5G Impact 2030

The impact of 5G on the economy, employment, and emissions in France, Spain, Poland, Belgium, and Romania in 2030

Commissioned by

orange

About this report

This Omdia report, commissioned by Orange, offers an independent assessment of the economic, employment, and greenhouse gas (GHG) emissions impact of 5G in 2030 in five countries in Europe: France, Spain, Poland, Belgium, and Romania. Omdia is exclusively responsible for the research, methodology, forecasts, and analysis in this report, with the exception of the Foreword by Orange.

About Orange

Orange is one of the world's leading telecommunications operators with sales of 42.3 billion euros in 2020 and 142,000 employees worldwide at 31 December 2020, including 82,000 employees in France. The Group has a total customer base of 259 million customers worldwide at 31 December 2020, including 214 million mobile customers and 22 million fixed broadband customers. The Group is present in 26 countries. Orange is also a leading provider of global IT and telecommunication services to multinational companies, under the brand Orange Business Services. In December 2019, the Group presented its new "Engage 2025" strategic plan, which, guided by social and environmental accountability, aims to reinvent its operator model. While accelerating in growth areas and placing data and AI at the heart of its innovation model, the Group will be an attractive and responsible employer, adapted to emerging professions.

Orange is listed on Euronext Paris (symbol ORA) and on the New York Stock Exchange (symbol ORAN).

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We create business advantage for our customers by providing actionable insight to support business planning, product development, and go-to-market initiatives.

Our unique combination of authoritative data, market analysis, and vertical industry expertise is designed to empower decision-making, helping our clients profit from new technologies and capitalize on evolving business models.

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We hope that this analysis will help you make informed and imaginative business decisions. If you have further requirements, Omdia's consulting team may be able to help your company identify future trends and opportunities.

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Contents

Foreword

As a provider that is committed to sustainable development, our mission is to build networks and services that have a positive impact.

In particular, we want to develop uses for technology that help simplify and enrich our users' lives. We also strive to contribute to employment and economic development, as well as to the reduction of CO_2 emissions.

In order to shine a light on players in the economic, institutional and civil society spheres, we have asked OMDIA to conduct an analysis on the economic, social and environmental impacts of 5G in 5 European countries that we operate in: France, Spain, Poland, Belgium and Romania. To our knowledge, this is the first study to be carried out that will simultaneously model and quantify these three impacts across these locations.

Digital technology is already an integral part of our lives, proving to be a tremendous asset in tackling the effects of the recent health crisis. Giving rise to solutions such as remote working, distance learning and even keeping in touch with loved ones from afar, we are convinced that digital technology will be an increasingly crucial innovation tool for more responsible and inclusive growth going forward.

5G is already able to provide broadband at around three to four times the speed of 4G. From 2022/2023, with the evolution of core networks, 5G will be able to offer connectivity on demand, and in real time, to cover essential functions or to fulfil specific needs, thanks to reduced waiting time and the ability to overlay multiple parts of the network (network slicing).

Combined with the potential of the Internet of Things, Artificial Intelligence and Edge computing, 5G is set to be a strong driving force in digital transformation and competitive business. 5G opens up a world of possibilities for players in the economic, industrial, transport, construction, health, urbanisation and agricultural fields.

As is the case for most technological breakthroughs, much of the potential is yet to be unlocked. That's why Orange is engaged in co-innovation projects, exploring the future uses of 5G with different European partners. The Orange 5G Lab is the spearhead of our mission to support local economic players with the opening of 9 sites in France, Belgium and Romania.

What's more, 5G has a much higher energy efficiency than that of 4G, helping its users to reduce their CO_2 emissions. Needless to say, it is essential that we continue our efforts in reducing the environmental impact of both our networks and our devices, particularly by pushing the development of a circular economy. But above all, the value of 5G lies in its potential to support regions and businesses in their ecological transition. It offers alternatives to business travel and helps to optimise energy and resource consumption in real time, preventing wastage. Beyond improved productivity, 5G will also play an essential role in closely managing our environmental impact in sectors such as water, energy, waste, transport, construction and smart cities.

The new uses and benefits of digital technology supported by 5G will also help to create new types of jobs, "worker augmentation", is an example of this. In a general sense, fields that were previously unaffected by digital technology, "blue-collar" or "manual" jobs for example (technicians, warehouse workers...), will also see an improvement to working conditions and security.

With this study, which is based on a solid methodology defined by OMDIA, Orange intends to take part in the collective reflection around the impacts of 5G and will continue to work with all involved parties to deepen these analyses.

The potential of 5G rests in our hands. It's up to us to create a positive impact with this technology, imagining the uses of tomorrow for sustainable and responsible growth!

Michaël Trabbia

Chief Technology and Innovation Officer, Orange

Executive summary

5G is set to be a crucial catalyst for technological change

Over the next decade, 5G will help to power the digital transformation of Europe, as will a host of other advanced technologies including cloud computing, the Internet of Things (IoT), AI, and robotics. The transition represents an unprecedented opportunity to deploy, scale, and integrate powerful new systems to create economic, social, and environmental value.

Of course, these benefits are not guaranteed. Governments have to support the rollout of 5G by bringing relevant spectrum to market and supporting the creation of new base station sites, among other things; communications service providers have to invest massively in new 5G networks and services; and the value of these new 5G services has to be compelling enough for the majority of organizations and individuals to adopt them.

In the countries covered in this report—France, Spain, Poland, Belgium, and Romania—this process is underway and will accelerate over the next decade. In fact, Omdia forecasts that by 2030, 5G will represent the greater part of the mobile markets in all five countries, ranging from 62% in Romania to 90% in Spain in that year.

5G will have a positive impact on the economy, jobs, and emissions across all five markets studied

While most consumers in the countries under study will have 5G rather than 4G smartphones by 2030, 5G is about much more than smartphones. It will also massively increase the scale and intelligence of mobile connectivity supporting the IoT and will help to support a new category of mission-critical services such as smart factories and smart energy grids. The creation of new categories of connectivity, along with the upgrade and enhancement of existing 4G services based on smartphones and other devices, will lead to total 5G-enabled sales of €407bn ($488bn) in 2030 across the five countries. As discussed in **5G-enabled sales encompass a broad range of economic activity across the 5G ecosystem**, the term *5G-enabled sales* represents the gross output or total sales from economic activity enabled by 5G.

The larger addressable market of 5G when compared to 4G will also have a positive impact on employment. In its analysis of the impact of 5G on work, Omdia finds that 5G could enhance the jobs of up to a fifth of the workforce, most notably those in mobile, field, and industrial roles. As a result of 5G's support for a broader base of occupations and workstyles than previous mobile systems, and therefore because of its broad impact across a range of industries, Omdia forecasts there will be 1.03 million 5G-enabled jobs across the five countries in 2030.

The power of 5G to connect things as well as people will also have a positive impact on the environment, specifically on GHG emissions. This is not to say that the impact of 5G will be entirely positive: it will clearly have some negative impacts on the environment, including GHG emissions from 5G base stations, terminals, and data centers. However, as 5G helps to bring connectivity and intelligence to more factories, buildings, cities, and farms across the five countries, it will increase efficiency and reduce the movement of people and things, thus reducing GHG emissions per unit of output. Omdia's research and forecasts suggest that 5G will enable other industries to reduce GHG emissions by far more than the amount of emissions created directly by 5G. As a result, Omdia forecasts that 5G services will enable a reduction in GHG emissions of 33 million tons of carbon dioxide equivalent (MtCO2e) across the five countries in 2030.

Omdia's forecasts for 5G impact in 2030 across all three segments in the five countries are provided in **Figure 1** below.

Figure 1: 5G-enabled impact across France, Spain, Poland, Belgium, and Romania in 2030

Source: Omdia

Unsurprisingly, 5G-enabled sales, employment, and avoided emissions will vary significantly by country in 2030 because of a host of factors including varying levels of economic growth, industrial scale and diversity, and 5G penetration. Across all segments, 5G will have the largest overall impact in 2030 in France, then Spain, Poland, Belgium, and Romania.

1. Introduction

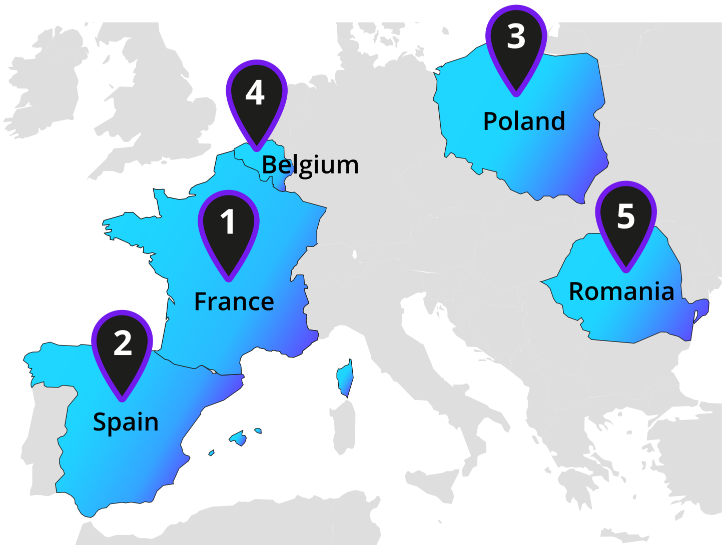
As one of the emerging engines of digital transformation, 5G will have a profound impact on the economy, employment, and environment of Europe and the world over the next 10 years, just as 4G has had over the last 10.

Since we are still at the dawn of 5G, with the first services launching in Europe in 2019, it can be instructive to cast our minds back over a decade to the beginning of the 4G era with the first commercial launch of LTE services in 2009. That same year saw the founding of Uber Technologies, which capitalized on the power and increasing ubiquity of 4G smartphones to build a global business that grew to have more than $11bn in revenue, 22,000 employees, and 3.9 million drivers supporting 14 million trips per day in more than 60 countries by the end of the decade. Although Uber has faced serious problems alongside its success, it illustrates the rise of the new ride-sharing industry that also includes a host of companies such as Lyft, Ola, and Didi. The ride-sharing industry is just one example of how 4G has enabled the creation of new companies, services, and jobs across the world. It also helps to illustrate the core methodology of this report, which is designed to quantify the indirect or enabling effects of 5G mobile technology on the broader economy and environment as measured by its impact on total sales, employment, and GHG emissions.

In other words, if this report was focused on 4G in 2020, the revenue and employees of Uber, its competitors, and every other company that relies on 4G smartphones as an integral part of its products or services would be included in our estimates of 4G-enabled sales and employment. At the same time, there is a case to be made that the efficiency and convenience that helped make Uber, Lyft, and other ride-sharing services so popular also had a positive impact on the environment through the use of GPS-enabled smartphones that improved the efficiency of dispatching and routing vehicles, reducing mileage per trip and, therefore, GHG emissions per trip. In Omdia's methodology, those would be classified as 4G-enabled reductions in GHG emissions.

While history is informative, the topic of this report is the future, specifically the impact that 5G services will have in 2030 on industry sales, employment, and GHG emissions in five countries in Europe: France, Spain, Poland, Belgium, and Romania (see **Figure 2** below). The countries were selected by Orange as five of the countries where it has operations in Europe, but the research and forecasts detailed throughout this report were developed independently by Omdia.

Figure 2: 5G impact in 2030 is assessed in France, Spain, Poland, Belgium, and Romania



Source: Omdia

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Looking beyond the pandemic to 2030

The COVID-19 pandemic has been devastating in many ways and will continue to affect our lives and economies for years to come, but it will not be addressed in detail in this report, since the focus here is on the impact of 5G services close to 10 years in the future. That is not meant to underplay the unprecedented scale and significance of the pandemic but rather to acknowledge that based on current developments in early 2021, including the rollout of highly effective vaccines, there is increasing confidence that the end of the COVID-19 crisis is at least in sight.

As the pandemic recedes over the next few years, Omdia expects 5G deployments to accelerate, expanding the potential for digital transformation across Europe. In this context, it is important to highlight that 5G is not just a linear upgrade of 4G but rather a fundamental redesign of mobile services to intelligently connect billions of people and things to create more efficient and valuable ways of working. Just as 4G created massive value by powering smartphones, which in turn enabled the application economy, 5G is designed to expand on that by creating not only smartphones but also smart factories, smart buildings, smart cities, and ultimately, smarter economies that create more value and jobs while potentially reducing GHG emissions.

Of course, 5G will not enable the rise of the smart economy on its own. It will be supported by and integrated with a host of advanced technologies and systems including the IoT, cloud computing, AI, augmented and virtual reality, and advanced robotics. Although these other technologies are not in the scope of this report, they are key components of many of the 5G use cases that will have significant impact on economies, employment, and emissions in 2030 in the countries under study.

5G-enabled sales, jobs, and avoided emissions

This report finds that in 2030 across France, Spain, Poland, Belgium, and Romania combined, 5G will enable €407bn ($488bn) in sales, 1.03 million jobs, and 33MtCO2e of avoided GHG emissions, as detailed in **Figure 3**. To put those forecasts into context, they represent 3.3% of total sales across the five countries in 2030, 1.3% of total employment, and 2.4% of total GHG emissions.

Figure 3: 5G-enabled impact across France, Spain, Poland, Belgium, and Romania in 2030

Source: Omdia

Since the geographic scope of this research is unique, Omdia has also extrapolated its findings to Europe as a whole to provide another basis for comparison. Although it is important to note that these are straightforward extrapolations from the results of the five countries covered in this report, the findings are that in 2030 the EU could see 5G-enabled sales in the region of €1.5tn ($1.8tn), 5G-enabled employment of 3.7 million, and 5G-enabled avoided emissions of 68MtCO2e.

A degree of context for these extrapolations for Europe can be provided by *Shaping The Digital Transformation in Europe*, a report by McKinsey & Company for the European Commission.[1] The report finds that new digital technologies could add €2.2tn ($2.7tn) in GDP in the EU by 2030. This GDP figure is not directly comparable to Omdia's figure for 5G-enabled sales, partly because GDP and total sales are different metrics, with total sales being considerably larger than GDP, as detailed in the **Economic impact** section below. In addition, although Omdia's methodology captures the impact of other digital technologies when they support use cases where 5G is a principal component, it does not cover the independent impacts of the other technologies.

Despite these differences, the McKinsey research does provide some level of validation for the scale of the findings in this report for 5G-enabled impacts in 2030.

[1] McKinsey & Company for the European Commission DG Communications, Network, Content and Technology (2020) *Shaping the Digital Transformation in Europe*

Economic impact

5G-enabled sales encompass a broad range of economic activity across the 5G ecosystem

In this study, the term 5G-enabled sales represents the gross output or total sales from economic activity enabled by 5G. Gross output or total sales is a much broader concept than GDP. GDP represents the monetary value of final goods and services to end users. Gross output includes the value of both final goods and services and the intermediate goods and services of producers.

The 5G value chain is diverse, spanning end users (consumers, enterprises and other organizations), telecoms operators, infrastructure vendors, device manufacturers, component providers, software and platform providers, content and application providers, and many more. Some of the players (e.g., telecoms operators) provide final goods and services (e.g., connectivity) to end users. Others (e.g., component providers) contribute intermediate goods (e.g., 5G modules) to final goods (devices).

The spread of 5G to industries that have largely eschewed cellular connectivity in the past (e.g., manufacturing) will drive a requirement for specialist cybersecurity providers and system integrators. In the previous decade, the deployment of 4G LTE helped unleash the app economy. In this decade, 5G holds the potential to enable revenue from new types of services and experiences. In combination with other capabilities, such as edge computing, cloud, and AI and machine learning, 5G will be an important catalyst of the transition to differentiated "as-a-service" business models and productivity improvements that will enhance sales. The concept of 5G-enabled sales captures this broader economic ripple effect: not only the sales of final and intermediate goods and services but also the enablement of sales through productivity enhancements and the development of new business models that will leverage 5G connectivity.

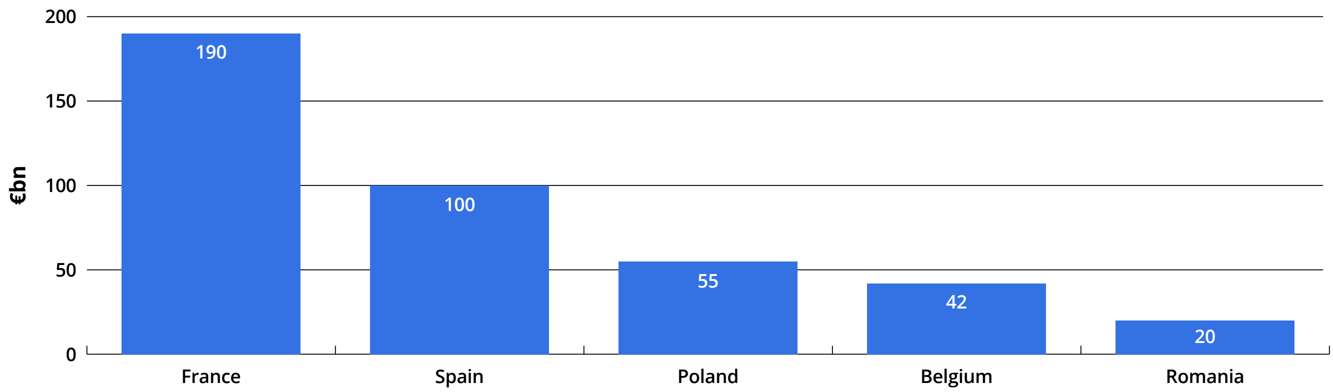
5G will drive sales across both traditional telecoms markets and new industry verticals

Omdia's ongoing syndicated research touches on several parts of the 5G ecosystem. For instance, according to Omdia's latest (February 2021) mobile subscription and revenue forecast, 5G will account for a third of total mobile subscriptions in Europe in 2025, when total mobile service revenues will exceed €117bn ($140bn).[2] And 5G will increasingly drive the global smartphone market, which represented 1.4 billion in shipments and $440bn in revenue in 2019.[3]

Omdia forecasts that worldwide 5G RAN and 5G core revenue (revenue earned by network equipment vendors through sales to operators) will approach $28bn in 2024.[4] In addition to 5G investment by operators, Omdia envisages significant spending by enterprises. Omdia expects spending by the manufacturing sector on 5G across seven major economies to exceed $48bn by 2030.[5]

So 5G's ripple effect will reach well beyond the operators, smartphone providers, and infrastructure vendors to intermediary producers and the industries that will ultimately use 5G to create new sources of revenue. By 2030, according to Omdia forecasts, 5G-enabled sales will account for around 3.3% of the gross output (total sales) of the economies of Belgium, France, Poland, Romania, and Spain. This will amount to €407bn in all: France will account for nearly half of the total, followed by Spain (a quarter), Poland (13%), Belgium (10%), and Romania (5%).

Figure 4: 5G-enabled sales by country, 2030



Source: Omdia

[2] Omdia, *Mobile Subscription and Revenue Forecast: 2020-25*
[3] Omdia, *Smartphone Model Market Tracker – 3Q20 Analysis*
[4] Omdia, *Mobile Infrastructure Market Tracker 3Q20 Database*
[5] Omdia, *5G in Manufacturing - i5G Report – 2020*

By 2030, the largest industry contributors to the €407bn in 5G-enabled sales will be manufacturing (25%), wholesale and retail trade (12%), and information and communication (9%). The leading positions of manufacturing and wholesale and retail trade reflect both the substantial scale of both industries and the diverse contributors to 5G-enabled sales, such as 5G investment on the factory floor, the sale of 5G-connected products and solutions, and the adoption of 5G asset tracking in the supply chain. The increased requirement for IT, cybersecurity, and systems (alongside connectivity) will drive 5G-enabled information and communication sales.

Employment impact

A net increase in jobs in 2030 created by 5G and its ecosystem

The term *employment impact* identifies the net increase in jobs in 2030 created by 5G and its ecosystem. The 5G value chain is diverse and spans a wide range of end users and market players, involving the supply of final goods and services as well as intermediate goods. In examining the employment impact, Omdia has taken this full value chain and the way different industries, activities, and job roles will be affected into consideration.

It is important to remember that 5G does not merely represent a linear technological progression from 4G: it is much more than a glorified speed upgrade. The three variants of 5G that are the building blocks for the 21 use cases Omdia has modeled in its impact assessment—Massive Internet of Things (MIoT), Enhanced Mobile Broadband (eMBB), and mission-critical services (MCS)—deliver a new and diverse range of communication and intelligence capabilities with the potential to change or enhance the way that people and machines operate. A true understanding of employment impact requires an analysis of how the unique attributes of 5G correlate to the individual roles and activities people execute in the workplace.

Research by a range of analysts indicates 5G will create jobs at between 0.6% and 2.5% of population

A number of studies have been completed in the last few years that include forecasts of the employment impact of 5G. At the more optimistic end of the scale, a 2020 report commissioned by Verizon and published by ACT / The App Association[6] indicates that in the US, 8.5 million more jobs (2.5% of the population) will be created over 2019–25 than in a counterfactual 4G-only world. In its 2020 report into how 5G will drive job growth[7] the Progressive Policy Institute (PPI) estimates that in 2034, 15 years after its introduction, 5G and related technologies will create 4.6 million jobs (1.3% of population) in the US relative to the baseline. Other US-focused studies by Accenture[8] and NERA Economic Consulting put the figure at 3 million jobs (0.9% of population) by 2024.[9] Within Europe, in 2019 Tech4i2 replicated and enhanced its earlier European Commission research to forecast that in 2030, 5G-enabled output will be supporting 137,000 jobs (1.5% of the population) in Switzerland.[10]

Omdia agrees that 5G will have a net positive impact on employment, although our estimate of 1.03 million net additional jobs (0.6% of population) across the five countries in 2030 is slightly more conservative, in line with the previous IHS forecasts.[11] Of course, forecasting the impact of a new technology, the use cases for which have yet to be developed (or, in many cases, imagined), is far from a precise art. So while consensus is comforting, it is important to examine exactly why it is commonly held that 5G will generate a positive impact on employment.

