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D2.3 – Vertical industries and rollout to markets 1st Report

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Executive Summary

Europe is faced with economic and societal challenges such as the ageing of populations, high fragmentation of economic framework, sustainable development and flat GDP growth. The introduction of digital technologies in economic and societal processes is key to addressing the challenges of this macroeconomic impasse situation with the goal to restart to grow again, gain new efficiencies and competitiveness.

5G network infrastructures will be a key asset to support this societal transformation, leading to a revolution impacting multiple sectors. With speeds up to 10 Gbps, reduced latency and unprecedented reliability, the connectivity based on the 5G standard could change the processes and the development scenarios of several different industries.

5G will provide European enterprises with ultra-fast and widespread mobile connectivity services, becoming the catalyst for innovation processes crucial for their competitiveness, for maximizing the economic potential of the digital revolution, to address their priorities, challenges, and propensity to embrace innovation.

Despite the different approaches and degrees of propensity to Digital transformation, the emerging needs to innovate will strongly influence the Verticals ICT spending in the next years, by pushing them to adopt Innovation Accelerators (see Essential Glossary) technologies and leverage 5G networks to successfully compete in the European market.

5G will play an essential role across all market industries to boost innovation, process automation and new innovative services, helping them to focus and overcome their main challenges. In particular, 5G will represent a driver in **the following industries**, which **show a high growth rate of their ICT spending for the period 2018-22:**

- **Automotive**. The ICT spending growth, coupled with opportunities for connected-vehicle services, meant that Automotive was identified at a very early stage as a primary target Vertical for services enabled by 5G mobile networks. Five main groups of connected-vehicle applications which can be expanded by 5G are **Information and entertainment, Navigation and journey, Usage-based services, Traffic balance and control, Vehicle autonomy.**
- **Manufacturing.** Future competitiveness of the sector will be influenced by two trends: the servitisation of Manufacturing and the growing importance of global value chains driving the demand for truly connected Manufacturing ecosystems. Key applications and benefits for 5G in smart factories will include: **Constant on-site connectivity**, **Constant inter-site connectivity**, **Use of VR/AR technologies, Wide-area connectivity, Enhanced industrial ecology, Decreased risks/alert management.**
- **Healthcare.** The Healthcare sector is facing a wide transformation: the delivery of care will be soon strongly decentralised, becoming truly patient-centric, reducing the hospitalisation of

patients and allowing them to receive treatments and to be closely monitored at home. Firstly, 5G will impact positively on the deployment of **Remote Health Monitoring** to monitor the physical condition of patients with chronic diseases. In future, after 2022, 5G is also expected to significantly improve connectivity, **to enable haptic feedback to underpin surgeons' capabilities to carry out remote robotic surgery.**

- **Energy.** Energy technology is shaking traditional utility value creation at its core. Not only is it fuelling a shift in the way energy is produced, distributed, and consumed, but also in the ownership of the production capacity itself. In parallel, digital technologies are disrupting decade-old processes, creating opportunities and threats to the traditional utility business model. The business potential of 5G in the Energy vertical is expected to be very high through the support of **next generation smart grid protection and smart metering.**

The ongoing development of 5G mobile communication technology will be the cornerstone to enable communications for automation in various vertical domains, but in the European macroeconomic environment with its high fragmentation and diversity, institutions and industry stakeholders should consider the following recommendations:

- **Start by clearly identifying in which industries and in which business processes 5G, as the next evolutionary stage of digitalization, could transform services and products,** generating real benefits in terms of cost or incremental revenues and in how success will be measured. The ability to understand the overall journey of Digital transformation for each vertical Industry will help drive the process of identifying which use case to prioritize first and develop a roadmap that will effectively advance Digital transformation across Europe.
- **Foster the development of a data-driven culture, enabling European businesses (mainly SMEs) to recognize the value of data.** Improving the capability to extract in real time value from information coming from many sources, devices, objects, will be a key success factor for these businesses to compete in the global market. As 5G networks support a massive number of connected devices and create a threat landscape different from previous networks, foster a data-driven culture means also recognizing and continuously working at new approaches to security, privacy, identity and regulatory compliance.
- **Recognise that the diversification of the European macroeconomic framework will initially generate several many small-size use cases** difficult to replicate and extend cross-sector or cross-country. 5G will penetrate European industries with differentiated timing and use cases, also in relation to the regulation and economic structure of the different countries.

1. Introduction

1.1 Scope and Purpose

5G will unlock new capabilities not attainable in current networks, opening the door for new applications that demand absolute reliability, such as in health care, energy, autonomous transportation. The Global5G.org Market Watch, led by IDC, zooms in on an in-depth analysis of four major vertical industries, namely automotive, manufacturing, energy and healthcare. As such, this document is oriented to provide:

- An overview about the impact of 5G on Western European Vertical Industries.
- An analysis about how 5G will transform Automotive, Manufacturing, Healthcare and Energy industries.

This analysis will be updated in December 2019 (Month 30).

1.2 Terms of Reference and Methodology

The results presented in this document for the four selected industries are based on IDC continuous research activities. They also draw on inputs from 5G PPP collaborative activities, meetings, webinars, calls as well as third party events, reflecting the context within which 5G innovations are being sketched, thereby covering multi-faceted perspectives, sector specific needs and approaches, as well as major cross-cutting issues.

1.3 Glossary of Terms

The table below lists the common definitions used in Global5G.org.

Acronym/ Abbreviation	Description
5G PPP	5G Infrastructure Public Private Partnership
5G AP	5G for Europe Action Plan
5G IA	5G Infrastructure Association representing the private side of the 5G PPP
3GPP	3rd Generation Partnership Project, providing complete system specifications for cellular telecommunications network technologies, leading 5G standardisation, currently in Phase 1 of the 3GPP 5G effort for Release 15. Full compliance with the ITU's IMT-2020 requirements is anticipated with the completion of 3GPP Release 16 at the end of 2019. In Phase 2 of the 3GPP 5G effort
ASIL	Automotive Safety Integrity Level
BEREC	Body of European Regulators for Electronic Communications
BSS	Business Support Systems
CAM	Connected and Automated Mobility
CAN	Controller Area Network
Capex	Capital expenditure
CPS	Cyber Physical System

CSP	Communication Service Provider
CTO	Chief Technical Officer
DA	Distributed Automation
DER	Distributed/Decentralised Energy Resources
DMS	Distributed Management System
eMBB	Enhanced mobile broadband (use cases mostly associated with rollout phase 1 of 5G)
EMS	Energy Management System
FCC	Federal Communications Commission
FoF	Factories of the Future
GDPR	General Data Protection Regulation
IOT	Internet of Things
ITU	International Telecommunication Union, the standards setting body within the United Nations
mIoT	Massive Internet of Things (use cases mostly associated with rollout phase 2 of 5G)
IS	International Standard
KPI	Key Performance Indicator
MCS	Mission critical services (use cases mostly associated with rollout phase 2 of 5G)
MEC	Mobile Edge Computing
MNO	Mobile Network Operator
MS	Member State
MTC	Machine Type Communications
MVNO	Mobile Virtual Network Operator
NFV	Network Function Virtualisation
OpEx	Operating expenditure
OSS	Operational Support Systems (or sometimes Open Source Software)
PPDR	Public Protection and Disaster Recovery
SDA	Strategic Deployment Agenda
SDN	Software-Defined Networks
URLLC	Ultra-Reliable Low-Latency Communications

Table 1: List of Common Terms

The table below is the Essential Glossary for this report.

Acronym/Abbreviation	Description
ESI	The Economic Sentiment Indicator (ESI) is a composite indicator made up of five sectoral confidence indicators with different weights: Industrial confidence indicator, Services confidence indicator, Consumer confidence indicator, Construction confidence indicator and Retail trade confidence indicator.
Digital transformation	For IDC the term Digital transformation means applying new technologies to radically change processes, customer experience, and value. Digital transformation allows organisations to become Digital Native Enterprise that support innovation and digital disruption rather than enhancing existing technologies and models.
Artificial Intelligence (AI)	IDC defines Artificial Intelligence (AI) systems as a set of technologies that use deep natural language processing and understanding to answer questions and provide recommendations and direction.

Internet of Things (IoT)	IDC defines the Internet of Things (IoT) as a network of uniquely identifiable end points (or things) that communicate bi-directionally without human interaction using IP connectivity.
Big Data & Data Analytics	IDC describes Big Data and Data Analytics as a new generation of technologies and architectures designed to economically extract value from very large volumes of a wide variety of data by enabling high-velocity capture, discovery, and/or analysis.
AR/VR	IDC defines Augmented Reality (AR) as purpose-built devices, worn on the head and over the eyes, which allow the wearer to see their surroundings while being served data or feedback. The device may overlay digital objects in the real world, or simply generate actionable feedback in the form of a heads-up display. IDC defines Virtual Reality (VR) as purpose-built devices, worn on the head and over the eyes, which completely obscure the wearer's vision of the outside world, creating an all-inclusive virtual reality.
Four Pillars	4 technology areas: Big Data & Analytics, Cloud, Mobile, and Social Media. These four technologies are important, foundational elements in a digital enterprise that can disrupt the market and successfully adapt to a new, Digital transformation-focused economy.
Innovation Accelerators	IDC has identified six technologies that, when combined with other 3rd Platform technologies, empower businesses to propel Digital transformation within their organisations. These Innovation Accelerators can aggressively propel growth and are necessary to bind organisations' strategic and tactical elements together to deliver enhanced digital experiences. The technologies are: IoT, AI, Robotics, 3D Printing, AR/VR, Next Gen Security. Blockchain technology is also part of Innovation Accelerators.

Table 2: Essential Glossary

1.4 Structure of the Document

The rest of this document is structured as follows, with each section corresponding to a major item as specified below:

Section 2: Gives an overview of IDC market demand trends and macroeconomic dynamics in Western Europe, focusing on the emerging digitalisation demand that 5G will address. This section also includes an overview of the diverse stakeholder engagement mechanisms in Global5G.org to ensure effective (inter)actions with key European industry associations.

Section 3: Is dedicated to the analysis of the four selected verticals focusing on their ICT demand and evolution towards the digital transformation. It gives an overview of the transformation and changes generated by 5G adoption in the four Verticals. It concludes with the main findings for each of the four verticals.

Section 4: summarises the main conclusions and provides a core set of recommendation key to realising the full benefits of 5G.

2. The impact of 5G on European Economy: why 5G will play an essential role in Vertical Industries Transformation

Europe is faced with economic and societal challenges such as ageing of populations, high fragmentation of the economic framework, and a flat growth of the GDP.

The introduction of digital technologies in economic and societal processes is key to meeting the challenges of this macroeconomic impasse situation with the goal to trigger growth, gain new efficiencies and competitiveness.

5G network infrastructures will be a key asset to support this societal transformation, leading to a revolution that will impact multiple sectors[1]. With speeds up to 10 Gbps, reduced latency and unprecedented reliability, the connectivity based on the 5G standard could change the processes and the development scenarios of several different industries.

As for the 3-4G connection, the path from trials to the actual market rollout for 5G will take between 2 or 3 years, the progressive extension of the 5G network will begin to make its effects felt in different areas by reducing the limits that have so far slowed down the applications of the Internet of Things.

5G will become the underlying infrastructure of an entire ecosystem of fully connected intelligent sensors and devices, capable of overhauling economic and business policies, and further blurring geographical and cultural borders. It will be capable of delivering impacts on every rung of the ecosystem's ladder, providing seamless, continuous connectivity for business applications.

5G will provide European enterprises with ultra-fast and widespread mobile connectivity services, becoming the catalyst for innovation processes crucial for their competitiveness, for maximising the economic potential of the digital revolution, to deal with priorities, challenges, and propensity to embrace innovation.

Despite the different approaches and degrees of propensity to Digital transformation, the emerging needs to innovate will strongly influence the Verticals ICT spending over the next few years, by pushing them to adopt digital technologies to successfully compete in the European market.

According to IDC, 5G will play an essential role in the Manufacturing, Utilities, and Healthcare markets, which show the highest growth rate of ICT spending for the period 2018-2022. Although investments in ICT are considerable, the innovation potential has not yet been exploited by the companies and organisations in these markets (according to the IDC Innovation Index). Therefore, fostering the uptake of 5G innovative services in these sectors will help boost innovation, process automation and overcome the main challenges.

[1] 5G empowering vertical industries, 5GPPP 2018.

2.1 European Macroeconomic Outlook

Leveraging IDC and other sources, this section provides an insight into the current and forecasted macroeconomic context in Europe, and how the European companies are investing in ICT. This analysis helps understand the role of 5G for the European industries, and which sectors may have the strongest impacts on the overall European ecosystem.

According to the January 2019 Consensus forecast[2], the European Union GDP growth is forecast to be 1.7% in 2019 and 1.6% for 2020. Looking more closely at Western Europe, the GDP growth is set at 1.5% for both 2019 and 2020.

The overall EU figures remained stable compared with the previous forecast. Nonetheless, looking at individual countries, GDP forecast was revised downwards for almost all countries, outlining that the region is experiencing some challenges, especially related to Brexit and the collateral effect of the U.S./China tariff war, which are creating overall uncertainty and caution in investments. This situation affected business confidence and had negative effects also on the European Sentiment Indicator (ESI)[3].

The ESI for the EU reached 106.2 points in January 2019, decreasing 3.9 points quarter-on-quarter (QoQ), showing some challenges across the region. Confidence in Austria, Belgium, and the United Kingdom deteriorated significantly, while in France and Germany the decrease was less strong. Portugal registered a small increase, due to favourable comparison QoQ.

The EU confidence decreased across all sectors, showing that all industries are currently experiencing a slowdown. Service confidence is limiting overall confidence, with a decrease of 4.2 points QoQ. Service sector confidence was particularly affected by a very weak performance in the United Kingdom and Austria. Construction sector confidence decreased by just 0.3 points.

The decline was contained thanks to a positive performance in Finland, Spain, France, and Italy, all of which registered an increase in confidence in the Construction sector. All other sectors, including Consumer (-2.4), Industry/Manufacturing (-3.1), and Retail (-3.2), experienced a confidence deterioration, outlining a challenged scenario. Retail was particularly affected by a double-digit decline in the U.K., where the Retail ESI dramatically dropped 11.8 points Quarter on Quarter (QoQ).

[2] https://www.consensuseconomics.com/.
[3] https://ec.europa.eu/eurostat.

Source: DG ECFIN Business and Consumer Survey, January 2019

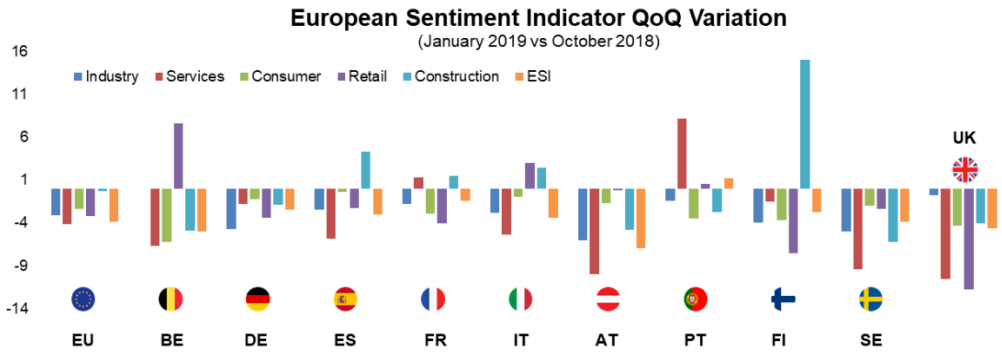

Figure 1: European Sentiment Indicator Quarter-on-Quarter Variation

The graph above shows the QoQ variation (January 2019 ESI vs. October 2018 ESI), of confidence by industry across the European Union (EU), Belgium (BE), Germany (DE), Spain (ES), France (FR), Italy (IT), Austria (AT), Portugal (PT), Finland (FI), Sweden (SE), and the United Kingdom (UK). The figures show significant downward fluctuations in confidence across the British, Austrian, and Swedish Service sector as well as in the Retail sector in the U.K. On the other hand, very few sectors experienced an increase in confidence, outlining that the political and economic situation is negatively impacting on European business confidence.

Major macroeconomic and political developments, as well as emerging technology trends and innovation are affecting confidence, GDP, and ICT investments. Key highlights include:

- **Brexit**. Uncertainty continues to stall investments in the U.K. as there are no clear points on future trade agreements between the U.K. and the EU. The U.K. will ask for an extension to leave the EU, but no agreement has been reached yet, causing the so called "Brexit deadlock". The financial sector is highly dependent on freedom of movement, as the EU passporting system for banks and financial services authorise them to trade freely in any EU or European Economic Area (EEA) country. Banks, investment banks, and financial services providers as well as London-based European institutions (such as the European Medicines Agency) have set out or completed relocation plans to continental Europe. It is estimated that the British financial services sector has moved €1 trillion in assets to the EU since the Brexit referendum. Immigration rules are set to toughen up in the future, and, although no measures are in place as of today, this is affecting the EU net migration to the U.K., which fell to lowest level in almost six years. This creates a risk of future shortage of skills, especially for technology companies and for the Healthcare sector (the National Health Service), which are dependent on overseas immigration to recruit highly skilled staff and fulfil missing skills.

  Brexit is the main example of how uncertainty can have an impact on the economy and on

the number of companies in a country. In fact, with many companies relocating assets or even headquarters from the U.K. to continental Europe, the number of businesses currently present in the U.K. soil is expected to diminish, in favour of countries such as Germany, France, Ireland, or the Netherlands.

- **Southern economies' slow recovery**. Italy faced a few months of political instabilities in 2018 as the country struggled to form a coalition government, which impacted negatively on its GDP. Political instability can impact budgets dedicated to IT investments across the Public sector, including central and local government, Healthcare, and Education. Southern economies, including Spain, Greece, Italy, and Portugal continue to have a tough job market, which constrains opportunities. SMEs budgets are limited, and this is reflected in more limited ICT investments across companies with less than 500 employees.
- **Social unrest in France**. Riots and social unrest have been taking place in France since November 2018, as the government announced increases in fuel prices. This turned out to become a resurgent protest which resulted in the PM Macron bowing to pressures and announcing a minimum wage hike and tax concessions. According to Consensus, this measure will cost the French government €10 billion, which it has indicated will be partially funded by spending cuts. ICT investments across the entire French Public sector (including local and state government, Education, and Healthcare) are expected to be cautious, if not set to experience a slowdown.
- **European Union elections**. The elections will be held in May 2019 and European citizens will have the chance to decide the future of the European Union. The overall EU political situation faces various degrees of uncertainty, with early indications that the composition of the Parliament will be more fragmented, with the decline of traditional parties and the rising voice of new populist/nationalist parties. Uncertainty comes not just about the outcome of the elections but also on the subsequent influence that the new parties will have in steering EU legislation over the next five years. This will have an impact on budgets and spending on ICT-related aspects such as digitisation and innovation.
- **American tariffs and U.S./China trade war**. The U.S./China trade war reflected slightly on Manufacturing companies highly exposed to import/export. Germany's economy slowed down in the last quarter of 2018, and it barely avoided sliding into recession. One reason behind the slowdown was the U.S./China trade war. American tariffs are impacting negatively on German steel-makers' sales, and Germany is also experiencing side effects caused by the trade war between China and the United States. The Automotive sector will remain strongly affected by the ongoing trade battle.

