Europe monitor

Accelerating the hydrogen economy in Europe

Macroeconomic update Europe

Country update Austria

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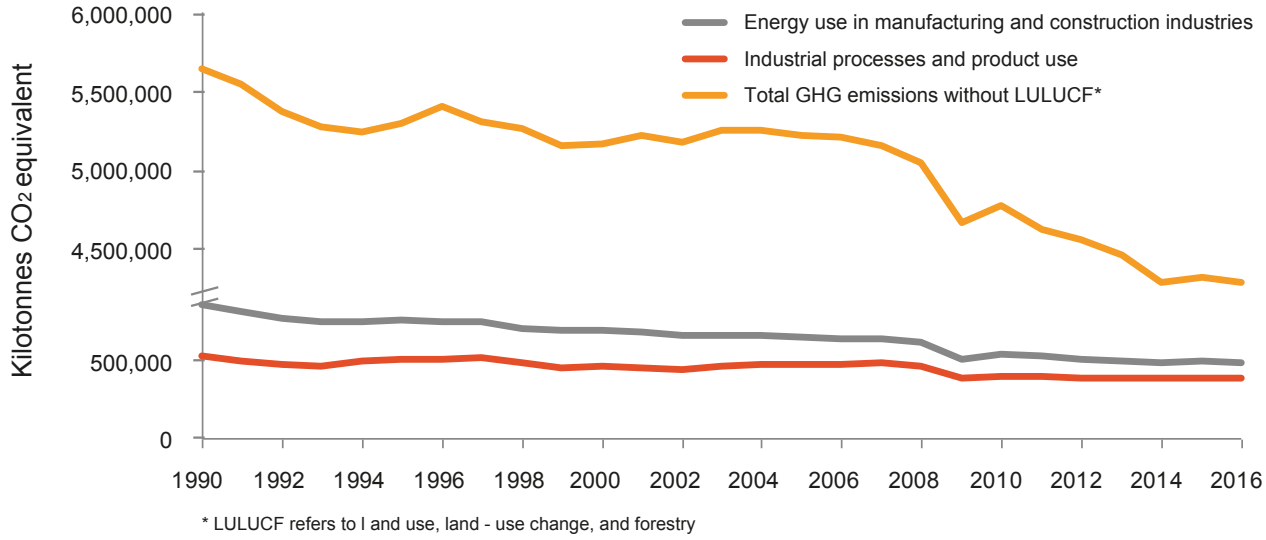
Accelerating the hydrogen economy in Europe[1]

The European Union aims to be carbon neutral in 2050. While significant progress has been made towards this goal, it remains challenging. The different energy-intensive functions of our economy – industry, transport, residential heating – are powered either by electrons (electricity) or molecules (thermal energy produced by burning of fuels). Several steps have been taken towards decarbonising electricity, but the production of molecules remains stubbornly dependent on fossil fuels. Hydrogen might be the molecule that helps Europe go fully carbon free, but its production costs remain prohibitively high. Scale based cost reductions will be a critical component of making hydrogen a viable option. It will be important to focus on applications that can be scaled quickly. PwC modelling on hydrogen's industrial applications shows that with ambitious, yet entirely feasible assumptions, industrial use of hydrogen[2] can become economically viable in the very near future.