[6] James E. Prieger (2020) *An Economic Analysis of 5G Wireless Deployment: Impact on the U.S. and Local Economies*, ACT / The App Association https://actonline.org/wp-content/uploads/ACT-Report-An-Economic-Analysis-of-5G-FINAL.pdf

[7] Michael Mandel & Elliott Long (2020) *The Third Wave: How 5G Will Drive Job Growth Over the Next Fifteen Years*, Progressive Policy Institute, www.progressivepolicy.org/publication/the-third-wave-how-5g-will-drive-job-growth-over-the-next-fifteen-years/

8 Accenture (2017) *How 5G Can Help Municipalities Become Vibrant Smart Cities*, https://api.ctia.org/wp-content/uploads/2017/02/how-5g-can-help-municipalities-become-vibrant-smart-cities-accenture.pdf

[9] Jeffrey Eisenach & Robert Kulick (2020) *Economic impacts of mobile broadband innovation: Evidence from the transition to 4G*, NERA Economic Consulting / American Enterprise Institute, www.aei.org/wp-content/uploads/2020/06/Eisenach-Kulick-Mobile-Broadband-Innovation-WP.pdf

[10] Tech4i2 (2019) *5G socio-economic impact in Switzerland*, https://asut.ch/asut/media/id/1465/type/document/Study_Tech4i2_5G_socio-economic_impact_switzerland_February_2019.pdf

[11] IHS Markit (now Omdia) (2019) *The 5G Economy: How 5G will contribute to the global economy*, www.qualcomm.com/media/documents/files/ihs-5g-economic-impact-study-2019.pdf

5G has the potential to trigger a paradigm shift in the impact of wireless across industries

In its aforementioned analysis,[12] the PPI argues that the potential employment impact of 5G is even greater than that of 3/4G, because of the impact on physical rather than digital industries; it notes that the former comprise a far greater proportion of the economy than the latter. The PPI argues that the properties of 5G stand to generate "cognitive-physical" blue-collar jobs, which use a combination of manual and problem-solving skills. The sense here is that 5G has the potential to create a paradigm shift, bringing the benefits of wireless connectivity and intelligence to swathes of the workforce untouched by the benefits of 4G, which largely empowered white-collar workers.

In addition to its structural effects on sectors of the employment market, 5G has potential geographic benefits. An article on TechRadar[13] cites the opportunity 5G brings to "democratize hiring opportunities outside of major tech hubs," and Omdia believes that, for example, the low-latency, high-bandwidth services delivered by 5G could help spur the digitization of the factory floor, potentially facilitating a shift to local distributed manufacturing and creating local jobs. A multiplication and dispersal of devices, the installation and maintenance of remote assets, and the distribution of production will have a distributed, localized impact on the job market in a manner that extends far beyond home working.

The root of 5G's positive employment impact lies in its effect on individual roles in the workplace

However, to truly understand the impact on employment, Omdia believes it is necessary to go beyond discussion of use cases and generic examples, to analyze human correlations to 5G, by which we mean the occupational tasks and skills that resemble a 5G capability. Omdia's 2020 report *Making Enterprise 5G Pay: The Human Factor*,[14] analyzed 10 such correlations in detail and undertook task analysis of more than 1,000 human occupations mapped against 5G's core capabilities. This meant the effect of 5G could be analyzed in relation to five distinct workstyles that encapsulate the activities workers carry out from day to day (see **Figure 5** below).

Figure 5: 5G impact on different employment workstyles

	Desk-centric	Nomadic		Deskless	
	Desk jockey	**Work surfer**	**Free mover**	**Local roamer**	**Holster nomad**
Description	Job requires a fixed position to perform tasks from a single location	Job requires a fixed position to perform tasks in multiple, ad hoc locations	Job tasks are both stationary and mobile in multiple locations	Job requires mobility to perform tasks in a single location	Job requires mobility to work in multiple locations
5G impact	Low	High	High	Medium	High
5G enrichment examples	• Superior broadband access speed in some areas (FWA) • Seamless network backup to complement fibre	• Rapid data processing • Secure ideation platform • Augmented visualization	• Live data sharing • Augmented visualization • Drone data capture	• Hands-free collaboration • Automation support • Sensor data access	• Live safety monitoring • Sensor data access • Voice-controlled apps

Source: Omdia

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[12] Michael Mandel & Elliott Long (2020) *The Third Wave: How 5G Will Drive Job Growth Over the Next Fifteen Years*, Progressive Policy Institute, www.progressivepolicy.org/publication/the-third-wave-how-5g-will-drive-job-growth-over-the-next-fifteen-years/

[13] Eric Hanson (2019) "5G's impact on the future of work," TechRadar, www.techradar.com/uk/news/5gs-impact-on-the-future-of-work

[14] Omdia (2020) *Making Enterprise 5G Pay: The Human Factor*, https://omdia.tech.informa.com/OM011176/Making-Enterprise-5G-Pay-The-Human-Factor

The report revealed that, among the five workstyles, the desk jockey will not, as such workers have in the past, hog attention and technological investment in the 5G era. Instead, it will be those in peripatetic, field, and industrial roles—the work surfer, free mover, and holster nomad—that stand to profit most. Omdia believes that with access to on-demand, real-time data intelligence and context-appropriate collaboration tools, these workers can make a true leap in value contribution that exceeds the traditional confines of their job description, both enhancing and creating employment across broad sectors of the workforce.

Indeed, the report's analysis of workstyle distribution across 16 industries indicates that a fifth of the global workforce, 635 million people, demonstrate workstyles in occupations that 5G can directly enhance. It should be noted in this context that service and manual workers represent half or more of employment in many countries and dominate industries such as manufacturing, construction, retail, and hospitality. The key message is that 5G can empower employees whether they are viewed as white-, pink-, or blue-collar workers.

Omdia believes 5G will generate 1.03 million net additional jobs in 2030 across the five countries

The net effect of the impact on employment across broad sections of the economy will be 1.03 million additional jobs in the five countries as a result of 5G in 2030, 0.6% of population and 1.3% of total employment. The breakdown by country is shown in below in **Figure 6**.

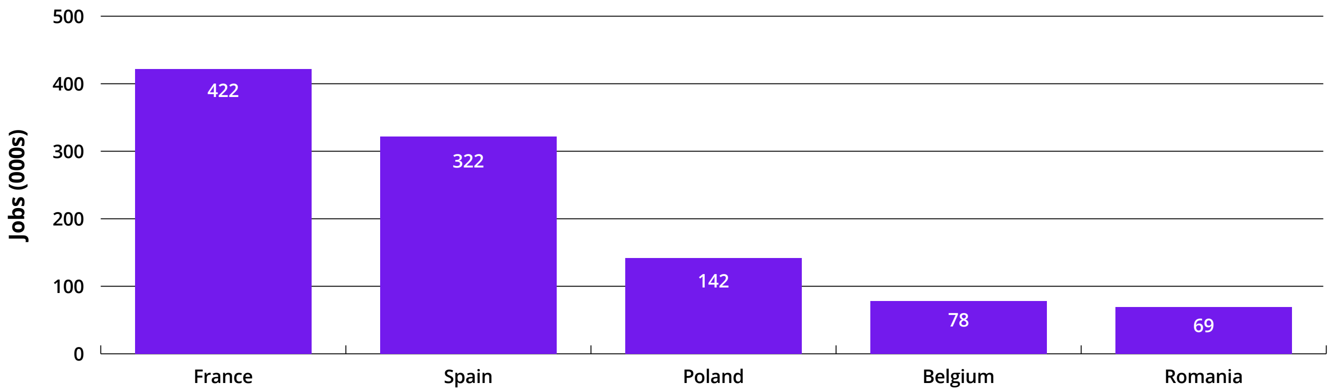
By 2030, the largest industry contributors to increased employment will be public service and defense (26%), information and communication (25%), and transportation and storage (9%). The leading position of public service and defense is in part a reflection of the significant number of people employed in that sector (9.5 million across the five countries), with the positive impact of 5G coming largely from a mix of enhanced mobile broadband (eMBB) use cases. These include enhanced indoor and outdoor wireless broadband and fixed wireless broadband deployments, for example, in the context of public spaces and buildings and organizational teamwork/collaboration. Omdia believes there will also be a positive impact in the public sector from smart city MIoT deployments.

The 258,000 additional jobs created in the information and communication sector relate to a smaller overall employment base of 3.7 million employees and reflect the high level of synergy between use cases and activities in the ICT sector as well as the direct effect of sales of 5G-connected products and solutions and an increased requirement for IT, cybersecurity, and systems (alongside connectivity). Use cases with a positive impact in this industry span all three use-case areas.

Of course, not all the effects of 5G will be positive: aspects such as increased automation will lead to job replacement in some roles, and Omdia expects to see a negative impact in a handful of use cases across the 16 industries. In the utilities and construction sectors, for example, physical infrastructure use cases that involve the remote monitoring of assets may see headcount reductions. Omdia believes that 5G communications will allow flexible integration of automated equipment and skilled workers on a construction site. On the plus side, structures will go up faster with fewer dangerous errors, and worksites will be safer; on the downside, this may require fewer construction workers in some situations. There are some agricultural contexts that may also lead to a reduction in the number of workers; for example, benefits of MIoT smart agriculture applications include optimization of watering and feeding, growing, and harvesting scheduling. This leads to increases in farm operational efficiency but also, potentially, to a reduced need for manual labor.

However, Omdia expects a degree of net positive employment impact across all industry sectors.

Figure 6: 5G-enabled employment by country, 2030



Source: Omdia

Emissions impact

The race is on to reduce GHG emissions

As 5G is deployed extensively throughout the five countries in this study through 2030, it will increasingly enable individuals and organizations to make progress on one of the key environmental goals of our era, the reduction of the GHG emissions that are one of the main drivers of climate change.

An increasing number of communications service providers (CSPs) are reporting on the environmental impact of their operations, including the GHG emissions generated by the networks, office buildings, and retail stores they operate. However, to put these direct GHG emissions in context, some CSPs have also started estimating, quantifying, and reporting on the reductions in GHG emissions enabled by the use of their products and services.

For example, because of the pandemic, offices have been closed and travel restricted, which has led to a boom in remote working, enabled by broadband connectivity and enterprise collaboration applications such as Microsoft Teams and Zoom. One of the many effects of this massive transition has been a reduction in GHG emissions because of reductions in all forms of travel, including work-related travel. In fact, while the pandemic is undoubtedly an extreme event on many levels, and hopefully highly unusual as well, one of its impacts has been to reduce global GHG emissions in 2020 by some 7% from 2019, the largest drop on record. As a comparison, in 2019 global GHG emissions increased by 0.6%, and in 2018 they increased 2%.

Forecasting emissions impact involves a number of challenges

While remote working is something that many have experienced directly during the pandemic, it is also an example that highlights some of the challenges of this study and how Omdia has addressed them. First, there is the challenge of forecasting during an extreme, exceptional, and global event that has had, and continues to have, a massive impact on almost every country, industry, company, and individual in the world. Although the pandemic itself is not the focus of this study, it does have an impact upon it, given the need to forecast how mobile markets in general, and 5G use cases in particular, will recover and grow as the pandemic comes to an end. To continue with the remote-working example, Omdia's research has found that after the pandemic, remote working will decline from the levels currently seen but will remain much more widespread than beforehand. This is because of a host of factors including a dramatic increase in the number of employers and employees convinced of the benefits of remote working after extensive experience and significant investment and improvement in enabling applications, devices, and services. However, in general it is fair to say that forecasting during an extreme event is more uncertain than forecasting during more normal times.

A second challenge of the research is that many of the use cases under study are complex and can involve multiple technologies, applications, services, and devices. This led Omdia to define 5G use cases as those in which 5G is an integral part of the solution creating value for end users. One example is enterprise teamwork and collaboration, which is related to the remote-working example above and one of the use cases examined in this research. But when we look closely at the use case, it becomes clear it can consist of many different applications, services, and connectivity technologies. For example, in markets such as France, which has high fixed broadband penetration, many remote workers use fixed broadband services to power enterprise teamwork and collaboration services, and this will continue to be the case in 2030. However, when travel resumes after the pandemic, and as 5G coverage increases, there will be opportunities for enterprise teamwork and collaboration to be enabled by 5G, for example, in airports and train stations.

Even after we have estimated how often a use case will be enabled by 5G as opposed to another connectivity technology, there is still a question of allocation: If a use case enabled by 5G and other technologies and services helps to avoid GHG emissions, how much of that avoidance should be attributed to 5G, given it is only one part of the use-case solution? In an effort to avoid unnecessary complexity, Omdia's answer to that question is when 5G is an integral part of a solution, the full impact of the use case is attributed to 5G.

Multiple studies point to mobile services helping other industries reduce GHG emissions

Although there are major challenges in estimating the avoided emissions of mobile services in general and of 5G services in particular, service providers and researchers have started to overcome the challenges. Service providers currently reporting their GHG direct emissions, and emissions avoided by the use of their products and services, include AT&T, BT, Deutsche Telekom, KPN, Swisscom, Telefónica, Verizon, and Vodafone. In annual reporting for 2017–20, the groups reported that their GHG abatement ratios (the ratio of avoided GHG emissions to GHG direct emissions) ranged from 1.2 to 3.8. In other words, the operators reported that the GHG emissions reductions enabled by their services were 1.2–2.9 times greater than the direct GHG emissions generated.

Groups that have published research on avoided emissions include the Global e-Sustainability Initiative (GeSI), which published its mobile carbon impact report in 2015. GeSI found that in 2015 the mobile industry in Europe and the US produced 36MtCO2e of GHG emissions but helped other industries avoid 180MtCO2e of emissions, giving an "abatement ratio" of 5:1. Then in October 2020, Accenture, working with the Canadian Wireless Telecommunications Association, published *Accelerating 5G in Canada: The Role of 5G in the Fight Against Climate Change*. Accenture found that 5G could help to avoid 6.4–12.2MtCO2e of GHG emissions in Canada by 2025, representing up to 2% of the total GHG emissions Canada forecasts it will have in that year.

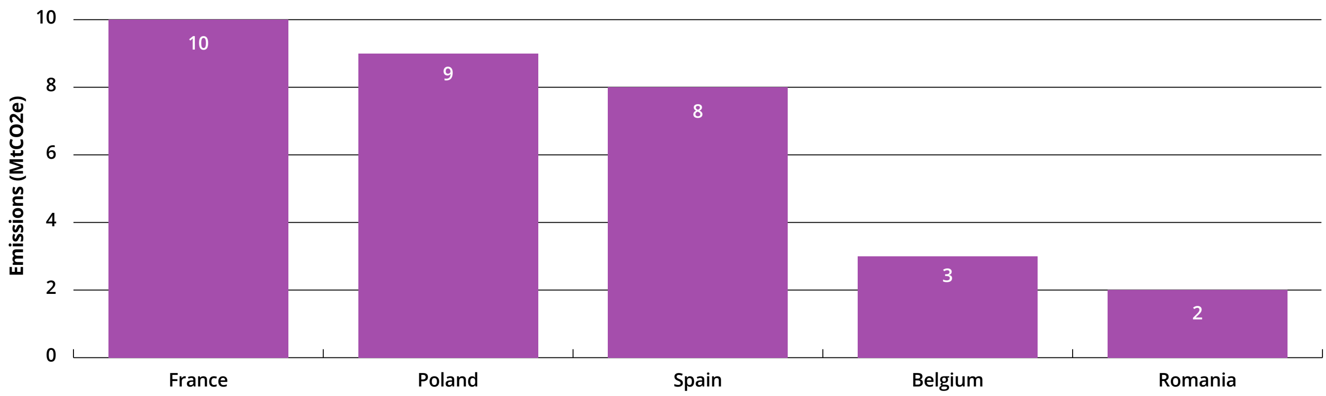
The Accenture research, which focuses on 5G only and provides a forecast for its avoided emissions impact in 2025, is the most directly comparable to Omdia's research and forecasts on 5G-enabled avoided emissions in five countries in Europe in 2030. As a high-level comparison, Omdia has found that 5G-enabled avoided emissions in 2030 across the five countries in this report will represent 2.4% of total GHG emissions expected in that year across all the countries, slightly higher than Accenture's finding of 2% for Canada in 2025.

5G will help reduce GHG emissions by 33MtCO2e in 2030 across the five countries

Omdia forecasts that 5G services will help reduce GHG emissions across the five countries by 33MtCO2e in 2030; a breakdown by country is shown in **Figure 7** below.

The different levels of avoided emissions are the result of a range of factors, including the penetration and maturity of 5G services in 2030, the carbon intensity of power production in each country, and the aggressiveness of nationwide targets for reducing GHG emissions. Further details on these findings are provided in the country sections later in the report, beginning with France.

Figure 7: 5G-enabled avoided greenhouse gas emissions by country, 2030



Source: Omdia

2. France

Overview

Of the five countries studied in this report, France has the highest GDP, employment, and level of emissions, and it is therefore not surprising to find that the positive impact of 5G will be highest in France. **Figure 8** below shows the precise degree of economic, employment, and emissions impact estimated by Omdia in 2030.

Figure 8: 5G impact in France, 2030

Source: Omdia

Before exploring the impact forecasts themselves, Omdia believes it is important to examine the 5G environment in France by indicating the current status of deployment, reviewing examples of recent initiatives, and elaborating on a pertinent use case of the kind that will ultimately generate a positive impact from 5G.

The 5G environment

5G deployment in France is gathering pace

In July 2018 Arcep, France's telecoms regulator, unveiled its roadmap for 5G.[15] This emphasized the importance of 5G to wider digital transformation, a coordinated pan-European approach, and the readiness of various public authorities for the deployment of 5G. It also set priorities such as frequency allocation, new use-case development, the support for 5G deployment, transparency and open dialogue on the planned rollout of new 5G sites, and the consequences of these deployments in terms of public exposure to electromagnetic fields.

France's 5G spectrum auction (for 3.4–3.8GHz) was completed in October 2020, having been delayed from April because of the pandemic. With 90MHz, Orange won the broadest range of frequencies, followed by SFR with 80MHz and Bouygues and Free Mobile with 70MHz each.

All four operators launched commercial 5G services in late 2020:

- Free Mobile is using 700MHz and 3.5GHz spectrum. It launched commercial services on November 15, 2020 with its network covering some 40% of the country's population.
- SFR launched commercial 5G services (using 2.1GHz and 3.5GHz spectrum) on November 23, 2020.
- Bouygues Telecom launched commercial 5G services (using 2.1GHz and 3.5GHz spectrum) on December 1, 2020 in 20 cities.
- Orange, using 2.1GHz and 3.5GHz spectrum, launched on December 3, 2020 in 15 municipalities, with plans to reach 160 by the end of 2020.

Recent 5G use-case developments

In 2020 there were a number of announcements about 5G use-case trials and implementations in France, such as Orange's Industry 4.0 collaboration with Schneider Electric.[16]

Omdia believes the focus on Industry 4.0 is pertinent, since 5G, in combination with other technologies, has the potential to enable sales in the manufacturing industry in several respects:

- Through enhancements in productivity, quality, and time to market on the factory floor
- Through the production of 5G-connected equipment and products for consumers, enterprise, and industry
- Through the development of as-a-service business models that leverage this connectivity and extend the relationship between manufacturer and end user beyond product sale

In the case of its partnership with Schneider Electric, Orange has deployed an indoor, private virtualized network using experimental frequencies to trial augmented reality (AR) and telepresence use cases. In the AR use case, 5G-connected tablets running Schneider's AR application EcoStruxure Augmented Operator Advisor superimposed real-time data onto physical objects in the factory such as a cabinet, a machine, or the whole plant. In the telepresence use case, a 5G-connected XYN mobile telepresence robot performed remote visits to the Le Vaudreuil factory. The use of 5G enabled the remote visitor to view video streams from the robot and interact via voice with the Schneider virtual assistant with limited time delay.

Omdia believes the strength of the manufacturing industry in France means there will be fertile ground for the

[15] www.arcep.fr/fileadmin/reprise/dossiers/programme-5G/Roadmap_5G_-_VA.pdf
[16] www.orange.com/en/newsroom/press-releases/2020/orange-and-schneider-electric-run-industrial-5g-trials-french-factory

France use-case example: Manufacturing

development of further 5G use cases, with positive benefits to the country.

Manufacturing needs to be innovative to navigate disruption

France's manufacturing industry, measured by gross output, is the largest across the five countries in this study. Capital-intensive, export-oriented industries such as automotive, aerospace and defense, and industrial equipment are strongly represented in the country. Traditional manufacturers in these sectors face many headwinds including growing competition from lower-cost economies, high fixed costs, an aging skilled workforce, and changing habits among their ultimate customers (e.g., the shift from car ownership to as-needed usage via services).

To mitigate such disruption and compete effectively, manufacturers must be innovative, become more efficient, adopt flexible processes, and align their business models with how their products, services, and solutions are consumed. Connectivity is integral to the transformation of manufacturing, and indeed, private wired (particularly Ethernet and Fieldbus) connectivity is well established on the factory floor. But wired connectivity has inherent downsides, notably the disruption involved in installing new cabling and its lack of suitability for some use cases, such as those requiring mobility. Historically, cellular adoption on the factory floor has been limited by the lack of internal expertise and by concerns over the reliability and security of public cellular networks.

