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The Impact of 5G on the European Economy

This report outlines the influence of 5G, the world's next technological breakthrough, upon the European Economy (the European Union member states and the United Kingdom). We will thoroughly examine the economic benefit driven by 5G, as well as illustrate how key industries will be affected through major industry use cases. Finally, we will identify opportunities to accelerate the economic benefits from 5G. 5G will be a force for growth and resiliency in a post-COVID European economy.

Accenture Strategy | February 2021

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The study was commissioned by Qualcomm Technologies, Inc. It was conducted by Accenture PLC, to assess the benefits of 5G and its impact on the European economy between 2021 and 2025.

01 Executive Summary

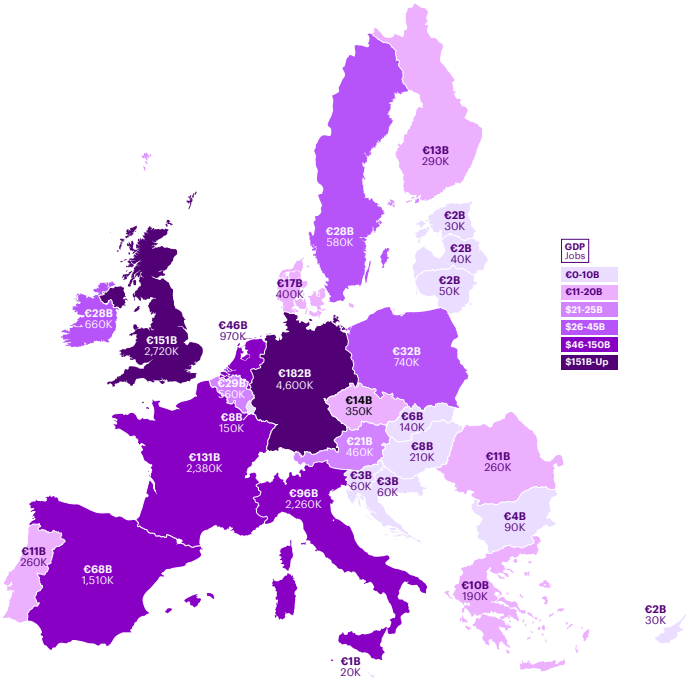
New mobile technologies profoundly impact economies and societies. In 2009, the first 4G LTE network launched in Sweden, setting a trajectory within Europe and globally for exponential growth within wireless telecommunications.[1] 11 years later, 5G networks and technology will further revolutionize wireless communications by transforming existing market sectors and industries. Beyond upgrading existing 4G-enabled capabilities such as faster video streaming, 5G will unlock new potential of technologies like artificial intelligence (AI), edge compute and the Internet of things (IoT). 5G will be instrumental to the success of these technologies by offering **rich bi-directional communications,**[a] **potential to support 1 million devices per squared kilometer**,[b] and **ultra-reliable sub-millisecond response**.[c] The capabilities offered by 5G enable a variety of use cases, paving the way for the economy to realize the cross-industry benefits of magnified connectivity.

According to Accenture's latest economic modeling analysis completed for this paper, the impact of 5G on the European economy[d] will drive up to **€2.0 trillion in incremental gross output** (sales) growth between 2021 and 2025.[e] Over the same period:

- 5G will add up to **€1.0 trillion to European GDP**.[f]
- 5G has the potential to create or transform up to **20 million jobs** across all sectors of the economy.[g]
- **Multiplier effects will be felt in every industry**. For example, for every euro introduced by the direct effect of 5G in Information Communication Technologies (ICT), an additional €1.0 will be created elsewhere throughout the economy.

The benefits of 5G will be felt across every corner of the region, ranging from an additional €10 billion in GDP and create or transform up to 190 thousand jobs in Greece, to €182 billion in GDP and 4.6 million jobs in Germany, as can be seen on the right:

Crucially, 5G technology will position the European economy for accelerated recovery as Europeans adjust to the turbulence caused by the COVID-19 pandemic. While businesses are grappling with unprecedented demand and supply chain disruptions today, 5G will fuel much-needed growth and facilitate long-term flexibility across value chains. Moreover, the 5G ecosystem will drive future economic resiliency



For detailed map, see appendix.

a eMBB: Enhanced Mobile Broadband
b mIoT: massive Internet of Things
c MCS: Mission Critical Services
d The European economy is defined in this paper as the economies of the EU member states and the United Kingdom.
e To arrive at these effects, we evaluated the increase in 5G on all economies based on historic growth from increased connectivity, and then adjusted industry-level relationships based on expected nuances in 5G use cases and impact.
f Gross Domestic Product is the value-add component of sales.
g Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

by untethering more workers from physical workstations, sparking growth in new industries that are digital at their core and increasing efficiency and productivity across a variety of other industries. An accelerated application of 5G can ensure that the economy will emerge from this crisis, even stronger than before.

5G in Action

5G is the foundational technology that enables other technologies to communicate and supports device development across the value chain, from chipset makers to infrastructure developers. Developing the wireless technology requires companies to invest heavily and consistently in R&D to drive innovation over a long-time horizon before the benefits materialize, prompting a balance between collaboration across the ecosystem and a robust IP protection strategy.

5G's outsized economic impact is predicated on its revolutionary technical capabilities, which include three major advances over previous generations of cellular connectivity:

Enhanced Mobile Broadband (eMBB)

5G can deliver high bandwidth and speed to enable rich bi-directional transfer of high-definition video and high-volume data. High speed broadband is foundational for enabling applications like augmented reality (AR) and virtual reality (VR) that require rich data transfer in both directions and will unlock entirely new ways of engaging with people and information in the age of computer vision (CV) and machine learning (ML).

Massive Internet of Things (mIoT)

5G can provide simultaneous connectivity to potentially one million connections per square kilometer. This massively dense connectivity is essential to the effective implementation of advanced industrial Internet of things (IIoT) applications. One example of this is enabling large networks of sensors and machines to capture the rich data sets necessary to apply AI in smart power plants.

Mission-Critical Services (MCS)

For mission-critical applications such as automated vehicles or remote intensive care units (ICUs), the reliability and speed of the connection are crucial. 5G can carry network traffic with latencies as low as 1 ms, safely supporting use cases for which a fraction of an instant can make the difference between life and death.[2]

The benefits brought by 5G will redefine the way workers engage with their profession—new levels of connectivity will unlock higher productivity and untether employees from the physical workstation in a way that has not been previously possible. For enterprises across all industries, 5G will help transform how business is conducted and everyday operations are run, presenting tangible productivity improvements through real-time flow of information. 5G will unlock the next wave of rapid data- and insight-driven decision making, allowing optimization of business functions and creation of new value for customers.

As a result of COVID-19, we are already seeing how tangible improvements in the connected worker experience can enable business shifts towards increased collaboration across geographies as well as support productivity gains and opportunities to upskill the workforce. 5G can provide connected workers with tools and data at their fingertips to drive more value for business and therefore, the economy.

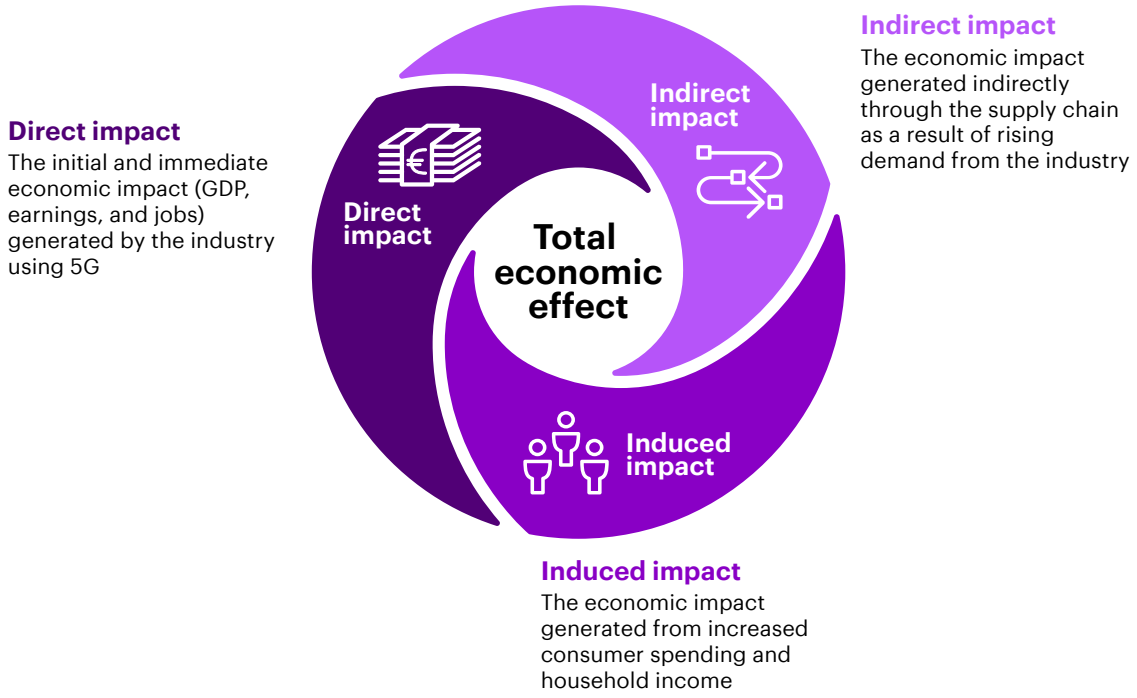
Economic Impact

The Impact of 5G on Total Sales

Between 2021 and 2025, 5G will drive up to €2.0 trillion in total new sales across all major industries in the European economy. Over this time period, 5G will create or transform up to 20 million jobs and drive up to €1.0 trillion to GDP.

5G's transformative impact on the European economy will fuel an engine of economic growth across all industries in the European Union and United Kingdom driven by the following:

- **Creation of new industries and sub-industries**: 5G will unlock new products, services and businesses based on high bandwidth, IoT and ultra-low-latency capabilities.
- **Cost optimization**: 5G will drive productivity improvements that will lead to increased economic output.
- **Product and service quality improvements**: 5G will generate increased customer value, driving up both willingness to pay and consumer surplus.



This paper examines specific use cases, illustrating how 5G will drive these shifts within industries. In addition to these examples (e.g. robotic process control in a manufacturing plant), many industries will experience economic growth because of their interconnections with other sectors. For example, manufacturing plants will play a key role in producing 5G devices both for consumers and to support transformation in other sectors like the automotive industry. Similarly, 5G's impact across industries will produce downstream ripple effects through their associated value chains.

The Multiplier Effect: 5G Value-Chain Impact

The economic effect of 5G will propagate throughout the value chain of every sector, extending past the direct effect of increased growth within the primary industry. To understand the multiplier effect, consider the impact of 5G on ICT, the industry sector that lies at the core of 5G.

Information and Communications Direct[h]

The end-user benefits of 5G cannot exist without the network, hardware, and software powering user devices. The direct economic effect of 5G activity on the ICT sector will account for €123.4 billion of the almost €1.0 trillion European GDP impact, and €273.3 billion of the €2.0 trillion additional sales.

Information and Communications Indirect (Supply Chain)

In addition to these direct benefits, 5G will create €58.1 billion in indirect GDP impact from suppliers and producers of intermediate goods and services. As ICT generates new sales and demand, their entire value chain will prosper. The companies that mine precious metals (e.g. gold) that are required to produce devices, for example, are part of the 5G indirect effect, as are professional service providers (e.g. accounting) that are employed within the industry.

Information and Communications Induced (Household Spending)

The labor income produced in the ICT value chain will in turn produce €69.2 billion in additional GDP, generated by increased household spending from workers and newly created ICT sector jobs. This spending will, in turn, lead to additional job creation in sectors like arts and entertainment, food and beverage, retail and transportation.

Information and Communications

*Multipliers are defined as the sum of direct, indirect, and induced jobs, divided by the direct job impact.
Source: Accenture Analysis

Because of the multiplier impact described above, for every euro introduced by the direct effect of 5G in ICT, an additional €1.0 will be created elsewhere throughout the economy, for a multiplier effect of 2.0 on the total GDP.[i] These multipliers exist in every industry and will be highlighted throughout this paper.

In addition to these quantified benefits on GDP and jobs, 5G will drive significant unmeasured consumer surplus, as consumers are provided with increasingly more value than they are paying for. 3G and 4G saw the birth of numerous free applications, some of which generated value for consumers in excess of $200 billion[3] (€224 billion), a trend that will continue with 5G.[4]

h Within this analysis, the ICT industry is defined to include communications providers, as well as the broader information technology sectors that develop software and hardware.

i To arrive at these effects, we evaluated the increase in 5G on all economies based on historic increases from increased connectivity, and then adjusted industry-level relationships based on expected nuances in 5G use cases and impact.

Consumer Impact

In addition to these quantified benefits for GDP and jobs, 5G will enhance **consumer value** in way that we have not quantified, such as a significant decrease in the number of road collisions, timely medical diagnoses, reduced pollution, and wider access to broadband connectivity.[j]

If addressed effectively within Europe, wider broadband connectivity can support and drive sustainability efforts that are top of mind for European consumers. By enabling improved WFH solutions, 5G also benefits the environment, as daily commutes to and from work contribute greatly to greenhouse gas emissions. A British clean air campaign determined that maintaining remote work after the lockdown could eliminate 11.3 billion miles of commutes, or two airports' worth of emissions.[5] Furthermore, research showed that an overwhelming amount of European consumers, over 50%, would be willing to pay a premium for environmentally friendly features, such as confidence in a zero-waste supply chain behind a product and in-home experiences.[6] These examples highlight both the consumer's increased willingness to pay as well as the ability to generate consumer surplus if 5G is implemented successfully in Europe.

Industry Impact

Each industry will be transformed in its own way. **5G will impact every industry by creating new products and revenue streams** (e.g. virtual care and connected vehicles), **delivering cost and productivity benefits** (e.g. fewer collisions and more efficient traffic management) **and supporting sustainability and resiliency** (e.g. smart factories and energy grids). To estimate the potential effects, our analysis subdivided the economy into 15 sectors, five of which are showcased based on potential for highly innovative use cases and benefits from 5G. Consider a snapshot of these findings:

Industry	Highlighted use cases	Potential benefits: New end services/ product	Potential benefits: Efficiency/ productivity	Potential benefits: Resiliency
Manufacturing 5G technology unlocks the ability to sense and respond for manufacturers in Europe, facilitating efficient communications between people and machinery.	Factory floor automation and robotic process control		●	●
	Intelligent asset management		●	
	Connected worker		●	●
	Quality assurance		●	●
Auto & Transport 5G technology will enable smarter, safer, greener and more efficient transport from connected vehicles and transit infrastructure in Europe.	Enhance vehicle safety and automation	●	●	●
	New intelligent transport systems	●	●	●
	Connected and automated train operations (ATO)	●	●	

j Economic analyses of digital services and cellular connectivity suggests that consumer surplus, the value consumers receive beyond prices paid for goods and services, is likely larger than sales and GDP impacts.

Industry	Highlighted use cases	Potential benefits: New end services/ product	Potential benefits: Efficiency/ productivity	Potential benefits: Resiliency
Healthcare 5G technology will allow more mobile/ home care, better patient outcomes and more capacity and flexibility within the healthcare system.	Remote patient monitoring	●	●	●
	Virtual consultations and care	●	●	●
	Connected hospital	●	●	●
Utilities 5G technology will enable reliability, safety and afford-ability throughout the utilities infrastructure and workforce in Europe.	Intelligent grid	●	●	●
	Next generation workforce		●	●
	Smart power plant		●	●
Agriculture 5G technology will drive more sustainable agriculture, safer crops, and healthier livestock management across Europe.	Automated pest and weed eradication using drones		●	●
	Connected tractor and automated equipment		●	●
	Livestock tracking		●	●

Source: Accenture Analysis

5G will not only provide improved performance compared to 4G, it will also profoundly expand the potential of what is possible with mobile data exchange. For example, there's a vast gulf between the user experience of **4G-enabled** telemedicine that lets a patient FaceTime with their doctor to get a prescription refill and a **5G-enabled** virtual visit that would equip a dermatologist to accurately diagnose skin cancer with real-time high-definition imaging. Existing applications that have been limited to small scale trials with 4G but can become more reliable, effective and pervasive with 5G.

Select Findings

Manufacturing
5G-enabled factories can see up to **20-30%**[63] in overall productivity gains, including improvements of **50%** in assembly time, **20%** in asset life, and **90%** in defect detection.[69]

Utilities
Two-way communication energy grids using smart sensors and meters can save households **billions of dollars**[167], and drive down **12%** of energy use.[173]

Agriculture
Improved connectivity and digitization can yield **up to 25%** increased productivity, **30%** decreased inputs, **20%** decreased costs[188], and **15%** increased crop yields.[195]

Auto & Transport
Connected vehicles could prevent **70%** of rear-end crashes and save **€450 million** in collision costs[104]; while automated trains will reclaim more than **£440 million**[116] in lost productivity and reduce railway energy consumption **by at least 20%**.[117]

Healthcare
Speed and millisecond latency of 5G supports remote ICU beds, enabling hospitals to expand ICU capacity virtually, beds cost **>£2000/day**; wearables will drive **16%** hospital cost savings through remote patient monitoring.[141]

Source: Accenture Analysis

Acceleration Opportunities

The potential benefits of 5G are immense but require a critical mass of network deployment, R&D and production of new devices across industries, along with significant investment from every major sector in the European economy. There are, however, prominent opportunities to accelerate the realization of these benefits, which could power further growth:

Opportunity #1: Intellectual Property (IP), Technology and the Ecosystem

Developing the wireless technology foundation and the subsequent products and devices requires continuous investment in R&D and innovation. Companies take on substantial risk to invest in an ecosystem that can take years to materialize. To maintain their incentives to continue investing in innovation, it's necessary to ensure that they can obtain fair returns on their innovations. Furthermore, connected devices do not work in isolation. There must be collaboration across the value chain in order to enable this communication technology for consumers. IP should be adequately protected to facilitate a culture of innovation and technological advancement.

Acceleration levers: Balance innovation stimulation with IP protections to ensure continuous investment. Encourage innovation via subsidies and government-funded R&D incentives, including in the startup ecosystem. Establish national strategy for 5G innovation, and industrial and ecosystem support. Ensure legal protections for IP and establish other policies that protect new technology and accelerate new developments.

Opportunity #2: Resilient Wireless Technology Supply Chain

Benefits to the economy from 5G use cases depend on uninterrupted delivery of the entire value chain from R&D, to manufacturing and solution development of the semiconductor, wireless devices and network, as well as industrial solutions. Breakdown of any component will slow down or disrupt economic benefits.

Acceleration levers: Develop policies to support reliable semiconductor, wireless device and network equipment innovation and design. Foster a robust global supply chain to power critical manufacturing, healthcare, automotive and other 5G use cases via trusted sources and reliable producers.

Opportunity #3: Network Deployment and Build Out

Building out the RAN presents multiple challenges.[k] The local and country-level permitting process can be slow and complex, and different European countries invest in infrastructure at different rates. Finally, the cost of network deployment threatens to limit timely buildout in rural areas.

Acceleration levers: Streamline local and municipal site approvals and processes. Provide education and training incentives to encourage the growth of the tower workforce. Further incentivize carriers to provide coverage in underserved areas. Support and fund the development of OpenRAN, which will allow interoperability and standardization of RAN functions to simplify integration across the network ecosystem and drive down cost.

Opportunity #4: End User Return-on-Investment (ROI)

5G has massive potential to grow the European economy at the macro level in terms of jobs and GDP. However, on a company-by-company basis, capital investment, complexity and legacy infrastructure can lead to a slower ROI. Enterprises need to see and be convinced of the effectiveness. Early adopters are most likely to derive a competitive advantage and improved ROI, while late joiners will see a reduction in relative competitiveness, as with most technology cycles.

Acceleration levers: Establish subsidies and tax incentives to encourage pilot projects or even full-scale testbeds that will demonstrate the benefits and possibilities of the technology. Provide investment support for use cases that have broad benefits throughout the economy and consider comprehensive frameworks such as Germany's Industrie 4.0. Supporting these test projects will lower investment risk and lead to improved ROI.

Opportunity #5: Spectrum Availability

The European Electronic Communications Code (EECC) initiative to harmonize the low, mid (generally 3.4 GHz – 3.8 GHz) and high bands (above 6 GHz) will benefit the acceleration of industrial and consumer application. However, the assignment for the high band is lagging especially for the mmWave.

Acceleration levers: Continue to accelerate the assignment and allocation of the 26GHz. Incentivize the development and deployment of mmWave networks.

k A RAN provides radio access and assistance to coordinate network resources across wireless devices like cellphones.

Opportunity #6: Balancing Regulations

Although industry regulations provide value to consumers and society, regulatory barriers, such as the lengthy timeline for EMA approval of medical-technology devices, can delay benefits and discourage investment in the development of 5G devices. The unintended result can be the slower implementation of key use cases that offer major potential benefits for the economy and consumers, alike.

Acceleration levers: Streamline industry-specific processes and policymaking, such as the EMA approval process for medical devices and healthcare use cases. Foster collaboration between the private sector and government, to balance public and economic benefit and accelerate timelines.

Conclusion

5G will have a transformative impact on both consumers and businesses that is only being accelerated for a post-COVID world. As the effect of 5G cascades throughout the European economy, it will drive up to €2.0 trillion in sales, create or transform up to 20 million jobs and contribute up to €1.0 trillion to European GDP between 2021 and 2025. As with the original Digital Revolution sparked by the advent of the Internet, this advancement will lead to the creation of industries not yet imagined. There are tangible and realizable business opportunities to speed up the deployment process and maximize the benefits—driven by tremendous market opportunities. In this whitepaper, we will expand upon the themes highlighted above in detail.

02 Introduction

5G will transform industries and change the way consumers use mobile technologies, generating substantive benefits beyond previous generations of connectivity technology, driven by three defining differentiators: enhanced mobile broadband (eMBB), mission-critical services (MCS) and massive machine Internet of Things (mIoT). In this paper, we present a study on how 5G will apply these benefits to transform industry landscapes, provide value to consumers and generate economic value throughout the economy in the form of new output, GDP and jobs.

Introduction to 5G

Benefits of 5G

Every decade, a new generation of wireless technology is released, representing a dramatic leap forward over the previous generation in terms of performance and capabilities. Compared to 4G, 5G can deliver up to 100 times higher bandwidth,[I] greatly improved reliability, substantially lower communications latency and connection to a much higher density of devices.

Gearing up for a 5G Connected World

Technology	3G	4G	5G
	Connecting humans	Connecting humans+devices	Connecting the world
Latency	**300ms**	**~55ms**	**<10ms**
High Bandwidth	**1hr** 3GB movie download	**18min** 3GB movie download	**55sec** 3GB movie download
Scale	**Millions** of devices	**Billions** of devices	**Trillions** of devices

Source: Accenture Analysis, OpenSignal

2G shifted the focus of wireless networking from analog voice to high fidelity digital voice. 3G focused on data and 4G improved speeds so that video streaming, navigation and rich email over wireless networks became commonplace. 5G will not only surpass 4G performance in terms of speed but will provide solution centric connectivity bringing together dimensions of speed, latency, reliability and high IoT connection density to support new use cases across all industries.

