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DIGITAL ENERGY

INFRASTRUCTURES, ENABLING TECHNOLOGIES AND THE ROLE OF THE CONSUMER

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EXECUTIVE SUMMARY

There is a lot of uncertainty about what the energy sector will look like in the near future. It will certainly be very different from the current paradigm that is already very different from what we had experienced in the recent past. The drivers for this transition are structural and deep.

Firstly, the close interweaving between energy and human development is so clear that there is no possibility to combat global social and economic imbalances and eradicate poverty without ensuring access to affordable, reliable, sustainable and modern energy for all (UN Sustainable Development Goal Number Seven). This means ensuring access to modern power for 1 billion people, predominantly rural dwellers, half of whom live in sub-Saharan Africa, still living without electricity. Moreover, approximately 3 billion people, largely located in Asia and sub-Saharan Africa, are still cooking without clean fuel and more efficient technology. If these numbers look impressive, we have to further take into account that the world population is expected to grow by 2.2 billion units in the next 35 years, mostly in Africa and Asia.

The second main driver for the energy revolution is environmental sustainability. Human activities are putting at risk the resilience of ecosystems and depleting basic ecosystem services. Above all, human GHG emissions are almost unanimously recognized as interfering with climatic patterns. Energy, as a whole, is by far the main emitting sector.

The two aforementioned global trends can converge only if energy production as well as consumption patterns are radically reshaped. Renewable energy generation, distributed generation, energy efficiency and storage technologies are emerging as large-scale market viable applications and represent the first blocks in the energy revolution.

As well as this global trend, the European Union has decided to embark on an integration process in the energy markets among member states and even beyond its southern and eastern borders. In order to reach this target, energy market structures have undergone a deep transformation, passing from vertically integrated state-owned monopolies to liberalized markets. This has had a remarkable influence on the relations between market actors, institutions and final consumers.

The deep changes in the energy sector are intersecting yet another radical change in modern society and economy – the digital revolution. Powered by the spectacular advances in the semiconductor industry, ICT applications are spreading worldwide across all sectors and can be considered as one of the key drivers for innovation, competitiveness and growth. Improvements in communication infrastructures and Internet protocols have overcome many natural and cultural barriers, enabling impressive data flows among people, firms and institutions. At the same time, computational power has boomed and allowed for advanced data management and information mining. Artificial intelligence, machine-to-machine communication and machine learning are becoming a reality.

ICT is already influencing the evolution of the power sector and more and more interaction is expected in the near future. Power grids (both transmission and distribution) are already highly automated. Advanced monitoring and maintenance are spreading among production facilities and grid nodes. New media are changing the relationships between suppliers and consumers. Policy and regulation at EU and member state level have to pave the way for the digital energy convergence.

The study aims at presenting an overview of current trends in digital energy at different levels, including infrastructure development, the role of technologies and the costumer perspective.

Chapter 1 focuses on the global trends in the energy sector. It highlights the impact of human economic activities on greenhouse gas emissions and the possible options to reduce the carbon footprint of the energy sector. Greenhouse emissions are driving climate change, which is affecting every country around the world. Climate change represents a global challenge that oversteps national borders and requires international cooperation to move toward a low-carbon economy.

The Paris Agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C. It aims at strengthening the ability of countries to deal with climate change. For that purpose, an appropriate framework (in terms of appropriate financial flows, new technologies and an enhanced capacity building framework) will be put in place. All countries are required to put forward their best efforts in order to limit global warming well below 2°C and if possible, below 1.5°C. According to the IEA projections, a 50% CO_2 emission cut to current policy scenario trends by 2040 is needed to limit the increase of the global average temperature within 2°C. In absolute numbers, this means emitting 18,850 Mt of CO_2 (450 scenario) by 2040 instead of 36,240 Mt (current policy scenario).

Europe is putting an extraordinary effort into reducing GHG emissions to meet its long-term decarbonization goals. At EU level, the 2020 targets – which is to reduce GHG emissions by 20% below 1990 levels – will be exceeded and an additional reduction is envisaged by 2030 (40% less than 1990). Projections estimate a further decrease in GHG emissions but the Energy Roadmap 2050 target (80% GHG emissions cut below 1990 level) is very challenging and unreachable under current conditions. An extra effort should be made. Indeed, according to the Primes projections, EU 2050 GHG emissions will be almost halved compared to 1990.

Projections show that emission reduction efforts in the carbon intensive industrial sectors – regulated under the Emission Trading Scheme (ETS) – are producing emission trajectories in line with long term goals, even if more effort is still required. 2050 ETS emissions are expected to decline by 66% compared to the 2005 level. On the other hand, non-ETS sectors (e.g. transport, services, agriculture, housing – regulated under the Effort Sharing

Decision - EDS) are far from reaching sustainable emission patterns. Non-ETS reductions do not reach 30% compared to 2005 levels.
Digital energy could provide an important momentum for reorienting EDS sector emissions, putting strategic sectors like transport, services and housing on track. Electric vehicle penetration, electrification of domestic consumption and energy efficiency are just a few examples where digital energy could play a key role.

Chapter 2 explores the different perspectives of ICT applications in the energy sector. It presents a brief overview of world investments in infrastructures, showing the role of electricity in global investments. Infrastructure investments totaled 2.3 trillion US$ in 2015. Energy has been the most attractive sector (more than 800 billion US$), followed by road transport and telecommunications, with 670 and 300 billion US$, respectively. The power sector remains one of the most attractive sectors for investments in infrastructure also in the medium/long term forecasts. Digital energy investments are becoming more and more important. In 2016, global grid investments reached 280 billion US$, 11% of which are in digital infrastructures. This represents a marked increase (+50%) compared to 2015. On top of this 30 billion US$, we must add around 18 billion US$ in smart building, smart industry applications and energy software investments.
The remainder of the chapter is dedicated to analyzing the three main building blocks of digital energy – sensors and actuators, connectivity and data management – and the crosscutting issues of standards and interoperability and cyber security.
Sensors and actuators detect information on the status of the different components of the infrastructure and, in more sophisticated applications, on surrounding parameters that can influence its functioning and on user behavior/status. Furthermore, they put into place the right actions, autonomously or remotely controlled by a human operator, in order to react to changing conditions. The sensor and actuator global market represented 3% of global semiconductor market sales in 2016 (approximately 10 billion US$). Among the different applications, sensors and actuators experienced the highest growth rate compared to the previous year (23% compared to an average of 1% for the whole sector). Many analysts agree that this segment will experience a major increase in the near future due to IoT and MtM applications. It is interesting to notice that Europe plays a marginal role in global semiconductor sales (only 10%), in a market dominated by Asia, but still could be competitive for system manufacturing and system integration. Sensors and actuators may have different applications in the power grid. We can roughly distinguish between industrial and retail applications. For the former, we can mention the real-time monitoring of grid status, including monitoring transient events and fault detection, substation condition-based management and Line Dynamic Rating. One of the main applications in retailing is represented by smart metering.
The amount of data generated by sensors must be transferred to data centers in order to be processed

and extract the desired information and, eventually, be stored for future applications. Symmetrically, streams of data have to be sent to actuators/end-users in order to produce the desired actions. This is where connectivity comes into play. Energy infrastructures are complex and involve a wide variety of geographical scale topologies, ranging from regional to home, with point as well as linear physical objects (generation units vs. transmission and distribution lines). The density of these objects can be very different and reach high concentrations in cities. Each specific application has its own requirements in terms of range, bit-rate, latency, accuracy and security. Due to this complexity, different wireless, as well as wired communication technologies find applications in the energy sector. The massive spread of energy-related MtM or IoT devices is expected to have an influence on current data transmission systems. Connected devices are expected to increase by a factor of 4 in the next 5 to 6 years. Some energy applications will require advanced and high-performance communication technologies. Communication infrastructures are thus a key element in digital energy development.

The last piece of the digital energy puzzle is data management. Data collected has literally no value if useful information is not extracted and subsequent adequate actions or feedback is not adopted. This is where Big Data analysis comes into play.

Advanced data management and Big Data analysis could find remarkable applications in the energy sector, at different levels. With the increase of detected data on the status of infrastructures (both transmission and distribution), wide area situational awareness will enable an advanced grid control. Situational awareness involves three main steps: perception, comprehension and projection. The last two steps are very resource-demanding in terms of data analysis and computing power. The projection on grid status allows for a more rapid and efficient reaction to potential grid faults by control room operators or/and automatic operations, thus resulting in a safer infrastructure management. It is clear that a timely detection of possible grid faults is a key issue and powerful data analysis algorithms have to be developed.

Another important application of Big Data analysis for the power sector is short-term load forecasting. Advanced energy metering provides access to more time resolved energy consumption data. Integrating this information with other data (e.g. temperature, humidity, home occupancy) and historical consumption patterns, allows for a more accurate prediction of short-term future electricity consumption. Clearly this is fundamental for grid operation and is enabling information for advanced demand management services.

Data is surely at the heart of the digital energy revolution. The benefit of this radical change in the energy sector will materialize only if a proper data management system can be adopted. Many issues are connected to this aspect. Who owns the data? Who is responsible for collecting, transmitting and storing data? Who has the right to extract information out of this data? What is the optimal use of this information? How to fairly distribute benefits and costs among different players in setting up this complex data management system? How to balance privacy and open access rights to market operators in order to maximize advanced energy services? There is a general consensus that the answers to these questions are not unique and depend on the specific application, market segment and national context being referred to. Broadly speaking, there is a first layer that is related to grid status data and optimal management of energy infrastructure. In this case the TSOs/DSOs role is prominent and the collaboration among these regulated entities is fundamental. A second layer is represented by data generated by consumers through digital meters. Of course, some of this information is relevant for DSOs operations, other has a more commercial value. The regulation of the latest stream of information is the most complex because many partially conflicting aspects have to be tempered. Privacy, information asymmetry, free competition and innovation are some of the main aspects to be taken into account.

The transition of the power sector from the “analog” to the “digital” era is a complex and long process. It will be achieved step by step, with both a top-down and bottom-up approach.

Legacy infrastructures and solutions will coexist alongside innovative ones. It will take some time before well-defined standards will emerge and business models become confirmed in the market. This is true both for software and hardware, as well as for system integration. For these reasons standardization and interoperability will play a key role in the transition phase. A paragraph of the study explores the main EU initiatives to promote common EU standards and an interoperability framework.

Finally, a specific focus is dedicated to cyber security. With the pervasive penetration of ICT and Internet in all economic activities, services and private life, cybersecurity should become one of top priority in security management at all levels, starting from EU and national level, ending up with firms and individuals. For the energy sector, this is particularly true since energy infrastructures are strategic and because energy data is sensitive for the privacy and security of consumers. Indeed, with the advent of IoT, networks will become a major target of cyber-attacks and the potential consequences are expected to be extremely serious. Smart infrastructures are based on the digital processing of data, and intelligent machines will automatically supervise vital functions, with more and more services being based on the availability of Internet to be able to deliver. An intentional or accidental cybersecurity accident could cause severe harm to institutions, companies and individuals. The awareness of EU firms and citizens does not seem to be adequate, and EU initiatives on cyber security are presented.

Chapter 3 focuses on the relationship between digital media and consumers. After analyzing the different levels of computer skills and digital service penetration in EU member states, the Chapter focuses on what digitalization means in the energy sector.

Internet is becoming the privileged place where people communicate, search for information, buy goods and services, interact with public administrations and conclude transactions. Each socio-economic field is taking on these new challenges even if each national context is reacting differently to the digital revolution.

Regarding individual internet usage, Northern Europe shows the best performance: in Luxembourg and Denmark the percentage of individuals not accessing the Internet in 2016 was only 2% (14% at European level) and those of individuals accessing the Internet daily were 93% and 89%, respectively (71% at European level). In general, there is a reverse relationship between age and Internet usage, so younger people are more inclined and able to use Internet even if in the more advanced countries, such as Denmark and Luxembourg, the percentage of older individuals accessing the Internet is very high (97% and 95%, respectively, for people aged between 55 and 64 years and 87% and 91%, respectively, for people aged between 65 and 74 years). There isn't, in general, big differences between male and female access.

Analyzing the activities carried out by individuals on the Internet, at the EU level, sending/receiving e-mails and information research for goods and services are the most frequent activities (71% and 66% of individuals, respectively).

Concerning social network penetration, the report *"Digital in 2017"* by We Are Social highlights that more than 2.8 billion people worldwide use social channels at least once a month, and more than 91% of them use mobile devices. Facebook is the most widely used platform with 1.871 billion users. At European level, 52% of individuals used Internet to participate in social networks in 2016. In general, there is a reverse relationship between age and participation in social networks, so younger people – in particular individuals aged between 16-24 and 25-34 years – are more inclined to participate in social networks.

Among digital services, e-commerce is one of the most important. Online purchases increased from 30% in 2007 to 55% in 2016, the highest percentages being found for the 25-34 and 16-24 age groups (72% and 67%, respectively). In 2016, the percentage of e-shoppers varied considerably across member states, ranging from 12% of Internet users in Romania to 83% in the UK. Clothes and sporting goods are the items most likely to be purchased online in the EU (34% of e-buyers), followed by travel and holiday accommodation (29%) and tickets for events.

Focusing on firms, large enterprises – which have more resources to invest in digital channels and are more aware of the importance of e-commerce – benefit more from e-commerce (22% on average at EU level). Ireland is the most advanced country (45% of the turnover of large Irish enterprises stemming from e-commerce).

Concerning financial activities and, in particular, Internet banking, Denmark is the best performer in Europe with 88% of users in 2016, followed by Finland (86%) and the Netherlands (85%). Greece, Romania and Bulgaria showed the lowest percentages with 19%, 5% and 4%, respectively. The most active groups by age are, in general, the 25 to 34 years and 35 to 44 years.

The Internet revolution in the power sector is resulting in new business models and regulatory frameworks. The utilities of the future need to become a fully digital system starting from their organization and business.

Internet, smart technologies and connected home appliances have changed energy systems. Hence, utilities should be more focused on customer needs, in order to create real value and unlock additional opportunities. Indeed consumers want more tailored experiences and more digital access. Moreover, energy companies can no longer provide only energy, but should also offer other relevant energy services.

Demand response is a good opportunity for consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives.

Managing mobiles, anywhere and at anytime, are the new key words. In the near future, a fast development of solutions will take place, allowing consumers to remotely manage home-appliances (i.e. air conditioning, heating, etc.). Gamification and social media will also play a fundamental role. Many consumers are interested in this tool to follow and interact with suppliers for a faster and easier service

Currently, in the EU there are different degrees of penetration for dynamic pricing, due to regulatory constraints as well as consumer awareness of the possible benefits and the popularity of fixed contracts among households. Many countries (17) use Time of Use (ToU) tariffs, generally splitting them into day/night periods. Critical peak pricing is used in Estonia, Romania and Spain. Other dynamic pricing methods apply to electricity consumers in Nordic countries, where consumers most often incur in spot market prices based on monthly average wholesale prices. At the same time, there is growing interest also in Explicit Demand Response in Europe, which has taken further (small) steps in the last two years.

According to Accenture, the electricity industry is ready to realize on value from the ongoing digitalization that could reach $1.3 trillion worldwide from 2016 to 2025. In the same period, the value creation for society could globally overtake $2 trillion.

Consumers are interested in the potential (energy and money) savings of digital energy. For example, consumers are generally interested in products and devices to make simple improvements in their own home in order to save electricity (76% of digital users and 57% of non-digital users); and in home energy audits to identify opportunities to save electricity (72% of digital users and 53% of non-digital).

Digital technologies and Internet are opening up unprecedented participation opportunities for citizens, civil society organizations and firms. Crowdfunding is surely one of these new frontiers and energy related projects one of the possible candidates for crowdfunding financing. From 2012 to 2015 crowdfunding in the energy sector raised $165 million, roughly 0.75% of overall crowdfunding funds volume, but very limited impact on energy investments). Despite the small size of the market, these types of initiatives are generally more successful than other campaigns.

Chapter 4 focuses on the systemic benefits of the digital energy and the potential role of advanced telecommunication infrastructures. Indeed, changing everyday life, decentralization and digitalization can support the revolution in the energy sector and bring about several benefits for individuals and communities, on the one hand, and for businesses and startups on the other.

Decentralization promotes the spread of the energy communities, a previous old way to produce and consume energy. Self-production, energy exchange through smart micro-networks and local networks and energy storage are the pillars on which energy communities are based with consumers really becoming more involved in the energy system. Different heterogeneous subjects, interested in different achievable benefits, can develop energy communities. For example, hospitals are interested in the certainty of supply, residential buildings in the reduction of energy spending, while industrial districts want a mix of the above. The energy community can also be useful in emergencies, continuing to provide an energy supply.

Digitalization of services has transformed Internet into a privileged place in which consumers interact and transact with companies, providing a huge amount of data and, consequently, new business models. According to the 2017 I-Com Index of Digital Preparedness of energy firms – which considers enterprises that: analyze big data, use cloud computing, send invoices for automated processing, use software of Customer Relationship Management and have formally defined a ITC security – the most prepared companies for digitalization are based in Finland (totaling 100 points), Sweden and Slovenia, while the less prepared in Latvia, Hungary and Luxemburg.

Across Europe 16% of enterprises analyze big data from any source. Among these companies analyzing big data, roughly 80% performs this activity in-house. It is an obvious sign there is a room for specialized companies.

According to the European Commission vision, businesses support, especially at the early stages, is an essential driver of innovation. Among the initiatives of the European Institute of Innovation and Technology, InnoEnergy supports the innovation in the sustainable energy sector, investing in businesses and helping develop innovative products, services, and solutions that have high commercial potential. The InnoEnergy Highway® program that supports the creation and the development of startups, turning innovative ideas into commercial solutions that together will change the way of producing and consuming energy. From 2012 to 2016, the InnoEnergy Highway® has supported 171 startups. These supported start-ups become members of the Europe-wide network of industrial partners, potential customers, and technology experts. The power of the community opens up opportunities across the continent to connect ideas and investors, entrepreneurs and enterprise, products and markets.

Digital services' deployment and penetration requires not only the individuals' interest, but also high-performance networks. Focusing on the fixed telecommunications networks, the percentage of households connected to the broadband at European level in 2016 was 83% while the percentage of households living in areas served by NGA is 76%.

Concerning the mobile network, instead, the European percentage of LTE coverage is 84,4%.

The extraordinary growth of mobile data traffic – favored by IoT's deployment and increasing importance of contents – underlines the need to promote research and investments to deploy higher performance technologies and, in particular, 5G's implementation.

Chapter 4 includes a description of 5G's performances and its impact on vertical sectors and an analysis of the actions and the roadmap identified by European Institutions to encourage 5G's deployment.

5G is the new generation of radio systems and network architecture that will revolutionize businesses and the lives of citizens/consumers guaranteeing a more advanced and more complex set of performance requirements, being able to support more users, more devices, more services and new use cases through more efficiency and speed.

ABI research predicts that 5G revenues may reach US$250 billion in 2025, with North America, Asia-Pacific, and Western Europe being the top markets, based on revenues connected to "Machine to Machine" communications' development in addition to enhanced mobile broadband services and underlining the benefits for industrial sectors.

The document *"5G empowering vertical industries"*, presented by the Commission and the Public Private Partnership on 5G highlights that the energy sector will benefit from the opportunities related to 5G implementation. In fact, Grid access, Grid backhaul and Grid backbone are the main cases identified in the document for the energy sector. Considering that the physical infrastructure will need to support a two-way energy flow originating from the distributed energy resources, which in turn implies new needs for communication technologies, intelligence, business models and market structure, it will be necessary to introduce "Smart Grids" and 5G will be very important in achieving this goal.

European institutions have underlined the importance of 5G deployment. In fact, on December 17, 2013, the European Commission signed a landmark agreement with the "5G Infrastructure Association" representing major industry players to establish a Public Private Partnership on 5G (5G PPP) and accelerate research development in 5G technology and at the Mobile World Congress 2015, the Commission and 5G PPP presented Europe's vision of the 5G technologies and infrastructures. This document stresses that 5G is a new network to be designed as a sustainable and scalable technology and analyzes the development prospects favored by technological evolution focusing on the transport sector, healthcare, energy and media and entertainment, showing that, in general, the digitization of factories will be a key stake for the 2020s.

In September 2016, the European Commission launched the *"5G for Europe: an Action Plan"* highlighting the importance and the benefits for several economic and industrial sectors and identifying eight actions to promote 5G deployment: 1) promoting preliminary trials from 2017 onwards and pre-commercial trials with a clear cross-border dimension from 2018, encouraging the adoption by member states of national 5G deployment roadmaps and the identification of at least one major city to be "5G enabled" by the end of 2020; 2) identifying – in according with member states – by the end of 2016, a list of pioneer spectrum bands for the initial launch of 5G services; 3) adopting an agreement around the full set of spectrum bands (below and above 6GHz) to be harmonized for deployment of commercial 5G networks in Europe; 4) setting roll-out and quality objectives for the monitoring of the progress of key fibers and cell deployment scenarios identifying actionable best practices to facilitate – also incrementing administrative conditions – denser cell deployment; 5) promoting by the end of 2019 the availability of the initial global 5G standard, the standardization of radio access and core network challenges and the conclusion of cross-industry partnerships; 6) planning technological experiments to be carried out as early as 2017 and presenting detailed roadmaps by March 2017 for the implementation of advanced pre-commercial trials; 7) encouraging member states to consider 5G infrastructure usage to improve the performance of communication services used for public safety and security; 8) identifying assumptions and modalities for a venture financing facility.

The EU member states are also aware of the importance of 5G deployment and many initiatives and investments are underway to achieve this goal.

The study concludes with the following policy considerations:

1) Data as a digital energy kingmaker

Data is at the heart of the digital revolution. In order to represent a real value for stakeholders, relevant information has to be extracted out of the mass of data generated by smart devices. In perspective, we should talk about data management as an infrastructure by itself. In order to develop this enabling infrastructure and fully grasp the benefits of digital energy, proper investments in the development of an advanced energy data management infrastructure have to be adopted at all levels. This involves investments in hardware, software and human capital.

All market actors are involved in this process. A favorable regulatory framework for regulated grid activities must be put in place. TSOs and DSOs can play an important role as data management hubs, considering the growing complexity of transmission and distribution grids (increase in cross-border interconnections, renewable energy penetration, storage, distributed generation and active participation in the demand, electric mobility). The TSO/DSO cooperation on data sharing has already started and must be further strengthened and defined in scope, responsibilities and procedures.