5G's technical capabilities are driving growing interest among manufacturers

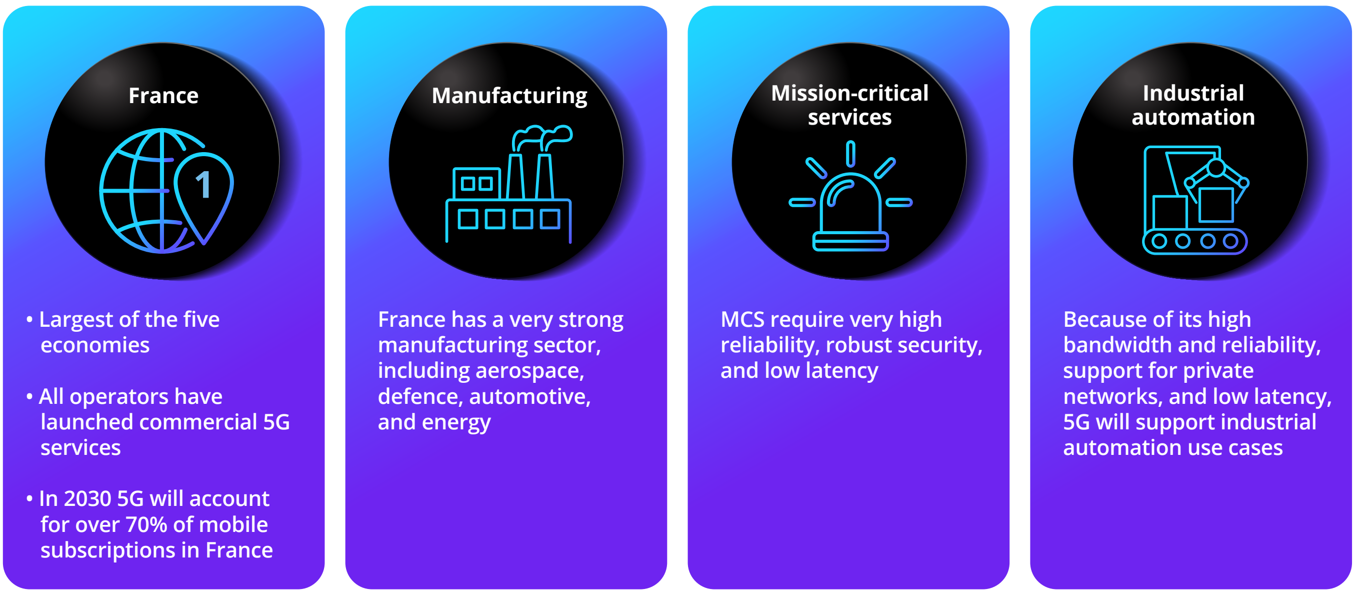
Omdia research suggests that 5G is driving a shift in attitudes among manufacturers. Omdia's IoT Enterprise Insights 2019/20 survey (December 2019) found that 67% of companies in the manufacturing, industrial, and extractive industries viewed 5G as a key technology for their future plans. Omdia's subsequent Industrial 5G survey (March 2020) found that real-time communications, flexibility, and low latency were viewed by manufacturers as 5G's key features in industrial deployments.

As discussed above, 5G-connected factory/Industry 4.0 use cases being tested in France and other countries include

- Modular/flexible factory setup and production
- Product quality control through real-time analytics
- Energy management
- Augmented equipment inspections and digital twins

Other use cases that leverage the low-latency and high-availability characteristics of 5G include automated guided vehicles, collaborative robotics, and closed-loop control.

Figure 9: France, 5G impact case study: Industrial automation



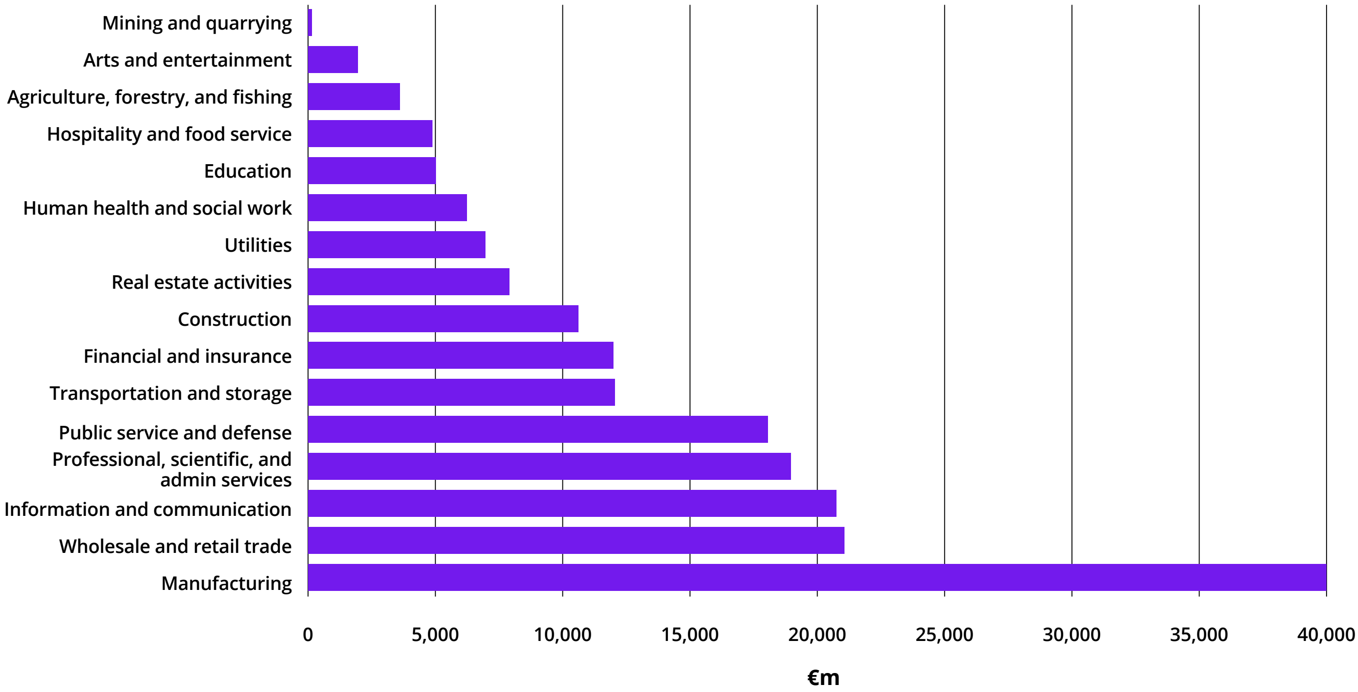
Source: Omdia

Omdia believes that as a result of the integration of 5G into the industrial landscape through examples such as those above, the technology will bring a range of positive benefits to France.

Economic impact

Omdia forecasts that 5G-enabled sales will reach €190bn by 2030

Figure 10: France, breakdown of 5G-enabled sales by industry in 2030



Note: Since this is a multinational study, industries are based on the International Standard Industrial Classification of All Economic Activities (ISIC), which is produced and maintained by the U.N. Statistics Division, rather than the classification of the National Institute of Statistics and Economic Studies (INSEE) in France.

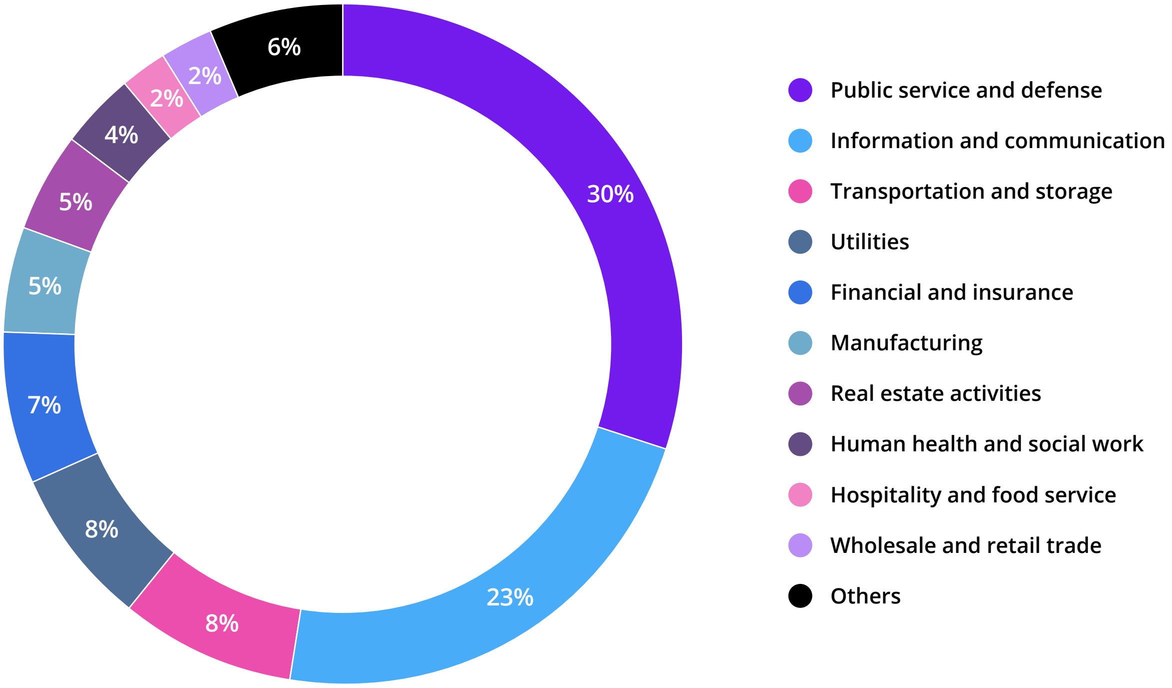
Source: Omdia

As **Figure 10** below shows, manufacturing will be the greatest beneficiary of France's €190bn 5G-enabled sales. By 2030, manufacturing will account for 21% of 5G-enabled sales, higher than its share of gross output or total sales in the economy (17%) by the same time.

This reflects the potential relevance of various 5G use cases, stretching well beyond industrial automation, for the manufacturing sector. Although new variants of Wi-Fi pose a competitive threat, growing interest in private LTE/5G among manufacturers reflects its potential to improve connectivity and boost productivity on the factory floor. Industrial companies are also investigating 5G's role in the more efficient usage of energy (a major source of factory opex) in the production process. Another use case, AR, also has the potential to aid technicians in their vital role of keeping machines running. Initially, traditional devices such as tablets will be the conduit for AR. Wearables with standalone 5G connectivity (as opposed to wired or wireless tethering) are still a few years out: getting the balance right between display, processing, and power consumption remains a challenge for the semiconductor industry and its partners.

The other industry that will disproportionately benefit from 5G is information and communication. It will account for 11% of 5G-enabled sales (against 5% of total output or gross sales). This outsized impact is down to the need for support from third-party IT, systems integration, and security specialists in setting up 5G connectivity, integrating with enterprise systems, and managing devices on an ongoing basis.

Figure 11: 5G impact in France, proportion of 422,000 net new employees by sector, 2030



Note: Since this is a multinational study, industries are based on the International Standard Industrial Classification of All Economic Activities (ISIC), which is produced and maintained by the U.N. Statistics Division, rather than the classification of the National Institute of Statistics and Economic Studies (INSEE) in France.

Source: Omdia

Employment impact

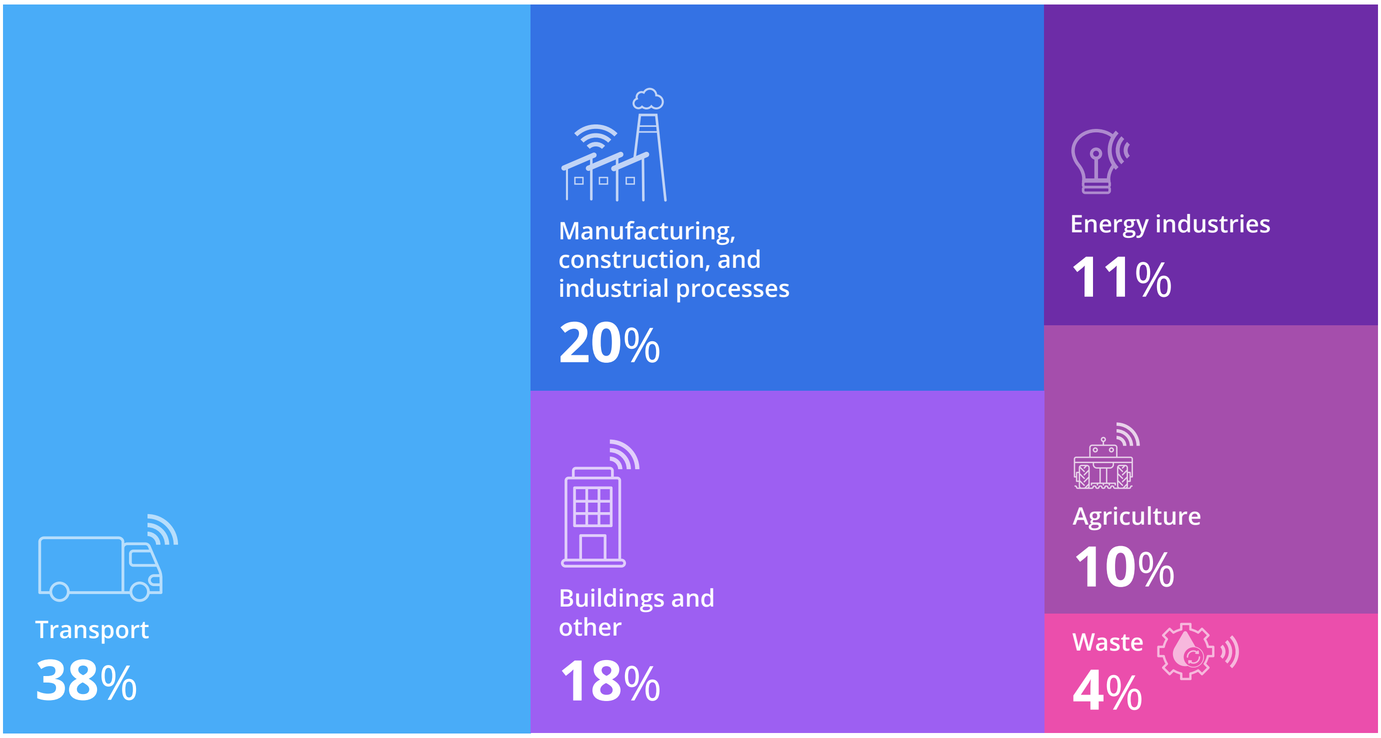
Omdia estimates that there will be 28.1 million people in employment in France in 2030, with 422,000 of those jobs created as a result of 5G, 1.5% of the national workforce and 0.6% of the population. These jobs will be spread across a broad range of industry sectors, with the largest volume of 5G-generated jobs created in public service and defense and information and communication (see **Figure 11** below).

It is notable that many of the sectors above are the same as those driving economic impact, exceptions being human health and social work, for example, which employs 5% of the French workforce but is not an engine of the economy by its very nature. There is, of course, a degree of correlation between the number of employees in a sector and the number of jobs 5G will stimulate, and indeed, the predominance of public service and defense 5G employment impact is partly explained by the fact that this sector is the biggest employer in France (employing 4.4 million people in 2030, 16% of the workforce). The 127,000 jobs forecast represents 2.9% of employees in the sector, one which has significant potential for 5G impact based on its broad range of white- and blue-collar roles. In the information and communication sector, 5G will have an even greater proportional effect on employment. The sector will benefit directly from the production and rollout of 5G equipment, while 5G will also have an impact on many elements of the supply chain. Huawei recently announced[17] that it will build a network equipment factory in France, potentially employing 500 people in the longer term. It is notable that a number of sectors not traditionally associated with wireless technology advancement, such as transportation and storage, utilities, manufacturing, and human health and social work, feature in the top 10 sectors by employment additions shown in Figure 11, a reflection of the breadth of impact through new sectors of the workforce and job roles.

[17] www.reuters.com/article/us-huawei-tech-france-idUSKBN28R2V7

Given the use case of industrial automation elaborated on above, it is pertinent to note that while the positive impact from 5G on employment will not be as significant as on the economy in general (because there is an extent to which automation will erode jobs), the net impact is nevertheless positive overall. This is thanks to the introduction of a diverse range of applications into the industrial workplace and the way in which this will not only enhance the jobs of certain types of blue-collar workers but will also lead to new jobs in skilled technical roles installing, operating, and maintaining a new generation of systems, sensors, and devices. There will also be a knock-on need for training (and trainers) associated with new roles,

Figure 12: France, 5G-enabled avoided emissions, sector share of total, 2030



Source: Omdia

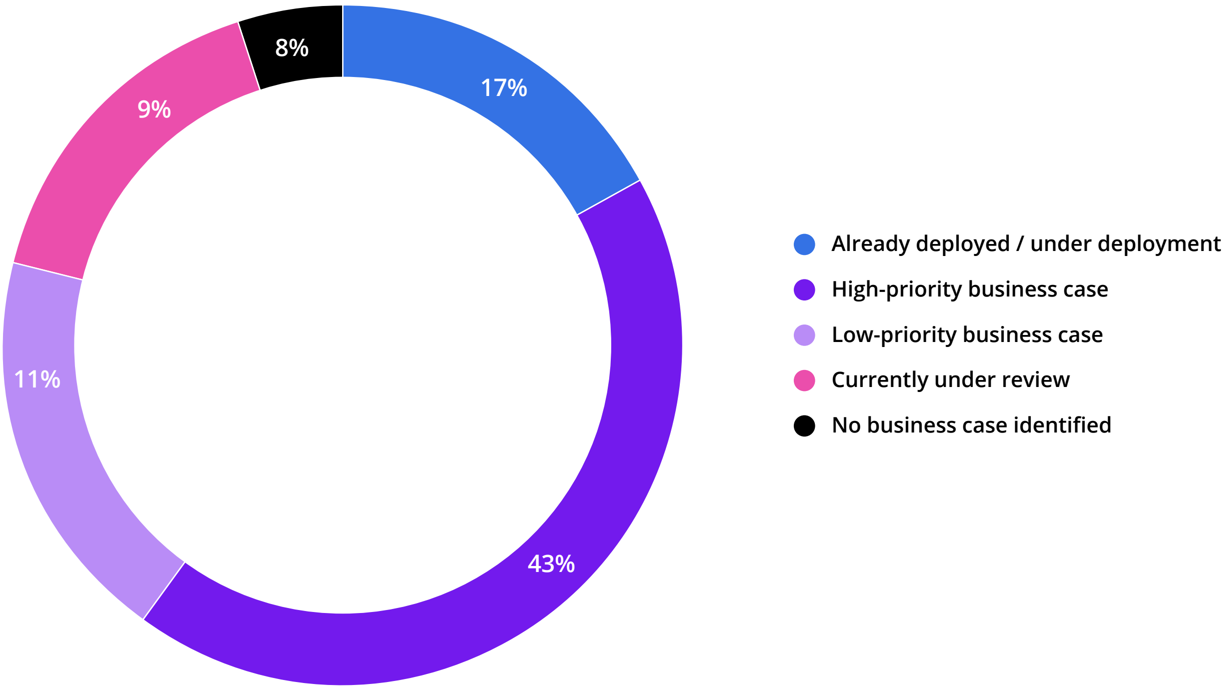
technologies, and systems.

Emissions impact

Omdia forecasts that 5G will help to reduce GHG emissions in France in 2030 by 10.1MtCO2e, representing 2.4% of the 416MtCO2e in total GHG emissions that France projects it will have in that year. The transport sector will account for the largest proportion of 5G-enabled avoided emissions in 2030 (38%). A breakdown of relative impact by sector is shown in **Figure 12**.

For transport, it is important to note two things that help to explain why it accounts for the largest share of 5G-enabled avoided emissions in France and many other countries. First, transport is the largest sector by far based on its GHG emissions, representing 30% of the total GHG emissions projected in France in 2030, ahead of manufacturing, construction, and industrial processes with 19% and agriculture with 18%. Second, a host of 5G use cases will help to avoid GHG emissions

Figure 13: Survey of manufacturers in Western Europe: Has your company identified a compelling business case for cellular?



Source: Omdia Manufacturing – ICT Enterprise Insights 2021; n=98

in transport and particularly in road transportation, the largest transport subsegment, across both the consumer and enterprise sectors. These will be discussed in more detail in the Belgium section.

In the manufacturing sector, there will be a significant investment in 5G networks, services, and applications in France over the next 10 years, with the common goal of improving the connectivity and efficiency of the complex interaction of people, machines, goods, and services that make up the manufacturing process. In fact, Omdia's ICT Enterprise Insights survey, conducted in 2020, found that 25% of the manufacturers surveyed in France had already deployed cellular infrastructure, including 4G LTE, 5G, or other cellular technologies, and another 63% identified it as a high-priority business case for investment. Although these figures should be taken as illustrative since the sample size of the survey in France was low, they show the same trend as the results for manufacturers surveyed across Western Europe, which had a more representative sample size and found that 17% of respondents had already deployed cellular, and another 43% identified it as a high-priority business case (see **Figure 13**).[18]

Omdia expects interest and investment in cellular to increase significantly through 2030 and to migrate from 4G LTE to 5G because of the latter's differentiating features including lower power consumption per bit and lower latency. This will lead to increased adoption of a range of 5G use cases by manufacturers in France, including enhanced indoor and outdoor wireless broadband, industrial automation, remote monitoring, and asset tracking. Given that energy is typically one of the highest

[18] Omdia, *Manufacturing - ICT Enterprise Insights 2021* (September 2020

costs in manufacturing, all 5G use cases will contribute to greater energy efficiency, which in turn will help reduce GHG emissions in the sector. Omdia forecasts that 5G use cases could help manufacturers in France avoid 2MtCO2e of GHG emissions that would have occurred without 5G, representing 2.5% of the 80MtCO2e in emissions expected in the manufacturing, construction, and industrial processes sectors in France in 2030.