Developing the technology of each wireless generation requires extensive R&D investment (as covered in Opportunity 1: IP, Technology and the Ecosystem) as well as deep industry collaboration among various ecosystem players orchestrated by industry bodies such as 3GPP.

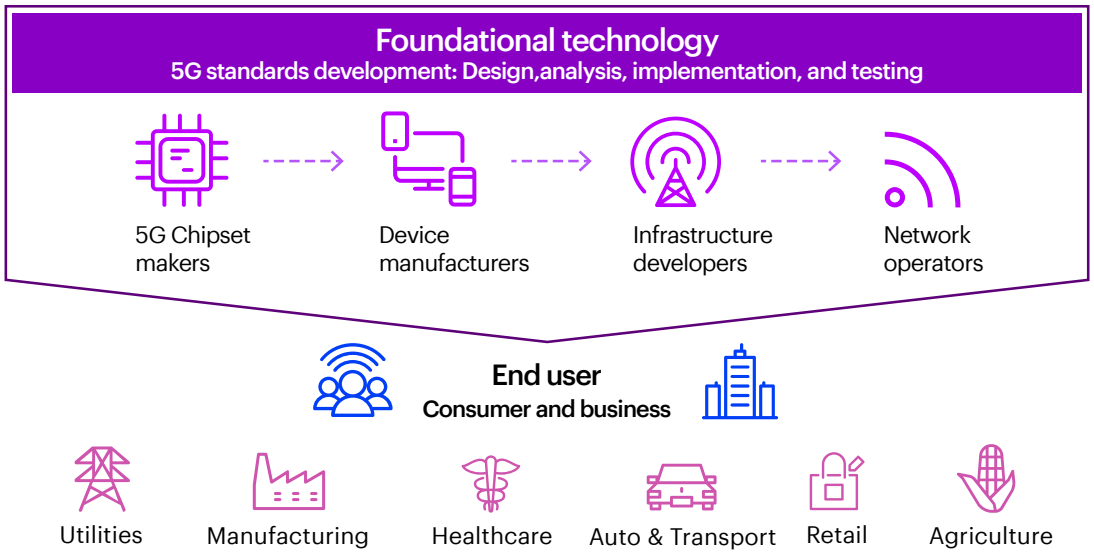
I Numbers are based on IMT-2020 requirements based on the ITU vision.

The foundation of 5G and any wireless communication technology starts with the efficiency of transmitting bits over the air in a reliable and secure manner. Technologists from chipset companies, equipment providers and device vendors collaborate to design the air interface standards. This involves key innovation around improvements in modulation and error protection schemes, encryption mechanisms, noise cancellations, antenna technologies, session setup and teardown flows.

Similarly, another team of technologists from the same companies work on developing the end-to-end network architecture which defines the various components, their functions, and standards-based interfaces allowing interoperability of equipment from different equipment vendors. This ensures end-to-end transmission and reception of data, interworking with other wireless or wireline networks, user identify management and the ability to manage the user experience, as well as track and bill for it.

Network equipment vendors and device OEMs work to ensure equipment and device are viable for commercial operations and in affordable economies.

Requirements from operators, industry players and governments play a crucial role in guiding this entire development process as well as the subsequent trials and regulatory approvals that test the readiness of this technology.



Source: Accenture Analysis

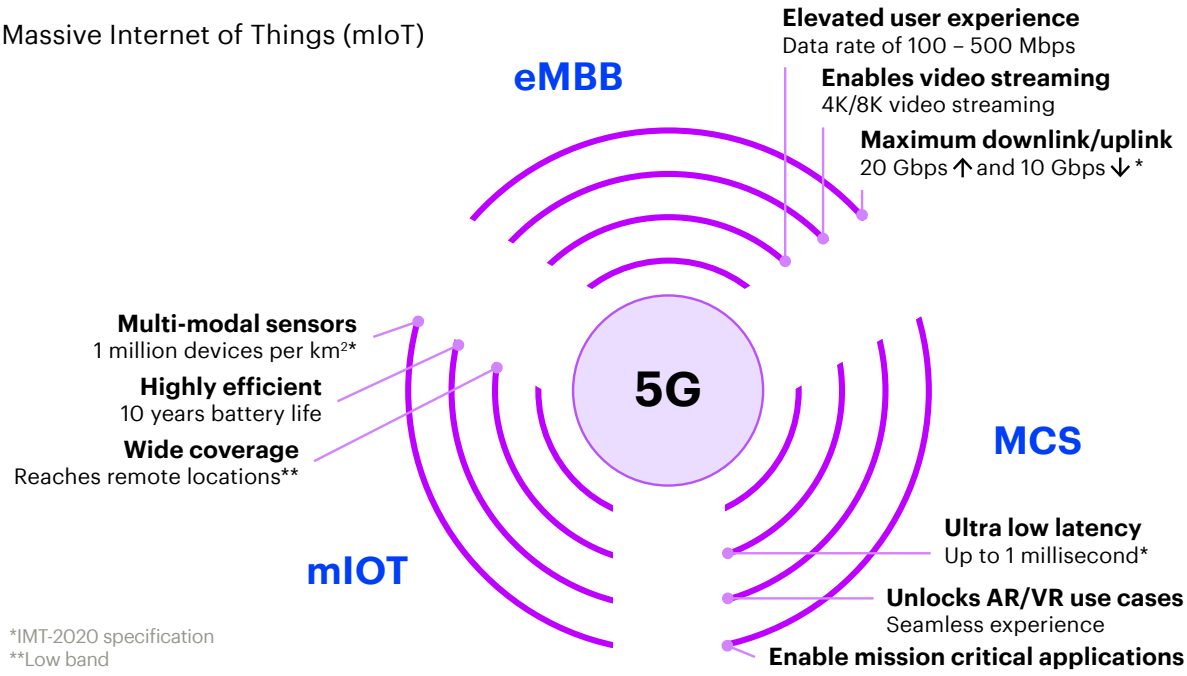
This foundational technology development process is a multi-year endeavor and entails significant investments from chipset makers, network equipment vendors and device makers, as well as operators and other industry players. Therefore, in order to ensure fair return on this investment and keep this ecosystem growing, it is crucial that we have:

1. Proper IP protection to encourage ongoing investment in R&D
2. A friendly business environment to encourage growth and adoption of the technology
3. An objective regulatory framework to protect consumer interest while removing unnecessary cost and barriers to 5G network rollouts

In July 2020, the wireless standards body 3GPP finalized Release 16, which enhanced the foundational aspects of the 5G system, such as latency and capacity, and expanded into different verticals, such as industrial IoT and automotive applications.[7] Looking forward, Release 17 is expected to continue bringing improvements to capabilities and support that could significantly expand use cases such as extended reality.

These advancements unlock the opportunity beyond traditional mobile broadband through three key capabilities:

- Enhanced mobile broadband (eMBB)
- Mission-critical services (MCS)
- Massive Internet of Things (mIoT)



Source: Accenture Analysis

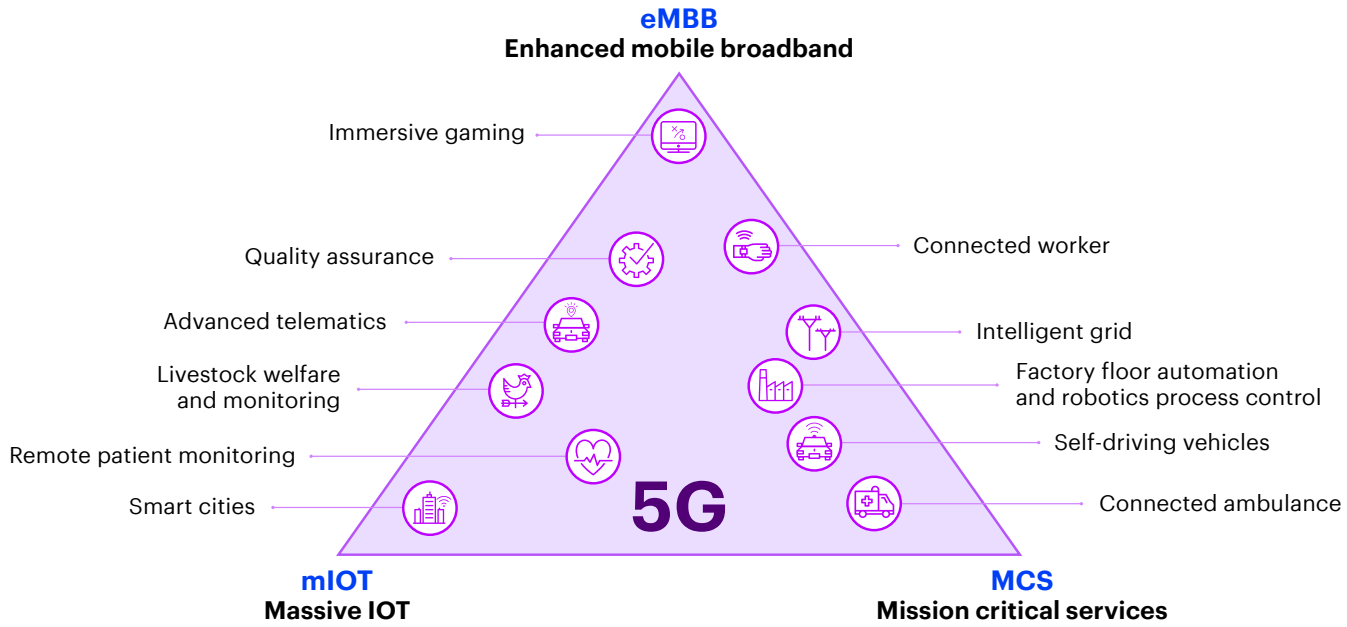
Enhanced Mobile Broadband (eMBB)

5G operates at speeds that can match the experience of using a wired connection, with an average data rate of 500 Mbps based on current implementations.[8] The technology is still evolving and testing using millimeter wave (mmWave), resulting in promising peak speeds of up to 5Gbps.[9] In addition, 5G can deliver symmetrical download and upload speeds.[m] These advancements are crucial because they optimize the network for industrial and business applications such as live video monitoring and AR/VR.[n]

In the automotive industry, for example, 5G will provide the capacity required to capture and analyze video data from various sensors within vehicles and on the roads in real time—not to mention streaming entertainment options.

m Symmetrical uplink performance based on the underlying time-division duplexing (TDD) technology and uniform experience especially at the cellular network edge (cell edge) using massive multiple input multiple output (mMIMO) antenna technology.

n Previous technology was designed with downlink performance (download) in mind. Faster uplink (upload) speeds are necessary for modern applications like video monitoring (4K video requires at least 25 Mbps)1 and AR/VR (at least 17 Mbps),2 and the performance needs to be maintained across the network, including at the cell edge.



Source: Accenture Analysis

Mission-Critical Services (MCS)

5G provides a millisecond-level response time between the outbound network request and the return signal from the connected device (connection integrity is dependent on the distance to the nearest cell tower and the presence of obstacles like foliage or man-made structures). This performance enables 5G to support time-critical applications. The latency of 4G networks, at 45 to 55 ms on average,[10] is not good enough to support crucial safety and quality specifications for many use cases. To meet latency requirements, 5G networks can prioritize critical traffic, such as machine-to-machine (M2M) communications over delay-tolerant, non-critical data like streaming video entertainment.

In medicine, healthcare workers can rely on 5G connectivity to support critical patient applications. Home-based patient monitoring devices can send a continuous stream of data to providers to enable instant response if critical conditions change for the worse.

Massive Internet of Things (mIoT)

The enormous increase in connection density will enable 5G to support the skyrocketing number of devices that will be part of the Internet of everything. There are more than 465 million phones in the European Union[11] and 182 million M2M connections in 2020.[12] M2M connections are expected to grow to 416.5 million connections by 2023,[13] growth that current infrastructure cannot support. In addition, the 5G network is designed to support the diverse variety of MTC connections in terms of location, environmental conditions like weather and foliage, bandwidth and latency requirements and form factor.

5G's mIoT capabilities will bring a consumer's physical and digital life closer together, unlocked by the high density and deep coverage of 5G-enabled sensors. As Cisco ex-CEO John Chambers said, "[The technology shift to IoT will] have a five to ten times greater impact on our lives than the impact of the Internet."[14] The development of smart cities and connected cars is already underway. For example, 5G-enabled road infrastructure in the United States will be able to tap into the power of the Internet, leveraging always-on, low-power 5G devices to maintain a consistent feedback loop among vehicles, infrastructure and mobile devices.

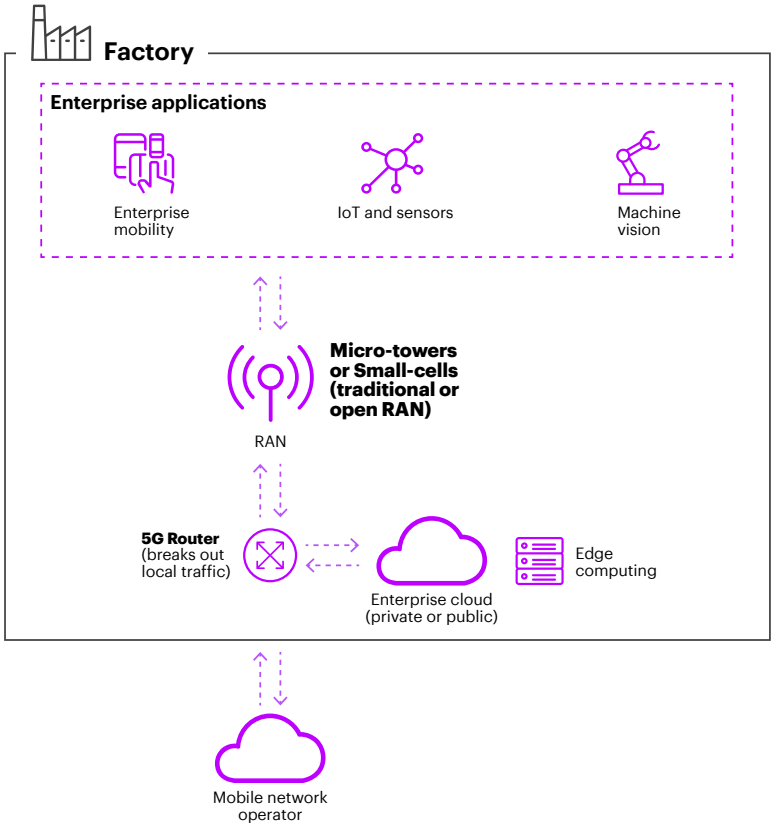
Comparing 5G to Other Technologies

	Wi-Fi 6	4G	5G
Latency	Several seconds	~55 milliseconds	<10 milliseconds
Mobility	Low	High	High
Coverage	10m (30 feet)	100m to km[1]*	100m to km[1]*
Bandwidth	High bandwidth[2]	Up to 20MHz band[3]	Up to 400 MHz[3]
Security	Reasonably secured[4]	Very secure[5]	Very secure[6]

[1]Depending on spectrum band; [2]Shared bandwidth (uplink), High bandwidth (downlink); [3]Guaranteed through scheduling/allocation; [4]WPA-3; [5]SIM-based security; [6]SIM-based security; hardware-based security at the chip/modem-level. *(traditional towers)

Source: Accenture Analysis

With 4G, consumers can already stream media with fast download rates, but 5G takes this a step further. 5G has faster bi-directional connectivity and enhanced latency that can unlock many use cases across industries that 4G could not such as augmented or virtual reality. 5G also offers several important benefits compared to Wi-Fi 6. While WiFi-6 offers low cost and high speed, it lacks wireless mobility, reliability over wide-area coverage and the low latency benefits of 5G (see figure: **Comparing 5G to Other Technologies**).



Source: Accenture Analysis

Key Enablers

Realizing the full benefits of 5G requires an ecosystem of enabling technologies. Three of the most critical ones are: private network, edge computing and OpenRAN.

1. **Private networks** take advantage of the highly modular architecture of the core network to enable enterprises to establish their own private 5G networks for their own communications needs such as broadband, HD video, sensor networks and voice calls. Enterprises can benefit by having more control over their networks (such as ensuring higher network reliability for mission-critical operations) as well as increased security offered by isolating their data from public networks.

The 5G private network is suited for industrial users with requirements for predictable and reliable performance. It can fulfill the needs of demanding industrial applications and can contribute to process automation across a range of sectors such as smart factories, energy, chemicals, ports, oil and gas, etc.[15]

2. **Edge computing** moves processing of IoT data from the cloud to devices at the network edge, performing analytics and decision-making near the sensors and components generating and using the data. Consolidating this capability at the edge of the network with 5G-connected devices guarantees low latency and higher performance for applications that need real-time response. The approach lowers bandwidth consumption, reduces long-term costs and ensures processing scalability as IoT device density increases over time.

3. **OpenRAN** is the concept of a virtualized radio access network (RAN) and the defragmentation of radio network components. The RAN may account for approximately 70% of the total network cost.[16] In the past, the monolithic nature of RAN infrastructure implementations has severely limited the ability for upgrades and deployment flexibility. Conversely, through decoupling and virtualization, OpenRAN gives operators the flexibility to select best-in-class RAN components from any equipment vendor, as well as position the components based on deployment needs. As an example, during the deployment of small cells, this may enable 5G small cells to be installed on lamp posts with minimal electronics located onsite, reducing footprint and load factor on the lamp post. This market dynamic stimulates greater competition and encourages new entrants to develop innovative alternatives to individual network components.

   The interoperable multi-vendor approach ensures that operators can rapidly innovate by co-creating and optimizing reference designs that can be deployed at scale—an imperative for Europe's growing wireless demand and evolving usage patterns. Moreover, early studies show that OpenRAN can reduce the total cost of ownership (TCO) by an estimated 30% to 49%.[17, 18]

   As wireless networks extend from macro site-based deployments serving smartphones to a wide variety of devices and various deployment models such as dense small cells and private networks, the flexibility and cost benefits of OpenRAN will also ensure the requisite ROI for enterprises investing in 5G by providing a flexible upgrade path. For more information on the benefits of this new vendor-neutral standard, the trials in progress and latest on the industry ecosystem coalescing around the OpenRAN project **click here**.

5G Accelerates Environmental Sustainability Goals

The technology is designed to efficiently use energy throughout its ecosystem and will play a significant role in promoting and attaining sustainability goals. The European Union has targeted 55% in greenhouse gas emission reductions with the 2030 Climate Plan;[19] switching to the more efficient 5G network equipment can help reduce carbon emissions from mobile networks by 50% over the next 10 years.[o] When 5G use cases are implemented across all sectors in the United Kingdom, it could reduce CO2 production by up to 269 megatons by 2035,[20] confirming that the technology and its applications contribute towards achieving the sustainability goals.

o Carbon emission reduction from 73 million tons to 34 million tons https://www.powerengineeringint.com/digitalization/fast-5g-roll-out-will-radically-impact-global-emissions/

03 Market Context

Business and Technology Landscape

By 2023, a whopping 29.3 billion devices[21] will be connected to the Internet via IP networks about three times the size of the global population. The world is becoming more and more connected as both consumers and businesses find innumerable ways to leverage connectivity that makes their lives easier and more sustainable. Wireless networking has typically been viewed in the context of personal smartphones but will be increasingly used for M2M communications.

There are three closely interlinked trends affecting businesses around the world that are driving the growth of these new wireless connections: **digitalization and IoT, personalization** and **AI and advanced robotics and automation capabilities**.

The growth of wireless devices in businesses like manufacturing, healthcare, transportation, agriculture and utilities will dramatically transform the scale, traffic patterns, security needs and precision required from cellular networks. This is where 5G comes in. With higher speeds, lower latencies, increased connection density, greater security and superior energy efficiency, the technology promises to remake how we work, play and most of all, how we do business. It will propel new use cases, upgrade existing ones and enable entirely new industries. And along the way, it will turbocharge the economy and enable sustainable innovations.

Digitalization and IoT

Underpinning every major technological trend is digitalization and the number of new connected devices. From smart-home applications to the connected car and beyond, businesses are seeking ways to digitize everything and connect it all to the Internet. In addition to the growth of devices connected to the Internet, the global number of M2M connections specifically is expected to reach 14.7 billion devices by 2023—equating to 50% of all networked devices.[22] The underlying advantage of having connected products and digitized services is that they can be refined and redefined simply by updating the code through the network. New offerings can be created without generating obsolescence of prior versions, unlike more traditional offerings where hardware and software is coupled together.

The best digitized services today are constantly evolving, pushing through new features or improving the experience. Often, the ability to evolve efficiently requires a modular IT architecture that ensures that new features don't upend old, beloved ones. Leading companies have recognized that while modernizing their technology infrastructure and shifting towards a cloud-first architecture requires a non-trivial effort, it enables them to make the most of an increasingly digitalized world. Moreover, 93% of large enterprises in a 2020 survey stated that they have a multi-cloud strategy[23] in order to provide operational scalability, ensure ultra-reliable system availability and support rapid innovation in a manner that upholds newfound commitments to carbon-neutral futures. Accenture has found that migrations to public cloud alone could generate a 5.9% reduction in total IT emissions—equivalent to taking 22 million cars off the road.[24]

The combination of all these new connected devices and the always-changing, experience-driven microservices behind them will only achieve its potential with the right wireless networking foundation. 5G's massively increased network capacity will ensure reliable connectivity for the surging number of simultaneously connected devices and their diverse usage patterns. Additionally, along with supporting a thousand-fold increase in network traffic, 5G networks are predicted to consume substantially less energy, given the efficiency of 5G cell sites compared to existing networks.

Personalization and AI

Another leading trend that affects both business-to-consumer (B2C) and business-to-business (B2B) companies alike involves AI and predictive personalization. With more data available through the digitalization of everything, competition between businesses is intensifying and business models are shifting to be more interactive with customers. This means that as customer preferences are captured, products and services can be customized for each individual customer's needs and wants.

An estimated 85% of executives agree that in order to compete in an era in which digitalized services and modernized technology infrastructure are table stakes, companies need to intelligently elevate their customer relationships.[25] Personalization will involve AI-driven feedback loops with cloud-stored rich datasets, such that devices become attuned to their current user. Moreover, some companies may use real-time data to design hyper-personalized experiences that are specific to the user, their environment and the moment. These more complex offerings require network infrastructures that can support these demanding needs end to end.

At grand scales, AI can be leveraged to predict usage behaviors of a large number of devices and appropriately allocate resources. For example, the energy consumption of network infrastructure in the communications sector[26] or electricity grids in the utility sector[27] can be assessed in real-time to determine the appropriate energy supply and reduce emissions.

The connectivity capability required to support heavy data and provide real-time AI-driven adjustments to live experiences requires substantial bandwidth and low reliability. This is where the concept of edge computing becomes vital to increasingly complex services by positioning computational power as close to devices as possible. IDC predicts that by 2022, edge computing will be a part of at least 40% of cloud deployments to support localized machine decisions. AI-led products and services that can produce secure and individualized connected experiences will be the keys to success in the post-digital era. The efficiency and intelligence of these personalized mobile experiences will depend on a 5G network with enhanced data bandwidth complemented by edge computing.