Figure 1 The scale of industrial emissions in the EU

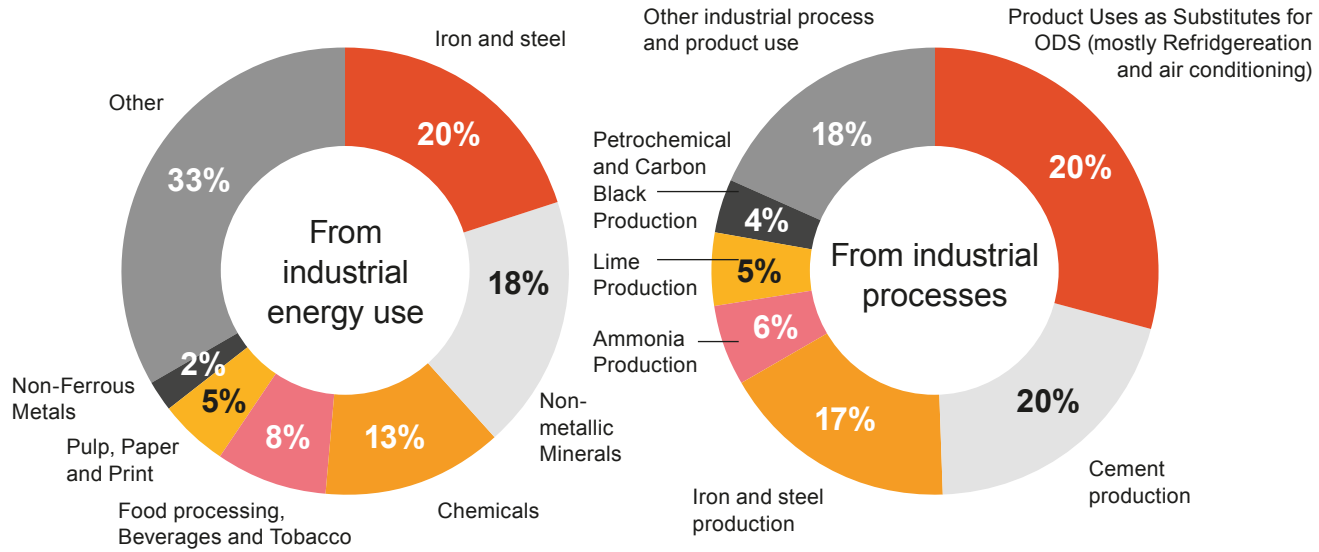


Source: The United Nations Framework Convention on Climate Change (UNFCCC)

1 This article is a summary of the World Energy Council report "Hydrogen – Industry as Catalyst", which can be accessed via this link: *http://www.wereldenergieraad.nl/wp-content/uploads/2019/02/190207-WEC-brochure-2019-A4.pdf*

2 Referring to green and blue hydrogen. Green hydrogen refers to the hydrogen that is produced without adding any CO_2 to the atmosphere. Blue hydrogen is produced from carbon-containing sources, but the CO_2 from the reactions is captured and stored using Carbon Capture and Storage (CCS) technology. Hydrogen is said to be grey if its production results in emission of CO_2 into the air.

Figure 2 The concentration in industrial emissions in the EU



Source: UNFCCC

Decarbonising industrial applications is one of the biggest challenges across the globe. While every region has a different mix of emission sources, in the EU nearly 20% of overall carbon equivalent emissions are rooted in industrial applications[3]. Using industry as a catalyst to accelerate the hydrogen economy is practical not just because of its scale. Industrial emissions originate from just a few industries. They are also highly concentrated in geographical clusters with strong interdependence within them. This concentrated stakeholder structure makes it easier to direct investments effectively to develop the hydrogen economy for industrial applications.

The hydrogen economy

It is estimated that the world produces between 45 and 50 metric tons (Mt) of hydrogen every year, 7.8 Mt of which is made in Europe (2010 estimate). Even though the current scale of hydrogen production is relatively small, industrial applications are already the leaders in hydrogen use. There are three main applications of hydrogen in the industry: industry pre-combustion feedstock, industry post-combustion feedstock (syngas) and industrial energy.

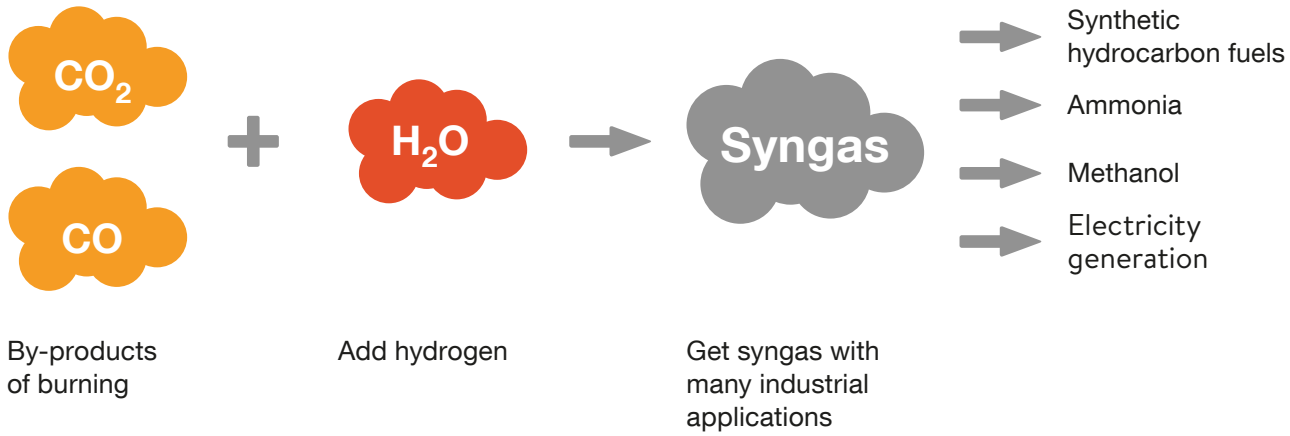
3 Energy use in manufacturing and industrial processes.