Other sectors where the adoption of 5G will help drive significant reductions in GHG emissions include energy industries and agriculture, which Omdia forecasts will have a combined abatement of 2.1MtCO2e emissions in France in 2030, representing 2% of the total GHG emissions of both sectors combined in that year.

3. Spain

Overview

Spain has the second-largest economy of the five countries studied for this report and the second-highest level of positive impact from 5G. **Figure 14** below shows the precise degree of economic, employment, and emissions impact estimated by Omdia in 2030.

Figure 14: 5G impact in Spain, 2030

Source: Omdia

© 2021 Omdia

Before exploring the impact forecasts themselves, Omdia believes it is important to examine the 5G environment in Spain.

The 5G environment

5G coverage in Spain is expanding rapidly

In line with the EU 5G Action Plan, Spain has published a 5G National Plan 2018-2020,[19] with the aim of positioning Spain as a leading 5G nation, and has already started its implementation. According to the government, the expectation is that 5G will have a cross-cutting effect on the economy and society as a whole.

Spain auctioned 3.6–3.8GHz spectrum as early as 2018. Vodafone won 90MHz, Orange 80MHz, and Telefónica 50MHz. MÁSMÓVIL was a bidder but did not win additional spectrum: it had previously acquired mid-band spectrum from Eurona and Neutra Network respectively. Spain had planned to auction 700MHz spectrum in 2020, but this has been delayed to 2021 as a result of the COVID-19 pandemic.

All of Spain's operators have launched commercial 5G services:
- Market leader Telefónica launched September 1, 2020, with the promise of 75% population coverage (using 3.5GHz, 2.1GHz, and 1.8GHz spectrum) by the end of 2020.
- Vodafone Spain launched commercial services using 3.7GHz spectrum holdings in June 2019; as of February 2021, its network had reached 21 cities.
- By the same point in time, 5G services, delivered on 3.7GHz spectrum, were available across 121 towns and cities in 39 provinces through Orange Spain.
- In September 2020, MÁSMÓVIL launched commercial 5G services in 15 cities based on a network-sharing agreement with Orange Spain; it also owns 80MHz of 3.4–3.8GHz spectrum.

Recent 5G use-case developments

There have been a number of recent developments regarding 5G deployments in Spain. In February 2021, for example, Telefónica announced a partnership with Real Club Deportivo de La Coruña, cinfo, and Ericsson to trial live broadcasting and experiences over 5G connectivity.[20] In the pilot, a dedicated 5G network using 3.5GHz and mmWave spectrum and a standalone and NSA (nonstandalone) network core was deployed in the Abanca-Riazor Stadium. The stadium has been equipped with five 5G robotic cameras to follow a soccer game in real time, two fixed cameras for game analysis, and one panoramic camera. These cameras, in combination with AI and edge computing, will allow for high-definition broadcasting, game analysis, and AR heat maps.

Telefónica also announced a partnership with Gestamp, an automotive components manufacturer, in the implementation of a 5G-connected factory at one of its plants in Barcelona.[21] The operator has connected the physical elements of the factory, such as robotic welding cells, with 5G to capture and process data from industrial equipment in real time. Such processing is performed by low-latency multi-access edge computing (MEC). The construction of a digital twin based on this data allows for more informed decision-making about how to run production.

In 2020 Orange was selected to take part in three projects awarded by the Spanish Ministry of Economic Affairs and Digital Transformation relating to 5G trials in three Spanish regions over the next two years.[22] A pilot in Valencia includes tests of critical communications and AR applications for the tourist industry, partnering Orange with companies including Vysion, Robotnik, COSCO Shipping, Intel, Fermax, HISPASAT, Viesgo, and Huawei as well as with Valencia's Polytechnic University and regional and municipal governments. In Galicia, a scheme will test high-resolution cameras carried by drones to control entries to the port of Vigo in addition to tourism, health, agriculture, and remote learning applications. In the Basque country, Orange is partnering with Euskaltel, R Cable, and Xfera ZTE España among others to test 5G use cases in cybersecurity, vehicle components, and maintenance services.

Also in Galicia, Orange has partnered with Lacroix, a specialist in the electronic design of embedded systems and industrial connected objects, and will assess the potential for 5G to develop the concept of a modular factory and enhance the technical management of buildings, particularly in relation to energy consumption.

Omdia believes that this Industry 4.0 smart buildings example is a pertinent use-case area, which will generate significant future benefits from 5G, and we have therefore chosen this area to explore in more detail below.

[19] Government of Spain (2018) *Plan Nacional 5G* [Spain's 5G National Plan 2018-2020], https://avancedigital.mineco.gob.es/5G/Paginas/medidas-5G.aspx
[20] www.telefonica.com/en/web/press-office/-/telefonica-real-club-deportivo-cinfo-and-ericsson-provide-abanca-riazor-with-the-largest-5g-coverage-in-a-european-stadium
[21] www.telefonica.com/en/web/press-office/-/telefonica-and-gestamp-promote-the-digitalization-of-the-industry-with-a-5g-connected-factory-use-case
[22] www.gtigroup.org/news/ind/2020-08-12/15427.html

Spain 5G use-case example: Smart buildings

Smart buildings play a central role in the smart city

During the COVID-19 pandemic, many businesses around the world have shifted most of their employees to remote working. This is not a universal trend though: hospitals, factories, warehouses, supermarkets, and other locations where vital activity continues remain open. Despite employee illness and restrictions on the movement of people, the construction of new buildings and facilities has also continued in many parts of the world.

Figure 15: Spain, 5G impact case study: Smart buildings

Source: Omdia

© 2021 Omdia

As the hosts of millions of employees and of major economic activity, smart buildings play a central role in the smart city. Landlords and business owners are paying increasing attention to providing resilient connectivity, improving energy efficiency, and creating a safe, comfortable, and collaborative working environment for employees in offices and other facilities. Owners of unoccupied buildings need to monitor them for unauthorized access or accidental damage to infrastructure or services.

As employees return to work, facilities managers will need to monitor occupancy, social distancing, and hygiene. These and related concerns are reflected in the findings of Omdia's *Smart Building End-Users Survey – 2020:*[23] around 73% of those surveyed said that they have smart building technologies/applications (e.g., lighting, energy management, and others) in their facilities. Developers in major construction markets, such as Spain, are factoring in the evolving needs of occupiers in the design and building of new facilities.

5G may play a differentiated role in a diversified connectivity environment

The smart building, like the smart city beyond its walls, is a diversified connectivity environment. A mixture of open and proprietary and wired and wireless technologies such as Ethernet, KNX, LoRaWAN, Modbus, Wi-Fi, and many more connect assets across access control, HVAC, lighting, and security. A consequence of such diversity is problems with achieving interoperability between different systems and the products of different vendors.

Although smart building connectivity is likely to remain fragmented, 5G is in a good position to play a differentiated role. The need for both resilient inbound connectivity and strong distribution of broadband throughout a building is driving increased activity around private LTE/5G, according to Omdia's LTE and 5G Private Networks research.[24] The low-power characteristics of 5G also put it in a strong position to monitor and various type of equipment and infrastructure, such as HVAC, PV invertors, and utilities. Omdia's *Low Power Wide Area Network LPWAN Market Report – 2020*[25] forecasts that both cellular and unlicensed LPWAN technologies will see strong adoption in connected spaces: smart cities, smart buildings, and other industrial or commercial connected spaces.

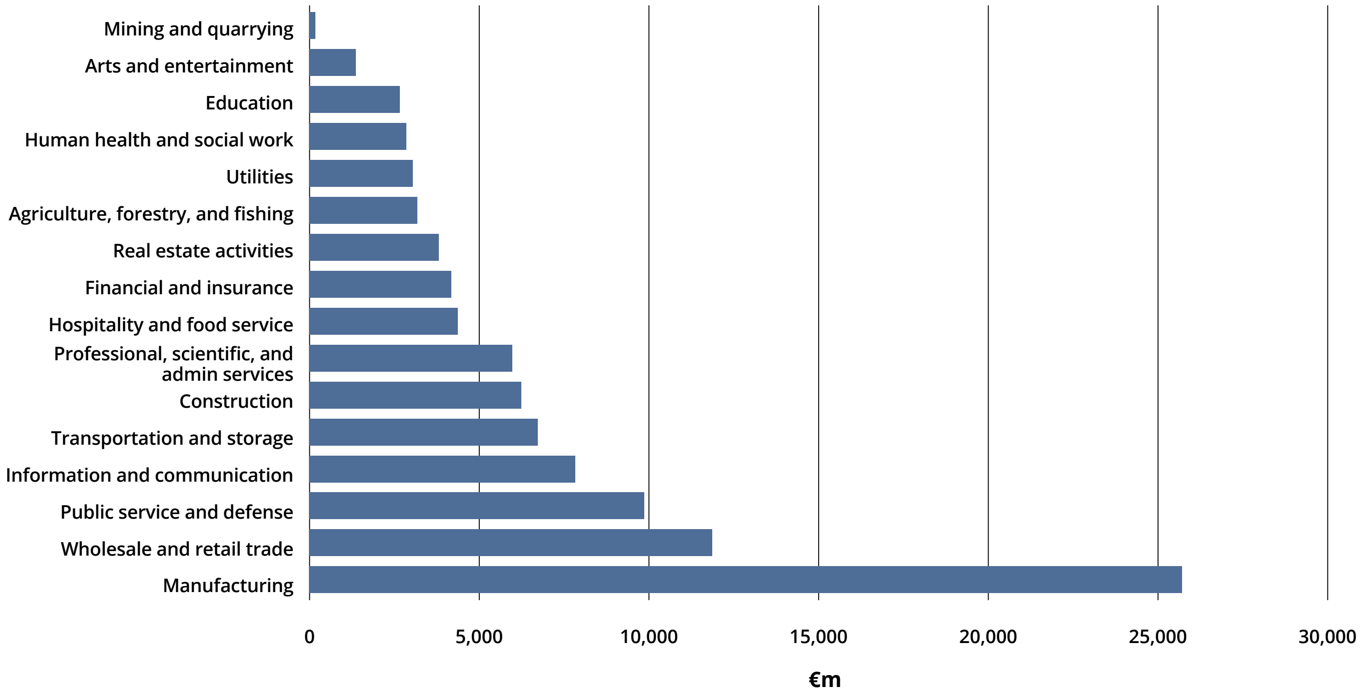
[23] Omdia, *Smart Building End-Users Survey – 2020* (June 2020)
[24] Omdia, *LTE and 5G Private Networks Tracker – 4Q20* (February 2021)
[25] Omdia, *Low Power Wide Area Network LPWAN Market Report – 2020* (August 2020)

Economic impact

5G-enabled sales will reach €100bn by 2030

As in France, the sheer scale of the manufacturing industry in Spain, coupled with the impact of several relevant 5G use cases, means that it will account for 26% of Spain's €100bn in 5G-enabled sales by 2030 (slightly lower than its contribution to gross output / total sales). By 2030, the largest five beneficiaries of 5G-enabled sales will together account for 63% of 5G-enabled sales.

Figure 16: Spain, breakdown of 5G-enabled sales by industry in 2030



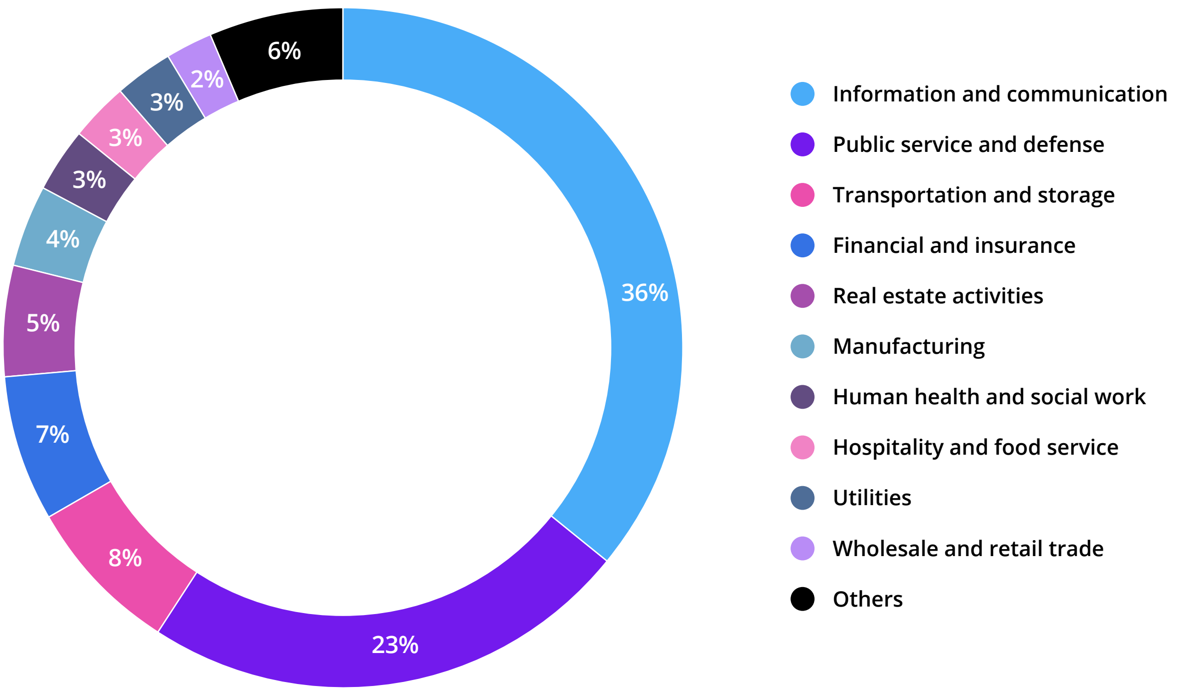
Source: Omdia

Among the other leading beneficiaries of 5G-enabled sales, professional, scientific, and administrative services and public service and defense are particularly noteworthy. By 2030, these will together account for 16% of 5G-enabled sales (slightly higher than their contribution to gross output / total sales). Professional, scientific, and administrative services and public service and defense encompass a very broad range of service-based and public sector activity. One key sector of activity in relation to this is the smart city / smart building environment (as per the use case above), a space in which Spain is particularly innovative. Though smart city and smart buildings represent a fragmented technology landscape, 5G is well positioned to address varied requirements for resilient connectivity, improved in-building coverage, and enabling remote access to enterprise applications for mobile workers.

Employment impact

Omdia estimates that there will be 20.3 million people in employment in Spain in 2030, with 322,000 of those jobs created as a result of 5G, 1.6% of the national workforce and 0.7% of the population. These jobs will be spread across a broad range of industry sectors, with the largest volume of 5G-generated jobs created in information and communication and public service and defense (see **Figure 17** below).

Figure 17: 5G impact in Spain, proportion of 322,000 net new employees by sector, 2030



Source: Omdia

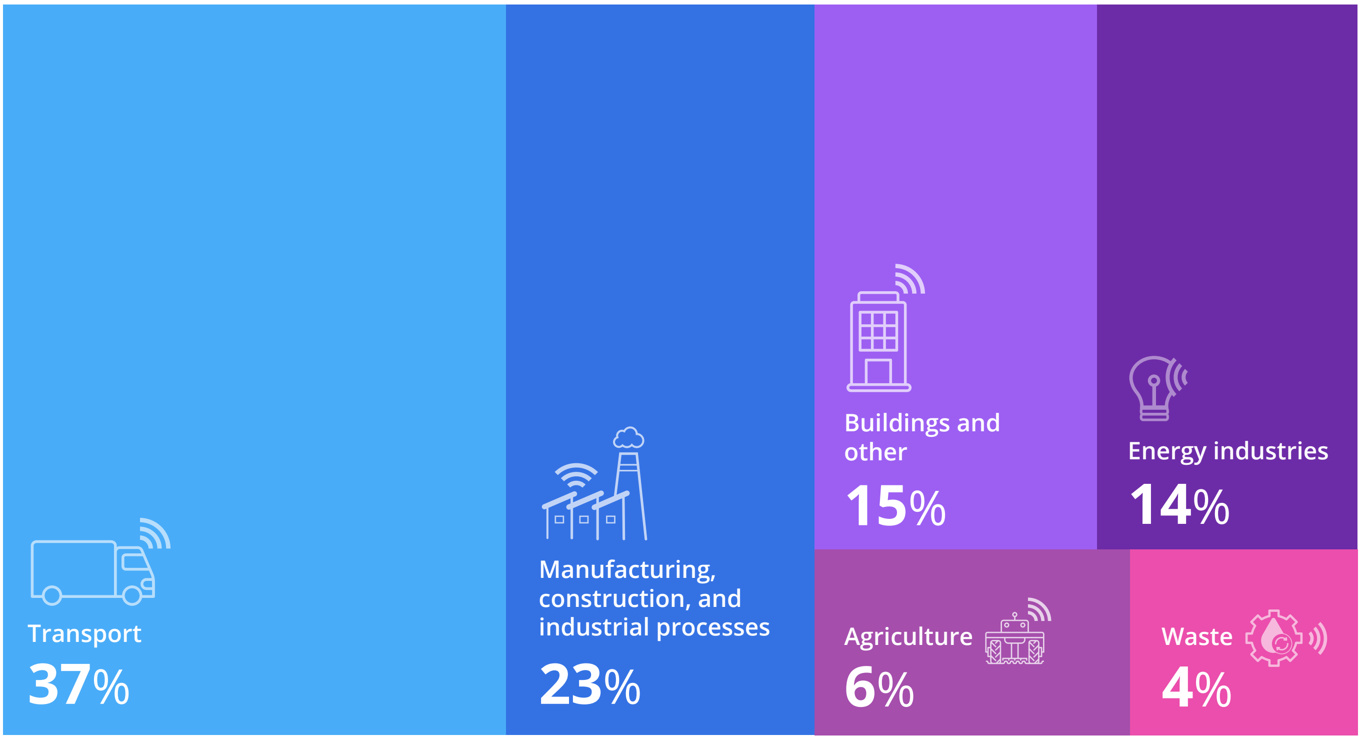
The predominance of information and communication, and the fact that this sector accounts for most new 5G-related jobs (having been the second-most significant sector in France) is partly explained by the fact that this sector employs around 8% of the workforce in Spain (compared to under 5% in France), and 5G will have the greatest proportional impact on this sector, given the number of use-case areas which come into play and its impact across the supply chain. Omdia believes that all of the eMBB use cases will create a degree of positive employment impact in this sector. Public service and defense again accounts for a significant proportion of the added jobs in Spain because it is a significant employer, accounting for nearly 13% of the workforce (although hospitality and food and real estate employ more people). In reference to the smart buildings use case above, Omdia believes this and broader smart city applications will trigger a degree of employment uplift in this sector. In the public sector realm, smart cities will involve an evolution of public services in the built environment to improve quality of service and quality of life for urban citizens, meaning modernization of services such as public transport and waste collection, with a need for workers to maintain and repair the necessary infrastructure, for example.

Again, it is notable that a number of sectors not traditionally associated with wireless technology advancement, such as transportation and storage, real estate activities, manufacturing, and human health and social work, feature in the top 10 sectors by employment additions shown in Figure 17, a further reflection of the breadth of impact of 5G through new sectors of the workforce and job roles, with 5G affecting more blue-collar jobs than previous technologies did, for example.

Emissions impact

Omdia forecasts that 5G will help companies, households, and others across Spain avoid 7.7MtCO2e in GHG emissions in 2030, representing 2.5% of the total GHG emissions that Spain projects it will have that year. As in France, transport will be the leading sector for GHG emissions avoided thanks to 5G, accounting for 37% of total 5G-enabled avoided emissions that year, ahead of manufacturing, construction, and industrial processes at 23% and buildings and other sectors at 15%.

Figure 18: Spain, 5G-enabled avoided emissions, sector share of total, 2030



Source: Omdia

Because the top two segments were discussed in the **France** section above and will see similar trends in Spain through 2030, this section will move on to focus on 5G-enabled avoided emissions in the buildings and other sector.

Commercial and residential buildings in Spain will help to avoid 1.1MtCO2e of GHG emissions thanks to 5G services in 2030, representing 15% of the total avoided emissions due to 5G services that year and 0.4% of Spain's total projected GHG emissions in 2030.

Since electricity, natural gas, and other forms of energy are a major cost for commercial buildings, and because of increasing awareness of the need to reduce GHG emissions because of their contribution to climate change, improving energy efficiency is one of the priorities of many smart building deployments today, and this trend will continue over the forecast period. This will be enabled by a host of solutions ranging from smart thermostats in individual rooms all the way through centralized building management systems connected to sensors and key devices throughout the building to optimize heating, air conditioning, and lighting based on occupancy, time of day, and other factors.

In its *Enablement Effect* report, the GSMA found that in 2018, mobile services enabled 214MtCO2e of avoided emissions in the smart buildings segment worldwide. That represents 0.4% of total global GHG emissions of 55,000MtCO2e in that year, which is the same proportion Omdia is forecasting for the avoided emissions 5G will enable in the broader "other sectors" category in Spain in 2030, compared to total projected GHG emissions in that year. In Omdia's view, reasons for the different findings likely include Omdia's very conservative approach to the emissions abatement potential of 5G services and the fact that even in 2030 in Spain, 5G will not have the same level of penetration and maturity as mobile services overall had worldwide in 2018.