Robotics and Automation

As increasing connectivity gives devices access to more information and AI continuously makes devices smarter, these developments will be paralleled by a trend towards increasing machine sophistication. Robotics and automation are transitioning from systematic processes in closed, controlled environments to complex performances in open, uncontrolled environments. 61% of organizations plan to use robotics in uncontrolled environments within the next two years and 95% within the next five years.[28] This growth trend has IDC predicting a global robotics market of €215 billion by 2023, at a CAGR of nearly 20%.[29]

The market projection refers to automation beyond the traditional mainstay of manufacturing facilities and warehouses and out into the open world. In agriculture, for example, the startup FarmWise is deploying automated robots that use various sensors and learning algorithms to handle seeding, weeding and harvesting optimized for each individual plant.[30] In this example and many others, along with the benefit of increased yield for farmers, there are also positive environmental impacts. Investments in new wireless technologies will be key in enabling reductions in greenhouse-gas emissions across European industries, while reducing the carbon footprint of the enterprises involved themselves.

The common denominator in these three industry examples is that the robots must be able to communicate with one another and safely operate in an environment with additional uncontrolled entities (e.g., animals, people, vehicles, aircraft). This means that robots will need the ability to sense, communicate and react to irregularities in an instant. The future of automation will rely on 5G's ultra-low-latency wireless technology as well as low-power, always-on connections between robots and their surrounding environments. 5G will also create new revenue growth opportunities within these sectors by paving a path for industry employees to move away from manual tasks to upskill and focus on more value-additive activities, improving their work experience. Additionally, as robotics penetrate the commercial environment, the need for entirely new jobs such as drone operators will develop within these industries. This job creation will be one of the key benefits that 5G will drive.

Consumer Context

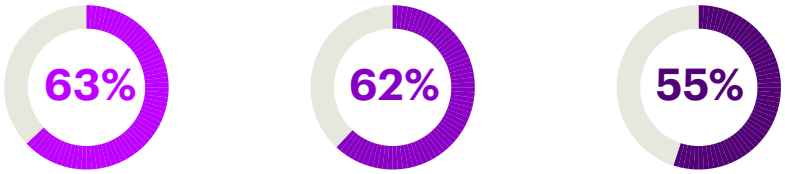
76% **of consumers consider high quality Internet a necessity.**

To the European consumer, connectivity is critical. With over 460 million active Internet users, the European Union and United Kingdom rank second globally in the total number of people that are online.[31] For European consumers, the ability to stay connected is a fundamental expectation.[32] The pandemic made these views stronger. An overwhelming 76% of consumers consider high-quality Internet a necessity due to remote-access education, healthcare and work. 5G networks can enable solutions to deliver on these expectations.

The COVID-19 pandemic set in motion a revolution in the demand for connectivity services. With a nearly overnight shift in circumstances amid stay-at-home orders and social distancing guidelines came a shift in consumer habits and needs. Over a fifth of the European labor force now works from home on a full-time basis.[33] Consumer sentiment showed that the work-from-home (WFH) revolution is real and here to stay. A resounding 74% felt that this new WFH lifestyle allows them the freedom to choose where they would like to live and provides them greater happiness in their personal lives.[34] Of those consumers who did not have an opportunity to work from home, more than half said they would if they could.

5G will be an important enabler of WFH. By providing high-speed connectivity that can be leveraged by employees in historically location-based occupations, 5G will enable a new set of jobs to be performed remotely. For example, field-service experts typically travel to customer locations to instruct technicians on how to solve a problem. By leveraging the ultra-low-latency capability of 5G, XR solutions like smart glasses can be used to provide direction to field workers without the expert technician leaving home. One case study found that working from home can make employees up to 13% more productive and decrease the likelihood that they will quit their jobs.[35] WFH is creating a win-win for employees and employers.

Consumers are also increasingly aware of their environmental impact and sustainability efforts. By enabling improved WFH solutions, 5G also benefits the environment, as daily commutes to and from work contribute greatly to greenhouse gas emissions. A British clean air campaign determined that maintaining remote work after the lockdown could eliminate 11.3 billion miles of commutes, or two airports' worth of emissions.[36] Furthermore, over half of consumers would be willing to pay a premium for environmentally friendly features, such as confidence in a zero-waste supply chain behind a product and in-home experiences.[37]



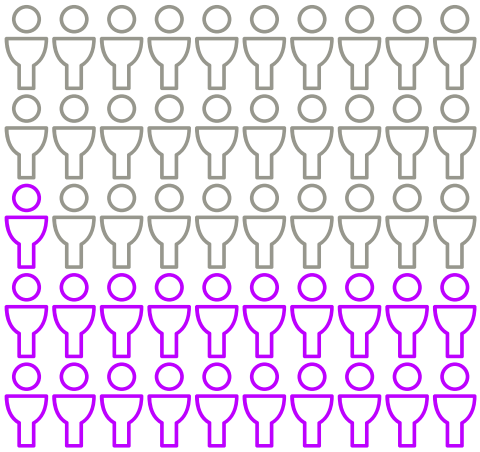
Working from home makes me happier in my personal life

I need faster internet in order to be able to work from home

I'd like the opportunity to work from home [but can't currently]

Source: Accenture Analysis

The pandemic also intensified the demand for activities like virtual hangouts and video co-working and showcased their usefulness. This ability to connect via video will only increase in value to users in the coming months. Consumers also asserted that secure online banking, streaming entertainment and virtual healthcare will grow in importance.[38] While there is some skepticism around futuristic features, consumers are most likely to pay premiums for advanced technology enabled by 5G, enabling shifts like virtual healthcare. These significant developments in product and service quality can generate increased value and consumer surplus.



41% of consumers Completely Agree or Somewhat Agree with the statement: "My service quality diminishes during high-demand periods."

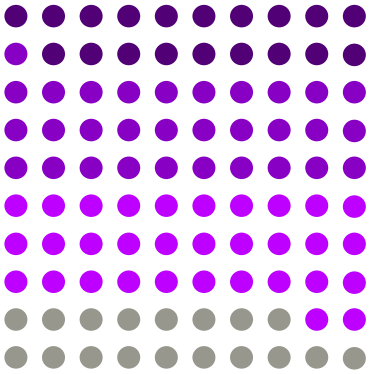
Source: Accenture Analysis

Current technology does not deliver the performance levels consumers now expect. The average person in the United Kingdom spends 25 hours a week online,[39] and a typical European household has an average of nine connected devices.[40] They require increased bandwidth, faster speeds and more connectedness with smart devices In a recent survey, 41% of consumers felt that their service quality diminished during high-demand periods.[41] Additionally, 39% of consumers also felt their ability to stream high-quality video outside the home was inconsistent. Offering faster speeds and greater connection density than 4G, 5G networks can provide faster streaming times and better video quality to consumers.[p]

Consumers are aware that there is a digital divide[q] within the European region. 60% of European consumers agree that access to the Internet is affected by the ability to pay.[42] Research also supports this sentiment. In Europe, the top 25% of income earners have a 90% take-up rate of fixed broadband, 30% higher than when compared the lowest 25% of all earners.[43] Bringing 5G connectivity to these

p Numbers are based on IMT-2020 requirements based on the ITU vision.

q A digital divide is defined as any uneven distribution in the access to, use of, or impact of information and communication tools amongst different groups.



19%
Buy or upgrade my service and/or required devices as soon as they are available

31%
Wait until hearing positive feedback from others before upgrading service and devices

32%
Wait until 5G becomes common to upgrade and purchase required devices

18%
Continue with my existing products and services

Source: Accenture Analysis

communities and rural areas will improve quality of life and address other citizen needs, such as access to remote work, virtual healthcare and virtual education.

To address this issue, many lower-income Europeans often rely on mobile connectivity for online access versus fixed broadband. This trend is rising, with about 96 active mobile broadband SIM cards per 100 people in the European Union—a penetration rate that has doubled over the last six years.[44] This means that mobile connectivity will be a powerful tool for addressing the digital divide in the future. 5G fixed wireless access, particularly in rural areas, will empower families who are currently constrained due to limited broadband with the speeds they need to support demands like virtual schooling, therefore reducing the disparity families today face at lower costs when compared to wired solutions. (See section: **Acceleration Opportunity** for more details.)

Though most believe that connectivity providers should be responsible for ensuring access to Internet connectivity in their households, an overwhelming majority also expect governments to play a major role (80% and 71%, respectively).[45] Consumers want governments to prepare this critical infrastructure for the future by working collaboratively with enterprises.

COVID-19 Context

COVID-19 has had an extremely disruptive effect on the world: The European Union and United Kingdom have seen millions of cases.[46] On average, GDP in the E.U. regions fell by 6.4%, with strong variation between individual countries.[47] The unemployment rate in the European Union reached 8.1% in August 2020, affecting more than ten million people in the region.[48]

Social distancing and shelter-in-place guidelines increased reliance on connectivity and the demand for remote services. Voice and data traffic volumes have increased 70% since the crisis began and are expected to continue growing as consumers rely more on digital services to work from home, connect with family and friends or shop online.[49] For example, the video-conferencing company Zoom saw 94 million downloads of its iOS app from April 1 to June 30, breaking App Store records.[50] These short-term trends may drive longer-term demand for robust connectivity and connected living services. Many companies have extended WFH orders, while others, such as Siemens, have announced permanent remote-friendly options, allowing employees to work remotely two or three days a week.[51]

Overall, COVID-19 is expediting trends that were already in flight: the acceleration of digital enterprise transformation, the evolution of all businesses to connected businesses, the proliferation of zero-touch experiences and value chains and the reevaluation of geography-based strategies for businesses.

- **Acceleration of Digital Enterprise Transformation**: 94% of executives say their operating model puts their organization's growth and performance at risk, and 85% are not confident that their operating model can meet shifting strategic priorities.[52] Business leaders must think about how to ensure continuous operations through digital transformations such as use of the cloud. With the capacity and performance of 5G, the new network can help businesses benefit from cloud computing.
- **Evolution of all Businesses to Connected Businesses**: It is crucial to connect employees, business partners and consumers so that they can understand one another's evolving needs. Business must be able to adapt to rapidly changing customer and technology opportunities in order to emerge from the pandemic in a leadership position. 5G's added capacity will be beneficial for both consumers and businesses as data demand and consumption grow.
- **Proliferation of Zero-Touch Experiences and Value Chains**: Physical distancing requirements have limited interactions with all parties along the value chain. Businesses and consumers are re-examining scenarios that require face-to-face interactions, leaning into the idea of limited touchpoints and automation. Not only does 5G have mission-critical properties for industrial applications, but it also provides extended range for widespread usage.
- **Reevaluation of Geography-based Strategies**:
  - **Supply Chains**: Globalization has been previously touted as a positive development, with global trade increasing from 40% of the world's GDP in 1980 to over 60% today.[53] The disruption of COVID-19 has provided a graphic demonstration of the drawbacks of global supply chains, however. Going forward, businesses must consider vulnerabilities in their supply lines and establish strategies to navigate future crises. 5G can provide the visibility to support more informed decisions through track and trace capabilities.
  - **Employment**: From 1961 to 2018, the number of people living in cities in the European Union and the United Kingdom has steadily and constantly increased; Europe's level of urbanization is expected to reach approximately 83.7% in 2050.[54] Previously, in-person presence at work required employees to be physically close to their offices. However, COVID-19 has forced businesses to shift their staffing models, allowing some employees to work at home. Despite this, some studies report that working remotely hasn't hurt productivity; in fact, 94% of employers said their company productivity was actually the same or higher.[55] Adoption of 5G will help enhance opportunities to work from home, as well as widen the pool of employees and talent available to employers.

Whether considered from a business standpoint, a consumer standpoint, or the pandemic standpoint, the importance of connectivity for economic and social benefit is now clearer than ever. 5G is imperative to meet the needs of both businesses and consumers. The new generation of wireless networking will ultimately help drive connection quality, as well as address the increasing reliance on connectivity and the skyrocketing number of devices as use cases emerge and mature.

04 Economic Benefits of 5G

5G technology will have a transformative impact on the European economy, fueling an engine of economic growth, driven by its ability to:

- Create new industries, products and business models. As 3G/4G unlocked the app economy, 5G will unlock new high bandwidth, IoT and ultra-low latency products and businesses.
- Improve productivity and optimize costs, leading to increased economic output from the same inputs.[r]
- Improve service quality significantly and, therefore, consumer willingness to pay for goods and services.

€2.0 Trillion sales

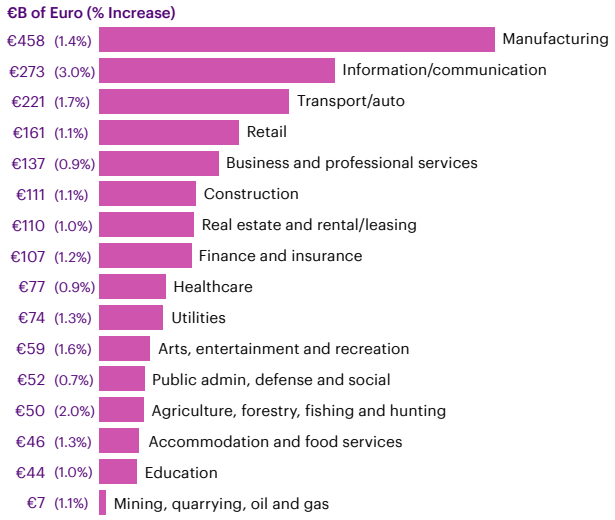
~€1 Trillion GDP

20 Million jobs

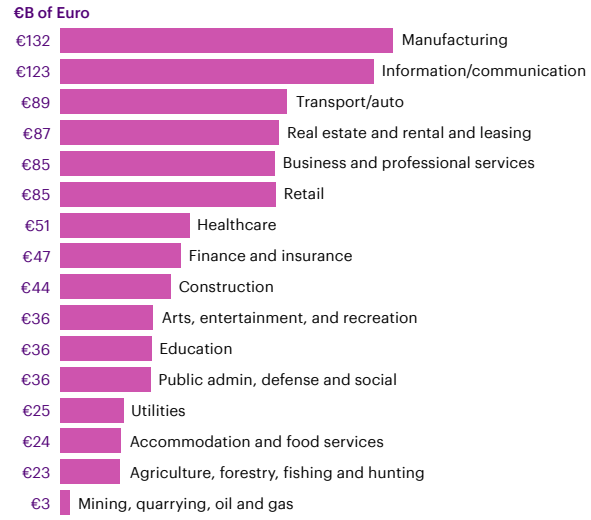
Source: Accenture Analysis

This increase is significant—our latest econometric model estimates that over the period from 2021 to 2025, 5G will drive up to €2.0 trillion in new economic gross output (sales), felt by every major industry. This translates up to nearly €1 trillion in GDP over the same five-year period. In addition, 5G has the potential to create or transform up to 20 million full-time, part-time and temporary jobs to meet this increased demand, generating labor income that will circulate through the economy. This growth will play a key role in Europe's post-COVID recovery and help build resiliency for the future.

5G Sales (€2.0 trillion)



5G GDP (€1.0 trillion)



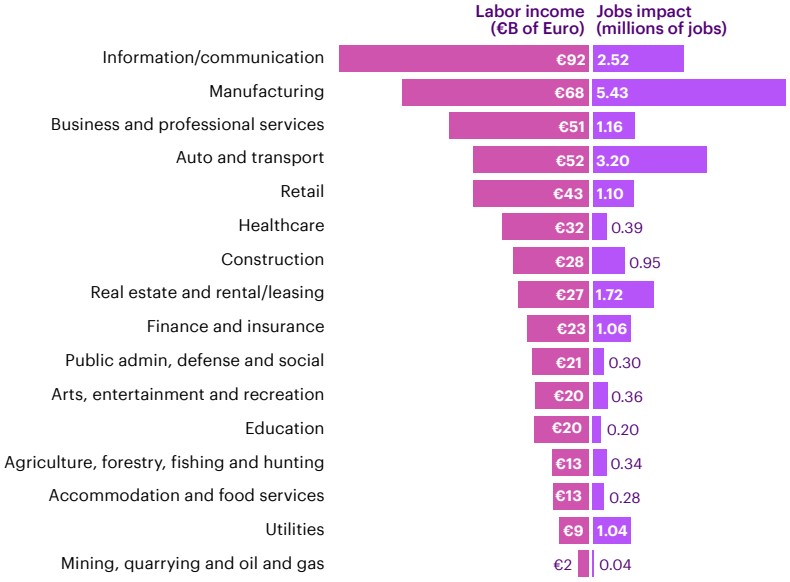
Source: Accenture Analysis

This benefit translates across industries, representing up to 3.0% additional sales in different sectors. The **Information Communication Technology (ICT) industry**, which includes **telecommunications** as well as **high-tech sectors**, is unsurprisingly at the core of this massive growth. Communications providers will play a key role, not only as the consumer-facing supplier of new 5G devices, but also through powering transformative 5G use cases within every other industry. As automotive manufacturers ramp up connected

r Based on our analysis this productivity is paired with new jobs and new types of jobs.
s Relative to one year of GDP.

vehicles and telematics applications, for example, communications service providers (CSPs) will be providing the network, devices and services that unlock their potential. Even more than past generations of connectivity, the information technology sector will be central to 5G benefit, working in tandem with CSPs to drive the cloud services, software and new tech-driven sub-industries that will be enabled by enhanced connectivity capabilities.

Jobs and Labor Income

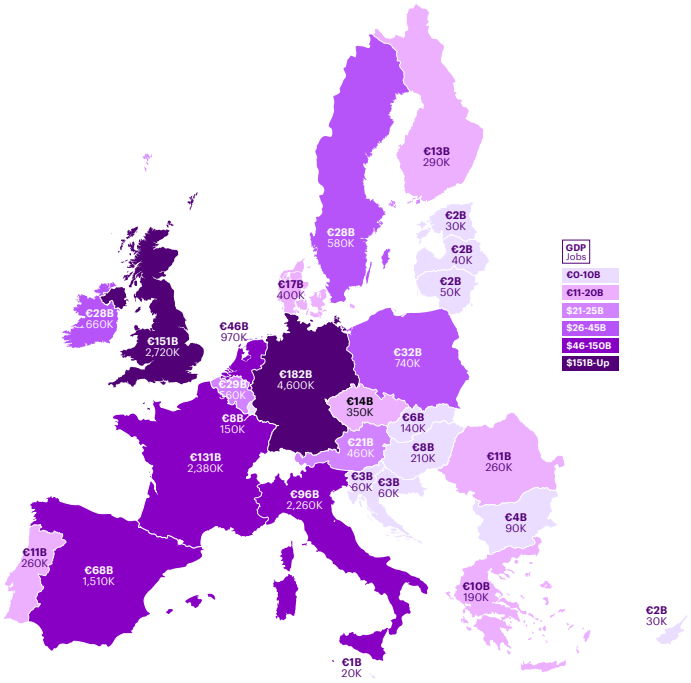


Source: Accenture Analysis[t]

5G has the potential to create or transform up to 20 million jobs across all sectors of the economy. While these are a mix of part-time, full-time and temporary jobs, in many sectors they represent high-quality employment at prevailing wages, and industries including education, health, public administration, arts and entertainment and retail will generate outsized labor income per job. The nature of these jobs will also change to higher-value professions, including more data scientists, engineers and automation professionals. For example, within the agriculture industry, we will likely see a focus on digitalization and automation, driving new jobs for drone operators to work alongside traditional farmers. As we will see shortly, this labor income is not only great for workers, but is also an engine for driving consumer spending throughout the broader economy.

Geographic Impact (2021-2025)

5G's impact will affect every corner of the Europe. Large countries unsurprisingly will reap a large portion of this benefit, partially due to a larger presence in the industries that are heavily impacted by 5G advancements. Germany, for example, can expect to create or transform up to 4.6 million jobs and €185 billion of GDP increase, and the United Kingdom will see up to 2.7 million and €151 billion, respectively. This effect isn't limited to behemoth countries: even in the Netherlands, 5G will create job growth equal to 6% of the country's 2019 population.[t]



t Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

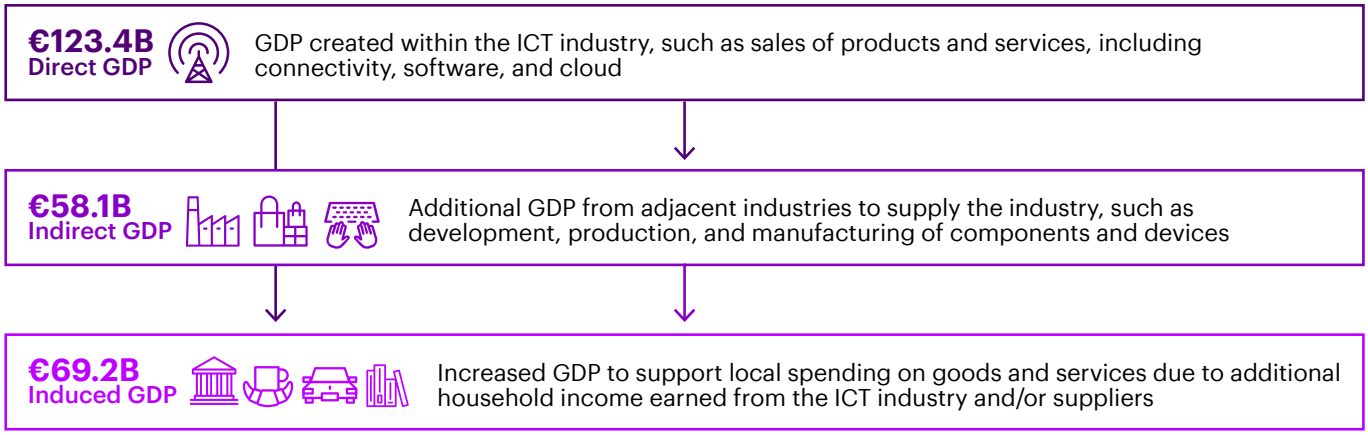
Value-Chain Impact

The growth generated by 5G represents the deep interdependencies between industry value chains within the European economy. As an example, let's consider how the effect plays out in ICT.

We established earlier that ICT plays a central role in realizing 5G benefits, intrinsically intertwined with the investments and activity in other industries pursuing new connectivity and generating substantial revenue (and jobs, GDP) in the process. However, the impact within ICT does not capture the full contribution the industry generates throughout the broader economy because of 5G. We can break these effects into three groups:

- **Direct effect:** Economic activity originating within the ICT industry and driven by industry sales, including elements of the ICT value chain that remain in ICT (e.g. tech spend on network services, software).
- **Indirect effect:** Economic activity from the suppliers to the ICT industry and producers of intermediate goods and services (e.g., manufacturers, raw materials).
- **Induced effect:** Economic activity from the household spending patterns from labor income generated in the ICT industry and its value chain (e.g. on retail, travel, real estate).

To illustrate, as we take the €123.4 billion in GDP driven by 5G within ICT, we can see through the graphic below how 2.0X total euros of GDP are generated throughout the broader economy through the indirect and induced effects. These effects are captured within other industries in our overall numbers. We list them here to show the interconnectedness across different sectors and the impact that demand in one industry drives in others.