All these macro-economic and political factors will have an impact on the economic and social environment in Europe also in the next two years and, together with the high fragmentation and

differentiation of enterprises distribution and demography, will influence and implicate different growth dynamics and timing of full adoption of digital technologies. In particular, more than 10.5 million enterprises, 90% with fewer than 10 employees, are active in the 10 main European Countries. The figures below show how they are distributed by area and vertical sector. The figures reveal key differences across the countries analysed.

The first figure shows major differences in terms of the number of companies in the main countries.

Source: IDC Western Europe, Number of Companies by Vertical and Size, 2017

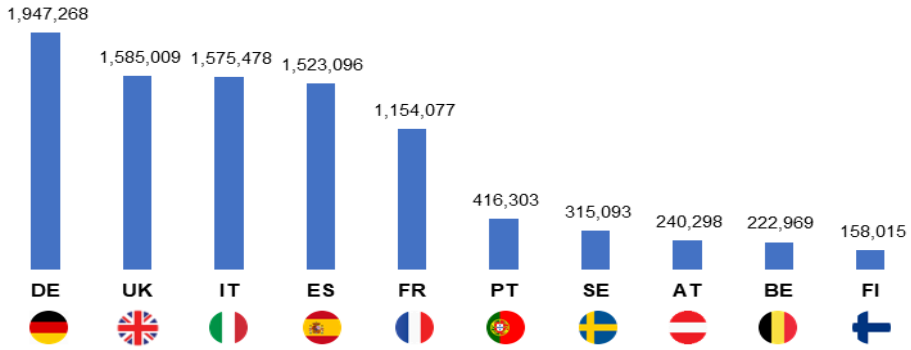

Figure 2: Number of Companies in main Western Europe Countries

The second figure shows distribution across vertical industries.

Source: IDC Western Europe, Number of Companies by Verticals & Size, 2017

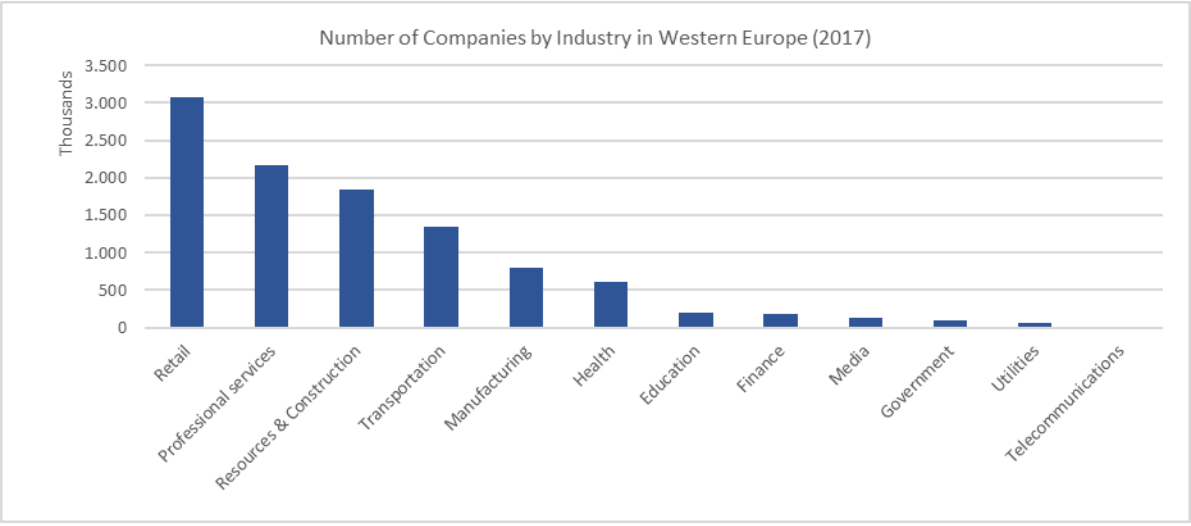

Figure 3 - Number of Companies by Industry in Western Europe (2017) (thousands)

The industries with the highest number of companies are by far Retail, Professional services, and

Resources & Construction. These industries are in fact characterised by a considerable number of SMEs, with very low investments in ICT. On the other hand, Telecommunications, Utilities, Government, and Media have a lower number of companies, which are mostly large and very large, where massive investments in technology are concentrated.

In this framework, SMEs will continue to play their essential role in the "excellence niches" that differentiate the European economic environment if digital technologies will ensure ubiquitous wireless connectivity and a simplified access to innovative services to facilitate interaction between human beings, business communities, supply chain and Public sector.

2.2 European Industry Business Priorities and Propensity to embrace Digitalization

According to the IDC European Vertical Markets Survey 2018-2019[4], business priorities of European companies will be Customers, Cybersecurity, and Efficiency.

Source: IDC European Vertical Markets Survey 2017-2018

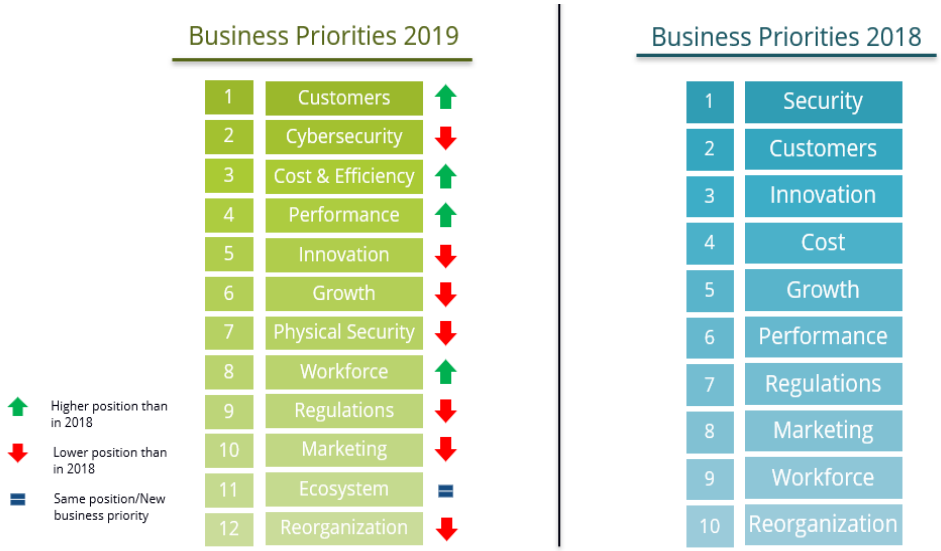

Figure 4: Comparison between European Companies' Business Priorities for 2018 and 2019

In this regard, two main evidences can be noticed by comparing the 2018 vs 2019 results. First of all, customers rise first, thereby replacing security, highlighting the increasing importance for European companies to continuously target the evolving needs of clients both in B2B and in B2C contexts. Secondly, the survey shows the increasing focus on cost and efficiency, which even outweighs innovation and is set to be one of the main areas of investment for the months to come.

[4] The IDC European Vertical Markets Survey 2018-2019 (with a sample of 2,759 companies all over Europe), analyses in detail business priorities and challenges of European industries in 2019.

By analysing the results at industry detail, it is interesting to note that **industries' business priorities in 2019 will follow four different patterns according to the specific importance ranking associated with each of them, namely customer-driven, cybersecurity-driven, efficiency and growth-driven.**

Source: IDC European Vertical Markets Survey 2018-2019

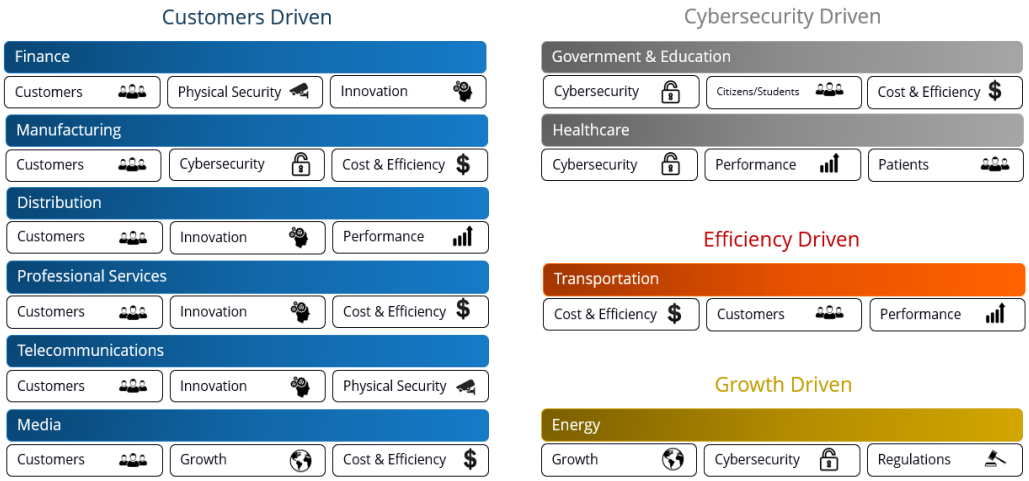

Figure 5: Top Three Business Priorities by Industry - The Four Strategic Patterns

A description of the top 3 business priorities across European companies is presented below[5].

Customers will be the top business priority for all profit-oriented businesses excluding Transportation and Energy, which will pursue respectively efficiency and growth-driven evolution patterns. Attracting and retaining customers is crucial for companies to boost customer satisfaction and increase their revenues. Competition increases, especially with newer and more tech-savvy start-ups focusing on highly innovative and disruptive services. Customers and customer experience become key strategic points for European companies to expand their customer base and to survive against competition, especially in the case of SMEs vs larger companies, where brand awareness and customer loyalty are more consolidated. This includes not only attracting but also retaining customers, as reducing churns decrease costs of acquisition (marketing, advertising), brings steady cash flows, and creates positive feedback and word-of-mouth. As an example, this will be the top business priorities in Finance and Manufacturing. Companies operating in Finance and Manufacturing will focus on the attraction of new customers and the retention of existing ones. To attract customers, banks will focus on improving interaction through digital platforms and mobile apps. The focus on customers will drive a lot of investments in the Distribution sector, particularly in Retail, where innovation will be based on customer experience and e-commerce services. Therefore, it will be essential for distribution

[5] IDC European Vertical Markets Survey 2018-2019.

companies to enhance multichannel e-commerce platforms able to communicate with store operations and to personalise the digital interaction between customers and the company.

Cybersecurity will be by far a key focus for the Public sector, including Healthcare, Government and Education. Digitalisation is forcing public institutions to put special attention on protection against digital attacks. National governments are especially taking care of the security of open data platforms, protecting the availability and accuracy of data. The Healthcare industry will also be focused on the provision of high security and data protection levels, as also requested by the strict General Data Protection Regulation (GDPR) requirements. Moreover, data loss and leakage prevention and identity and access management will be ever thornier for patients. Rising barriers against cyber-attacks will be under the spotlight also across manufacturers. In fact, the special attention to provide at each stage of the supply chain a significative added value will be fostered by the radical changes happening in the industry under the so-called "Industry 4.0" paradigm, which will require companies to pay increasing attention towards cybersecurity.

Efficiency and growth will be strategic focus areas and top priorities respectively for the Transportation and Energy sectors. Transportation will be the only efficiency-driven industry in 2019, putting customers in second place. Even more than in other industries, the motivation should be found by the extreme competition of the market due to services that are perceived as commodities by customers. For this reason, the main priority for Transportation companies is becoming the optimisation of operating processes to cut costs and be able to face the ongoing price war. For Energy companies, more than for others, the core business priority will be represented by the expansion and consolidation of their shares in emerging business areas such as renewables, electric vehicles, and smart home solutions. Cost, efficiency and performance will be focal points on the agenda of Manufacturing firms as well, highlighting the endless importance of leveraging managerial and technological advancements to continuously improve production processes and operating models.

Source: IDC, 2019

Figure 6: IDC's Four Pillars and Innovation Accelerators (IAs)

Regarding the propensity to embrace digitalisation, the results of the IDC European Vertical Markets Survey 2018-2019 provide relevant indications about the main current and emerging trends across European industries.

The IDC reference framework (described in the picture above) was used to structure the analysis. The IDC framework is based on the distinction between the so-called Four Pillars (Cloud, Big Data, Mobile, Social Media) and seven Innovation Accelerators (IoT, AI, Robotics, 3D Printing, AR/VR, Blockchain, Next Gen Security). While the Pillars represent the basis for the digitalisation of the company, the IAs are the latest technological advancements fostering the re-invention of the business.

According to the survey's results, the main technologies currently used by European companies across Verticals are Cloud and Social Media, two paradigms that are now already consolidated and whose business benefits are clear to firms. In terms of emerging trends, other four technologies will represent the main perspective for European business progress, namely Big Data and Mobility (two of the IDC's Four Pillars), and Robotics and AR/VR (two of the IDC's Innovation Accelerators).

Source: IDC European Vertical Markets Survey 2018-2019, Western Europe, N=2, (183 Respondents)

Pillar/IA	% of organisations already using the technology	% of organisations planning to start using it in the next 12 months
Cloud	42.1%	16.3%
Big Data	29.3%	18.9%
Mobile	37.5%	17.7%
Social Media	64.5%	11.3%
IoT	37.8%	12.6%
AI	23.0%	16.6%
Robotics	18.0%	18.2%
3D Printing	12.3%	13.7%
AR/VR	17.8%	17.8%
Blockchain	4.6%	13.6%

Table 3: % of Western European organisations already using and planning to start using Four Pillars and IAs in the next 12 months

Despite their maturity, Big Data and Mobility will still be the focus of European firms also for the months to come. The former as a pre-requisite for business success and as an enabler for more advanced applications (e.g. Artificial Intelligence), the latter as an indispensable way to reach and engage customers in the modern economy. On the other hand, Robotics and AR/VR will increasingly be the real drivers for innovation, relying on sound technological principles and on a potentially unlimited range of applications.

Source: IDC Customer Insights & Analysis, 2019

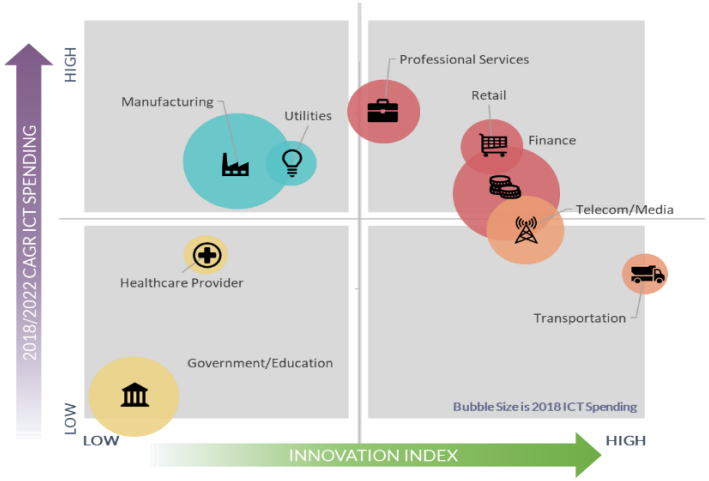

Figure 7: IDC Innovation index: industries propensity to embrace innovation

In the ICT ecosystem, different industries have a different propensity towards innovation. In order to quantify that, IDC developed the "innovation index", which combines different dimensions of innovation leveraging the IDC's European Vertical Market Survey 2018-2019 and the Worldwide Semi-annual ICT Spending Guide Industry and Company Size data. In particular, the methodology used leverages 4 components:

- The share of budget that industries devote to innovation rather than to maintaining or upgrading an existing system.
- The strength on the 4 pillars technologies, including Cloud, Big Data, Mobility and Social Media.
- Strength on innovation accelerators, including IoT, AI, Robotics, AR/VR, 3d Printing, Blockchain and next generation security.
- Digital transformation maturity, which is measured across 5 stages.

Mixing these ingredients, we obtained an indicator on a 5-point scale measuring industries propensity to embrace innovation.

Retail, Finance, and Professional services are the "sweet spots" (red bubbles in the graph above) lying where both the innovation index and the ICT spending growth are high. The safe spots quadrant (light blue bubbles) includes industries with growing ICT spending. New use cases and organisations-wide digital transformation initiatives will eventually allow these industries to shift to the sweet spots quadrant. The invent quadrant (yellow bubbles) includes industries with higher resistance to innovation and increasing ICT spending.

Lastly, the plan quadrant (red bubbles) includes industries with high potential industries. These industries need to focus on proven ROI projects and develop a clear roadmap.

Retail, Professional services, and Finance were identified as the most innovative industries, with a high propensity to innovate and to spend on IT. This is because there is a strong need for automation and enhancement of back-office processes. Hence, companies operating in these sectors, typically very content and data-heavy, are looking at technology to improve processes and experiences. Strong needs for automation are flanked by an increasing interest towards customer experience solutions based on analytics to provide personalised experiences. These industries are highly customer-facing, so ensuring a connected, seamless, and highly integrated experiences to customers is key for success.

Manufacturing and Utilities spend is high, but innovation propensity remains low. This is due to industry assets requiring stronger efforts to innovate and to a lower propensity of companies operating in these industries to embrace an innovative-oriented culture. Both industries are nonetheless spending a lot on IT due to their constant effort to use technology to lower cost and optimise processes. As might be expected, the Public sector (including Government, Education, and Healthcare) is the least innovative as budgets are constrained and bureaucracy high, limiting digital transformation and innovation propensity. Telecom and Transport companies are very innovative,

although spend does not stand out compared with other Verticals. The advent of 5G will push innovation across Telecommunications and will enable high interest for the next-generation of AI and IoT-based use cases, which can bring strong benefits to business.

A key message emerging from the analysis is that sectors like Manufacturing (including Automotive), Utilities and Healthcare will be the main industries where 5G adoption could have the most important impacts: 5G services could drive the digital transformation of companies active in these markets.