Pre-combustion feedstock is the most mature of all applications, since the technology has been around for decades. Of the hydrogen produced in Europe, 90% is used as feedstock for various industrial processes like the production of ammonia. *Post-combustion feedstock* refers to hydrogen use after combustion, for the production of syngas. By combining the off-gases from chimneys with hydrogen, one can create synthetic gas (syngas) which can be used to build a broad range of products, from ammonia to synthetic fuels. Lastly, hydrogen can be used purely as an *industrial energy source* where it is very effective particularly for high heat processes.

The economics of industrial hydrogen

Most of the hydrogen currently used in Europe is grey, involving CO_2 emissions[4]. Conversion of grey hydrogen production today into blue and green hydrogen production tomorrow, is a very important step in the roadmap towards a full-scale renewable hydrogen economy. For this, existing hydrogen production facilities will need to be converted and additional blue and green hydrogen production capacity will need to be created to achieve the desired scale of a renewable hydrogen economy. We looked at each of the three industrial applications of hydrogen to assess their feasibility under various assumptions.

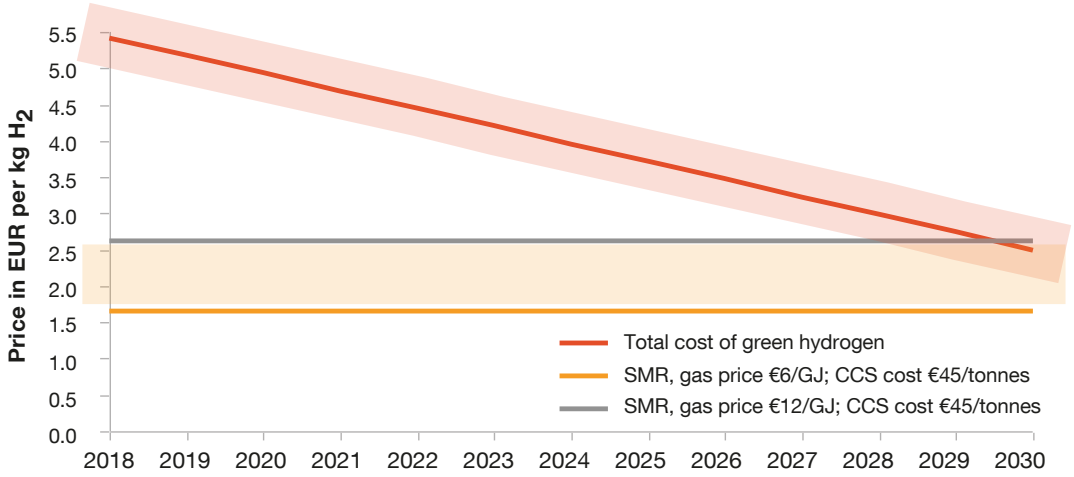
Figure 3 Syngas production



Source: PwC.

4 Please see note 2 to for an explanation of grey, blue and green hydrogen.

Figure 4 Green hydrogen could be competitive by the late 2020s



Source: PwC.

Pre-combustion feedstock

Currently, the price of green hydrogen is not cost competitive with grey hydrogen. The cost of producing grey hydrogen (based on a Steam Methane Reforming or SMR process) is based directly on natural gas prices, which make up 70-80% of the total cost and CO_2 emission cost[5]. The cost of producing grey hydrogen is expected to increase in the future due to increasing natural gas prices and higher costs related to CO_2 emissions (due to annually decreasing emission allowances).

The cost of green hydrogen depends mainly on the prices of electricity and capital as well as operational costs for the required electrolysers and any transportation costs for the hydrogen. Considering the declining cost of renewable energy and electrolysers, green hydrogen could be competitive by the late 2020s.

Post-combustion feedstock

One of the most interesting post-combustion applications of hydrogen is syngas and synthetic fuels. By combining green hydrogen with carbon from waste gases[6], CO_2 emissions are postponed as the carbon they contain is reused.

Since the cost of the electricity used in electrolysis is a main component of the production costs of syngas and synthetic fuels, the local availability of affordable electricity is an important element to consider when looking at the viability of this application in the EU. If this remains price-prohibitive, synthetic fuels could be imported from regions where renewable energy can be produced at a lower cost. Our analysis indicates that use of synthetic kerosene may become a viable alternative for aviation as early as 2030 under certain assumptions.