Source: Accenture Analysis

The full results for ICT are shown below:

Information and communications technology industry

€273.3B in new 5G revenue

	Direct industry impact	Total value chain impact	Multiplier effect
Gross Domestic Product	€123.4B	€250.7B	2.0x
Labor Income	€92.2B	€178.8B	1.9x

Jobs and Employment

2.2M jobs[u]

Note: Multiplier is calculated as the ratio of total value chain impact to direct industry impact.

Source: Accenture Analysis

Cross-Industry Impacts

The ICT results above are just one example. 5G will generate a multitude of benefits that are shared across enterprises and consumers in all industries. Key among these include the ability for businesses to leverage complementary technologies like cloud and edge computing more effectively through enhanced connectivity in office settings and remote locations. This enhanced connectivity also fuels analytics by effectively facilitating linkage within disparate data sets managed by various stakeholders. New business models will be made to address these tasks, thereby creating new data-focused jobs in all industries. The effective management of data connections can lead to better processes for all businesses, increasing return on major investments and decreasing operating expenses.

5G also impacts European consumers directly, in excess of the GDP and Job results shown in this paper. For instance, take the concept of consumer surplus, the value generated for consumers when there is a delta between their willingness to pay and the price charged for a product or service. Over time, consumer surplus has steadily increased as the quality-adjusted price for devices and connectivity continue to decrease.[56] Studies have also shown significant consumer value driven by new applications, enabled by stronger connectivity—one social-media application generated €270 billion in consumer surplus from launch to 2019.[57] 5G will continue these patterns and significantly increase the economic well-being of customers by improving their everyday lives well in excess of cost.

To further bring the overall impact of 5G to life, we explored five other industries in detail: manufacturing, automotive and transport, healthcare, utilities and agriculture. In each industry section, we illustrate how specific 5G use cases contribute to the economic impact, as well as detail the broader story about 5G benefits and the impact they will drive within the industry.

u Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

05 Industry Deep Dives

Manufacturing

5G technology unlocks the ability to sense and respond for manufacturers across Europe, facilitating efficient communications between people and machinery.

The next five years of 5G impacts in the manufacturing sector will drive:

€458.3 billion in additional industry revenues
€131.8 billion in added GDP contributions
5.4 million jobs created or transformed[v]

The low latency, massive capacity and enhanced bandwidth of 5G will be instrumental to a variety of use cases:

Highlighted use cases	Potential benefits		
	New end services/product	Efficiency/ productivity	Resiliency
Factory floor automation and robotic process control		●	●
Intelligent asset management		●	
Connected worker		●	●
Quality assurance		●	●

Source: Accenture Analysis

Industry and Technology Context

After adopting and automating vital, streamlined processes, manufacturing is at the precipice of another great push towards digitalization, with 5G as a critical enabler that will help tackle key challenges. Today's consumers demand more new features, better performance and greater personalization, and they want it all right now.[58] To respond, manufacturers need to predict this demand and shift their processes to accommodate production. The current hard-wired state of most manufacturing floors inhibits fast changeovers, however.

Manufacturers are under pressure to keep pricing competitive, but operating expenditures can be crippling. The International Federation of Robots estimates that unplanned stoppages at a large automotive factory could cost $1 million (€1.1 million) per hour[59] Assuming a scrap rate of 1.2%, €93 billion

v Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

was lost to scrap in 2019 alone.[60] As a result, 49% of manufacturers are hoping to lower scrap costs with new equipment, while 58% are looking to upgrade inspection technology in 2020.[61] A further 47% of manufacturers plan to buy new equipment to reduce cycle time and bottlenecks.[62]

Worker safety and health compliance are always top of mind, with processes like the pre-startup safety review (PSSR) in place to catch any potential hazards. Despite this, the manufacturing industry had the highest injury incidence rate of all public and private industries (18.7%) in 2017.[63] The risk of serious consequences pushes executives to perform detailed due diligence on new processes.

Furthermore, manufacturers must be conscious of the availability of qualified workers, especially as veteran operators and engineers leave the workforce. The British Chambers of Commerce revealed that manufacturing was facing the largest skill shortage in 30 years; 40% of U.K. manufacturers report 40% of their workforce are above the age of 50, and 81% struggled to fill open roles.[64] The labor gap is exacerbated by evolving demographics: only 19% of parents reported encouraging their children to pursue careers in manufacturing.[65] Thus, manufacturers find new ways to ensure they have the talent they need.

Data and data analytics can help manage some of these issues. Still, manufacturers have problems like connectivity interference and inadequate coverage. As a result, not enough data is being gathered and processed to yield actionable information. Indeed, 36% of manufacturers cite a lack of available data and insights as their biggest frustration.[66] Without enough data, manufacturers face an uphill battle in overcoming these hurdles.

COVID-19 Impact

The coronavirus pandemic has disrupted supply chains and shuttered businesses around the world, impeding production by restricting shifts and closing some factories. Manufacturers today are anticipating a change in operations in the future to strengthen their resiliency and increase visibility.

How 5G Can Help

At the highest level, 5G gives manufacturers the ability to sense and respond, facilitating efficient communications between people and machinery. 5G provides secure, pervasive connections throughout the shop floor and a level of automated movement, synchronization and control that wasn't possible before. Manufacturers can use 5G with other complementary technologies to draw insights and respond to improve precision, productivity and efficiency.

UK wireless operator O2 estimates that **40 megatons of carbon** can be saved by using **5G networks for manufacturing**

5G also improves sustainable manufacturing. In 2017, manufacturing contributed to 12% of GHG emissions globally;[67] however, 5G can help track and reduce consumption through improved flexibility and visibility.

O2, a U.K. wireless operator, estimates that using 5G networks for manufacturing in the U.K. will remove 40 megatons of carbon by 2035;[68] scaling this to the European continent would have an even more profound effect on the environment.

Economic Impact

Since manufacturing touches almost everything globally and significantly contributes to GDP, it is a key strategic area for 5G. 5G is expected to provide a direct productivity increase to the manufacturing industry in both sales uplift and cost savings. Based on Accenture analysis, manufacturing will see an incremental sales uplift up to €458.3 billion across the E.U. member states and the United Kingdom, or 1.4%.

Manufacturing industry

€458.3B in new 5G revenue

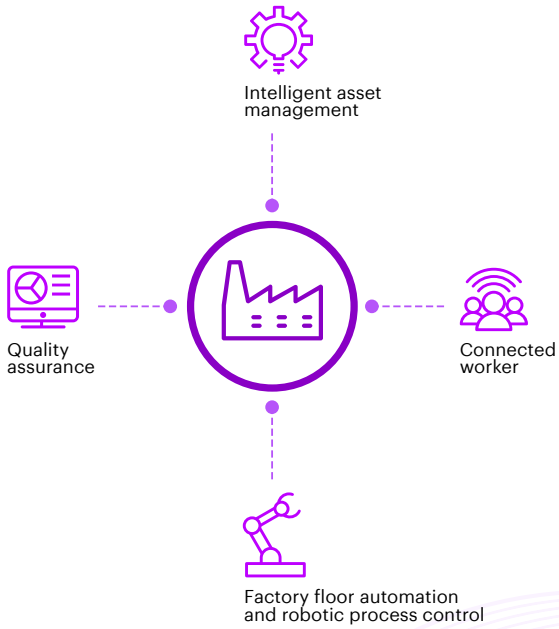
	Direct industry impact	Total value chain impact	Multiplier effect
Gross Domestic Product	€131.8B	€431.9B	3.3x
Labor Income	€67.6B	€133.8B	2.0x

Jobs and Employment

5.4M jobs[w]

Note: Multiplier is calculated as the ratio of total value chain impact to direct industry impact.

Source: Accenture Analysis

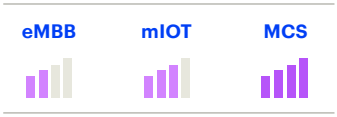


Manufacturers will not only be creating the components, devices and infrastructure that enable 5G, but also the products that will be used in other 5G applications. Each industry's manufacturing operations will require distinct equipment from each of their providers and will in turn provide different end-products down the value chain. This increase in demand for 5G-enabled equipment and services will create or transform jobs, resulting in a direct GDP impact of up to €131.8 billion. This direct impact will cascade throughout the economy, including materials providers, logistics companies, OEMs, retail, and other businesses.

w Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

5G Use Cases and Benefits

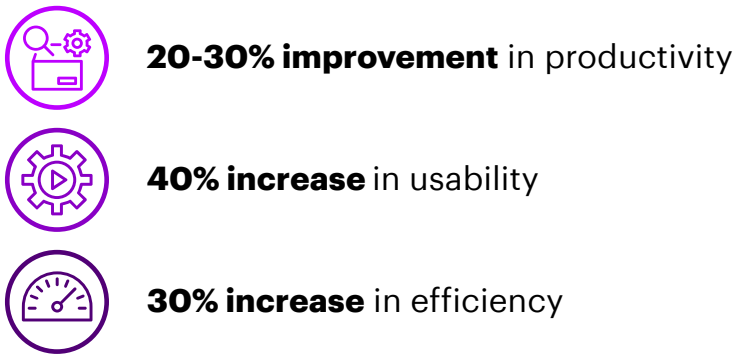
Manufacturers acknowledge the importance of digital transformations to drive productivity. Yet, today, less than 30% of manufacturers globally report extensive adoption of digital technologies,[69] including 5G. Overall, activating multiple use cases in tandem using 5G and other enabling technologies such as edge computing and AI will yield 20% to 30% productivity gains.[70] Below we will discuss four key use cases in manufacturing: factory floor automation and robotic process control; intelligent asset management; the connected worker; and quality assurance.



Source: Accenture Analysis

Factory Floor Automation and Robotic Process Control

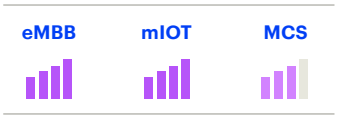
Factory floor automation and robotic process control encompasses applications like mission-critical remote control of machines, synchronized robots and smart logistics with automatedly guided vehicles (AGVs). Though complete factory automation represents a longer-term transformation, some synchronized robots and AGVs can be implemented in the short-term, ultimately contributing to about 10% of 5G-enabled GDP in manufacturing.[71]



Source: Accenture Analysis

Ford,[72] which brought 5G private networks to one of its electric vehicle (EV) plants, believes that the factory of the future will need to be able to quickly reconfigure facilities to address rapidly changing needs. Wireless control of machinery allows manufacturers to optimize their floor layouts and improve reconfiguration times, ultimately leading to more efficient production. Low latency is essential for mission-critical remote control and human-machine interactions to promote coworking and safety. In addition, factories equipped with 5G can be used to further analyze and optimize their floors for power consumption and output efficiency; for example, AGVs that can detect and optimize their routes in real time will reduce vehicle journeys, ultimately resulting in less wastage.

Nokia recently used AGVs and 5G private networks to improve manufacturing logistics. Nokia's AGVs were initially connected to a dedicated Wi-Fi network, but coverage was insufficient, requiring manual reconnection.[73] 5G significantly improved material transportation without requiring separate network reconfigurations. The company saw a 40% increase in operational equipment effectiveness (OEE) and a 30% increase in efficiency. It also reported a 98% decrease in maintenance work, changing the cadence from daily to monthly and the time interval from hours to minutes.



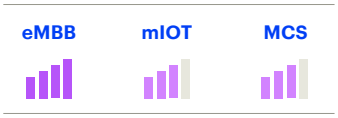
Source: Accenture Analysis

Intelligent Asset Management

Intelligent asset management enables better visibility, management and control of assets. This includes capabilities for real-time asset-health monitoring and predictive and prescriptive maintenance to reduce unplanned downtime, extend the useful life of assets and improve key metrics, such as mean time between failures (MTBF). Intelligent asset management will contribute about 15% to 5G-enabled GDP in manufacturing, driven by its large impact on unscheduled downtime and capital expenditures.

Non-invasive techniques such as attaching sensors and using UHD video analytics are immediately available solutions. With the vast data collected, AI can predict the remaining useful life of an asset and detect developing defects before they go critical. This allows maintenance and operations to schedule targeted repairs at a time that minimizes costs and impact to production. Asset owners can get the most out of equipment instead of replacing good components unnecessarily, resulting in not only cost abatement, but also waste and CO2e abatement from excess parts manufactured elsewhere.

Accenture and KPN, a Dutch telecommunications company, brought 5G to Shell's refinery to test industrial applications, including pipe maintenance.[74] UHD cameras scanned 99,000 miles of connected piping, then processed the data using machine learning to identify high-risk corrosion areas and determine the best corrective actions.[75] Predictive maintenance can reduce inspection costs by 10% to 20%, improve uptime and productivity by over 10% and increase asset life by more than 20%.[76] 5G allows manufacturers to "sweat their assets" by maintaining asset integrity and maximizing its useful life.



Source: Accenture Analysis

Connected Worker

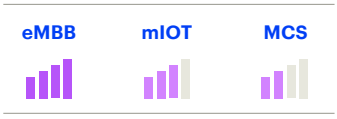
Connected worker technology offers employees a safer and more seamless work experience, including use cases such as location monitoring and remote inspection, worker safety, and enterprise training using XR. By enhancing the work experience, manufacturers can upskill their workers while monitoring floor safety. These productivity improvements will contribute up to 5% to 5G-enabled GDP in manufacturing.

5G has the potential to improve the AR/VR experience by enhancing the quality of immersion through increased throughput, lower latency (worker safety, minimal buffering) and greater mobility (the ability to cope with quick movements, such as constant head movement). AR/VR can be used across the value chain. AR/VR in field service can improve first-time fix rates by 20% to 40% for technicians and reduce injuries by 5% to 15%.[77] On the floor, AR/VR can reduce downtime by 10% to 35%, lower scrap and rework by 15% to 25% and reduce assembly time by 20% to 50%. With 5G, companies can upskill their workforces quickly and drive additional productivity per worker. Combining improved productivity and reduced wastage from scrap material will also result in a more sustainable, environmentally friendly factory.

Lockheed Martin has implemented AR-based how-to manuals for building spacecraft components.[78] The AR solution includes assembly animations, helping reduce the time required to interpret instructions by 95% and overall training time by 85%. It has also boosted productivity by more than 40%. In addition, the company's space unit used AR to realize savings of roughly $38 (€34) per fastener; for a company that buys more than two million fasteners per year, that's equivalent to $76 million (€68 million) in savings.[79]

Field Service
Technician productivity, safety and effectiveness: 20-40% improvement in first time fix rate, 5-15% reduction in injuries

Manufacturing and supply chain
Increased worker productivity, quality and safety: 10-35% reduction in downtime, 15-25% lower scrap and rework, 20-50% reduction in assembly time



Source: Accenture Analysis

Quality Assurance

Quality assurance monitors and reacts to quality breaches through in-line quality monitoring, digital quality inspection and precision monitoring. Improving quality monitoring processes via 5G will also naturally boost overall productivity, using cameras, sensors and AI to provide up to a 50% increase in quality testing throughput and a 90% improvement in defect detection.[80] Reducing scrap from defects and pseudo-defects will contribute up to 3% to 5G-enabled GDP in manufacturing.

50% increase in quality test productivity

90% improvement in defect detection

5G increases network capacity, providing easy access to UHD video streams and sensor data. With rapid access to high volumes of data, manufacturers can use analytics to help identify defects and dynamically test based on real-time conditions, improving on scrap rates and total cost of quality.[x] Furthermore, 5G's mission-critical service and low-latency properties can support rapid response to the program's results, providing immediate feedback to correct upstream processes and remove scrap. Correctly identifying defects and pseudo-defects will directly reduce wastage for both power and raw materials.

For example, Bosch implemented industrial AI to improve its quality processes. The operation used cross-value-stream analytics to optimize downstream processes, identify cross-component influences and reduce manual visual inspection efforts.[81] By automating optical inspection, the company achieved a 0% escape rate[y] and a false-alarm rate below 0.5%.[z] In addition, Bosch was able to remove redundant tests and predict calibration settings, resulting in a reduction of 45% in test time and a savings of $1.3 million (€1.5 million) at a single plant.

5G Adoption Challenges and Mitigations

Although these use cases and their benefits are tangible, manufacturers struggle to adopt 5G technology, facing two main challenges: the large upfront investment and device and ecosystem readiness.

Investments and ROI

Capital expenditures are one of the largest outlays for manufacturers, who expect their legacy infrastructure to last 10 to 20 years. Manufacturers hesitate to invest before they have a clear idea of potential benefits because of the high impact on output. Because of this risk, they seek reassurance in a clearly defined ROI and will slowly retrofit new technology over longer time horizons. 92% of U.K. manufacturers report that the government needs to incentivize long-term investments and supply patient capital to remain competitive.[82] Although the investment may be prohibitive at the firm level, the benefits of adopting 5G will ripple throughout the broader economy, far beyond the ROI of an individual plant.

x Total cost of quality is defined here as the aggregate cost of poor quality or product failures, as well as expenses incurred to prevent or resolve quality problems.
y The escape rate is defined as the percentage of defective products that were not identified by quality assurance teams.
z The false alarm rate is defined as the number of false defect detections per total number of detections.

The government can facilitate adoption of 5G technologies by providing prescriptive policies and creating financial incentives. For example, the United Kingdom and German governments have set aside £40 million for 5G trials[83] and €400 million to develop Industrie 4.0, respectively.[84] These initiatives successfully kickstarted adoption; Vodafone and Ford received £65 million in public funds to create a 5G smart factory.[85] While this shows progress, these funds are still small relative to the size of their respective economies; a significant, coordinated public investment plan to drive 5G adoption will yield the most benefits.

Device and Ecosystem Readiness

Manufacturing infrastructure today is fragmented with a mix of legacy and new technology protocols. Equipment providers focus on proprietary protocols to ensure product stickiness. In a heterogeneous connectivity landscape populated by competing standards, manufacturers frequently do all they can just to make the current products work for them. Moreover, there are few commercially ready 5G-ready devices available in the ecosystem, partially due to the early stages of the technology adoption for manufacturing. Finally, manufacturers are wary about data privacy, noting security and access as key concerns.[86]

New devices must be developed in conjunction with progress on networks, with backward compatibility for retrofitting. Upgrading new devices will not only enable manufacturing's use cases, but also create additional value for equipment providers by increasing capability and compatibility. Leading groups such as the Open Platform Communications (OPC) Foundation are pushing for the inclusion of 5G into roadmaps to enforce interoperability; the government can also ready the industry for adoption through incentives and guided policy that promotes adoption of technologies and devices compatible with 5G. Policymakers can also facilitate R&D by fostering an environment that promotes innovation and competition while protecting IP.

Policy Example: South Korea

South Korea is pushing adoption of 5G and smart-factory technology, with a goal of 30,000 smart factories in the country by 2025.[87] The major telecommunications networks are offering 5G-enabled services that help enhance the efficiency of existing systems, including smart sensors to determine maintenance schedules. Creative plans to help onboard small and medium enterprises, including subscription-based smart-factory solutions and free trials have been established. With guided policy and cooperation across all ecosystem players, the country has been able to coordinate solution development while bringing manufacturers along.

COVID-19 Impact

One major concern is that manufacturers may be cash-strapped, delaying capital expenditure, IT and operational technology budgets. However, firms that invested in and integrated new technologies recovered faster.[88] Though connected businesses are a well-known practice, COVID-19 has shown manufacturers that it is a critical time to explore automation technologies due to physical distancing requirements. This year, BMW saw an opportunity in stalled factories to install new technologies, including AI-powered quality-control checks.[89] Automation tools that formerly took years to fully roll out can now be installed in months, with the COVID-19 crisis acting as a catalyst for testing and adopting new technologies.

Conclusion

The manufacturing industry has much to gain from the adoption and implementation of 5G technologies. By activating use cases such as factory-floor automation, intelligent asset management, connected workers and quality assurance, manufacturers could see a direct sales increase up to €458.3 billion in the European Union and United Kingdom. This growth would cascade through materials and equipment providers and throughout the value chain, resulting in a direct GDP impact of up to €131.8 billion and an additional €300.1 billion across the value chain. Companies must overcome several hurdles regarding investment and ecosystem readiness, but policymakers can facilitate adoption in the industry through efforts such as earmarked funds and guided policy.

Automotive and Transport

5G technology will enable smarter, safer, greener and more efficient transport from connected vehicles and transportation infrastructure across Europe.

The next five years of 5G impacts in the automotive and transportation sector will drive:

€220.5 billion in additional industry revenues
€89.5 billion in added GDP contributions
3.2 million jobs created or transformed[aa]

The low latency, massive capacity and enhanced bandwidth of 5G will be instrumental to a variety of use cases:

Highlighted use cases	Potential benefits		
	New end services/product	Efficiency/ productivity	Resiliency
Enhance vehicle safety and automation	●	●	●
New intelligent transport systems	●	●	●
Connected and automated train operations (ATO)	●	●	

Source: Accenture Analysis

Industry and Technology Context

The automotive and transport sector plays a critical role in European economies and mobility throughout the continent. Together, this sector represents more than 10% (€3 trillion) of the combined European Union and United Kingdom gross output in the year 2019.[90]

Decreasing sales numbers have intensified competition among OEMs and are contributing to the impetus for industry transformation. Studies estimate that E.U. vehicle sales growth has slowed year over year[91] and that vehicle production has dropped from 16.4 million[92] in 2017 to 15.8 million[93] in 2019. The major technology trends behind the evolution of both automotive and transport business models are captured by the term C.A.S.E. (Connected, Automated, Shared, Electrified). Enabling all four of these mega-trends is none other than 5G communication technology.

By 2030 European rail transport is expected to experience passenger and freight demand growth of 30% and 34%, respectively.[94] That said, many European rail operaters are already running close to full capacity, and delays due to rail switches alone are totalling an estimated to 92 million minutes every year.[95] With a rapidly shrinking capacity buffer, train delays will cascade through rail networks far too easily. Because of the enhanced capabilities of 5G, there is reinvigorated attention for railway connectivity and train

aa Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

automation. Investments in these two major technological transformations will not only combat capacity issues but also improve the safety, sustainability and social accessibility of mobility in Europe.

Connected
Equipping vehicles with cellular connectivity will enable new services and capabilities through over-the-air updates.

Automated
The transition from cruise control to automated lane changing and eventually no driver at all is receiving a lot of industry attention.

Shared
Mobility-as-a-service (e.g. Uber, Lyft, Zipcar) is becoming an increasingly popular mode choice.

Electrified
Concern for sustainability and recent battery innovations have given the electric vehicle movement substantial momentum.

Modernization of Rail
To support the digitization, sustainability, and competitiveness of rail transport, European railway authorities are promoting the European Rail Traffic Management System (ERTMS)—a system of standards that includes:

Connectivity
The existing 2G standard for rail connectivity, GSM-R, is soon to be succeeded by a giant leap in capabilities with the 5G-powered Future Railway Mobile Communications System (FRMCS).

Automation
The European Train Control System (ETCS) is a signaling standard of ERTMS laying the foundation for automated train operations (ATO) and significantly reduced energy consumption in rail.

