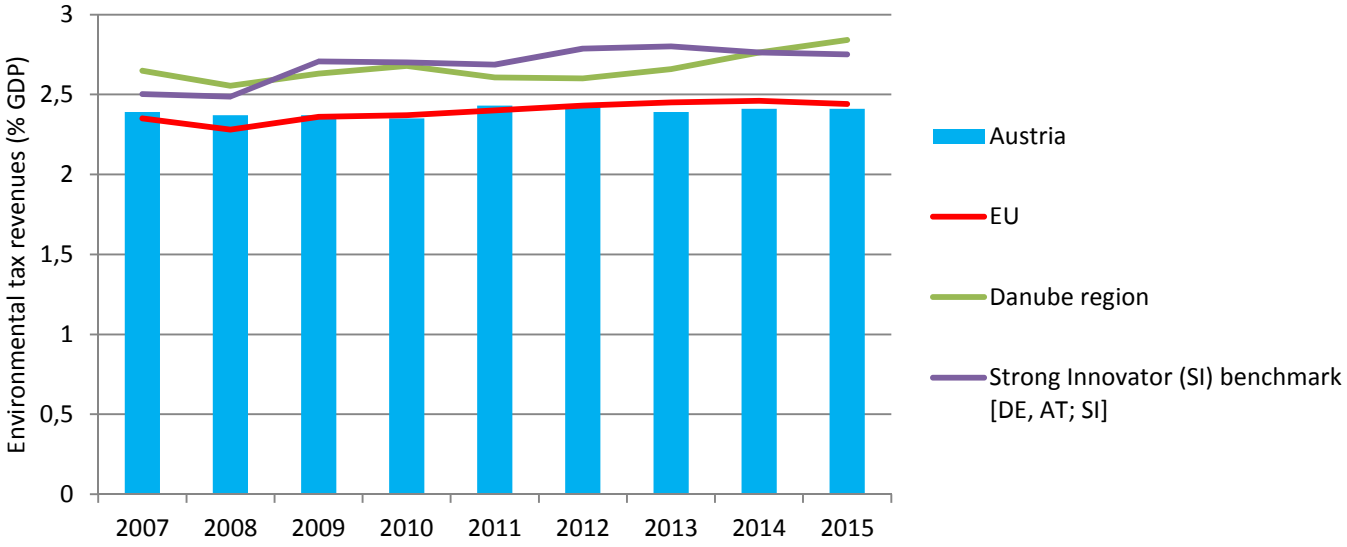


Figure 13: Total environmental tax revenues (% GDP), (source: Eurostat)

Tax / GDP (%)	2007	2008	2009	2010	2011	2012	2013	2014	2015
EU (28 countries)	2,35	2,28	2,36	2,37	2,4	2,43	2,45	2,46	2,44
Austria	2,39	2,37	2,37	2,35	2,43	2,42	2,39	2,41	2,41
Bulgaria	3,19	3,28	2,85	2,75	2,68	2,67	2,8	2,73	2,9
Croatia	3,69	3,44	3,37	3,66	3,31	3,19	3,51	3,87	4,11
Czech Republic	2,32	2,26	2,31	2,29	2,34	2,23	2,13	2,09	2,09
Germany	2,17	2,14	2,26	2,13	2,17	2,11	2,04	1,99	1,92
Hungary	2,77	2,68	2,62	2,75	2,63	2,71	2,59	2,56	2,65
Romania	2,04	1,75	1,86	2,09	1,93	1,97	2,04	2,34	2,43
Serbia	2,89	2,68	3,26	3,33	3,31	3,15	3,39	3,97	4,21
Slovakia	2,07	2	1,91	1,82	1,81	1,72	1,72	1,78	1,77
Slovenia	2,95	2,95	3,49	3,62	3,46	3,83	3,97	3,89	3,92

Table 6: Total environmental tax revenues (% GDP) in individual DR countries (source: Eurostat). *Green and red colours indicate country-specific positive or negative development, respectively.*

The implicit tax rate on energy measures the effective tax burden for energy consumption. High tax rates should thus represent a certain incentive for energy saving. Austria does not give strong incentives (figure 14). Unlike EU and DR countries average, implicit tax rates in Austria show no increase but some minor fluctuations. Values are markedly below EU average and remained basically at the levels of 2007. In that respect Austria has failed to recognize the urgency of energy saving.

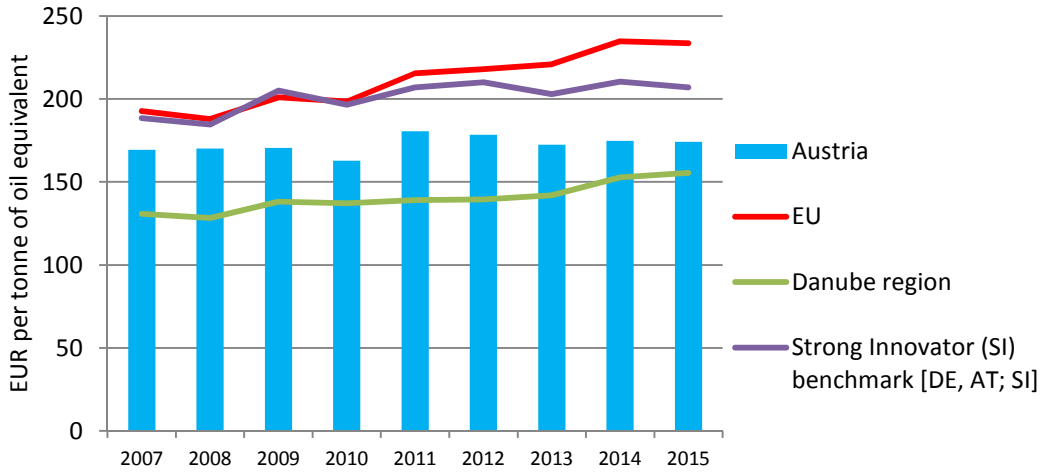


Figure 14: Implicit tax rate on energy *(ratio between energy tax revenues and final energy consumption),* ***(source: Eurostat)***

5.5 Environmental Protection Expenditure

This subchapter first reflects Austria´s overall (i.e. DR countries) positioning with respect to environmental protection expenditures by the public sector. To preclude some oversimplifying reasoning it is followed by a more detailed inspection into national environmental protection financing units and expenses dedication.

A decade ago, Austria´s public sector spent comparatively much on total environmental protection (figure 15, left). Unlike DR countries´ and EU average, however protection expenditures markedly declined. Following a drastic drop between 2007-2008, expenditures continued to decrease until 2011 and might – at best- have stabilized. Austria clearly lies below EU and SI average. Such low expenditures contradict the growing demand for environmental protection. Regarding investments into environmental protection by the public sector Austria performs distinctly weaker than other countries (figure 15, right). It spends not even half the amount (% GDP) compared to EU average. Interestingly, for this indicator DR countries outperform EU average.