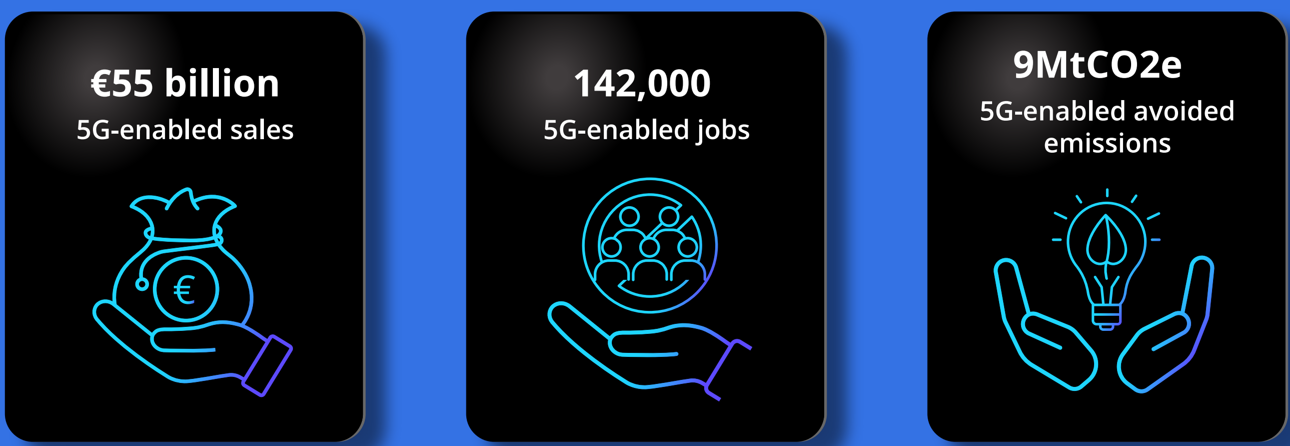
Smart buildings are an important part of smart cities, but there are many others, including smart traffic management systems. These will increasingly incorporate 5G as a key component over the next 10 years and will help to significantly reduce traffic congestion in major cities, which in turn will help drive a major reduction in GHG emissions from road transportation in Spain in 2030.

4. Poland

Overview

Poland has the third-highest level of positive impact from 5G of the five countries studied. **Figure 19** below shows the precise degree of economic, employment, and emissions impact in 2030 estimated by Omdia.

Figure 19: 5G impact in Poland, 2030



Source: Omdia © 2021 Omdia

Before exploring the impact forecasts themselves, it is important to examine the 5G environment in Poland.

The 5G environment

Poland's operators launch initial 5G services

In 2018, the Polish government issued a 5G Strategy for Poland, laying out the rationale and importance of 5G to the Polish economy and a roadmap for the implementation of 5G.[26]

More recently, in April 2020, Poland's telecoms regulator UKE paused its planned 5G auction because of the COVID-19 crisis. The auction, for spectrum in the 3.4–3.6GHz band, would have resulted in the issue of four nationwide licenses and 80MHz of spectrum, valid for 15 years. The auction has now been postponed to 2021, but three of Poland's operators have launched commercial 5G services based on their existing spectrum holdings:

- Orange, Polkomtel (Plus), and T-Mobile launched commercial 5G services in 2020. Orange and T-Mobile used 2.1GHz spectrum and Polkomtel 2.6GHz.
- At launch, Orange Poland's 5G network covered around 6 million people across major cities.
- Poland's smallest mobile operator, Play, has yet to commercially launch 5G services.

Recent 5G use-case developments

There have been several recent announcements regarding 5G activities in Poland. In late 2019, for example, T-Mobile established an indoor 5G network and edge computing infrastructure in the hub:raum innovation center in Krakow,[27] and in the same year Orange Poland conducted 5G tests in Zakopane using the 26GHz band and in Warsaw and Lublin on the 3.5GHz band as part of the Orange Cities project.[28]

More recently, in April 2020 Nokia announced that PGE Systemy, a unit of Poland's largest energy company PGE Capital Group, had chosen it to deploy a private network based on a proof-of-concept LTE network based on the 450MHz band for smart grid applications.[29] The network, which can be upgraded to 5G, will on completion be able to connect 15,000–20,000 private radio users and provide connectivity for up to 14 million smart meters and 35,000 existing and future SCADA (supervisory control and data acquisition) connections.

Given Poland's ambitious plans with regard to emissions reduction and decarbonization, Omdia has elaborated further on smart energy as a use-case area with significant relevance and potential impact in Poland.

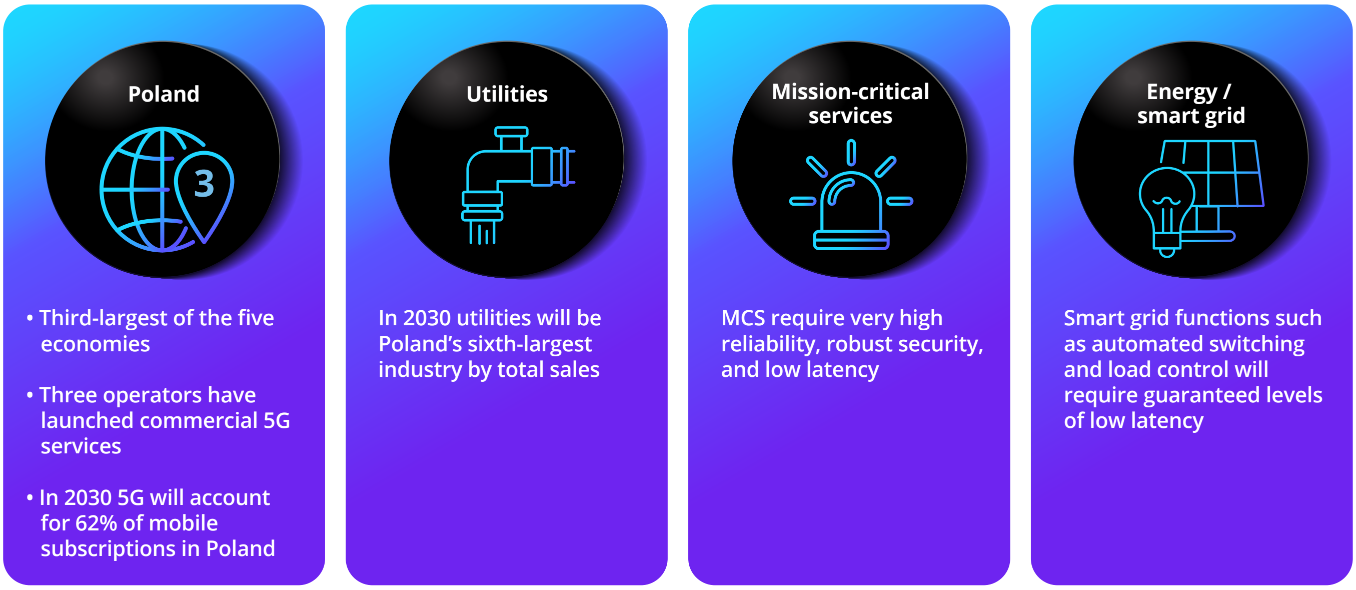
[26] www.gov.pl/web/cyfryzacja/strategia-5g-dla-polski
[27] www.telecompaper.com/news/t-mobile-poland-launches-indoor-pilot-5g-area-in-krakow--1313241
[28] https://raportzintegrowany.orange.pl/raport2019/
[29] www.nokia.com/about-us/news/releases/2020/04/07/nokia-deploys-worlds-first-450-mhz-private-wireless-lte-network-poc-for-power-grid-operators-in-poland/

Poland 5G use-case example: Smart energy

Poland is aggressively pursuing the decarbonization of its economy

In 2019, more than two-thirds of Poland's electricity generation was from coal. The country has ambitious plans to both reduce emissions and stimulate new jobs and investment through the decarbonization of the economy. The development of offshore wind capacity is central to these plans. By 2030, the country plans to have installed 3.8GW of offshore wind capacity, rising to 10GW by 2040 and 28GW by 2050.[30]

Figure 20: Poland 5G impact case study: Smart energy



Source: Omdia

Cellular technologies look likely to play a leading role in Poland's energy sector

The journey from energy generation to distribution and ultimate consumption is a complex one. The integration of nontraditional and less predictable sources, such as wind and photovoltaic energy, onto the grid adds to the complexity. Over the course of the journey, demand must be tracked and predicted, supply monitored, and the condition and performance of the distribution network maintained. Integrated sensors to monitor distributed infrastructure and actuators to exercise control and prevent failure are critical components.

According to Omdia research, communicating meters accounted for a fifth of the installed base of electricity meters in Poland in 2020.[31] By 2026 this proportion is going to rise rapidly to nearly two-thirds. There are many ways of connecting meters, including cellular, unlicensed LPWAN technologies, and various forms of wired connectivity. In Poland, cellular looks likely to play a leading role in metering and other types of energy infrastructure. Since 2019 the country has been testing a proof-of-concept LTE network based on the 450MHz band for smart grid applications, a technology subsequently embraced by PGE Systemy in its 2020 deployment with Nokia.

5G will drive several types of economic activity

Various aspects of 5G will be relevant in the energy sector. The deep-range characteristics of 5G will be important for metering and the monitoring of generation at remote sites (wind-power plants). Various aspects of electric-power distribution (primary frequency control, distributed voltage control, distributed automated switching, and smart grid load control) will demand a fast response time (low latency) to operate effectively.

[30] https://windeurope.org/newsroom/news/poland-adopts-historic-offshore-wind-act/#:~:text=The%20Polish%20Parliament%20unanimously%20adopted,by%20the%20President%20of%20Poland.

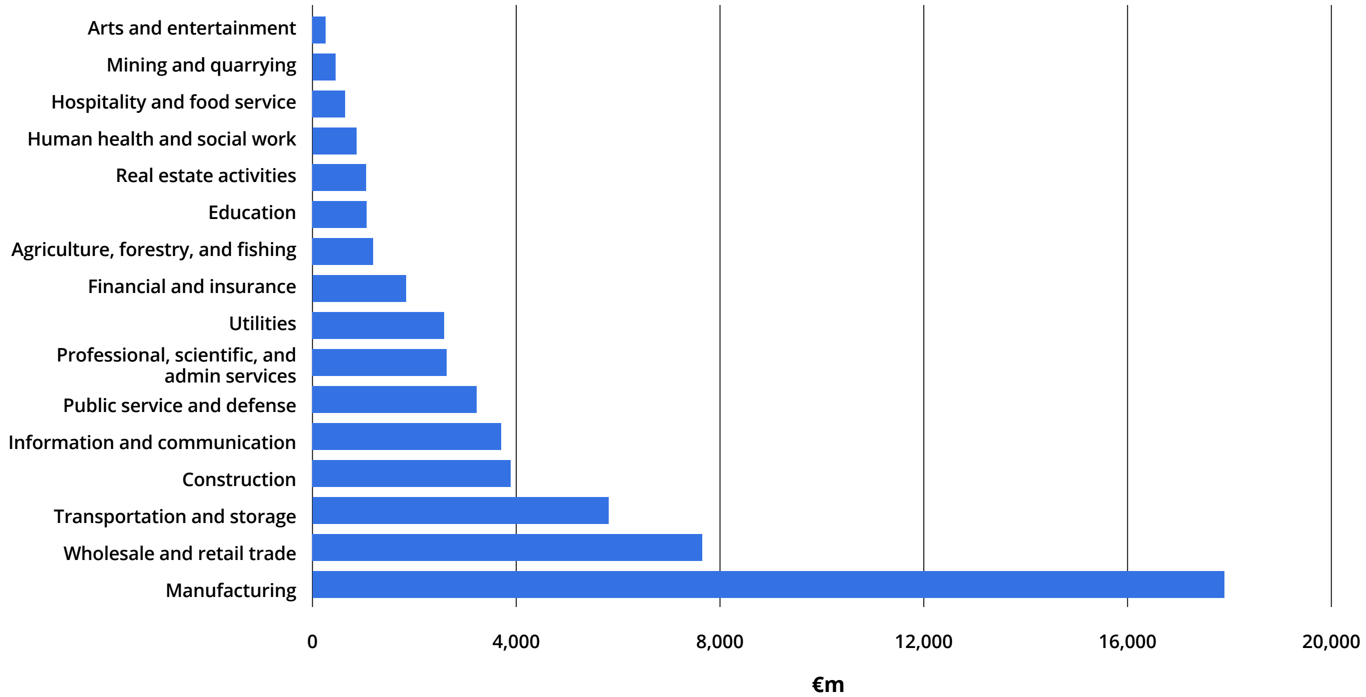
[31] www.telecompaper.com/news/t-mobile-poland-launches-indoor-pilot-5g-area-in-krakow--1313241

Economic impact

5G-enabled sales will reach €55bn by 2030

As in France and Spain, the sheer scale of the manufacturing industry in Poland, coupled with the impact of several relevant 5G use cases, means that it will account for nearly a third of Poland's €55bn in 5G-enabled sales by 2030. By 2030, the largest five beneficiaries of 5G-enabled sales will together account for 71% of 5G-enabled sales.

Figure 21: Poland, breakdown of 5G-enabled sales by industry in 2030



Source: Omdia

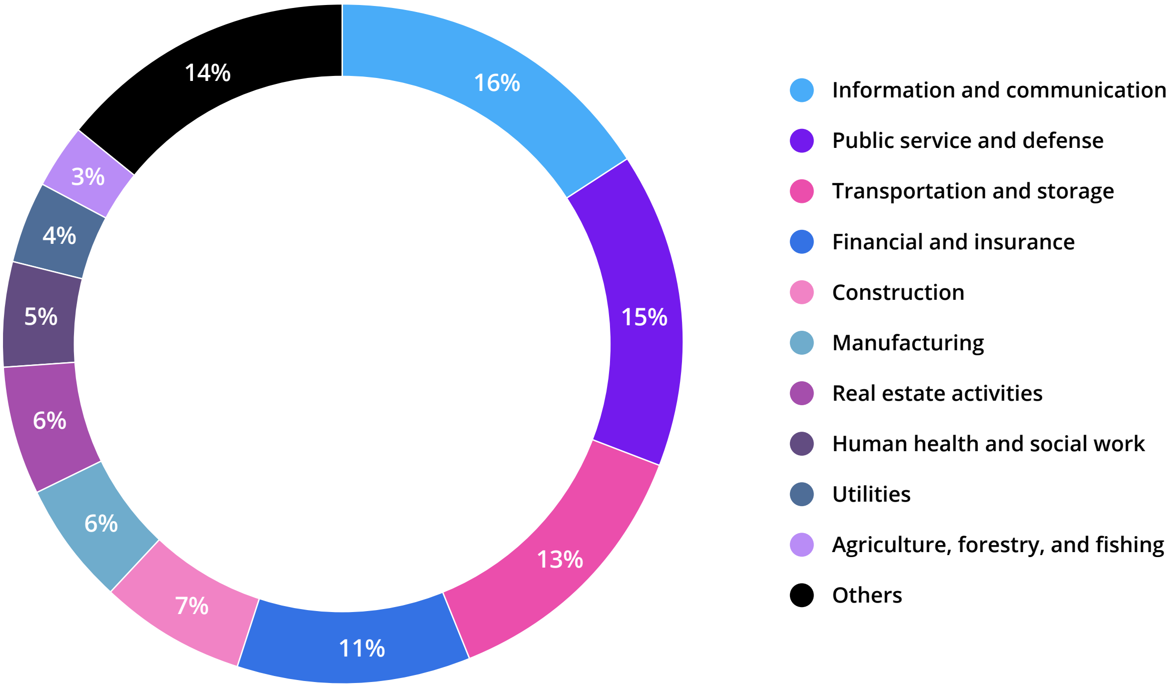
Other industries where 5G will have an outsized impact (compared to the industry's share of gross sales / total output) include wholesale and retail trade and transportation and storage. Both benefit from Poland's position as a major European market and its central location between Western European markets and Eastern European economies.

However, 5G will bring slightly different potential benefits for these industries. In the case of wholesale and retail trade, the 5G facets of enhanced indoor wireless broadband coverage (eMBB) and asset tracking (MIoT) will be relevant. In the case of transportation and storage, enhanced outdoor wireless broadband coverage (eMBB) is more important. Though regulatory and other factors may inhibit their adoption in the short term, the mission-critical aspects of 5G will drive the development of new forms of transportation, such as (semi) autonomous vehicles and drones.

Employment impact

Omdia estimates that there will be 16.1 million people in employment in Poland in 2030, with 142,000 of those jobs created as a result of 5G, 0.9% of the national workforce and 0.4% of the population, a notably lower proportion than in France and Spain. These jobs will be spread across a broad range of industry sectors, with the largest volume of 5G-generated jobs created in information and communication and public service and defense, but it is notable that together these two sectors account for only 31% of the additional jobs from 5G, compared to 53% in France and 59% in Spain (see **Figure 22** below).

Figure 22: 5G impact in Poland, proportion of 142,000 net new employees by sector, 2030



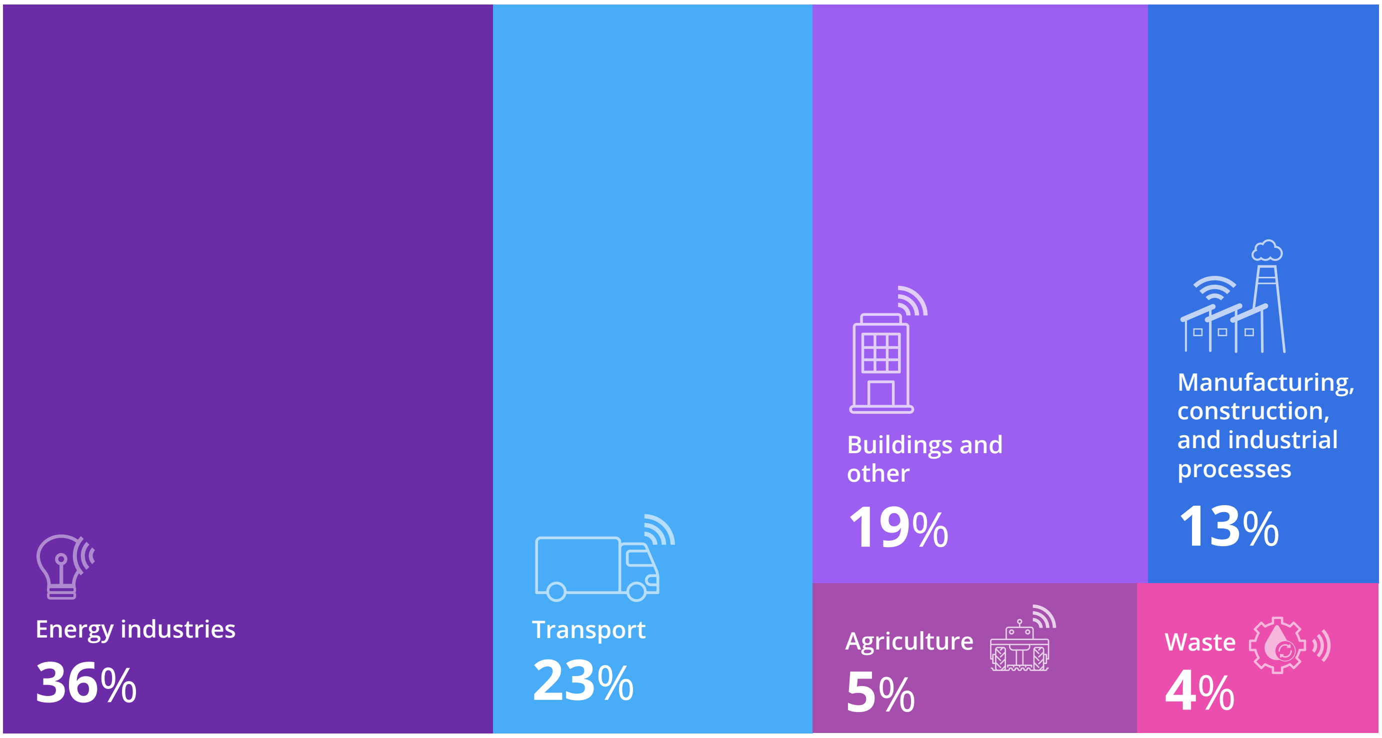
Source: Omdia

Indeed, Figure 22 shows that there is a more even spread of impact across a range of sectors, with the contribution of transportation and storage greater. In the transport infrastructure area, the capabilities of MIoT together with networks of sensors can be used to monitor physical structures such as bridges, roadways, and train tracks, with real-time monitoring enabling prioritization of repairs and improvements, important in any country with aging infrastructure. Two additional sectors also feature in Figure 22: construction and agriculture, forestry, and fishing. Construction accounts for around 20% of employment in Poland (double the proportion in France and Spain), but it should be noted that the 9,600 net new jobs created in construction represent only 0.3% of those employed in the sector, one of the lowest penetration rates of new jobs by sector. A similar pattern concerns agriculture, which accounts for 8% of employment (more than double the proportion in Spain and treble that in France) but in which the new jobs created account for 0.4% of the sectors workforce. It is notable also that the proportion of jobs made up of "others" is more than double the level in France and Spain, again reflecting a more even distribution across a range of sectors in a country where the employment market itself is more evenly distributed on the whole. The smart energy use case described above is pertinent in a market where 5G has an important role to play in the utilities sector, although this will only translate into a moderate impact in terms of job increases.