Source: Accenture Analysis

COVID-19 Impact

The shutdown and lingering conditions caused by the pandemic may have affected as many as 15 million automotive and transport jobs across the European Union and the United Kingdom.[96] Automakers and rail operators alike are finding it harder to stay profitable and combat the reduction in sales caused by a drastic reduction in the mobility of businesses and consumers. It will take a lot of time for the sector to return to some level of normalcy.

Automotive production interruptions taking place across globally connected supply chains has made it near-impossible for some OEMs to assemble a complete vehicle today. Going forward, the industry will need to focus on dual-sourcing strategies[bb] as a precaution against similar supply-chain disruptions. And to keep customers engaged, amidst historically decreasing sales trends, the industry may need to transition to online, mobile and contactless sales channels as well as virtual trade fairs. As pandemic conditions ease and customers return, the automotive recovery process will be difficult and expensive. It will require OEMs to synchronize a disordered supply chain and idle workforce back into the highly coordinated process of just-in-time production. The visibility of the manufacturing process that 5G-enabled technology can create will help with this.

Travel restrictions and sanitary measures have led to drastic reductions in rail travel, and as the situations vary in each country, pan-European transport will be difficult to resume. Safeguarding

bb Dual sourcing is a means of supply chain risk diversification that involves leveraging two unrelated suppliers for the same component, such that any disruption to one does not impact the supply from the other.

passengers and employees is of primary concern for rail authorities, which has required a variety of new operator procedures and investments.[97] Rail transport remains an important and sustainable mode of transport in Europe, and despite the remaining obstacles for operators, ERTMS infrastructure upgrades are still viewed as a pan-European priority.[98] If the industry can continue its digital evolution, it may even be instrumental to its resiliency against future disruptions. New connected services, more automated operations and network-enabled safety measures could address a variety of the challenges imposed by social distancing.

How 5G Can Help

Over the course of the next decade, investments in 5G networks and enabling technologies such as multi-access edge computing (MEC) will transform the automotive and transport sector. Vehicles and railways will become smarter, safer, greener and faster. Using 5G's increased device capacity, all private vehicles, enterprise road fleets, road infrastructure, rolling stock and railway infrastructure will be able to tap into the power of the Internet. New low-power networking equipment will maintain feedback loops between rail and road vehicles and the infrastructure with more efficient energy consumption. The 5G network's enhanced bandwidth will provide the network speeds required to capture and analyze video data from various sensors within vehicles and on the roads in real time—not to mention support nearly boundless entertainment streaming options.

Mission-critical to realizing the future of both connected and automated mobility (CAMs) as well as the automation of high-speed rail transport is 5G's ultra-reliable low-latency, which ensures that information can travel between devices nearly instantaneously to make vital driving decisions and maintain effectively 100% network reliability. The combination of these powerful 5G capabilities will result in improvements in travel efficiency, substantial reductions in crashes, lives saved, better access to transport services, lower pollution and CO2 emissions, and a more productive economy overall.

Economic Impact of 5G

Automotive and transportation industry

€220.5B in new 5G revenue

	Direct industry impact	Total value chain impact	Multiplier effect
Gross Domestic Product	€89.5B	€300.5B	3.4x
Labor Income	€51.8B	€95.6B	1.8x

Jobs and Employment

3.2M jobs[cc]

Note: Multiplier is calculated as the ratio of total value chain impact to direct industry impact.

Source: Accenture Analysis

cc Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

5G in the automotive and transport sector will drive up to €300.5 billion in total GDP across European Union member states and the United Kingdom. Road and rail vehicles are essential to a vast number of public and private sectors, including delivery and logistics, agriculture, construction, emergency services, tourism, public transit and, of course, consumers and commuters. Over the next five years, the effects of 5G will boost European automotive and transport revenues by up to €220.5 billion, and up to €89.5 billion in direct GDP impacts. These figures encompass sales of CAMs, connected services from automakers and rail operators, mobility-as-a-service business models, improved logistics solutions and more.

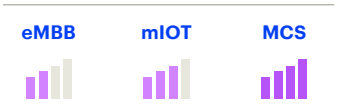
The indirect economic impact of 5G on automotive and transport supply chains could generate up to €85.9 billion in additional GDP. These supply chains include everything from raw materials processing (e.g. metals and plastics) to chipsets, sensors and cameras for connected road or rail vehicles and infrastructure. In addition, governments and private mobility operators will be investing heavily in massive construction projects to roll out 5G-enabled road and rail infrastructure. The incremental labor to support this level of economic growth could create or transform up to 8.0 million jobs across the value chain, generating approximately €95.6 billion in labor income. Software developers, device designers and equipment engineers will account for a large proportion of these positions, given the increasing digitization of road and rail vehicles as well as new over-the-air mobility applications.

5G Use Cases and Benefits

Connected vehicles can transmit data through various types of M2M communications. These vehicles will exchange data with road infrastructure (V2I), other vehicles (V2V), pedestrians or cyclists (V2P), power grids (V2G) and of course, wireless networks (V2N). Enabled by 5G, cellular vehicle-to-everything (C-V2X) connectivity underpins a variety of new use cases being advanced by the major technology trends discussed above

Likewise, train transport—particularly long-distance heavy rail—has a similar array of connectivity types due to the complex environments being traversed as well as the needs of its passengers and freight. The key network linkages include train-to-infrastructure, inter-carriage (between carriages), intra-carriage (for devices on or within each carriage), in-station wireless access and infrastructure-to-infrastructure.[99]

In this paper, we will be exploring the economic, social and environmental benefits of three important applications of 5G in automotive and transport: 1) enhanced vehicle safety and automation; 2) intelligent transport systems (ITS) or smart traffic management; and 3) connected and automated train operations (ATO).



Source: Accenture Analysis

Enhanced Vehicle Safety and Automation

The advanced capabilities of 5G promise to bring an ecosystem of automated vehicles and machines to reality. That being said, there are many incremental steps on the way to a fully-automated vehicle, designated as Level 5[dd] per the International Society of Automotive Engineers (SAE) taxonomy.[100] While Tesla's Autopilot system demonstrated the viability of L2 vehicle automation, the next step for OEMs is to manufacture and sell L3-enabled vehicles. Among Japan and South Korea, the

dd Vehicle automation is classified as level 0 (no automation), level I (cruise control), level 2 (advanced driver assistance systems; e.g., acceleration, braking and steering), level 3 (conditional automation—vehicles self driving in many, but not all, situations), level 4 (automated vehicle but with driver override), and level 5 (self-driving in all situations).

European Union has aligned on new regulations that will come into effect in January of 2021 to permit L3 automated vehicle systems under certain speeds and road conditions.[101]

In conjunction with 4G LTE, 5G plays a key role in one of the most promising wireless standards for CAMs, cellular vehicle-to-everything (C-V2X). 5G-V2X has both short-range and long-range capabilities, allowing vehicles to communicate with devices in the immediate and distant surrounding. Effectively, 5G-V2X gives vehicles the ability to look through multiple cars ahead and instantaneously predict how hidden vehicles will react to events just up the road. M2M offers simultaneous two-way communications for a massive number of vehicles and devices using C-V2X and ultra low-latency helps ensure vehicle safety given the reaction times required in fast-moving CAMs.

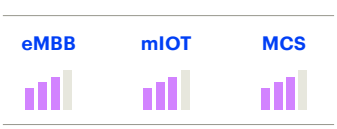
Initially 5G-V2X will support early iterations of self-driving vehicles in supervised, enclosed areas (e.g. private campuses) with virtually defined perimeters (i.e. geofencing) as well as tele-operated driving and automated parking in these controlled environments. With 5G network coverage, these two use cases can be extended into less controlled environments such as public parking lots and, ultimately, roads. 5G will also enable cooperative maneuvers and long-range sensor sharing, which require 10-millisecond service latency.[102] This would mean that existing highway traffic must be able to initiate a speed adjustment almost instantaneously after an incoming vehicle prepares to merge from the on ramp.

Safety applications like these are top of mind for O2 and London's Smart Mobility Living Lab, who have teamed up to test 5G connectivity for driverless vehicles using V2X communications.[103] They will be starting with 3.4-GHz 5G-ready spectrum to test the real-world applicability of CAMs on both public and private roads in London.

Highly automated driving systems could free up to 95 hours a year for commuters, and save **400,000 metrics tons of CO2** in 2025 alone

These C-V2X applications offer a glimpse of the near-term possibilities of 5G, which are expected to have powerful impacts on the environment and public safety. Automotive supplier Bosch estimated that by 2025, in Germany alone, automated vehicles could prevent more than 30,000 crashes or 70% of rear-end collisions, equating to €450 million in repair and collision cost savings.[104] In addition, highly automated driving systems could free up to 95 hours a year for German commuters and save 400,000 metrics tons of CO2 in 2025 alone—the same amount that Germany's Black Forest National Park produces over three years.[105]

Overall, C-V2X connected vehicle automation and sales over the next 5 years is estimated at up to 30% of the economic impact of 5G in the European automotive and transport sector.



Source: Accenture Analysis

New Intelligent Transport Systems

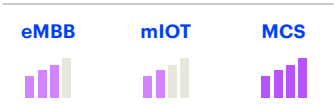
5G technology can completely transform traffic-management systems and road infrastructure such as road signage, toll collection, road monitoring and traffic lights. In addition, 5G-enabled transport infrastructure can facilitate new vehicle safety solutions, advanced weather analysis, enhanced public transit, smart parking management, etc.

Where V2V use cases need all nearby vehicles to be equipped with M2M communications technology, ITS use cases generate immediate value for both connected and non-connected vehicles. And as more vehicles come online, 5G networks have the quality of service (QoS) features to give preferential allocations of the network to safety-critical messages, such as emergency services.

There is an extensive list of V2I services that can be found through the European Commission's C-ITS platform, some of which have been deemed as "Day 1", or technologically ready for deployment today.[106] One such possibility is Traffic Signal Priority Pre-emption Requests, which equip emergency vehicles to be dynamically granted green lights and also signal nearby vehicles to yield right-of-way. In the United States, the city of Detroit has been spearheading early V2I applications including signaling priority for emergency services and has demonstrated 20% improvements to response times.[107] This example demonstrates the advantages using just one local area of intersections, that can be scaled thereafter.

It is estimated that traffic congestion costs 1% of the European Union's GDP, which equates to €100 billion every year.[108] In the United Kingdom alone, traffic congestion costs may reach €307 billion or €2057 per household in 2030.[109] The European Commission views Cooperative Intelligent Transport Systems (C-ITS) as a key enabler to the future of automated driving and estimates that the long-term benefits outweigh costs by as much as three to one.[110] Early experiments, such as the Alibaba City Brain's smart highway project in China's Hangzhou province, have demonstrated the substantial potential benefits of connected infrastructure with 15% fewer crashes, 15% less traffic congestion and 20% greater workload efficiencies for the road response teams.[111]

Investments in intelligent transportation systems are foundational because they lay the groundwork infrastructure for improved vehicle automation and expanded telematics offerings. These systems are likely to drive only 5% of the total economic benefit from 5G in the sector (primarily from improved smart parking utilization and connected toll-road demand and collections, among others). Nevertheless, it is imperative to advance these systems to enable an ecosystem of benefits that are related to vehicle automation and expanded telematics, like improved passenger safety and faster commutes.



Source: Accenture Analysis

Connected and Automated Train Operations (ATO)

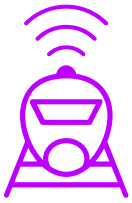
In some European cities, there are trains already operating at the 4th grade of automation.[ee] That said, this level of automation has been exclusive to light-rail metro systems; heavy rail has yet to reach advanced grades of automation due to a variety of factors. These factors include complex environments, train type variety, long distances, complicated station layouts and volume of potentially conflicting trains operating simultaneously. With the 5G-enabled FRMCS rollout, increasingly automated train operations (ATO) will be finally possible in heavy rail. This will deliver substantial improvements to safety, energy consumption and social access, in addition to introducing a variety of new mobility services.

In the near-term, improved wireless connectivity at stations can support real-time monitoring of ticketing queues, real-time passenger capacity rates and better services for passengers. 5G will enable the predictive maintenance of rolling stock and rail infrastructure using AI and video data, as more trains are retrofitted with sensors and connected technology. MEC and a 5G-powered railway communications system will deliver the computing power and service-level latency required of these data-heavy smart-rail applications.

ee Grade of Automation (GoA) has four levels: At level 1 there is no automation in driving, but assistance systems such as automatic train protection can engage the brakes when at risk; at level 2 the train drives automatically once staff initiates it and a human driver is still on stand-by for manual override; at level 3 the train has automated departure and adaptive block distances, but still requires staff for emergencies; finally, at level 4 the train can be completely unattended for all functions.

With a more pervasive deployment of IoT and FRMCS across Europe, the challenge of creating a driverless (GoA-3) or unattended train operation (GoA-4) in heavy rail will be achieved. These highly automated operations will involve more adaptive block[ff] distances and real-time monitoring of track conditions, which will substantially improve the capacity utilization of rail infrastructure. 5G is the only technology that can enable these railway advancements due to its wide area MCS capabilities. The ultra-low latency ensures instantaneous reaction times and reliable connectivity, even if a train is travelling up to 500 kilometers per hour.

Many European rail operators have started experimenting with 5G due to the known benefits of ATO. Among others, Siemens, Nokia and German Rail (DB) are developing a standalone 5G system to test ATO in 2021.[112] Thales and Vodafone have partnered to test-run driverless trains controlled through 5G networking slicing[113] and FirstGroup and Blu Wireless have announced a project to deploy track-to-train 5G broadband to high-speed trains.[114]



The more consistent driving patterns of **automated trains** could **reduce energy consumption by 20%**

By making trains more accessible and schedules more reliable, these innovations in railway communications can address the 38% of train delays that exist today due to unpredicted asset maintenance.[115] Additionally, ATO can save the average commuter up to five hours per year and reclaim the £440 million in lost productivity in the United Kingdom.[116] Despite already being one of the most sustainable modes of transport, the more consistent driving patterns of automated trains could reduce energy consumption by at least 20%.[117]

The 5G overhaul of railway systems is a massive pan-European endeavor with investments that will cascade through the economy. An aggressive deployment in the near-term could drive 5% of the total economic benefit from the automotive and transport sector, through more connected and automated operations that improve efficiency, accessibility and demand for rail.

5G Adoption Challenges and Mitigations

Modernization and Security of the Connected Vehicle

A substantial challenge for the CAM ecosystem will be ensuring end-to-end cybersecurity from each vehicle and other connected devices, through the edge or cellular network and out to the cloud. The technology that enables the mechanical processes within a vehicle to be software controlled are the many electronic control units (ECUs) interconnected by a digital nervous system, known as the standard CAN bus.[118] The issue is that this 30-year-old standard was not designed with wireless IoT security in mind. It lacks basic security features such as message authentication and device attestation. In 2016, the Keen Security Lab of Tencent demonstrated these vulnerabilities by wirelessly hacking into a connected car.[119]

To address such concerns among others, the Automotive Information Sharing and Analysis Center (Auto-ISAC) was formed to share global intelligence related to vehicular cybersecurity risks and capabilities.

ff A unit of measurement in both distance and duration that is used to allocate rail tracks to rolling stock. With 5G, there will be more capacity because each block unit can be minimized, fit-for-purpose and dynamically adjusted.

Beyond security risks related to hackers, there is a substantial amount of vehicle data (recall, some 100 million lines of code[120]) that legitimate businesses will seek to access. Fortunately, in 2020 the European Data Protection Board (EDPB) published personal data use guidelines for connected vehicles and mobility applications that include sensitive information such as geolocation data, biometric data or legal infractions.[121] As new connected vehicle services evolve and continue to grow, these guidelines and the legal actions that follow will need further development at a commensurate pace.

Regulatory Decisions on Pan-European Device Standards

The deployment of CAMs and connected road infrastructure around the world is caught between two opposing device standards. These technologies include the well-established short-range standard DSRC and the more recent standard of C-V2X, which can be used for both short-range and long-range communications over cellular networks.

Despite increasing global support and European automakers such as Audi shifting their vehicle designs towards the use of C-V2X,[122] the European policy environment continues to drive industry uncertainty around 5G. In April 2019, the European Commission put forward a proposal to adopt DSRC technologies as the vehicle-to-everything standard, which was not only viewed as contrary to its own support for 5G-enabled mobility in Europe but also received a considerable amount of pushback from the connected vehicle ecosystem.[123] Likewise, the proposal did not pass and little progress has been made to date.

Until industry and regulator alignment occurs, the two technologies may be slow to deploy without concerted guidance from authorities. Technology standardization in Europe is particularly important to ensure cross-border interoperability. Moreover, a concerted effort to harmonize devices would ensure that modernized vehicles and infrastructure do not bear the full costs of deploying both standards.

Recently, the 5GAA conducted a study on the cost of delivering intelligent transport systems (ITS) through cellular networks versus the dedicated road-side units (RSUs) used in short-range communications and discovered it is significantly less expensive using cellular technology.[124] These findings suggest that wherever possible local and national authorities should accelerate the deployment of cellular-based ITS solutions, knowing that the systems have the ability to leverage today's LTE networks and will be future-proofed for 5G.

Fortunately, whichever device standard is adopted going forward, both will benefit from the European Commission's decision to maintain the purpose of the 5.9 GHz spectrum band and even expand the spectrum allocated to road and urban-rail transport.[125]

FRMCS Deployment and Spectrum Requirements

The European Union and European authorities have an important role to play in the migration from GSM-R to FRMCS and the licensing of necessary spectrum bands during migration and thereafter. While almost a dozen new projects have received a total of €400 million in public investment through the E.U.'s 5G-PPP initiative,[126] and private case studies have highlighted the industry's engagement, concerns remain regarding timelines.

With respect to migration from GSM-R to FRMCS, European authorities will need to find ways to accelerate deployment and incentivize rail operators. Up until 2025, there may still be investments underway to upgrade rail operations to GSM-R as well as the signaling standard known as ETCS.[127] These massive

up-front costs, combined with the replacement life cycle of railway equipment, suggest that GSM-R will remain for another 15 years and FRMCS will need to co-exist. It will be more costly to leverage two systems in parallel, but the future of rail must become digital in order to remain competitive and support increasing demand. In addition, the near 30-year and still on-going ETCS roll-out highlights that the need to act fast. Close cooperation between the European Union and the International Union of Railways (UIC), which founded the FRMCS standard, will be necessary to establish the appropriate legal decommissioning obligations for Class B systems and the removal of upgrade exemptions. Furthermore, national authorities may need to increase funding mechanisms to support migration and help to ensure rapid implementation without harm to the rail operators' business case.

Along with costly transitions, the industry will require some certainty with respect to spectrum availability for FRMCS, given its requirements for dedicated mission-critical connectivity. The UIC aims to obtain both low- and mid-band spectrum during the GSM-R-to-FRMCS migration period and thereafter. Specifically, FRMCS aims to use the 900 MHz band that has inopportunely been deemed as attractive across various industries, the 1900 MHz band that is coming available due to expiring communications provider licenses and the 2300 MHz band that has historically been claimed for defense and security services (e.g. closed-circuit TV surveillance).[128] European authorities will be responsible for ensuring harmonization across borders and ensuring the optimal spectrum allocation between countries and industries in a timely fashion.

Conclusion

The future of automotive and transport is to leverage 5G to create feature-rich, secure and reliable connected and automated modes of transport that are seamlessly integrated with the surrounding road and rail infrastructure within cities and across countries. To achieve this goal, the industry will closely coordinate with telecommunications players as well as local and federal authorities. 5G has the potential to transform not just the automotive and transport industry, but also people's lives. European countries can accelerate their travel into the 5G future through heightened vehicle cybersecurity investment and policy support, a concerted effort to establish pan-European V2X interoperability and optimal spectrum allocations and upgrade requirements for rail operators.

Healthcare

5G technology will allow more mobile/home care, better patient outcomes and more capacity and flexibility within the healthcare system in Europe.

The next five years of 5G impacts in the healthcare sector will drive:

€77.0 billion in additional industry revenues
€51.2 billion in added GDP contributions
0.4 million jobs created or transformed[gg]

The low latency, massive capacity and enhanced bandwidth of 5G will be instrumental to a variety of use cases:

Highlighted use cases	Potential benefits		
	New end services/product	Efficiency/ productivity	Resiliency
Remote patient monitoring	●	●	●
Virtual consultations and care	●	●	●
Connected hospital	●	●	●

Source: Accenture Analysis

Industry and Technology Context

The healthcare industry in Europe accounts for a substantial portion of economic activity, including 10% of GDP[129, 130] and 7% of total jobs (as high as 12% in Sweden).[131]

Healthcare is facing fundamental shifts—longer life expectancies and the aging baby boom cohort are dramatically boosting demand for services, with increasingly complex medical cases and comorbidities. These factors are expected to drive the majority of the 5% to 6% growth in annual healthcare spend.[132] 80% of the current healthcare budget across Europe is driven by treatments for chronic disease, and 86% of deaths are linked to those same diseases, which will only grow with a graying population.

This surge in demand is going to result in extreme labor shortages. Studies have identified shortages for physician and nurse jobs in the hundreds over the years.[133] The situation is only getting worse: shortages across physicians, nurses and other healthcare professionals are expected to reach 4.1 million by 2030.[134, 135] Technology and more scalable models of care will be critical to bridging this gap.

gg Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

In parallel, healthcare is facing a new shift towards consumerization, with patients increasingly playing a more active role in health decisions and demanding more scrutiny in service choice. These challenges are compounded by both the high volume of health data being generated and new expectations for transparency and ownership.

COVID-19

During the pandemic lockdown, the virtual medicine trajectory in Europe made substantial progress in a matter of months. Still, the future outlook and lasting impacts remain uncertain; a hybrid model is likely in Europe as certain segments of consumers still value in-person physician relationships, and the structures for full virtual care as a replacement for in-person visits are not yet in place.

In Italy, historically a slow adopter of telehealth, but also one of the regions most affected by the pandemic, COVID-19 has caused a dramatic shift and accelerated the adoption of telehealth. 75% of physicians now believe telehealth plays a critical role, where perception used to be a major barrier.[136] At the same time, many European countries have updated their regulations and protocol to recognize and expand telehealth/telemedicine, opening the doors to more virtual care than ever before.

How 5G Can Help

Broadly, 5G is a critical enabler for Internet of Medical Things applications by providing:

- Rapid transmission and processing of high quality and quantity of medical data being collected by increasing number of wearables, multi-modal sensors, etc.
- Richness of in-person physician interactions to remote/home settings (rich bi-directional communication, HD video and a wide array of biometric and other sensors).
- Reliability and extreme low latency in critical patient applications.
- Mobility and ability to maintain the above across distances and at high speeds.

Economic Impact of 5G

Healthcare industry

€77.0B in new 5G revenue

	Direct industry impact	Total value chain impact	Multiplier effect
Gross Domestic Product	€51.2B	€79.7B	1.6x
Labor Income	€31.5B	€49.9B	1.6x

Jobs and Employment

.4M jobs[hh]

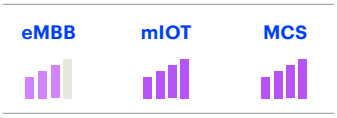
Note: Multiplier is calculated as the ratio of total value chain impact to direct industry impact.