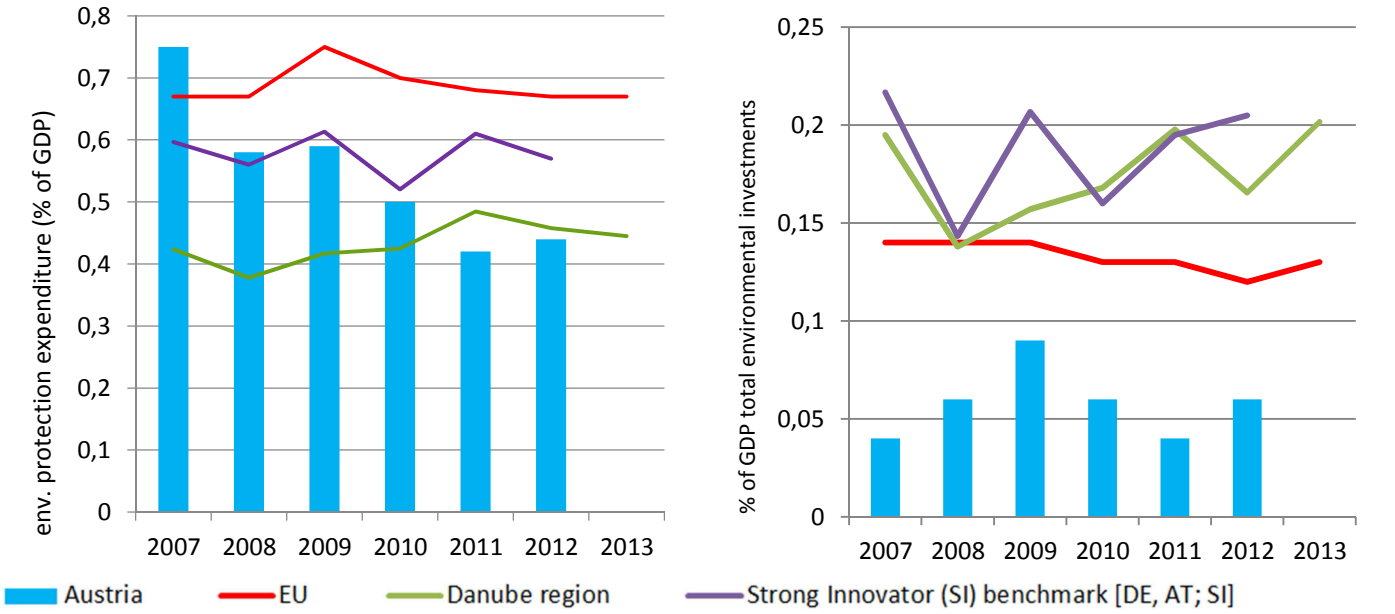


Figure 15: Public sector total expenditures on environmental protection (left) and – more specifically – investments into environmental prortection (right); *both indicators expressed as % of GDP* ***(source: Eurostat;*** *limited data availability)*

OBSTACLES: With respect to environmental expenditures, Austria´s public sector should catch up with other countries, especially regarding expenditures with the potentially most-sustainable effects, i.e. investments.

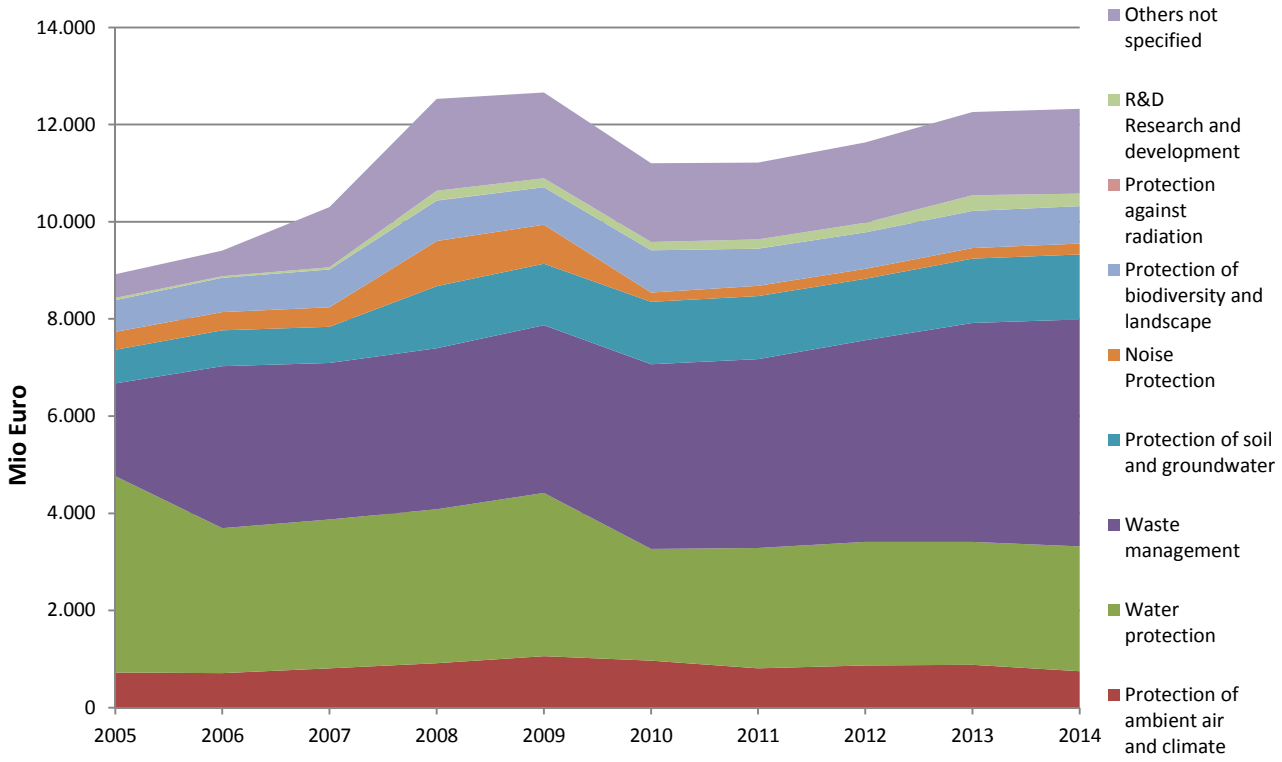


Figure 16: Environmental protection expenditures in Austria dedicated to nine sectors (source: Statistik Austria)

Austria spends approximately 12.000 Mio Euro per year on environmental protection. Expenditures comprise nine sectors, which show divergent development over the monitoring period (2005-2014) (figure 16). For most sectors a characteristic drop related to the economic crisis in 2009 can be noted. Expenditures on biodiversity and landscape protection remained almost constant, contrasting the growing need (outlined in above chapters). Waste management activities, accounting for the largest proportion in environmental protection expenditures, remained unaffected by the economic crisis. In fact, the crisis

stimulated expenditure growth in this specific (i.e. waste management) sector, indicating a crisis-related motivation to explore `waste´ as an economic resource. However, growing expenditures in waste management barely reflect on recycling rates or resource productivity (figures 8-11). Regarding anticipated decoupling of economic growth from environmental impacts, investments in the categories `R&D´ and `biodiversity & landscape protection´ hold particularly strong potential. Currently, these two categories only have a marginal share in environmental protection expenditures (table 7). Since 2005 (earliest data available) R&D expenditures have grown more than five-fold. The declining trend, commencing after a peak in 2013, is worrying. Similarly, contrasting the increasing demand for nature preservation, protection expenditures have not recovered from a sharp drop in 2011.

Expenditures in **Mio Euro**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Protection of biodiversity and landscape	655,4	700,9	779,2	832,6	771,7	866,5	760,5	747,9	769,3	772
R&D	43,9	37,0	41,2	197,7	185,2	169,1	192,0	200,8	318,2	256,2

Table 7: Environmental protection expenditures in Austria on two selected categories, biodiversity/landscape protection and on R&D (source: Statistik Austria)

OPPORTUNITY: More incentives for companies and start-ups in the fields of environmental protection should be provided to ensure that previous efforts are bearing fruit. Austria´s research institutions (e.g. BOKU, AIT) have leading experts in biodiversity, plant and environmental science as well as biotechnology. Intensifying their exchange with industrial partners can raise treasures that otherwise at best end up in peer-reviewed publications.

Environmental expenditures derive from four financing units whose individual contributions differ both in size and time development (figure 17). Enterprises make the strongest contribution. Those from the public sector and NGOs are comparatively low. Following a steady increase during 2005 to 2008/2009, overall and individual expenditures transiently declined. For enterprises, this effect is a likely consequence of the economic crisis. Additional, more complex factors presumably account for the decline or stagnation exhibited by the other financing units. As of 2014, total environmental expenditures/investments have not yet caught up with pre-crisis values; (especially if one takes GDP development into account), giving the impression that environmental protection is considered a luxury.