Industrial energy

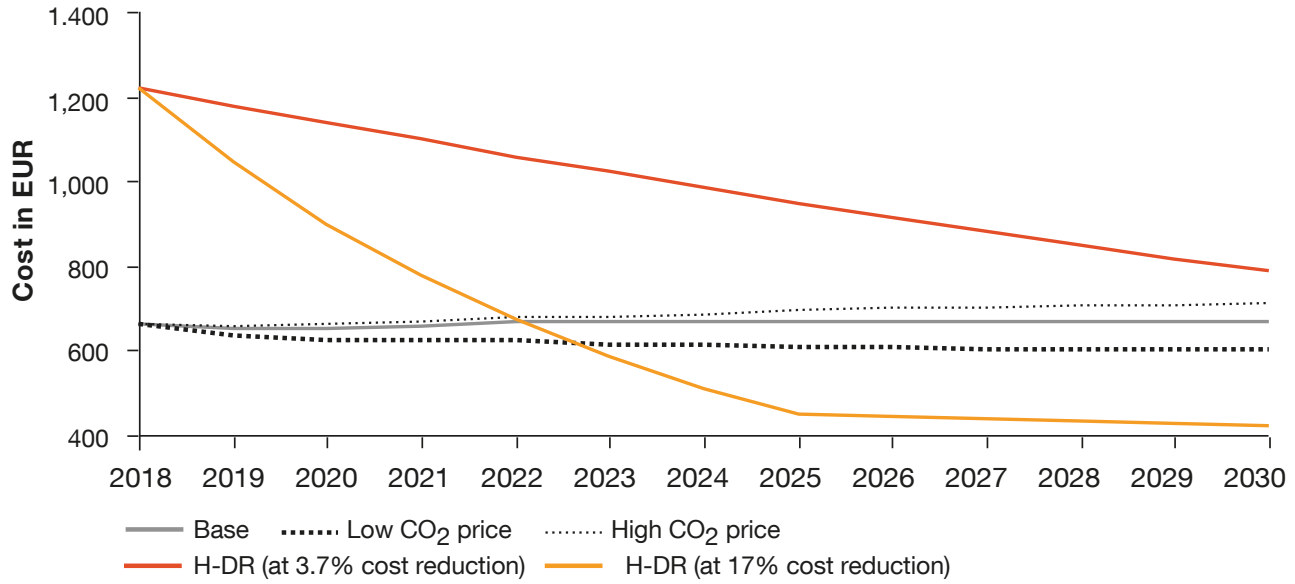
The biggest polluter from industrial energy use in the EU is the iron and steel industry. Here exists a large potential for hydrogen. The majority of crude steel production takes place via either the

5 Costs for emitting CO_2 in Europe are determined by the ETS price
6 Or with carbon that is captured from the air, sea or bio-based sources

blast furnace-basic oxygen furnace (BF-BOF) or the scrap-electric arc furnace (scrap-EAF) methods, which both lead to high CO_2 emissions. Hydrogen offers a technologically viable alternative through the direct reduction method (H-DR).

The cost of producing crude steel via the H-DR route is likely to decrease, with the exact rate mainly depending on the speed of cost reductions in terms of capex and, to a lesser extent, on the electricity price. At the same time, the cost of producing crude steel using the BF-BOF method is expected to stay relatively stable. If we assume a 3.7% annual reduction in cost for H-DR (same as experienced in the wind energy sector), H-DR might make a business case by the 2030s[7]. Assuming a more ambitious scenario with annual cost reductions of around 17%, (as experienced in the solar energy sector), H-DR will have a competitive business case compared to BF-BOF already in the early 2020s.

Figure 5 Strong cost reductions can make H-DR competitive



Source: PwC.

7 The cost level will still be above the coal-based method, but the proximity of the two price tags indicates that H-DR might make a business case