Market activities too have to benefit from the possibility to offer innovative and advanced energy services, especially smart metering. Energy efficiency and demand management are the simplest examples. The access to commercially sensitive data should be as open as possible, in order to create a competitive context for traditional energy retailers and new incomers. Of course, this has to be tempered with data ownership, privacy and information asymmetry between consumers and retailers/service suppliers.

However, any new data collection and exchange, as well as information elaboration burden imposed on any market actor, should be carefully studied under a cost/benefit analysis.

Costs and benefits of the implementation of the data management infrastructure should be equally distributed among the system stakeholders.

It is clear that careful data management governance has to be implemented. Probably, there is not a one-size fits all solution among member states. Different models are being implemented across Europe, in particular for handling end-user data. Some countries are opting for fully involving independent grid operators, either TSOs or DSOs, others are setting up independent regulated entities specifically devoted to smart meter data management. Centralized vs. distributed data management models are being applied. In the first case, data management is a regulated activity and smart metering data is collected by a central data hub. In the second case, data remains stored on the consumers' premises and a competitive market for energy data service is set up. Compliance with General Data Protection Regulation has to be guaranteed, and consensus on data sharing a key issue.

With the massive roll-out of IoT and, consequently, the possibility to gain insights into final energy consumption from sources other than smart meters, it is expected that the borders between these models will become less defined. Still, legal energy metering will maintain a vital role for grid operations.

However, in order to be in line with the principles of the Energy and Digital Single Market, general rules and principles should result in a level playing field and give stable and clear long-term signals to investors and consumers.

2) Cyber-security and interoperability as cornerstones for digital energy uptake

Cyber-security is surely one of the main concerns for digital energy. The massive spread of connected energy devices both at grid and consumer level widens the potentially vulnerable surface of the EU energy system. Increased interconnection between national grids extends the issue well beyond national borders. Serious security and privacy concerns are present for different digital energy applications. COM (2017) 477 poses some important priorities for setting a common EU cyber-security framework. In this sense, it would be important to create, as soon as possible, a specific working group within the EU Cyber-security Agency (ENISA) specifically dedicated to digital energy.

With the expected massive spread of energy related IoT devices, technology cyber-security certification of appliances is an important step to guaranteeing the quality of devices for consumers. In the long term, the introduction of high quality standards would bring important benefits for the competitiveness of the IoT value chain of EU enterprises and protect the market from low quality products. The energy sector has already experienced the importance of introducing high quality standards for energy devices, as was the case for the quality certification for PV and SWH technology. In new fast growing segments time is a key issue.

Certification of components and systems is as important as certification of competences and skills. Again, the energy sector has already shown the importance of taking into account this aspect as demonstrated by the experience of technicians in RES installations. We consider the introduction of a common EU framework for the certification of cyber-security skills for the different applications (e.g. data protection, asset security, etc.) a priority.

At the same time, interoperability is mandatory for a sector where standardization processes are still ongoing, where market dynamics are evolving fast and technology cycles are long, so that the contemporary presence of legacy and innovative technologies is taken into account. Digital energy interoperability will benefit from the EU Single Market and create opportunities for consumers and firms in terms of market competition and competitiveness.

3) Digital energy as the gateway to non-ETS GHG reduction targets.

Europe is putting an extraordinary effort into reducing GHG emissions to meet its long-term decarbonization goals. Projections show that emission reduction efforts in the carbon intensive industrial sectors – regulated under the Emission Trading Scheme (ETS) – have emission trajectories in line with long term goals, even if even more effort is still required. On the other hand, non-ETS sectors (e.g. transport, service, agriculture, housing – regulated under the Effort Sharing Decision - EDS) are far from reaching sustainable emission patterns. Digital energy could provide an important momentum for reorienting EDS sector emissions, putting strategic sectors like transport, services and housing on track. Electric vehicle penetration, electrification of domestic consumption and energy efficiency are just a few examples where digital energy could play a key role. Here, a coordinated initiative by the EU Commission could promote concrete actions and investments in order to increase the impact of digital energy on non-ETS emission reduction.

4) Digital energy and smart energy consumers

Consumer empowerment and awareness are real challenges for energy consumers. Indeed, digitalization in the energy sector is progressively resulting in a large variety of services. Thanks to new technologies, consumers have potential access to a huge amount of data and information, but they are not always able to take advantage of this. On the one hand, it is increasingly important to spread an energy and digital culture to empower consumers. On the other hand, in order to give value back to consumers, third parties (companies, aggregators, institutions) could help in closing the gap and support consumers in understanding and better managing their consumption patterns. Unfortunately, it should be considered that consumer awareness is not enough to fully tap into the potential of the ongoing digital transformation. Under certain circumstances, automation is a key answer. Communication between machines and prompt device reaction to signals (e.g. price signal, network needs, etc.) should be promoted by European and national regulations, while, at the same time, regularly checking that consumers are actually benefiting from it.

5) Nurturing a competitive ecosystem for digital energy players

Digital energy prompts potential spillovers outside the energy sector. The digital energy value chain involves traditional energy firms (TSOs, DSOs, power producers, retailers, etc.), traditional ICT enterprises (hardware, software and system integration) and, potentially, innovative SMEs, start-ups and scale-ups in many different sectors (data mining, behavioral analysis, advanced manufacturing, just to quote a few). The creation of an EU wide digital energy single market could create a robust demand for advanced digital energy solutions, foster strategic cross-sector fertilization and allow for a sustainable growth of a competitive "Made in EU" digital product/services offer. The sector should also aim at penetrating non-EU markets to seize worldwide digital energy investment opportunities. As already mentioned, an advanced EU framework for standardization and quality requirements are key elements to creating a sustainable digital energy value chain. Europe can play a central role also in stimulating and supporting firms in innovation and workforce qualification by specific competence and skill development programs. Also critical would be a thriving financial eco-system, funding promising start-ups and scale-ups and allowing for a rapid commercial development of technologies applied to the energy sector.

6) Converging infrastructures for digital energy deployment

The European Commission, aware of the importance of network development for new service deployment (e.g. IoT) and the future of the European Union, has proposed policy and regulatory measures to encourage network investments, setting new connectivity targets for network access and adapting the current regulatory regime to the competitive evolution of broadband markets.

Considering that fixed and mobile ultra-broadband network deployment require tremendous investments, it is very important, in general, to create a regulatory investment friendly environment (also through a stable and predictable telecom regulatory) and guarantee the respect for net-neutrality to encourage the development of new business models and new services. With regard to the regulatory framework, instead, it would be opportune to reduce and simplify rules, ensuring an EU harmonization, license timing able to encourage investments, guarantee a reasonable return on investments for network operators and, in general, respect for non-discrimination principles. Then, considering the importance of OTT and the (r)evolution of competitive dynamics, for healthy telecommunication markets it is crucial to analyze the role of platforms, promote actions aimed at shifting from ex ante to common ex post rules and ensure a level playing field where the same services are subjected to the same rules. A specific effort should be put into identifying possible synergies between energy and ICT networks.

5G will be a key enabler for IoT and new digital service deployment. Considering that Europe has a history of leading the development of mobile technology in the 2nd and 3rd generation, it is very important to take the lead also in 5G development. To achieve this goal, complying with the Commission's initiatives and planning, it is vital to step up investments, simplify and remove barriers to small cell deployment, plan a roadmap and a shared timing in Europe, ensure a harmonized and efficient spectrum management, the availability of adequate spectrum bands to 5G deployment and the strong cooperation of all stakeholders. The implementation of sustainable 5G digital energy business models could help in the development of this key communication technology.

The radio-spectrum is crucial for the increasing demand and growth of mobile services. Considering the huge increases in data traffic and the importance of investments requested by the operators, it is essential to ensure a technical spectrum harmonization, a spectrum release timing shared by member states – to minimize cross-border interference and facilitate international roaming -, harmonized and adequate license duration (to encourage investments) and a flexible spectrum use. In fact, considering that spectrum is a scarce resource and demand is quickly increasing, it would be appropriate to foresee flexible ways of using spectrum such as Supplemental Downlink (SDL) in the lower UHF band (470 – 694 MHz) and Licensed Shared Spectrum (LSA). Finally, it's important to guarantee that spectrum auctions are efficient, based on market mechanism and not oriented to short-term fiscal targets.

7*) Converging regulations for converging sectors*

Digital energy means also challenging regulations. Traditionally, communications and energy have been treated separately. This legacy is clear in the architecture of most of the EU and member state institutions. The discontinuity introduced by the digital revolution imposes a change in this approach. Communications and energy could be a first example of how to innovate policy and decision-making in the digital era. The EU Commission should take the lead in this regulatory convergence and draw up one or more integrated communications and energy proposals.

PART 1

(R)EVOLUTION IN THE ENERGY SECTOR

1. (R)EVOLUTION IN THE ENERGY SECTOR

1.1. PARIS AGREEMENT ON CLIMATE CHANGE

The greenhouse emissions from human activities are accelerating climate change, which is affecting every country around the world. The impact of the ongoing change involves weather patterns, rising sea levels and more extreme weather events. Climate change represents a global challenge that oversteps national borders and requires international cooperation to move towards a low-carbon economy. According to the United Nations, without actions, the world's average surface temperature is projected to rise over the 21st century, being likely to exceed 3°C.

In order to address this critical issue, in December 2015, more than 190 attending parties agreed on the common goal to limit global warming to well below 2°C and if possible, below 1.5°C.

As well, the Agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting actions of developing and the most vulnerable countries, in line with their own national objectives.

In order to achieve the long-term temperature goal, parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country arties. All countries are required to present and update their best efforts in "National Determined Contributions" (NDCs). These contributions should be reported every five years and be registered by the UNFCC Secretariat. Each additional ambition should be more ambitious than the previous one, in line with the progression principle.

The party conference should periodically (every five years starting from 2023) check the status of the implementation of the agreement to assess the collective progress towards goals. The assessment will cover all the key issues of the Agreement – NDCs, adaption actions and financial commitment. A first assessment will be carried out in 2018 to take a stock of the collective efforts in relation to progress towards the goal set in the Paris Agreement and to inform about the preparation of NDCs.

The Paris Agreement entered into force in November 2016, as result of reaching the threshold (i.e. the ratification of at least 55 countries that account for at least an estimated 55% of total global greenhouse gas emissions).

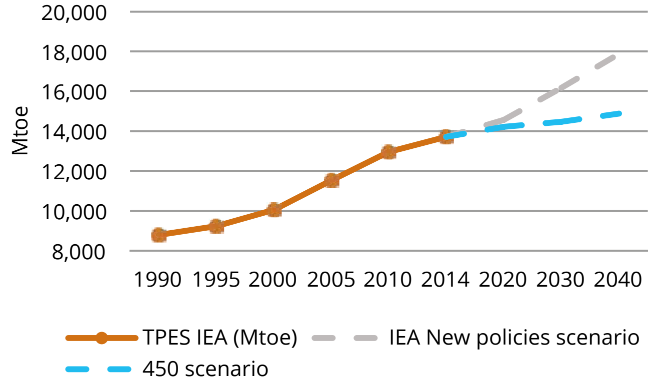
The reduction in temperature can only be achieved through a significant reduction in the emission of greenhouse gases. The Information and Communications Technology sector (ICT) has the potential to play a significant role in driving carbon reductions, while generating substantial economic and socio-economic benefits. ICT can help improve business competitiveness with additional economic benefits and efficiencies, while leveraging existing digital competencies to spur competitiveness and growth. According to the BT vision, ICT has the potential to reduce EU carbon emissions by over 1.5

Gt CO2equivalent by 2030 (just over a third less than the 2012 EU emissions). 53% of the ICT-enabled carbon reductions derives from improved energy efficiency, a 0.8 Gt CO2equivalent reduction across the EU[1].

Moreover, ICT re-designs business models and helps in the transition from a linear to circular value chain by avoiding waste (e.g. re-use). Although, European countries are currently at different stages of development and readiness in being able to take advantage of these benefits, ITC can boost the competitiveness and the growth of EU economies.

Fig. 1.1 Total primary energy demand – World

Source: I-Com elaboration on IEA data



1.2. GLOBAL TRENDS

World primary energy demand grew from 1990 to 2014 by 56% from 8.772 Mtoe to 13.669 Mtoe (fig. 1.1). Forecasts for the future agreed on a general increase in world primary energy demand. According to the IEA New Policies Scenario, from 2014 to 2040, the world demand is expected to grow by 30% to 17.866 Mtoe. Despite the continuously growing trend, the increase of the 450 Scenario forecast (compatible with a global average temperature increase of up to 2° by 2100) is narrower than the new policies scenario, reaching 14.878 Mtoe by 2040 (+9% more than 2014). In order to achieve this goal a further reduction of 2.988 Mtoe regarding the New Policies Scenario (-16,7%) will be essential.

In fact, the present projections for primary energy demand in OECD countries estimate a reduction over the coming decades that is more than offset by the increases in non-OECD countries.

Global installed capacity is estimated to rise from 6.119 GW in 2014 to more than 11.000[2] GW in 2040 (fig. 1.2). Coal-fired capacity could decline from 31% (1,882 GW) in 2014 to 22% (2,437 GW) in the New Policies Scenario or to 10% (1.194 GW) in the 450 Scenario. The share of oil, which will decrease from 7% to 2% of the total capacity installed, and the share of hydro (to 17% from 19% in 2014) remain stable in both scenarios. Significantly different is the potential share of renewable energy, 29% (3.265 GW) in the New Policies Scenario and 44% (5.155 GW) in the 450 Scenario.

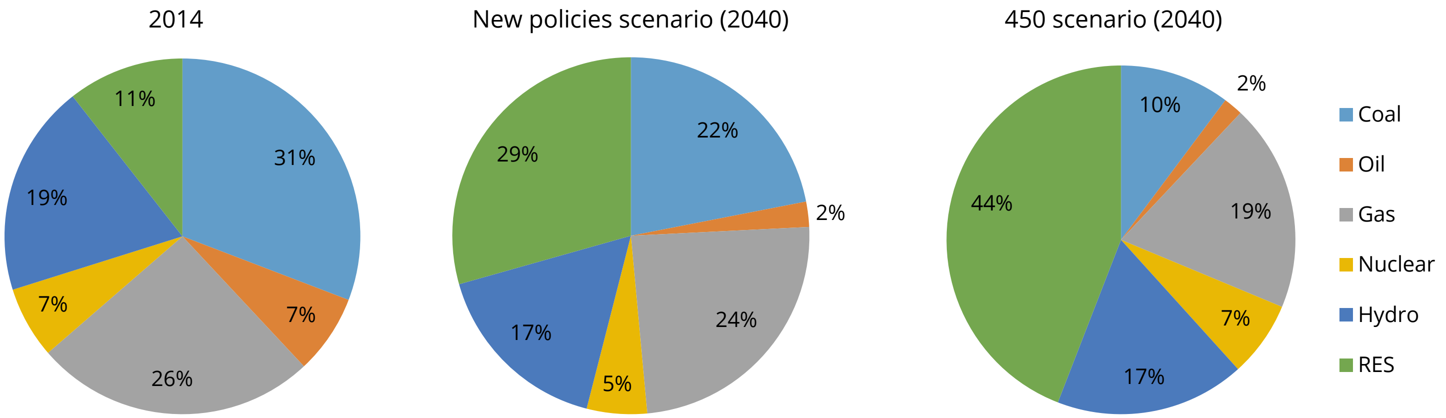
Although progress has been made in recent years, the transition towards a low-carbon future still remains a very challenging goal. In the New Policies Scenario –

1 BT – The role of ICT in reducing carbon emissions in the EU – May 2016.

2 Specifically, 11.168 GW in the New Policies Scenario; 11.766 GW in the 450 Scenario.

Fig. 1.2 Installed generation capacity – World

Source: I-Com elaboration on IEA data



which reflects the NDCs pledges – global energy-related CO_2 emissions continue to rise. In the 450 Scenario, energy-related CO_2 emissions could reach the peak before 2020 and drop to around 18.000 Mt by 2040, from roughly 32.381 Mt in 2014 (fig. 1.3). That transition requires huge efforts to be made across all the energy sector, going beyond the commitments of the NDCs and the results of the New Policies Scenario. Energy efficiency and renewables will be key elements making up more than one third of the emission reductions (6.200 Mt and 6.440 Mt respectively).

In the New Policies Scenario, by 2040, CO2 emissions from all sectors will be at least at the same level as 2014 (32.381 Mt vs. 36.240 Mt), even if the emission growth rate of most sectors will be lower than over the past decades (0.8% compared to 1.8%).

Fig. 1.3 Global emissions reduction in the New Policies Scenario and 450 Scenario

Source: I-Com elaboration on IEA data

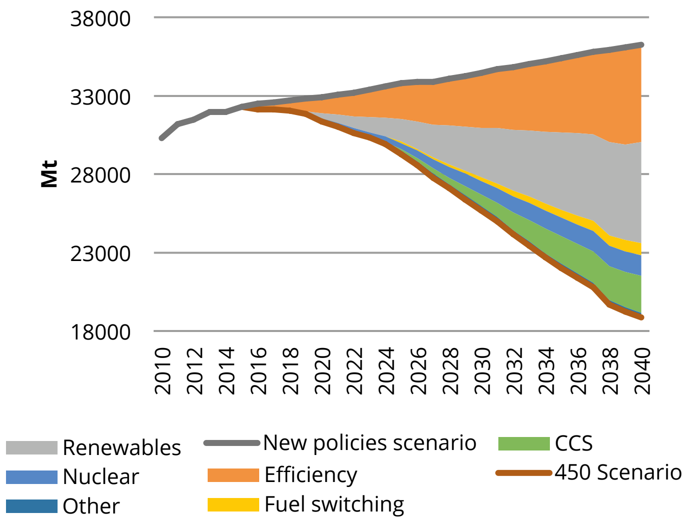
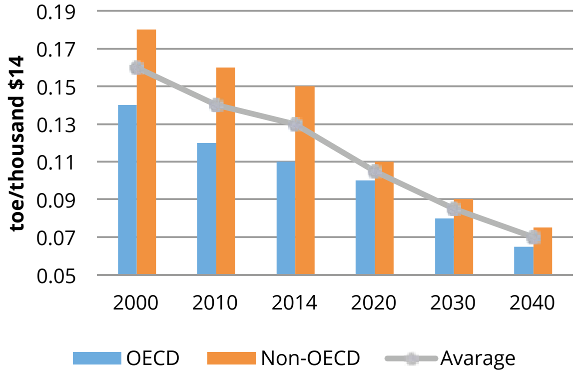


Fig. 1.4 Energy intensity of GDP (New Policies Scenario) – World

Source: I-Com elaboration on IEA data



According to the New Policies Scenario, energy intensity will decline by 46% between 2014 and 2040 (fig. 1.4). Despite the non-OECD countries' energy intensity remaining higher than others, both OECD and non-OECD countries will more than halve their energy intensity from 2000 to 2040 (-53% and -59% respectively) reaching an average of 0.07. Following a more climate-friendly scenario, the average energy intensity should decline to 0.06 by 2040.

1.3. EUROPEAN REGULATORY FRAMEWORK

In order to achieve the goal of a single internal energy market, policies should help, on the one hand, to remove or reduce frictions on cross-border trade in the Union, and on the other hand, to harmonize the governance and regulation of energy among the different member states. Following three Energy Packages from the mid-1990s to 2009, in February 2015, the European Commission established a framework for the creation of a new energy policy, the European Energy Union[3]. The goal of the Energy Union is "to give EU consumers — households and businesses — secure, sustainable, competitive and affordable energy". In order to achieve these goals, five interrelated dimensions were set out: energy security, solidarity and trust; a fully integrated European energy market; energy efficiency contributing to moderation of demand; decarbonizing the economy; and research, innovation and competitiveness.

Within this context, to speed up the clean energy transition and boost growth and job creation in the EU, in November 2016, the European Commission published "Clean Energy for All Europeans[4]", also known as the "Winter Package". Going beyond the 2020 horizon, the document is a legislative proposal, which covers energy efficiency, renewable energy, electricity market design, security of electricity supply, and governance rules for the Energy Union. In addition, the Commission proposed a new way forward for eco-design as well as a strategy for connected and automated mobility. The package also includes actions to boost clean energy innovation and to modernize buildings in the Union. It provides measures to encourage public and private investments, promote EU industrial competitiveness and mitigate the societal impact of the clean energy transition.

3 Communication (COM(2015) 0080), "A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy".
4 Communication (COM(2016) 0860), "Clean Energy for all Europeans".

In October 2014, with the purpose to lead the clean energy transition, the EU set the 2030 goals. EU member states have agreed to cut emissions in the EU by a least 40% below 1990 levels by 2030, increase the share of renewables to at least 27% of energy consumption by 2030, and increase energy efficiency to at least 27% by 2030. The Winter Package goes beyond energy efficiency and proposes a binding EU target of at least 30% by 2030, based on earlier conclusions of the European Council. Indications for long term emission reduction targets are set to -80% by 2050 compared to the 1990 values.

Putting energy efficiency first, achieving global leadership in renewable energies and providing a fair deal for consumers are the three main goals of the Winter Package. The European Commission focused on these objectives to turn energy transition from a challenge into an economic and environmental opportunity. Indeed, the transformation of global energy markets is unavoidably ongoing. Consistent with the International Energy Agency, renewable energy surpassed coal as the main power capacity source in 2015 and by 2030, half of the EU's electricity generation will come from renewable sources.

The Renewable Energy Directive and the proposals on the New Electricity Market Design will set a regulatory framework to ensure investor certainty and allow a level playing field for all technologies according to climate and energy targets.

In order to better integrate the growing share of renewables, wholesale markets should provide adequate rules that allow shorter trading terms and reflect the variable generation features. Renewables producers will be able to earn revenues from the market, including ancillary markets. Moreover, by introducing trading closer to delivery time, electricity markets will also reward flexibility for generation, demand or storage. Thus, renewable energy will be increasingly market-based, because the new rules will allow renewable electricity generators to earn increasing shares of their revenues from the market.

The global clean energy transition started a long time ago and the European Union wants to lead it by setting and achieving ambitious climate and energy targets whilst maintaining a competitive economy in the Union.

According to the Commission vision, the most efficient energy is that which is not consumed at all, as it results in less energy use. Thus, energy efficiency should be considered as a source of energy. Indeed, challenging energy efficiency goals can reduce a state's dependence on energy imports, boost its economy, improve competitiveness and create additional green jobs.

In relation to a long-term perspective and a vision towards de-carbonization, building renovation will lead to the transformation of the EU building stock – increasing the rate and level at which buildings are renovated – while generating growth and jobs.