Again, another 2018 IDC industry survey carried out on over 100 mobile operators, shows that Manufacturing, Automotive and Healthcare are among the industries presenting the highest revenue potential as early targets for 5G-enabled services, as they are placed in the top 4 5G target verticals by more than 38% of respondents.

Source: IDC, 5G in Vertical Applications: Automotive - Q. Which industries present the most revenue potential as early targets for 5G-enabled services? - EMEA44566918

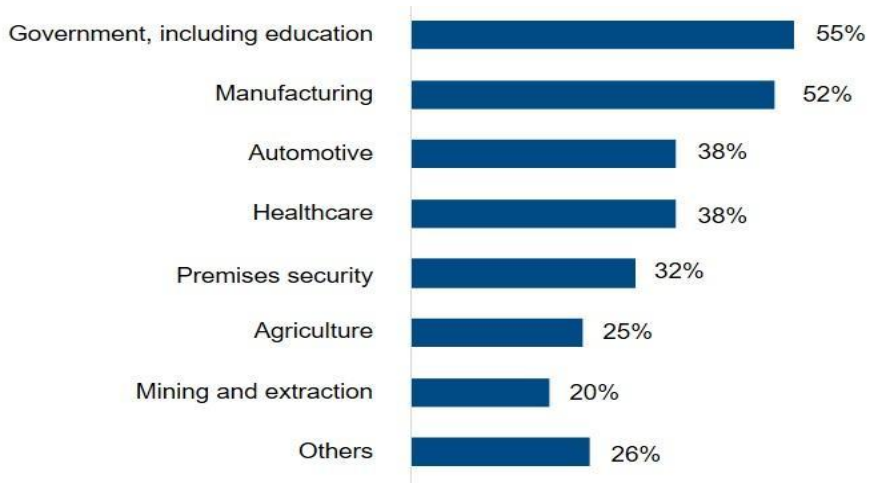

Figure 8:Industries presenting the highest Revenue Potential as Early Targets for 5G-enabled Services

2.3 ICT Spending Overview across Industries and Forecasts

The European ICT end-user spending (including hardware, software, IT services, business services, and telecom services) reached €689 billion in 2018. As the overall macroeconomic situation improves across European countries, ICT spending is expected to increase by 2.5% in 2019, reaching €706 billion.

In 2019, Consumer, Banking, and Manufacturing will be the biggest ICT spenders, while Retail and Professional services will experience the fastest growth in 2019. Consumer spending will experience a slight increase and will go up by 1.2% in 2019. Professional services, Retail, and Manufacturing will

have the fastest growth considering their 2017-2022 CAGRs[6].

Source: IDC Worldwide Semi-annual ICT Spending Guide Industry and Company Size, 2019

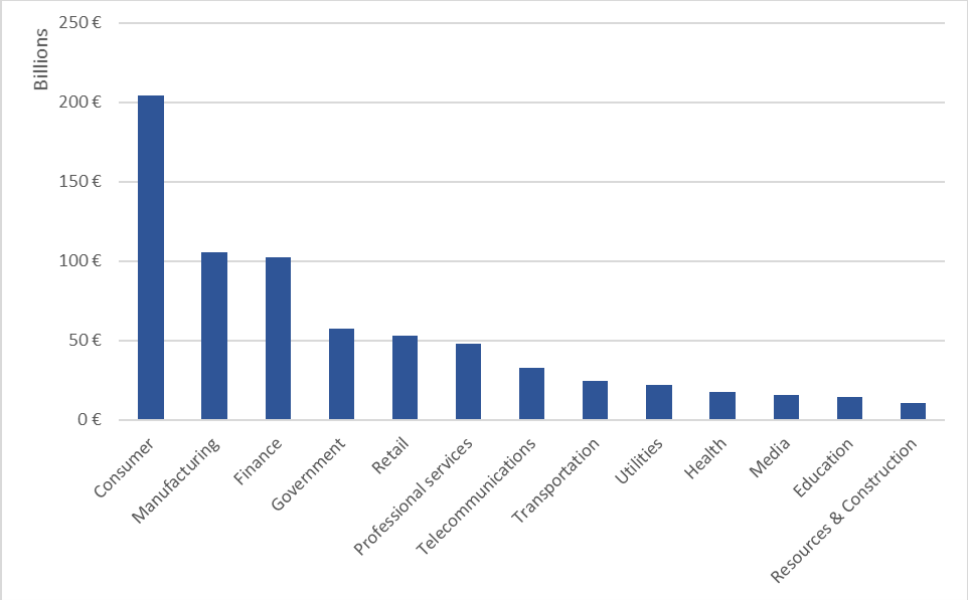

Figure 9: Total ICT Spending by Industry in Western Europe (2019) (€ billions)

In terms of average ICT spending per company, the top industries turn out to be Telecommunications (€2.1 million/company), Government (€0.7 million/company), and Finance (€0.5 million/company). Although many economic and political challenges across European countries put pressure on the ability of organisations to increase technology budgets, the EU ICT spending growth is highly dependent on digital transformation and on increasingly higher investments around emerging technologies such as AI, Edge Computing, Blockchain, IoT and Data Analytics, all of which play a key role in optimising business processes but also in enhancing customer experience.

In the mid-term, 5G development will generate many opportunities for European businesses to take driverless cars, remote surgery, precision medicine, or smart home devices to the next level, making them more seamlessly connected and higher performing thanks to improved connectivity. Customer experience is another emerging trend around which European companies, particularly retailers, are focusing their efforts and budgets on, especially in areas such as personalisation at scale through AI-driven technologies.

[6] IDC Customer Insights & Analysis, 2019.

Source: IDC Customer Insights and Analysis, 2019

Figure 10: IT-related Trends and Investments Areas by Industry

Countries such as Ireland, Sweden, Norway, Finland, and Germany will support most of the growth in 2019 as their technology investments will grow faster compared with the rest of Europe. This trend depicts a clear technology landscape in Europe with Northern economies significantly increasing ICT spending as their digital transformation efforts gain in relevance over time.

Countries such as Sweden, Norway, and Denmark are early adopters of new technologies with many businesses being at the forefront of digital innovation.

On the other hand, Southern economies remain behind with countries such as Italy, Spain, Portugal, and Greece growing at a slower pace compared with the Nordics. In fact, Greece will experience a small decline as its economic situation remains weak. IT investments will grow modestly in Portugal, while growth will accelerate a bit faster, but still limited, in Italy and Spain. SMEs remain a segment that continues to struggle as budget availability is limited and constrains investments in innovation.

The figure above shows the latest ICT-related trends and investments areas that European companies have been focusing on by industry. ICT spending trends by vertical market will be differentiated by vertical sector as follows[7]:

- **Financial services**. The Financial services industry is very technology-intensive and will keep investing in hardware, software, and IT services, but will also be better-positioned to launch pilot projects in new areas. AI and Blockchain will be under the spotlight across Financial services as financial institutions continue to embrace digital transformation to keep up with

[7] IDC Customer Insights & Analysis, 2019.

competition. AI will help businesses optimise internal processes, protect customer accounts, safeguard financial information against cyberthreats. Blockchain lends itself to several common use cases including regulatory compliance, cross-border payments and settlements, custody and asset tracking, and trade finance and post trade/transaction settlements. Security will continue to be a key concern for banks and Insurance companies, with the Financial sector keen on implementing multilayer access based on biometrics (facial and voice recognition) to verify customer credentials when they access their accounts.

- **Manufacturing**. Automation is a strong focus and will help enterprises to simplify complex tasks or processes and ease human resources from heavy and time-consuming workloads. This will be possible through the deployment of robotics or collaborative robots (cobots) that will help manufacturers achieve efficiency benefits and enable staff to save time without compromising employment prospects. Deep learning, natural language processing, and computer vision will help manufacturers improve how they design, manufacture, and deliver their products. Interest in industrial IoT will continue to drive investments in IT. IoT solutions will enable manufacturers to monitor manufacturing equipment and improve field services.
- **Distribution**. Focus on customer experience will drive retailers to invest in solutions that will make life easier for shoppers, ranging from virtual customer assistants to automated sales recommendation. Due to the highly customer-centric nature of retail, efforts in providing superior and differentiated customer experience is the key industry focus from 2018 and in the years to follow. Retailers that want to stand out from competition need to embed the latest technologies into their business models and offer products and services to customers, following changing habits and purchasing patterns. Big Data will be crucial in the definition of personalised services to customers to maximise potential revenues. AI will enable the efficient integration of web platforms with store operations and the optimisation of order fulfilment. IoT will be the main component in the complete automation of the supply chain. AR/VR will contribute to inventory management and the training of employees.
- **Professional services**. This data-intensive industry will continue to support cloud investments, but it will also look at Big Data and Artificial Intelligence for automation purposes. Professional services will continue to ride the digital transformation wave to surpass old-fashioned business models and adopt more innovative ones, enabling prompt, automated, and valuable interaction with customers. Relevance of cloud will keep on increasing also for non-IT companies progressing in their journey to digitalisation (e.g. legal and accounting, business consultancy). Focus on social media will continue to grow in order to strengthen or build relations with existing or potential customers.

- **Healthcare**. Western European Healthcare organisations are not ready to fully exploit the Innovation Accelerator opportunity, especially as investments are linked to public funds, which are sometimes limited. Robots, especially for surgery and logistics purposes, are becoming more affordable, and hospitals will start to invest more significantly in coming years. Investments in wearables, IoT, and AI will grow as there will be a stronger need to monitor patient behaviour and accidents for elderly people with medical conditions to provide prompt emergency support.
- **Transportation**. Customer experience will drive investments as transport companies are looking at new ways to deliver innovative and on-time services to guarantee pleasant journeys to passengers exploiting data and analytics generated from passengers' movement to optimise strategies and operations. Smart trucks are gaining popularity due to the ability of automating processes through the integration of different types of technologies.
- **Telecommunications**. Digitising customer experience will help telecom providers in this aspect, especially for customer service purposes. AI will play a strong role in that: on the one hand, solutions such as virtual assistants and chatbots will gain ground, while on the other hand, AI will enable companies to automate support services, reducing labour costs and allowing savings. Telecom providers will also work to partner with the aviation industry to provide in-flight connectivity services. The Telecommunications industry is one of the most active across the entire spectrum of technologies analysed with considerable efforts in several business applications. Among them, attention will be high on both public and private cloud solutions, mainly used as a means to continuously update the service offer to their customers. Social media presence will also be one of the highest across verticals, with final end-users expecting ubiquitous interaction with Telecom service providers. In the continuous race to costs optimisation and customer retention, Big Data and AI will play the main role. The former especially on customer profiling and offer definition, the latter on the automation of customer service, for instance through chatbots.
- **Media**. Investments in new ways of delivering content through social media and immersive experiences (AR/VR) will drive some of the IT spending. There will be a strong focus on strengthening mobile content that is accessible to everyone from their mobile devices. This will have a positive impact on customer experience. Big Data and mobile applications will be the two pillars that will still be leveraged by Media companies to reach customers and enable the personalisation of content provided to them. In the personalisation of customer promotions, AI will be a further technological underpinning to be used. AI will also represent the basis for the integration of virtual assistants into web platforms as well as for the automation of the related digital services. Another fundamental innovation in the industry will be brought by remote applications such as broadcasting network maintenance

and asset surveillance made possible by IoT connectivity.

- **Utilities**. The industry's efforts to look for new business models will drive the acceleration of digital transformation. The Utilities industry is a challenging one, where all players have easy access to cutting-edge technologies, whereby digital transformation is a key enabler for companies to stay ahead of competition. Efforts to connect, monitor, and maintain remote assets will drive investments in IoT and predictive analytics.
- **Resources and Construction**. This will remain a very small market. Investments remain slow, but projects revolving around IoT, AR/VR, and drones are drawing attention. Wearables for construction site operators are also gaining ground, and they are used to monitor technicians and keep the workforce safe and trackable in the event of an accident.
- **Government and Education**. Governments are working to reduce internal bureaucratic processes through automation. In fact, long back-office tasks slow down critical government work, resulting in longer waiting times for citizens to access services. Smart city projects will continue to push investments in technology, especially for safety purposes such as video surveillance and for public transport optimisation. Some Education institutions in Western Europe are lagging behind in terms of connectivity and ICT awareness. Digitisation is not yet fully embraced in many Education institutions.

The advent of 5G will represent the next evolutionary stage in the digitalisation journey, albeit with differences across industries in terms of digitalisation trends. 5G will extend mobile communication services beyond mobile telephony and broadband internet with new communication services to provide automation for various use cases and innovative services.

Although the entire economy and the society will strongly benefit from the advent of 5G, market data shows that the next generation network will have the strongest impacts on specific markets, supporting the players in implementing new applications, transforming their business processes and the entire supply chain:

- **Manufacturing and Automotive:** are the verticals most focused on automation to simplify complex tasks or processes and ease human resources from heavy and time-consuming workloads. Due to their ICT spending, their innovation approach and their needs to innovate products and processes, these industries will be early adopters of 5G.
- **Healthcare organisations** are not yet ready to fully exploit the Innovation Accelerator opportunity, especially as investments are linked to public funds, which are sometimes limited. 5G services could have great impact in the mid-term, changing the delivery processes to monitor patient behaviour and accidents for elderly people with medical conditions to provide prompt emergency help, following the diffusion of wearables. Instead, robots for surgery and logistics purposes, which require huge investments and high

reliability of connectivity, will be deployed in the long-term.

- **Utilities** industry's efforts to look for new business models will drive the acceleration of Digital transformation and 5G adoption. Efforts to connect, monitor, and maintain remote assets will drive investments in IoT and predictive analytics. 5G services will help this industry to gain efficiency and compete in the European complex arena of renewable energy resources.

2.4 Global5G.org Engagement Mechanisms for Vertical Industries

Global5G.org engages with vertical industries through several mechanisms:

- Phase 2 projects within 5G PPP, e.g. the Verticals Cartography as an online tool tracking the progress of over 60 use-case experiments, including benefits for a wide variety of end-users. Activities are coordinated through the Trials Working Group. Global5G.org is also monitoring inputs to 5G standardisation, both in general and in relation to vertical industries through the Pre-Standardisation Working Group, chaired by Ericsson as a member of the 5G Infrastructure Association (5G-IA).
- The Verticals Task Force of the 5G-IA, chaired by TIM, defining engagement levers and ensuring coordination across the 5G PPP. One of its main targets is EU-based/led industry associations, with a view also of creating strong synergies through Memorandums of Understanding. This lever is complemented by the one described below to ensure economies of scale.
- The Task Force of the 3GPP and its market representation partnerships (MRPs) through the 5G-IA. Engagement is taking place with vertical industry associations that are also 3GPP MRPs, such as the 5G Automotive Association (5GAA); 5G Industrial Internet of Things (5G-ACIA); EMEA Satellite Operators Association (ESOA); Public Safety Communications Europe (PSCE). On top of these, the Task Force also brings on board the European Broadcasting Union (EBU); the International Railway Union (UIC); the European Utilities Telecom Council (EUTC); the European Connected Health Alliance (ECHAlliance), with joint efforts to on-board other associations and stakeholders into the 5G standardisation process.
- The Global5G.org Advisory Board (AB) is tasked with filling existing gaps in vertical coverage on the one hand, and supporting educational/awareness programmes on the other. Good examples of the latter include healthcare (Health 4.0) and IIoT (Industry 4.0), where Global5G.org endeavours to support the understanding of 5G benefits amongst stakeholders (e.g. public-sector organisations, SMEs, large companies, and in the case of healthcare, also patient associations). The AB thus further complements the diverse engagement mechanisms used within Global5G.org.

On top of this and in relation to the automotive industry, Global5G.org is an active contributor to the 5G PPP Automotive Working Group (since August 2018), and more recently of the Strategic Deployment Agenda.

KEY FINDINGS

Europe is faced with economic and societal challenges such as the ageing of populations, high fragmentation of the economic framework, and flat GDP growth.

Europe experienced a challenged during the first quarter of 2019, with some instabilities related to the macro-economic outlook and political developments, including Brexit, slow recovery of Southern European countries, social unrest in France, and uncertainty surrounding the upcoming European elections. This has had an impact on the EU business confidence, which decreased across all sectors, showing that all industries experienced a slowdown.

The introduction of digital technologies in economic and societal processes is key to addressing the challenges of this macroeconomic impasse situation with the aim of triggering growth while gaining new efficiencies and competitiveness.

5G will provide European enterprises with ultra-fast and ubiquitous mobile connectivity services, thereby becoming the catalyst for innovation processes crucial for competitiveness, for maximising the economic potential of the digital revolution, thereby addressing top priorities, challenges, and propensity to embrace innovation.

Despite the different approaches and degrees of propensity to Digital transformation, the emerging needs to innovate will strongly influence the verticals' ICT spending over the next few years, by pushing them to adopt Innovation Accelerators technologies and leverage 5G networks to successfully compete in the European market.

5G will play as essential role for Manufacturing, Utilities, Healthcare providers:

- **Manufacturing and Automotive:** are the verticals more focused on automation to simplify complex tasks or processes and ease human resources from heavy and time-consuming workloads. Due to their ICT spending, their innovation approach and their needs to innovate products and processes, these industries will be the early 5G adopters.
- **Healthcare organisations:** 5G services could have great impact in the mid-term, changing the delivery processes to monitor patient behaviour and accidents for elderly people with medical conditions to provide prompt emergency help, following the diffusion of wearables.
- **Energy** industry's efforts to look for new business models will drive the acceleration of Digital transformation and 5G adoption. Efforts to connect, monitor, and maintain remote assets will drive investments in IoT and predictive analytics. 5G services will help this industry gain efficiency and compete in the European complex arena of renewable energy resources.

Direct engagement with these and other verticals, including the IDC webinar series, ensures Global5G.org is able to convey its main findings through a variety of mechanisms.

3. How 5G will transform Automotive, Manufacturing, Healthcare and Energy Industries

3.1 Automotive

3.3.1 Automation is the emerging need

The Automotive industry undergoing significant changes, superseding the traditional approach based on individual ownership of vehicles, the rigid separation between public and private transport, and limited insights on optimal journey choices. With increasing urbanisation, European cities are facing significant challenges in terms of congestion, pollution and parking, and this trend is expected to increase moving forward.

IT spending, including hardware, software, and IT services, across Western European organisations in the Automotive sector will be close to €9.4 billion in 2019, a 4.0% 5-year CAGR[8]. This highlights that technology investments will grow throughout 2022 with Automotive companies looking at IT to drive digital transformation as well as to enhance passenger and driving experiences. The graph below shows year-on-year growth in IT spending across Western European Automotive companies between 2018 and 2022.