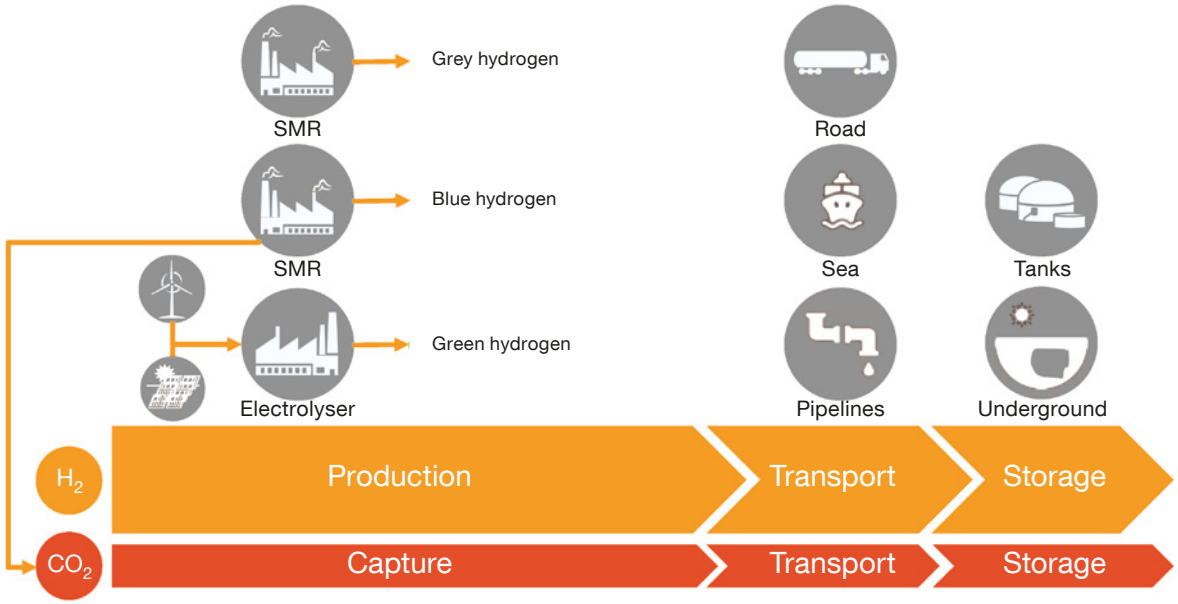
Setting off the industrial hydrogen flywheel

The need for hydrogen in the industry is well established. However, at each stage of the hydrogen value chain, various barriers to adoption need to be tackled. For the production of blue and green hydrogen to be viable, it is important to price in the negative externality of CO_2 emissions. At the transport and storage stage, it is relevant to avoid natural monopolies, since pipeline infrastructures and large-scale carbon storage will have a tendency to develop natural monopolies due to the high cost of investments and need for scale economies. For setting off the industrial hydrogen flywheel, some action will be required particularly on the part of governments and regulators.

A clear strategy needs to be defined

The EU and national governments need to demonstrate commitment and reduce uncertainty. They should therefore formulate clear strategies designed to bring about a hydrogen economy and specify a regulatory environment that will create clarity amongst investors. An ambitious plan would

Figure 6 The hydrogen value chain



Source: PwC.

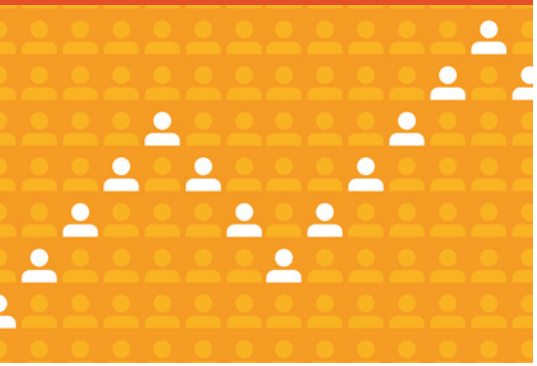
also help push the price of CO_2 closer to its real social cost, which is ultimately necessary for the adoption of carbon abatement technologies like blue and green hydrogen production.

Both green and blue are needed
To stimulate investments in green hydrogen, governments should announce their plans for parallel adoption of blue and green hydrogen. While the ultimate goal is to green all hydrogen, blue hydrogen is an essential transitory step – it contributes to the development of a hydrogen infrastructure, which will ultimately facilitate the adoption of green hydrogen.

The organization and coordination of infrastructure should be encouraged
Both the use of hydrogen (transport) and Carbon Capture & Storage (transport and storage) require large-scale infrastructure, exposing the nascent industry to many potential market failures. Governments need to start offering clarity on who will be responsible for specific parts of transport and storage. They should research if there is a need for direct investment in infrastructure and put appropriate regulatory frameworks in place.

Governments need to generate technology push for a limited time
The EU en national governments should help push technologies through the cost curves. Many industrial hydrogen applications currently face the 'valley of death', or a phase when the technology is too new and consequently cost-prohibitive. Depending on the technology readiness phase, governments should use the appropriate tools to bring costs down. Temporary subsidy programs can also speed up the adoption process.

Macroeconomic Update Europe



Indicators concerning the last quarter of 2018 clearly demonstrated an economic slowdown. Differences in growth dynamics between countries are large, and both Italy and Turkey are currently facing more challenging times than e.g. Spain and Austria.

GDP growth

In the final three months of 2018, Eurozone GDP growth was 1.1% compared to the same quarter in the previous year. Throughout 2018, economic growth in the Eurozone has clearly decelerated from a year-on-year rate of 2.4% in the first quarter, to 1.6% in the third quarter. Thanks to higher economic growth in Eastern Europe, economic activity in the EU held up slightly better with 1.4% GDP growth on an annual basis in the fourth quarter of last year. Economic growth in both European areas was negatively impacted by changes in inventories, but net trade, fixed capital formation, household consumption, and government expenditure all contributed to growth.