Thanks to eco-design measures, only energy efficient appliances can now be sold across the Union. The EU energy labelling system ensures that consumers can make informed choices when buying energy appliances. As reported by the EU Commission, consumers using only energy efficient products in their homes could save an average of €500 annually per household by 2020.

Finally, consumers are the main focus of the Energy

Union. Currently, but more and more in the future, consumers across the EU will be entitled to generate, store, share, consume or sell electricity back to the market. Households and businesses will become more involved in the energy system, better controlling their energy consumption and responding to price signals.

The Commission will accelerate the deployment of smart meters to promote the spread of dynamic electricity prices, essential to bridge the gap between consumers and the market. Operators could use data available to the market to offer tailor-made solutions, ensuring data privacy and security. Thereby, the better-regulated and non-discriminatory access to consumer data will advantage the consumers through increased competition among market actors.

As stated in the Winter Package, the clean energy transition will be the growth sector of the future. Indeed, according to the European Commission, clean energies in 2015 attracted global investment of over 300 billion euros. By mobilizing up to 177 billion euros of public and private investment per year from 2021, the package will be able to generate up to a 1% increase in GDP over the next decade and create 900,000 new jobs (EU Commission, 2016).

1.4. EUROPEAN STATE OF ART IN THE ENERGY SECTOR

In line with the 2020 strategy, the European Union has launched several initiatives to increase energy efficiency, reduce energy demand and decouple it from economic growth. Among different goals and targets set in the framework, the EU aims at cutting its energy consumption by 20% by 2020.

In 2015, Gross Inland Consumption was 1.626 Mtoe (Fig. 1.5). After a period of substantial stability from 2005 to 2008, Gross Inland Consumption declined by 5.8% in 2009, due to the global financial and economic crisis, that resulted in a lower level of economic activity. There were many (also relatively large) fluctuations from 2009 to 2014 but in 2015 the level of energy consumption in EU was almost the same as it had been in 1990 (1.626 Mtoe vs. 1.667 Mtoe respectively). 2050 projections predict a further decrease in Gross Inland Consumption, achieving 1.491 Mtoe (8.3% less than 2015).

As is known, many factors influence the Gross Inland Consumption of every EU member state. These include the structure of the internal energy system, the availability of natural resources for primary energy production and state of the economy.

Fig. 1.5 Gross Inland Consumption in the EU28 (historical and projections)

Source: I-Com elaboration on Eurostat and Primes data

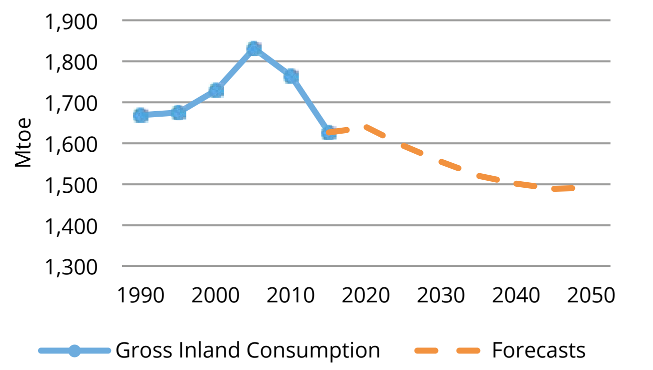
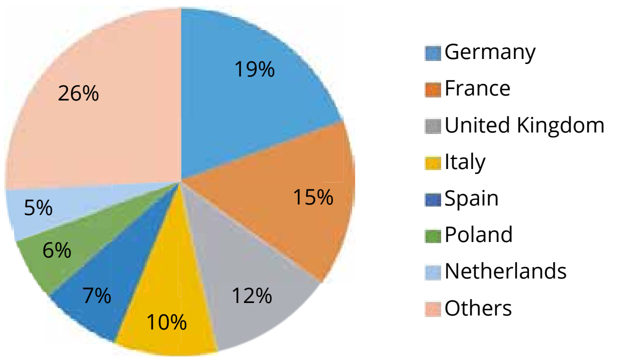


Fig. 1.6 Gross Inland Consumption – Member States (%, 2015)

Source: I-Com elaboration on Eurostat data

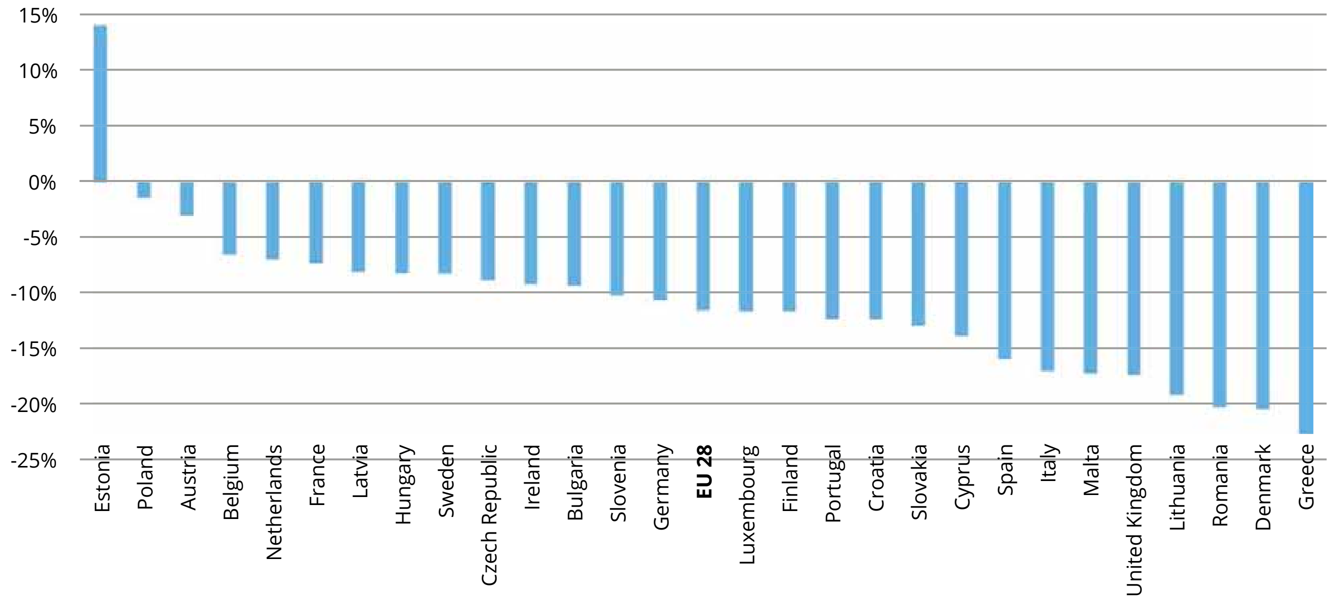


In 2015, Germany had the highest level of Gross Inland Consumption of energy, 19% of the total, followed by France (15%), the United Kingdom (12%) and Italy (10%). Together these four countries accounted for 56% of the EU-28's Gross Inland Consumption, more than double the "Others" rank, which accounts for 21 countries (fig. 1.6).

Analyzing the percentage change between 2006 (peak year) and 2015, Greece emerges as the best performer (perhaps due to the financial crisis), in terms of Gross Inland Consumption reduction, followed by Denmark, Romania (-20%). Italy registered a decrease of 17%, 5 p.p. above the EU average.

Fig. 1.7 Gross Inland Consumption [Δ (%), 2006-2015]

Source: I-Com elaboration on Eurostat data

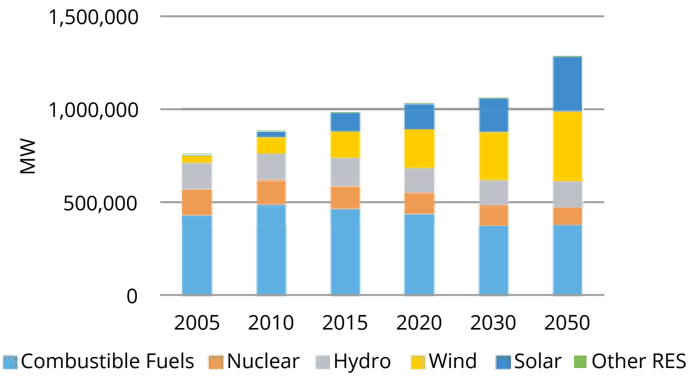


The EU28 installed electrical capacity is presented in Figure 1.8. It has increased by 7.1% in ten years from 758.023 MW to 981.870 MW. In this period, the structure has gradually changed. The share of combustible fuels and nuclear, as a whole, was 75% of the total of installed capacity in 2005 and dropped to 60% in 2015, in favor of renewable sources (especially wind and solar), which generally accounted for 24% in 2015 (vs. 5% in 2005). Looking at the future, in 2050, the share of combustible fuels and nuclear will continue to decline to 37%, while RES will increase to 52%.

As mentioned above, according to the renewable energy directive, the EU must reach a set target of 20% of final energy consumption from renewable sources by 2020. Member states have committed to reaching their own national renewable targets, ranging from 10% in Malta to 49% in Sweden, 17% in Italy (Fig. 1.9). They are also each required to have at least 10% of their transport fuels come from renewable sources by 2020.

Fig. 1.8 EU28 installed capacity

I-Com elaboration on Eurostat and Primes data



Almost half of the member states have already reached this goal (Sweden, Finland, Denmark, Croatia, Estonia, Lithuania, Romania, Slovenia, Bulgaria, Italia, the Czech Republic, Hungary) and many others are very close to this objective (Austria, Portugal, Slovenia, Slovakia, Greece). The worst performers in 2015 were the Netherlands, which is 8.2 p.p. from the target, followed by France 7.2 p.p. and the United Kingdom and Ireland (6.8 p.p.).

2050 projections foresee a further increase in RES penetration in all member states. The northern countries will continue to be the best performers. The Swedish RES penetration rate in 2050 is estimated to be 62%, followed by Finland at 51% and Latvia 46%. At 34%, Italy will be above the EU average (31%). Malta, Luxemburg and Netherlands are expected to have the lowest percentage of RES in gross final consumption (18%, 9% and 21%, respectively).

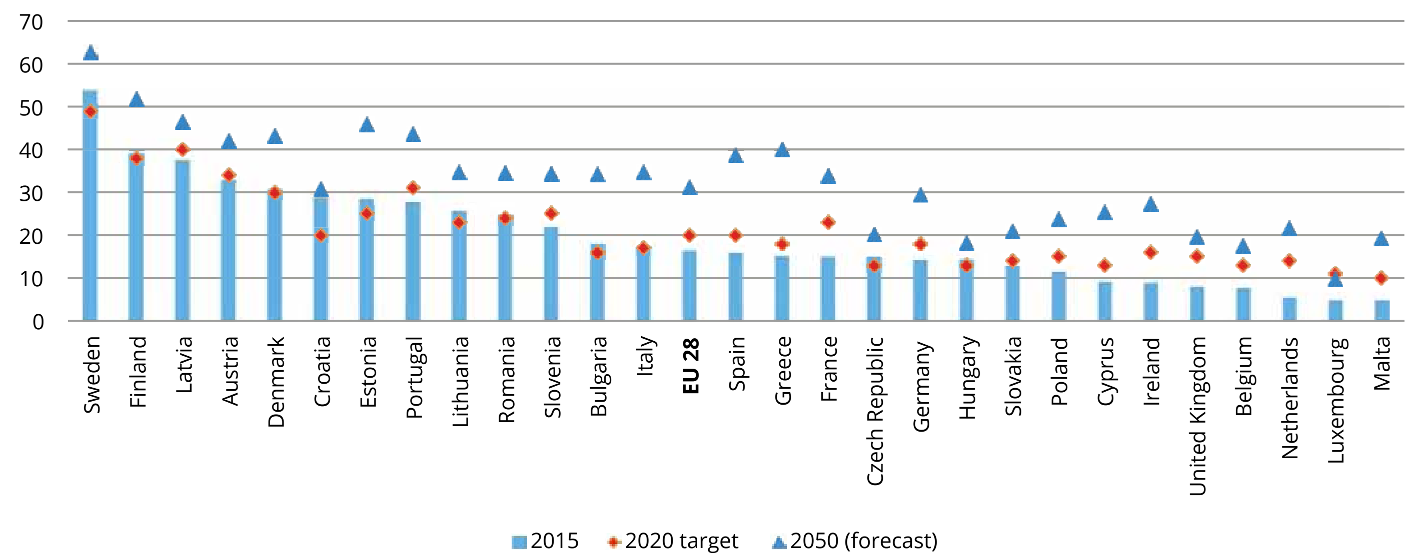
The use of renewable energy boosts the reduction of greenhouse gas emissions, diversification of energy supplies and reduces fossil fuel dependence. The development of renewable energy sources may also promote employment in the EU, through the creation of jobs in new green technologies.

Hence, renewables will continue to play a key role in supporting the EU to meet its energy needs beyond 2020. Therefore, in order to make the EU a global leader in renewable energy and ensure that the 2030 target will be achieved, in November 2016, the European Commission published the proposals for a revised renewable energy directive.

Greenhouse gas emissions in the EU28 dropped to 4.450 million tones of CO_2 in 2015, declining by 22% compared

Fig. 1.9 RES in Gross Final Energy Consumption (%)

I-Com elaboration on Eurostat and Primes data



to 1990 levels (Fig. 1.10 – 1.11). The EU exceeded its 2020 target, which is to reduce GHG emissions by 20% by 2020. An additional reduction is envisaged in 2050 (32% less than 2015). Although the projections estimate a further decrease in GHG emissions, the target indicated in the Energy Roadmap 2050 (to cut GHG emissions to 80% below 1990 levels) is very challenging and unreachable under current conditions[5]. More effort needs to be made. Indeed, according to Primes projections in 2050, GHG emissions will be 47% less than 1990.

The EU member state with the highest emission level in 2015 was Germany (926 million tonnes of CO_2 eq.) with roughly 21% of total EU28 GHG emissions. The UK and France follow with 534 million tonnes of CO_2 eq. (12%) and 475 million tonnes of CO_2 eq. (11%) respectively. Lithuania, Latvia and Estonia accounted for the biggest decrease compared to 1990 (–58%, –56% and –55%). However, Cyprus Spain and Portugal reported the biggest increases (+44%, +19% and+18%).

The overall EU GHG goal was split in two targets for ETS (emissions trading system) and Non-ETS sectors. The

5 The Reference Scenario evaluates policies and measures adopted at EU level and in the member states by December 2014. In addition, amendments to three Directives only agreed at the beginning of 2015 were also considered. This concerns the ILUC amendment to the RES and FQD Directives and the Market Stability Reserve Decision amending the ETS Directive.

Fig. 1.10 GHG (historical and projections)

Source: I-Com elaboration on Eurostat and Primes data

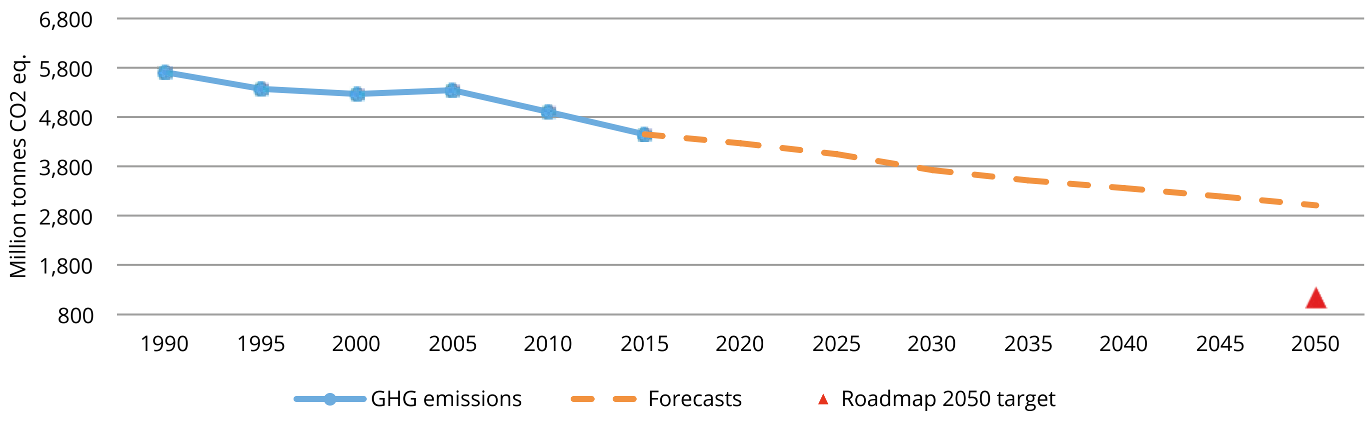
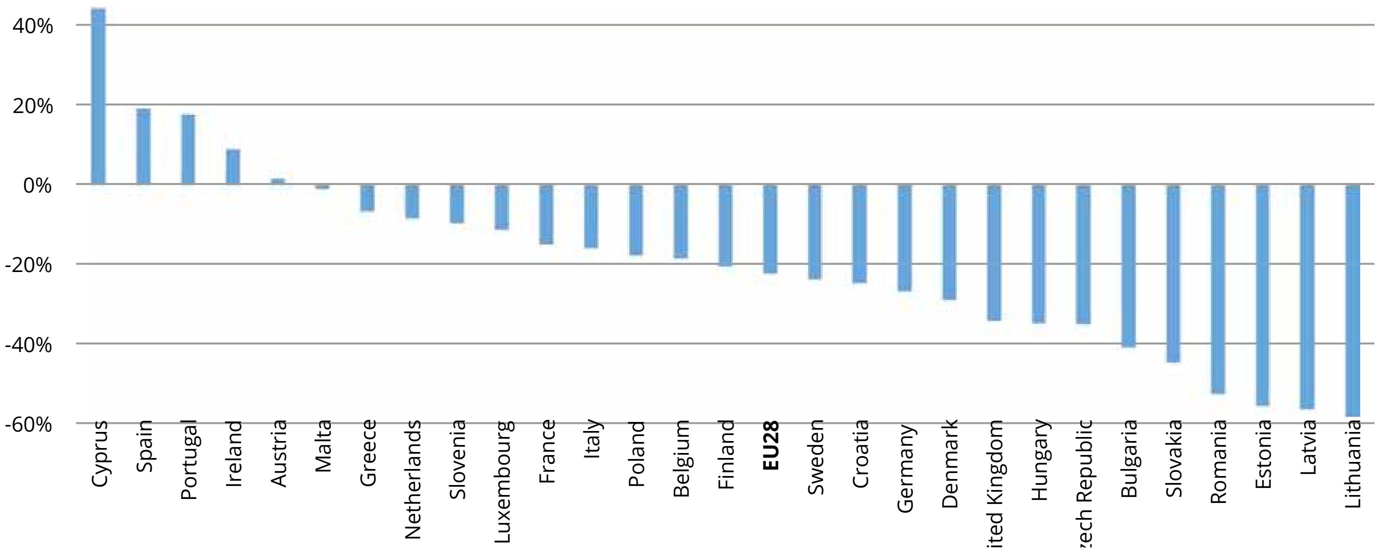


Fig. 1.11 Percentage change GHG (1990 – 2015, EU28)

Source: I-Com elaboration on EEA data



ETS is a key tool for reducing greenhouse gas emissions cost-effectively, by placing a limit – which is reduced each year – on overall emissions. Within this limit, companies can buy and sell emission allowances as needed. This "cap-and-trade" approach gives companies the flexibility they need to cut their emissions.

According to 2020 goal, emissions from sectors covered by ETS will be 21% lower than in 2005, and 43% lower in 2030.

The Effort Sharing Decision establishes targets for emissions from most sectors not included in the EU ETS such as transport, building, agriculture and waste. By 2020, the EU will collectively deliver a reduction of around 10% in total EU emissions from the sectors covered, compared to 2005 levels.

When the binding target of at least – 40% (compared to 1990) by 2030 was set in October 2014, EU leaders specified that Non-ETS sectors must reduce emissions by 30% (compared to 2005).

According to the projections, the EU could exceed the 2020 targets, but the 2030 target, especially for Non-ETS sectors (Fig. 1.12) is more uncertain. Even though 2050 goals have not been set, it is possible to assume that emissions from ETS sectors will continue to decrease, while for Non-ETS sectors the same assumptions cannot be made.