Source: IDC Worldwide Semiannual Manufacturing IT Spending Guide, 2018

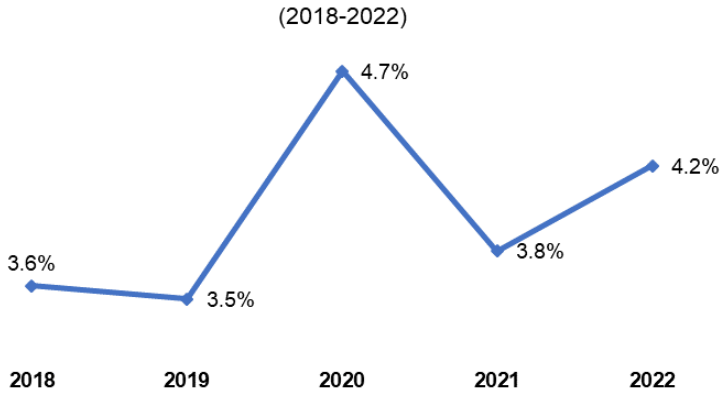

Figure 11: IT Spending across Western European Automotive Companies

Automotive players are strongly investing on a full digitalisation of their products and services, with regulators and providers in the sector promoting the adoption of common data management rules and data platform design principles to cultivate an open and competitive connected vehicles data marketplace. This enables safer, more efficient and sustainable mobility, while fostering new business

[8] IDC Worldwide Semiannual Manufacturing IT Spending Guide, 2018.

models and opportunities in the broad sector ecosystem, as highlighted in the White Paper of the 5G Automotive Working Group, to which Global5G.org has contributed[9].

Manufacturers have accepted the fact that their customers do not see them anymore as a mere supplier of a piece of product but as the potential source of an end-to-end solution. Product functionality as a service without the hassles of owning and maintaining is going to be the new market for manufacturers. Moreover, consumers want personalised services with a competitive price tag. This presents a fantastic opportunity for manufacturers to expand their existing market and serve new customers or the complementary needs of existing customers.

To maximise the overall driving experience and ownership, Automotive manufacturers must look into multiple other complementary product or service features such as in-car entertainment, passenger engagement (gaming), easy maintenance, parking and so forth, all of which require a syndication approach. It must revaluate the role of existing vendors and partners and then play along with external entities or contractors. A recent case in point is Automotive players providing a car's trunk as storage/locker facility for delivering consignment from Amazon Retail. Enabled through smart locks and a cloud-connected camera, this cross-industry collaboration proves how customer needs can be met by extending the core industry definition. IDC observes healthy trends of collaborative growth with the natural adjacent industry (e.g., retail-CPG company's referral) or even with disconnected sectors (e.g., automotive and delivery services) [10]. Profit margin per transaction may be lower when selling through ecosystems, but access to a wider consumer base will generate more demand than it otherwise would, thereby compensating for any shortfall. Growth “outside the box” also comes with a greater role in innovation, production, and distribution, improving efficiencies and optimising product and service levels from start to finish.

Automation is a strong focus and will help companies simplify complex tasks or processes and ease human resources from heavy and time-consuming workloads. This will be possible through the deployment of Robotics or collaborative robots (cobots) that will help manufacturers achieve efficiency benefits and enable staff to save time without compromising employment prospects. Deploying robots in the Automotive industry will bring great advantages: robots can run 24 hours a day without supervision, carry out repetitive tasks for long periods, perform dangerous tasks, or work in hazardous conditions. At the same time, they are accurate and can produce high-quality products faster than humans. For example, Ford's manufacturing factory in Germany uses cobots alongside humans to fit shock absorbers to cars. Cobots lift and position shock absorbers into the wheel arch, enabling the company to achieve higher product standards.

Digital transformation is not only about changing the way companies think about how they engage customers, but it is also about empowering employees and optimising operations. Artificial

[9] 5G PPP Automotive Working Group, Business Feasibility Study for 5G V2X Deployment (February 2019).
[10] IDC Customer Insights & Analysis, 2019.

Intelligence and Big Data/Analytics also play a big role. AI is poised to experience strong growth over the next five years. Deep learning, natural language processing, and computer vision will help manufacturers improve how they design, manufacture, and deliver their products. For example, Rolls-Royce uses AI solutions to learn from design engineers and recommend new engine designs with little human support. It also uses AI for equipment health monitoring, so engineers can predict when certain components may fail.

Security is another focus for Automotive companies in Europe. With vehicles becoming more and more autonomous, connected, and controlled, both drivers and passengers are increasingly concerned about their personal data. Therefore, automakers and all the stakeholders need to make sure that confidential passenger information is kept secure from data breaches through, for example, through multi layers of built-in security features. In fact, data loss and leakage prevention remains one of the top security priorities for manufacturers, which will continue to invest in security measures to avoid breaches of passenger or vehicle-related information[11].

More frequently, today's most innovative cars boast features resembling local Wi-Fi, allowing passengers mobile devices to experience an onboard 4G LTE connection. But with the increasing number of people connecting to Wi-Fi to stream music, movies, or download content and using connectivity services on their mobile phones or tablets in mobility, having a fast internet connection for everyone may well be challenging. With lower latency and enhanced signal capabilities, 5G will be at the very foundation of autonomous vehicles as well as the in-built car services of the future. Faster, better and more reliable connectivity will help deliver personalised services and create an environment with seamless interaction between cars, smart cities, and service providers. The Automotive industry will invest in 5G to tackle this issue and make sure that there is enough bandwidth and speed so that each passenger can experience an enjoyable connected journey. Not only will this result in a more positive experience for passengers, but also automakers will be able to gather more data and insight from connected cars to improve remote monitoring and control of autonomous cars. As we move towards an “electrified car era”, vehicles will need to be more connected to the internet, so automakers can monitor battery levels, issue charging status alerts, search for and suggest charging stations, as well as to asses traffic and suggest routes to avoid congestion.

The Automotive industry is investing in electric vehicles and will continue this strong focus in the years to come. For example, in the UK, the "Sector Deal" involves both the British government and industry, both of which will invest about a quarter of a billion pounds to develop and manufacture electric vehicles. This investment marks a key milestone towards the mass production of electric batteries and vehicles and aims to create a world-leading testing environment for Connected and Autonomous Vehicles.

A large share of the German Manufacturing market is dedicated to the Automotive industry. In this

[11] IDC's European Vertical Markets 2018-2019 Survey.

context, connected vehicles are the most important IoT use cases. However, OEMs are not only investing in technologies around connected vehicles, but also supply chain and adjacent service suppliers that are beginning to shift their business models from being product suppliers to becoming service/technology providers. An example is the tire manufacturer Continental, which is not only producing tires, but also developing services around its tires (tire-as-a-service) and providing solutions for autonomous driving, electro mobility, connectivity, infotainment, and vehicle security.

Another key technology for the sector is the IoT. In fact, the IoT ecosystem will accommodate vehicles, road infrastructure and connected objects, with close attention to safety critical aspects of automated driving. With more than €100 million of EU funding, the goal of the IoT Large Scale Pilots (LSP) Programme is to foster the deployment of IoT solutions in Europe, demonstrate their feasibility and benefits and promote the development of a sustainable IoT ecosystem[12].

According to IDC, infotainment vehicle solutions, fleet management, and vehicles security drive European expenditures in the connected vehicles domain, representing more than €4.5 billion spending in 2017. EU connected vehicles' investment priorities in the coming years will focus on vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) solutions and infrastructure, focusing on increasing situational awareness and reducing road risks and crashes.

3.3.2 5G enhances Connected-vehicle Applications

Newly purchased motor vehicles are now routinely shipped with mobile connectivity for use by drivers, passengers, and a car's functional and maintenance systems. Since April 2018, all new vehicles in the European Union (EU) are required to enable connectivity in compliance with the eCall Mandate, an initiative for equipping vehicles with the ability to make automatic calls to emergency services in the event of a collision. As a result, motor vehicles have become a new and fast-growing class of mobile-connected devices[13]. According to Statista, the number of connected cars in Europe will grow from 49,5 million in 2019 to 109.9 million by 2023[14].

A key enabler of this evolving context is connectivity. In the Automotive sector, connectivity is about the communication between vehicles and other vehicles (V2V), infrastructure (V2I), pedestrians (V2P), and the network (V2N). These are collectively referred to as vehicle-to-everything (V2X) communications.

Today, there are two major technologies competing for this market in Europe: one is based on the IEEE 802.11p Standard; the other on standardised cellular networks promoted by the 3rd Generation Partnership Project (3GPP), that is, LTE, 5G, and beyond. While factors such as the radio performance

[12] https://european-iot-pilots.eu/.
[13] IDC 5G in Vertical Applications: Automotive EMEA44566918, 2018.
[14] https://www.statista.com/outlook/320/102/connected-car/europe#market-revenue.

can determine the adoption of these technologies, the businesses that can be built on top of these technologies will also become key determining factors for their success[15].

In recent times, one of the biggest attention-grabbers among emerging technology areas has been autonomous vehicles. The vision of self-driving cars, making roads less congested, more efficiently utilised, and safer, is an appealing one, and there are enough technology enablers in place to make the vision seem enticingly close. Technology is not the only factor to deal with though, before autonomous vehicles can become mainstream, a great deal of regulatory and legal work needs to be done in areas such as responsibility and insurance liability, and a great deal of infrastructure instrumentation will also be required. **All this means that it will be some years before we start seeing fully autonomous vehicles on our roads as a matter of course[16]**.

The Automotive industry has defined five levels of vehicle autonomy:

- **Level 1**: Driver assistance.
- **Level 2**: Partial automation.
- **Level 3**: Conditional automation.
- **Level 4**: High automation.
- **Level 5**: Full automation.

Actually, there are already vehicles on the road operating at levels 1 and 2, with functionality such as enhanced cruise control and self-parking. The question of when vehicles operating at levels 3 to 5 will come onto the roads is still a matter of debate. Some cars, such as the Audi A8, are already capable of level 3 autonomy, though they are not yet allowed to operate at that level on the open road. An optimistic scenario, outlined for example by Daimler-Benz's head of R&D, Ola Källenius, is that level 3 vehicles will be on the road by 2020, with level 4 and level 5 vehicles in service by 2025. Thus, even optimists acknowledge that fully autonomous vehicles are still some way away from the commercial mainstream. **Automotive is an early target vertical for 5G, but fully autonomous vehicles are still some way away from the commercial mainstream.**

However, autonomy is not the only big change in progress for road vehicles. The Automotive industry is currently working hard on a shift from hydrocarbon-fuelled to electrically powered engines, and the industry is also making the vehicles increasingly software-controlled and internet connected. These three big shifts in vehicle development, autonomous, connected, and electric, are taking place in parallel (see Figure below), and they tend to get conflated with each other. **In particular, "connected vehicles" and "autonomous vehicles" are often taken to mean the same thing. It is important to understand clearly that these are two separate (though related) areas of vehicle development**,

[15] European Commission – 5G PPP Phase 2: 5GCAR Project, https://5gcar.eu/.
[16] IDC Connected Car: Near-Term Opportunities for Telecom Providers, EMEA43645318.

where opportunities from the connected car are far more immediate than those arising from autonomous vehicles. Moreover, there are already several concrete cases.

- **Connected vehicles** contain software, sensors, and IP-enabled connectivity. They leverage the cellular network, either independently or through a mobile device, for the purposes of service delivery, data collection, and/or asset management.
- **Autonomous vehicles** are a subset of connected vehicles that contain additional cameras, sensors, lidar, and/or radar to safely operate in a dynamic environment independently of a human driver.

Source: 2018, Connected Car: Near-Term Opportunities for Telecom Providers, EMEA43645318

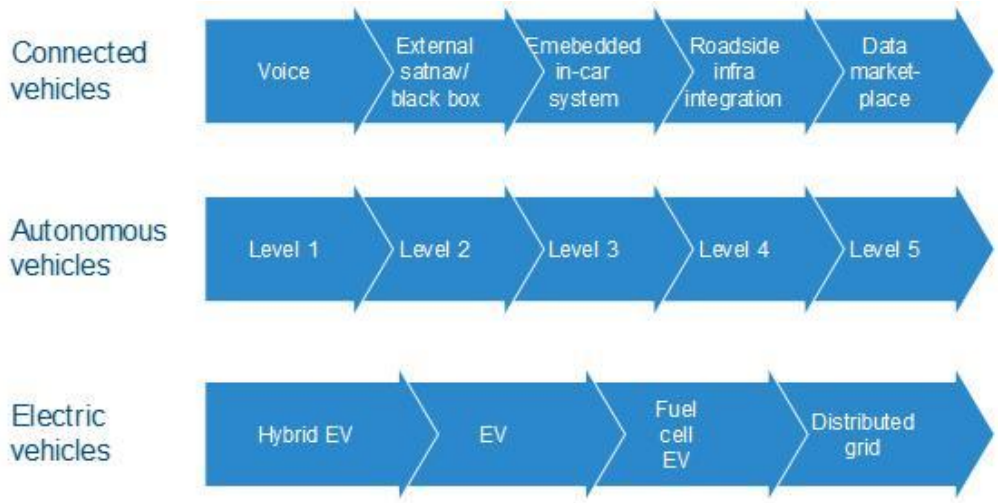

Figure 12: Three Major Areas of Vehicle Development are Running in Parallel

An increasing percentage of sold new cars now come with their own independent connection to the mobile network (in some cases, multiple connections for different purposes). This connectivity caters both to the increasing use of internet-connected devices within cars and growth in software-controlled functionality. As a result, some connected-car use cases are already seeing adoption, with more in prospect in the near term.

The factor that makes Automotive a promising 5G vertical is that there are several distinct and diverse service opportunities in connected-vehicle applications, which will emerge and grow in phases during the next few years. Some of these opportunities can be supported by today's 4G networks, enhanced and expanded by 5G. Others will be unlocked by the new capabilities that 5G can bring to mobile networks, such as ultra-fast response times, high connection density, and quality-of-service guarantees[17].

[17] IDC 5G in Vertical Applications: Automotive EMEA44566918, 2018.

The deployment of 5G presents great opportunities to develop new business and ownership models based on vehicle digitalisation and decarbonisation.

Connected Vehicle not just as an opportunity, but as a series of opportunities, some of them enhanced by the capabilities of 5G, and some of them enabled by those capabilities.

IDC defines five main groups of connected-vehicle applications, all of which can be expanded by 5G as shown in the Figure below. These are:

- **Information and entertainment.** Vehicles are being equipped with mobile connections enabling infotainment applications and related content and services, to be used by drivers and passengers. Personalised content such as local information about tourism and services, transport news, and location-based advertising will grow in importance. An increasingly rich and complex range of multimedia, gaming, and other interactive content will be involved, as cellular network performance and coverage improve, and as user uptake grows.
- **Navigation and journey.** We will see growth in the production, delivery, and usage of advanced navigation information using a combination of emerging technologies. High definition 3D maps, updated in real time with contextual information, will enhance the capabilities of in-car navigation. Navigation will be enhanced as vehicles detect, record, and share information about obstacles such as road bumps, potholes, and dangerous bends, creating a networked hazard-mapping system. Dashcam video sharing will become increasingly popular, enabling over-the-shoulder collaborative support.
- **Usage-based services.** As vehicle connectivity grows, a platform-driven data market will emerge, based on information coming from vehicles. Data from vehicles will be collected and shared among stakeholders, enabling features such as in-car ecommerce and travel experience customisation by sharing car data with partners such as fuel suppliers, retailers and restaurants. This use case is powered by advanced data mining techniques and cognitive technologies.
- **Traffic balance and control.** With widespread vehicle connectivity, data from a large number of vehicles in a locality can be aggregated and analysed to optimise traffic management. This typically involves partnerships between vehicle manufacturers and local authorities. Benefits for drivers include receiving up-to-date information and advice, such as warnings about upcoming congestion and emergency vehicles, as well as optimal speed for catching green-light signals.
- **Vehicle autonomy.** Vehicles interact directly with each other and with their environment to assist drivers in performing their functions, to take over some functions from drivers, and ultimately replace drivers altogether.

Source: IDC, 5G in Vertical Applications: Automotive, #EMEA44566918

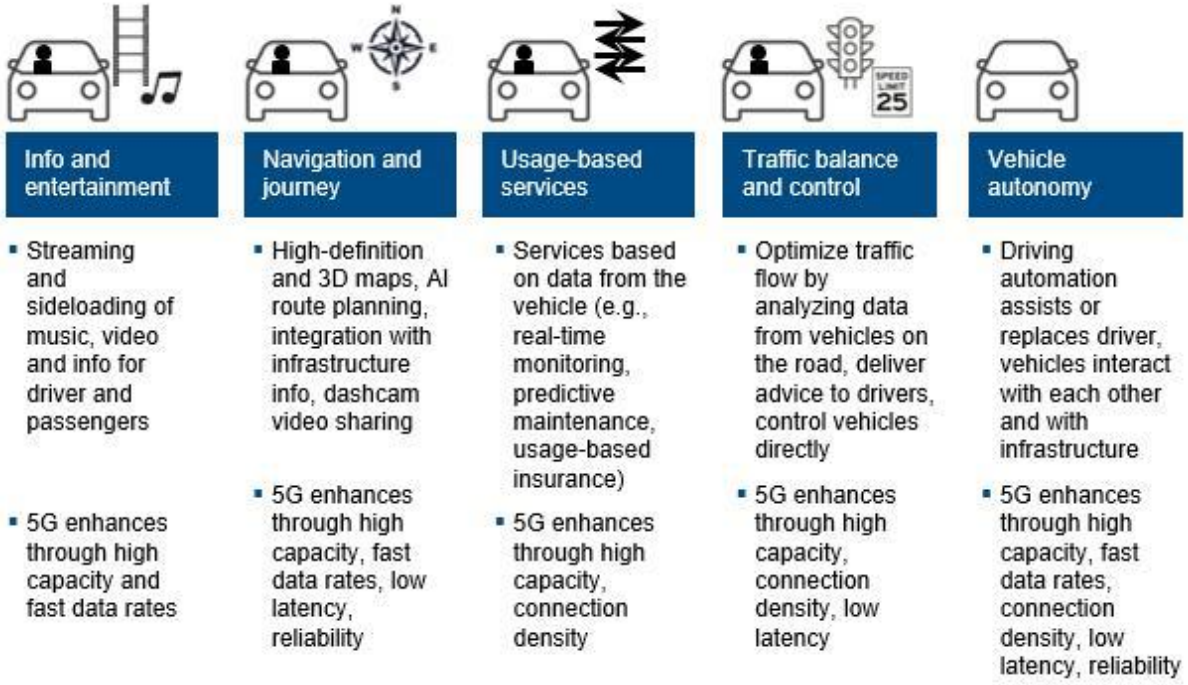

Figure 13: Five Groups of Connected-Vehicle Applications

The first four application groups are already commercial, at least to some extent. They offer immediate and near-term 4G opportunities for mobile operators, as well as longer-term opportunities enabled by 5G. But the most distinctively 5G application groups will be related to vehicle autonomy.