Emissions impact

Omdia forecasts that in 2030, 5G will help to reduce GHG emissions in Poland by 9.3MtCO2e, representing 2.3% of the 405MtCO2e in total GHG emissions that Poland projects it will have in that year. Energy industries will account for 36% of 5G-enabled avoided emissions in 2030, followed by transport with 23%; buildings and other segments 19%; manufacturing, construction, and industrial processes 13%; agriculture 5%; and waste 4%.

Figure 23: Poland, 5G-enabled avoided emissions, sector share of total, 2030



Source: Omdia

Energy industries lead in 5G-enabled avoided emissions in 2030 partly because they are the largest sector for GHG emissions overall, representing 40% of Poland's total projected GHG emissions in 2030. This is largely a result of Poland's traditional reliance on coal-fired power plants for producing electricity, but as noted above, Poland has ambitious plans to transform its electricity production, from more than 75% based on coal in 2018 to more than 75% based on wind by 2050. That will require a massive investment in new smart wind farms and smart grids to transport power efficiently from creation to consumption. Increasingly throughout the decade, 5G will be used to improve the connectivity, resilience, and intelligence of power infrastructure from production and distribution through final consumption.

For example, wind farms, particularly when offshore but even when onshore, are often not in areas with cellular coverage. This means that engineers inspecting or repairing wind turbines may have to use satellite communications systems, which can have limited bandwidth and high costs compared to cellular systems. To address this, wind-farm operators could install a private 5G network to provide better connectivity to engineers and other staff onsite, potentially reducing the downtime of wind turbines, which in turn could lead to significant reductions in GHG emissions in Poland, since the main alternative source of power in 2030 will still be aging coal-fired power plants.

In fact, in late 2020 Ericsson and Chunghwa Telecom partnered to build 5G-ready, private LTE networks at the Orsted wind farms off the coast of Chunghwa, Taiwan to provide robust voice and data communications for engineers and others onsite.[32]

[32] www.ericsson.com/en/news/2020/11/cht-connected-wind-farms

5. Belgium

Overview

Belgium has the fourth-highest level of positive impact from 5G of the five countries studied. **Figure 24** below shows the precise degree of economic, employment, and emissions impact estimated by Omdia in 2030.

Figure 24: 5G Impact in Belgium, 2030

Source: Omdia

Before exploring the impact forecasts themselves, it is important to examine the 5G environment in Belgium.

The 5G environment

A slower start for 5G in Belgium

In its Digital Belgium[33] policy framework, the Belgian government stated that a proactive 5G framework "will ensure 'Digital Belgium' is in the lead when the Internet-of-everything is rolled out." However, a planned auction of 700MHz and 3.4–3.8GHz spectrum in 2020 has been postponed to late 2021 because of delays in forming a new coalition government following federal elections in May 2019. This has limited commercial 5G activity:

- As of early February 2021, only one of Belgium's operators, Proximus, had launched commercial 5G services.
- On April 1, 2020 Proximus launched services using existing 2.1GHz spectrum in 30 communities around the country. By December 2020, it had lit commercial 5G services in parts of Antwerp, Ghent, and Haasrode using 3.6–3.8GHz spectrum granted to Proximus and four other operators on a provisional basis in July 2020 by Belgium's telecoms regulator BIPT.

Recent 5G use-case developments

Orange Belgium announced in December 2019 that it had established the Orange Industry 4.0 Campus in the Port of Antwerp.[34] This was the country's first 5G testing hub for business. The test network was based on 5G standalone architecture and supported network slicing, very low latency, and MIoT. Initially, Orange Industry 4.0 Campus was based on seven sites in the Port of Antwerp, rising to 14 in April 2020.

In October 2020, Orange Belgium shared results of innovation with several partners at the Orange Industry 4.0 Campus.[35] All of these leveraged the operator's 5G standalone test network. The partnership with Antwerp Port Authority involved the connection of a tugboat to the 5G network, allowing the vessel to stream real-time images and other data to the port's control room.

Covestro, a hi-tech polymer manufacturer, used the 5G network to enhance the field inspection of chemical plants. Field workers were equipped with a tablet or smart glasses. These connected to the 5G network to give the workers access to large volumes of technical data and videos, including 3D models of the installation. In a collaboration with Borealis, plant equipment used in the production of polyolefins, base chemicals, fertilizers, and melamine was connected by 5G with cloud-hosted AI-powered quality control systems.

BASF worked with Orange Belgium to equip its employees and visitors with multifunctional, ruggedized 5G smartphones. These included both mission-critical communications (Push-to-X) and access to other smartphone applications. Other characteristics of 5G considered by BASF included location-based safety (geofencing in hazardous environments), high-quality real-time image transmission, and network slicing to prioritize channels used for emergency communications.

In February 2020 Proximus signed a memorandum of understanding (MOU) with the Port of Antwerp.[36] Under the MOU, Proximus agreed to deploy a private NSA 5G network and evaluate various use cases during an initial six-month pilot.

It is notable that these two recent use-case examples both relate to the Port of Antwerp. Belgium is one of the main gateways into the EU single market and beyond to major trading partners. The country's proximity to the EU's two largest markets (France and Germany) and commercial ports such as Antwerp make it a strategically important trading route for goods in transit. As a result, Omdia believes that a key function pertinent to trade through such ports is asset tracking, on the subject of which a use case has been outlined below.

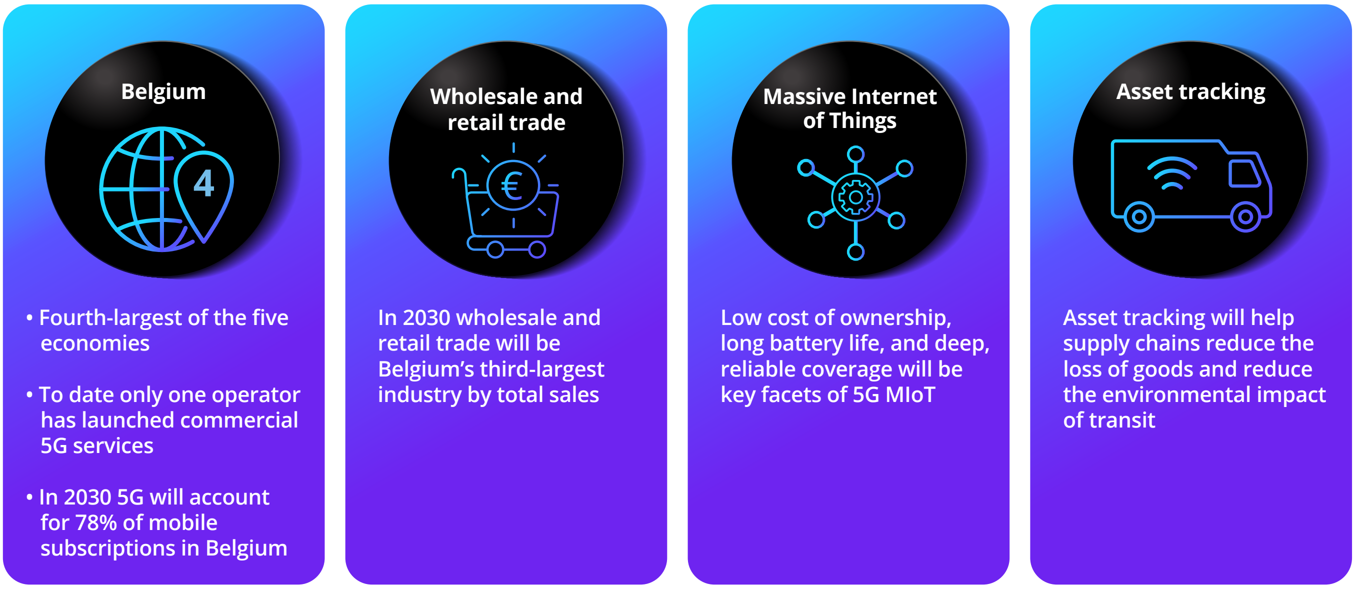
[33] http://digitalbelgium.be/wp-content/uploads/2017/07/compressed_Brochure_DB_FINAL.pdf
[34] https://corporate.orange.be/en/news-medias/orange-belgium-first-launch-5g-testing-hub-business-belgium-orange-industry-40-campus
[35] https://corporate.orange.be/en/news-medias/first-5g-innovations-proposed-orange-belgium-and-its-industrial-partners-port-antwerp
[36] www.proximus.com/news/2020/20200205-Proximus-and-Port-of-Antwerp-are-preparing-for-the-port-s-digital-transformation-by-developing-a-private-5G-network-.html

Belgium 5G use-case example: Asset tracking

Tracking location and condition underpins vital supply chains

The importance of tracking the location of goods in transit (or the vehicles carrying them) is well understood in the logistics and supply chain industry. The loss of goods in transit as a result of misplacement is a long-standing challenge, and businesses have sought to mitigate such risks by adopting asset-tracking solutions. According to Omdia research,[37] asset tracking is the largest cellular IoT application globally.

Figure 25: Belgium 5G impact case study: Asset tracking



Source: Omdia

Increasingly, asset-tracking solutions address the requirement to monitor the condition of goods in transit or their environment. For instance, perishable goods (e.g., food) and pharmaceutical products need to be transported at specific temperatures, the so-called cold chain. Such qualitative parameters are increasingly integrated into the commercial contracts of suppliers and transportation companies.

5G will build on cellular's strong position in asset tracking

Given the need for wide area network connectivity to track asset location and condition over long distances, cellular adoption has been strong in this space. Historically, 2G and LTE have paid an important role. Orange Belgium has deployed nationwide LTE-based NB-IoT and LTE-M networks, which can be used for a variety of use cases including asset tracking. These technologies were introduced in 3GPP Release 13. Several specifications in 3GPP Release 14, 3GPP Release 15 (which introduced the first 5G specifications), and subsequent releases will introduce enhancements in areas such as power consumption, coverage, and positioning (e.g., the ability with 5G to locate goods and assets within a 10 meter range without the requirement for GPS or ultra-wideband on the device). These enhancements will take some time to be available on commercial networks and devices but will expand the relevance and addressable market of 5G-based asset tracking in the long term.

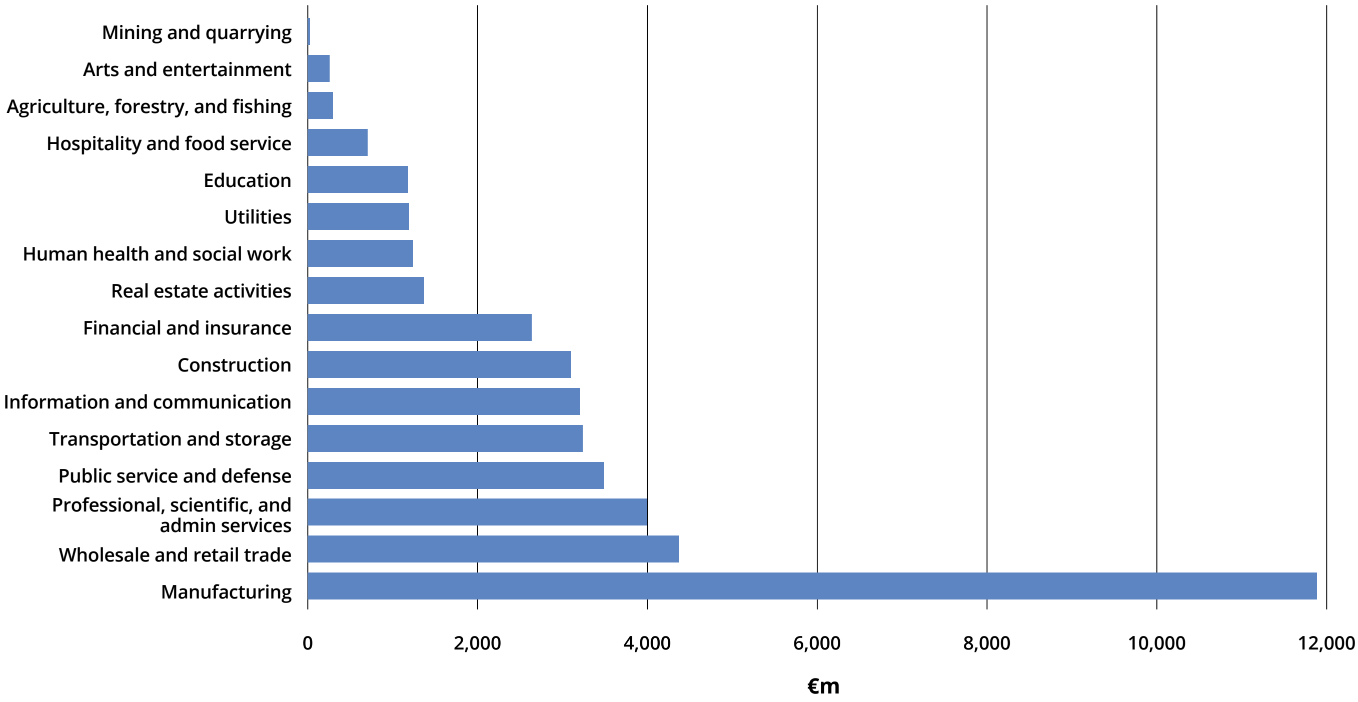
[37] Omdia, *Cellular IoT Market Tracker – 3Q20 Data* (December 2020)

Economic impact

5G-enabled sales will reach €42bn by 2030

The sheer scale of the manufacturing industry in Belgium, coupled with the impact of several relevant 5G use cases, means that it will account for around 28% of Belgium's €42bn in 5G-enabled sales by 2030. By 2030, the largest five beneficiaries of 5G-enabled sales (manufacturing, wholesale and retail trade, professional, scientific, and administrative services, public service and defense, and transportation and storage) will together account for 64% of 5G-enabled sales.

Figure 26: Belgium, breakdown of 5G-enabled sales by industry in 2030



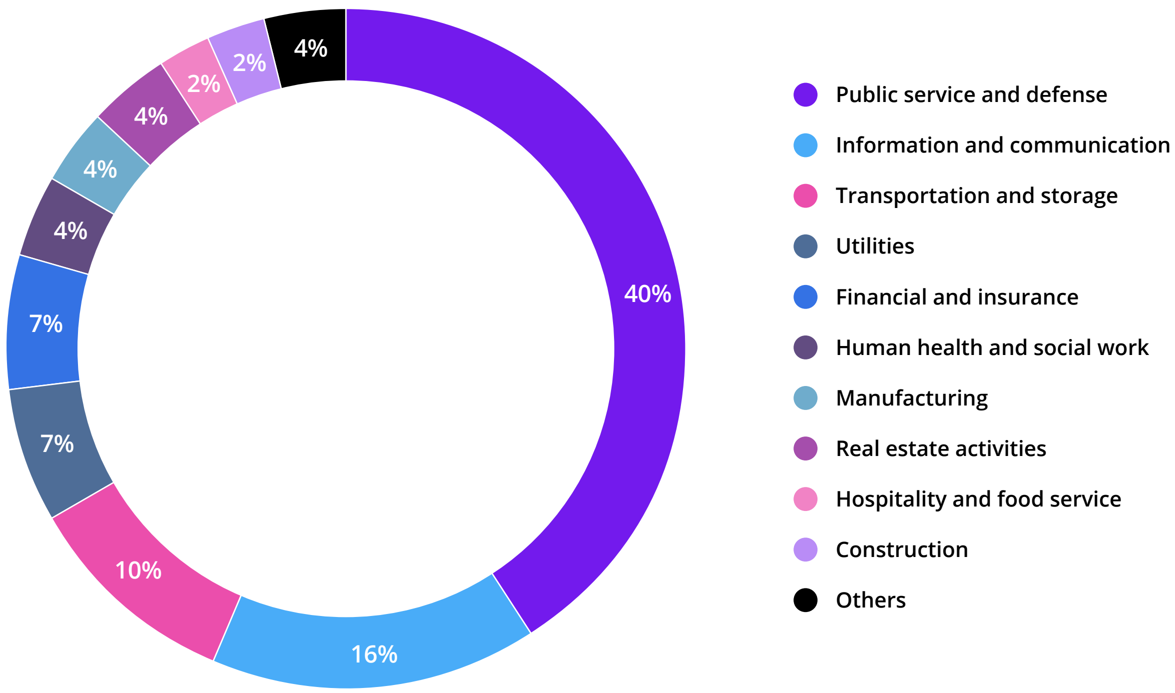
Source: Omdia

Other industries where 5G will have an outsized impact (compared to the industry's share of gross sales / total output) are wholesale and retail trade (accounting for 10% of 5G-enabled sales compared to 9% of gross output / total sales) and public service and defense (accounting for 8% of 5G-enabled sales compared to 6% of gross output). The tracking of assets in transit will be of increasing importance to wholesale and retail trade: as a key trading hub, Belgium is well placed to benefit from this use case.

Employment impact

Omdia estimates that there will be 5.2 million people in employment in Belgium in 2030, with 78,000 of those jobs created as a result of 5G, 1.5% of the national workforce and 0.6% of the population. These jobs will be spread across a broad range of industry sectors, with the largest volume of 5G-generated jobs created in public service and defense (see **Figure 27** below).

Figure 27: 5G impact in Belgium, proportion of 78,000 net new employees by sector, 2030



Source: Omdia

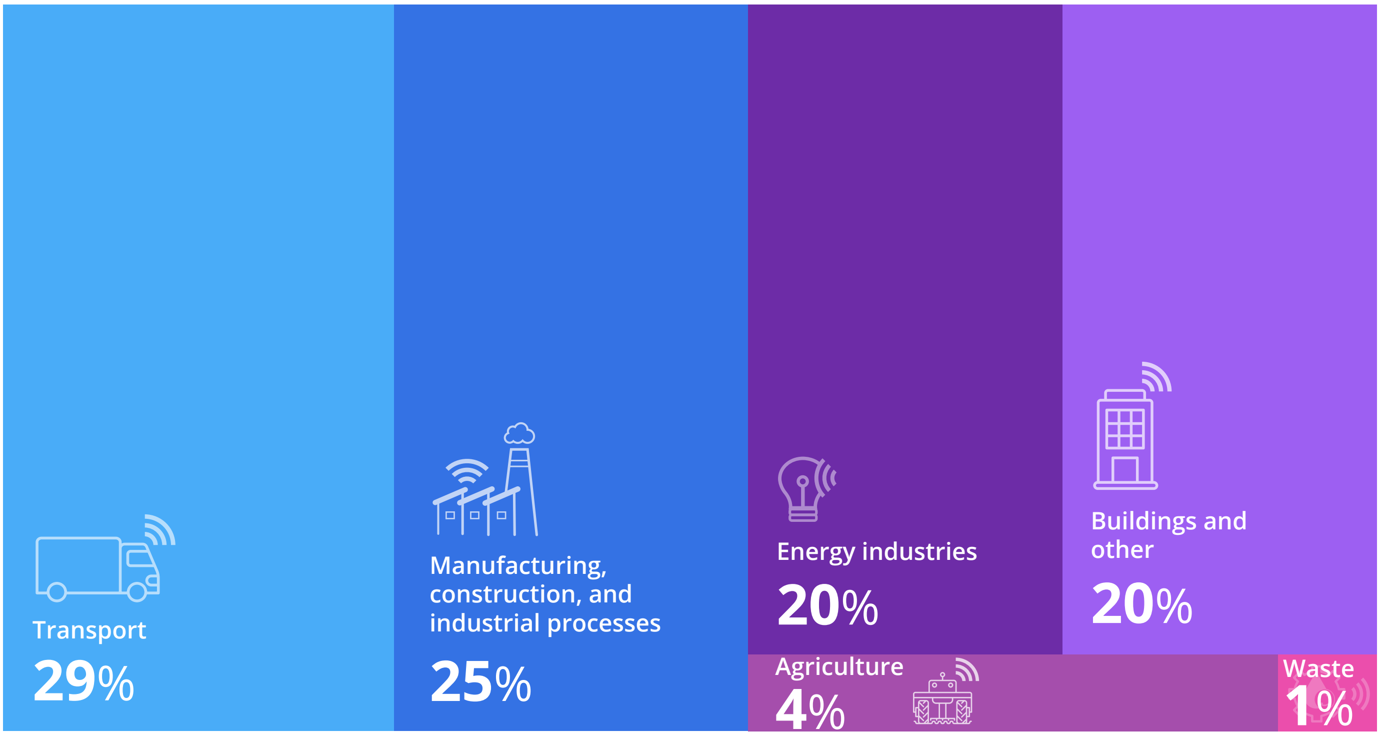
The predominance of public service and defense is in part driven by the fact that this sector accounts for 21% of the workforce in Belgium, the highest proportion of all the markets and three times the level in Poland, for example. Beyond this there is a similar spread as in other markets, with construction featuring again as in Poland and with a number of sectors not traditionally associated with wireless technology advancement featuring in the top 10 sectors by employment additions.

Given the focus on the asset-tracking use case discussed above, it is interesting to note that transportation and storage accounts for 10% of additional 5G jobs, second only to Poland among the countries studied. Enhanced indoor and outdoor wireless, enterprise teamwork and collaboration, enhanced digital signage, and drones will also all have a small beneficial impact on employment in this sector.

Emissions impact

Omdia forecasts that in 2030, 5G will help to reduce GHG emissions in Belgium by 3MtCO2e, representing 2.4% of the 128MtCO2e in total GHG emissions that Belgium projects it will have in that year. Transport will account for 29% of 5G-enabled avoided emissions in 2030. The relative impact of other sectors is shown in **Figure 28**.

Figure 28: Belgium, 5G-enabled avoided emissions, sector share of total, 2030



Source: Omdia

To understand why transport is the leading sector for 5G-enabled avoided emissions in Belgium, along with most of the other countries covered in this research, first it is important to note that it is one of the leading sectors for GHG emissions overall, representing 22% of total GHG emissions projected in the country in 2030.