Fig. 1.12 GHG emission – ETS vs. Non-ETS

I-Com elaboration on Primes data

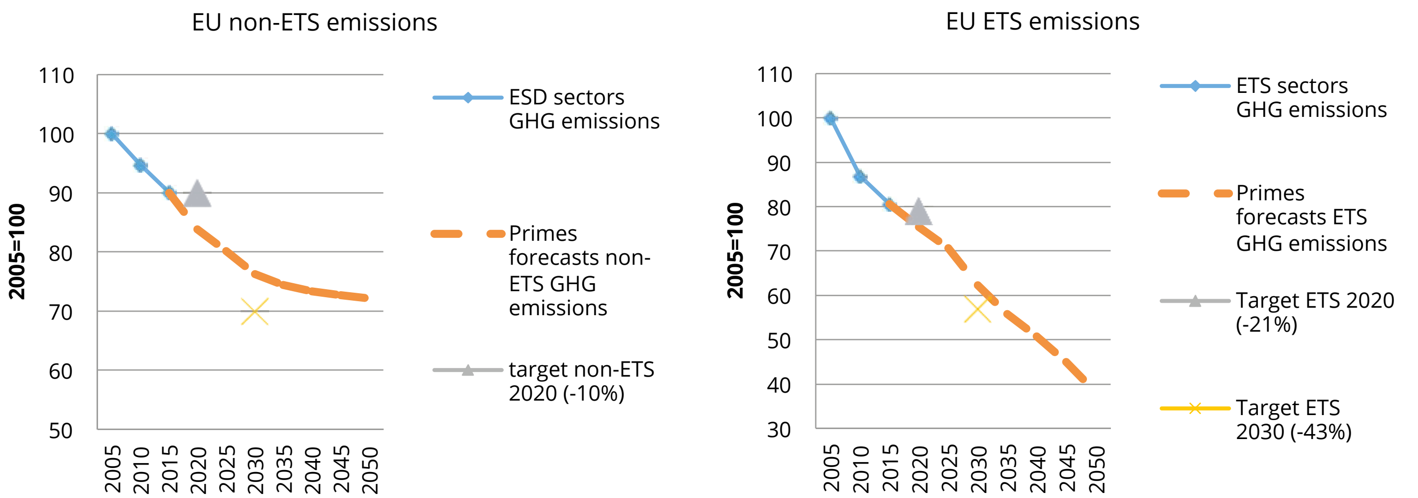


Fig. 1.13 Energy Intensity in the EU28

Source: I-Com elaboration on Eurostat data

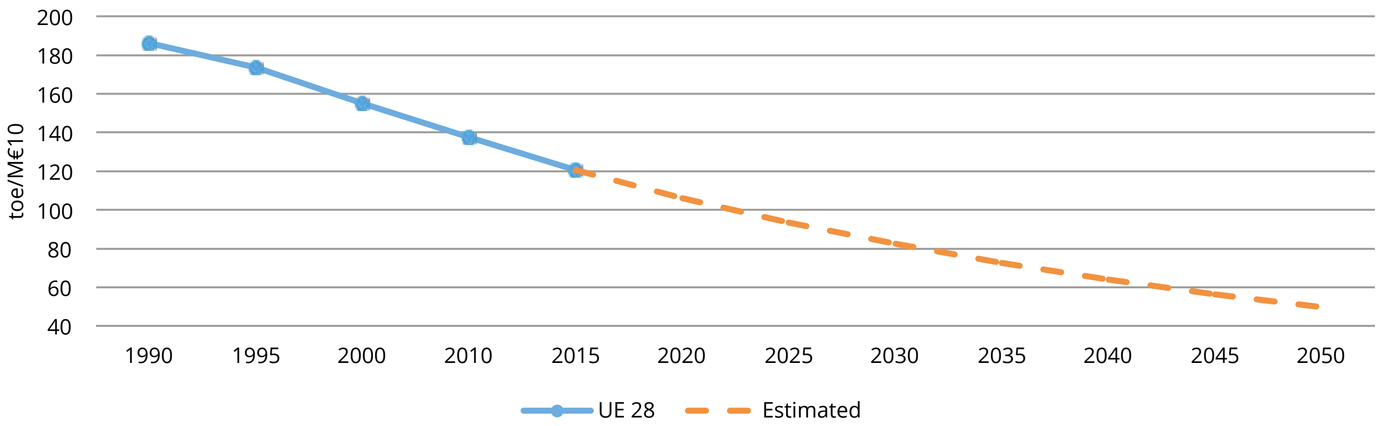
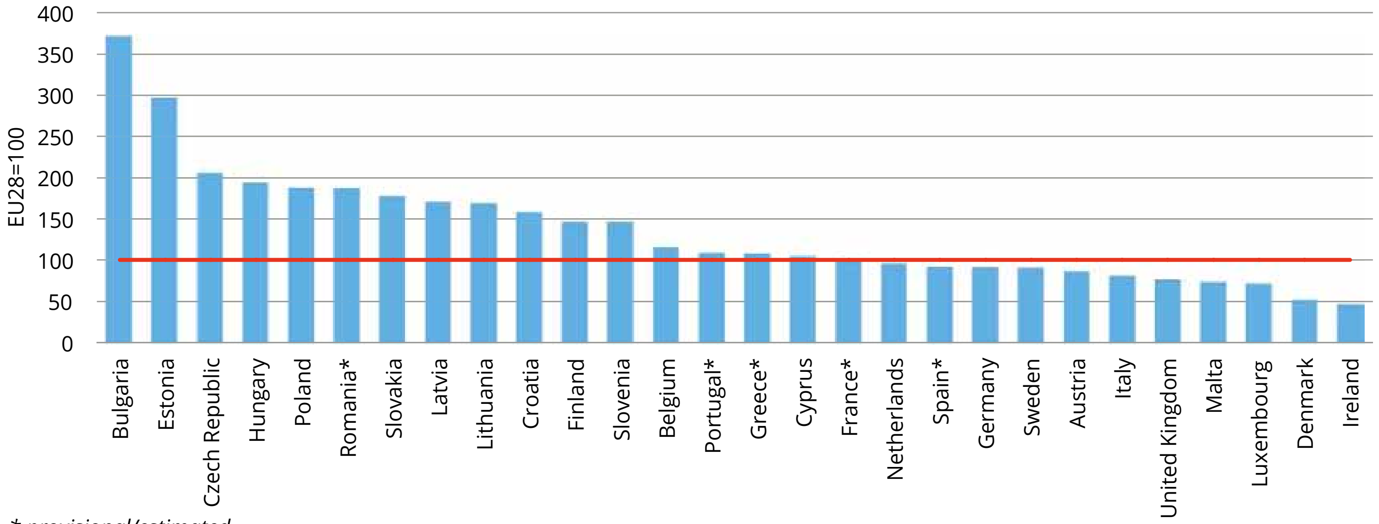


Fig. 1.14 Energy Intensity (2015)

Source: I-Com elaboration on Eurostat data



** provisional/estimated*

Energy intensity measures the energy efficiency of the economy. Between 2005 and 2015, EU energy intensity went down by 19%. All member states improved their energy savings and the energy intensity of each economy decreased. In 2015, Malta recorded the biggest reductions in energy intensity (-44%), followed by Slovakia (-39.4%), Romania (-36,5%), Luxembourg (-33,9%) and Ireland (-33,7%), where the amount of energy required to produce a unit of economic output fell by at least one third in ten years. Only three countries recorded an energy intensity reduction below 10% – Finland (-7,8%), Estonia (-4,3%) and Greece (-3,1%).

Assuming the same compound annual growth rate over the last three years (2.5%), I-Com estimates that by 2050 energy intensity will have declined by roughly 59% compared tothe 2015 level, reaching 49.8 toe/M€$_{10}$.

In 2015, the European least energy-intensive economies[6] were Ireland, Denmark, Luxembourg, Malta and the United Kingdom (Fig.1.14). On the other hand, the most energy-intensive EU member states were Bulgaria and Estonia. Obviously, the structure of the economy influences the energy intensity, in fact, service-based economies have relatively low energy intensities, while economies with heavy industries (such as iron and steel production) may have a considerable proportion of their economic activity in industrial sectors, thus leading to higher energy intensity.

6 They used the lowest amount of energy relative to their overall economic size (based on GDP).

PART 2

THE POTENTIAL ROLE OF ICT IN THE ENERGY SECTOR

2. THE POTENTIAL ROLE OF ICT IN THE ENERGY SECTOR

2.1. INTELLIGENT INFRASTRUCTURES

Efficient infrastructures are a key element of modern societies and ensure the delivery of the everyday-life flow of goods and services that underlie human progress and welfare. Examples of infrastructure sectors range from transportation to communication, from water to energy supply. Infrastructures attract a remarkable amount of investments worldwide. Figure 2.1 shows data and projections on infrastructure global investments, presenting a business-as-usual and a best-case scenario ("investment need scenario" and based on the investment that would occur if countries were to match the performance of their best performing peers).

Infrastructure investments totaled 2,3 trillion US$ in 2015. The investment share for the main sectors is shown in Fig. 2.2. Energy has been the most attractive sector (more than 800 billion US$), followed by road transport and telecommunications, with 670 and 300 billion US$, respectively.

It is interesting to look at the composition of projected infrastructure investments by sector and by country in detail. Fig. 2.3 shows the leading role of the electricity sector in infrastructure investments. For what concerns

Fig. 2.1 Infrastructure investments: data and projections [trillion US $]

Source: I-Com elaboration on Global Infrastructure Outlook (2017) data

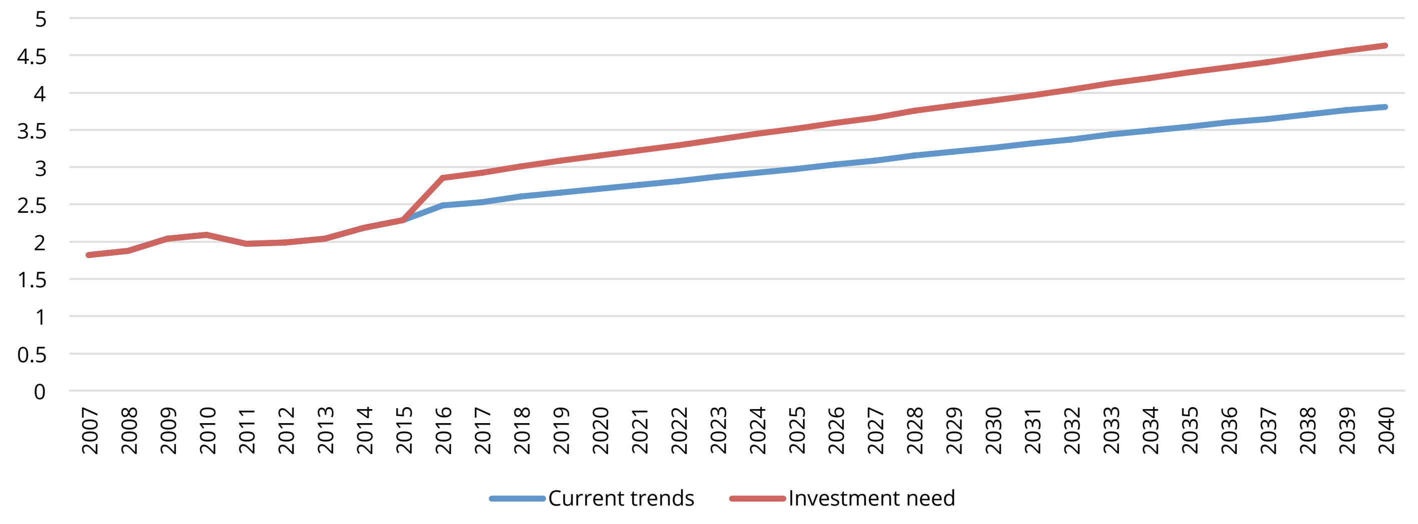
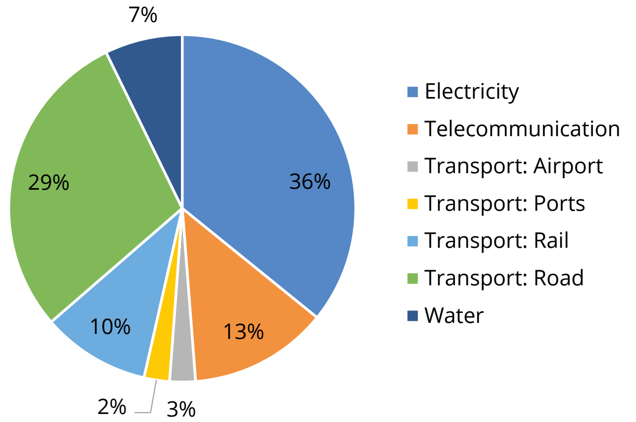


Fig. 2.2 Infrastructure investment share by sector (2015; total=2,3 trillion US$)

Source: I-Com elaboration on Global Infrastructure Outlook (2017) data



the regional distribution of investments, Africa and Asia are expected to have a higher share of investments in GDP as a consequence of the existing infrastructure gap compared to the more developed countries.

Finally, if we look at the composition of investments in infrastructures in Europe, the situation depicted in Fig. 2.4 shows that France, the UK and Italy are expected to invest more in absolute terms. Regarding the analysis by sector, it is interesting to highlight that the relative weight of the electricity sector is around 27%, with a peak at 34% for France and the lowest value for the UK at 18%. With 15 billion US$/year, Italy ranks second after France if considering the absolute investment volume in the power sector.

Fig. 2.3 Average 2016-2040 investment trends (as % of GDP)

Source: I-Com elaboration on Global Infrastructure Outlook (2017) data
Note: Europe includes France, UK, Germany, Italy, Spain, Poland, Croatia, Romania, Russia

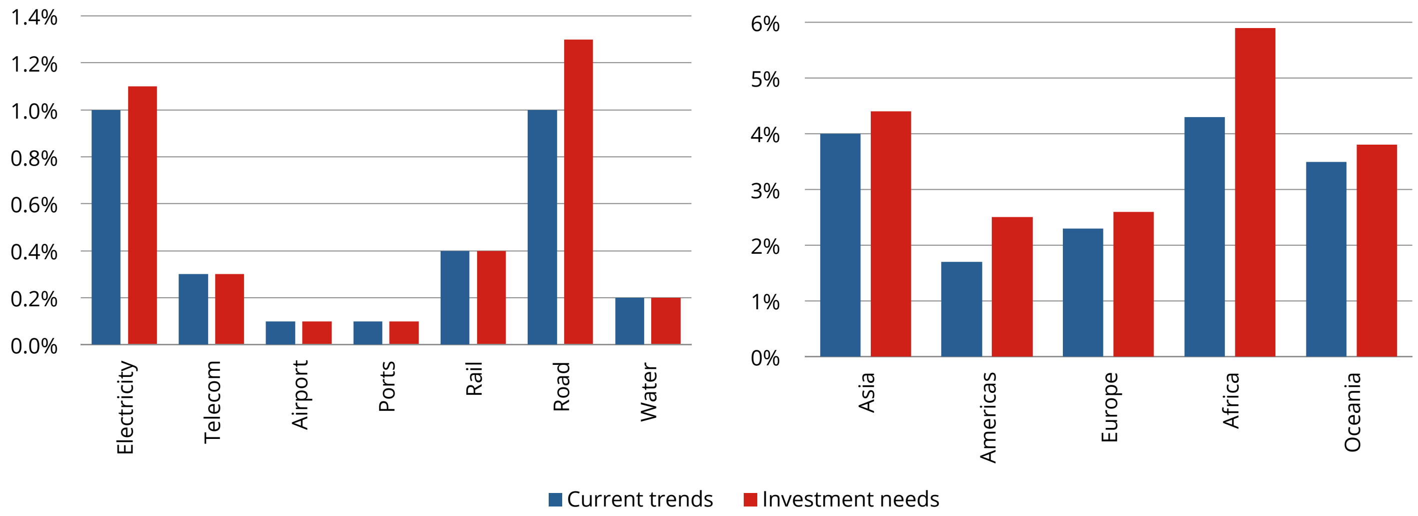


Fig. 2.4 Average 2016-2040 investment trends (billion US$; investment need scenario)

Source: I-Com elaboration on Global Infrastructure Outlook (2017) data (figures on investments in electricity are reported)

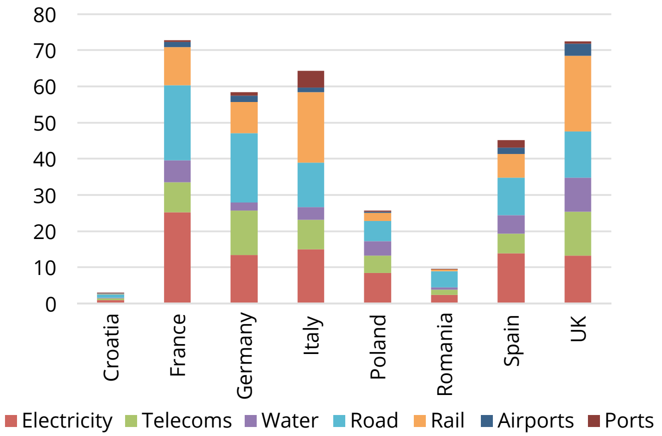
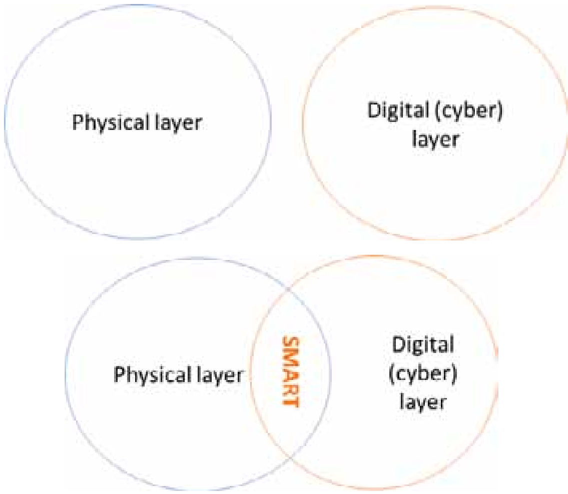


Fig. 2.5 Schematic representation of a "dumb" (above) and an intelligent infrastructure (below)



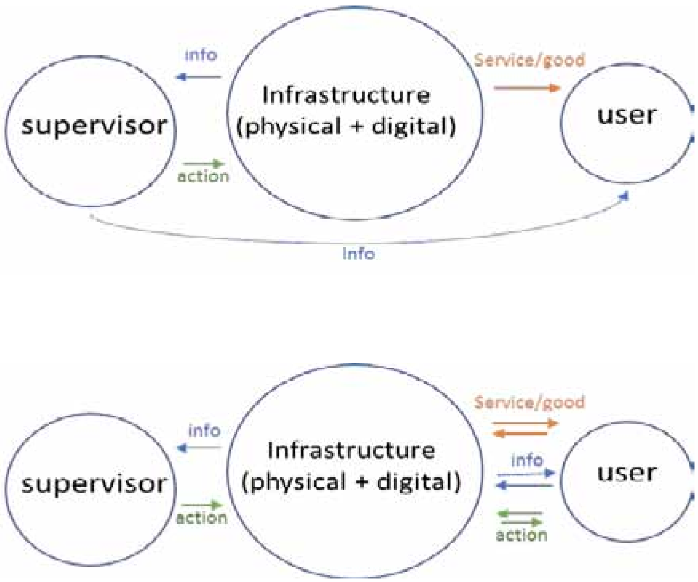
Infrastructures are typically made up of physical elements (e.g. wires, streets, bridges, pipes.) and a control system (sensors, data acquisition, elaboration and transmission of information). The physical layer enables the flow of goods and services to end-users, the control system is responsible for the proper management (e.g. efficient and safe) of the infrastructure itself. With the advent of the digital era, the cyber-layer of infrastructures is booming, and many different ICT applications are emerging as enabling factors to run modern and efficient networks. The term "intelligent" or "smart" related to infrastructures is becoming more and more common.

We can define an intelligent infrastructure, as opposed to a dumb infrastructure, as a system that is able to collect information on the state of the infrastructure, elaborate data and interact with customers/service providers. In this view, a dumb infrastructure is unable to communicate, adapt to external conditions and connect to other networks (see Fig. 2.5).

The more the cyber-layer is integrated with the physical layer, the more the infrastructure is expected to be responsive.

The physical and cyber layer can be so interwoven that the term "smart" is now becoming more and more common when referring to certain applications. We can try to establish a difference between intelligent and smart infrastructures. An intelligent infrastructure collects and processes data into real-time actionable information, which is then used by it or a human operator (service provider/customer) in making optimal decisions. The fundamental concept of real time adaptation to external or changing conditions is then introduced. A smart infrastructure is a further expansion of this concept. We can define "smart" as an infrastructure capable of collecting and processing data, taking autonomous and appropriate actions that are dynamic and adaptive to changing conditions. The interaction with consumers is real-time and ubiquitous. Ideally, in a smart infrastructure, as depicted in Fig. 2.6, there is a continuous bi-directional flow of information, goods/services and actions between the consumer and the infrastructure itself. This represents a deep change of paradigm in the infrastructure sector compared to the past.

Fig. 2.6 Schematic representation of an "intelligent" (above) vs. smart infrastructure (below)



2.2. ICT AND POWER INFRASTRUCTURES

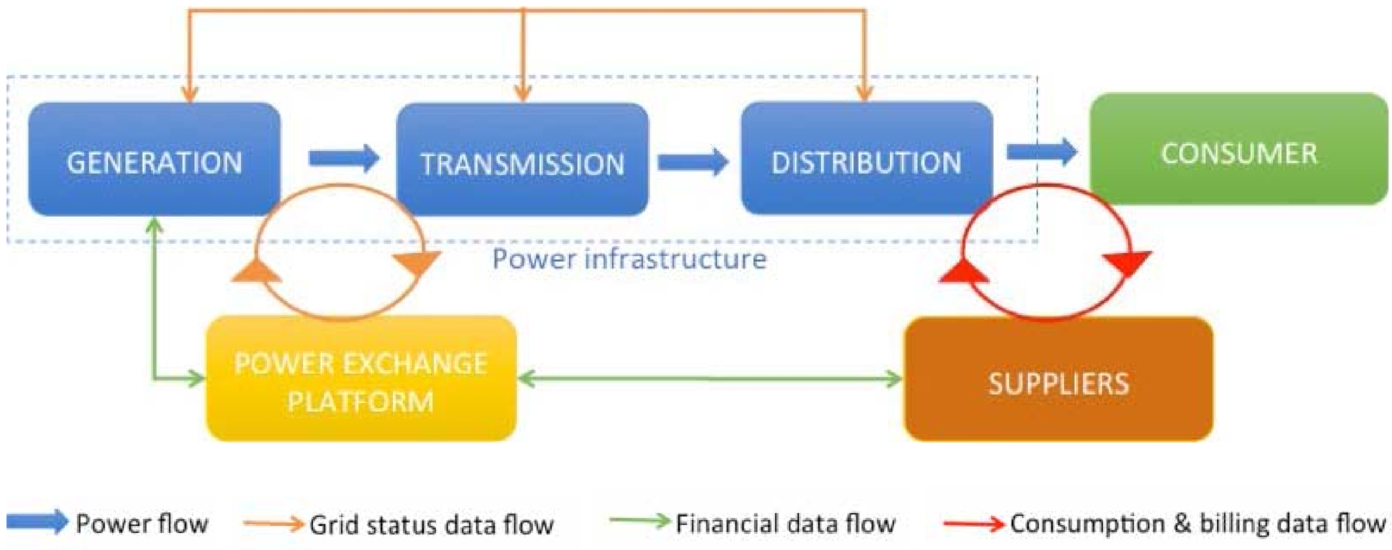
It is not surprising that power infrastructures are fully involved in the digital revolution described in the previous paragraph. In Chapter 1, we highlighted some of the major challenges that the energy sector must tackle to guarantee a universal fair access to sustainable energy and to de-carbonize energy systems. In order to achieve these goals, energy saving, energy efficiency and renewable energy technologies are the cornerstones of the new model. ICT technologies can increase the level of integration of renewable energy in the energy mix, improving the management performance of transmission and distribution grids. For developing countries, it can contribute to a bottom-up growth of power infrastructures, with micro-grids progressively developed and integrated and with a massive use of local renewable energies and storage. In developed countries, where energy infrastructures are well established, it can help in the transition of infrastructure as well as energy markets towards a more sustainable, safe and competitive structure. We have already mentioned the possibility to integrate renewable energy generation and storage in a more efficient and effective way. It can also contribute to fully deploying the saving potential of efficient technologies, by optimizing their use and integrating different technologies. ICT is expected to contribute to changing the way we use energy, helping consumers to make optimal choices and change consumption behavior. Digital technologies are also expected to play a major role in the e-mobility revolution.

In general terms, we can say that digital technologies will improve the flexibility of power infrastructures, thus introducing the possibility of new technological applications, change in the relations among existing market actors, and the introduction of new market opportunities and agents.