Within the EU, GDP growth rates differ significantly between countries. Among the best performers are Eastern European EU members, such as Hungary and Poland that realised year-on-year growth rates of almost 5% in the last quarter of 2018. Turkey is an exception in Eastern Europe, as the country is coping with the impact of a currency crisis and high inflation. Turkey is an exception in Eastern Europe, as the country is coping with the impact of a currency crisis that led to high inflation. Domestic demand and investments shrank substantially via higher borrowing cost due to tight monetary policy in response to higher inflation. As a result, the Turkish economy shrank with 3% in the final quarter of 2018 and the country is now in a technical recession as this was the second quarter of negative GDP growth.

Private consumption

At the close of 2018, private consumption was once more a stable contributor to GDP growth in the Eurozone and the EU. Compared to the last quarter of 2017 and during the final three months of last year, household consumption rose with 1.0% and 1.4% in respectively the Eurozone and EU. Although consumers have become more careful, as reflected in a decline in confidence, high employment, wage increases and fiscal measures will continue to support consumption growth at more modest rates this year.

Capital investments

Investment in fixed capital increased with 2.8% in the Eurozone and last quarter of 2018. For the EU the increase was 2.3% for the same period and compared with the previous year. We may see investment growth decline from current rates, as economic growth has slowed and has led to a lower business confidence.

Net exports

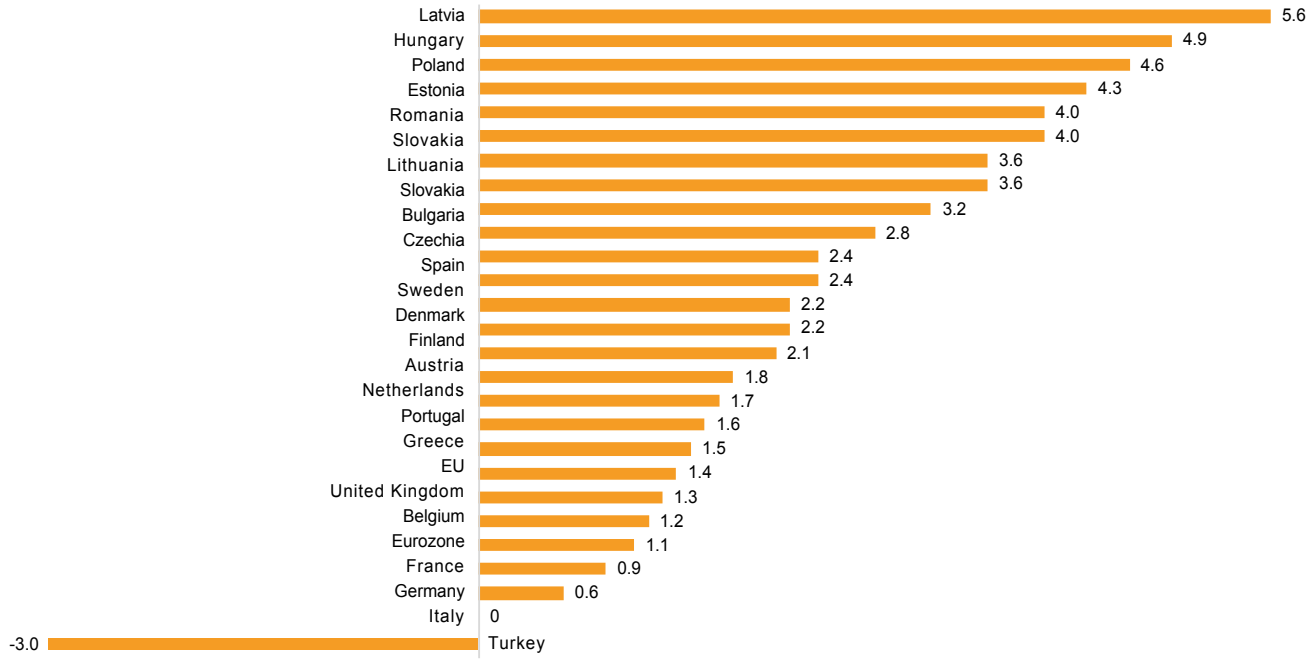
In the last quarter of 2018, export in the Eurozone and EU increased with 0.9% and 1.1% respectively. As imports rose with 0.5% in the Eurozone and 0.8% in

the EU, the net contribution of trade to GDP growth was positive in the closing months of last year. The latest export figures point to resilience regardless of global trade frictions. Nonetheless, significant risks in the form of a no-deal Brexit, US tariffs on European cars, and a larger than expected decline in demand from China, remain a threat for trade in the coming quarters. In Turkey foreign trade contributed to growth, as imports declined because of a sharp decline in domestic demand, whereas depreciation of the Turkish Lira raised exports.