Second, Omdia forecasts that in Belgium in 2030, 78% of mobile subscriptions will be via 5G devices, mainly 5G smartphones. That means that the vast majority of avoided emissions enabled by 4G smartphones today in Belgium will migrate to, and be enabled by, 5G smartphones in 2030. Examples of smartphone applications and services that help to avoid transport emissions by enabling users to do things virtually rather than via physical travel include mobile calling, conference calling, video calling, videoconferencing, mobile shopping, mobile banking, remote working, and virtual conferences. This means that even without considering new 5G use cases or incremental gains that 5G services will bring over 4G, the vast majority of the avoided emissions enabled by today's 4G mobile services will be enabled by 5G mobile services in 2030. As a comparison, the GSMA found that this type of mobile application, which it names smart working, living, and health, accounted for 39% of the total avoided emissions enabled by mobile services worldwide in 2018.

[38] GSMA (2019) *The Enablement Effect*, https://www.gsma.com/betterfuture/wp-content/uploads/2019/12/GSMA_Enablement_Effect.pdf, p. 10

6. Romania

Overview

Romania has the fifth-highest level of positive impact from 5G of the five countries studied. **Figure 29** below shows the precise degree of economic, employment, and emissions impact estimated by Omdia in 2030.

Figure 29: 5G impact in Romania, 2030

Source: Omdia

The 5G environment

ANCOM highlights 5G’s potential role in digitalizing industry and public safety

In June 2019, Romania’s telecoms regulator ANCOM released its 5G strategy for the country.[39] This cited the modest level of technological intensity of the production processes in the Romanian processing industry (8% in industries with advanced technologies) and the need for further digitalization, aided by 5G. It also set several priorities, namely the availability of optimal spectrum, 5G-friendly infrastructure (allowing for site sharing), the harnessing of 5G for public safety and security (e.g., in response to natural disasters), and partnerships for testing and validating 5G use cases.

Multiband spectrum auctions will open up 5G to competition

ANCOM had planned to hold a multiband (700MHz, 800MHz, 1.5GHz, 2.6GHz, and 3.4–3.8GHz) auction in 2020, but indicated in February 2021 that it would decide on the process and timing before the end of 2021.

To date, Digi Romania, Orange, and Vodafone Romania have launched commercial 5G services:

- Digi Romania and Vodafone Romania (both June 2019) and Orange Romania (November 2019) have launched commercial 5G services.
- All three used existing 3.5GHz spectrum holdings, which expire in 2025, in the 3.5GHz bands.
- Telekom Romania has yet to launch commercial 5G services.

Recent 5G use-case developments

Orange Romania has been involved in the Alba Iulia smart city project for several years.[40] Since 2019, 5G use cases in the areas of mobility and energy have been assessed. A pilot to assess energy consumption in public buildings was also initiated in November 2020. From 2021, pilots to evaluate 5G-enabled infotainment services and security on public transport are planned.

Agriculture is another industry area in which Omdia believes there is potential for use-case development in Romania, creating a positive impact from 5G. In ANCOM’s 2019 5G Strategy,[41] agriculture is identified as one of seven key use-case areas in Romania. The others are Industry 4.0, connected and self-driving cars, transport and logistics, energy, public utility service, and health.

Agriculture, forestry, and fishing is a major contributor to Romania’s economy. According to Omdia, by 2030 it will account for $33bn in gross output, representing close to 4% of the country’s total in that year. Although manufacturing will be the dominant sector of the Romanian economy in 2030, representing 27% of gross output, the majority of industries in the country, including agriculture, will contribute 2–5% of gross output.

As ANCOM points out, with around 30% of the population employed in agriculture and low labor productivity in this sector, increasing agricultural productivity is a strategic priority. ANCOM believes that 5G can provide the infrastructure needed to develop precision agriculture, and it identifies six possible application areas:

- Connected agricultural equipment
- Smart irrigation
- Crop monitoring
- Soil sensors
- Directing and monitoring livestock
- Unmanned aircraft systems (drones)

Given the strategic importance of agriculture in Romania and existing views of the potential benefits from 5G to the sector, potential 5G use cases in agriculture are elaborated on below.

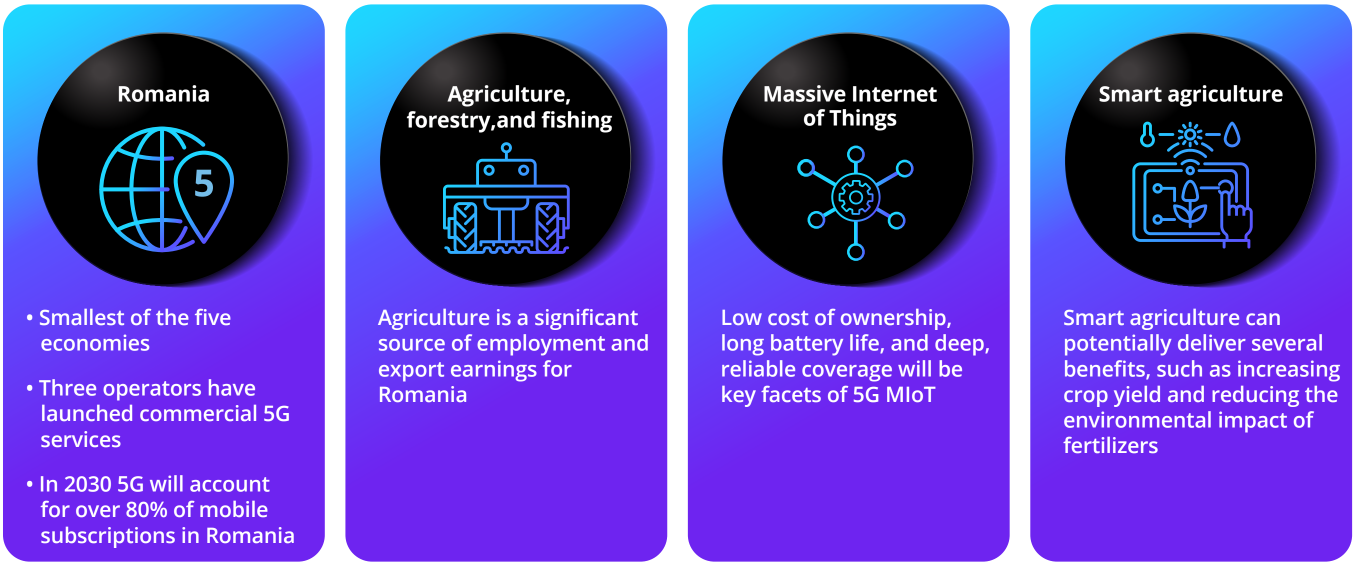
[39] ANCOM (2019) *The 5G for Romania Strategy*, www.ancom.ro/uploads/articles/file/ANCOM/The%205G%20Strategy%20for%20Romania__.pdf
[40] www.5g-victori-project.eu/2020/11/5g-victori-alba-iulia-romania/
[41] ANCOM (2019) *The 5G for Romania Strategy*, www.ancom.ro/uploads/articles/file/ANCOM/The%205G%20Strategy%20for%20Romania__.pdf

Romania 5G use-case example: Agriculture

Agriculture is a strategic sector for Romania

Romania is one of the largest agricultural exporters in the EU, and arable and livestock goods are an important source of export earnings. As in other countries, farmers face high recurring costs related to energy consumption, fertilizer, and animal food on the one hand and strong bargaining power from large-scale customers on the other. Therefore, there is much focus in the industry on how to manage resources more efficiently and achieve improvements in yield.

Figure 30: Romania 5G impact case study: Smart agriculture



Source: Omdia

IoT is relevant to both arable and livestock farming

There is a wide range of agricultural IoT use cases, including livestock tracking; management of tanks, tractors, and combines; tracking of animals; and monitoring of soil conditions such as moisture and chemical composition. Connected sensors can help farmers to decide on the optimal time to sow seeds and to harvest, and the right type and amount of fertilizer or pesticide to use. The data from IoT sensors aids adherence to changing environmental regulations and allows farmers to identify health issues affecting their animals.

5G will play a diverse role in a crowded connectivity space

Leading agricultural vehicle manufacturers such as John Deere and Caterpillar have a long legacy in integrating cellular connectivity for telematics use cases such as machine-health monitoring and control. Today, 4G LTE has a strong position in this space, and this will pave the way for future 5G adoption as networks are rolled out and use cases become more advanced.

A variety of short-range and wide area network technologies are being deployed to support the tracking of animals and monitoring of environmental conditions. Leading European operators Deutsche Telekom and Vodafone have collaborated with partners on agricultural solutions leveraging NB-IoT connectivity. Deutsche Telekom's T-Mobile Poland is working with agricultural specialist eAgronom on an NB-IoT-based environmental monitoring solution.[42] Vodafone has partnered with the Spanish winemaker Emilio Moro on a project, leveraging NB-IoT connectivity, to monitor environmental conditions at its vineyards.[43] The UK-headquartered group has also partnered with Cellnex and Sociedad Agraria de Transformacion Trops in Vélez-Málaga (Spain) on the trial of 5G and MEC for smart harvesting and crop automation.[44]

Reliability (i.e., high levels of network availability) and cost are at the forefront of farmers' minds when they are assessing different suppliers and technologies. Telecoms operators targeting the agricultural sector will need to ensure that their networks are configured to support deep coverage and lengthy battery life for devices. Extensive collaboration with industry specialists will also be required to ensure that 5G-based solutions hit the right cost points for different types of farmers.

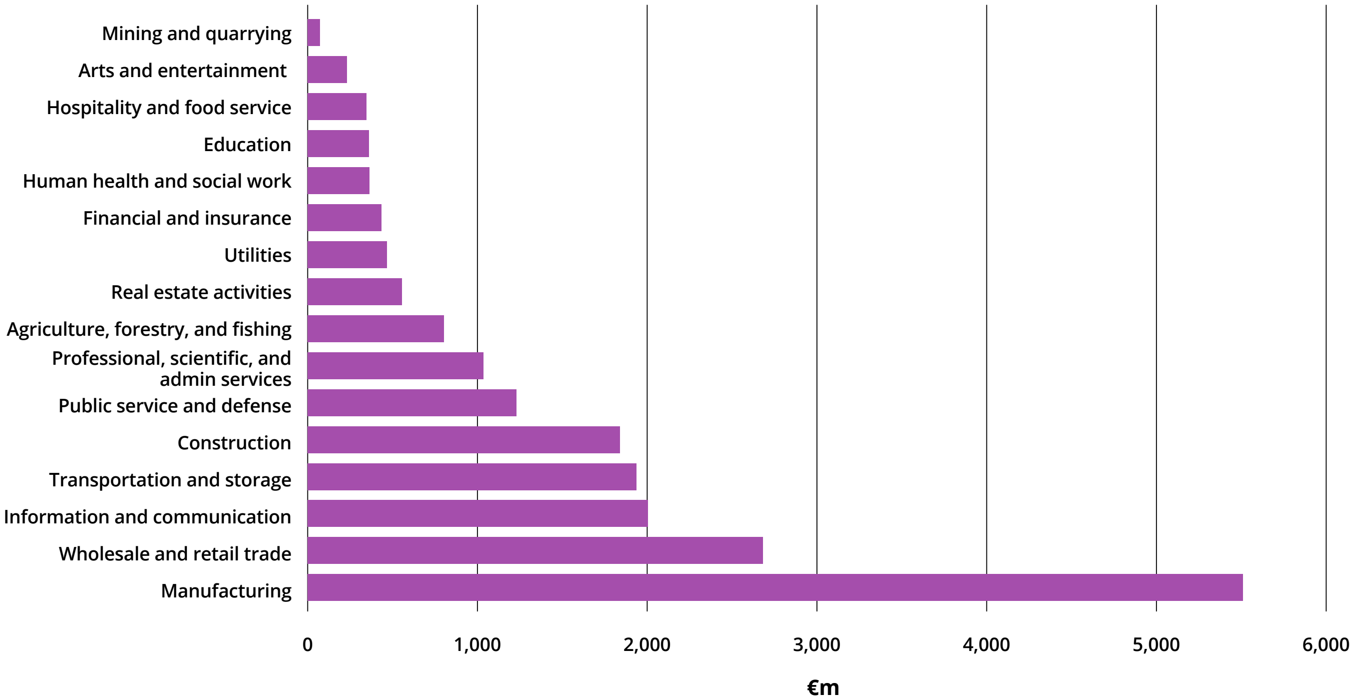
[42] https://firma.t-mobile.pl/dla-mediow/aktualnosci/informacja-prasowa/2021/01/inteligentne-uprawy-dzieki-wspolpracy-eagronom-i-t-mobile-polska.html
[43] www.emiliomoro.com/en/alliance-with-vodafone-to-create-the-winery-of-the-future/
[44] https://cellnextrends.com/la-digitalizacion-de-la-agricultura-clave-para-su-competitividad/

Economic impact

5G-enabled sales will reach €20bn by 2030

The sheer scale of the manufacturing industry in Romania, coupled with the impact of several relevant 5G use cases, means that it will account for around 28% of Romania's €20bn in 5G-enabled sales by 2030. By 2030, the largest five beneficiaries of 5G-enabled sales will together account for 70% of 5G-enabled sales.

Figure 31: Romania, breakdown of 5G-enabled sales by industry in 2030



Source: Omdia

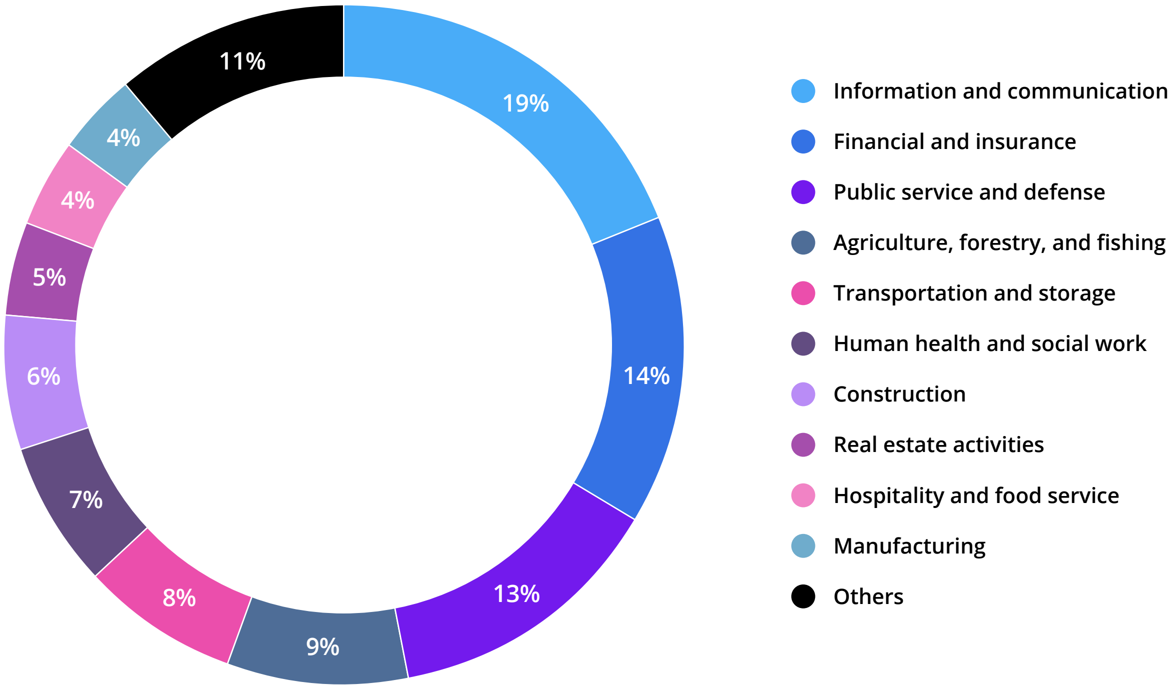
By 2030, construction will have a larger share of both 5G-enabled sales (9%) and gross output / total sales than in the other countries in this study. Here, 5G has a potential role to play in several ways, including in providing connectivity to high-value machines and the remote monitoring of assets. Developers are factoring in the evolving needs of occupiers in the design and building of new facilities.

Farming is a strategically important sector of the Romanian economy. Agriculture, forestry, and fishing accounts for 4% of 5G-enabled sales but is also a major source of export earnings for the country.

Employment impact

Omdia estimates that there will be 8.2 million people in employment in Romania in 2030, with 69,000 of those jobs created as a result of 5G, 0.8% of the national workforce and 0.4% of the population. These jobs will be spread across a broad range of industry sectors, with the largest volume of 5G-generated jobs created in information and communication and financial and insurance (see **Figure 32** below).

Figure 32: 5G impact in Romania, proportion of 69,000 net new employees by sector, 2030



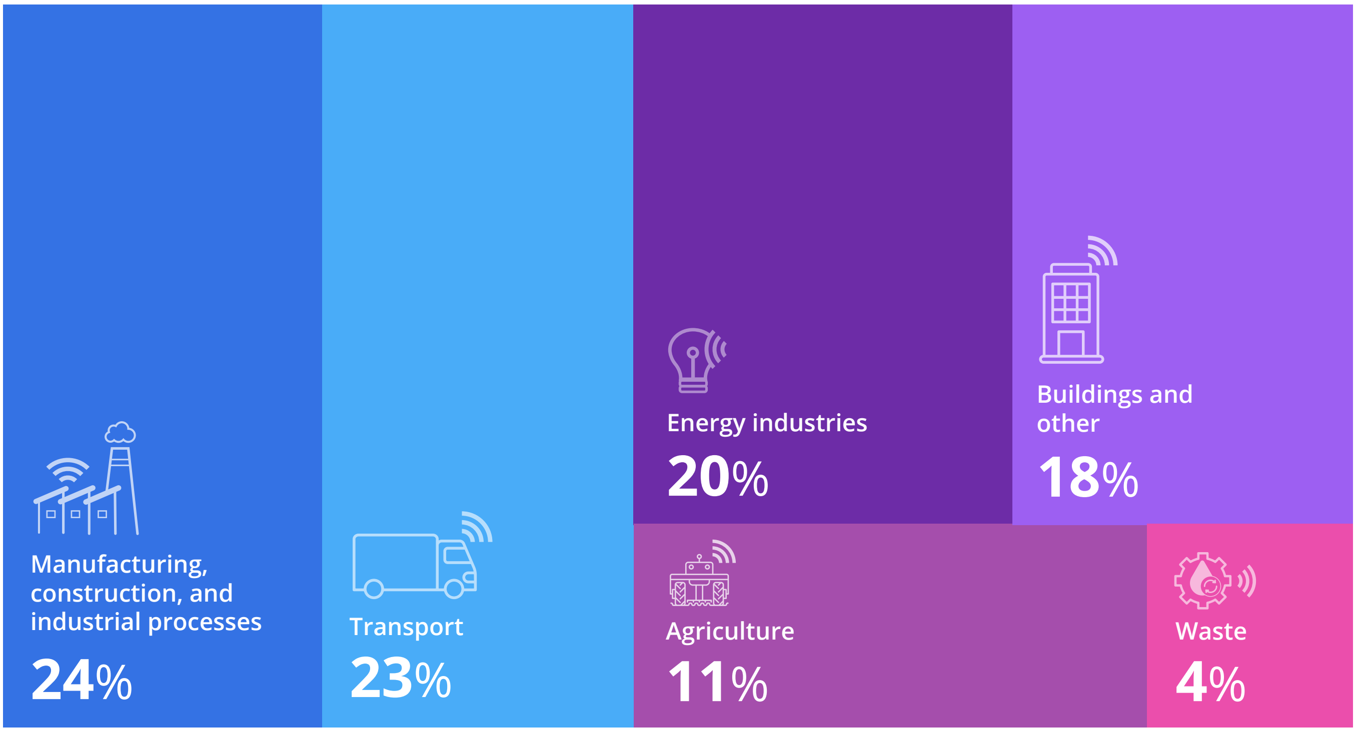
Source: Omdia

Indeed, Figure 32 shows that there is a relatively even spread of impact across a range of sectors. Public service and defense is only third in terms of magnitude of 5G employment, with financial and insurance featuring higher than it does elsewhere. Agriculture, forestry, and fishing notably accounts for nearly 9% of the jobs generated by 5G, partly as a result of this sector accounting for a far higher level of employment than in other countries. Not all of the impact of 5G in agriculture will be positive—smart agriculture will lead to a number of job losses—but Omdia believes that application areas such as enhanced outdoor and indoor wireless broadband and industrial automation will bring job gains with a net positive effect overall. The other sector contributing most significantly to overall employment, construction, also features more than it does in markets such as France and Spain.

Emissions impact

Omdia forecasts that in 2030, 5G will help to reduce GHG emissions in Romania by 2.4MtCO2e, representing 1.9% of the 126MtCO2e in total GHG emissions that the country projects it will have in that year. Manufacturing, construction, and industrial processes will account for 24% of 5G-enabled avoided emissions in 2030. A breakdown by sector is shown in **Figure 33**.

Figure 33: Romania, 5G-enabled avoided emissions, sector share of total, 2030



Source: Omdia

Romania, as one of the major agricultural producers in the EU, will see that sector account for the largest share of total 5G-enabled emissions of any country in this study. Although that is partly because the sector accounts for a larger share of total GHG emissions in Romania than other countries, it is also because large commercial farms control almost half the country's farmland, and they are in a better position to invest in advanced technology to improve efficiency and yield.