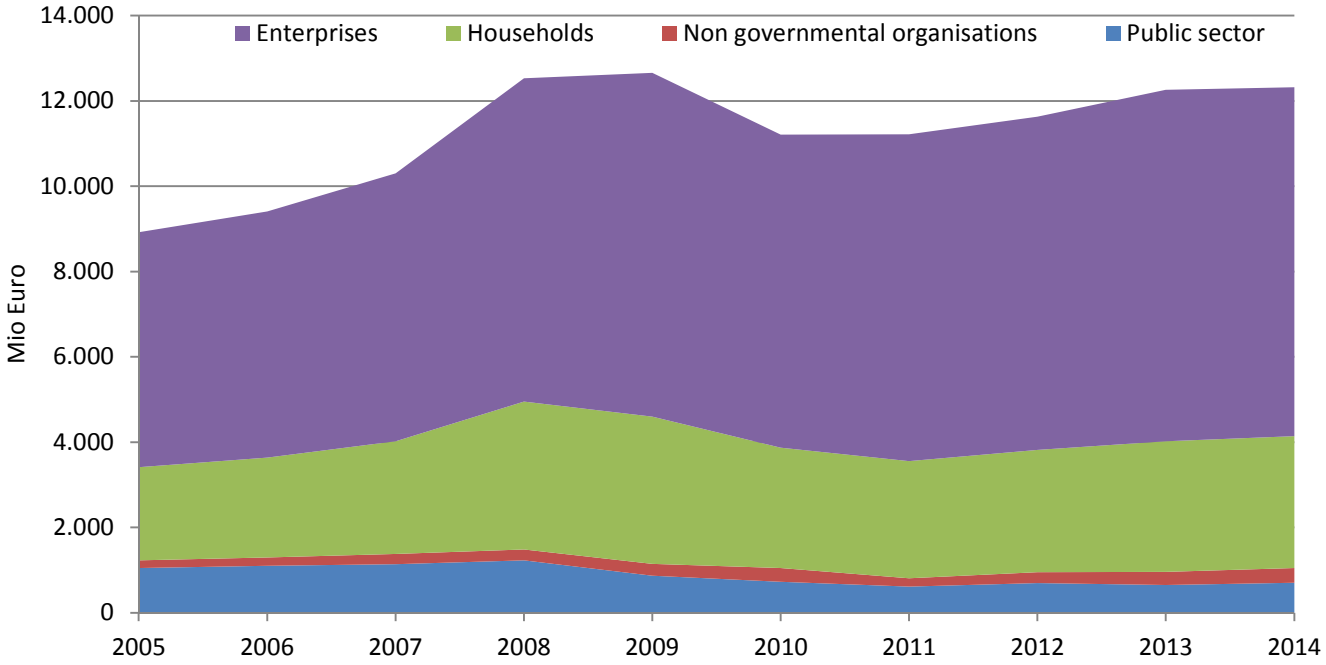


Figure 17: Contribution of financing units to total environmental protection expenditures in Austria (source: Statistik Austria)

Final consumption expenditure on environmental protection services

Paralleling overall development in EU countries[53] final consumption expenditures of Austrian households progressively increased (as a net result of consumption and GDP growth) and remained seemingly unaffected by the economic crisis (table 8). However, household expenditures dedicated to environmental protection do show the characteristic drop after 2009. In 2014, the latest data point available, those expenditures still remained below pre-crisis levels. Divergent development of (increasing) total consumption and (decreasing/stagnating) spending on environmental protection become even more apparent when looking at the ratio of these indicators (table 9, bottom row).

Expenditures	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
final consumption expenditure of households (Mio Euro)	147970	153183	153681	158025	165634	170585	174241	177813	181282	186189
env. protection expenditures of household Mio Euro	2645	3463	3455	2823	2753	2872	3057	3092	:	:
household expenditure on env. Protection (%)	1,79	2,26	2,25	1,79	1,66	1,68	1,75	1,74	:	:

Table 8: Austrian households: Expenditures on total final consumption and environmental protection** (´:´no data available) **(source: Eurostat and Statistik Austria)

OPPORTUNITIES: Consumer behaviour can substantially affect environment protection initiatives and give incentives to providers of eco-innovative products and services. Reciprocally, consumers will prefer eco-products over conventional products if the latter are taxed more heavily. In 2008/2009 households `were willing/able´ to spend >2.2 % of total consumption expenditures on environmental protection. Nothing speaks against demanding a similar share in the future. Different tax rates for eco- vs. non-eco products/services could set the right incentives.

[53] http://ec.europa.eu/Eurostat/en/web/products-datasets/-/TSDPC520

REFERENCES

Alamar MDC, Falagan N, Aktas E, Terry LA. 2018. Minimising food waste: a call for multidisciplinary research. *J Sci Food Agric* **98**(1): 8-11.

Aune JB, Coulibaly A, Giller KE. 2017. Precision farming for increased land and labour productivity in semi-arid West Africa. A review. *Agronomy for Sustainable Development* **37**(3).

Balafoutis A, Beck B, Fountas S, Vangeyte J, van der Wal T, Soto I, Gomez-Barbero M, Barnes A, Eory V. 2017. Precision Agriculture Technologies Positively Contributing to GHG Emissions Mitigation, Farm Productivity and Economics. *Sustainability* **9**(8).

Carboneras C, Walton P, Vila M. 2013. Capping Progress on Invasive Species? *Science* **342**(6161): 930-931.

Chen R, Hu B, Liu Y, Xu J, Yang G, Xu D, Chen C. 2016. Beyond PM2.5: The role of ultrafine particles on adverse health effects of air pollution. *Biochim Biophys Acta* **1860**(12): 2844-2855.

Genovesi P, Carboneras C, Vila M, Walton P. 2015. EU adopts innovative legislation on invasive species: a step towards a global response to biological invasions? *Biological Invasions* **17**(5): 1307-1311.

Jadhav D, Grippo AM, Shylesh S, Gokhale AA, Redshaw J, Bell AT. 2017. Production of Biomass-Based Automotive Lubricants by Reductive Etherification. *ChemSusChem* **10**(11): 2527-2533.

Karrer G, Skjoth CA, Sikoparija B, Smith M, Berger U, Essl F. 2015. Ragweed (Ambrosia) pollen source inventory for Austria. *Sci Total Environ* **523**: 120-128.

Kaufman JD, Adar SD, Barr RG, Budoff M, Burke GL, Curl CL, Daviglus ML, Roux AVD, Gassett AJ, Jacobs DR, et al. 2016. Association between air pollution and coronary artery calcification within six metropolitan areas in the USA (the Multi-Ethnic Study of Atherosclerosis and Air Pollution): a longitudinal cohort study. *The Lancet* **388**(10045): 696-704.

Knop E, Zoller L, Ryser R, Gerpe C, Horler M, Fontaine C. 2017. Artificial light at night as a new threat to pollination. *Nature* **548**(7666): 206-209.

Lorenz M, Furst C, Thiel E. 2013. A methodological approach for deriving regional crop rotations as basis for the assessment of the impact of agricultural strategies using soil erosion as example. *J Environ Manage* **127 Suppl**: S37-47.

Milner AM, Khamis K, Battin TJ, Brittain JE, Barrand NE, Fureder L, Cauvy-Fraunie S, Gislason GM, Jacobsen D, Hannah DM, et al. 2017. Glacier shrinkage driving global changes in downstream systems. *Proceedings of the National Academy of Sciences of the United States of America* **114**(37): 9770-9778.

Panagos P, Borrelli P, Poesen J, Ballabio C, Lugato E, Meusburger K, Montanarella L, Alewell C. 2015. The new assessment of soil loss by water erosion in Europe. *Environmental Science & Policy* **54**(Supplement C): 438-447.

Peters GP, Andrew RM, Canadell JG, Fuss S, Jackson RB, Korsbakken JI, Le Quere C, Nakicenovic N. 2017. Key indicators to track current progress and future ambition of the Paris Agreement. *Nature Clim. Change* **7**(2): 118-122.

Rasmussen K, Thyrring J, Muscarella R, Borchsenius F. 2017. Climate-change-induced range shifts of three allergenic ragweeds (Ambrosia L.) in Europe and their potential impact on human health. *Peerj* **5**.

Schulze F, Gao X, Virzonis D, Damiati S, Schneider MR, Kodzius R. 2017. Air Quality Effects on Human Health and Approaches for Its Assessment through Microfluidic Chips. *Genes (Basel)* **8**(10).

Schutte G, Eckerstorfer M, Rastelli V, Reichenbecher W, Restrepo-Vassalli S, Ruohonen-Lehto M, Saucy AW, Mertens M. 2017. Herbicide resistance and biodiversity: agronomic and environmental aspects of genetically modified herbicide-resistant plants. *Environ Sci Eur* **29**(1): 5.

Van Hoesel W, Tiefenbacher A, Konig N, Dorn VM, Hagenguth JF, Prah U, Widhalm T, Wiklicky V, Koller R, Bonkowski M, et al. 2017. Single and Combined Effects of Pesticide Seed Dressings and Herbicides on Earthworms, Soil Microorganisms, and Litter Decomposition. *Front Plant Sci* **8**: 215.