The autonomous-vehicle scenario is still some time ahead, but it may be well within the planning horizon of Automotive industry stakeholders. Some observers are optimistic about the pace of autonomy development. Eventually, when autonomous vehicles and intelligent road infrastructure become widespread, low latency and high reliability of 5G networks can play a crucial role in governing the operation of traffic, mediating vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-server interactions. These interactions are generally referred to as V2X.

There is considerable debate at present about whether autonomous vehicles' V2X interactions will use:

- **Mobile network connectivity,** referred to as cellular V2X (C-V2X). 3GPP Release 14, published in 2016, included the first specifications for V2X interactions over 4G (LTE). Subsequent releases will enhance C-V2X capabilities and define a migration path to 5G.

- **Local-area connectivity for direct interactions between vehicles and infrastructure.** The IEEE 802.11 WiFi standard has been progressively incorporating V2X capabilities since version 802.11p, published in 2012. This is sometimes referred to as dedicated short-range communications (DSRC).

Both cellular and local-area V2X connectivity have a durable role to play. In the early stages, local DSRC connectivity is likely to predominate because it is quicker to develop and roll out, and because it is easier to support low-latency communication that way. But C-V2X has the advantage of being able to support both local and long-distance interactions.

As 5G coverage spreads, and as 5G latency comes down, improved functionality and better scalability that wide area connectivity enables will lead to a growing role for 5G in vehicle autonomy. For example, CV2X can potentially improve road safety at junctions by increasing the range over which a car can detect the behaviour of other cars, well beyond line of sight. For similar reasons, C-V2X is likely to be more suitable for supporting vehicle autonomy at high speeds. The 5G Automotive Association (5GAA) has carried out several detailed studies comparing and contrasting the two technologies in autonomous-vehicle applications[18].

We are at the very beginning in terms of transforming the driving experience enabled by connectivity. The industry is making a concerted push towards increasing levels of autonomy in vehicle operation, and this will need levels of performance and reliability that today's mobile networks cannot deliver.

5G networks will overcome these limitations by delivering higher capacity, lower latency, denser connectivity and service-level guarantees, while cooperation between regulators, the public sector, automotive manufacturers, Telecom stakeholders will play an essential role in accelerating the societal benefits of connected vehicles.

So, we see a progression of changes for auto makers, service providers and network operators in automotive transformation. The automotive supply chain that supports the creation of the connected car is increasingly complex and multi-layered. The Figure below highlights the main categories of technology and participants that interact within the connected car ecosystem.

[18] http://5gaa.org/.

Source: IDC PlanScape 2016, EMEA44204118

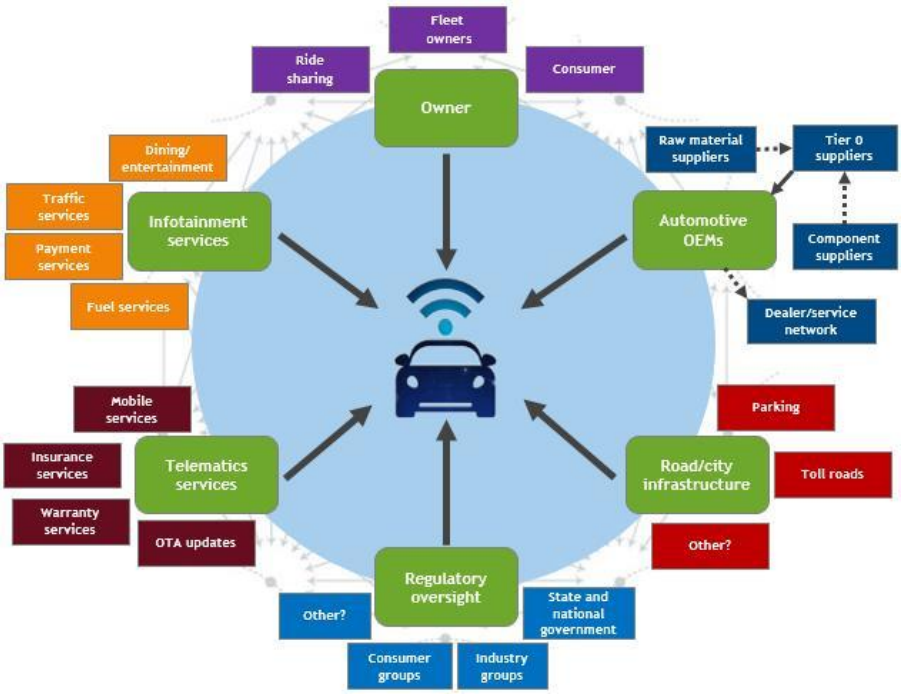

Figure 14: The Connected Car Ecosystem

The autonomous vehicles development is a key disruptor to the traditional vehicle manufacturing status quo. Differentiators span contracting with specialty, technology vendors and start up, while most manufacturers are targeting early generation high-level automated systems starting from Mobility-as-a-Service solutions.

Some near-term opportunities are already being enabled by today's 4G networks. And as 5G networks come on stream, they will support a major expansion in both the scale and the scope of new services and capabilities that will be available to drivers over the coming decade. It is important to note that the one over-riding requirement that mobile networks need to meet to ensure advantages to the above players: 5G road coverage.

Among this supply chain the 5G commercial launch will represent an important monetisation opportunity for Connected Vehicle Service Providers and especially for Telecom providers. All autonomous vehicles contain a connected component, even though the specific functionality may not leverage that connectivity. Most of the opportunities for Telecom providers arising from the connected-car use cases are concerned with providing connectivity and with collecting, analysing, and monetising Big Data sets. Connectivity provision has always been the core business of Telecom providers, and it needs no explanation. Big Data monetisation, however, is a more recent and less universal area of Telco activity.

In the course of conducting their business, Telecom providers generate and store large data sets about their customers, including personal information, demographics, activities, and location. By correlating and implementing analytics on these data sets in combination with third-party sources, Telecom providers are creating new, revenue-generating services for business customers in areas such as:

- **Footfall analytics:** providing intelligence to sectors including Retail, Public transport, Tourism, and local government.
- **Driver/passenger motion analytics:** providing real-time intelligence about traffic flows to detect and predict congestion events.
- **Predictive location information:** to deliver marketing offers at a time and place when the receiver is most likely to find them interesting.

Other relevant revenue opportunities could come from Autonomous Platform Providers that are rapidly developing their solutions as auto OEMs that are building out their individual projects through a combination of in-house development alongside strategic partnerships and acquisition. Meanwhile many vendors involved in the connected vehicle spaces are developing a multi-faceted offering, providing service in multiple areas, or at least offering a solution capable of serving a number of distinct use cases[19].

3.2 Manufacturing

3.2.1 "Industry 4.0" leads the Interconnection of IT and OT

Manufacturing IT spending, excluding the Automotive sector, will reach around €68 billion in Western Europe in 2019, showing a 2.9% year-on-year growth[20]. In terms of IT spending, the main investments will come from the main traditional European manufacturing countries, namely Germany, UK, and France.

Manufacturing is living a digital renaissance, characterised by the interconnection and cooperation of resources across the industrial system (plants, people, information) both within the factory and along the entire value chain. This is enabling renewed competitiveness and efficiency of companies operating in this sector. The fourth industrial revolution, commonly known as "Industry 4.0", is driven by a heterogeneous set of both IT (Information Technology) and OT (Operational Technology) technologies that are being leveraged to allow the continuous interaction of the real and virtual worlds, thereby increasing operational effectiveness, improving the decision-making ability of workers, and integrating the factory with the supply chain. Ultimately, this will pave the way for the creation of new business models.

[19] IDC Connected Car: Near-Term Opportunities for Telecom Providers, EMEA43645318.
[20] IDC Worldwide Semiannual Manufacturing IT Spending Guide.

Source: IDC, 2019

Figure 15: Industry 4.0: Concept and Enabling Technologies

The main Industry 4.0 technologies enabling the digitisation of Manufacturing as well as their key features and business impacts are as follows:

- **Cloud Manufacturing:** Cloud Manufacturing is allowing the widespread and on-demand access to a digital set of resources to support production and supply-chain processes. The applications of Cloud Manufacturing can work at diverse levels (i.e. IaaS, PaaS, SaaS) but they all have the final objective of connecting companies in industrial ecosystems, thus improving efficiency and collaboration among the stakeholders.
- **Big Data:** Thanks to sensors and the IoT, huge amounts of data are now becoming available and can be processed through advanced analytics, simulation and forecasting algorithms, thereby decreasing the time for decision-making activities and improving the allocation of resources. Big Data applications are also changing the way manufacturing companies are conducting technological improvement, from the finalising mechanical components to optimising chemical processes. For example, Robert Bosch GmbH, headquartered in Germany, uses Big Data to predict the internal failures of components along assembly lines. Components more likely to fail can then be tracked and thereafter recovered.
- **Internet of Things (IoT):** IoT continues to be a fast-growing technology market in Western European Manufacturing, with a third of Manufacturing customers having already invested in the technology and a third either evaluating or planning to adopt in the short term[21]. However, the potential of this technology is still vastly underexplored. For example, most adopters collect and analyse data but have yet to see direct impact on the business. The most common use

[21] IDC European Vertical Markets Survey 2018-2019.

cases include improving predictive maintenance/customer services and sensor-based control and coordination of shop floor devices. The next big push will be using IoT data for the automation of the shop floor and operational processes, which in combination with AI and better resilience to cybersecurity threats, including proactive risk management, will lead to greater autonomy.

- **Digital twins:** Digital twins or virtual representations of products and assets, can be used to manage multiple aspects of a manufacturing business, including highly complex, customised products and connected assets, such as manufacturing plants or facilities and the assets within them. Data and processes from multitier supply chains, service plans and execution, and the operating environment perpetually feed digital twins to ensure the most up-to-date view of the past, current, and future performance and condition of products, assets, facilities, and plants. The deployment of digital twins enables the dismantling of operational silos, which European manufacturers will benefit from. However, development will take longer since the region is natively fragmented and not swift enough in connecting systems, especially compared with its global peers. Overcoming these weaknesses will lead to significant impact for European companies deploying advanced digital twins. Moreover, the ability to scale operational awareness with much fewer levels of management will lead to a substantial financial return.
- **Artificial Intelligence:** the quality of predictive models is being enhanced by the progress of AI applications, which are also contributing to the improvement of quality control and robotic process automation. In addition, AI has already been successfully applied in the design and production of new products based on the existing unstructured knowledge available in the company. For instance, the European aerospace corporation Airbus, headquartered in the Netherlands, has used AI-based generative design to explore permutations of possible solutions, drawing on insights about what was working from each generation. As a result, Airbus has been able to develop optimised components for the passenger compartment. AI will also be increasingly decisive in predictive maintenance, allowing the efficient monitoring of assets based on the data directly collected from the field.
- **Advanced Robotics:** advancements in automation are leading to the use of so-called collaborative robots (co-bots), i.e. robots with a high cognitive and context-aware ability that can operate next to the workers on the shop-floor, thereby improving efficiency and the range of activities that can be done. For example, the Dutch manufacturer DEONET is using ABB co-bots to optimise its production of key rings, pens, and USB sticks. The ABB co-bots are helping DEONET workers with high-precision tasks like memory cards placing and manipulation by guaranteeing human safety and smart adaptation to the working environment.
- **Additive Manufacturing (i.e. 3D Printing):** Additive Manufacturing is allowing the rapid and decentralised production of objects through an innovative production approach. It enables the

fast and low-cost prototyping and manufacturing of new products thus expanding product ranges and dramatically reducing time-to-market. For instance, BASF is already offering their customers from B2B to B2C a wide range of 3D-printed components, to be used as spare parts. Examples include static mixers and electric circuit connectors for B2B, as well as objects for the home and sports activities on a B2C basis.

- **AR/VR:** Recent progress in wearable devices and human-machine interfaces is leading to increased usage of touch displays and AR/VR glasses able to support workers in the control of production and assembly processes or during maintenance activities, which significantly reduces cycle times while giving workers access to up-to-date and reliable sources of information.
- **Blockchain:** The application of blockchain technology also represents one of the biggest opportunities for the manufacturing sector. This new paradigm for managing transactions can be successfully applied for the authentication of raw materials and components along the entire supply chain and for securing robotic process automation.
- **5G:** Deploying 5G technology in manufacturing will bring positive impacts as a considerable number of new products and services will be enabled against lower investments. 5G technologies will bring many benefits including shop-floor machine synchronicity, speed, reliability, low latency of plant communications, and easy integration with existing industrial ethernet solutions. Furthermore, other innovation accelerators, such as AI, Robotics, and IoT can highly benefit from 5G technology, speeding up the integration process of these technologies into the smart factory concept. Currently, the 5G-ACIA (5G Alliance for Connected Industries and Automation) is acting as the global forum with a mission to discuss and assess all technical and business implications of 5G implementation in the manufacturing industry. As noted in section 2.4, Globbal5G.org interacts with 5G-ACIA through its activities with the 5G-IA.

Despite the wide range of innovative concepts available, the digital maturity of manufacturing firms will considerably influence the adoption and integration of these technologies in their business. Chief among sector stakeholders, are Small and Medium Enterprises (SMEs), which will have to complete the transition to the digital factory, focusing mainly on Cloud, Big Data, and Mobile applications. For these companies, external collaboration and the creation of digital ecosystems will be crucial to access digital services at affordable prices and be able to scale innovation. On the other hand, large companies are rapidly moving towards the smart factory concept, reaching the full automation of the shop floor through IAs orchestration. For these companies, the focus will be on the exploration of cutting-edge applications (e.g. Blockchain) and on the re-skilling of workers to readapt to organisational changes.

The relevance and the extreme variability in the digital transformation readiness of European Manufacturing companies was also analysed in the IDC European Vertical Markets Survey 2018-2019, which clearly points out several steps that firms still need to take to reach the full digital maturity:

Source: IDC European Vertical Markets Survey 2018-2019; Manufacturing respondents N = 281

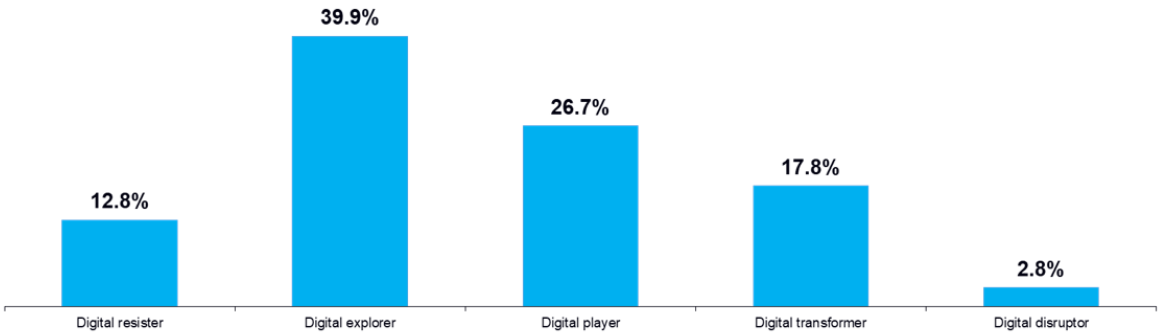

Figure 16: Digital maturity of European Manufacturing companies

While just a small number of manufacturing firms define themselves as digital resisters (for example companies where the IT strategy is not integrated at all in the overall business strategy), most firms turn out to be digital explorers that have yet to embrace digital transformation in a systematic way. The second largest portion of companies are digital players, where digital innovation is organised on a project basis but not yet focusing on the full potential of digitalisation. An even lower percentage of firms identified themselves as digital transformers able to provide digitally-enabled product/service experiences on a continuous basis. Finally, just a very small component are digital disruptors, namely companies directly influencing digitalisation in the industry through original technological and business innovation.

The manufacturing industry is undergoing a deep transformation that, despite the massive investments already made, will still need considerable efforts to adapt and orchestrate technologies to specific business environments and reach the full exploitation of their implementation and integration. In this context, the ability of large companies to drive this transformation and of government institutions to coordinate the innovation actions will be crucial to address the diversity of the European manufacturing ecosystem and foster sustainable economic growth.

3.2.2 5G as the key enabler of Factory of the Future use cases

Industrial IoT and its use cases gives a good overview of the needs and requirements for 5G in this area. Basically, Industrial IoT is about automation, which is divided into[22][23]:

[22] Global5G UE project, D2.1 Identify Use Cases from Verticals.
[23] https://industrial-iot.com/2017/04/5g-enhance-industrial-iot-transform-industry-starting-2020/.

- **Factory automation**: the automation of operations in the production of items such as electronics, cars, appliances, etc.
- **Process control**: automatically controlled processes based on continuous data gathering and analysis.

Factory of the Future (FoF) is a wide topic which includes a very large number of use cases. In terms of mobile communications, each Industrial IoT use case has specific requirements[24]. In such a context, it appears that 5G will bring a high added-value to the Industry of the Future, but requirements will vary according to use cases.

5G, as a key enabler for the Factory of the Future, will impact four groups of use cases:

- **Process automation**: monitoring, diagnostic functions, real-time adaptation on demand, machines capable of contacting the 'human-support' by themselves, to repair automatically when needed, or to replace malfunctioning components.
- **Production automation**: control of manufacturing processes, automatic production of goods based on customer's requirements.
- **Logistics**: mobile service robots, autonomous transport, product identification, tracking (when and where a product was manufactured), security checks (rapid and targeted recalls in case of failure) and localisation of people and assets.
- **Company IT**: portable monitoring and control devices, augmented reality, integration of production facilities in company IT infrastructure, remote staff being able to repair machines remotely.

Future communication solutions are expected to ensure connectivity between different globally distributed production sites and new actors in the value chain (e.g. suppliers, logistics) seamlessly, in real time and in a secure way. Innovative strategies such as Industry 4.0 (and their design principles) are gaining more and more acceptance and will influence present and future 5G requirements.

At this stage, the main use cases identified for the Factory of the Future are: **time-critical process control**, **non-time-critical factory automation**, **remote control**, **intra/inter-enterprise communication** and **connected goods**.