Precision agriculture, also known as smart farming, aims to move from the traditional approach of applying fertilizer, water, and pesticides uniformly across vast fields to using technology to provide more targeted treatment for individual plants based on their condition and needs. This can increase crop yields while also reducing chemical and other inputs and GHG emissions from farm equipment.

A current example is See & Spray, a system developed by Blue River Technology (which was acquired by John Deere), which uses a farm machine equipped with computer vision and machine learning to analyze plants as it passes and only sprays with pesticides those it identifies as weeds. The company has also partnered with Vodafone to develop a 5G-powered drone equipped with its See & Spray system. Connected and increasingly autonomous drones are also being developed to monitor crops to identify whether they need treatment or are ready to be harvested.

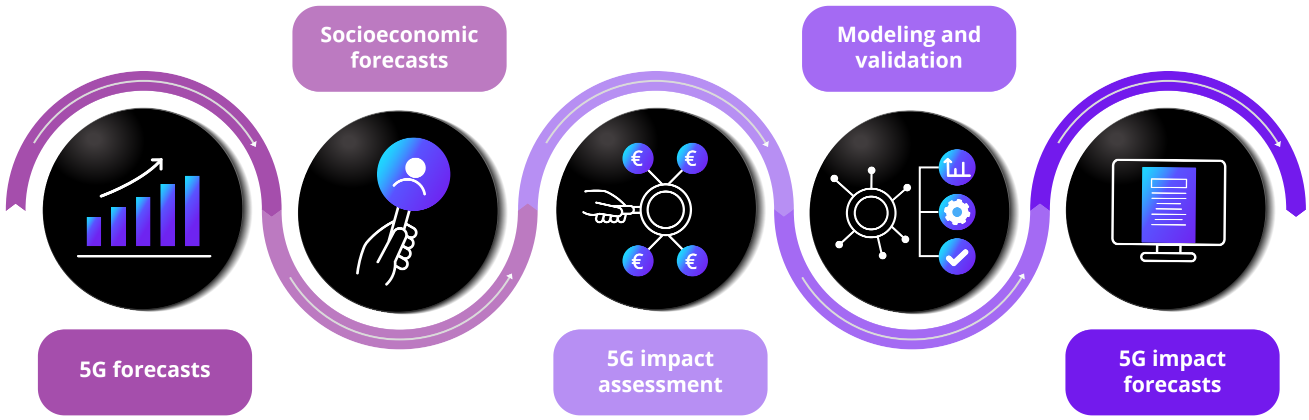
7. Methodology

Omdia's research on the impact of 5G on the broader economy, including its impact on economic output, employment, and GHG emissions, is based on Omdia's long-standing research on the worldwide telecoms, media, and technology (TMT) markets in general and the emerging 5G market in particular. This report combines Omdia's extensive research and forecasts on the dynamics and outlook of the 5G market globally with an assessment of the broader impact that 5G will have in 2030 on the economies of five countries in Europe: France, Spain, Poland, Belgium, and Romania.

Omdia's methodology for assessing the economic impact of 5G was initially developed in 2016 for the publication of the report *The 5G Economy: How 5G technology will contribute to the global economy*[45] in 2017. The report was updated in November 2019,[46] and in February 2020 IHS Markit Technology, the co-author of the report, became part of Omdia. Omdia then co-authored the latest version,[47] which was published in November 2020.

The methodology that Omdia has developed for assessing and forecasting the broader economic impact of 5G has five main components, as illustrated in **Figure 34**.

Figure 34: Omdia 5G impact methodology



Source: Omdia

[45] IHS Economics & IHS Technology (2017) The 5G economy: How 5G technology will contribute to the global economy www.qualcomm.com/media/documents/files/ihs-5g-economic-impact-study.pdf

[46] IHS Markit (2019) The 5G Economy, www.qualcomm.com/news/releases/2019/11/07/5g-economy-generate-132-trillion-sales-enablement-2035

[47] Omdia and HIS Markit (2020) The 5G Economy in a Post-COVID-19 Era, https://www.qualcomm.com/media/documents/files/the-5g-economy-in-a-post-covid-19-era-report.pdf

5G market forecasts

Omdia researches the 5G market extensively and continuously to produce and update a host of forecasts that have been used as inputs in this research, including the following:

- Subscription forecasts by country
- Subscription forecasts by spectrum
- Mobile infrastructure forecasts by technology
- IoT connection and device forecasts by country, industry, and technology

Socioeconomic forecasts

These include the following forecasts, which have been used as inputs in Omdia's 5G impact forecast model:

- Total nominal sales by country by industry
- Total employment by country
- Population and labor force by country
- GDP and GDP per capita by country
- EU greenhouse gas emissions projections[48]

There are three things to note about the EU GHG emissions projections used in this research: they are based on the "with existing measures" (WEM) scenario; they cover all GHG emissions, with non-CO_2 emissions converted into CO_2 equivalent (CO2e) emissions; and they exclude the land use, land use change, and forestry category, which offsets manmade emissions and reduces total emissions since trees and other plants absorb CO_2.

5G impact assessment

Omdia designed this part of the methodology to answer the key question about 5G commercial services: What level of impact will they have on the sales, employment, and GHG emissions of other industries in 2030 in the five countries being studied?

Given the scope, scale, and complexity of the question, Omdia developed a number of methods to arrive at an answer. First, Omdia built on and extended its existing 5G market forecasts by defining 21 5G use cases that will be most likely to have significant impacts in the segments above in 2030. These use cases, which extend across the three main 5G use-case categories of eMBB, MIoT, and MCS, are shown in **Table 1**.

Table 1: 5G use cases defined for impact analysis

Enhanced Mobile Broadband use cases
1. Enhanced indoor wireless broadband
2. Enhanced outdoor wireless broadband
3. Fixed wireless broadband deployments
4. Enterprise teamwork/collaboration
5. Training/education
6. Augmented and virtual reality
7. Enhanced mobile computing
8. Enhanced digital signage
Massive Internet of Things use cases
1. Asset tracking
2. Smart agriculture
3. Smart cities
4. Energy/utility monitoring
5. Physical infrastructure
6. Smart homes
7. Remote monitoring
8. Beacons and connected shoppers
Mission-critical services use cases
1. Autonomous vehicles
2. Drones
3. Industrial automation
4. Medical
5. Smart energy/grid

Source: Omdia

[48] European Environment Agency (2020) Member States' greenhouse gas (GHG) emission projections, www.eea.europa.eu/data-and-maps/data/greenhouse-gas-emission-projections-for-7

[49] United Nations Statistics Division, ISIC Rev. 4, https://unstats.un.org/unsd/classifications/Econ/Structure

The next step was to adopt an industry or sector segmentation for each of the areas—economic, employment, and GHG emissions—in order to conduct a more granular and robust assessment of the impact of the 21 5G use cases. For the analysis of economic and employment impact, Omdia used industries as defined by Revision Four of the International Standard Industrial Classification of All Economic Activities (ISIC), which is produced and maintained by the United Nations Statistics Division.[49]

Although the industries used in this research are as defined by ISIC, Omdia did combine some ISIC industries, typically those where the impact of 5G was expected to be limited, into broader categories. The result is that Omdia has defined 16 industry sectors for this research, some of them representing multiple ISIC industries. The details of the industry categories used in this research, and how they map to ISIC industries and codes, is provided in **Table 2**.

Table 2: ISIC codes and industries mapped to the related industries used in this research

ISIC code and industry		Classification used in this research
A	Agriculture, forestry and fishing	Agriculture, forestry, and fishing
B	Mining and quarrying	Mining and quarrying
C	Manufacturing	Manufacturing
D	Electricity, gas, steam and air conditioning supply	Utilities
E	Water supply; sewerage, waste management and remediation activities	Utilities
F	Construction	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	Wholesale and retail trade
H	Transportation and storage	Transportation and storage
I	Accommodation and food service activities	Hospitality and food service
J	Information and communication	Information and communication
K	Financial and insurance activities	Financial and insurance
L	Real estate activities	Real estate activities
M	Professional, scientific and technical activities	Professional, scientific, and admin services
N	Administrative and support service activities	Professional, scientific, and admin services
O	Public administration and defense; compulsory social security	Public service, defense, and other
P	Education	Education
Q	Human health and social work activities	Human health and social work
R	Arts, entertainment and recreation	Arts and entertainment
S	Other service activities	Public service, defense, and other
T	Activities of households as employers	Public service, defense, and other
U	Activities of extraterritorial organizations and bodies	Public service, defense, and other

Source: Omdia

For the analysis of the impact of 5G on GHG emissions, Omdia adopted the classification of GHG-emitting sectors as defined by the Intergovernmental Panel on Climate Change (IPCC).[50] This is the classification used by IPCC member countries, including EU member states, when reporting their GHG emissions and projections. The IPCC classification is unique and distinct from the industries as defined by ISIC in that the IPCC classification is organized by the type of activity that creates GHG emissions, with the main sector being the sourcing and use of energy and the other sectors being industrial processes, agriculture, waste, and other.

It is important to note that the energy sector as defined by IPCC includes the sourcing, refining, and use of energy, often through combustion, across all economic activities including energy industries (which includes electricity and other utilities, manufacturing and construction, and all forms of transportation). This classification means that the energy sector accounts for the vast majority of GHG emissions in most countries, including the five countries in the scope of this research. For example, in France in 2020, the energy sector accounted for 71% of the country's total GHG emissions, according to the GHG projections France submitted to the European Environment Agency as part of its obligations as a member of the IPCC.

[50] Intergovernmental Panel on Climate Change (IPCC), 2006 IPCC Guidelines for National Greenhouse Gas Inventories, available via the Task Force on National Greenhouse Gas Inventories, www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

Given the nature of the IPCC classification, Omdia has segmented the dominant sector—energy—into industries and subindustries as defined by IPCC but has not done that for the remaining, smaller sectors. The IPCC classification sectors, and how they map to the segments used in the emissions area of this research, are provided in **Table 3**.

Table 3: IPCC classifications for GHG emissions mapped to those used in this research

IPCC sector	IPCC industry	Selected IPCC subindustry	Sectors, industries, and subindustries used in this research
Energy	Energy industries		Energy industries
	Manufacturing industries and construction		Manufacturing, construction and industrial processes
	Transport		Transport, comprising
		Domestic aviation	Domestic aviation
		Road transportation	Road transportation
		Railways	Railways
		Domestic navigation	Domestic navigation
		Other transportation	Other transportation
	Other sectors		Buildings and other sectors
	Fugitive emissions, fuels		Buildings and other sectors
	CO2 transport and storage		Buildings and other sectors
Industrial processes			Manufacturing, construction and industrial processes
Agriculture			Agriculture
Waste			Waste
Other			Buildings and other sectors

Source: Omdia

One thing to note about the IPCC classification is that the industrial processes sector only covers emissions that are the direct byproduct of an industrial process, including by thermal or chemical reaction. An example is the production of cement, which includes the thermal decomposition of calcium carbonate into lime and carbon dioxide as a byproduct. The energy used to produce cement therefore also generates carbon dioxide emissions, but those are accounted for in the manufacturing industries and construction segment in the energy sector.

After defining industries for assessing economic, employment, and GHG emissions impact, Omdia developed a framework for analyzing the impact that 5G will have in each segment in each of the five countries under study through 2030. This includes detailed forecasts for the adoption of the 21 5G use cases in each of the five countries through 2030, which build on Omdia's existing forecasts for 5G subscriptions, IoT connections, and IoT devices.

Having created forecasts for the adoption of 5G use cases in each country, Omdia then developed separate but linked assessments of the impact that 5G will have on sales, employment, and GHG emissions in each country. In each of the three areas, and for each of the five countries, Omdia assessed the impact that each 5G use case will have on each industry.

Given the very high level of uncertainty and lower levels of quantitative visibility inherent in forecasting both the adoption of 5G over 10 years and its impact on the economies of five countries in 2030, Omdia adopted a qualitative approach in this part of the research methodology. Omdia's experts scored the impact of each 5G use case in each industry in each country in 2030 on a scale of zero to five, with zero being no impact and five being maximum impact. It is important to note that the economic, employment, or emissions impact that each 5G use case will have in a particular industry and country was assessed in relation to competing technologies such as 4G. In other words, if another technology such as 4G would also be able to support a use case in 2030, it received a lower impact score as a 5G use case because of that potential competition.

To clarify the extent of this exercise, in two of the areas, economic impact and employment impact, Omdia assessed the impact of 21 distinct 5G use cases in 16 industries across five countries, for a total of 1,680 assessments across both areas. In the work to gauge the impact of 5G on GHG emissions in 2030, Omdia assessed the impact of the 21 5G use cases in 11 sectors in each of the five countries, leading to a total of 1,155 assessments. This means that across all three areas, Omdia conducted 2,835 assessments of the impact that 21 5G use cases will have in 2030 on three major areas across 11–16 industries in five countries.

Modeling and validation

After completing detailed assessment of 5G impact in 2030 across the five countries, Omdia then developed models to translate the outputs of the assessment in each area into economic, employment, and emissions impact respectively. The first step was to establish a baseline in each country through 2030 for total sales (also known as gross output), total employment, and total GHG emissions. The baseline outlook in each area was established by the following existing forecasts referenced earlier:

- Total sales by country by industry to 2030
- Total employment by country to 2030
- EU greenhouse gas emissions projections to 2035, using the WEM scenario

Next, Omdia developed a methodology to translate its qualitative assessments of 5G impact into quantitative levels of impact on sales by industry, employment, and avoided GHG emissions. Omdia designed the methodology to answer the following question: Of the total sales, employment, and avoided emissions in each country in 2030, what amount will be enabled by 5G services?

It is important to note that the term enabled is chosen carefully given the focus of this research is not primarily on the direct impact of 5G but on the impact through, for example, investment in 5G networks, services, and retail outlets, and the sales, employment, GHG emissions, and avoided emissions that will be generated as a result. Although the direct impacts of 5G are in the scope of the research, the focus is on the indirect impact of 5G on other industries and economies overall, because this will be much larger than the direct impact of 5G alone. In other words, as 5G services are deployed and the 21 5G use cases in the scope of this study are adopted, some existing goods and services will become more efficient, productivity will increase in some cases, and new goods and services will be created. It is the sales, employment, and avoided emissions of these goods and services enabled by 5G that are the focus of this report.

For 5G-enabled sales and employment, Omdia updated its existing model initially developed in 2016 by IHS Markit and validated by the Berkley Research Group. The model, which has been regularly updated over the last five years, takes into account technology diffusion cycles and the historical impact of analogous technologies on sales and employment throughout the economy. For example, Omdia has researched the historical economic and employment impact of 4G in selected countries and regions and used the findings to help validate the forecasts of the impact of 5G in the five countries in 2030.

In the area of GHG emissions, previous research has shown that mobile services have a net positive impact, because the total of the emissions they help to reduce in other industries is much greater than the direct emissions of mobile services. One example of such research is the mobile carbon impact report, published by the GeSI in 2015.[51] GeSI found that in 2015 in Europe and the US, the amount of GHG emissions reductions that mobile communications enabled in other industries was five times the direct emissions of the mobile industry itself in those regions. In other words, GeSI found that for the mobile industry in the regions studied in 2015, the abatement ratio (defined as the ratio of GHG emissions abated in other industries to GHG emissions produced directly) was 5:1.

Other, more recent research found mobile services have a higher abatement ratio. One example is *The Enablement Effect*, a report published by the GSMA and Carbon Trust.[52] It found that in 2018 the global mobile industry produced 220MtCO2e in GHG emissions, but enabled emissions reductions of 2,135MtCO2e in other industries, giving it a GHG emissions abatement ratio of 10:1.

This research is mentioned here because these are examples of the existing literature on the topic that Omdia used to help model, quantify, and validate the level of impact 5G could have on GHG emissions in the five countries. However, it is important to note that Omdia did not assume that 5G's impact on emissions in 2030 in the five countries would be similar to the impact that all mobile services had on emissions in 2015 and 2018 in different geographies as found in the reports cited above. There are significant differences between the scope and focus of this research and that of existing literature in the area.

Details of the publicly available research that Omdia used to validate its 5G impact research across all three segments are provided below. This research is in addition to the significant amount of internal Omdia research and forecasts used in validation.

Economic and employment impact research

Omdia (including IHS Markit and Ovum)

- *The 5G Economy in a Post-COVID-19 Era* (November 2020) https://www.qualcomm.com/media/documents/files/the-5g-economy-in-a-post-covid-19-era-executive-report.pdf
- *The 5G Economy* (November 2019) www.qualcomm.com/news/releases/2019/11/07/5g-economy-generate-132-trillion-sales-enablement-2035
- *The 5G economy: How 5G technology will contribute to the global economy* (January 2017) www.qualcomm.com/media/documents/files/ihs-5g-economic-impact-study.pdf

[51] Global e-Sustainability Initiative (2015) *GeSI Mobile Carbon Impact*, https://gesi.org/public/research/gesi-mobile-carbon-impact
[52] GSMA (2019) *The Enablement Effect*, https://www.gsma.com/betterfuture/wp-content/uploads/2019/12/GSMA_Enablement_Effect.pdf

- *How 5G Will Transform the Business of Media & Entertainment* (October 2018) https://newsroom.intel.com/wp-content/uploads/sites/11/2018/10/ovum%E2%80%93intel%E2%80%935g%E2%80%93ebook.pdf
- *Making Enterprise 5G Pay: The Human Factor* (2020) https://omdia.tech.informa.com/OM011176/Making-Enterprise-5G-Pay-The-Human-Factor

Research from other sources

- WPI Economics for Vodafone (2020) *Levelling Up: How 5G can boost productivity across the UK*, https://newscentre.vodafone.co.uk/app/uploads/2020/06/Vodafone-5G-Report-final.pdf
- James E. Prieger (2020) *An Economic Analysis of 5G Wireless Deployment: Impact on the U.S. and Local Economies*, ACT / The App Association, https://actonline.org/wp-content/uploads/ACT-Report-An-Economic-Analysis-of-5G-FINAL.pdf
- Michael Mandel & Elliott Long (2020) *The Third Wave: How 5G Will Drive Job Growth Over the Next Fifteen Years,* Progressive Policy Institute, www.progressivepolicy.org/publication/the-third-wave-how-5g-will-drive-job-growth-over-the-next-fifteen-years/
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- Eric Hanson (2019) "5G's impact on the future of work," TechRadar, www.techradar.com/uk/news/5gs-impact-on-the-future-of-work

Greenhouse gas emissions impact research

- High Council for Climate (2020) *Maîtriser L'Impact Carbone de la 5G [Master the Carbon Impact of 5G]*, www.hautconseilclimat.fr/en/publications/maitriser-limpact-carbone-de-la-5g/
- Mission Innovation Net-Zero Compatible Innovations Initiative (2020) *The Avoided Emissions Framework*, www.misolutionframework.net/pdf/Net-Zero_Innovation_Module_2-The_Avoided_Emissions_Framework_(AEF)-v2.pdf
- Accenture & Canadian Wireless Telecommunications Association (2020) *Accelerating 5G in Canada: The Role of 5G in the Fight Against Climate Change*, www.cwta.ca/wp-content/uploads/2020/10/5G_Role_In_Fight_Against_Climate_Change.pdf
- Global Mobile Suppliers Association (2019) *The Enablement Effect*, www.gsma.com/betterfuture/wp-content/uploads/2019/12/GSMA_Enablement_Effect.pdf
- Global e-Sustainability Initiative (2015) *GeSI Mobile Carbon Impact*, https://gesi.org/public/research/gesi-mobile-carbon-impact
- STL Partners & Huawei (2019) *Curtailing Carbon Emissions – Can 5G Help?* https://carrier.huawei.com/~/media/CNBGV2/download/program/Industries-5G/Curtailing-Carbon-Emissions-Can-5G-Help.pdf
- IC&CO, Cenex, and O2 (2020) *A Greener Connected Future*, https://connect.o2.co.uk/greenerconnectedfuture
- The (Re)Set Company (2020) Evaluation of Omdia 5G Impact Research

5G impact forecasts

The results of the research detailed above are the 5G impact forecasts provided in this report. Although Omdia has developed a robust methodology for the forecasts and fully validated them against a host of internal and external research, it should be noted that these forecasts are subject to a very high level of uncertainty. This is not unusual for forecasts in general, but it is nevertheless important to be clear on some of the main reasons for the high level of uncertainty of these forecasts in particular:

- **Ten-year timeline.** The forecast timeline to 2030 is appropriate to assess the impact of 5G, since that will allow time for the more novel and advanced 5G use cases, including those supporting mission-critical services, to be deployed and reach scale. However, a ten-year forecast timeline also means the research is subject to a very high level of uncertainty, with the level of uncertainty increasing year on year throughout the forecast period.
- **Scope and complexity.** Other factors driving the significant uncertainty of these forecasts are their broad scope and their high level of complexity. The scope of the forecasts is broad in that they address the impact of 5G across the entire economies of five countries with a focus on their impact on industry sales, employment, and GHG emissions. This broad scope increases the complexity of the forecast methodology and modeling, which in turn increases uncertainty.
- **Pandemic uncertainty.** The COVID-19 pandemic, with its dramatic impact on some economies and industries, has introduced another level of uncertainty into the research. This is because the pandemic and its economic impacts are unprecedented in many ways and thus are challenging to forecast. In particular, the timing and pace of economic recovery as the pandemic recedes are highly uncertain, which creates additional uncertainty in the forecasts used in this methodology and published in this report.

Omdia has addressed these very high levels of uncertainty by adopting a conservative approach in its methodology and forecasting and acknowledging that these forecasts should be seen as directional rather than exact, and they are subject to future revision.

Appendix

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