Zuberbier T, Lotvall J, Simoens S, Subramanian SV, Church MK. 2014. Economic burden of inadequate management of allergic diseases in the European Union: a GA(2) LEN review. *Allergy* **69**(10): 1275-1279.

6. ECONOMY AND DEMOGRAPHY

Kalpana Scholtes-Dash

The Republic of Austria is an open economy with a GDP that amounted to 353,296.9 million euro in 2016 in current prices, an increase by 2.6% from 2015 levels. The export of goods and services amounted to 52.3% of the GDP. Service sector accounted for 71% of the gross value added of the economy making it the largest sector in Austria. Industry accounted for 27.7%. Austria had a population of 8.7 million in 2016 and a long-term unemployment rate of 1.9%.

6.1 Per-capita Gross Domestic Product (GDP)

The per capita GDP of Austria in PPS terms declined by 0.8% from 2015 to 37,100 in 2016, after registering 3.9% growth in 2014-2015. In the Danube region and the EU, the average GDP per capita was 22,470 PPS and 29,100 PPS respectively. The GDP per capita at market prices in PPS terms registered an average growth rate of 1.5% between 2007 and 2016 in Austria as opposed to 2.1% in the Danube region during the same period. (Figure 1).

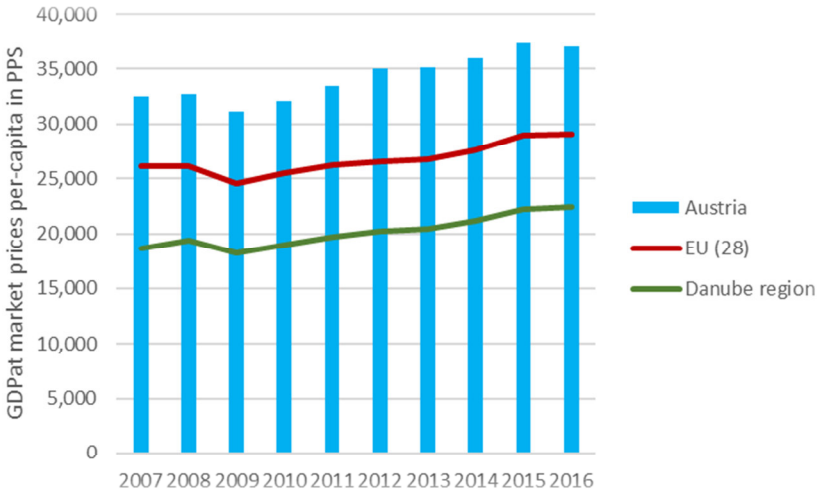


Figure 1 Gross domestic product at market prices in PPS per capita (Source: Eurostat)

After rather positive economic outlook during 2006 and 2007 when the real GDP grew at 3.4% and 3.6% respectively, in 2009 during the global economic downturn, it dipped to -3.8%. However, in 2011, the growth rate peaked at 2.8% to be followed by slower growth in consecutive years (1% in 2015). (Figure2). In comparison, the average real GDP growth in the Danube region which dipped to -5.5% in 2009, has registered a 2.6% growth in 2015.

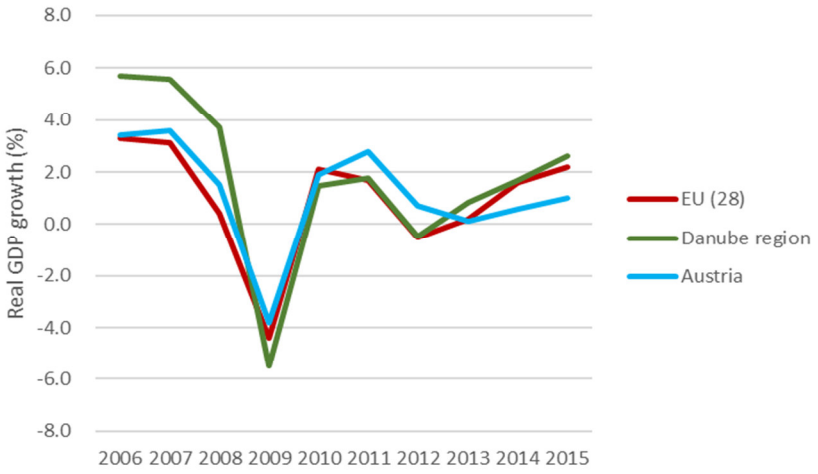


Figure 2 Real GDP growth (Source: Eurostat)

6.2 Labour Market

A total of 4.220.300 people were in employment in Austria in 2016, of which 2.234.500 were male and 1.985.900 female. According the Austrian Public Employment Service Act, its labour market policy has two tasks:[1]

- Preventing and eliminating long-term unemployment;
- Balancing the supply and demand for workers to as great an extent as possible and in an economically meaningful and sustainable way while adhering to social and economic principles.

The labour market policy aims to achieve its tasks through three approaches:

- Passive labour market policy includes all the measures that ensure subsistence during unemployment;
- Active labour market policy envisages to promote better functioning of the labour market by, among other measures, increasing transparency, providing vocational training, promoting mobility of the workforce, etc.
- Activating labour market policy measures, for example, may include part-time benefits for elderly workforce, public funding to ensure livelihood during training, etc.

The Public Employment Service Act (Arbeitsmarktservicegesetz, AMSG) that regulates Public Employment Service (AMS), Labour Market Policy Financing Act that ensures funding provisions for unemployed, and The Unemployment Insurance Act that implements compulsory unemployment insurance and conditions for claiming unemployment benefits are the main legislations that deal with the labour market regulations in Austria.

Indicator: Employment rate as a share of total population of age group 20-64

The employment rate is the percentage of the population aged 20 to 64 who hold an employment. This indicator is based on the EU Labour Force Survey.[2] In Austria, 74.8% of the population between the age of

[1] Sozialministerium

20 -64 were employed in 2016, as apposed to 71% and 73% in the EU and the Danube region respectively. (Figure 3) The employment rate has not shown any significant variation across the region during 2006-2016.

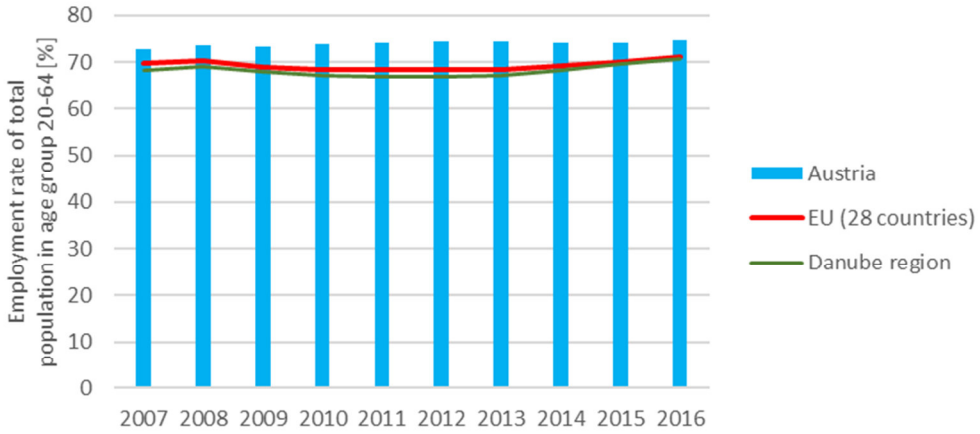


Figure 3 Employment rate as a share of population age 20-64 (Source: Eurostat)

Indicator: Total unemployment rate as percentage of active population

Total unemployment is defined as the percentage of the entire labour force (total number of people employed and unemployed) who are unemployed.[3] Austria had an unemployment rate of 6% in 2016. Germany and Czech Republic have lowest unemployment rate in 2016 in the region at 4.1% and 4% respectively. Since 2013, the unemployment rate in the Danube region and in the EU have shown a downward trend, whereas Austrian unemployment rate has been increasing from 4.6% in 2011 to 6% in 2016.