5G will eliminate lag times between machine communications, and data connections between machines will be 10 to 100 times faster. That allows machines to detect production glitches in real time, which could **lead to big increases in productivity**. 5G's ability to handle far more data over its network means that factories can meet rising data demands resulting from adding smart technologies and **increasing production**. As a result, a major part of the 5G value in the context of the Factory of

[24] Afif Osseiran, Jachim Sachs, Marzio Puleri, "Manufacturing reengineered: robots, 5G and the Industrial IoT".

the Future is in getting data from the physical environment to the computers and making better decisions based on that.

5G will also bring strong added-value to Factory of the Future, such as:

- **Increased efficiency**: up-to-date information enabled by the best possible manufactured output.
- **Competitive innovation**: 5G will foster innovations.
- **Less energy used**: advanced technologies and built-in efficiencies actually lower energy bills for manufacturers. Optimisation of consumption will be based on energy efficiency (production optimised according to the cost of energy and its availability).
- **Stronger economies**: smart manufacturers bolsters production capabilities, help workers and strengthens economies.

While specific use cases for Factory of the Future involving 5G are not yet well defined, the drivers are clear.

Network connectivity and communications is one of the main drivers. The Factory of the Future is a merge between factories as we know them today and Internet technologies, powering the Industrial Internet of Things (IIoT), which will connect machines, sensors and infrastructure all together. While the type of required connectivity will vary depending on use cases, it appears that wireless communication with high bandwidth and low latencies, such as 5G, will be a prerequisite. With connectivity comes interoperability, which will have to be addressed correctly in order to allow a smooth transition toward the Factory of the Future, thus facilitating the integration of applications/devices in the production system.

Integration of Industrial Internet of Things: as highlighted in the Factory of the Future white paper[25] from IEC, IoT and M2M technologies (and therefore IIoT) will affect the operational environment of manufacturers considerably, as both technologies contribute to the convergence of the classical manufacturing space with Internet technologies and the increasing intelligence of devices used to improve manufacturing environments.

Improvement of efficiency and quality and **shorter life cycle times**: as reported by KPMG FoF makes quality management a reality[26]. 24-hour production is monitored without interruption, along with quality while efficiency is constantly being optimised. As a result, the target of a zero-error rate is now within reach. Machine failures also become a thing of the past, for the data that is available allows a preventive maintenance strategy and planning that avoids unplanned and unpredictable downtimes. Production can be run around the clock at maximum capacity. The "Factory of the Future" secures a

[25] http://www.iec.ch/whitepaper/pdf/iecWP-futurefactory-LR-en.pdf.
[26] https://assets.kpmg.com/content/dam/kpmg/es/pdf/2017/06/the-factory-of-the-future.pdf.

competitive advantage for itself as a result of quicker production cycles, higher throughput with reduced inventory and lower costs.

Real-time adaptation: real-time production optimisation through Artificial Intelligence, advanced analytics and Big Data, connectivity. For example, improved demand forecasting enables close to real-time management, avoiding the need for large and expensive warehouse facilities and stock holding, thus reducing overall costs based on just in time delivery methods.

Edge computing, i.e. the capacity to collect and analyse data as close as possible to the machine which produces them is a key technology. Adding intelligence in the objects/machines themselves or setting-up mini clouds near the process will be key for industrial monitoring.

Factory of the Future 5G use cases will be made possible if they bring a strong added value. They will exist, and be sustainable, only if a robust wireless telecom infrastructure is deployed, and if a wide variety of things (equipment, control systems and products) are given the ability to communicate. Some machines within these processes are connected, for instance, conveyors, robots, logistics assets, inventories and energy systems. Facility managers and quality-control teams obtain data on these elements for security purposes or product quality assessment. However, the data collected is often limited to a specific field and does not, or barely, integrates exogenous information, on subjects such as the environment, the market, customer needs and feedback, or other data linked to the production itself, which could be provided through 5G powered solutions.

Key applications for 5G in smart factories will include, for example:

- **Constant on-site connectivity**: enabling continuous transmission and sharing of manufacturing information. Use cases will include the sharing of time critical sensor data and video, non-time critical information collection, and data to enable remote control of equipment and systems.
- **Constant inter-site connectivity**: tracking materials, components and products through the manufacturing process, for collation of data in data centres, and transmission of control instructions between sites.
- **Use of AR/VR technologies** to enable virtual collaboration on complex designs by engineers in diverse locations.
- **Wide-area connectivity**: for employee, customer and partner collaboration, and for tracking/optimising goods following delivery. Use of wireless networks in product lifecycle management through end-to-end tracking, and supply chain enhancement, from the initial order, through materials buying and production processes, to end consumers, alongside the creation of new services by analysing data collected from connected products.
- **Enhance industrial ecology**: Improve efficiency by reducing the consumption of material resources and saving energy by using the information given by each machine involved in the

production line and by taking into account the volume of demand, thus improving the impact on the environment: the process optimisation can include management of waste materials and monitoring of the recycling (from cradle to cradle perspective).

- **Decreased risks**: alert management systems can notably play a part in reducing industrial damage on the environment, chemical leakages for example, and by providing earlier warning and hence prevention and remedial interventions.

A reliable communication layer capable of dealing with an increase in several orders of magnitude in the number of assets, variety of information and reaction times in future manufacturing systems is fundamental for Industry 4.0.

5G promises to be a key enabler for Factories of the Future by:

- Delivering an evolution of mobile broadband networks.
- Providing the unified communication platform needed to disrupt with new business models and overcome the shortcomings of current communication technologies.

5G is therefore expected to have the potential to amplify and accelerate the on-going transformation and unlock a next level of efficiency gains in manufacturing, including for the vast number of European SMEs.

3.3 Healthcare

3.3.1 Focus on Operations and Cost Effectiveness

European healthcare providers are investing in digital transformation to impact operations and cost effectiveness, along with benefits associated with the implementation of digital solutions to engage patients and improve customer experience. National digital transformation programmes are fostering industry-specific investments. The focus on operational efficiency and patient experience is reflected by investments in clinical decision support, patient administration solutions, and patient portals. 3rd platform readiness, as well as the integration of Innovation Accelerators (particularly AI and IoT) are key features of new sought-after solutions. Western European Healthcare ICT spending will increase by 2.9% in 2019, reaching €17.1 billion. Spending will increase throughout the forecast period, growing to €18.9 billion in 2022 across Western European countries[27].

The graph below outlines the year-on-year growth in ICT spending across Western European Healthcare organisations between 2018 and 2022. Healthcare investments in ICT will grow at a 3.1% CAGR throughout 2022, as several investments programmes trigger spending on technology, especially supporting the deployment of new tech such as AI and IoT.

[27] Worldwide Semiannual ICT Spending Guide Industry and Company Size, 2019.

Source: DC Worldwide Semiannual ICT Spending Guide Industry and Company Size, 2019

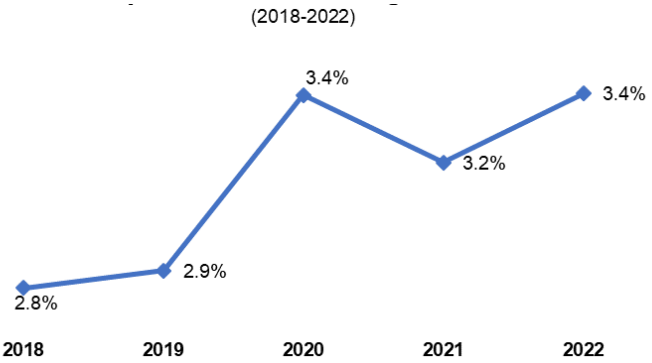

Figure 17: Spending across Western European of Health organisations

As a group, the top 5 Western European economies are expected to represent 71% of total Healthcare IT spending in 2019. The UK remains the biggest IT market, with a growth rate at around 2.1%, which is still below the total market growth due to uncertainties over government budget adjustments after the Brexit agreement and the impact of limitation of freedom of movement on the National Health Service (NHS) workforce.

Germany continues to be a fast-growing market with a 4.0% year-on-year growth expected in 2019, followed by France. French Healthcare providers' spending will continue to be sustained by Groupements hospitaliers de territoires (GHT) initiatives and by the relaunch of the national electronic summary health record. Italy maintains a stable growth (around 2.5%), driven by regional initiatives around patient services modernisation and regional Electronic Health Record (EHR) platforms. However, IDC has some reservations about the long-term outlook, considering the uncertainty around Italian government digitalisation strategies and the evolution of public sector expenditure.

The focus of hospital digital transformation projects is on business model transformation, while other healthcare providers are looking to leverage information better. The industry wants to redesign the way healthcare is delivered, providing integrated and personalised services. Implementing solutions that enable quick sharing of information will boost investments in data management. There is a strong need for data sharing between doctors, different medical units, or hospitals to enable faster services and avoid duplicating efforts. Higher investments in cloud suggest interest toward infrastructure and operations optimisation. In the UK, the Health and Social Care Network (HSCN) will provide an efficient and flexible way for health organisations to access and exchange electronic information by implementing cloud solutions that will benefit staff and patients. Even if deployments are still marginal, industry clouds are getting attention across European Healthcare providers, which are starting to consider new business and operations models involving peers, suppliers, and patients enabled by the nexus of 3rd Platform technologies.

Western European Healthcare organisations are not fully exploiting the Innovation Accelerator

opportunity yet, as investments are linked to public funds, which are sometimes limited. Nonetheless, robots, especially for surgery and logistics purposes, are becoming more affordable, and hospitals will start to invest more significantly in the coming years. Robotics can be helpful also in reducing the level of invasiveness of surgical procedures by deploying robotic surgery. One UK company has launched a robotic surgery solution, Versius, which is expected to operate on patients this year and will be used in more than 70 hospitals. During surgical procedures, the solution will be controlled by a doctor sitting at a console using two joysticks and a 3D screen.

The Healthcare industry in Western Europe is highly fragmented, including different regulations, depending on the country. For example, data is more accessible in France, therefore data and analytics can bring a lot of opportunities there, especially in the field of precision medicine. Investments in wearables, IoT, and AI will grow as there will be a stronger need to monitor patient behaviour and accidents for elderly people with medical conditions to provide prompt emergency help. Predicting diagnosis will drive AI investments in Healthcare, especially in the U., where HM government has announced AI investments to help doctors predict early-stage cancer and prevent thousands of cancer-related deaths by 2033. Devices such as smart glasses and wrist-worn displays are bringing a high-tech approach across top Western European Healthcare organisations, and they will help doctors improve monitoring of patients and reduce response times in case of emergencies or serious conditions. Looking at the 2017–2022 CAGR, Healthcare stands out with a very strong double-digit five-year growth. AI advances in Healthcare are leading to important breakthroughs in improving patient care models, in early detection and treatment of diseases, in diagnosis, and in medical research. AI is helping doctors automate diagnosis by extracting insight from a patient data to facilitate decisions and personalise treatments.

With new technologies transforming the Healthcare sector such as wearables, smart watches, AR/VR devices, AI and IoT-based solutions, personal computing devices deployed in mobility, habits and expectations are changing and are becoming more interactive. Hospitals are working toward innovation and individualisation of services by increasing their digital transformation efforts and transforming the way care services are delivered and revolved around patients. 5G can play a key role in boosting this transformation, allowing Healthcare organisations to complete their transformation and to open a new era where care services are fully patient-centric. With Healthcare models transforming rapidly due to the impact of macroeconomic, demographic, and economic changes, empowering patients and their carers with next-generation technologies (AI, IoT, 5G) has become an increasingly important strategy for the Healthcare sector in Europe. Emerging network technologies (LTE or 5G) will allow the Healthcare sector to have strong foundations to enable IoT and AI solutions, but also to deliver smart pharmaceuticals and individualised medicine. **Thanks to 5G, the current state of many solutions and services will be pushed to the next level and will enter a new phase thanks to enhanced networks and connectivity, which will boost capabilities of current use cases.**

The figure below shows the number of Healthcare companies across Belgium (BE), Germany (DE), Spain (ES), France (FR), Italy (IT), Austria (AT), Portugal (PT), Finland (FI), Sweden (SE), and the UK. The figure outlines a strong presence of health organisations across France and Italy, in contrast with Nordic countries such as Sweden and Finland where the number of health organisations is limited.

Source: IDC Western Europe, Number of Companies by Vertical and Size, 2017

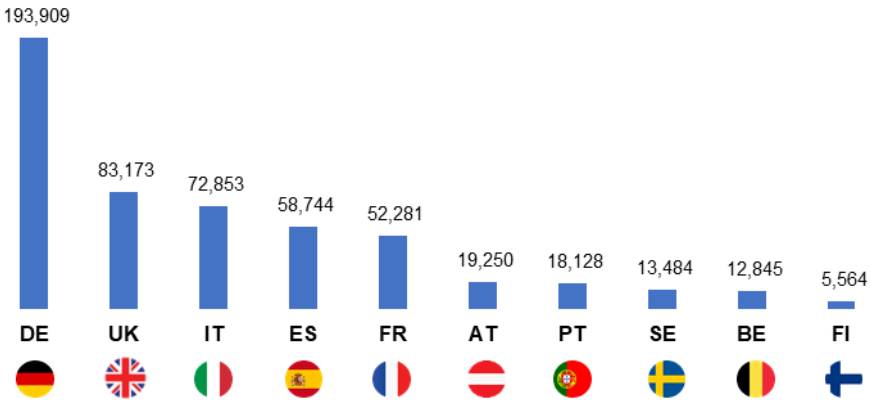

Figure 18: Number of Companies in Healthcare Sector in Selected Countries

The strong presence of Healthcare organisations in France is triggering investments in innovation and digitisation to promote a patient-oriented culture and a more connected and integrated experience for both doctors and patients. In fact, in France, at the end of 2018, the government announced investments of €1 billion in Healthcare digital transformation, with €420 million dedicated to the digital hospital programme. Several investments in Healthcare will boost spending in innovation and, more generally, in ICT. The British Healthcare industry has increasingly become more tech-savvy as new technologies are being introduced in the sector aimed at improving treatments for patients, while reducing the costs of various operations and treatment plans for Healthcare providers. Different types of investments and funding programs have taken place in the country. In fact, researchers in Leeds (UK) have been awarded a £10m million investment from UK research and innovation to expand a digital pathology and AI programme across the North of England. In 2018, the UK invested £65 million to set up five new AI digital pathology and imaging centres, fully operative in 2019. The UK government has provided £50 million in funding (through the Industrial Strategy Challenge Fund) for five medical diagnostic centres to develop AI-based solutions to support early diagnosis and personalised treatments for various diseases, including cancer.

Several Healthcare organisations across Europe have been hit by cyber-attacks on multiple occasions. With GDPR and Network and Information Security directive (NIS) implementation, single institutions as well as entire Healthcare systems have taken steps towards improved cybersecurity and data governance. Healthcare organisations see cybersecurity as a major priority, with Central and Eastern European respondents feeling higher pressure to implement IT security strategies in 2019.

Investments in that space are strong too. By the end of 2018, the Spanish security office invested €2 million in cybersecurity services for the third year in a row. The Austrian Landsburger Clinic has invested €10 million to secure three-year software security licenses.

Smart pharmaceuticals (such as smart asthma inhalers, insulin pens and smart wound dressings) solutions will allow Healthcare organisations to collect real-time information from patients to enhance care models and target specific patient needs as well as address specific pathologies in appropriate and personalised ways. The hyper-connection of medical devices such as infusion pumps, monitors, ventilators and hospital beds will result in high integration between patients and doctors, which will ultimately have an impact on patient experience as well as on efficiency and improved patient care of health organisations.

3.3.2 5G as the effective Catalyst of the IoMT

A wide range of innovative applications in the health scenario are enabled or strongly benefit from the 5G capabilities in several different ways[28].

5G is a particularly effective catalyst of the Internet of Medical Things (IoMT) thanks to:

1. Greatly enhanced mobile broadband data rates that enable ever faster flows of greater amounts of information.
2. Ultra-low latency and ultra-reliability, which is suitable for mission-critical services.
3. Ability to significantly and efficiently scale to connect a massive number of sensors.
4. Capillary, seamless connectivity that makes it “ubiquitous”.
5. Enhanced, built-in security.

5G will support and enable:

- **Continuous monitoring and processing of data from numerous sensing devices**. This will dramatically increase the effectiveness of preventive care, which in turn will lower the burden of chronic diseases on the Healthcare systems.
- **Distributed computing:** harnessing the potential of the huge amounts of health data that will be available. By enabling smart aggregation and correlation of data, 5G will support medicine research and improve our understanding of the human body.
- **Application of Virtual/ Augmented Reality** and high-quality imaging, allowing improved diagnostics and remote medical intervention of expert practitioners.

[28] Global5G project, D2.1 Identify Use Cases from Verticals.

- **High reliability and extremely low latency** will support mission-critical applications such as the treatment of stroke patients.

The entire Healthcare system will be revolutionised over the next decade, with changes in patient-carer relationship, and new business models. This is exactly where the Health 4.0 approach comes into play as a win-win solution for all stakeholders to manage the new socio-economic landscape. The Health 4.0 concept is derived from the Manufacturing industry's well-known Industry 4.0 concept which consists mainly in combining cyber-physical systems, IoT and Cloud computing. Development of Health 4.0, just as Industry 4.0 is based on six design principles:

1. Interoperability.
2. Virtualisation.
3. Decentralisation.
4. Real-time Capability.
5. Service orientation.
6. Modularity and reconfigurability.

One of the challenges of Health 4.0 is to integrate, aggregate and ultimately make sense of an exponentially growing amount of data from a variety of sensors and smart devices. Infrastructures will need to evolve and health data will need to comply to universally recognised standards, ideally complying to the FAIR principles (being Findable, Accessible, Interoperable and Re-usable). Health care providers will need to adopt new roles, namely to establish the governance and develop the management skills to protect patient data on the interface between medicine and ICT.

The Healthcare sector business model will be revolutionised: the delivery of care will be strongly decentralised, becoming truly patient-centric, drastically reducing the hospitalisation of patients and allowing them to receive treatment and be closely monitored at home. Because Healthcare is a highly regulated industry, public policy has a critical role to play in enabling this transformation.

According to the Ericsson report "From Healthcare to Homecare", the proliferation of machine-type IoT sensor communications poses the challenge of connecting many devices communicating at low-data rates[29]. For instance, in remote health monitoring, wearable devices, such as heart monitors and glucose monitors, require high frequency updates of the central data repository at low-data rates.

Existing networks cannot provide the desired quality of support while connecting a large number of such devices. 5G promises to address this challenge.