Government expenditure

In comparison to the fourth quarter of last year, government expenditure rose with 1.2% and 1.3% in the Eurozone and European Union respectively. This was a higher increase than the previous quarter, when expenditure rose 0.7% in both areas. We expect expansionary fiscal policy to continue to contribute to economic growth in Europe this year.

Figure 7 *'A spectrum of growth'*; change in GDP for the 4th quarter of 2018



Source: Eurostat. Note: percentage change compared to the 4th quarter of 2017 and seasonally adjusted.

Labour markets

Compared to the fourth quarter of 2017, the number of persons employed rose with 1.3% in the Eurozone and 1.2% in the EU. Employment growth in both areas has consistently been positive since the second quarter of 2013. In this period, the number of people employed has risen by 10.2 million in the Eurozone and 15.7 million in the EU. According to Eurostat, the number of people employed in both the EU and the Eurozone has reached the highest level ever recorded. This trend is expected to continue, albeit at a slower pace, and contribute to economic growth via private consumption.

In the last three months of 2018, employment increased at the quickest pace in the sectors 'information and communication' as well as 'construction', with year-on-year growth rates of more than 3%. Employment declined most in 'agriculture, forestry and fishing'. According to the European Commission, employment plans in the construction industry deteriorated in February. As such, we are likely to witness lower employment growth in this sector going forward.

Inflation

Inflation in the Eurozone and February this year rose to 1.5% from 1.4% in the preceding month. For the EU inflation was 1.6% in February, up from 1.5% in January 2019. February was the third month in which

inflation was well under 2%, which is used by the ECB as the reference value for price stability.

Lower inflation and economic growth forecasts, have prompted the ECB to indicate that interest rates will remain unchanged until at least the end of 2019. The central bank further unexpectedly introduced new Targeted Longer-term Refinancing Operations (TLTROs) in March, with the aim of stimulating bank lending in the monetary union.

Turkey is on the other end of the inflation spectrum with annual CPI reaching 19.7% in February of this year, a decline from 20.4% in the previous month. The Turkish government is actively trying to curb price rises via direct sales of fruit and vegetables to citizens, tax reduction on various products etc. Measures that are also aimed to bolster consumer spending. Value added taxes on various products have been reduced for the same purpose as well. Inflation is expected to decline gradually in the course of 2019.

Figure 8 Key economic indicators, selected European economies

	GDP growth (% change)	Industrial production (% change)^	Consumer spending (% change)	Capital investment (% change)	Unemployment rate (%)^^	Consumer prices (% change)^^^
Eurozone	1.1	1.4	1.0	2.8	7.8	1.5
Austria	2.1	-0.7**	1.7	2.8	4.8	1.4
Belgium	1.2	-3.7**	-2.0	3.5	5.6	2.0
France	0.9	1.3	1.5	2.2	8.8	1.6
Germany	0.6	-0.9	3.1	3.0	3.2	1.7
Italy	0.0	1.7	-0.9	0.1	10.5	1.1
Luxembourg	3.1*	-0.8	2.8	-2.4	4.9	2.1
Netherlands	1.8	2.9	2.7	3.6	3.6	2.6
Spain	2.4	3.6	0.3	4.6	14.1	1.1
Switzerland	1.5	-2.7**	0.9	-0.8	2.2	0.7
Turkey	-3.0	1.0*^	-8.9	-12.9	12.7**	19.7
United Kingdom	1.3	0.7	-1.4	-1.4	4.0**	1.8**