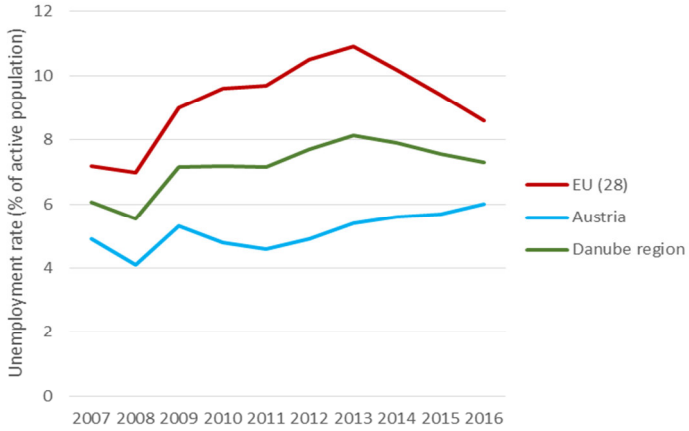


Figure 4 Unemployment rate as a share of active population (Source: Eurostat)

[2] The survey covers the entire population living in private households and excludes those in collective households such as boarding houses, halls of residence and hospitals. Employed population consists of those persons who during the reference week did any work for pay or profit for at least one hour, or were not working but had jobs from which they were temporarily absent. (Eurostat)

[3] Unemployed persons comprise persons aged 15 to 74 who were: a. without work during the reference week, b. currently available for work, i.e. were available for paid employment or self-employment before the end of the two weeks following the reference week, c. actively seeking work, i.e. had taken specific steps in the four weeks period ending with the reference week to seek paid employment or self-employment or who found a job to start later, i.e. within a period of, at most, three months. This table does not only show unemployment rates but also unemployed in 1000 and as % of the total population. (Eurostat)

Indicator: Long-term unemployment rate

Long-term unemployment is the percentage of total labour force who are unemployed for 12 months or more.[4] The Austrian labour market scenario in case of long-term unemployment is similar to the total unemployment rate, even though the former at 1.9% in 2016 is considerably lower that the latter. Long-term unemployment in Austria is still lower than the EU (4%) and the Danube region (3.5%) average in 2016. However, in contrast to the EU and the Danube region where long-term unemployment has declined from 2013, in Austria it has increased from 1.3% in 2013 to 1.9% in 2017. (Figure 5)

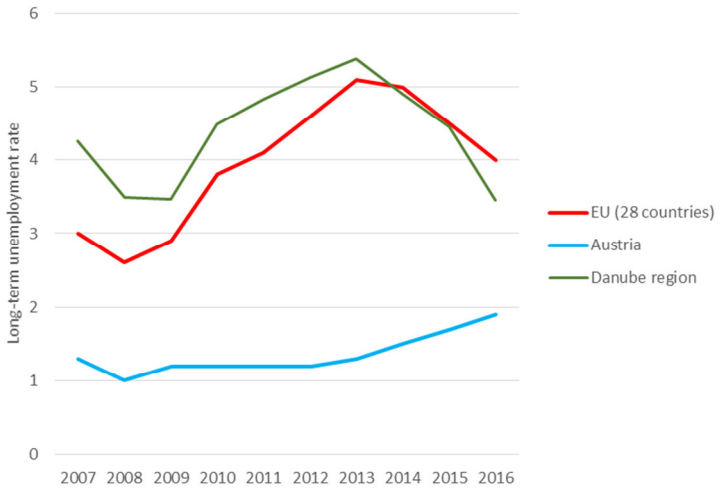
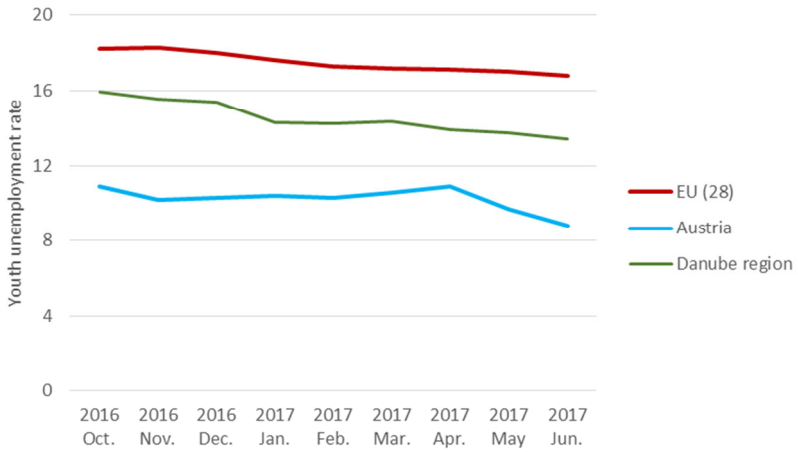


Figure 5 Long-term unemployment (%) (Source: Eurostat)

Harmonised youth unemployment rate (age group 15-24)

Harmonised youth unemployment rate refers to the percentage of the labour force according to the ILO definition within the age group 15-24 who are unemployed.[5] Austrian youth unemployment at 8.8% in June 2017, was considerably lower than Danube region average 13.4% and EU average of 16.8% during the same period. (Figure 6)



[4] The duration of unemployment is defined as the duration of a search for a job or as the period of time since the last job was held (if this period is shorter than the duration of the search for a job).(Eurostat)

[5] Persons aged 15 to 24 who: - are without work; - are available to start work within the next two weeks; - and have been actively seeking work in the past four weeks or had already found a job to start within the next three months. Data are presented in seasonally adjusted form.

Figure 6: Harmonised youth unemployment rate (age group 15-24) (Source: Eurostat)

Labour Cost

The hourly labour cost[6] in Austria stood at 32.7 euro in 2016, higher than the EU average 25.4 euro and Danube region average of 14.9 euro. From 2012, the labour cost in Austria has increased by 10.1%, almost at the same rate (10%) as in the Danube region, and at a higher rate than the EU average that was 6.3% during the same time.

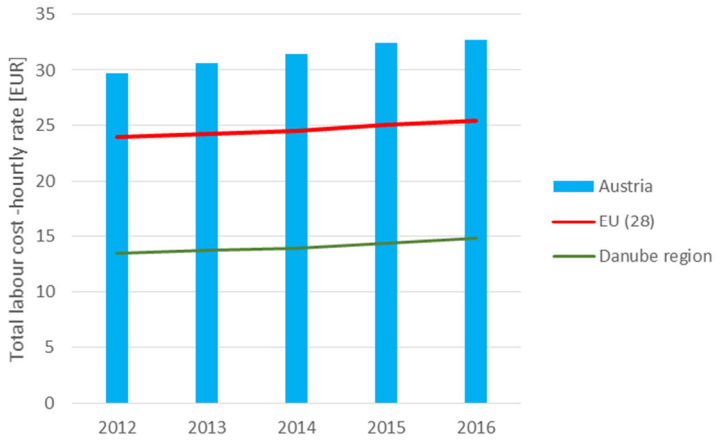


Figure 7 Hourly labour cost (Source: Eurostat)

Job vacancy rate

The job vacancy rate (JVR)[7] in Austria (2.6%) in the second quarter of 2017was higher than that of EU (2%) and Danube region (2.04%). Though the JVR varies between quarters, the rise in the JVR in Austria during the first two quarters of 2017 is rather significant. (Figure 8)

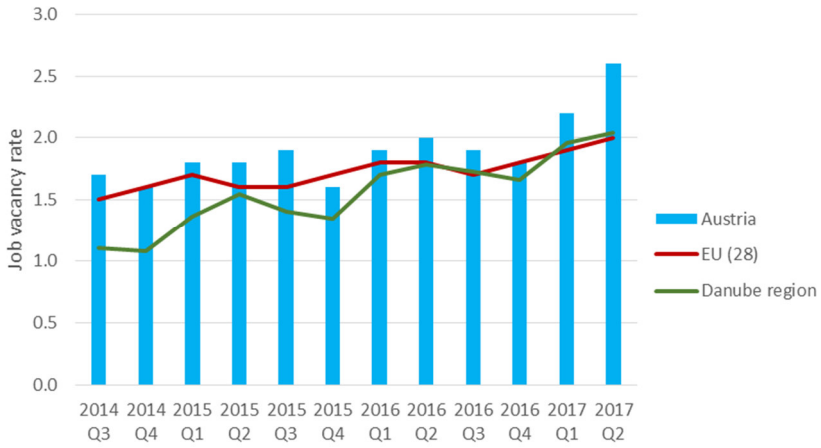


Figure 8 Job vacancy rate (Source: Eurostat)

[6] Average hourly labour costs which are defined as total labour costs divided by the corresponding number of hours worked by the yearly average number of employees, expressed in full-(Employerssocial contributions plus taxes less subsidies: D12+D4-D5)(Eurostat)