Up to a few decades ago, the power system was made up of a fully predictable generation capacity that had to meet a fully random power demand. The power infrastructure had to meet the final energy demand and ensure grid stability, however, the system had a high degree of rigidity. A schematic block representation of the power system is reported in Fig. 2.7.

The main features of this picture are a clear distinction in the different roles of the actors, a unidirectional flow of energy and scarce information exchange between the energy infrastructure and consumers. The system displays clear inefficiencies. First of all, the infrastructure is somehow over-sized in terms of generation and transmission capacity in order to reach peak demand and grid stability. The progressive growth of electricity demand started to pose economic and financial issues on the feasibility of such a model. At the same time, non-hydro renewable technologies started to be widely installed both on a utility scale and distribution level. Distributed generation opened the possibility for consumers to be an active element of the system, allowing them to become "prosumers" (producers and

Fig. 2.7 Representation of the traditional relations among power market actors



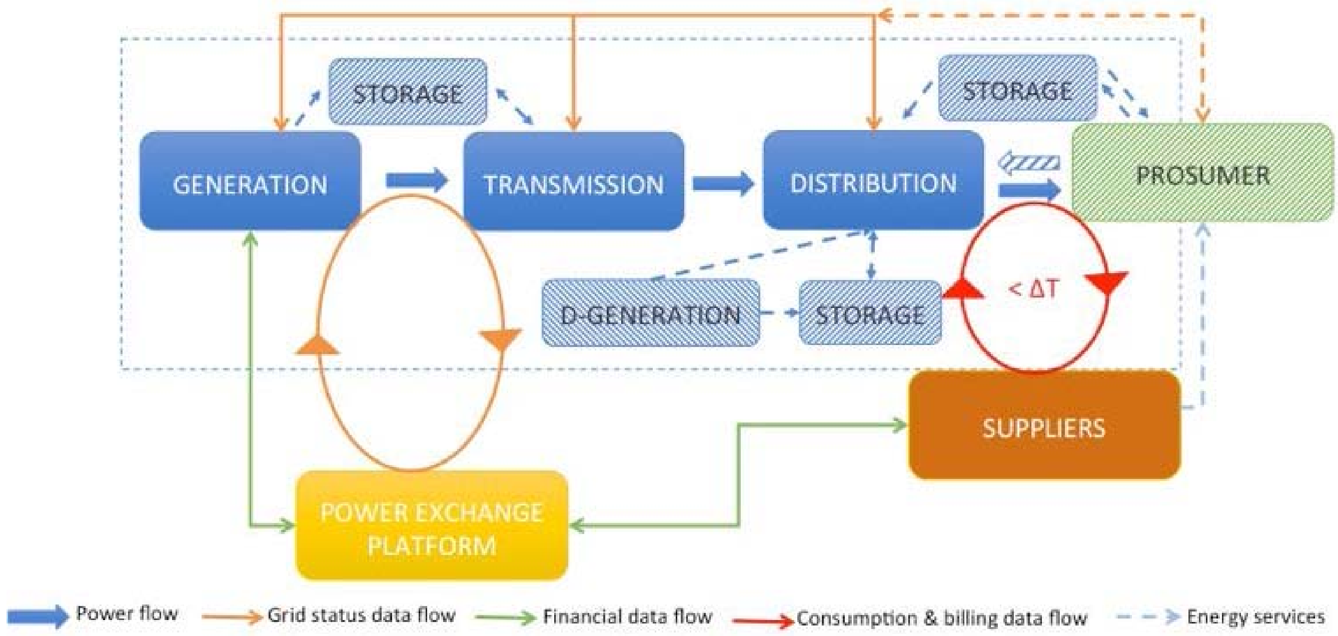
consumers at the same time). Finally, the evolution of the market structure now requires a deep change in the relations between suppliers and consumers.

A schematic overview of the new smart grid paradigm is depicted in Fig. 2.8.

Distributed generation, possibly associated with storage, allows distribution grids to become an active element of the system. Storage improves the flexibility of the infrastructure and allows more variable renewable energy resources to be connected to the grid. The information flows from consumers to DSO allows for a more efficient grid management and raises the possibility for effective demand side management. At the same time, improved communication from suppliers to consumers allows for more precise billing and for creating innovative energy services, including energy saving. Finally, due to the active nature of distribution grids, TSO/DSO information exchange and cooperation becomes even more important.

It is clear that a lot of the innovation presented in the new power paradigm is strongly related to ICT technologies. As detailed in the following part of the present study, the roll-out of sensors and actuators at different levels, the possibility to exchange information between the

Fig. 2.8 Representation of innovative relationsamong power market actors

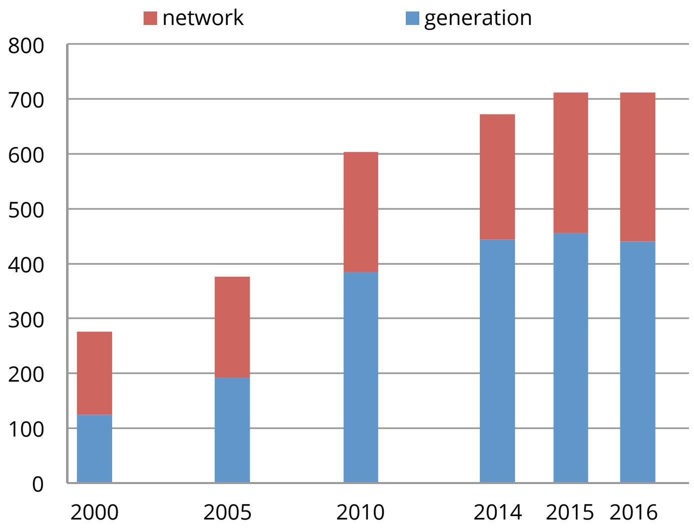


different segments and actors of the energy system and the ability to analyze and store the information are all key elements in this new picture.

As briefly described in the previous paragraph, the power sector attracts important flows of investments at global level, as shown in Fig. 2.9. Investments have grown substantially in the last decade and have become more polarized towards generation rather than the grid. In 2016 global energy investments totaled 700 billion US$ (40% in networks). According to IEA scenarios, investments in the power sector are expected to increase, reaching 1.7 trillion US$ in 2050 in order to reduce the carbon footprint of the power sector (the so-called beyond 2°C scenario).

Fig. 2.9 Global power sector investments [billion US$]

Source: I-Com elaboration on IEA (2017)



Digital energy investments are becoming a reality for the sector. Fig. 2.10 shows the composition of grid investments in the last three years – 11% of the total 2016 grid investments (280 billion $) are in digital infrastructures and show an increase (+50%) compared to 2015.

Fig. 2.10 Spending on electricity networks [billion US$]

Source: I-Com elaboration on IEA (2017)

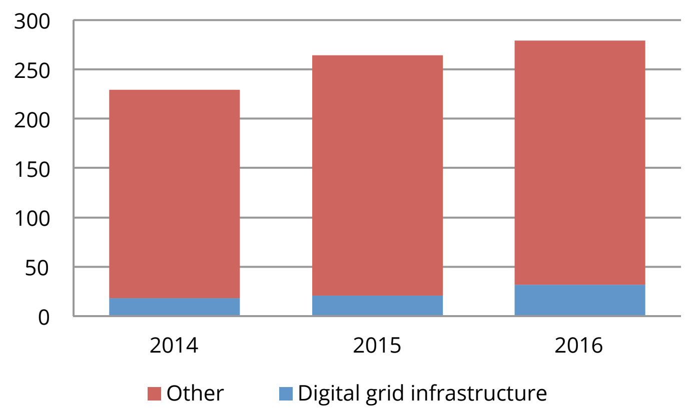
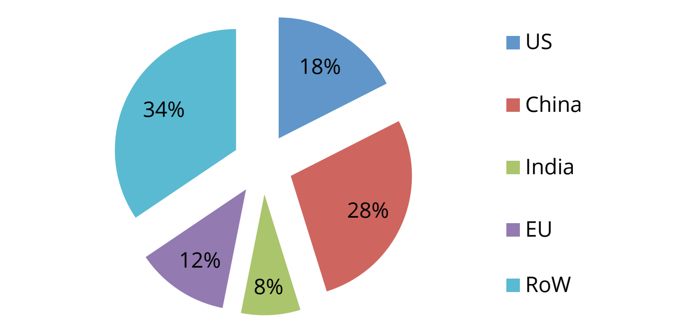


Fig. 2.11 Share of investments in networks by region (2016)

Source: I-Com elaboration on IEA (2017)



Unfortunately, a geographical distribution of digital investments is not available, but the overall composition of global power grid investments is reported in Fig. 2.11. Europe is seen to be lagging behind China and US.

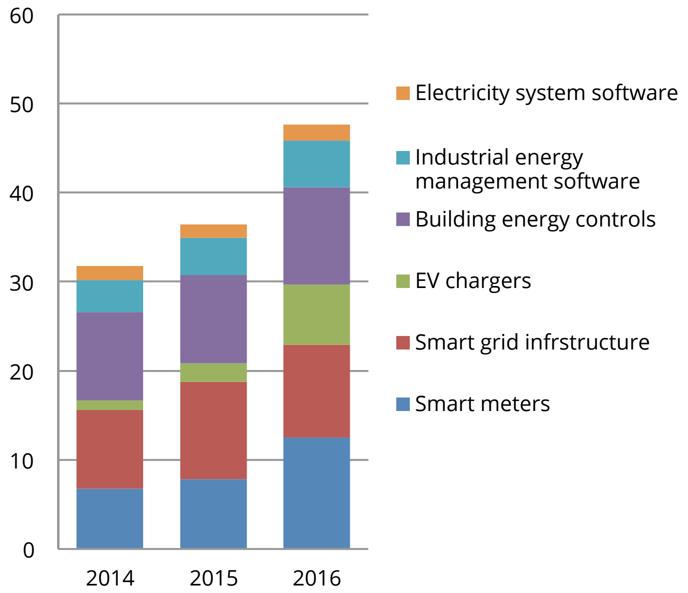
Fig. 2.12 shows in more detail the composition of digital investments in the energy sector.

They include approx. 30 billion US$ for grid infrastructures, with smart meters (approx. a quarter of the total investments) and electric vehicles that have increased remarkably in the last two years. The remainder is divided between building controls and software for industrial applications.

Improving the penetration of ICT technologies in the power sector can help in managing the complex electricity infrastructures and more efficiently reshape the power market structure. To give a rough idea of the complexity of the system, it is interesting to give some numbers on the European power infrastructure. At transmission level 41 TSOs in 34 Countries (EU members plus neighboring countries with transboundary interconnections) cooperate to create a synchronous system. The extension of the transmission grid is around 300,000 km, with 394 AC and 29 DC cross frontier interconnections[7]. The EU transmission grid is connected to the distribution grid through 10,713 DSO/TSO interconnection points (primary substations). The distribution grid extends for about 10,000,000 km with 4,000,000 medium and low voltage transformers (secondary substations) and around 260,000,000 power meters. There are 1,857 European DSOs (198 with more than 100,000 consumers)[8]. Final energy users can count on approximately 220,000,000 households (2016) and 26,000,000 active enterprises (2014 – no data from Greece)[9]. The EU generation capacity totaled 982 GW in 2015. The penetration of distributed generation makes it very difficult to find figures on the generation units. However, to give an idea, Italy, with 114 GW of installed capacity in 2016, has 6,361 thermoelectric generation units and 742,340 renewable energy units[10].

Fig. 2.12 World investments in digital infrastructure for the electricity sector [billion US$]

Source: I-Com elaboration on IEA (2017)



7 ENTSO-E Statical Facsheet (2016).
8 Eurelectric, Power Distribution in Europe. Facts & Figurea (2016).
9 Eurostat (2017).
10 Terna Statistics.

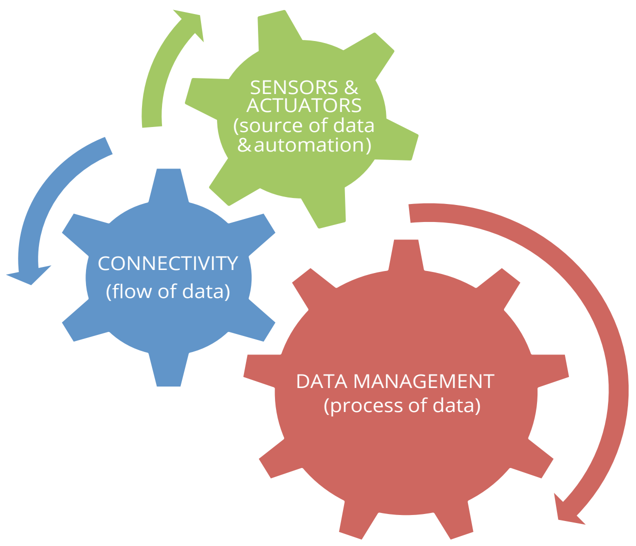
2.3. THE BUILDING BLOCKS OF THE DIGITAL POWER INFRASTRUCTURE

As already stated in the introduction, the role of ICT applications for infrastructures is fundamental in order to improve the overall management efficiency and effectiveness. It becomes strategic when dealing with complex and strategic infrastructures as the power grid. The main building blocks of the cyber layer of power infrastructures are seen in Fig. 2.13

2.3.1. Sensors and actuators

A smart infrastructure must be able to detect information on the status of the different components and, in more sophisticated applications, on surrounding

Fig. 2.13 Key ICT technologies for digital energy



parameters that can influence its functioning and on users' behavior/status. Furthermore, in order to react to changing conditions, it must be able put into place the right actions, autonomously or remotely controlled by a human operator. Sensors and actuators play this role.

Sensors and actuators benefited from the spectacular advances in the semiconductor industry in terms of miniaturization, cost reduction and performance improvements such as elaboration, storage capacity and energy performance. The core elements of a sensor are the transducer (converting physical properties into electrical signals), the AD converter (to convert electric signals into digital numbers) and a communication unit- (to send out data). Depending on the complexity of the sensor, it can also have data storage and elaboration capacity. On the other hand, an actuator is composed of a communication unit (to receive commands), a DA converter (to convert the digital signal into an analog one), and a transducer (converting electrical signals into physical changes). Again, depending on the complexity of the device it can have data storage and elaboration capacity.

The sensor and actuator global market represented 3% of the global semiconductor market sales in 2016 (approximately 10 billion US$, see Fig. 2.14). Among the different applications, sensors and actuators experienced the highest growth rate compared to the previous year (23% compared an average of 1% for the whole sector). Many analysts agree that this segment will experience a major increase in the near future due to IoT and MtM applications.

It is interesting to notice that Europe plays a marginal role in semiconductor sales (only 10%), in a market dominated by Asia. The importance of Asia in the semiconductor industry is also very clear when looking at the patent applications (Fig. 2.15) – 57% of all patents granted by the US Patent Office up to 2015 in the semiconductor sector come from Asia and only 7% from the top 4 EU countries (Germany, France, UK and Italy).

Sensors and actuators may have different applications in the power grid. We can roughly distinguish between industrial and retail applications. For the former, we can mention the real-time monitoring of grid status, including monitoring transient events and fault detection. Phasor Measurement Units (PMU) GPS synchronized for V/I/f measurement at 30-60 Hz are becoming an important application for TSOs and DSOs. Also, substation condition-based management through the measurement of a set of multiple parameters to determine maintenance needs are improving the reliability of the grid and efficiency of maintenance operations. Finally, an interesting application is related to Line Dynamic Rating. Power lines have limited transmission capacity due to many parameters and, apart from the intrinsic characteristics of the conductors, depend on external conditions such

Fig. 2.14 Global semiconductor industry sales by category (left) and country (right) [2016 =338.9 billion US$]

Source: I-Com elaboration on Semiconductor Industry Association and World Semiconductor Trade Statistics data (2017)

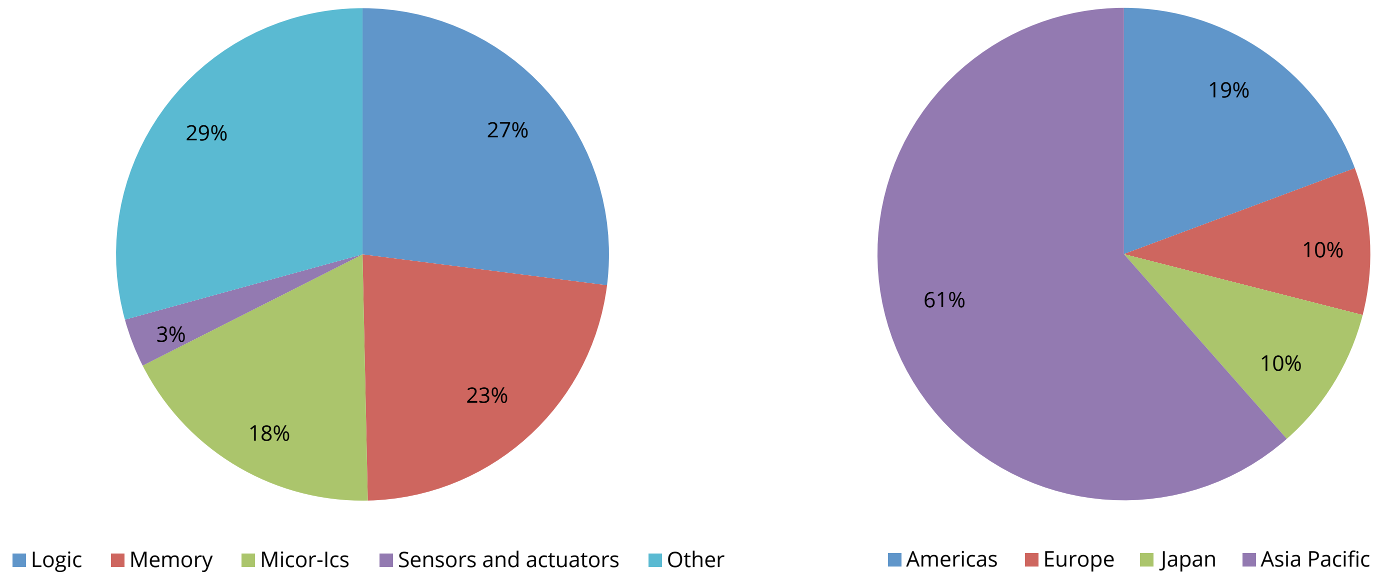
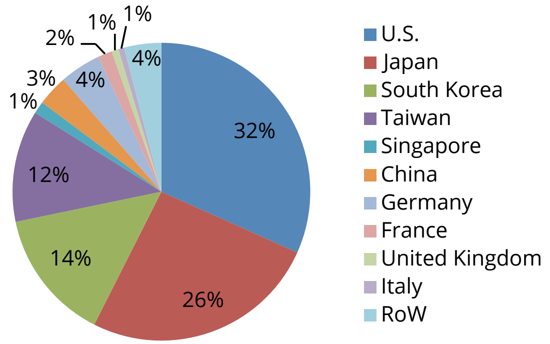


Fig. 2.15 % of patents granted by the US Patent Office – Semiconductor Devices and Manufacturing (up to 2015)

Source: I-Com elaboration on Semiconductor Industry Association data (2017)



as temperature and wind speed. Transmission capacity is usually evaluated quite conservatively, using worst case scenarios. Having access to real time environmental conditions could allow for a dynamic evaluation of the transmission capacity, with the opportunity to increase the overall efficiency of infrastructure use and planning. Sensors and actuators have important applications also in retailing. A classic example is represented by smart metering. The possibility to monitor energy consumption with a greater time resolution (in the range of 15 to 1 minute instead of once every two months) allows for more accurate billing and opens up the possibility for advanced energy management services (e.g. dynamic pricing and load management/control). Sensors and actuators can also cross over the divide between infrastructure and energy end-users – represented by the meter – and reach energy appliances and leaving/working spaces. It is the so-called Internet of Things (IoT). The detection of this variegated number of parameters and the possibility to directly access energy appliances and influence its operation open up unprecedented opportunities in terms of energy applications, in particular for energy efficiency and saving.

Box 2.1 Evaluation of data generated by smart devices

To give and idea of what digital energy means in terms of the amount of data to be managed, it is interesting to give a rough estimate of the volume of data generated by digital meters.

Under general conditions, we can assume that a single digital record is composed of 206 bits (46 bits for ID, 32 bits for timestamp and 128 bits for data recording). The annual volume of data generated by a single energy meter depends on the number of parameters measured and on the sampling rate. Suppose the meter is recording 5 parameters at three different sampling rates –

Case 1: once every two months

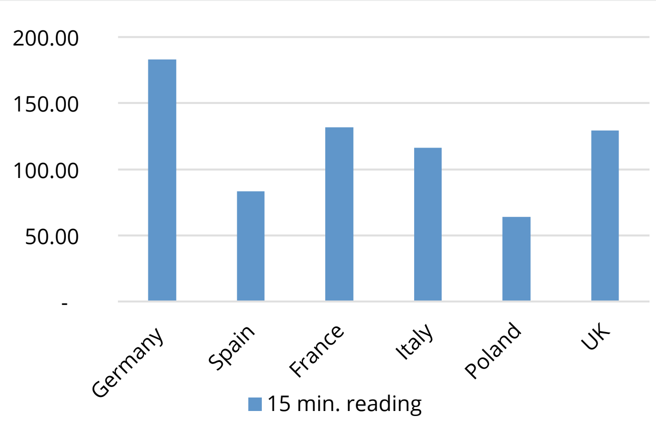
Case 2: once each 15 minutes

Case 3: once each second.

The annual data generated by the smart meter under the three different hypotheses are:
Case 1: 0.77 kByte/year
Case 2: 4.5 MByte/year
Case 3: 4.1 GByte/year.

The change in the order of magnitude of data to be managed in the three different cases is striking. The following figure shows an estimation of the amount of data generated in case 2 if all domestic end users have a smart meter in the different EU countries.

In the case of a 15 minute sampling rate, the annual volume of data generated in the most populated EU countries is in the range of hundreds of Tera Byte. In the case of a 1 second sampling rate, the order of magnitude jumps to hundreds of Peta Byte. Thi is a revolution for a sector used to measuring consumption once every two months on an average.



It is also interesting to provide some numbers on more advanced grid metering technologies, in particular, PMU. If we take the measurement of 20 parameters at a 60 Hz sampling rate, the amount of data generated in a year by a single PMU unit is slightly less than 1 TByte. This means that 100 MPUs will generate approx. 100 TByte/year.