[29] Ericsson, "From Healthcare to Homecare - The critical role of 5G in healthcare transformation" https://www.ericsson.com/en/networked-society/trends-and-insights/consumerlab/consumer-insights/reports/transforming-healthcare-homecare.

Engaging patients (and a wide part of the healthy population for health scanning) in health data harvesting is important in particular in the early stages of the shift towards digital health where there is still cultural opposition to sharing health data. According to Ericsson, 60% of patients are open to sharing their data with Healthcare providers and making it available in a central repository – if it improves the Healthcare services they receive, helps monitor chronic ailments, improves the quality of diagnosis and reduces wait times[30]. However, 61% of patients with chronic ailments are concerned about data from health patches being used without their permission.

As Healthcare becomes more dependent on wearables and connectivity, consumers express concerns about reliability. In fact, 59% of consumers say that they are concerned about poor connectivity affecting data transmission. Battery charging is another issue, with 56% of consumers with chronic ailments worrying about their health patches suddenly running out of battery.

Security, reliability and battery life are the top concerns of consumers moving towards 5G Healthcare.

Hopefully the model of delivery in the Healthcare sector may shift from "volume-based" to "value-based". As highlighted by The World Economic Forum and Boston Consulting Group, traditional delivery of healthcare has rewarded vendors (e.g., physicians and specialists) based primarily on measures of volume[31]. Paradoxically, the traditional "fee-for-service" compensation model provides incentives for over-treatment. What is required, they argue, is a shift towards a world of "value-based health care" or (alternatively) "outcome-based health care." The essence of this new approach is to base the Healthcare system on the delivery of the outcomes that matter the most to consumers, at the lowest possible cost. Goldman Sachs estimates that the transition to value-based care could generate upwards of €580 billion in savings by 2025 by shifting care to lower-cost settings, moderating price inflation and reducing the estimated €1.3T in annual health care waste in the US[32].

In Western Europe, 5G will impact positively on the deployment of Remote Health Monitoring services use cases that connect Healthcare providers and consumers through IoT technology for monitoring the physical condition of patients with chronic diseases, by allowing access to wearables collecting and transmitting health indicators, such as heart rate, glucose levels, blood oxygen concentration or movement. Spending for Remote Health Monitoring services deployed by Healthcare Providers in Western Europe will grow from 1.300 to 2.300 million euro (CAGR 2018-2020=+16%) (see Figure

[30] Ericsson, "From Healthcare to Homecare", op cit.

[31] World Economic Forum and Boston Consulting Group Insight Report, "Value in Healthcare: Laying the Foundation for Health System Transformation", April 2017 http://www3.weforum.org/docs/WEF_Insight_Report_Value_Healthcare_Laying_Foundation.pdf.

[32] Goldman Sachs Global Investment Research, "Healthcare's Holy Grail: Better Outcomes at Lower Costs", February 2017.

below)[33].

In the future, after 2022, 5G is also expected to significantly improve connectivity, to enable haptic feedback to underpin surgeons' capabilities to carry out remote robotic surgery. Although fibre can deliver low latency connectivity, experts say 5G would be preferable for availability reasons. While optical fibre is used for backhaul network, 5G is most likely to provide the last mile connectivity which is also mobile. Flexibility in terms of moving equipment around to locations where fibre is not available might be a reason for higher preference for 5G over fibre. Furthermore, highly-immersive virtual simulations are increasingly used to train Healthcare professionals in critical medical procedures, while remote procedures such as robotic surgery will be conducted in a virtual environment. Like haptic feedback, virtual reality demands low-latency and high-bandwidth communication for effective operation.

Source: IDC IoT Spending Guide, 2019

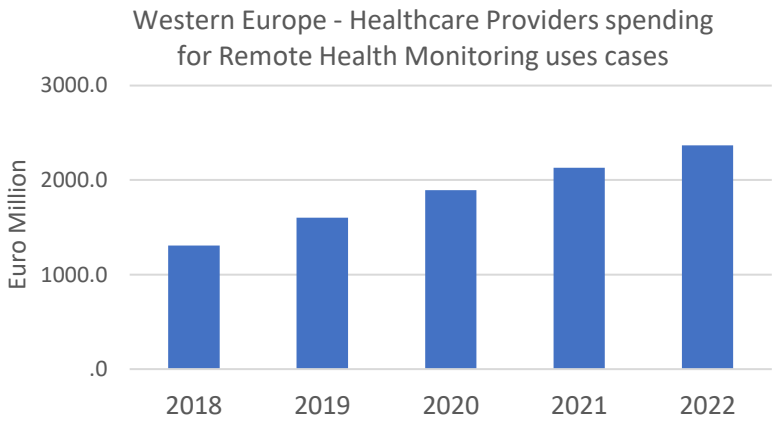

Figure 19: Healthcare Providers spending for Remote Health Monitoring Uses Cases

5G is also expected to impact positively on life insurance premiums. The EU insurance market is the largest globally with a 35% share of the total global market. Life insurance is the largest segment (in 2014, €714 billion was paid in life insurance premiums in the EU, an average of €1900 per capita).

Some functionality of sharing data from wearables with life insurance businesses already exists but the ubiquitous nature of 5G will enhance real-time capabilities and connectivity to the cloud, enabling the enhanced monitoring of more people. 5% of projected savings are attributable to 5G.

5G IoT capabilities will provide consumer benefits of approximately €207m/year in the European market in reduced life insurance premiums[34].

Benefits for health insurance companies: the role of insurance companies is controversial and calls

[33] IDC IoT Spending Guide, 2019.
[34] Global5G project, D2.1 Identify Use Cases from Verticals.

for precise regulations for accessing sensitive personal health data, and enforcing security controls. Health data is a valuable resource of income for insurers.

Benefits for third parties: The Pharmaceutical industry is a third party that has considerable interest in Healthcare. This segment of the industry is one of the most active health application developers. However, their impact on the market is still low, despite the high potentials. One area where 5G-enabled IoT can make an impact is in smart pharmaceuticals, where drug trials are an expensive and unavoidable cost for pharmaceutical companies, particularly in phase 3 of the research and development process on human volunteers.

IoT has the potential to track patient conditions more closely, to provide additional health information that can show potential side effects at an early stage and can track outcomes more closely. Just as in many other examples, real-time continuous monitoring provides better, richer data sets for clinical trial teams and regulators to assess a drug more actively in the field. This would also enable drugs to be withdrawn more rapidly if problems arose and for information to be fed back to volunteers. According to McKinsey, IoT-based solutions could conservatively reduce phase 3 costs by 15%, citing a recent case study that suggested a saving of 85%[35]. The assumption is that 5G capabilities could radically extend the reach and reliability of various wearable and portable health monitors that would provide rich bio-data information from volunteer patients living anywhere. SMART 2014-0008 estimates that if 5G capabilities comprised 5% of savings (of 15%), savings could amount to approximately €72m/year for the European Pharmaceutical sector[36].

Suppliers of Medical Devices and Equipment are producing wearables and apps to provide personalised medications and services for their customers. The market of smart medication is addressing in particular chronic diseases such as asthma and diabetes.

Smart pill boxes equipped with sensors and cellular antenna are already on the market, monitoring patient's intake of prescribed drugs, which allows pharmaceutical companies to check that a patient is sticking to her/his prescription, such as generating alarms for missing a dose via text messages, flashing lights or chimes on the bottle itself.

Further opportunities facilitated by 5G lie for instance in the development of new functionalities such as live dose adjustment and automatic dispensing of medicine based on real-time monitoring from wearables, while gathering valuable information for future research and product improvement.

5G IoT capabilities will provide third party benefits of approximately €72m/year to the European pharmaceutical research and development sector.

[35] SMART 2014/0008, p. 57.

[36] Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe (SMART 2014/0008), https://ec.europa.eu/digital-single-market/en/news/5g-deployment-could-bring-millions-jobs-and-billions-euros-benefits-study-finds.

3.4 Energy

3.4.1 Changing the Production and Transport of Energy and Customer Approach

The Utility industry is transforming down to its core. This transformation is characterised by three main features: divergent, decentralised, and digital. To execute this transformation, Utilities must embody the "3Rs factors": relevance, risk, and resilience. **Utilities face many challenges in their transformation journeys to remain relevant, mitigate risk, and embody resilience.** They must succeed and deliver value to their shareholders, employees, customers, and society as well as overcome siloed initiatives. This is possible by integrating and orchestrating change across the organisation and strengthening weak road maps, which are responsible for the transformation deadlock. Moreover, Energy companies need to close their talent gaps and conquer ability to scale up innovation.

Energy firms are expected to massively invest in almost all the Pillars and Innovation Accelerators to keep up with the rapid changes in the market. In particular, the focus will be on Big Data, Robotics, and AR/VR technologies able to foster the upgrade of those companies to more advanced digital business environments. In addition, the Energy sector considers itself ready to adopt Blockchain technology, able to potentially revolutionise the way energy trading and grid balancing are currently managed.

Technological advances are changing the way energy companies are producing, transporting, and consuming energy, while outlining new approaches for interaction with customers. Therefore, in order to handle all the multifaceted dynamics and consolidate their shares in the market, firms in this industry will have to keep on developing new business models. Indeed, in the future it will be even more important to innovate the offer of digital-based products and services, integrating all the business processes into core digital platforms that enable interaction across assets, employees, and customers. The ability of companies to integrate new concepts such as renewables, e-mobility, and smart buildings solutions in their business in an efficient and flexible way will also be fundamental to guarantee the long-term economic and environmental sustainability of society. In fact, just the proactive contribution of energy firms in using digital technologies to improve the benefits of their extended stakeholders will ensure the achievement of the challenging sustainability objectives set by international institutions.

Source: IDC, 2019

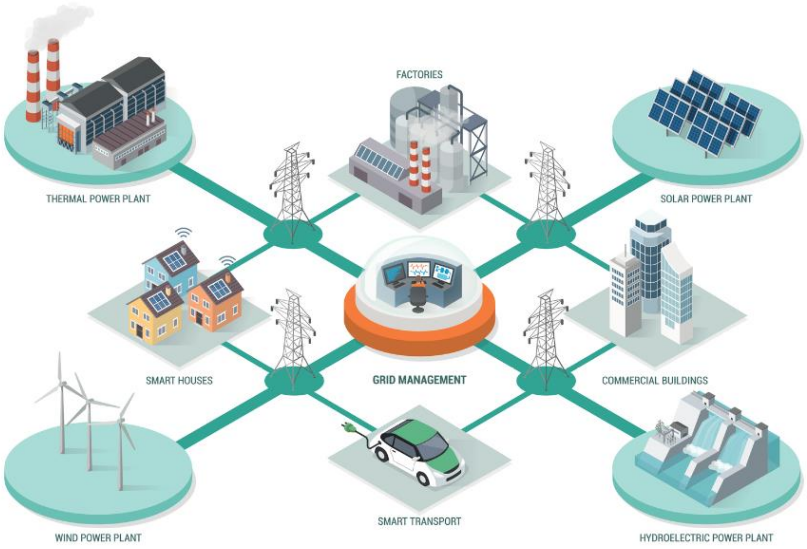

Figure 20: Smart Energy Management Concept and Use Cases

These are the main technologies enabling the digitalisation of the Energy sector, including key features and business impacts:

- **Cloud**: Cloud solutions, including both public and private Cloud, are relevant in the Energy sector as current adoption is above market average across European companies. Especially for Utilities companies, access to Cloud is fundamental to manage the entire pipeline in an integrated way, from energy generation to billing, and to efficiently processing and storing the data of the end users throughout a given territory. Moreover, the continuous need for compliance with new regulations is forcing companies to re-design and implement business processes in a rapid and scalable manner.
- **Big Data:** Even though the use of Big Data in Energy is currently below average, its application is expected to grow exponentially in the immediate future. The dissemination of the technology is having a positive impact on both the technological and business sides. On the technological side, it is becoming more and more important for smart grids optimisation, balancing the energy loads matching availability and demand, and for predictive maintenance of plants and meters, identifying corrective actions before the failure. For example, E.ON is using Big Data to predict when medium voltage cables in windmills need to be substituted. On the business side, Big Data is supporting energy consumption analysis, forecasting also the future needs of industrial and domestic users, and customer interaction, providing updated data about customers' profiles and choices.

- **Internet of Things (IoT):** Given the complexity of the technologies and infrastructures managed by Energy companies, IoT can have great potentialities in remote connection across assets and fast communication to decision makers. Through a dense network of sensors, IoT will support firms in the monitoring of power grids and smart meters, with positive impact both on internal operativity and communication with relevant stakeholders. In Oil & Gas, IoT is already being used extensively, especially for the diagnostics and maintenance of refineries and pipelines.
- **Digital Twins:** Digital twins, or virtual representations of products and assets, can be used to manage multiple aspects of an energy business, including highly complex, customised products and connected assets. Currently, digital twins are predominantly used in fixed-asset-intensive industries such as oil and gas and utilities to operate individual assets and model asset performance within the collective asset of the plant.
- **AI:** Based on the progress of Big Data use, AI will also grow. AI will empower Big Data applications with advanced predictive features, enabling smart energy trading operations and assets maintenance. Moreover, it will become increasingly helpful in customer interaction thanks to the use of chatbots assisting end users in service choices. Finally, AI will also allow energy companies to improve identification of cyber threats and to put in place preventative measures to avoid data breaches.
- **Robotics:** Robotics already represents an essential technological enabler for energy with use continuing to grow in the future. Drones allow companies to reduce the risks of dangerous operations, requiring human intervention only in exceptional cases. For instance, monitoring of plant security and radiation is one of the key applications. Further uses of robots will be then increasingly frequent, ranging from repair of infrastructures (Utilities) to drilling operations (Oil & Gas). Eni, an Italian multinational oil and gas company, is using drones for inspection of flaring stacks in gas processing plants, to control energy distribution near motorways or in urban locations, to monitor solar installations, or sock-pulling during transmission line construction.
- **3D Printing:** As in other industries, 3D Printing will enable the rapid prototyping and manufacture of components for equipment and plants. This will result in a dramatic reduction of cycle times, energy consumption, and environmental impact. The most relevant example is represented both for Utilities and Oil & Gas by spare parts. Through on-site 3D-printed components, companies are saving considerable amounts of money in the production and transportation of finished parts from remote locations.
- **AR/VR:** The huge potential of AR/VR has just recently been discovered by the Energy industry though a real explosion of this technology is expected in the years to come. AR/VR can completely change the way companies are approaching everyday operations in two different areas. First, in the assistance to technicians during their on-field interventions for monitoring and repairing critical assets. Second, in the enhanced training of personnel enabling contextualised help

according to the specific needs and abilities of the worker. For instance, UK-based EDF is using a voice-activated augmented reality system to help authorised technicians take images and videos of smart meter installations. This way, the hands of the technician are always free, and the information taken is always reliable, avoiding the need for a further quality visit by another technician.

- **Blockchain:** The use of Blockchain technology in Utilities will be one of the highest in the near future. Even though most of the on-going projects are still in the piloting phase, Blockchain projects will soon be implemented in cutting-edge applications such as securing energy trading and grid balancing. Blockchain will also enable the reliable automation of meter-to-cash processes and of e-mobility services. One of the most active companies in this space is Enel, an Italian multinational energy company operating in the sectors of electricity generation and distribution. Enel is currently exploring three possible applications of Blockchain technology, namely for medium and low voltage grids management, for peer-to-peer trading platform, and for payment systems on renewables-supplied micro-grids.
- **5G**: The innovative capabilities of 5G can play a key role in enabling transformation in the sector. The potential of 5G first identified back in 2015, when the European Union's 5G Public Private Partnership (5G-PPP) published a white paper setting out the socio-economic drivers of the industry and use cases of 5G that can contribute a response to those drivers. For several years, mobile networking vendors have been developing a detailed set of use cases for 5G in the energy vertical. For example, Ericsson published a white paper in 2016 entitled “Opportunities in 5G”, which summarises the results of a survey with C-level heads of ICT infrastructure, covering the potential benefits of 5G in their organisations. The results show high levels of interest among respondents for a diverse set of 5G use cases, ranging from customer-facing applications such as smart metering, through to heavy operational applications such as using robots in dangerous exploration and extraction sites.

Compared to other industries, digital transformation in Energy companies is already well underway. In many cases, the digitalisation process is in a virtuous cycle where current results are pushing even higher investments in almost all the technological areas identified. For this industry, the transformation is not just a source of competitive advantage in the market, but a real prerequisite to survive. The industry will keep on investing in ICT on an incremental basis, driven by the high average size of companies as a key factor in reaching critical masses. Triggering further digital transformation process will enable the continuous upgrade of a firm’s products and services portfolio, thus driving uptake of cutting-edge technologies (e.g. Blockchain). According to IDC, by 2022, 20% of digitally-driven revenues in the utilities market will come from new products and services. By 2023, utilities will have digitally connected 75% of their critical assets.

Despite these general positive trends, energy companies currently show different levels of digital maturity, which is influencing their strategies for digital transformation.

Source: IDC's Digital Transformation Executive Sentiment Survey 2018; N = 281]

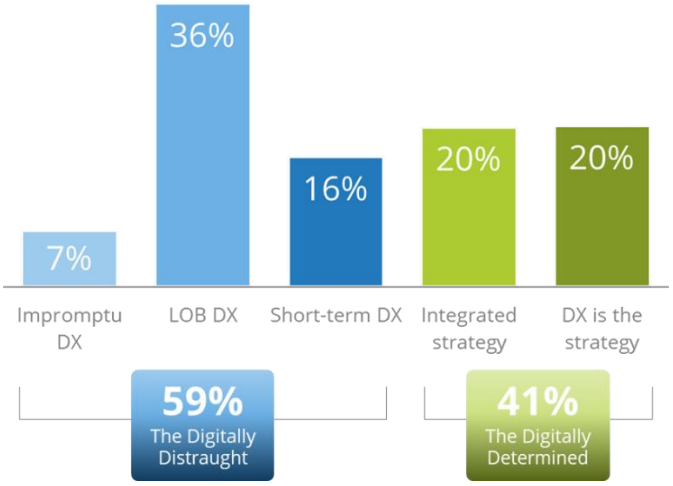

Figure 21: Digital maturity of European Energy firms

The figure above compares the percentage of companies with just an impromptu digital transformation strategy (the digitally distraught), suggesting a late and often ineffective reaction to technological advances, with companies that claim to have embraced a purely Lines of a Business digital strategy without any integrated company vision.