[7] JVR = number of job vacancies / (number of occupied posts + number of job vacancies) * 100. Job vacancy rates for DK, FR, IT and MT are probably under-estimated due to a partial coverage of the respective economies. (Eurostat)

Labour productivity

Labour productivity[8] in Austria has increase by 4.8% between 2010 and 2016, which is lower than the Danube region and the EU where the increase was 11% and 6% respectively. In 2016, labour productivity in Austria declined slightly where as in the Danube region it creased by almost 2 percentage points. (Figure 9)

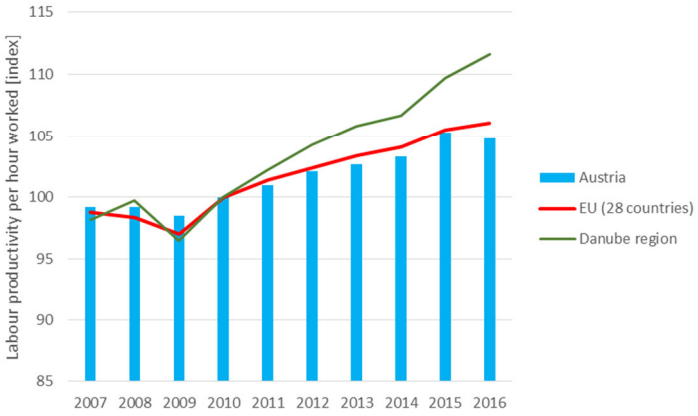


Figure 9 Labour productivity Index (2010=100) (Source: Eurostat)

6.3 Business Environment

Business friendly economies usually attract investors and foster growth. Business surveys conducted among stakeholders of an economy help compile simple statistics to indicate confidence in various sectors. Industrial confidence in Austria as well as EU and the Danube region demonstrate an equally positive outlook for the industry sector (figure10 left), whereas services confidence indicator in Austria is higher than the EU and Danube region average. (Figure 10 right)

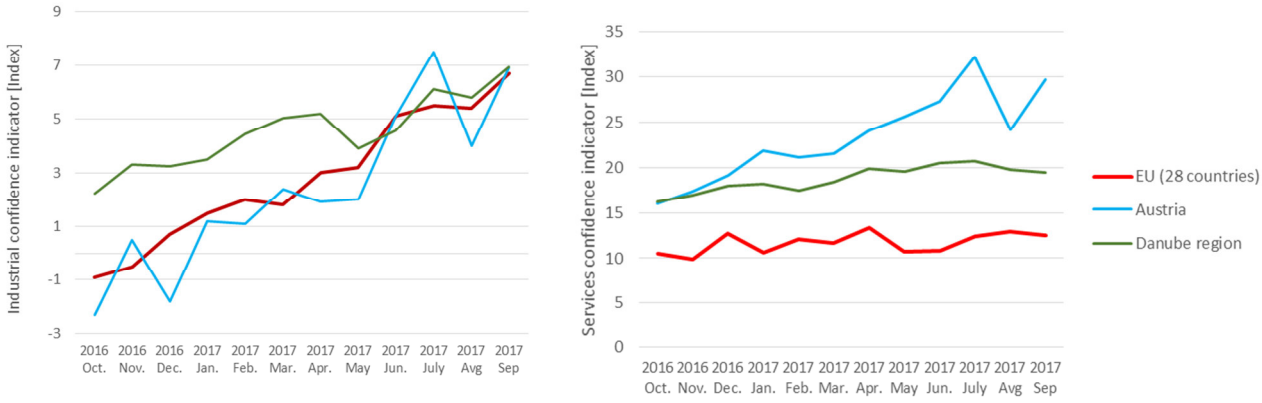


Figure 10 Industrial service sector confidence indicator

The Economic Sentiment Indicator (ESI) is a composite indicator made up of five sectoral confidence indicators with different weights: Industrial confidence indicator, Services confidence indicator, Consumer

[8]Labour productivity per hour worked is calculated as real output (deflated GDP measured in chain-linked volumes, reference year 2010) per unit of labour input (measured by the total number of hours worked).(Eurostat)

confidence indicator, Construction confidence indicator Retail trade confidence indicator.[9]

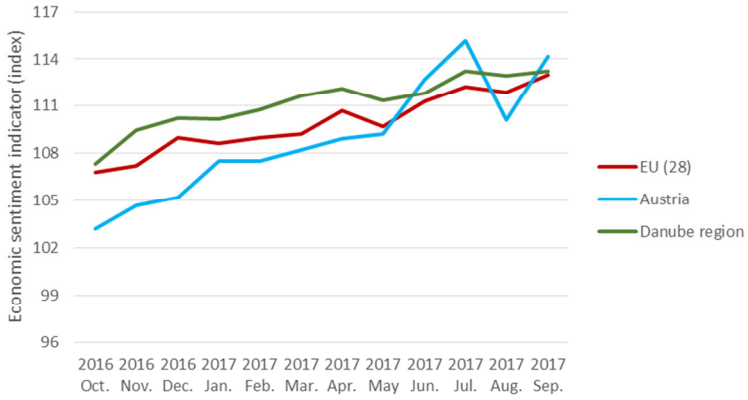


Figure 11 Economic Sentiment Indicator (ESI) (Source: Eurostat)

The REER (or Relative price and cost indicators) aim to assess a country's (or currency area's) price or cost competitiveness relative to its principal competitors in international markets.[10] A higher value of this index means lower competitiveness. According to this method Austrian economy's competitiveness is lower than the EU and the Danube region average. (Figure 12)

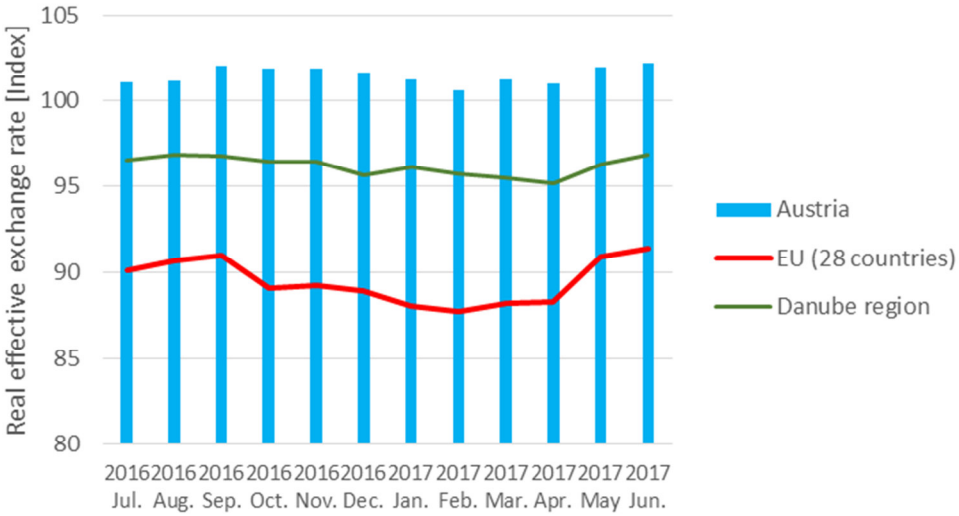


Figure 12 Real effective exchange rate, Austria - 42 trading partners (Source: Eurostat)

The Corruption Perception Index (CPI) assigns scores that help rank countries/territories according to how corrupt a country's public sector is perceived to be. It is a composite index that is based on several surveys

[9] Confidence indicators are arithmetic means of seasonally adjusted balances of answers to a selection questions closely related to the reference variable they are supposed to track (e.g. industrial production of for the industrial confidence indicator). Source: DG ECFIN

[10] The indicator is deflated by the price index (total economy) against a panel of 42 countries (= EU28 + 14 other industrial countries: Australia, Canada, United States, Japan, Norway, New Zealand, Mexico, Switzerland, Turkey, Russia, China, Brazil, South Korea and Hong Kong). Double export weights are used to calculate REERs, reflecting not only competition in the home markets of the various competitors, but also competition in export markets elsewhere. Data source: Directorate General for Economic and Financial Affairs (DG ECFIN). Data are non-seasonal adjusted.

and assessments of corruption. The CPI is the most widely used indicator of corruption worldwide.[11]The CPI of Austria is higher than the Danube region average and has been increasing gradually since 2012 indicating a growing cleaner image of the country over time. (Figure 13)