2.3.2. Connectivity

The amount of data generated by sensors must be transferred to data centers in order to be processed and extract the desired information and, eventually, be stored for future applications. Symmetrically, streams of data have to be sent to actuators/end-users in order to produce the desired actions. This is where connectivity comes into play.

As previously highlighted, energy infrastructures are complex and involve a wide variety of geographical scale topologies, ranging from regional to home, with point as well as linear physical objects (generation units vs. transmission and distribution lines). The density of these objects can be very different and reach high concentrations in cities.

Fig. 2.16 Overview of the standard communications architecture for power grid applications.

Source: ANISA (2015)

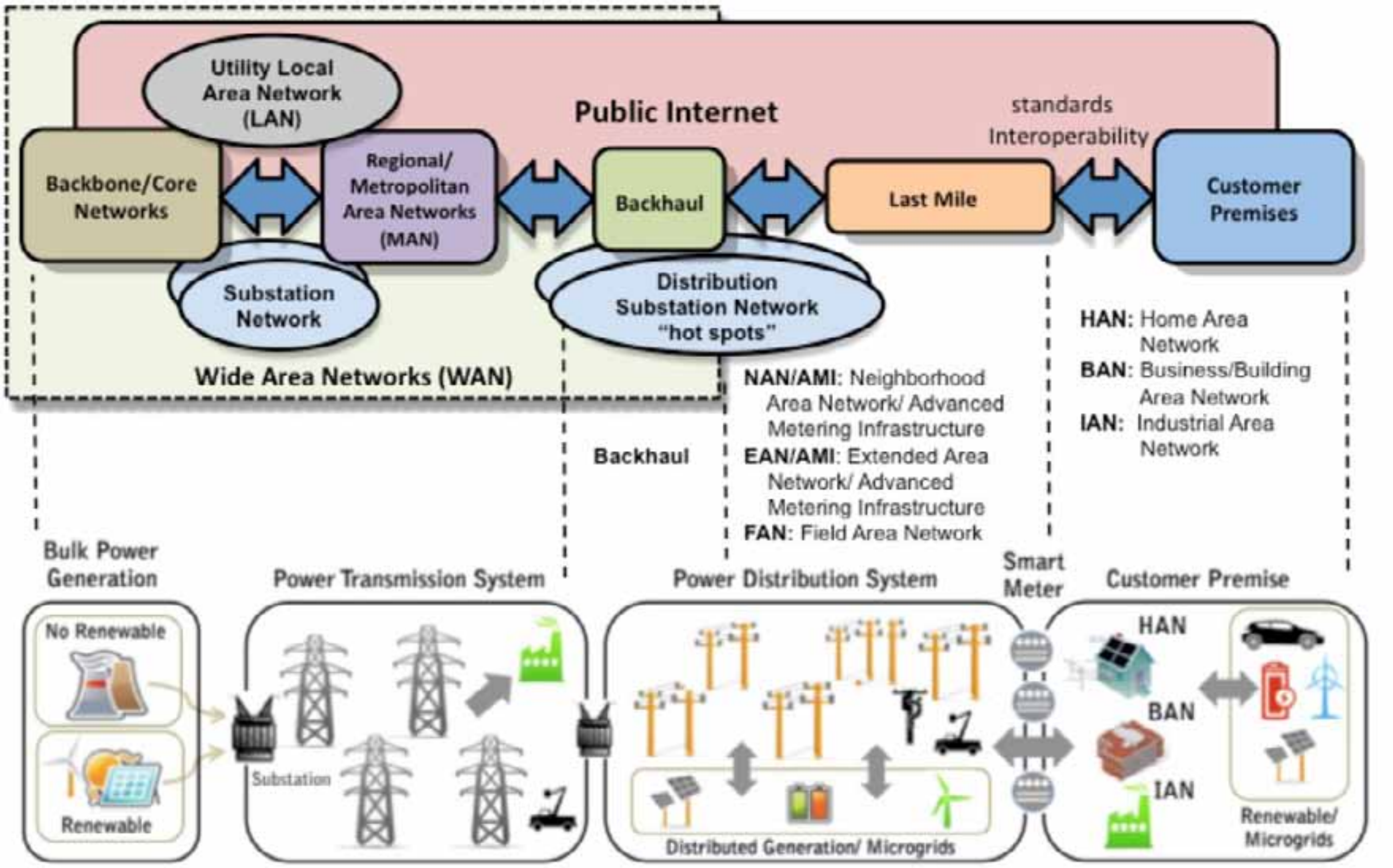
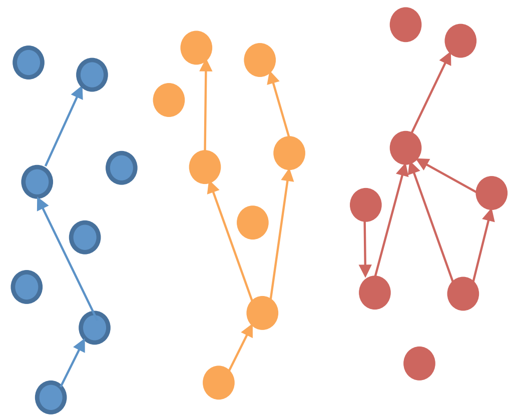


Fig. 2.17 Possible communication patterns for digital energy applications



A schematic overview of the standard communications architecture for power grids is given in Fig. 2.16

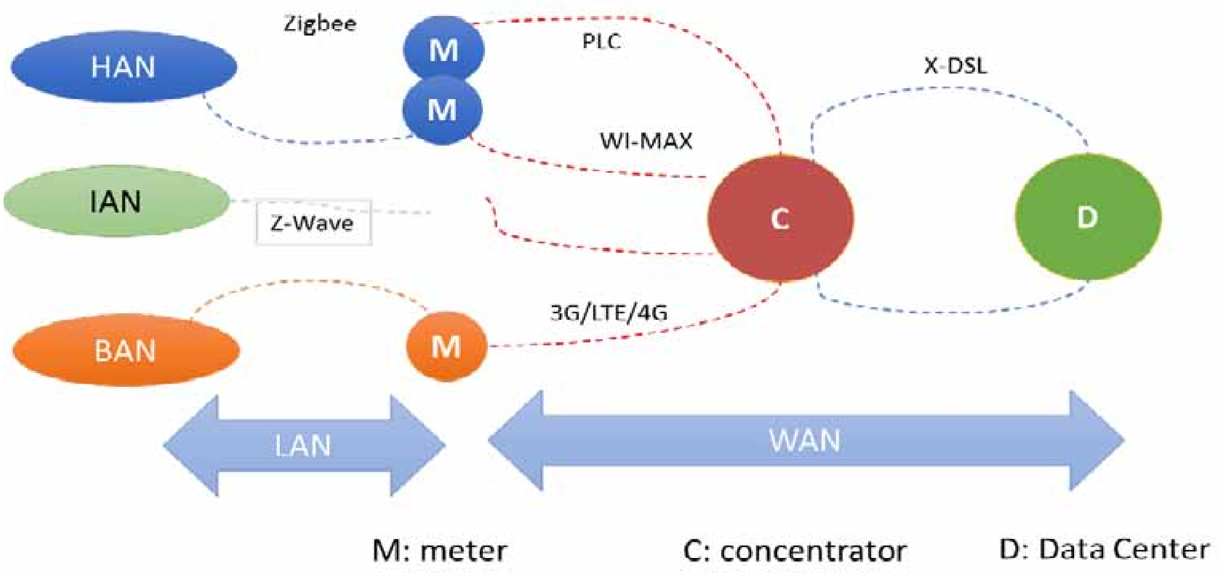
Communication patterns can be one-to-one as well as one-to-many or many-to-one (Fig. 2.17).

Each specific application has its own requirements in terms of range, bit-rate, latency, accuracy and security. Finally, wireless, as well as wired technologies, can find specific applications, depending on the operational context and state of art communication infrastructure.

Fig.2.18 shows an example of the network architecture that connects energy end-users with data centers, including some possible technologies used to interconnect different devices within the network.

Fig. 2.18 Example of network architecture connecting energy end-users with data centers and possible interconnection technologies

Source: I-Com elaboration on ANISA data (2015)

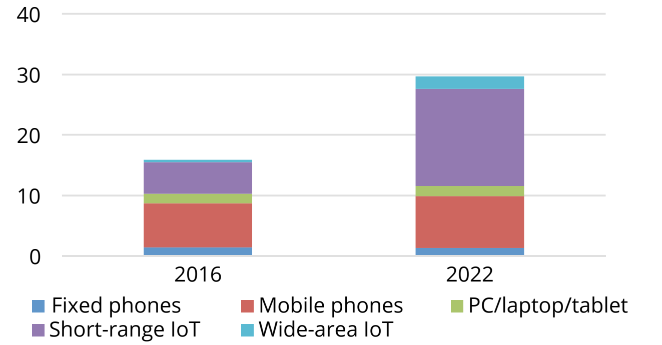


The main features of key communication technologies is summarized in Table 2.1

There is a wide consensus among experts on the step increase of interconnected devices in the near future. Fig. 2.19 shows data and projections on global connected devices elaborated by Ericsson. As a whole, connected devices are expected to double in the next 6 years. Short range IoT are mainly responsible for this growth, passing from 5 million in 2016 to 16 billion in 2022. Also wide-area IoT will experience a high growth rate (CAGR 2016-2022=30%), but the absolute numbers are one order of magnitude smaller than short range IoT.

Fig. 2.19 World connected devices [bill.]

Source: I-Com elaboration on Ericsson data (2017)



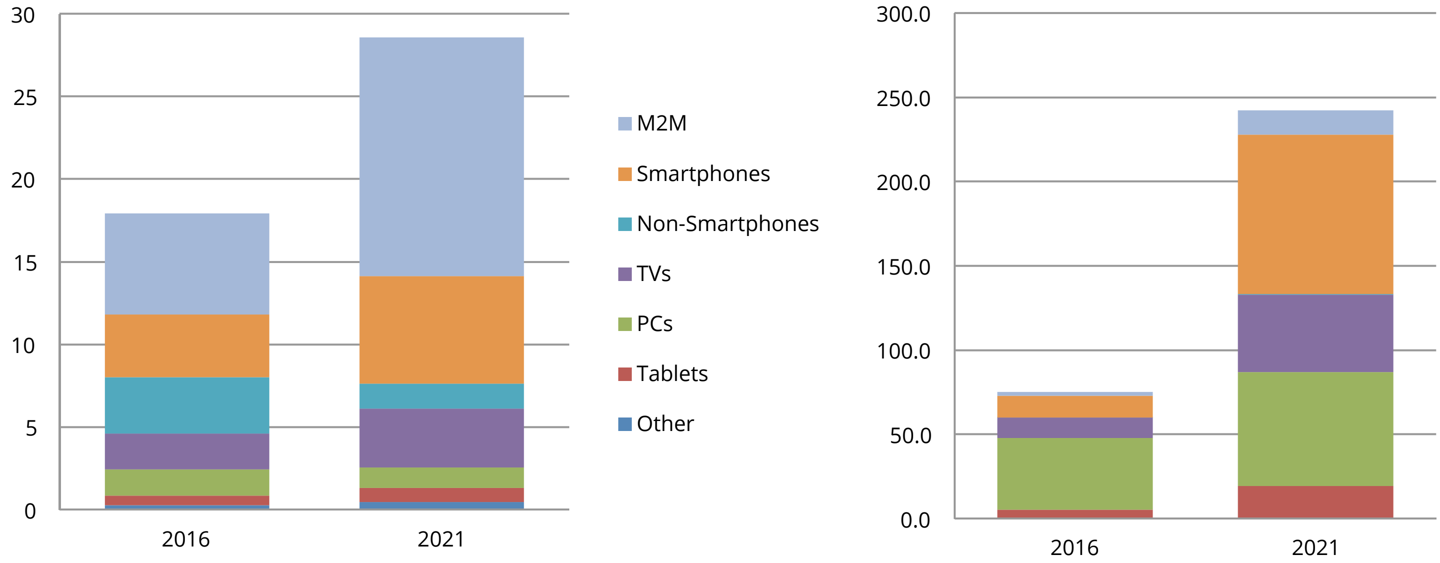
Tab. 2.1 Main features of key communication technologies

Source: I-Com elaboration on various sources and Fondazione Ugo Bordoni data

	TECHNOLOGY	BIT-RATE	RANGE	FEASIBILITY
Low Data Rate –wireless	Zigbee	250 kbps	10-100 m	Ok – with gateway towards High Data Rate networks
	Z-Waves	0,1 Mbps	10-100 m	Ok – with gateway towards High Data Rate networks
	WI-FI	1-150 Mbps	Up to 100 m	Ok – with gateway towards High Data Rate networks
Low Date Rate – fixed	NB-PLC	Up to 500 kbps	Several Km	Ok- yet deployed by DSO.
	BB-PLC	Up to 200 Mbps	Several Km	Ok- yet deployed by DSO.
High Data Rate – wireless	WI-MAX	Up to 100 Mbps	Up to 50 Km	Spectrum re allocation
	3G	Up to 20 Mbps	Up to 50 Km	Ok
	4G	Up to 128 Mbps	Up to 50 Km	OK
Long Range – Low Rate	LoRA	290 bps – 50 Kbps	Up to15 Km	Ok – Not licensed solution suitable for rural areas
	SigFox	Up to 100 bps	Up to 50 Km	Ok – Not licensed solution suitable for rural areas
	WmBus	2,4 Kbps – 100 Kbps	Up to 15 Km	Ok – Not licensed solution suitable for rural areas
High Data rate – fixed	X-DSL	Up to 100 Mbps	Up to 500 m	Not applicable

Fig. 2.20 World connected devices [left;in bill.] and global internet traffic by device [right; hexabyte/month]

Source: I-Com elaboration on The Zettabyte Era: Trends and Analysis data (CISCO, 2017)



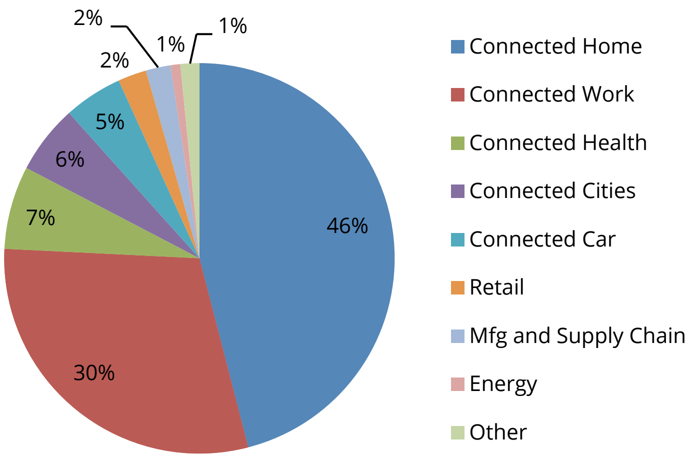
Similar conclusions are drawn by CISCO, as reported in Fig. 2.20. Global connected devices will reach almost 28 billion by 2021. Although the growth rate of specific technologies is different compared to the scenario reported above, MtM (IoT in the Ericsson scenario) is the fastest growing segment and will represent 50% of all connected devices by 2021. It is interesting to note that, in spite of the absolute number of MtM connected devices, the forecasted volume of data generated is small (6% of the total data volume) and Internet traffic will be dominated by video applications.

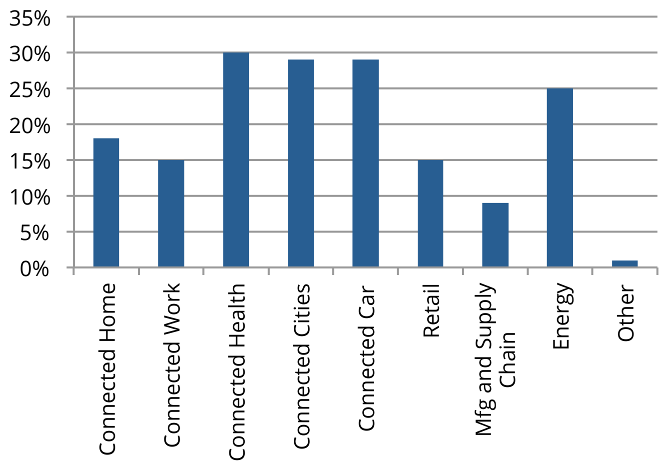
It is also interesting to analyze the composition of 2021 connected devices by application. The model assigns a small role to energy (only 1% of total applications) but it is interesting to note that energy applications can be potentially found in many horizontal sectors present in the list, such as connected homes, work cities and cars.

Consequently, IoT market data and projections are growing. In 2016, the global market volume was forecasted to reach 737 billion US$ in 2016, including investments in hardware, software, services and connectivity. Forecasts for 2017 are around 800 billion US$ (Fig. 2.22). The industries making the largest IoT investments in 2017 are Manufacturing (183 billion US$), Transportation (85 billion US$), and Utilities (66 billion US$). Cross-Industry IoT investments, which represent

Fig. 2.21 Share of connected devices by application (2021; left) and CAGR (2016-2021)

Source: I-Com elaboration on The Zettabyte Era: Trends and Analysis data (CISCO, 2017)



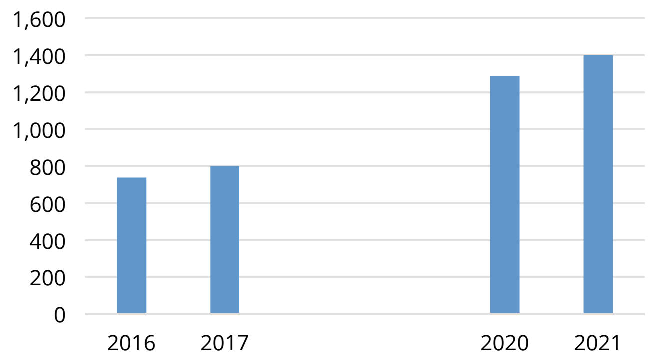


use cases common to all industries, such as connected vehicles and smart buildings, will be 86 billion US$ in 2017 and rank among the top segments throughout the five-year forecast. Consumer IoT purchases will be the fourth largest market segment in 2017 at 62 billion US$, but will grow to become the third largest segment by 2021. Meanwhile, the industries that will see the fastest spending growth are Insurance (20.2% CAGR), Consumer (19.4%), and Cross-Industry (17.6%)[11].

As far as connectivity is concerned, technology availability doesn't seem to be a key issue for the spread of digital

Fig. 2.22 Global IoT market value [bill. US$]

Source: I-Com elaboration on IDC data (2017)



11 https://www.idc.com/getdoc.jsp?containerId=prUS42799917.

energy. For many applications, the communication infrastructure already deployed seems to be adequate in terms of requirements and the 5G technology promises strategic improvements and performance (see infra).

The three main issues at the top of the agenda for the digital revolution of the energy sector are standards and interoperability and cybersecurity. Standards for specific energy applications are not fully defined yet, since potential applications of digital energy are still not completely clear. It is reasonable to assume that the development of digital energy will be step-by-step, and both top-down and bottom-up. Thus, to have an ordered and efficient development of the system, the communication layer must ensure full interoperability. Finally, the possible exposure of energy strategic infrastructures and private sensitive data to cyber attacks must be a priority for policy-makers and market actors (see Chapter 2.5).

Box 2.2 Transmission of data generated by smart devices

Among the technical criteria for communication technologies, data rates and latency are very important. Data rate (or bandwidth) is a measure of how much information can be sent in a second. Latency is a measure of the time between sending and receiving a signal. In general, the higher the data rates, the lower the latency. For each specific digital application, a minimum standard for bandwidth and latencies should be identified. As an example, typical disconnection services latency ranges from 1 to 10 minutes. Classical metering readings are in the range of 10 to 30 seconds. Grid automation should have latencies of 1 to 2 seconds, while advanced protection or PMU measures are in the order of milliseconds. The amount of data generated and the number of connected devices influence the choice of the technology. Also environmental conditions have to be considered (e.g. physical accessibility) and, as well, the number of other devices competing with the energy application for the bandwidth can influence network performance.

It has been demonstrated[12] that the 4G networks can manage without any problems classical metering functions for data volumes of 400 Mbit. If the volume of the information increases, the real bandwidth conditions have to be carefully evaluated.

12 S. Persia, V. Petrini, L. Rea, A. Valenti, "Wireless M2M capacity analysis for smart distribution grids," AEIT2015, October 2015

2.3.3. Data Management

The last piece of the digital energy puzzle is data management. Data collected has literally no value if useful information is not extracted and subsequent adequate actions or feedback are not adopted. This is where Big Data analysis comes into play.

Big data analysis is an emerging segment of data science. It involves highly sophisticated techniques and computing power that allow for the analysis of a considerable volume of data deriving from different sources in a limited timeframe. There is not a clear definition of how "big" is big or how "fast" is fast. We can talk, in a qualitative way of the 5V characteristics of Big data analysis:

- Volume: the size of the set of data to be analyzed is in the terabytes, petabytes and even exabytes range.
- Variety: data should originate from different sources. As an example, domestic energy consumption data could be correlated to weather conditions, geographical location, age and social condition of the consumer, occupancy rate of the home, etc.
- Velocity: the necessary information has to be extracted from the dataset in a limited timeframe. As an example, this can be in the range of minutes for typical demand side management applications, while it could be in the range of milliseconds for grid fault detection.
- Value: it is very important to evaluate the value of the information to be extracted from datasets. Data is considered to be next century's gold commodity and datamining a key job in the near future
- Validity: the degree of reliability of data analysis can vary greatly according to the specific application, particularly when associated to automatic MtM activities.