Source: Accenture Analysis

hh Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

5G's impact on healthcare will be significant, driving up to €77.0 billion in economic output, €51.2 billion in GDP and up to .4 million jobs. These results stem from not only healthcare use cases and new services, but also from the impact of other industries. As revenue and associated tax contributions grow throughout the economy, reinvestments in healthcare systems will drive additional economic activity. Healthcare will also produce benefits that will be felt across sectors—our analysis predicts that one 5G job in healthcare will result in 2.5X total jobs throughout the economy, including in life sciences, medical device manufacturing, raw materials (extraction and agriculture) and more. Most critically, the improvements resulting from 5G will help workers and consumers live longer, healthier lives, driven by better patient outcomes and access, leading to a more productive workforce across the economy and more years of consumer spending.

5G Use Cases and Benefits



Source: Accenture Analysis

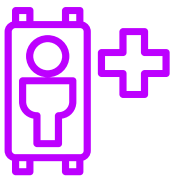
Remote Patient Monitoring

The cost, capacity and skilled labor constraints in healthcare are acutely felt within inpatient services, where beds, specialists and round-the-clock monitoring are in short supply. Remote patient monitoring has the potential to alleviate these constraints. Instruments can continually gather and analyze data on patients located off-site, sending alerts to initiate prompt intervention when needed.

Existing applications are limited by current connectivity technology consisting of periodic one-directional, passive sensors. 5G allows for more continuous, reliable and secure monitoring, with integration of multiple sensors with high data volume, critical for driving better patient outcomes, including.

- Short-term monitoring for patients with **sensitive/critical conditions**, including opportunities to treat in outpatient settings.
- Continuous loop of data and feedback to **manage chronic conditions, medication management and preventative care**.

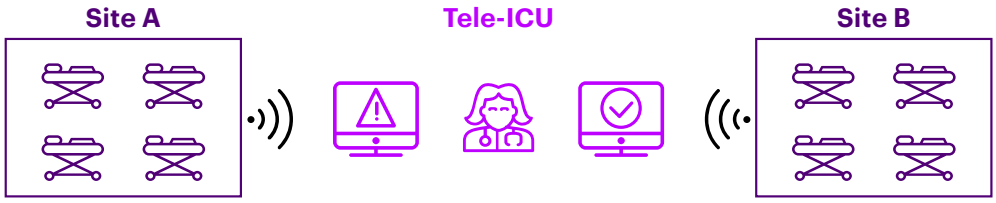
In **acute and post-acute care**, 5G remote patient monitoring is at the center of the next generation of hospital-at-home applications. Patients who are treated in the ER and assessed for suitability can instead be outfitted with remote monitoring devices and go home to essentially have a connected hospital bed in their own dwelling. A remote-care team can then monitor the patient's recovery and deploy in-person mobile staff only when needed. This results in shorter stays, reduced costs, higher patient satisfaction and better health outcomes.



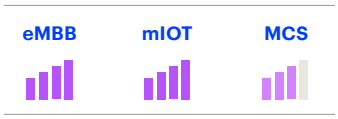
Connected **Hospital-at-Home** models offer **30% cost savings** and better **patient outcomes**

This model is already generating value, but the eligible conditions and level of acuity are limited. 5G's potential to incorporate more sensors and real-time feedback will not only improve the quality of care and economics of this model (e.g., leveraging AI with multi-modal data to pre-emptively predict intervention needs), but also expand the breadth and criticality of medical conditions it can serve.

Intensive care is one of the most expensive elements of healthcare: A single day of treatment costs as much as €2,025.[137] In the Netherlands, for example, ICU costs drive 20% of overall hospital budget, with costs per day, three to five times higher than for general wards.[138] ICU capacity is unevenly distributed across European states and demand is expected to rise rapidly with changes in demographics. The COVID-19 pandemic exposed vulnerabilities in this care segment and exacerbated shortages. The tele-ICU model allows a team of intensivists (and other health professionals) to remotely manage many remote ICU patients at once, using a "hub-and-spoke" model to expand capacity with much less investment from the health system. The approach also increases flexibility, allowing better management of supply and demand versus managing satellite sites in person, and can reduce length of stay by up to 50%.[139]



For **chronic and preventative care**, 5G will allow better in-home monitoring and better use of the explosive growth in medical data being driven by wearables and smart medical devices. Beyond the short interventions in acute and intensive care, healthy individuals and those with chronic conditions will be able to get a much richer picture of their health. With high-speed, high-bandwidth and secure data transfer, 5G will allow timely treatment through AI-driven risk prediction beyond what is possible today (e.g., predictive warning of impending heart attack or stroke risk). Early diagnosis and intervention significantly improve patient outcomes.[140] 5G offers the potential to delay disease states or prevent them from developing entirely. Together, this family of applications will drive substantial economic benefit for healthcare, including a reduction in hospital cost of up to 16% due to the use of wearable remote monitoring.[141] In total, remote patient monitoring is estimated to account for 30% of the 5G economic benefit. More important, the benefits in terms of healthcare quality and patient outcomes will improve the quality of life for millions of Europeans.



Source: Accenture Analysis

Virtual Consultations and Care

Barriers to healthcare access exist throughout Europe. In the United Kingdom, for example, only 13% of doctors went to hospitals serving rural areas,[142] and access to specialists often requires travel to urban centers. In 2019, more than 2% of Europeans reported having an unmet health need and delayed medical examination due to cost, long wait times or travel distance.[143] By removing the requirement of commuting and physically visiting a doctor's office, virtual consultations and care offer the promise of better health access from home and remove or lower many of these barriers, while improving patient outcomes and reducing cost.

5G can **improve virtual consultations and care,** which have seen increased traction

Telemedicine and telehealth are already a reality and have been accelerated by pandemic; France alone has seen millions of additional virtual consults during the crisis.[144] While current communications

technology is viable for voice and lower-definition video, 5G supports higher definition and more complex multi-modal data streams with bi-directional interaction. In addition, there's a critical relationship between virtual care and the remote patient monitoring solutions described previously: The longitudinal, rich data captured on patients will provide context that simply does not exist today.

The bandwidth and speed limitations of current wireless networks remain major barriers to expanding the scope of services that can be provided remotely. Services such as dermatology, wound care and cardiac care, for example, require high-definition and responsive images/video. As 5G drives improvement in accuracy and precision, countries and regulatory bodies will provide support and reimbursement for a wider set of care options and drive greater adoption of virtual care adoption.

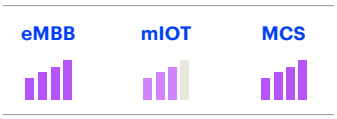
The opportunity created by virtual care also extends beyond the home. With 5G, large health networks will be able to share specialists virtually across sites, balancing coverage across locations to increase system capacity and provide a better overall standard of care. By partnering with larger centers and conducting remote specialist consults, rural hospitals and primary-care offices can offer access to services that aren't otherwise available in their community, and at a fraction of the cost.

To reach full potential, virtual care requires 5G-level connectivity. Remote consults can involve the transfer of massive amounts of data such as for MRI images or CAT scans. High-speed, high-bandwidth connectivity is essential to ensure effective and accurate coordination of care among patient, provider and specialist. In the future, the millisecond latency and high reliability of 5G may enable remote surgical consults, with the specialist weighing in or even performing surgery robotically from an off-site location. Without the reliability and millisecond latency afforded by 5G, this would not be possible.

In a real-world example, United Hospitals Birmingham has used 5G virtual care to bring scale to its health system. A remote facility staffed by lower-cost health professionals was set up to enable physicians to access stethoscope data, ultrasound scans and ECGs, increasing overall capacity.[145]

In addition to increasing access and providing more timely, cost-effective care, virtual health provides a safer alternative. Hospital-acquired infections (HAIs) are responsible for 3.8 million infections and nearly 90,000 deaths in Europe annually,[146] some of which would be mitigated with a shift to more virtual care and post-care.

Overall, virtual care applications are expected to drive 20% of the overall 5G-enabled economic impact, as a result of volume increases from new healthcare access as well as productivity/cost optimization throughout the system.



Source: Accenture Analysis

Connected Hospital and Ambulance

Hospitals are heavily reliant on wired connections for everything from surgical equipment to heart monitors, with dedicated rooms for specific types of care. Wired connections prevent rapid scaling up or repurposing of healthcare capacity and space; rooms are limited by their wired connectivity.

Previous generations of wireless connectivity have not had the reliability needed to truly untether hospitals. With 5G and private networks, adding or repurposing inpatient capacity is no longer reliant

on physical wiring, adding flexibility to respond to disasters (e.g., future pandemics, floods) by rapidly scaling up capacity. In China, this was critical to their COVID-19 response and ability to stand up 1,600 new hospital beds within 10 days at the Leishenshan and Huoshenshan pop-up sites.[147]

European hospital care is intertwined with ambulance services, a critical part of the healthcare system that is not only responsible for transporting a large proportion of patients to the hospital, but also plays a major role in on-site treatment and deflecting visits entirely. Depending on the country, between four and 33 ambulance trips are completed per 100 people and the models differ substantially: UK ambulances are staffed by paramedics and focused on transport, while those in France and Germany have physicians on board and emphasize remote treatment.

While existing ambulances are effectively isolated from the hospital other than basic communication. 5G offers a transformation of this relationship. In the near-term, better connectivity will allow for rich HD video and remote procedural equipment, supporting consultation of specialists for immediate response. This not only allows for more cases to be resolved and reduces hospital volume and wait times, but also ensures more prompt transfers and higher throughput for patients who do make it to hospital, as the local team has full context. Longer term, by unlocking V2I and V2V capabilities (see Automotive section), the connected ambulance will be able to clear traffic and ensure shorter response and transport times. UHB[148] and the Catalan research center[149] have separately developed successful trials of this technology, allowing access to remote specialists and completion of procedures, including ultrasounds, from remote locations.

Together, the benefits of connected hospital and ambulance applications are expected to drive 15% of the overall 5G-enabled economic impact, alongside the public safety benefits of reducing wait times and being able to rapidly respond to disasters and scale healthcare capacity.

5G Adoption Challenges and Mitigations

EMA Approval and Regulatory Barriers

5G healthcare use cases are closely linked with technologies subject to complex approval processes. For example, AI applications have received extra attention from bodies such as the EMA, including due to the risk of bias and fairness,[150] while cloud and edge technologies receive extra scrutiny over the security and privacy of user data. Streamlining and ensuring that appropriate structures are in place to efficiently evaluate key technologies (including cloud, edge and AI), without sacrificing public well-being, can help accelerate economic benefit.

Reimbursement Models

European countries represent a diverse range of different healthcare systems and funding schemes, each with their own reimbursement models that have embraced virtual health and Internet of Medical Things applications at different rates. As developers of 5G diagnostic technology and physicians prove the relative efficacy of remote/virtual solutions, individual country policymakers should ensure that the right models are in place to encourage usage and that their citizens are able to access the benefits.

Network Deployment and Digital Divide

In-home applications are dependent on network rollout; critically, the areas that can benefit the most from virtual health because of their existing health access limitations (rural communities and smaller European

member states) also tend to be the most disadvantaged in terms of connectivity, a trend that is likely to continue with 5G. There is a huge affordability divide, not only within countries but also across: Today, Austrians pay less than 1% of household income on mobile connectivity, while Bulgarians spend 8% for the same service.[151] A European 5G strategy and incentives/public investment in rural fixed wireless access, has the potential to not only address the large infrastructure and affordability gaps across countries but also unlock dramatic economic benefit and patient outcomes in these areas.

Conclusion

The healthcare system in Europe is facing unprecedented challenges. 5G is positioned to play a critical role in meeting these demands by unlocking the Internet of Medical Things and providing better, more affordable services and treatment across the continuum of care. This will improve patient outcomes and the lives of European consumers, and give the healthcare system the resiliency it needs to face the challenges of our time.

Utilities

5G technology will enable reliability, safety and affordability throughout the utilities infrastructure and workforce across Europe.

The next five years of 5G impacts in the utilities sector will drive:

€73.6 billion in additional industry revenues
€25.1 billion in added GDP contributions
1.0 million jobs created or transformed[ii]

The low latency, massive capacity and enhanced bandwidth of 5G will be instrumental to a variety of use cases:

Highlighted use cases	Potential benefits		
	New end services/product	Efficiency/ productivity	Resiliency
Intelligent grid	●	●	●
Next generation workforce		●	●
Smart power plant		●	●

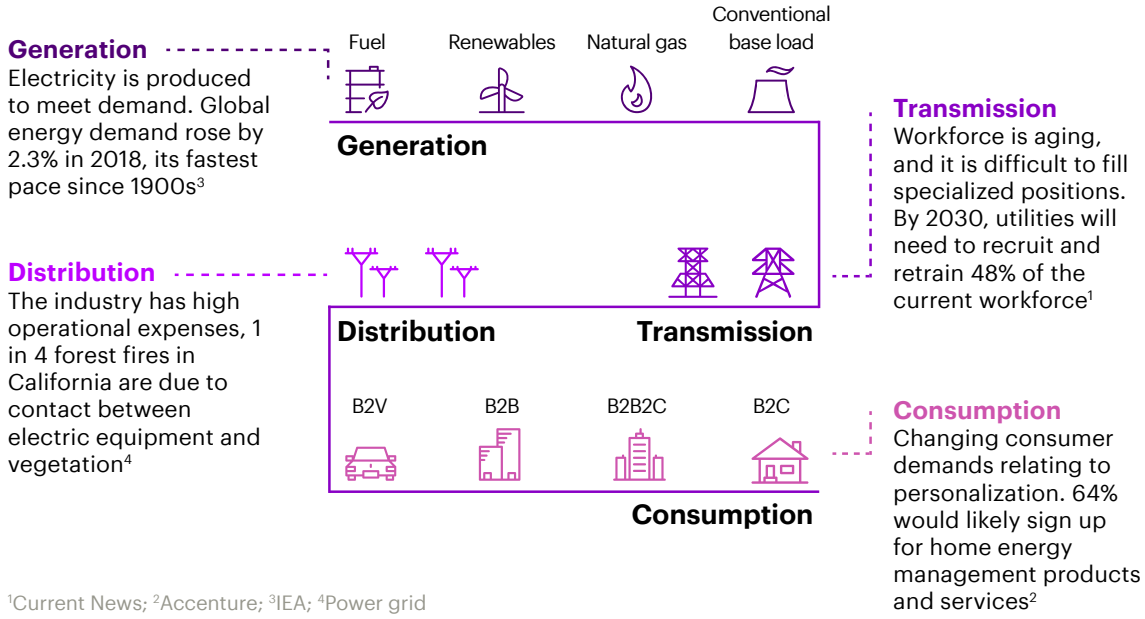
Source: Accenture Analysis

Industry and Technology Context

Approximately 446 million people in the European Union depend on reliable utility services such as energy, gas and water. In this paper, we have focused on the largest sub-sector within utilities,[152, 153] the energy sub-sector, because of the transformation of jobs and infrastructure that can be realized across the four elements of the value chain: generation, transmission, distribution and consumption.

ii Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

Electrical Delivery System



[1]Current News; [2]Accenture; [3]IEA; [4]Power grid
Source: Accenture Analysis

The energy utilities industry faces several major challenges, including vegetation and asset management, energy supply and resiliency and an aging workforce, all of which can be positively addressed by 5G.

Vegetation/Asset Management

Operating costs within the energy utilities industry are high,[jj] and asset management is a top operating expense.[154] Utilities have an aging infrastructure[155] that is spread across large geographical areas and requires labor-intensive preventative measures and corrective maintenance. When equipment fails, the resulting damages can be very expensive. Equipment health is a key aspect of preparing for extreme weather and natural disasters.[156] Similarly, vegetation management is expensive as it requires a crew to manually survey and identify vegetation that needs pruning, trimming and removal.[157] Utilities thus need a solution to manage the cost of equipment maintenance and vegetation management.

Energy Supply and Resiliency

Electricity demand increased more than 35.4%, and electricity consumption in households increased by 16.5% over the period from 2000 to 2018.[158] When the electrical supply cannot be balanced to match demand needs, the entire system will experience disruptions such as power failures. This is not the only challenge. Electric supply reliability is at further risk for disruption from calamities such as fires[159] and unpredictable weather patterns.[160] The industry is further cognizant of the additional demand that will come with the rise in EV adoption from 0.3% in 2014 to 9.5% in 2050.[161] Demand generation trends are also rising to accommodate for sustainable renewable energy; Austria's APG grid operator is investing €2.5 billion over the next 10 years to support the infrastructure's push for wind and solar.[162] As demand increases and changes, energy supply resiliency needs to be enhanced through reliable connectivity and digitization.

Next Generation Workforce

Within the next ten years, the utilities industry is projected to lose 27% of its current workforce, much of which consists of soon-to-be retiring baby boomers.[163] The loss is exacerbated by the inability to

jj Median Operating Ratio of 0.74 across the value chain.

attract and train new hires.[164] A utility worker is highly skilled, with training that combines education and extensive on-the-job experience. As a result, training in Germany can take up between 2 to 3.5 years.[165] It is imperative that the industry to maintain productivity while continuing to build skills of the utilities workforce, which may include leveraging new techniques/tools and teaching them to operate and maintain new power delivery equipment.

COVID-19 Implications

Utilities are essential to businesses and consumers, and the service must be dependable, reliable and consistent. As a result, governments are banning utility shutoffs and are providing financial assistance to counter hardships introduced by COVID-19.[166] The energy generation sector specifically relies heavily on an in-person workforce. Therefore, COVID-19 has generated safety concerns due to the risk of contracting the infection while on the job. 5G can provide workers with reliable and secure access to important information from home and the ability to do more traditionally in-field jobs remotely.

How 5G Can Help

Utility companies sit at a precipice of change, eager to transform operations and provide new value to society. With a connected 5G network, they will have the infrastructure to do so, through:

- **Reliability**: 5G can be leveraged to ensure reliability for customers and support real-time communications for mission-critical situations and sensor-driven efficiency across the grid.
- **Safety**: 5G can drive major improvements in the workforce through safety training via AR/VR tools. Wireless-supported vegetation management improves environmental safety by protecting against forest fires.
- **Affordability**: 5G enables cost optimization by removing operational costs via real-time monitoring of high value assets in remote areas.

Economic Impact of 5G

Utilities industry

€73.6B in new 5G revenue

	Direct industry impact	Total value chain impact	Multiplier effect
Gross Domestic Product	€25.1B	€63.8B	2.5x
Labor Income	€8.9B	€19.7B	2.2x

Jobs and Employment

1.0M jobs[kk]

Note: Multiplier is calculated as the ratio of total value chain impact to direct industry impact.

Source: Accenture Analysis

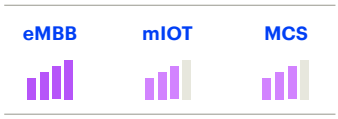
kk Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

Accenture estimates that within the utility industry, 5G-enabled technology will grow sales up to 1.3% or €73.6 billion in sales and €25.1 billion in economic benefits. This is driven not only by utilities use cases and new services,[II] but also because of the impact from other industries.

Furthermore, 5G will create an additional €38.7 billion in GDP as this impact flows through the value chain. Because utility poles can host radios to enable next-generation communications and IoT capabilities, this will unlock the pathway to future employment offerings across industries, including smart city and automated vehicle use cases. Using 5G will allow utilities and home energy in the United Kingdom to see a potential removal of up to 181 megatons of CO2 from the atmosphere by 2035.

5G Use Cases and Benefits

The benefits of digitization across utilities are driven by 5G-enabled solutions that can solve the previous pain points mentioned. To explore these benefits, the use cases include intelligent grid, connected worker and smart power plant.



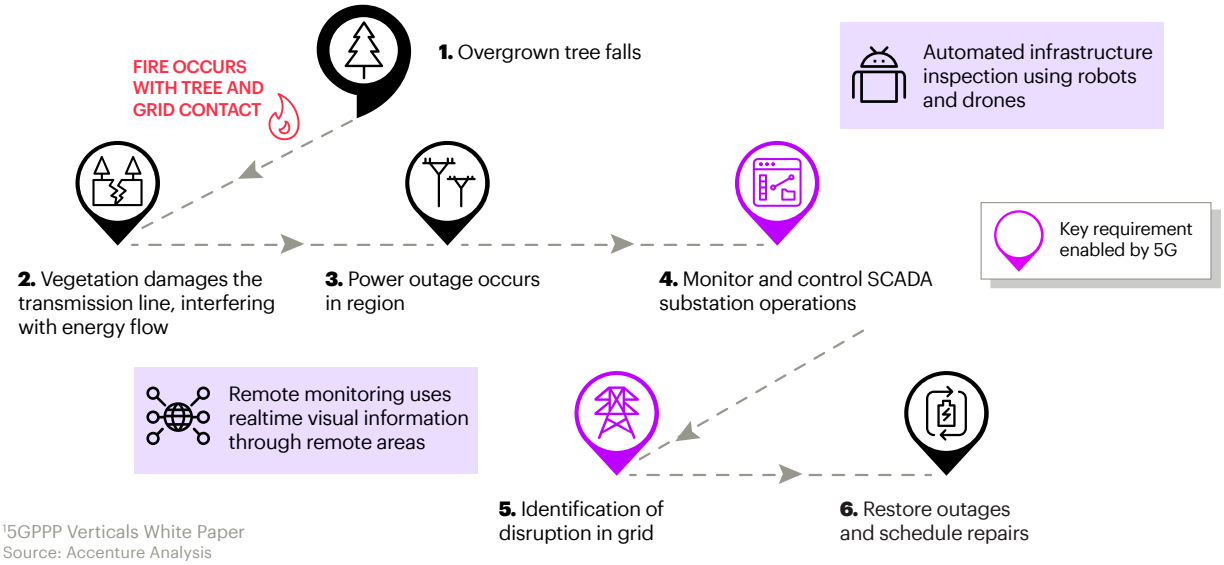
Source: Accenture Analysis

181 megatons of CO_2 can be saved by using **5G for utilities and home energy** by 2035 in the UK

Intelligent Grid

The intelligent grid is the improvement of the power grid across transmission and distribution, which helps mitigate the number of energy disruptions and reduce excessive operational expenses. The intelligent grid consists of three main elements: automated infrastructure inspection, remote monitoring and distributed energy management. These use cases are estimated to contribute up to 28% to 5G-enabled GDP from utilities by supporting the transformation to a reliable, affordable and real-time intelligent grid.

Intelligent Grid 5G Use Case Journey



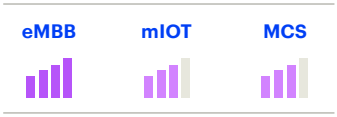
[1]5GPPP Verticals White Paper
Source: Accenture Analysis

II With 5G emerging across multiple industries, utilities will play a key role in 5G network densification because of their existing assets and telephone poles throughout the country. This is a significant opportunity for utilities to be part of the CSP ecosystem and set up new business models in partnership with operators.