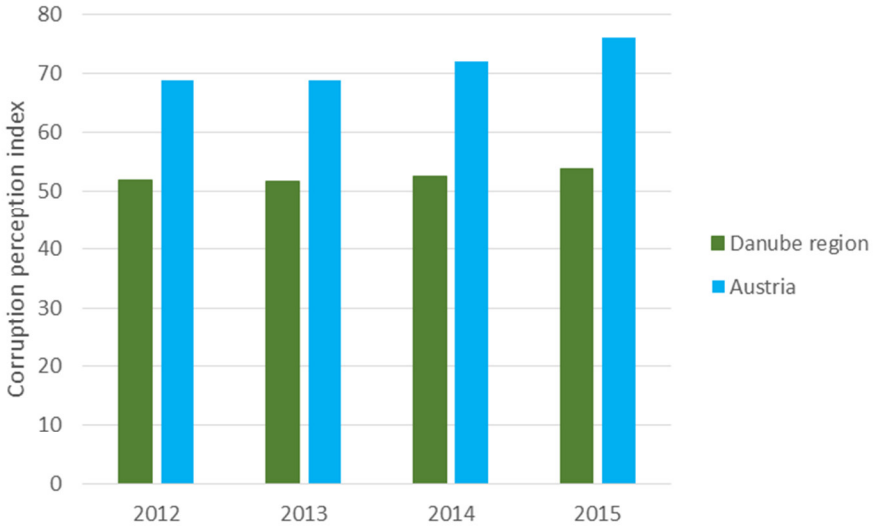


Figure 13 Corruption Perception Index (CPI)

6.4 Effective Tax Rate

Effective average tax, on non-financial sector in Austria has remained almost same (23%) between 2007 and 2016, whereas there has been a slight reduction in the EU and Danube region averages. (Figure 14)

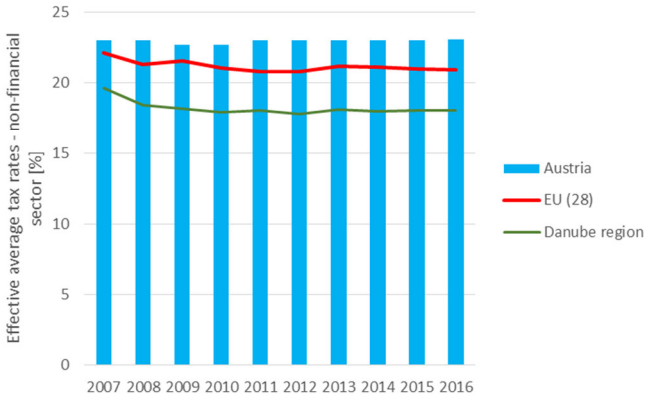


Figure 14 Effective average tax rates, non-financial sector (%)(Source: Eurostat)

In Austria, taxes levied on capital contributed 7.4% to the GDP in 2015, up from 7.1% of the GPD in 2007. In the Danube region the effective tax rate has declined from 5.9% in 2007 to 5.2% in 2017. Taxes on labour,

[11] A country/territory's score indicates the perceived level of public sector corruption on a scale of 0-100, where 0 means that a country is perceived as highly corrupt and a 100 means that a country is perceived as very clean.

on the other hand, contributed 24.8% to the GDP which is higher than in the Danube region (16.8% of the GDP) and the EU (19.3% of the GDP)

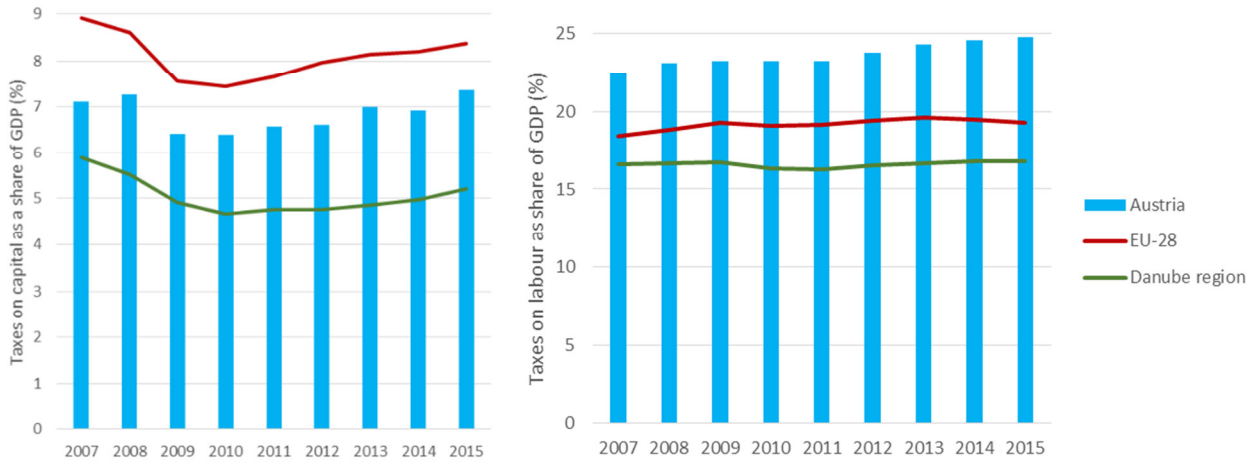


Figure 15 Taxes on capital and Labour as percentage of GDP (Source: Eurostat)

6.5 Education

Public expenditure on education as a whole, accounted for 5.8% of the total GDP which is slightly higher than the EU (5.25%) and Danube region (4.54%) average. Share of public expenditure on tertiary education accounted for 1.56% in 2011, up from 1.28% in 2002 (Figure 16)

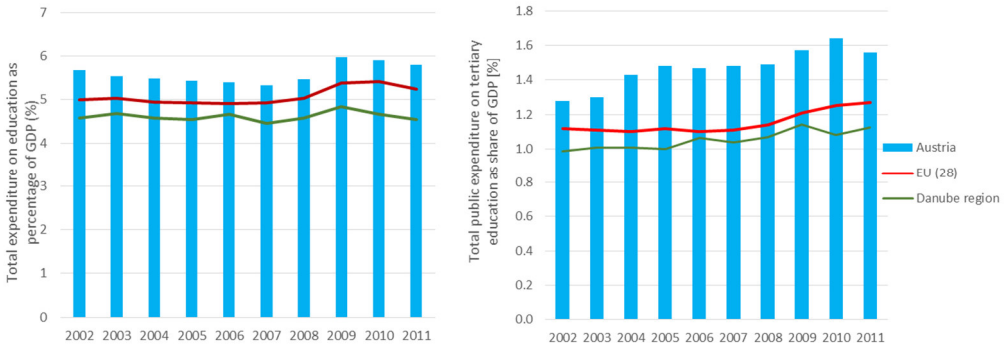


Figure 16 Public expenditure on education ad percentage of GDP (Source: Eurostat)

Mathematical and scientific performance of 15 year olds measured for PISA provide an indication of the effectiveness of the education system in forming logical and analytical minds. Austria ranks slightly better than the OECD average. (Figure 17)

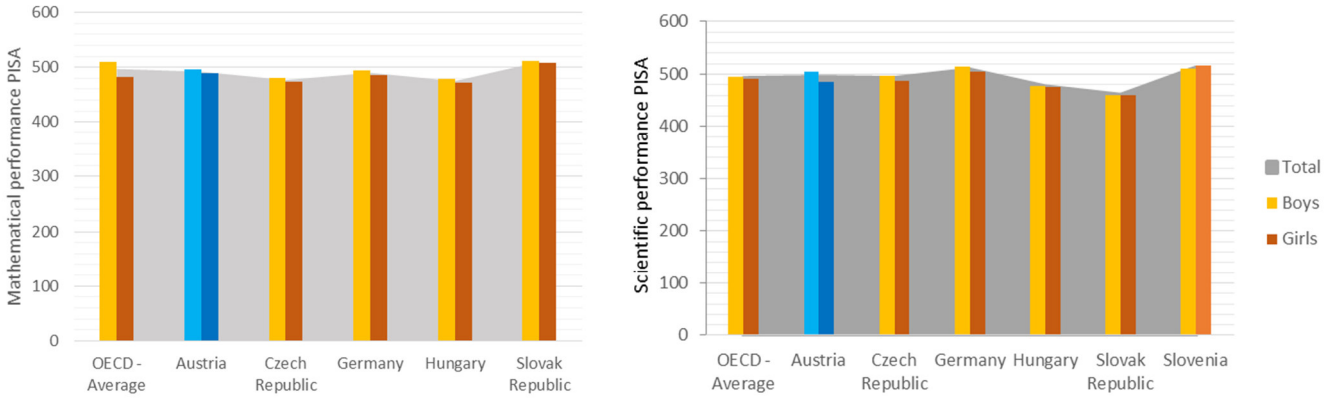


Figure 17 Mathematical and scientific performance PISA (Source: OECD)

OBSTACLES and OPPORTUNITIES: Austria, an open and robust country, has one of the highest GDP per-Capita in the Danube region. However the growth of real GDP, which was higher than EU and Danube region averages, had fallen below these levels from 2013 onwards. The Unemployment rate which is still better than the EU and Danube region averages is slowly increasing where the unemployment rates in the EU and the Danube region is in a downward trend. Job vacancy rates are higher in Austria than the Danube region, and the labour cost is much higher in Austria and Labour productivity is lower. The two factors together reduce the competitiveness of the economy.