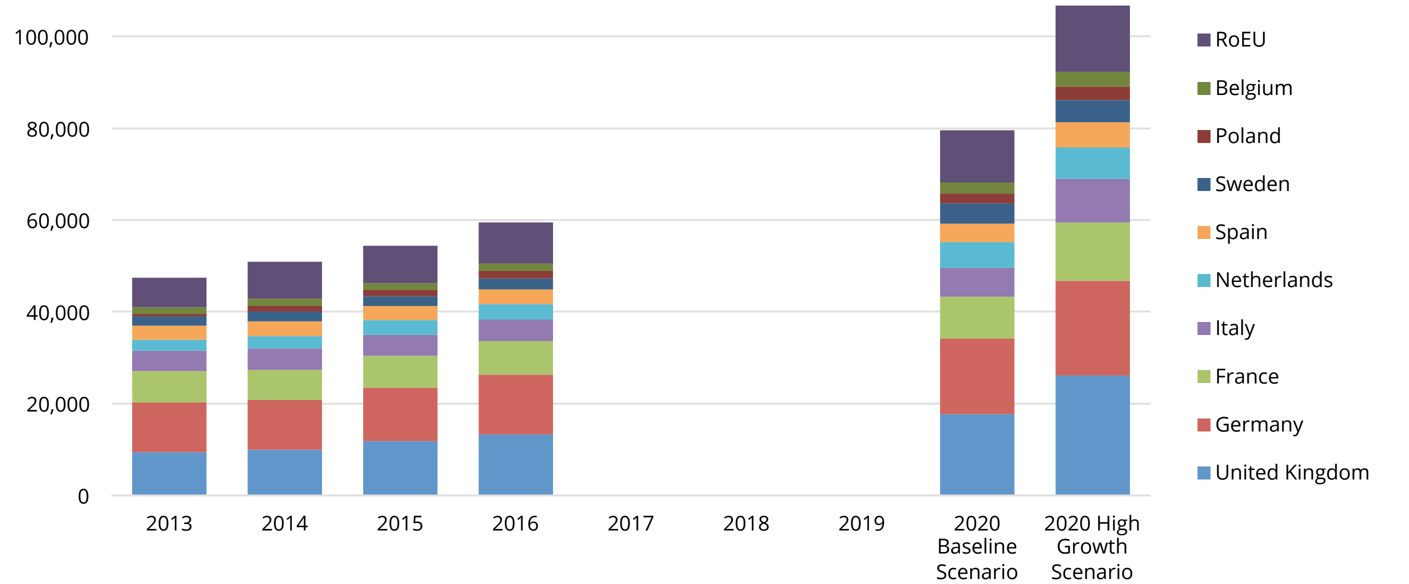
Advanced data management and Big Data analysis could find remarkable applications in the energy sector, at different levels. With the increase of detected data on the status of infrastructures (both transmission and distribution), wide area situational awareness will enable an advanced grid control. Situational awareness involves three main steps: perception, comprehension and projection. The last two steps are very resource-demanding in terms of data analysis and computing power. The projection on grid status allows for a more rapid and efficient reaction to potential grid faults by control room operators or/and automatic operations, thus resulting in a safer infrastructure management. It is clear that a timely detection of possible grid faults is a key issue and powerful data analysis algorithms have to be developed.

Another important application of Big Data analysis for the power sector is short-term load forecasting. Advanced energy metering provides access to more time resolved energy consumption data. Integrating this information with other data (e.g. temperature, humidity, home occupancy) and historical consumption patterns, allows for a more accurate prediction of short-term future electricity consumption. Clearly this is fundamental for grid operation and is enabling information for advanced demand management services.

Fig. 2.23 shows the evolution and projections of the market value of data in Europe. In 2016, total value reached 60 billion € and is expected to grow with an average annual growth rate in the range of 7.5% – 15.7% in the next 4 years, and settle at 80 – 107 billion € by 2020.

Fig. 2.23 Data market value in Europe [M€]

Source: I-Com elaboration on IDC data (2017)



70% of the market value is concentrated in 5 countries (UK, Germany, France, Italy and Netherlands – see Fig. 2.24).

If we consider the sectors, manufacturing, financial services, professional services, retail and wholesale, and ICT represent more than three-quarters of the market value. The energy sector has a share of 4% (Fig. 2.25)

It is interesting to analyze some indicators on the attitude of European firms to Big Data. Fig. 2.26 shows the percentage of enterprises with more than 10 employees that systematically analyze big data originating from all sources. Energy sector data is compared to the average figures for all sectors and to ICT and the retail trade. Only 10% of all European enterprises analyze Big Data, while

Fig. 2.24 Data market share by country in Europe [M€]

Source: I-Com elaboration on IDC data (2017)

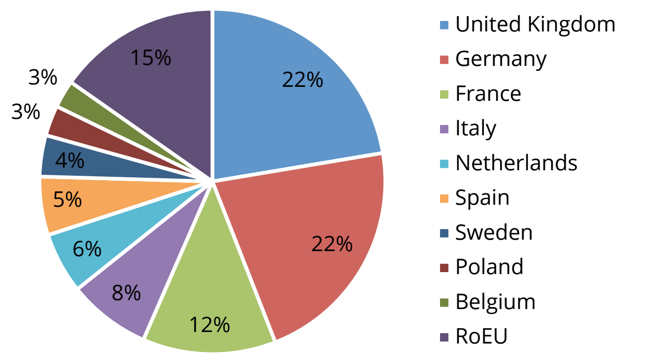


Fig. 2.25 Data market share by sector in Europe [M€]

Source: I-Com elaboration on IDC data (2017)

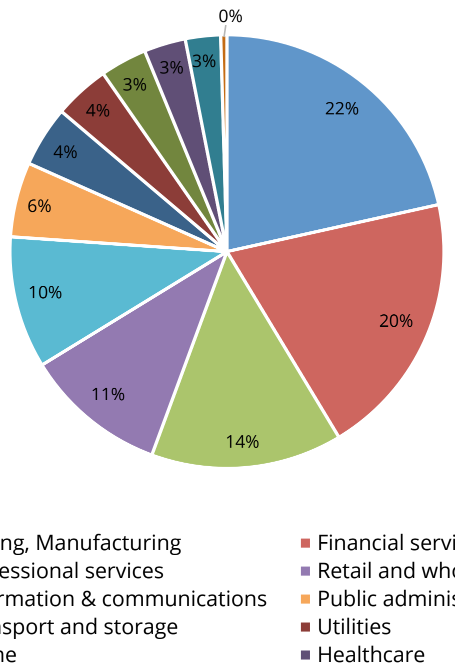
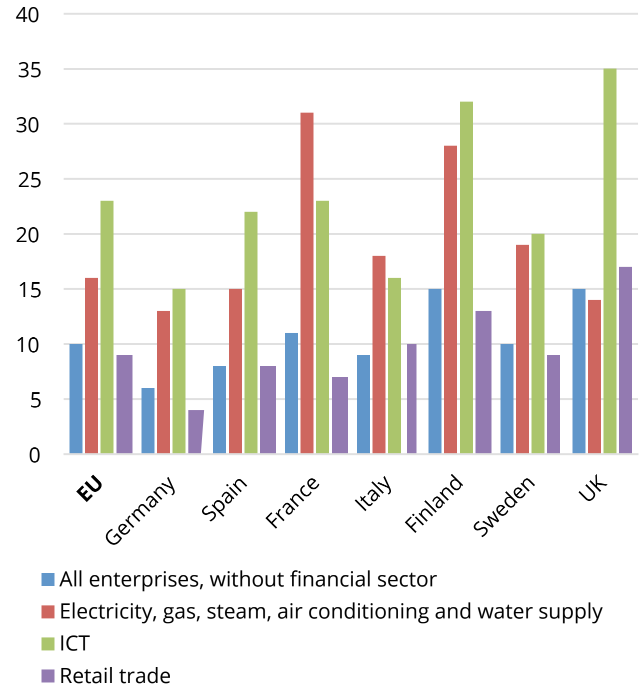


Fig. 2.26 Firms analyzing Big Data from any data source (% of all firms > 10 employees, 2016)

Source: I-Com elaboration on IDC data (2017)

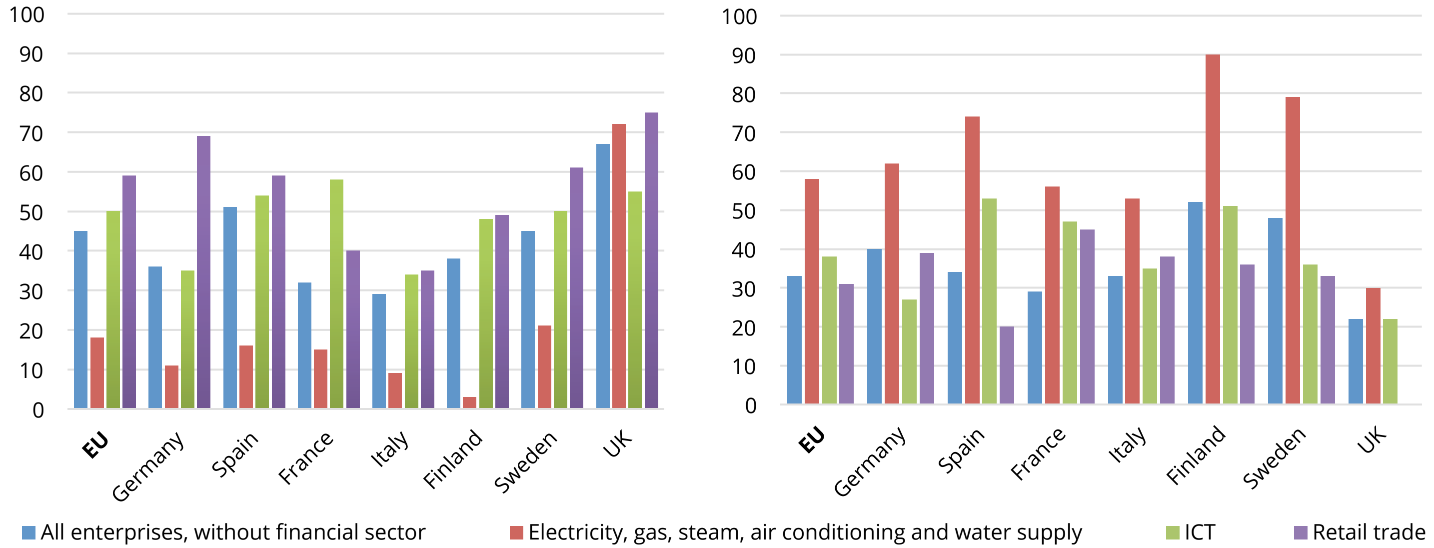


in the energy sector the percentage reaches 16%. The highest percentage is registered for ICT (23%). Looking at the details per country, we can see that in France one out of every three enterprises in the energy sector deals with Bid Data, while in Italy this percentage is18% (the highest score after Sweden and Finland).

A more detailed picture can be gained by looking at the different data source of Big Data. Fig. 2.27 presents findings for two main data sources- social media and smart devices and sensors. Social media is the preferred origin of data for 45% of firms in Europe, while this percentage is much lower for energy firms (18%). The situation is similar as a general trend for all countries studied, except for the UK, where the percentage of firms looking at social media data is 67% and reaches 72% for the energy sector. Instead, for smart devices and sensors, in Europe, on average, firms analyze data from this source in 1 out of three cases, while in the energy sector this percentage is 58%. The highest percentages are registered in Finland (90%) and Sweden (79%), followed by Spain (74%).

Fig. 2.27 Firms analyzing Big Data from social media (left) and from smart devices & sensors (right) (% of firms analyzing Big Data, 2016)

Source: I-Com elaboration on Eurostat data (2017)

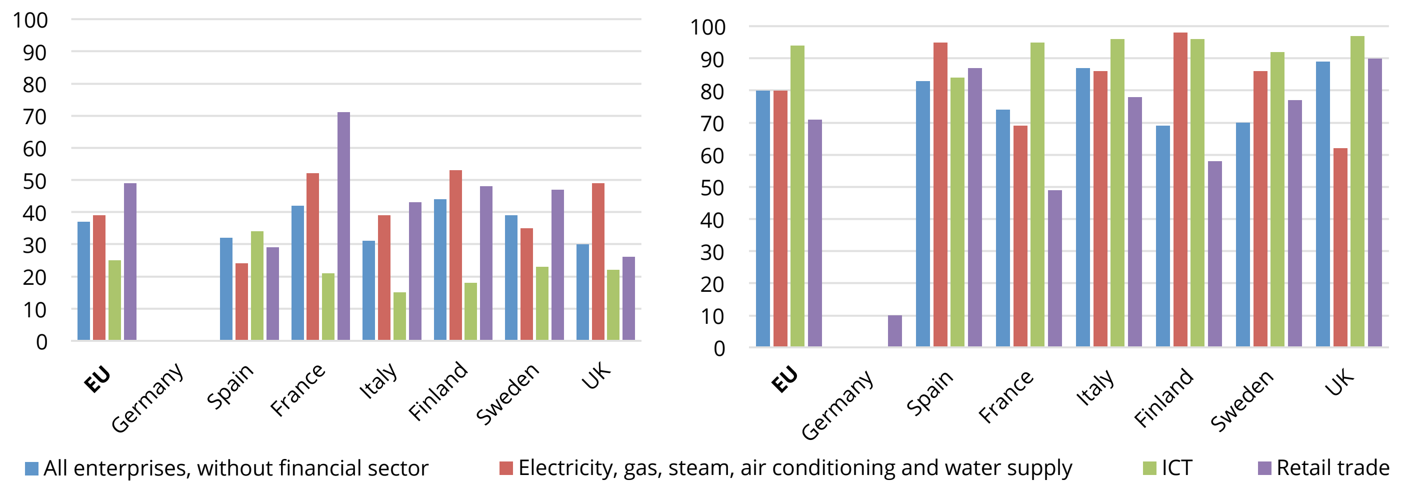


Big Data analysis is a highly specialized activity and it is interesting to note how firms deal with this task. As shown in Fig. 2.28, at a European level, most firms turn to internal resources (80%) rather than outsourcing to specialized companies (37%). The situation is similar in the energy sector and does not show significant differences in the countries considered. Fig. 2.29 reinforces the tendency for the delay in the acquisition of advanced data services by European firms. With the notable exception of ICT, all sectors appear to be reluctant to buy specialized Cloud Computing services. Only in the case of the UK is the percentage of all sectors substantially higher than 10%. Similar values are registered for the energy sector.

Data is surely at the heart of the digital energy revolution. The benefit of this radical change in the energy sector will materialize only if a proper data management system can be adopted. Many issues are connected to this aspect. Who owns the data? Who is responsible for collecting, transmitting and storing data? Who has the right to extract information out of this data? What is the optimal use of this information? How to fairly distribute benefits and costs among different players in setting up this complex data management system? How to balance privacy and open access rights to market operators in order to maximize advanced energy services? There is a general consensus that the answers to these questions are not unique and depends on the specific application,

Fig. 2.28 Firms outsourcing (left) and in-house (right) Big Data analysis (% of firms analyzing Big Data, 2016)

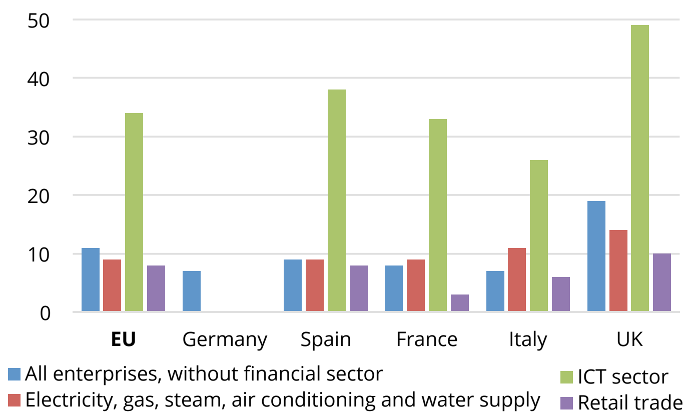
Source: I-Com elaboration on Eurostat data (2017)



market segment and national context being referred to. Broadly speaking, there is a first layer that is related to grid status data and optimal management of energy infrastructure. In this case the TSOs/DSOs role is prominent and the collaboration among these regulated entities is fundamental. A second layer is represented by data generated by consumers through digital meters. Of course, some of this information is relevant for DSOs operations, other has a more commercial value. The regulation of the latest stream of information is the most complex because many partially conflicting aspects have to be tempered. Privacy, information asymmetry, free competition and innovation are some of the main aspects to be taken into account.

Fig. 2.29 Firms buying advanced Cloud Computing services* (% of firms with more than 10 employees, 2016)

Source: I-Com elaboration on Eurostat data (2017)
* accounting software applications, CRM software, computing power



2.4. STANDARDS AND INTEROPERABILITY

The transition of the power sector from the "analog" to the "digital" era is a complex and long process. It will be achieved step by step, with both a top-down and bottom-up approach. Legacy infrastructures and solutions will coexist alongside innovative ones. It will take some time before well-defined standards will emerge and business models become confirmed in the market. This is true both for software and hardware, as well as for system integration. For these reasons standardization and interoperability will play a key role in the transition phase.

A standard is a voluntary formal agreement on doing something in the same way, repeatedly. It can be developed for products, processes, management and services. More specifically, standards are defined by the International Organization for Standardization (ISO) as "documents, established by consensus and approved by a recognized body, that provide for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context".

Why we need standards

Standards are essential to ensure the exchange of data between machines, systems and software within a networked value chain, as a product moves into and through the 'smart factory' towards completion, as well as to allow robots to be integrated into a manufacturing process through simple 'plug-and-play' techniques. If data and communication protocols are proprietary or only recognized nationally, only the equipment of one company or group of companies will be compatible. Thus, competition and trade can be expected to suffer and costs rise.

On the other hand, independent, commonly agreed, international standard communication protocols, data formats and interfaces can ensure interoperability across different sectors and different countries, encourage the wide adoption of Industry 4.0 technologies, and ensure open markets worldwide for European manufacturers and products.

A 2014 study by the European Commission emphasized the need for anticipating standards requirements and accelerating their development in Europe[13] The benefits of standards for the European industry are tremendous. Standards lead to cost reduction or cost savings derived mainly from economies of scale, the possibility to anticipate technical requirements, the reduction of transaction costs and the possibility to access standardized components.

According to the World Bank[14], one of the most important economic benefits of standards is that they increase productive and innovative efficiency. They allow suppliers to achieve lower per-unit costs by producing large homogeneous batches. In addition, producers gain skills and experience by focusing on fewer product variations. Another benefit is improved market access as

13 Joint Research Centre, How will standards facilitate new production systems in the context of EU innovation and competitiveness in 2025?, 2014

14 Quality Systems and standards for a competitive edge (drafted by J. Luis Guasch, Jean-Louis Racine, Isabel Sanchez and Makhtar Diop), The International Bank for Reconstruction and Development/ The World Bank, 2007

a result of increased competitiveness due to increased efficiency, reduced trading costs, simplified contractual agreements (the characteristics and functionalities of the product are clear as a result of the standards) and increased quality. Standards also lead to better relations with suppliers and clients derived from increased safety for consumers, increased trust, reduced liability risk and wider choice of suppliers for the same reasons mentioned above. Minimum safety standards are the most straightforward example of standards used to solve imperfect information problems. European standards have an immense value for the competitiveness of the enterprises working in the fields of transport, machinery, electro-technical products and other manufacturing industries, as well as in the field of telecommunications.

Well-designed and timely European standards can support innovation in a number of ways. Existing standards can codify and spread the state of the art in various technologies. They can also facilitate the introduction of innovative products by providing interoperability between new and existing products, services and processes, for example in the field of eco-design, smart grids, energy efficiency of buildings, security and eMobility. In some instances, innovations can more easily gain market acceptance if they comply with existing standards for safety, quality and performance.

Interoperability standards can underpin a technological platform on which other innovation can take place, especially for services (for example, using LTE mobile services as a platform for mobile commerce solutions or public cloud computing platforms for eGovernment applications). Finally, standards can help bridge the gap between research and marketable products or services. A standard can codify the results of publicly funded research, thus making them available as a basis for further innovation.

Box 2.3 The benefits of standards

Source: ETSI

- **Safety and reliability** – Adherence to standards helps ensure safety, reliability and environmental care. As a result, users perceive standardized products and services as more dependable – this in turn raises user confidence, increasing sales and the take-up of new technologies.
- **Support of government policies and legislation** – Standards are frequently referenced by regulators and legislators for protecting user and business interests, and to support government policies. Standards play a central role in the European Union's policy for a Single Market.
- **Interoperability** – the ability of devices to work together relies on products and services complying with standards.

- **Business benefits** – standardization provides a solid foundation upon which to develop new technologies and to enhance existing practices. Specifically, standards:
  - open up market access
  - provide economies of scale
  - encourage innovation
  - increase awareness of technical developments and initiatives
- **Consumer choice** – standards provide the foundations for new features and options, thus contributing to the enhancement of our daily lives. Mass production based on standards provides a greater variety of accessible products to consumers.

What the world would be like without standards:

- Products might not work as expected
- They may be of inferior quality
- They may be incompatible with other equipment – in fact they may not even connect with them
- In extreme cases, non-standardized products may be dangerous
- Customers would be restricted to one manufacturer or supplier
- Manufacturers would be obliged to invent their own individual solutions to even the simplest needs, with limited opportunity to compete with others.

The European strategy for standardization

The digitization of European industry and services represents an important opportunity for the growth of European businesses and society, as well as an important milestone in achieving a Digital Single Market. Industry in Europe has held a longstanding leading position in factory automation and intelligent manufacturing technologies. Currently, the digitization of industry and services and the application of cognitive technologies is establishing connections across sectors, as well as throughout the value chain, from innovator to manufacturer and from provider to consumer. This is a catalyst for innovation and technology integration throughout the value chain. Regulation (EU) No 1025/2012 establishes a legal basis for European product and service standards, identifying ICT technical specifications, and financing of European standardization practices. It also sets an obligation for European Standardization Organizations (CEN, CENELEC, ETSI) and National Standardization Bodies to comply with transparency and participation. Articles 15 to 19 of the regulation lay down the legal basis of the EU financial support for the European standardization system, the total amount available – approximately €20 mill. annually – being constant over the last years.

The EC package on "Digitizing of European Industry", as well as several initiatives at member state level and within industry federations recognizes that standardization has an important role to play, helping European industry secure its leadership in manufacturing and service provision by adopting the best available digital technologies. As the Communication states, "an effective standardization environment for digital technologies is crucial for Digitizing European Industry, and is key to the Digital Single Market. ICT standards allow devices and services to connect seamlessly across borders and technologies. In the future, billions of connected devices – including appliances, industrial equipment, and sensors – will depend on such seamless communication, regardless of manufacturer, technical details, or country of origin."

2.4.1. The Communication of the European Commission: ICT Standardization Priorities for the Digital Single Market

The proposal for a 2017 Work Program for European standardization identifies services and ICT sectors as priority areas for future standard-setting, given their cross-cutting role in the economy.

In April 2016, the Commission had already proposed concrete measures to speed up the ICT standard setting process by focusing on five priority areas: 5G; cloud computing; Internet of Things; data technologies; and cybersecurity. Action in these areas can accelerate digitization and immediately impact competitiveness in domains such as eHealth, intelligent transport systems and connected/automated vehicles, smart homes and cities, and advanced manufacturing[15].