Automated infrastructure inspection uses real-time enabled aerial surveying and ground imagery with image analytics and AI to supplement historically manual, time-intensive procedures, improving the safety and reliability of the grid. Lack of visibility of the grid and equipment contact with vegetation are the primary causes of fires. It is estimated that utilities will globally spend around €13 billion per year on drones and robotics by 2026.[167] The intelligent grid can utilize 5G to enable accurate monitoring across the entire grid using sensors/IoT devices.[168] The quality of the video stream, along with processing speed, need to be reliable for the visual intelligence of drones.[169] 5G provides the bandwidth, connection density, speed and low latency required to support these efforts.

5G-enabled remote monitoring can help reduce operational costs of faulty equipment across the entire grid via the use of alarm management and at times through the control of equipment (e.g., pylon stability). E.ON in Germany, Europe's largest operator of energy networks with 1.56 million kilometers of power and gas grids is spending €13.5 billion on its energy grid by including drones and alarm management.[170] Cameras and sensors (heat, sound and force) can help utilities management make better informed business decisions through real-time response. Pylon stability sensors equip utility workers to predict and reduce the risk of instability and theft. Pylon stability with 5G offers the ability to monitor the grid system over vast, remote areas with a more effective and flexible communications system.[171]

Furthermore, the value of distributed energy resource (DER) management allows for efficient energy control in generation and distribution across increasingly distributed sources of energy, including renewables. A 5G transformation provides the flexibility to detect and respond to fluctuating demand. Using real-time information and advanced analytics in the two-way grid, it supports better response to peak demand to mitigate potential blackouts.[172] With 5G connected intelligent grids in the United Kingdom, households that spend about £1,208 on gas and electricity a year can save £145 per household.[173] This presents an opportunity for utilities to invest in 5G-technologies to create a smarter and more responsive power grid.



Source: Accenture Analysis

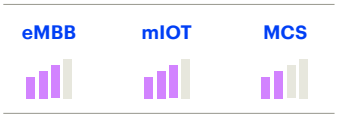
Next generation workforce

The next generation worker can perform activities with real-time data visibility and decision making, improving worker safety and reliability. Utilities are facing an aging workforce, and the number of qualified workers is diminishing. By leveraging digital tools, fleet telematics and safety monitoring, connected worker applications will drive up to 3% of the total 5G-enabled GDP benefit in utilities.

By 2030, the industry needs to re-train and recruit about 227,000 workers, equivalent to around 48% of the current workforce.[174] Digital tools improve worker productivity by presenting information electronically, without the delay of historically manual methods. Utility work is essential to the energy industry, but it can be dangerous, making it imperative for workers to constantly be vigilant of their surroundings and to use proper safety protocols. Digital tools provide easy access to real-time insights and data and can provide further assistance for operations through AR/VR, thus creating a safer work environment. AR/VR helps deliver real-time problem solving and remote assistance. The use of AR/VR unlocks further training applications and helps prevent accidents through visual trainings. For example, Schneider Electric is using AR in field services for remote expertise, leading to 20% less equipment downtime and outages.[175] Microsoft's Dynamics 365 Remote Assist with the Hololens 2 enables technicians to have real-time communication and problem-solving using video.[176]

Another important element of the connected worker model is fleet telematics and safety monitoring. Fleet telematics combines 5G connectivity and input from the mIoT to support dynamic routing and optimal utilization of vehicles and equipment by collecting fleet data for analysis.

Utility fieldworkers operate in environments with high voltage and other types of hazards. In order to provide better workforce support, increased worker safety is needed when in high-voltage environments. Building a highly skilled workforce and ensuring the safety of a worker is important, as 30% to 50% of workers are concerned about workplace hazards.[177] For example, Honeywell is currently deploying cloud-based gas detection hardware to help workers safely monitor their environment for gas leaks.[178] With added 5G connectivity, workers can use equipment to deliver real-time awareness, improve productivity and respond faster to emergencies when time is of the essence.



Source: Accenture Analysis

Smart Power Plant

The smart power plant[mm] consolidates the control of all sources of electricity generation in one place and helps mitigate the challenge of maintaining energy resiliency while reducing operational costs. 5G technology elevates the smart power plant by enabling digital twin technology and remote monitoring. With benefits of overall increases in efficiency, convenience and improvements in power plant security, the smart power plant is estimated to contribute up to 8.2% to 5G-enabled GDP in utilities.

Proactive **5G-enabled real-time remote monitoring** could save utilities operators **10% or more in operating costs**

A digital twin is a detailed model of a physical asset that is updated with a steady stream of real-world sensor input. Digital twin technology, supported by 5G, can unite both the physical geospatial landscape and operational electric grids in real time, enabling operators, maintenance and planners to visualize data and monitor systems. The result is a virtual clone of the power plant that can be used to check on an asset's current condition, productivity and activation scenarios. This will result in availability of real-time asset information that can be used for immersive simulation of operating scenarios.

Real-time remote monitoring captures and communicates critical information essential to the power-generation infrastructure of a utility. Windmill turbines, for example, need regular preventive maintenance due to the harsh operating environment. By using 5G and near-real-time monitoring, it is possible to keep the digital twin aligned with corresponding physical assets over large, remote areas. This supports the identification of issues and solutions proactively before dispatching a crew to the remote location, an approach that could reduce operating costs by up to 10%.[179] For example, GE's smart power plant for steam in France uses over 10,000 sensors to improve energy efficiency and further reduce carbon emissions by 3%.[180] Combining these technologies with 5G further reduces costs and increases affordability for utilities.

mm With 5G emerging across multiple industries, utilities will play a key role in 5G network densification because of their existing assets and telephone poles throughout the country. This is a significant opportunity for utilities to be part of the CSP ecosystem and set up new business models in partnership with operators.

5G Adoption Challenges and Mitigations

Limited Network Availability and Need for Reliability

Utilities operate in rural and uninhabited areas and may have limited or no wireless connectivity due to poor return on investment for CSPs. In populated areas, their traffic may not be prioritized when the network is congested, especially during emergencies, which is when connectivity is most crucial to troubleshooting and restoring services. Due to these issues, the government should consider providing incentives and encourage collaboration, not only to provide connectivity in the rural and remote areas, but also to prioritize utility traffic during emergencies such as natural disasters.

Cost Intensive Infrastructure and Devices

5G use cases will require the installation of new technology, sensors and even network connectivity (private networks), all of which are capital intensive. For example, the infrastructure cost for 5G is higher than for previous wireless generations due to the increased RAN density required to provide adequate coverage. Key collaboration with CSPs is important to mitigate these issues. By 2020, it is expected that almost 72% of European consumers will have a non-5G smart meter.[181] 5G meters drive high benefit of real-time data, but the cost to replace the millions of meters already on the market would not outweigh the benefits for individual operators. Supported by government incentives, utilities should form an alliance to align on a common requirement and reference design to ensure interoperability and drive the cost of devices down.

Security of the Grid

As the power grid becomes more connected, security is paramount to protect against cyberattacks. Utilities deliver energy to the up to 99% of European customers that are connected to the distribution grid.[182] Devices are connected to 10 million kilometers of transmission and distribution lines across Europe and must be tamperproof.30 Governments can speed up deployment by incentivizing and encouraging development of secure technology, including subsidizing R&D.

Conclusion

One half of European consumers consider electricity fluctuations to be a major pain point in their lives.[183] 5G-enabled use cases like the intelligent grid and the smart power plant will vastly improve power reliability and affordability. This will benefit society with more efficient control over energy management and provide utility companies with substantial operational savings. Future prosperity is attributable to transformation, leading to the reinvention of the worker experience through the connected worker and enabling better worker safety. In addition, the utility industry will be a cornerstone in providing the essential infrastructure and support for 5G connectivity.

Major utilities have provided consistent value for decades, sidestepping the ebbs and flows of technology trends, but for the industry to unlock the next level of benefit for consumers and help fuel 5G growth, they must double down on the 5G opportunity. This, in turn, will drive up to €73.6 billion sales in five years by 2025 and create or transform up to 1.0 million jobs. Leading utilities are paving the way for next-generation communications and are opening new sub-industries such as smart cities and automated vehicles. Utility players can leverage their current strengths and take hold of their future as the demands of the industry are evolving.

Agriculture

5G technology will drive more sustainable agriculture, safer crops, and healthier livestock management across Europe.

The next five years of 5G impacts in the utilities sector will drive:

€50 billion in additional industry revenues
€23.4 billion in added GDP contributions
0.3 million jobs created or transformed[nn]

The low latency, massive capacity and enhanced bandwidth of 5G will be instrumental to a variety of use cases:

Highlighted use cases	Potential benefits		
	New end services/product	Efficiency/ productivity	Resiliency
Automated pest and weed eradication using drones		●	●
Connected tractor and automated equipment		●	●
Livestock tracking		●	●

Source: Accenture Analysis

Industry and Technology Context

The agricultural industry[oo] is a cornerstone of the economy: In 2018 alone, European agriculture contributed directly to the livelihood of 22 million people and accounted for approximately €434 billion in revenue.[184] The industry is highly fragmented, with 89% of European farms being family-owned and run by the owner and their immediate family.[185] Farmers are facing increasingly tight margins. They receive about 15 cents for every Euro a consumer spends on food, which is half of what farmers received in 1980.[186] There are some key challenges the industry faces today that critically affect crop and livestock yield, contributing to these tight margins.

- **Poor harvests due to climate change and growing production costs are affecting the quantity and quality of farmed products**. According to high-increase greenhouse gas emission scenarios, yields of non-irrigated crops like wheat and corn in southern Europe will drop by up to 50% by 2050.[187]
- **Destructive weeds are leading to increased reliance on pesticides by farmers, while consumers are demanding sustainably produced food**. Up to 30% of a farmer's crop can be destroyed by weeds. Nevertheless, European policymakers are actively pushing towards greener farming solutions with goals of cutting chemical pesticide use in half by 2030 and decreasing fertilizer use by 20%. This has

nn Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.
oo Agriculture is defined as NACIS code 11 and similarly within NACE Rev 2 in the economic model.

been exacerbated by the COVID-19 pandemic, due to even more consumer demand for healthier, chemical-free foods.[188]

- **An aging workforce, combined with the reluctance of the younger generation to join the agriculture industry, is contributing to a labor shortage in Europe**. In the United Kingdom, one third of all farm owners were over the typical retirement age of 65 years in 2018. In juxtaposition to this, the proportion of farmers younger than 35 years was just 3%.[189]
- **Unpredictable farm animal needs and illness are resulting in loss of livestock**. The World Organization of Animal Health (OIE) estimates that morbidity and mortality due to diseases cause the loss of at least 20% of livestock globally. For example, one in three dairy cows in Europe suffer from mastitis,[pp] representing a €159 million loss for farmers annually.[190]

Many of these pain points can be addressed with digital communications technology. In the last six years, the industry has invested €192 million in technology solutions.[191] Moving forward, 30% of a farming company's R&D budget will be invested in exploring applications for machinery advancement like connected equipment.[192] 5G connectivity can drive significant additional improvements in this space when used with synergetic technologies.

COVID-19 Implications

46% of European farming businesses have been impacted by the pandemic.[193] Half of these farmers suffered declines in revenues. Although the European food supply has largely been able to keep up with demand, farmers across the region are facing reduced profits. Border closures, shut down orders and illness have disrupted supply chains and exacerbated the existing labor shortages, impeding farmers' ability to harvest crops and maintain distribution systems.[194] These difficulties threaten to put more and more farmers out of business in an industry that is already struggling. The pandemic highlighted the workforce agility required within the industry, an issue that can be improved with 5G connectivity.

The pandemic has also changed consumer food consumption habits. 85% of consumers shifted their behaviors, including buying produce more often, washing it longer and cooking on their own. There is a heightened need for healthier foods. This means additional consumer scrutiny on where food comes from and what it contains. As these habits develop for a larger portion of the population, there will be increasing pressure for transparency within the agriculture industry and a decrease in usage of chemical pesticides. 5G, combined with other technologies, can drive the move towards a collaborative commitment among agriculture ecosystem partners to ensure that consumer needs are addressed holistically through the value chain.

How 5G Can Help

Many farmers today do not have the digital and connectivity infrastructure they require to collect and act upon the rich data that can be acquired on their farms. 5G gives farmers the ability to draw precise, data-driven insights from the field, unlocking the opportunity to optimize every square meter of crops. This can lead to an estimated 15% increase in crop yield.[195] Connectivity in rural areas can do more than just enable

pp Inflammation of the mammary gland and udder tissue due to trauma or infection in dairy cows.

the next evolution of farming businesses. It can lead to the improved quality of life for many citizens that live in more remote areas of Europe by unlocking education and work opportunities.

Automation has already improved efficiency in the industry today.[196] The big upcoming change will be connectivity-enabling data-driven decision making. With 5G, farmers can unlock numerous use cases that leverage technologies such as automated vehicles, sensor-based field monitoring and artificial intelligence to more resourcefully leverage land and increase crop yield.

Economic Impact of 5G

Agriculture industry

€50.0B in new 5G revenue

	Direct industry impact	Total value chain impact	Multiplier effect
Gross Domestic Product	€23.4B	€50.9B	2.2x
Labor Income	€13.2B	€23.9B	1.8x

Jobs and Employment

0.3M jobs[qq]

Note: Multiplier is calculated as the ratio of total value chain impact to direct industry impact.

Source: Accenture Analysis

Accenture estimates that 5G-enabled technology will grow industry sales by approximately €50.0 billion and contribute €23.4 billion in GDP over the next five years. This improvement in agriculture production will generate more supply stability domestically, leading to less risk and reliance on import products. The economic impact is not only to the food production, processing and consumption sectors but also within industries that use agriculture inputs for non-food manufacturing.[rr, 197] For example, in Europe specifically, over 200,000 jobs are related to cotton production for clothing manufacturers.[198] As the impact of 5G on agriculture flows through the value chain, it will create an additional €27.5 billion in GDP. New jobs, specifically within digital agriculture like drone engineers, will be required to support development of the solutions that 5G unlocks, creating new, attractive job opportunities in farming and in adjacent industries, such as manufacturing and software development. In fact, agriculture technology startups globally have been gaining both traction and funding, amassing over $4.1 billion (€4.6 billion) in funding for 413 deals so far in 2020 alone.[199] 5G is estimated to lead up to a 0.9 million increase in total jobs across the entire value chain.[ss] The impacts of 5G will enable higher yield per square meter, resulting in the above-mentioned economic benefits within the European economy.

5G Use Cases and Benefits

The agriculture industry serves a vital need globally and is even more important to the European economy. In this paper, we will highlight three 5G-enabled use cases:

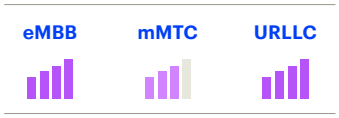
- Pest and weed eradication using drones and AI

qq Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.
rr These include products like oils, clothing, energy, cosmetics and industrials to name a few.
ss Within the model, this is defined as direct, indirect and induced.

- Connected tractor using real-time kinematics (RTKs)
- Livestock welfare and monitoring via geofencing and sensors

The specific use cases this paper explores are estimated to represent 50% of the total value driven by 5G within the agriculture industry.

Automatic Pest and Weed Eradication using Drones and AI



Source: Accenture Analysis

Weeds, insects and pathogens can wreak havoc on crops. Weeds alone account for 30% of that amount, corresponding to annual losses of up to €42 billion in Europe. [200, 201] In response, farmers apply pesticides, herbicides and various other types of weed control, which increase yield but also increase usage of chemicals. For example, in France, pesticide usage increased by 21% in 2018 compared to 2017.[202] These high levels of pesticide usage have come under scrutiny due to concerns over long-term health problems. Total pesticide and herbicide sales in Europe have not decreased despite many preventative regulatory actions taken by the European Union. In one study, 7% of drinking groundwater stations reported excess levels of measured pesticides. Alarming statistics like this have led to E.U. mandates to decrease chemical usage by 50% in the next decade.[203]

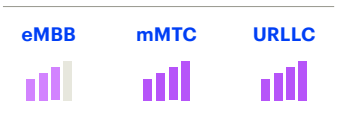
5G connectivity can help. By combining a low-flying unmanned aerial vehicle (UAV) with cloud-based AI via 5G, farmers can target specific weeds for precise herbicide and pesticide dispersion. Light detection and ranging (LIDAR) sensors can use spatial distancing for vegetation detection and discriminate weeds from crops.[204] An unmanned ground vehicle (UGV) can also be leveraged for this use case if there are complications with overhead vehicles seeing through canopy foliage.

Reduced herbicide usage by up to 50% using 5G

Spraying pesticides and herbicides via UAV can be 40 to 60 times faster than manual spraying operations.[205] Currently, for drones to work effectively, target areas need to be mapped out in advance to ensure the route can be completed in the amount of flying time available.[206] With 5G, the precision of drones increases due to AI's targeted dispersion capability. The biggest value is that the farmer no longer needs to overspray to ensure crop safety, decreasing pesticide/herbicide usage by up to 50%.[207]

Certain weeds like the Palmer Amaranth, a pigweed, grow quickly and devastate crops to the point of rendering arable land unfarmable. By enabling farmers to survey the land with extreme precision and identify specific types of weed that the human eye cannot identify, 5G can drive tremendous value. In addition to decreasing chemical usage, this also increases the long-term sustainability of the arable land.

Automatic Equipment (Connected Tractor)



Source: Accenture Analysis

Agricultural activities are both labor and time intensive. Labor represents over 50% of farm operating costs, and farmers consistently report a shortage of workers.[208] Additionally, European youths do not see farming as an attractive profession.[209] This means that the workforce will likely shrink even further in the coming years. The limited labor pool has prompted 31% of farmers to switch to less labor-intensive crops like squash and leaving fruit such as strawberries unpicked. [210, 211] In the long-term,

31% of farmers are moving to less labor-intensive crops due to labor shortages

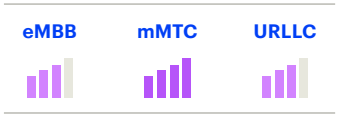
these types of decisions could lead to more food shortages, increase in food prices or changes in import competition protections. The border closures implemented due to the pandemic have further aggravated the situation. Automation and real-time monitoring using 5G technology can bring significant benefits.

5G has the potential to enable remote-controlled, connected tractors that can perform tasks such as planting and harvesting the field. With the high bandwidth and low latency of 5G connectivity, onboard sensors can be used to assess soil and plant health.[212] Thus, the tractor can accurately vary the rate of seed, fertilizer and other chemicals depending on the needs of the soil. This improves overall soil health and productivity, therefore increasing output using the same resources. The machinery can do all of this while transmitting vehicle telematics like fuel levels and required equipment maintenance to user apps.

These tractors, when enabled by RTKs, can navigate and course correct throughout crops with up to 1 cm of accuracy as they traverse the fields. The heavy machinery also drives over less land because the path it travels is predetermined, thus significantly reducing soil compaction.

The continuous exchange of information between the farmer and his land will also support sustainable farming by allowing more precise action to be taken when crops are wilting and need to be immediately picked. This reduction in food wastage also means a reduction in water wastage.

Recently, Valtra and Elisa launched a remote-controlled tractor that is controlled with the help of a host of cameras and improved connectivity.[213] As an added benefit, the cost of this type of machinery tractor will decrease with 5G enablement because the data compute power would no longer need to be built in the tractor and could instead be processed in the edge and/or cloud.



Source: Accenture Analysis

Livestock Tracking via Geofencing and Sensor-based Healthcare

Europe has a substantial population of livestock, in 2018, there were 148 million pigs, 87 million bovine animals,[tt] and 98 million sheep and goats.[214] The OIE estimates that morbidity due to animal diseases causes production losses of at least 60 million tons of meat and 150 million tons of milk, with an estimated global value of approximately €253 billion per year.[215]

5G real-time livestock health monitoring can **reduce mortality rates by up to 80%**

The ability to locate and monitor livestock—particularly in upland areas and ranches—is critical to farmers. Livestock location becomes more important when it is calving season to ensure that the offspring is delivered safely, and help can be offered in time in case of emergencies.[216] 5G can be leveraged for real-time livestock tracking and health monitoring, reducing mortality rates by up to 80%.[217] Using 5G-enabled sensors embedded within collars, livestock can be identified and tracked in real-time across large areas.[218] The locations of the device can be tracked against a geofence map, triggering an alert to the farmer if an animal crosses over a boundary.[219]

tt Bovine animals include cattle, bison, buffalo, etc.

Additionally, health monitoring of livestock can boost productivity and efficiency of the farm. For example, tracking how much a cow eats, rests and moves via wireless monitors can indicate the early onset of health issues, similar to the way fitness trackers work. It also prevents the spread of disease in a farm. 5G will enable real-time monitoring of livestock health and will send alerts to vets and farmers in case of any anomalies. Using sensors, biometric data is gathered and sent over a 5G network to the cloud, where it is analyzed, and status is shared with both the farmer and the vet.

As an example, consider a dairy cow. Ideally, a cow should get between 10 and 14 hours of rest per day, which minimizes risk of lameness, increases blood flow to the udder and reduces stress hormones. Along with fertility status, these health factors influence milk production for each animal. The farmer can keep a digital tally of a cow's milk production and record her health and fertility status and determine how much milk she is expected to give.

Improvements in livestock management are also key to reduce climate pollutants from the atmosphere. Livestock products are responsible for more greenhouse gas emissions than another other food product. According to the UN, improved management practices can reduce emissions by 20% to 30% across production systems. Increasing livestock productivity helps the agriculture industry improve their livelihood and the world improve food security. It also supports best practices to negating the negative impacts of climate change.[220]

5G Adoption Challenges and Mitigations

Rural 5G Infrastructure Deployment and Industry Adoption

These use cases are all very promising. The great unknown is the availability of 5G connectivity in rural areas. If the network is available, it can change value streams within agriculture completely. Additionally, the European agricultural market is fragmented, and there are many farmers who need to understand the value behind the investment they are making. If the value that the use cases drive is not tangible, they will be hesitant to change historical practices. In these circumstances, governmental facilitation and education figures can play the role of a central enabler for research and development. Additionally, they can help negotiate better prices and drive adoption through funding incentives. Providing agricultural subsidies, including through existing schemes like the E.U. Common Agriculture Policy (CAP) program, to farmers who adopt digital technologies will be key.[221]

Conclusion

5G connectivity delivers the mobility farmers need to implement the next generation of digital agricultural solutions. Supporting the high density of sensors and equipment and the low latency necessary for these types of use cases, 5G will increase the quality and quantity of production while equipping farmers to adapt to changing market needs. This will drive up to €50.0 billion sales in five years by 2025 and create or transform 0.3 million jobs directly. Leveraging 5G can usher in the next agricultural revolution. With this, it will also bring on green farming practices and reductions in energy, water and food waste.

The value 5G generates within the agricultural industry will monumentally impact both farmers and consumers. It will also alleviate domestic food-supply shortages, securing more food locally as the population and sustenance needs grow. The technology is truly positioned to usher in the next agricultural revolution.

06 Acceleration Levers

As previously discussed, the benefits to be derived from 5G are significant and will be felt throughout the economies of Europe and the United Kingdom. The question is how quickly the effects will be manifested. Significant opportunities exist to maximize those benefits and realize them sooner.