However, with a high CPI, that indicates a generally perceived clean image of the public sector, combined with a relatively high economic sentiment indicator, and an effective labour market strategy, Austria can work on increasing labour productivity. This in turn can contribute to real GDP growth rate.

7. CONCLUSION

While Austria has the second highest R&D intensity (as a share of GDP) in the EU, behind Sweden and the Though Austria has the second highest R&D intensity (as a share of GDP) in the EU, innovation output is lower than would be expected given the comparatively generous R&D funding. While some momentum is lost in the transformation process of the high innovation R&D expenditure into innovation output, the strong investment activity shows up even less in terms of the impact on employment. Austria lies below the EU average regarding the share of employment in fast-growing enterprises and of knowledge-intensive services exports but also with respect to sales of new-to-market and new-to-firm innovations.

Austria has strong eco-innovation activity. It ranks second in the EU regarding the share of firms introducing innovations with environmental benefits. Firms are not only actively engaging in eco-innovation, but also produce an above-average patent and publication output in the field. However, employment in eco-industries and the circular economy as well as revenue in eco-industries and the circular economy both lie below the EU average.

Both with respect to the innovation system in general and to eco-innovations in particular, the innovation effort does not show up in employment and sales figures as strongly as would be expected and hoped for. Austria needs to identify the reasons for efficiency losses or "leakages" in the innovation transformation process. Solutions should be found so that (eco-)innovation activity lead to high sales of innovative products and higher employment in innovative sectors. An explanation for the relatively low innovation impact might be that the Austrian economy is characterised by a relatively large medium-low technology segment and a smaller share of the high-technology sector. It will take time and effort to strengthen the knowledge-intensive segments of the economy. The same is true for the low employment share in fast-growing enterprises. Easier access to venture capital financing might be helpful for the establishment, growth and strengthening of young innovative enterprises. Measures like these are definitely necessary if Austria wants to fulfil its aim of becoming a European innovation leader by 2020, as stipulated in the Strategy Plan for Research, Technology and Innovation by the Austrian government in 2011. Concerning eco-innovations, more financial input might also be needed.

It has to be kept in mind however that interpretations founded upon an indicator-based analysis are dependent on the availability of meaningful indicators and on a suitable indicator selection. While innovation inputs and activities can be quantified quite easily, it is much more difficult to measure the impacts resulting from innovations. The European Innovation Scoreboard indicators for determining the innovation impact currently focus on employment and (export) sales shares of selected industries or products. While employment indicators are well-suited for showing the prevalent, historically-evolved industry structure, (export) sales indicators are better suited for measuring the economic effects resulting from current innovation activity. Interpretations of the relatively low innovation impact in Austria thus need to take the limitations of the available and selected indicators into consideration. Indicators capable of measuring actual innovation outcomes across all sectors (as opposed to the size of the sector classified as being knowledge-intensive) would enable improvements in innovation analysis. Nevertheless, the general message that Austria needs to make sure that its substantial innovation input should show up more strongly in innovation output (patents) as well as innovation impacts in the form of sales and employment should be taken seriously.

Austria has a wealth of natural resources, many of which are under increasing threat. Having the largest per-capita ecological footprint among all Danube region countries, Austria clearly lives beyond its means.

Only with drastic reductions in Greenhouse gas (GHG) emissions will Austria be able to reach the targets set in the Paris Climate Act agreement. Actions should aim for fossil fuel independence (by reducing fuel demand and by intensifying exploitation of renewable energy sources) and for cutting down material consumption. The required transitions in society and in all industrial sectors are intertwined. For instance, cut-down in meat consumption can decrease agriculture-derived GHG emissions, halt soil erosion and help restore biodiversity. Regarding environmental expenditures, Austria´s public sector should catch up with other countries, especially in expenditures with the potentially most-sustainable effects, i.e. investments.

Despite EU-wide efforts (e.g. `Roadmap to a Resource-Efficient Europe´, 2011) towards higher resource productivity in order to decouple economic growth from resource use and its environmental impact, decoupling is not in sight. Austria´s measures taken during the past few years had disappointingly little effect.

The national implicit tax rate on energy (a measure of effective tax burden for energy consumption) lies markedly below EU average and – unlike that of other DR countries – has not grown over the last decade. Higher pricing of energy would set incentives for energy saving as well as for R&D of innovative energy-efficient products and services.

Transformation from a throw-away society to the increased use of durable goods can trigger desirable re-orientation of the industrial sector. As recognized by an increasing number of innovation-oriented companies, valuing “waste” as alternative resource represents a profitable business. Unlike the situation in many DR countries, waste recycling rates in Austria - though within EU average - have not developed favorably. Appropriate means to explore synergies and thus maximize waste recycling in the entire Danube region encompass intensive exchange of knowhow and technologies, again ideally to be accompanied by public awareness raising. Be it for waste generation, energy saving or innovation output, transparency can create a desirable contest, both between companies and within the society.

Incentives and sanctions for both industry and households would be an effective means to cut down on material consumption and to improve resource efficiency/productivity. Appropriate measures include: mandatory separation of waste, higher waste disposal costs, awareness raise towards sufficiency, enforcement of module-type equipment design and support of deconstruction rather than demolition concepts. Importantly, sanctions and legislative restrictions for companies must be well-planned (e.g. balanced with a more sustainable funding support of eco-innovative projects) to avoid further increase of the already comparatively high production costs and resultant negative economic impacts as well as migration into countries with lower environmental standards.

As the only representative of Danube region countries in the `Powering Past Coal Alliance´, launched at the UN climate summit (Bonn, Nov. 2017), Austria committed itself to quickly phasing out coal. In order to have a wider impact on improving air quality (particulate matter levels are worryingly high throughout the Danube region), Austria should encourage other countries to join by developing and demonstrating way-out solutions and associated benefits. Innovations in the fields of photovoltaics (e.g. Smart Flower Technology GmbH) and battery technology / charging systems (Kreisel Electrics GmbH) hold strong potential for transnational application. Complementary, combining invasive plant species removal with biomass fuel generation deserves transnational attention.

There is an increasing number of flagship initiatives and eco-innovative “success stories” whose purposeful positioning in the media should give impetus to further green re-orientation, development, investment and cooperation. Accompanied with respective support through financial incentives, consulting services, lowering bureaucratic hurdles etc., numerous “small-scale” eco-innovative solutions can have substantial

cumulative effect on the environment. Since many breakthrough innovative concepts evolve from "outside-the-box-thinking" and transdisciplinary approaches, eco-innovative players, irrespective of how diverse their backgrounds are, should be made aware of each other.

The role of involving the general public - awareness raising and citizen science - cannot be over-emphasized. Consumer behaviour can substantially affect environment protection initiatives and give incentives to providers of eco-innovative products and services. Reciprocally, consumers will prefer eco-products over conventional products if the latter are taxed more heavily.

Austrian research institutions have leading experts in biodiversity, plant and environmental science as well as biotechnology. Intensifying their exchange with industrial partners can raise treasures that otherwise at best end up in peer-reviewed publications. Austria´s R&D infrastructure and human resources form a solid ground for innovation development. Innovative, fragile "siblings" (start-ups, emerging products, services) thrive best if carefully integrated into a growing innovation landscape.