The set of energy digitally "distraught" firms is completed by enterprises linking Digital transformation initiatives to a company strategy but only with a short-term focus. The rest of the firms belong to the so-called digitally "determined". In particular, the same amount of companies stated to adopt respectively an integrated strategy for digital innovation and even to leverage digital transformation as a source of competitive advantage, influencing markets with new digitally-based business models and services.

Digitalisation will be one of the key pillars of Energy industry development in the years to come. While there are still different maturity levels and approaches in facing the digital transformation process, energy companies already have a sound background on which to build further advancements. For this reason, the industry can be considered a reference point for the dissemination of new business paradigms and for the experimentation of innovative technological concepts. The main challenges will come from the need to guarantee innovative solutions for sustainable development (e.g. renewables, energy storage systems) for society as a whole, and flexible services at ever lower prices for consumers.

3.4.2 5G as an enabler of the next Wave of Smart Grid and Smart Meters

The business potential of 5G in the Energy vertical is expected to be very high through the support of critical machine type communication (MTC) applications for energy grid protection and for smart metering.

The performance and flexibility promised by 5G will enable a communication infrastructure capable of supporting many use cases for 2020 and beyond, starting from distributed generation and storage of power and micro-grids.

5G technologies will play an essential role in the development of the Internet of Energy (IoE), the upgrading and automating of electricity infrastructures for energy producers. Enhanced connectivity, low latency and edge computing features of 5G communications will allow energy production to move forward more efficiently and cleanly with the least amount of waste. In order to manage efficiently the energy supply and demand in the power grid, energy routers will be able to adjust dynamically the energy distribution in the grid, which is so called the Internet of Energy.

With 5G real-time communications and access to all dispersed devices, the current problem of renewable energy systems curtailment can be smoothened. Better data monitoring and more precise energy generation and consumption forecasting will pave the way to fully implement the Internet of Energy. **According to NRG-5 EU project[37] and several Utilities Stakeholders that IDC interviewed in the past few months, the most important application area of 5G technology will regard:**

- **The next wave of smart grid:** supervisory monitoring (cyber & physical), fault localisation, isolation/self-healing and energy re-routing, with reduced latency, very high availability and security (URLLC).
- **Smart metering features** and efficiency, integrating many devices into the grid through low-cost connections, managing demand and load balance, helping reduce electricity peaks and reduce energy costs, while little communication or measurement capability in last mile infrastructure**.**

5G will enable new power grid industrial control services but also inherit the information collection services supported by the current 2G/3G/4G public networks. In this way, multiple slices of the power grid can be deployed, managed, and maintained in a unified manner, which helps customers of the power grid industry reduce costs effectively. The Huawei report “5G Network Slicing Enabling the Smart Grid” envisages four areas of smart grid functionality enabled by 5G network slicing (see Figure below) [38]:

[37] http://www.nrg5.eu/.

[38] Huawei, China Telecom, State Grid, “5G Network Slicing Enabling the Smart Grid", January 2018, http://www-file.huawei.com/-/media/CORPORATE/PDF/News/5g-network-slicing-enabling-the-smart-grid.pdf.

- Intelligent distributed feeder automation.
- Millisecond-level precise load control.
- Information acquisition from low-voltage distribution systems.
- Distributed power supplies.

5G technologies could meet the requirements of power smart grids as:

- **Industrial control services:** typical examples are intelligent distributed feeder automation and millisecond-level precise load control. Ultra-reliable and low-latency communication (URLLC) is a typical slice designed for this type of services.
- **Information collection services:** typical examples are information acquirement of low voltage distribution systems and distributed power supplies. Massive machine type communication (mMTC) is a typical slice designed for this type of services.

In addition, the power grid industry may also require eMBB (typical service scenario: remote inspection using drones) and voice slicing (typical service scenario: manual maintenance and inspection).

Source: Huawei report "5G Network Slicing Enabling the Smart Grid", 2017

Service Scenario	Communication Latency Requirement	Reliability Requirement	Bandwidth Requirement	Terminal Quantity Requirement	Service Isolation Requirement	Service Priority	Slice Type
Intelligent distributed feeder automation	High	High	Low	Medium	High	High	URLLC
Millisecond-level precise load control	High	High	Medium/low	Medium	High	Medium/ high	URLLC
Information acquirement of low voltage distribution systems	Low	Medium	Medium	High	Low	Medium	mMTC
Distributed power supplies	Medium/high	High	Low	High	Medium	Medium/ low	mMTC (uplink) + URLLC (downlink)

mMTC: Massive machine-type communications
URLLC: Ultra-reliable, low-latency communications

5G Network Slicing Enabling the Smart Grid

According the EU report "Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe", several benefits arise from the increased deployment of 'next generation' smart meters[39]. Most of the smart meters installed today use mobile phone-type signals to send meter readings to suppliers, and other wireless technologies to send information to in-home/premises displays. **The next generation of smart meters, which could be supported by 5G capabilities,** will offer a range of 'more intelligent' functions, including real-time data exchange and better energy management. These benefits could include (see Figure below):

- **Strategic benefits for utilities providers**: 5G capabilities will enhance data storage and sharing, leading to further strategic benefits. Strategic benefits of installing smart meters with embedded 5G capabilities will arise from increased access to data and real-time information provision. This will support efficient energy generation, enabling savings in generation capacity, particularly during periods of high demand. In the EU report "Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe"[40], it is assumed that 5G capabilities embedded in smart meters will bring further strategic benefits of 10% due to real-time data exchange and data sharing enhancements. Smart meters with embedded 5G connectivity will thus give strategic benefits of €2.75 per smart meter. Considering that there will be 282 million smart meters in EU Member States in 2025 and 319 million in 2030, 5G data capabilities in smart meters will give strategic benefits in the utilities industry of €775 million in 2025 and €877 million in 2030.
- **Operational benefits for Utilities** are also likely to arise from data generated by smart meters. Smart meters with embedded 5G capabilities allow Utilities providers to avoid frequent site visits for meter readings and safety inspections. Smart meters are also expected to establish a more effective communication platform for maintenance and feedback. This will reduce costumers' enquiries and complaints, reducing call centre costs and introducing further operational benefits. More accurate and up-to-date billing systems, enhanced by smart meters with 5G capabilities, should also eliminate the requirements for utility companies to 'estimate' bills, leading to reductions in billing enquiries. It is assumed that 5G capabilities embedded in smart meters will provide further operational benefits of ten per cent due to real-time data exchange and data sharing enhancements. Smart meters with embedded 5G connectivity will thus provide operational benefits of €9.81 per smart meter.
- **Benefits for Consumers:** increased use of smart meters is expected to enable customers to better understand their energy consumption by devices and activities (via IoT capabilities), allowing access to historical information and anonymised information about neighbour's habits

[39] Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe (SMART 2014/0008), op cit.
[40] Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe (SMART 2014/0008), op cit.

and best practices on energy use and consumption. Households' access to this data and information is important in reducing energy consumption. Savings in energy consumption will obviously be dependent on household energy consumption habits.

It is assumed that 5G capabilities embedded in smart meters will provide further consumer energy saving benefits. In line with previous predictions these are estimated to be ten per cent. In reality it is probable that the benefits of knowing energy consumption of individual devices in a home will only be fully reached when IoT capabilities supported by 5G real-time data exchange and data sharing enhancements are introduced. The contribution of 5G could thus be significantly greater. Nonetheless, the ten per cent added value from 5G equates to €10.7 per meter. 5G data capabilities in smart meters will provide consumer benefits in the Utilities industry of € 3 billion in 2025 and € 3.4 billion in 2030.

Source: Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe, 2017 - study carried out for the European Commission

	2025	2030
Smart Meters	282m	319m
Strategic benefits at €2.1 / Smart Meter	€ 775m	€ 877m
Operational benefits at €19.8 / Smart Meter	€ 2.7 bn	€ 3.1 bn
Consumer benefits at €10.8 / Smart Meter	€ 3.0 bn	€ 3.4 bn

Figure 22: Energy Utilities Benefits

Energy utilities transition towards more decentralised renewable-oriented systems will also open new issues regarding network management, automation and programmability, security, resilience, scalability and portability. **Realising the 5G full potential for the Energy sector will require many challenges and changes within the industry, including critical concerns like trust, control and liability, as well as a favourable policy and regulatory environment.**

Many of these challenges are likely to be supported by wireless technologies, including 5G. Energy policy is still a patchwork of national policies. The regulatory environments in which Utilities work vary significantly between countries, though most are progressing towards deregulation (division of transmission and retail supply, and elements of market competition), which has put new pressures on the companies to maximise efficiency[41].

5G is supporting the transformation of the Energy Industry, as the changing energy scenario in Europe requires a dramatic re-thinking of how to keep the lights on while both making the best use of

[41] Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe (SMART 2014/0008), op cit.

new energy sources and keeping infrastructure costs down (see Figure below). Instead of only extending/reinforcing physical infrastructure, which is extremely costly and disruptive to local communities, complementary IT solutions are being introduced, adding communication, sensors and automation allowing the Distribution System Operators (DSO, operating managers/owners of energy distribution networks) to actively manage the varying generation and demand. This combination of solutions is what is commonly referred to as a smart grid.

Source: IDC Energy Insights, 2018

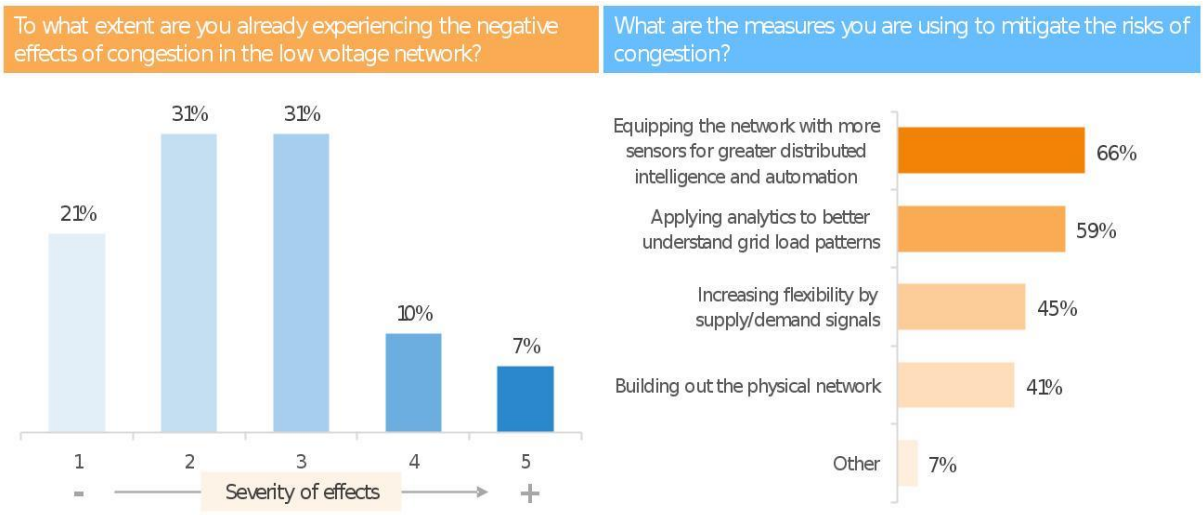

Figure 23: European Distribution System Operators Dealing with Congestion in the Low-Voltage Network

New roles for Europe's Distribution System Operators are set in the context of the challenges that the energy transition, evolving energy customer, and digitisation of businesses are posing to grid operators. On the one hand, moving to a distributed renewable energy system requires that networks are actively managed, giving DSOs a bigger role in managing the overall system. On the other, consumers increasingly demand control over their energy and convenience from the energy ecosystem. As these forces act in opposite directions, smart meters as well as digital and data management solutions enable DSOs to offer renewed value and customer proximity.

The task of synchronising the bulk transmission system with the local distribution network while ensuring the optimal use of power resources to meet electric demand is becoming more and more complex.

Distributed Energy Resource Management Systems (DERMSs) are becoming increasingly important to Utilities as they adapt to a steady and continuing wave of decentralised forms of clean renewable generation along with battery storage, increased numbers of electric vehicles, and demand-side management advancements over the past several years. This change in supply and demand fundamentals within the power sector has forced the hand of many utilities to invest in technology

advancements such as DERMSs in order to reliably and efficiently meet the changing needs of their electricity customers.

5G will offer important benefits to Distribution System Operators in the future energy retail market given the developments towards smart grids, as the distributed energy resource management system use cases represent the key to Digital transformation initiatives across utilities.

3.5 Key Findings for the Four Verticals

Although different approaches and propensity to digital transformation, the emerging needs to innovate will strongly influence ICT spending of the four verticals analysed Verticals over the next few years, pushing them to adopt Innovation Accelerator technologies and leverage 5G networks to successfully compete in European market.

The **Automotive industry** is strongly investing on a full digitalisation of its products and services. Manufacturers have accepted the fact that their customers do not see them anymore as a mere supplier of a piece of product, but as the potential source of an end-to-end solution. Product functionality as service without the hassles of owning and maintaining is going to be the new market for the manufacturers. To maximise the overall driving experience and ownership, Automotive manufacturers must look into multiple other complementary products or service features such as in-car entertainment, passenger's engagement (gaming), easy maintenance, parking and so forth, requiring a syndication approach.

The need for automation coupled with growing opportunities for connected-vehicle services, made Automotive a primary vertical target at a very early stage for services enabled by 5G mobile networks. IDC defines five main groups of connected-vehicle applications, all of which can be expanded by 5G: **Information and entertainment, Navigation and journey, Usage-based services, Traffic balance and control, Vehicle autonomy.**

The **Manufacturing industry** is living the fourth industrial revolution, “Industry 4.0”, driven by a heterogeneous set of both IT (Information Technology) and OT (Operational Technology) technologies that are being leveraged to allow the continuous interaction of the real and the virtual worlds, increased operational effectiveness, improved workers’ decision-making ability, and the integration of the factory with the supply chain. Ultimately, this will pave the way for the creation of new business models. Despite the massive investments already made, considerable efforts will still be needed to adapt and orchestrate technologies to the specific business environments and to reach the full exploitation of their implementation and integration. In this context, the ability of large companies to drive the transformation and of government institutions to coordinate the innovation actions will be crucial to address the diversity of the European Manufacturing ecosystem and foster sustainable economic growth.

Future competitiveness of the sector will be influenced by two trends: the “servitisation” of Manufacturing and the growing importance of global value chains driving the demand for truly connected manufacturing ecosystems. Key applications and benefits for 5G in smart factories will include: **constant on-site connectivity**, **constant inter-site connectivity**, **use of VR/AR technologies, wide-area connectivity, enhanced industrial ecology, decreased risks/alert management.**

The **Healthcare industry** is highly fragmented and faces many different regulations, depending on the country, and limited public funds. Healthcare providers are investing in digital transformation to impact operations and cost effectiveness, along with benefits associated with the implementation of digital solutions to engage patients and improve customer experience. With new technologies transforming the Healthcare sector such as wearables, smart watches, AR/VR devices, AI and IoT-based solutions, personal computing devices deployed in mobility, Healthcare providers are working toward innovation and individualisation of services by transforming the way care services are delivered and revolve around patients.

The Healthcare sector is facing broad transformations: the delivery of care will soon be strongly decentralised, becoming truly patient-centric, reducing the hospitalisation of patients and allowing them to receive treatment and be closely monitored at home. Firstly, 5G will impact positively on the deployment of **Remote Health Monitoring** to check the physical condition of patients with chronic diseases. In future, after 2022, 5G is also expected to significantly improve connectivity **to enable haptic feedback to underpin surgeons' capabilities to carry out remote robotic surgery.**

The **Energy industry** is expected to massively invest in almost all the Pillars and Innovation Accelerators to keep up with the rapid changes in the market: the focus will be on Big Data, Robotics, and AR/VR technologies helping companies upgrade to more advanced digital business environments. Technological advances are changing the way Energy companies are producing, transporting, and consuming energy, outlining new approaches for interaction with customers. Compared to other industries, digital transformation in Energy companies is already well underway. For this industry, the transformation is not just a source of competitive advantage in the market, but a real prerequisite to survive.

This industry is shaking traditional utility value creation at its core. Not only is it fuelling a shift in the way energy is produced, distributed, and consumed, but also in the ownership of the production capacity itself. In parallel, digital technologies are disrupting decade-old processes, creating opportunities and threats to the traditional utility business model. The business potential of 5G in the Energy vertical is expected to be very high through the support of **next generation smart grid protection and smart metering.**

4. Conclusions and Recommendations

With speeds of up to 10 Gbps, reduced latency and unprecedented reliability, the connectivity based on the 5G standard is destined to change the processes and the development scenarios of a number of different industries.

As for the 3-4G connection, the path from trials to the actual market rollout for 5G will take within 2 or 3 years, and even longer for some of the verticals. Yet, the progressive extension of the 5G network will begin to make its effects felt in different areas by reducing the limits that have so far slowed down the applications of the Internet of Things.

5G will provide European enterprises with ultra-fast and ubiquitous mobile connectivity services, becoming the catalyst for innovation processes based on mobile edge computing (i.e. the ability to process data from multiple sources and devices distributed throughout the territory), which are crucial for maximising the economic potential of the digital revolution in various production sectors.

Despite the presence of different approaches and degrees of propensity to digital transformation, the emerging needs to innovate will strongly influence the four vertical markets analysed in the next years, by pushing them to adopt Innovation Accelerator technologies (see The Essential Glossary) and leverage 5G networks to successfully compete in the European market.

The on-going development of 5G mobile communication technology will be the cornerstone to enable communications for automation in various vertical domains, but in the European macroeconomic environment with its high fragmentation and diversity, institutions and industry stakeholders should consider the following recommendations:

- **Start by clearly identifying in which industries and business processes 5G could transform services and products as part of the next evolutionary stage of digitalisation**, generating real benefits in terms of cost or incremental revenues and how success will be measured. The ability to understand the overall journey of digital transformation for each vertical industry will help drive the process of identifying which use case(s) to prioritise first and develop a road map that will effectively advance digital transformation across Europe.
- **Foster the development of a data-driven culture, enabling European businesses (mainly SMEs) to recognise the value of data.** Businesses improving their capability to extract in real time value from information coming from many sources, devices, objects, will be a key success factor to compete in the global market. As 5G networks support a massive number of connected devices and create a threat landscape different from previous networks, fostering a data-driven culture also means recognising and continuously working at new approaches to security, privacy, identity and regulatory compliance.
- **Recognise that the diversification of the European macroeconomic framework will initially generate several many small-size use cases** difficult to replicate and extend cross-sector or

cross-country. 5G will penetrate European industries with differentiated timing and use cases, also in relation to the regulation and economic structure of the different countries.