Opportunity #1: IP, Technology and the Ecosystem

Even as network deployment proceeds, there is a distinct lack of mature, 5G-enabled devices available in the ecosystem. Without these devices, companies cannot adopt and reap the benefits of 5G. The scarcity of new devices and technology in the ecosystem can be largely attributed to two factors: (1) the ongoing standards development and (2) the nascent stage of device development across industries.

First, 5G networks and standards are still being rolled out and ratified. Although the pandemic caused some delays, 3GPP ratified 5G Release 16 in July 2020, which was a major step towards improving 5G performance and enabling V2X and IIoT deployments.[222] Concurrently, the partnership also warned that Release 17 is at "high risk" of being delayed. According to GSMA, commercial volumes for more standard, simpler devices typically lag standards ratification by 12 to 18 months while development, testing, trials and pre-commercial activities take place.[223] As a result, even for IIoT and V2X applications, which have been highly touted as drivers of value in 5G, specialized and industrial devices will not be seen until mid-to-late 2021 at earliest.

To address this, stakeholders should continue pushing for timely standards ratification and releases, to prevent excessive delay in equipment availability. The ratification process of Release 16 can serve as a benchmark and provide ideas on best practices for Release 17. Stakeholders should also encourage collaboration among regulatory bodies and trade and research associations to give a voice to all groups and ensure full coverage of the advancements and capabilities of 5G. In addition, the establishment of standards should balance utilizing the full spectrum of international expertise with national security to ensure seamless connectivity globally.

Next, vendors have not made enough progress in R&D to put out industrial products that are fully ready for migration to 5G. As with any revolutionary technology, developing the wireless technology and the devices associated with 5G requires heavy upfront R&D investment. For example, the semiconductor industry has invested more in R&D since the 1990s than all other major industrial segments individually,[224] with major companies such as TSMC, Intel and Qualcomm leading the way for cutting edge, technological innovation.[225] Device makers must be able to continue pursuing R&D to expedite commercial viability of new device types and pave the way for a smooth transition to 5G. Yet, incentives for device makers should not come at the expenses of those that have already invested in the developed of the foundational technology. Companies that have developed the 5G standard have taken on substantial risk to enable an ecosystem that took years to come to fruition and must therefore be encouraged with a supportive regulatory framework. In other words, the need to encourage investments in 5G-enabled devices must be balanced with the need to protect inventors that have made 5G possible.

Ultimately, government and regulatory bodies should balance innovation stimulation with IP protections to ensure that the reinvestment cycle continues. There is an opportunity to lay the groundwork for and accelerate 5G adoption by promoting innovation and R&D through public investment. This can be implemented in a variety of ways, including a combination of more guided policy with financial incentives like subsidies, direct investments and tax credits. Furthermore, policymakers can maintain a level playing field through IP protection; this will encourage competition, leading to a proliferation of commercially viable devices within the ecosystem that can access and harness 5G's full array of benefits.

Opportunity #2: Resilient Wireless Technology Supply Chain

Benefits to the economy from 5G use cases depend on uninterrupted delivery of the entire value chain from R&D to manufacturing, as well as development of semiconductors, devices and network and industrial solutions. Breakdown of any component will slow down or, worse, disrupt the economic benefits. Disruption is most significant up the value chain, the development, manufacturing and delivery of chips, wireless devices and equipment; The chips are the 'brains' that provide the intelligence for modern electronics. The wireless devices and network equipment use them to transfer information for processing and necessary action—for example, a connected utility worker fixing a malfunctioned furnace in a plant requiring precise instructions. To de-risk the development and delivery of 5G technology, it is imperative ensure the supply chain resiliency of chips, devices and equipment.

The development of policies to support reliable semiconductor, wireless device and network equipment innovation and design, and a reliable global supply chain will power critical manufacturing, healthcare, automotive and other use case solutions by trusted sources and reliable producers.

Opportunity #3: Network Deployment and Build Out

Compared to previous generations of wireless technology, 5G deployment is very complex. Especially in the higher-frequency spectrum bands, 5G networks may require 10 to 100 times as many antennas as 4G networks, due to the shorter propagation range of higher bands and also limited ability of these frequencies to penetrate structures. The cost of this infrastructure is substantial, requiring at least €156 billion spend in Europe by 2025, the third highest in the world behind Asia Pacific and North America.[226]

Existing European legislation poses significant restrictions on deployment, establishing large exclusion zones around 5G sites to minimize human exposure. These limits vary by country and, in Poland, Italy and Switzerland, create exclusion zones greater than 100 m surrounding small cells, dramatically hindering deployment in dense cities.[227] Perceived health concerns have halted or stalled deployments in many regions, including in Switzerland,[228] and Europe's largest carrier, Deutsche Telekom, recently had to relocate cells further away from protesting residents in the Bavarian district of Graswang. [229]

In addition to the volume of small cells required, municipal approvals and permitting can be a barrier delaying network availability. The European Commission has made progress to streamline some of this, including creating an exemption from municipal planning processes (also adopted by the United Kingdom), but the impact will depend on individual country implementations.[230] Continued focus, including at the member state level, is critical to ensure that some regions are not left behind regarding 5G access and associated economic benefit.

The benefits of 5G will not be felt equally across Europe. While studies have shown 5G fixed wireless can provide a cost-effective way to improve rural connectivity (40% savings vs traditional FTTP deployment), today, only 60% of rural Europeans have fast broadband access, compared to 86% of the overall population.[231] Past studies have shown a strong relationship between connectivity and economic growth: A 10% increase in broadband penetration is expected to drive a 0.9% to 1.5% incremental GDP increase. Applying a purely valuation-based perspective, operators are not always incentivized to bridge this gap in the areas most critically affected. Because of this, developing a rural 5G strategy with funding and incentives could both help bridge the digital divide and pay dividends throughout the economy.

Opportunity #4: End User Return on Investment

Although 5G is expected to drive appreciable benefits throughout the economy, the required levels of investment remain prohibitive relative to the ROI for many industry use cases. For a number of industries, the changes to infrastructure, supply chain, workforce, user device migration and education are costly.

In order to realize the benefits of 5G, businesses require significant capital outlay, not only for network connectivity infrastructure, but also for the devices, software and new processes and operating models. In many industries, this issue is compounded because of long asset lifetimes, where replacement cycles are spread over a decade or two. These investment cliffs represent tangible barriers for 5G deployment and will stymy the level of economic impact throughout the economy. Cost barriers also represent clear opportunities to accelerate impact through new financing/incentive initiatives.

In manufacturing, for example, investments in key 5G use cases are being held up because of concerns around ROI relative to capital expenditure, compounded by long depreciation schedules of existing assets and cultural adoption barriers. Enabling a single use case requires new equipment, as well as integration with a complex network of legacy hardware and software to drive value for the enterprise, a costly endeavor.

Industries are going to lag in their own investment unless the returns from 5G use cases are above the hurdle rate and competitive investments for their industry. This, unfortunately, creates a disconnect relative to the positive externalities and economic impact driven by 5G and represents a clear lever for driving benefit throughout the broader economy, with the support of external incentives.

Opportunity #5: Spectrum Availability

The European Electronic Communications Code (EECC) initiative to harmonize the low-, mid- (generally 3.4 GHz to 3.8 GHz) and high-frequency (26 GHz) bands by the end of 2020 for 5G usage will benefit the acceleration of industrial and consumer applications.[232] The harmonization across the UK and EU block will result in benefits such as lower cost of the standardized network equipment and devices. By the end of Q1-2021, major Western European countries will have between 310 MHz and 400 MHz of mid-band allocated and commercially available.[233]

The assignment for the high band (i.e. mmWave) is lagging. By the end of 2021, less than a third of the UK+EU country block will have allocated the 26 GHz spectrum earmarked by EECC. The high-band (i.e.

mmWave) supports 5G uses that require high-capacity, high-speed, and ultra-low latency, such as IoT and enterprise applications. In the U.S., the launch of iPhone 12 supporting mmWave (28 GHz) is the starting point for the consumer demand for the experience it will deliver. Furthermore, a recent test on mmWave has demonstrated performance of 100 Mbps at a distance of over 5 km. [234] With the complements of other 5G radio technology enhancements (e.g., antenna technologies such as beamforming and MIMO), the performance will translate into commercial applications. Therefore, the UK+EU should accelerate the allocation and assignment of mmWave and incentivize its development and deployment.

Opportunity #6: Balancing Regulation

About 70% of value generated through digitalization in the next ten years will be based on platform-enabled, ecosystem-based business models. 5G will play an essential role in this development. Governmental agencies should collaborate with stakeholders across industries, civil agencies and enterprises to ensure that 5G's full potential value is attained.[235] This collaboration is key for the successful realization of 5G economic and consumer benefits.

Inherently, 5G is a secure network. However, when the network is combined with a broader ecosystem of IT infrastructure and proliferation of connected devices, security concerns can arise. The General Data Protection Regulation (GDPR) was passed in mid-2018. Amongst other applications, the regulation guarantees that data protections are built into the design of new products and services.[236] Therefore, European policymakers are already taking into consideration the new security developments needed with a 5G roll-out. Moving forward, regulatory agencies and policy makers should examine security measures holistically and partner with businesses to balance security best practices without hindering growth and deployment.

Major regulatory and policy concerns can be broken down into two key areas:

- Security and privacy (i.e., cyber security and consumer data privacy)
- Industry-specific regulations

The key will be to streamline 5G deployment effectively and transparently to ensure economic prosperity and consumer benefits. Keeping an eye towards the future, regulatory agencies must manage risk and understand the costs of additional regulations to ensure that they do not hinder deployment. To do so, policymakers need to aid in facilitating conversations that highlight the benefits of 5G-enabled technology while alleviating concerns about the risks.

Security Requirements

The 5G standard builds upon previous wireless generations to result in a more secure, flexible network built around best practices, including heightened encryption and end-to-end authentication. The risk that needs to be addressed is the increase in overall volume and types of connections, data and applications.[237] Safeguarding the new applications that will leverage a secure 5G network is key. Identifying and addressing new vulnerabilities exposed by the connected 5G ecosystem without slowing down deployment due to security measures is an important balance to strike.

Device and equipment manufacturers are already building in higher reliability and security than current regulations require. It is fair to assume that new use cases will deploy the best security practices at an early stage. Businesses are also aligned with adapting to new security standards as needed with 5G deployment. For example, to comply with the new GDPR requirements around consumer data, Audi changed how they will seek consent in the future by being honest and upfront with customers.[238] From an enterprise view, the technology framework and mindset is already in place for an ultra-secure build out.[239] Governments must work with them in a thoughtful manner to ensure data security, collection and storage concerns are addressed to balance policy and messaging with business goals and consumer needs.

5G also strengthens specific security measures for consumers, such as offering improved subscriber identity protection, among other benefits.[240] But consumers are still worried about how their data will be leveraged. For consumers to trust and benefit from the value that 5G enables, they must be given agency over their data to decide how and when it is used. Businesses understand this, with more and more companies giving customers the option to manage data on a constant basis.[241] Alongside this, GDPR legislation promises more consumer visibility into how personal data is processed.[242] As businesses tread this fine line between delivering on consumer expectations and ensuring regulatory compliance, government officials must address and dispel these consumer fears and propel development.

Industry Regulations

Heavily regulated industries such as healthcare and automotive also face headwinds due to stricter policy and regulatory guidelines to meet consumer safety needs (e.g. through EMA). But the COVID-19 pandemic highlighted the need for a stronger digital Europe, one which focused on data-sharing across borders. For example, restrictions to cross-border health data reduced the effectiveness of contact tracing solutions that could help mitigate the spread of the virus.

Government agencies and businesses must understand what a 5G ecosystem will enable from the beginning and address their plans for handling vulnerabilities without inhibiting progress through uncompromising regulations. Aligning early on with other governing bodies from certain industries regarding 5G expectations facilitates quicker deployment and adoption.

The regulatory challenges outlined above are an identified selection based on current understanding of 5G. As with any transformational digital technology, there will be the need for significant engagement amongst partners to realize the full value that can be unlocked.

07 Conclusion

5G offers tremendous potential and will undoubtedly transform industry landscapes and consumer life. This will drive a substantial impact throughout the U.S. economy, fueling up to €2.0 trillion in gross economic output (sales), creating or transforming up to 20 million jobs[uu] and adding up to €1.0 trillion to GDP between 2021 to 2025, with lasting benefits for years to come.

Critically, as the European Union and United Kingdom look forward to a long period of recovery in the wake of COVID-19, 5G has the potential to power a new wave of growth, creating new industries and jobs and setting up European businesses, workers and consumers to thrive in the new normal. For enterprises, the IoT, AI and edge/cloud benefits we've anticipated for years can finally come to fruition. For workers and consumers, 5G will unlock the fullest potential of remote and digitally enabled work, add new scalability to the services we use every day and drive significant consumer value. This will touch every element of European life, from our relationship with cars and transportation, to healthcare quality and access. These benefits to the end consumer are substantial and represent an excess consumer surplus benefit on top of the macroeconomic figures we've described above.

Today, the European Union and United Kingdom are able to maximize this potential, if the right actions are taken. By making 5G a priority and taking advantage of the levers available, the European Union and United Kingdom can capitalize on the tangible acceleration opportunities. This will allow the sizeable benefits of 5G to be realized faster and maximized, improving the lives of every European and injecting new life into the economy at this critical juncture.

uu Includes full-time, part-time and temporary jobs; Assumes no labor supply constraints, some of these jobs will be replaced by upward pressure on prevailing wages instead.

08 Appendix

Economic Model Methodology

In the fall of 2020, Accenture conducted a comprehensive study on 5G's expected impact on key macroeconomic outcomes for Europe. To arrive at our answer, we asked two key questions:

1. How did the increase in mobile penetrations affect economic outcomes for past connectivity technologies?
2. How is 5G's impact going to differ compared to past connectivity technologies?

To quantify the impact of 5G technology across the economy, we looked at the historical penetration of past connectivity technologies and their relationship with the increase in industry output over time. Data on mobile penetration of previous connectivity technologies such as 2G, 3G and 4G, along with projected 5G penetration was obtained from Global Systems for Mobile Communications (GSMA). Data on historical and projected gross output by industry for all 16 industries was obtained from Oxford Economics for all relevant geographies including US and all countries in European Union and United Kingdom. Additional endogenous determinants of output growth such as consumption, government expenditure and trade were also obtained from Oxford Economics. The projected metrics from Oxford Economics account for the baseline COVID-19 scenario.

We use the Arellano-Bover/Blundell-Bond dynamic panel data estimator to estimate the relationship between gross output/sales and increased mobile penetration. Using this estimated relationship, we project out the impact on sales from increased 5G penetration based on projected GSMA and Oxford Economics data on 5G penetration and gross output. This projection gives us a baseline increase in sales.
5G differentiates itself from past connectivity technologies and unlocks industry value that would not have been possible with past generations (including 4G). To account for this differentiated impact, we, in consultation with internal and external industry subject matter advisors, evaluated the potential outsized benefit of 5G compared to 4G for each industry on: creation of new industries, productivity gains, cost optimization, service improvements, time to impact. We then adjusted our baseline results to account for the differential impact of 5G. Based on the relationship in the national input-output tables, we then estimate the resulting GDP, jobs and earnings impact from the increase in sales for each industry, country, or state.

In order to arrive at value-chain impact, we leverage inter-industry relationships inherent in the national input-output tables to estimate the indirect and induced effects of mobile penetration for key industries.

In interpreting our value-chain results from the input-output analysis, we need to bear in mind some standard assumptions of this type of analysis:

1. **Fixed purchase patterns**: assumes that industries do not change the mix of inputs used in their production process.
2. **Industry homogeneity**: assumes that businesses within an industry use the same production process.
3. **No supply constraints**: assumes that there are enough inputs in the economy to meet the increase in demand by the industry and that supply shortages or price changes of inputs do not occur.

Industry Definitions

NAICS Codes	Industry
72	Accomodation and food services
11	Agriculture, forestry, fishing and hunting
71	Arts, entertainment and recreation
48, 49*	Auto and transport
55, 56	Business and professional services
23	Construction
61	Education
52	Finance and insurance
62	Healthcare
51	Information/communication
31, 32, 33*	Manufacturing
21	Mining, quarrying, oil and gas
92	Public admin, defense and social
53	Real estate and rental/leasing
42, 44, 45*	Retail
22	Utilities

* Automotive manufacturing and retail have been included as part of "Auto and transport"; all other manufacturing remains in "Manufacturing".

NAICS to NACE/ISIC crosswalk was used to define industry groups for Europe.

Consumer Survey Methodology

In September 2020, Accenture surveyed a nationally representative sample of 2,000 Europeans (400 people each from France, Germany, Poland, Sweden and the United Kingdom) between the ages of 18 and 64 via an online survey conducted by a leading global research firm.

Direct, Indirect, and Induced Economic Effects

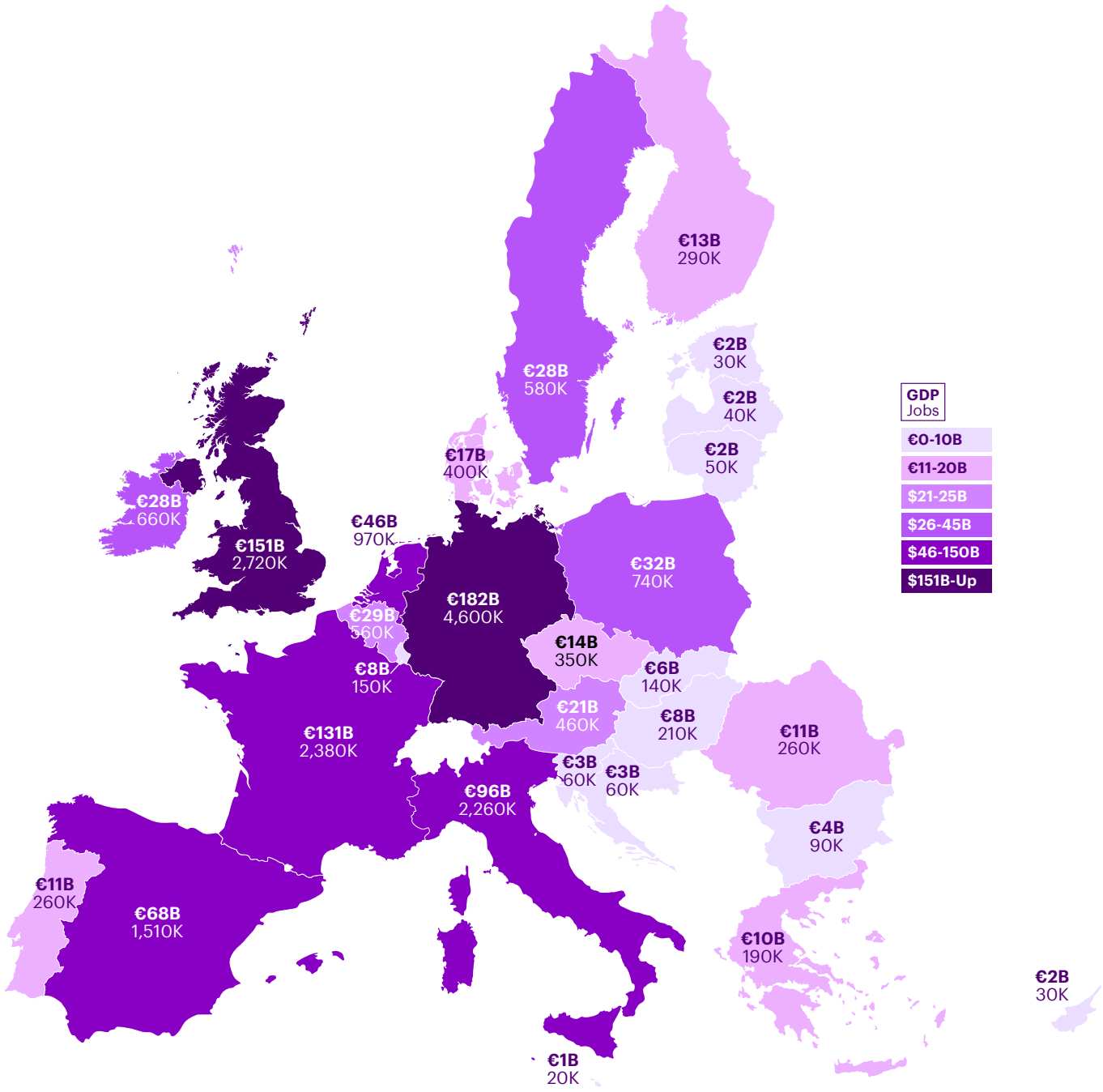
Effects on GDP

Figures in €B of EUR	Direct Industry Impact on GDP	Indirect Impact on GDP	Induced Impact on GDP	Total Value Chain Impact on GDP
Accommodation and Food Services	€24.2	€10.8	€12.3	€47.3
Agriculture, Forestry, Fishing, and Hunting	€23.4	€12.6	€14.9	€50.9
Arts, Entertainment, and Recreation	€36.3	€11.8	€20.4	€68.5
Auto and Transport	€89.5	€85.9	€125.2	€300.5
Business and Professional Services	€84.9	€29.7	€68.6	€183.3
Construction	€43.7	€27.9	€43.0	€114.7
Education	€36.0	€3.5	€6.6	€46.0
Finance and Insurance	€47.1	€21.4	€42.6	€111.1
Healthcare	€51.2	€10.5	€18.0	€79.7
Information / Communication	€123.4	€58.1	€69.2	€250.7
Manufacturing	€131.8	€138.1	€162.0	€431.9
Mining, Quarrying, and Oil and Gas	€3.3	€1.3	€2.1	€6.7
Public Admin, Defense, and Social	€35.6	€12.0	€16.7	€64.3
Real Estate, Rental, and Leasing	€86.5	€25.4	€28.1	€140.0
Retail	€84.8	€31.6	€44.9	€161.4
Utilities	€25.1	€19.1	€19.6	€63.8

Effects on Labor Income

Figures in €B of EUR	Direct Industry Impact on Income	Indirect Impact on Income	Induced Impact on Income	Total Value Chain Impact on Income
Accommodation and Food Services	€12.8	€5.8	€6.6	€25.2
Agriculture, Forestry, Fishing, and Hunting	€13.2	€4.7	€6.1	€23.9
Arts, Entertainment, and Recreation	€19.5	€4.8	€8.7	€33.1
Auto and Transport	€51.8	€18.3	€25.5	€95.6
Business, and Professional Services	€51.2	€9.2	€21.7	€82.1
Construction	€28.3	€8.9	€13.5	€50.8
Education	€20.4	€2.4	€4.7	€27.6
Finance and Insurance	€22.6	€5.1	€9.8	€37.5
Healthcare	€31.5	€6.8	€11.6	€49.9
Information / Communication	€92.2	€39.3	€47.3	€178.8
Manufacturing	€67.6	€30.5	€35.7	€133.8
Mining, Quarrying, and Oil and Gas	€1.5	€0.6	€0.8	€3.0
Public Admin, Defense and Social	€27.0	€14.2	€15.0	€56.1
Real Estate, Rental, and Leasing	€43.4	€14.5	€21.0	€79.0
Retail	€51.8	€18.3	€25.5	€95.6
Utilities	€8.9	€5.6	€5.2	€19.7

5G Impact on GDP and Jobs by Country[vv]



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