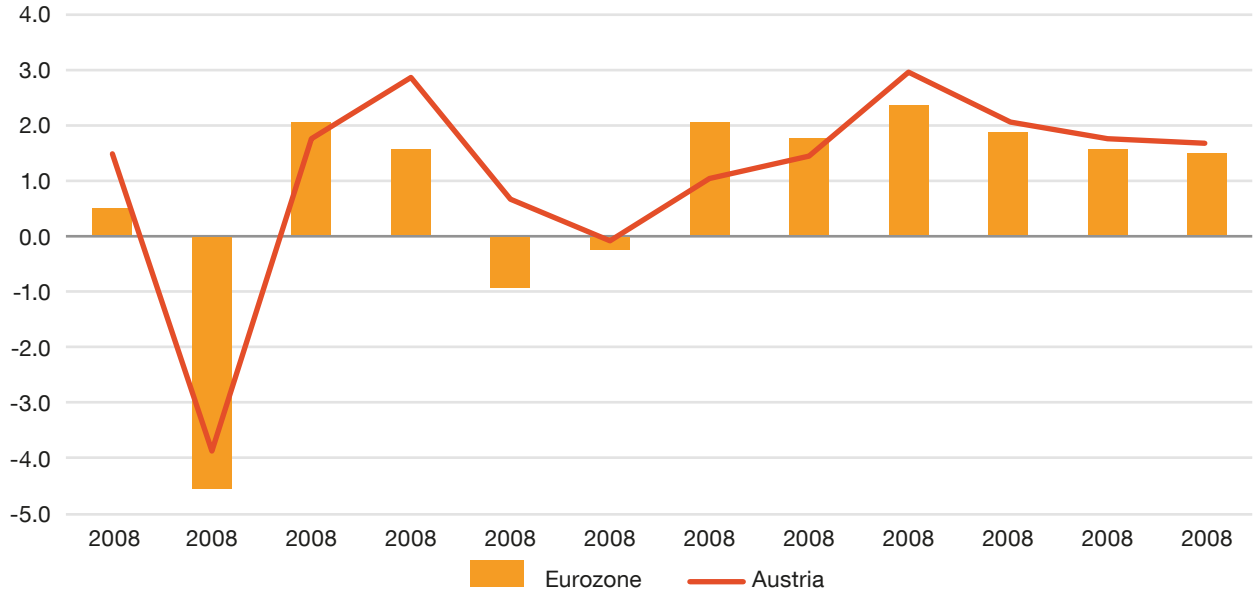
Note: Figures are the latest available values i.e. the fourth quarter of 2018, unless specified differently. Figures are further reported quarterly, unless otherwise stated, and on basis of year-on-year change (where applicable). Consumer prices are reported according to the HICP methodology, except for Turkey.
^ Month-on-month change, January 2019 ^^ Seasonally adjusted, January 2019 ^^^ February 2019
* Q3 2018 ** November 2018 ** December 2018 *^ Seasonal and calendar adjusted
Source: Thomson Reuters, Eurostat, Turkstat.

Country Update: Austria

After a period of strong economic performance between 2015 and 2017, the Austrian economy will continue to grow, yet, at a slower pace. GDP growth is set to be 1.8% in 2019, compared to 3.0% and 2.7% in 2018 and 2017 respectively. Economic momentum is waning due to a lower contribution from trade. This is because of instability in the global trade environment, Austria's relatively large exposure to the slowing German economy, and the appreciation of the euro, especially against several emerging markets' currencies, which diminishes Austria's exports price competitiveness. Despite the slowdown, Austria's economic growth is more favourable than most of its European peers.

While the slowing global trade environment may dampen Austria's growth, the economy will continue to reap the benefits of its government's progressive income tax reforms of 2016. For example, the lowest income tax rate applicable for annual taxable income between €11,000 and €18,000 was reduced

Figure 9 Austrian GDP growth in comparison to that of the Eurozone



Source: BMI. Note: e = estimate, f = forecast.

from 36.5% to 25%, and the high rate of 50% was adjusted to apply to incomes of more than €90,000, from €60,000 previously. The reforms lead to an estimated €5 billion in overall tax relief. Additionally, in October 2018, the government introduced a €400 million tax incentives package aimed at boosting investments on the municipal level. The reforms stimulated private consumption, making it the main contributor to GDP growth and this is set to continue in 2019. Strong private consumption will in turn lead to higher production, allowing for more job creation and investments.

Job creation will support labour market developments, which are expected to improve further, pushing down unemployment even more. In January this year, seasonally adjusted unemployment was 4.8%, and is forecasted to decline to 4.3% by 2024. A strong labour market and low unemployment rates will benefit private consumption.

Fixed investment has been the weak spot in economic activity. However, this is expected to change, with capital expenditure growth accelerating to 2.4% on average in 2018-2022. Construction in particular will see strong growth, as prices in Austria's residential housing market continue to be in upward trend. Furthermore, the government's housing initiative is pumping an additional €5.5 billion into the housing market. At the same time, industrial capacity utilisation is high, at 88.5% in the fourth quarter of 2018, suggesting that companies are expected to start expanding production facilities.

Strong employment growth and robust consumer demand will bolster tax revenues, while debt service costs remain subdued as interest rate levels rise only gradually. Consequently, public finances are expected to achieve a surplus in 2018 for the first time in over 40 years, as revenue growth exceeds expenditure growth.

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