Tab. 2.2 European Commission's ICT standardization priority areas

Source: European Commission

CLOUD COMPUTING	
Cloud computing supports new digital services by providing the massive data storage and computational power needed for the digitization of European industry and science. Proprietary solutions, purely national approaches and standards that limit interoperability can severely hamper the potential of the Digital Single Market	The Commission will: ■ Intends to support funding the development and use of the ICT standards needed to further improve the interoperability and portability of the cloud, also making more use of open source elements by better integrating open source communities by the end of 2016. ■ Facilitate the adoption of cloud computing services by supporting the finalization of international standards on service level agreements, by mid-2017. This will ensure transparency and quality for end users, especially SMEs. ■ Request ESOs to update the mapping of cloud standards and guidelines for end users (especially SMEs and the public sector), in collaboration with international SDOs, cloud providers and end users, by mid-2017.7.

15 Communication of the European Commission, ICT Standardization Priorities for Digital Single Market, COM (2016) 176, 19.04.2016.

INTERNET OF THINGS	
The IoT technology connects more objects to the internet – including household equipment, wearable electronics, vehicles and sensors. The number of such connected devices is expected to exceed 20 billion by 2020. The IoT also has the potential to help address many societal challenges including climate change, energy efficiency and ageing. However, the IoT landscape is currently fragmented because there are so many proprietary or semi-closed solutions alongside a plethora of existing standards	The Commission will: ■ Foster an interoperable environment for the Internet of Things, working with ESOs and international SDOs. The Commission will assess if further steps are needed to tackle identified interoperability failures, and if necessary, consider using legal measures to recommend appropriate standards. ■ Promote an interoperable IoT numbering space that transcends geographical limits, and an open system for object identification and authentication. ■ Explore options and guiding principles, including developing standards, for trust, privacy and end-to-end security, e.g. through a 'trusted IoT label'. ■ Promote the uptake of IoT standards in public procurement to avoid lock-in, notably in the area of smart city services, transport and utilities, including water and energy.
5G COMMUNICATION NETWORKS	
5G networks enable seamless global communication between different kind of 'nodes', connecting data, vehicles and other objects, smart sensors or voice. 5G is expected to become the essential global infrastructure for communication and critically depends on standards to ensure interoperability and security, privacy and data protection	The Commission will: ■ Foster the emergence of global industry standards under EU leadership for key 5G technologies (radio access network, core network) and network architectures notably through the exploitation of the 5G public-private partnership results at the level of key EU and international standardization bodies. ■ Ensure that 5G standards are compatible with innovative use cases of vertical industries, notably through broader participation of industries with sector-specific needs, in 5G standardization organizations.
CYBERSECURITY	
Cybersecurity provides the bedrock of trust and reliability on which the Digital Single Market will be built. As the number of connected objects grows, and communication channels multiply, European citizens and businesses will expect a very high quality of security standards to be built-in to any new technology or service. Incorporating security-by-design principles is essential to mainstreaming cybersecurity considerations into all emerging ICT standards and reference architectures	The Commission will: ■ Invite ESOs, other SDOs and relevant stakeholders to draw up practical guidelines aimed to ensure that security and seamless secure authentication are considered from the outset in the development of ICT standards. The Commission will consider adopting a Recommendation by end 2017 regarding the integration of cyber security requirements including data protection-by-design and data protection-by-default. ■ Invite ESOs and other SDOs and relevant stakeholders to develop standards by the end of 2018 that support global interoperability and seamless trustworthy authentication across objects, devices and natural and legal persons based on comparable trust models. ■ Over the next three years, support the development of standards-based cybersecurity risk management guidelines for organizations and of corresponding audit guidelines for authorities or regulators with oversight responsibilities
DATA TECHNOLOGY	
Data is the fuel of the digital economy. Open standards, as well as initiatives such as Open Data Portal, can help overcome barriers to data sharing between technologies, scientific disciplines and countries. Future data infrastructures will require standards not only for security and privacy, but also for metadata, data preservation, semantics, data values, and others.	The Commission will: ■ Increase R&D&I investment specifically for data interoperability and standards as of 2016. This will cover areas such as (i) cross-sectorial data integration; (ii) better interoperability of data and associated metadata. This will also be used to contribute to global standardization in the field of data. ■ Bring the European data community together to identify missing standards and design options for a big data reference architecture, taking into account existing international approaches, by 2018. ■ Support, as of 2016, together with stakeholders and relevant global initiatives26, data and software infrastructure services for access and long-term preservation of scientific data.

ESO: European Standardization Organization, SDO: Standard Development Organization

In June 2016 the Commission presented its standardization package, where it set out its vision for a single and efficient standardization policy that adapts to the changing environment, supports multiple policies and brings benefits to companies, consumers and workers alike. The package included the Communication, European Standards for the 21st Century. Here the Commission recommends a renewed focus on the services sector[16]. While services account for 70% of the EU economy, service standards only account for around 2% of all European standards. The fragmentation of standards acts as a barrier to the cross-border provision of services. Complementing other initiatives under the Single Market Strategy to facilitate cross-border provision of services, the Commission proposes to prioritize and promote the targeted development of voluntary European service standards. Examples of service standards include terminology used in hotels and other tourism accommodation. The package also includes the Annual Union Work Program for 2017, setting out the priorities in European standardization for the following year, and a Joint Initiative on Standardization – a dialogue process bringing together the relevant stakeholders (industry, institutions, consumers, union etc.). The partnership will develop concrete actions to better prioritize, speed up and streamline standardization work by the end of 2019.

16 Communication of the European Commission European Standards for the 21st Century, COM (2016) 358 final.

2.4.2. The Joint Initiative on Standardization

To reinforce the partnership between the European institutions and the European standardization community, the European Commission announced in its Single Market Strategy the launch of a Joint Initiative on Standardization, bringing together public and private institutions and organizations in a collaborative dialogue. The initiative is driven by stakeholders (EU and EFTA Member States, standardization organizations and bodies, European industry and industry associations, SMEs, and societal stakeholders), with the European Commission playing a mainly coordinating role and building consensus.

These partners will commit to modernizing, prioritizing, and speeding up the timely delivery of standards by the end of 2019. The JIS will better align standard setting priorities with research and innovation impetus, with support from the EU research and innovation program Horizon 2020. The JIS will also promote the use of European standards at an international level.

Signatories to the initiative have agreed on a joint vision on standardization based on mutually-agreed underlying principles. To begin the process for improving the European standardization system, a Steering Group is drafting a set of actions, accompanied by pilot projects, based on three cluster domains identified as priorities:

- Awareness, Education and Understanding of the European Standardization System i.e. increasing the relevant use of standards and participation at all levels;
- Coordination, Cooperation, Transparency and Inclusiveness, i.e. ensuring adequate, high-quality,

user-friendly and timely European standards;

- Competitiveness and International dimension, i.e. standards supporting European competitiveness in global markets.

All actions will address provisions under the Joint Initiative, as expressed in the Single Market Strategy of 2015 – prioritization, modernization and the appropriate speed for timely standards.

However, it should be taken into account that the Joint Initiative on Standardization is not legally binding.

2.4.3. The New European Interoperability Framework

The new European Interoperability Framework (EIF) was established with a European Commission Communication adopted on 23 March 2017[17]. The framework gives specific guidance on how to set up interoperable digital public services.

It offers public administrations 47 concrete recommendations on how to improve the governance of their interoperability activities, establish cross-organizational relationships, streamline processes supporting end-to-end digital services, and ensure that both existing and new legislation do not compromise interoperability efforts.

The new framework puts more emphasis on how interoperability principles and models should be applied in practice. The number of recommendations has increased from 25 to 47. The updated recommendations on interoperability have been made more specific to facilitate their implementation, with a stronger focus on openness and information management, data portability, interoperability governance, and integrated service delivery.

All EU countries are currently digitizing their public administrations. By following the recommendations provided by the new EIF, EU countries will follow a common approach while making their public services available online, integrating them end-to-end, managing their information sources, or dealing with security and data protection rules.

This will ensure that services are accessible, not only within their national borders, but also across countries and policy areas. In other words, they will apply interoperability in practice. Thus, public administrations can save time, reduce costs, increase transparency, and improve the quality of services that they offer to citizens and businesses.

The EIF is accompanied by the Interoperability Action Plan, which outlines priorities that should support the implementation of the EIF from 2016 to 2020.

The Interoperability Action Plan is made up of five focus areas – addressing issues related to the identification of mechanisms to govern interoperability, collaboration between organizations, engagement of stakeholders, and raising awareness of the benefits of interoperability. It also covers the development, improvement and promotion of key interoperability enablers, while considering the needs and priorities of end users.

The European Commission will govern and coordinate the implementation and monitoring of the framework, using

17 Communication of the European Interoperability Framework, COM (2017) 134, 23.03.2017.

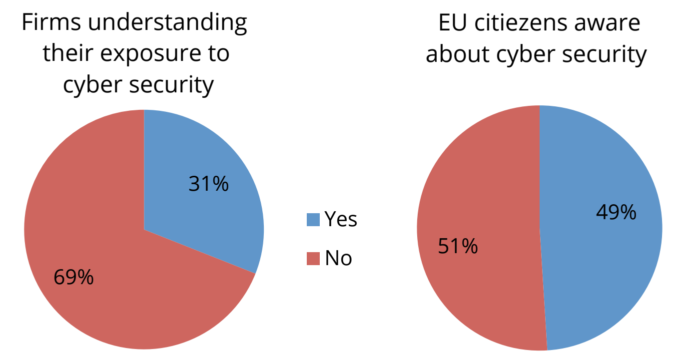
key performance indicators and measurable targets.
EU countries are expected to complement the EU's actions, identified in the Interoperability Action Plan, with national actions, thus ensuring coherence. This is essential for the successful application of interoperability in the public sector within the EU. The Commission will evaluate the implementation of the new EIF by the end of 2019.

2.5. CYBERSECURITY IN DIGITAL ENERGY

With the pervasive penetration of ICT and Internet in all economic activities, services and private life, cybersecurity should become one of top priority in security management at all levels, starting from EU and national level, to end up with firms and individuals.
For the energy sector this is particularly true since energy infrastructures are strategic and because energy data is sensitive for the privacy and security of consumers. The advent of IoT will exacerbate this situation. Indeed, with the advent of the Internet of Things, networks will become a major target of cyber-attacks and the potential consequences are expected to be extremely severe. Smart infrastructures are based on the digital processing of data, and intelligent machines will automatically supervise vital functions, with more and more services being based on the availability of Internet to be able to deliver. An intentional or accidental cybersecurity accident could cause severe harm to institutions, companies and individuals. To have an idea of the threat, it is useful to remember that in the EU, there are more

Fig. 2.30 Enterprises and EU citizen awareness and knowledge about cyber threats (%, 2016)

Source: I-Com elaboration on EU Commission factsheet State of the Union data (2017)



than 4,000 ransomware attacks[18] per day and in some member states 50% of all crimes are cybercrimes.
Despite the growing risks, awareness and knowledge of cybersecurity are still insufficient, as shown inFig. 2.30. 69% of EU companies are not aware of their exposure to cyber risks, while more than half of EU citizens (51%) do not feel they are properly informed about cyber threats. Cyber-attacks are different in the way they work and the target of the attacks. In addition to ransomware, another typology of attack is botnet – a widespread attack by a large number of devices infected by a silent malware activated by hackers to direct all traffic generated by them to a server or energy grid causing a crash or a blackout due to overload. The first could prejudice online activities of enterprises and the access to services by consumers, e.g. an attacked online market website is a hard blow to

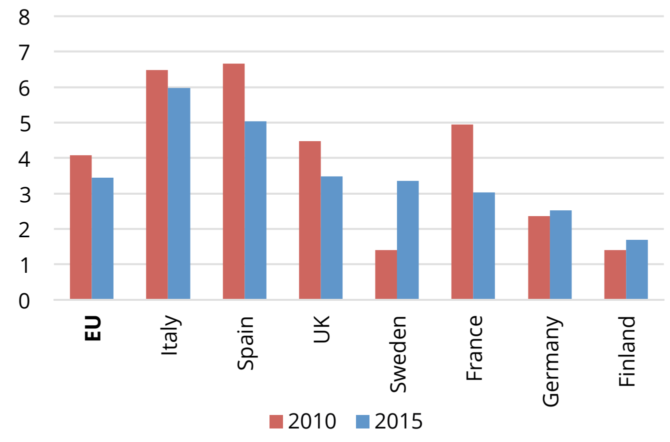
18 How to protect your networks from ransomware (CCIPS, 2016)

managers and to potential consumers. The latter, instead, is a large-scale attack on a system, causing serious repercussions to its stability. Indeed, the latest type of attack is the typical one of terrorist or war activities.

Cyber attacks could also compromise the privacy and sensitive data of consumers. Fig. 2.31 shows the percentage of European citizens experiencing a cybercrime related to the violation of personal data. Figures have to be carefully read. Indeed, we can see a decrease in the percentage of people reporting cyber-violation from 2010 to 2015, for the EU average and for many single countries, in spite of the growth of digitalization. A striking exception is Sweden and Finland, where the digitalization process is very advanced and the percentage of cyber-crimes reported to public authorities has increased. A possible explanation could be that only

Fig. 2.31 Individuals experience of digital abuse of personal information and/or other privacy violations (%)

Source: I-Com elaboration on Eurostat data (2017)



a small portion of cyber-attacks is even perceived and that only the most advanced digital societies are starting to address the phenomenon more carefully.

Digital energy is potentially very sensitive to cybercrimes, both for what concerns the infrastructure in general and in relation to data violation.

Firms play a key role in promoting cyber-security and cyber-resilience. Fig. 2.32 shows the percentage of enterprises that have formally adopted an ICT security policy. On average, at EU level, only one out of three firms have defined cybersecurity protocols. The percentage is higher in the utility segment, but still below 50%. Only for Sweden and Finland is this data higher than 50%. Not surprisingly, the ICT sector boasts a better situation. Regarding times involved for cyber-security protocol, we can see that most enterprises adopted or updated the policy within 12 months (around 60%) while 20% within 12 and 24 months.

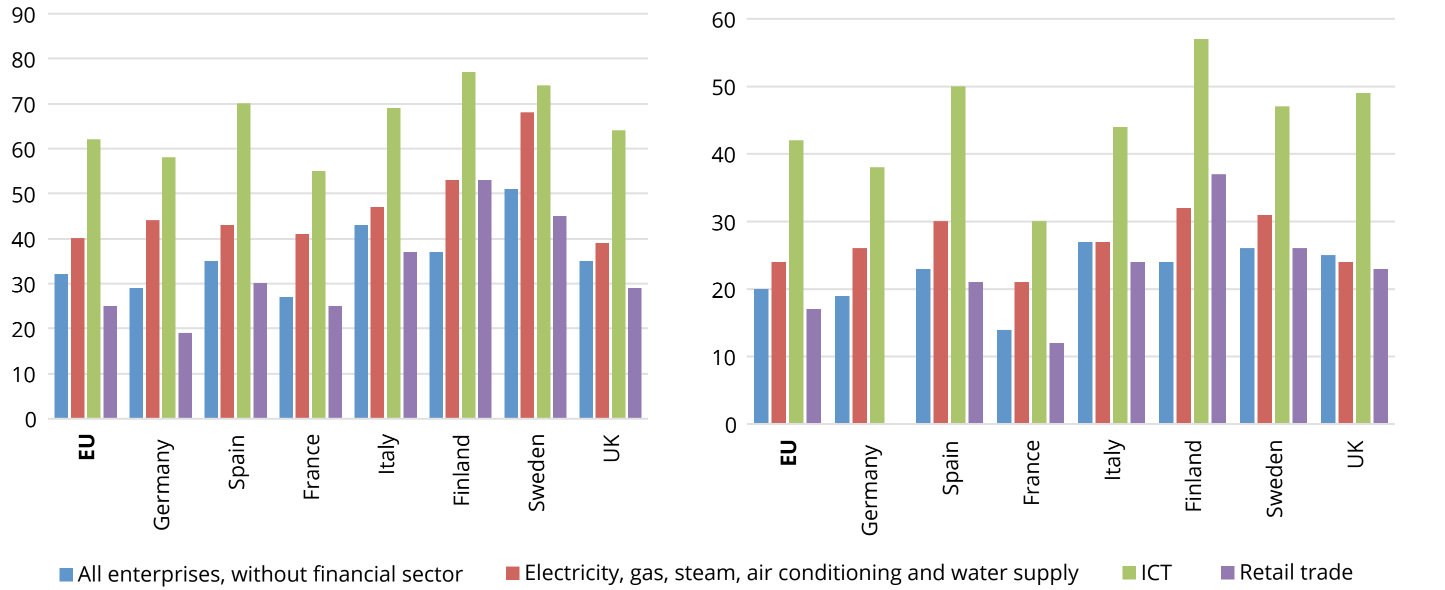
We can say, in general terms, that in spite of the importance of the issue, only a minority of firms has a proactive attitude towards cyber security.

Currently, three main regulatory issues are at stake at European level:

1. the need to increase cybersecurity capabilities, reaching the same level of development in all EU member states, and ensuring that exchanges of information and cooperation are efficient, also at cross-border level;
2. aiming at making the EU a strong player in cybersecurity. Europe needs to be more ambitious in nurturing its competitive advantage in the field of cybersecurity to ensure that European citizens, enterprises (including

Fig. 2.32 Enterprises with formally defined ICT security policy (%, 2015. Left – total; right – new or reviewed ICT security policy within the last 12 months)

Source: I-Com elaboration on Eurostat data (2017)



SMEs) and public administrations have access to the latest digital security technology, which is interoperable, competitive, trustworthy and respects fundamental rights including the right to privacy. This should also help take advantage of the booming global cybersecurity market. To achieve this, Europe needs to overcome the current cybersecurity market fragmentation and foster the European cybersecurity industry;

3. the need for mainstreaming cybersecurity in EU policies by embedding it in the future EU policy initiatives from the start, in particular with regard to new technologies and emerging sectors such as connected cars, smart grids and, more in general, the Internet of Things (IoT).

Both governments and the private sector have a significant role to play here. For this reason, the Commission is working with all relevant players to strengthen cybersecurity. Since the adoption of the EU cybersecurity Strategy in 2013, the European Commission has stepped up its efforts to better protect Europeans online. It has adopted a set of legislative proposals, specifically on network and information security, earmarked more than €600 mill. in EU investment for research and innovation in cybersecurity projects during the 2014-2020 period, and fostered cooperation within the EU and with global partners. Moreover, the EU Cybersecurity Strategy launched in 2013 established 5 priorities: increasing cyber resilience; drastically reducing cybercrime; developing EU cyber defense policy; developing the industrial and technological resources for cybersecurity; and establishing a coherent international cyberspace policy for the EU.

Following on from this strategy, several initiatives emerged from both the European Commission and the European Parliament.

A European Agenda on Security was launched by the European Commission in 2015, setting 3 priorities – terrorism, organized crime and cybercrime – and proposing, with regard to the latter, the following actions:

- placing renewed emphasis on the implementation of existing policies on cybersecurity, attacks against information systems, and combating child sexual exploitation;
- reviewing and possibly extending legislation on combatting fraud and counterfeiting of non-cash means of payments taking into account the newer forms of crime and counterfeiting of financial instruments;
- reviewing obstacles to criminal investigations on cybercrime, notably on issues of competent jurisdiction and rules on access to evidence and information;
- enhancing cyber capacity building action under external assistance instruments.

On 6 July 2016, within the Digital Single Market Strategy, a public-private partnership (PPP) on cybersecurity was signed by the Commission and the European Cyber Security Organization (ECSO), an industry-led association, which includes a wide variety of stakeholders such as large companies, SMEs and start-ups, research centers, universities, end-users, operators, clusters and associations as well as public authorities. The partnership is supported by EU funds from the Horizon 2020 Research and Innovation Framework Program (H2020) with a total investment of up to €450 mill. until 2020.

The goal of the partnership is to stimulate European competitiveness and help overcome cybersecurity market fragmentation through innovation and trust-building between member states and industrial actors as well as helping align the demand and supply sectors for cybersecurity products and solutions, by:

- gathering industrial and public resources to deliver innovation on a jointly-agreed strategic research and innovation roadmap;
- focusing on targeted technical priorities defined jointly with industry;
- maximizing the impact of available funds;
- providing visibility to European research and innovation excellence in cybersecurity.
- Finally, in July 2016, the Commission also adopted a Communication on Strengthening Europe's Cyber Resilience System and Fostering a Competitive and Innovative Cybersecurity Industry, including measures aimed at:
- stepping up cooperation across Europe, by encouraging member states to make the most of the cooperation mechanisms under the Network and Information Systems (NIS) Directive and to improve how they work together to prepare for a large-scale cyber incident – i.e.

working more on education, training and cybersecurity exercises;

- supporting the emerging single market for cybersecurity products and services in the EU (e.g. through the introduction of a certification framework and a labelling scheme), scaling up cybersecurity investment in Europe and supporting SMEs active in the market;
- establishing a contractual public-private partnership (PPP) with industry, to nurture cybersecurity industrial capabilities and innovation in the EU.

The European Parliament, on the other hand, adopted three measures in the last three-year period.

The first measure was the Regulation on Electronic Identification Authentication and Signature (EIDAS), entering into force on 17 September 2014 and applicable starting from July 2016, in the field of electronic identification and trust services for electronic transactions in the internal market. It provides a predictable regulatory environment to enable secure and seamless electronic interactions between businesses, citizens and public authorities. More specifically, it ensures that people and businesses can use their own national electronic identification schemes (eIDs) to access public services in other EU countries where eIDs are available and creates a European internal market for eTS – namely electronic signatures, electronic seals, time stamps, electronic delivery services and website authentication – by ensuring that they will work across borders and have the same legal status as traditional paper-based processes. It is only by providing certainty on the legal validity of all these services that businesses and citizens will use the digital interactions as their natural way of interaction.

This regulation provides for a predictable legal framework for people, companies (in particular SMEs) and public administrations to safely access services and carry out transactions online and across borders. Indeed, rolling out eIDAS means higher security and more convenience for any online activity such submitting tax declarations, enrolling in a foreign university, remotely opening a bank account, setting up a business in another member state, authenticating Internet payments, bidding on online calls for tenders, and so on.

In early 2016, the Parliament reformed the legal framework as regards data protection and issued the General Data Protection Regulation (GDPR), the aim being to protect all EU citizens from privacy and data breaches in an increasingly data-driven world that has become vastly different from when the 1995 Directive was first established (see Box 4 for a specific focus). Although the key principles of data privacy still hold true to the previous Directive, many changes have been proposed to the regulatory policies. These concern several issues:

1. increased territorial scope, by extending jurisdiction of the GDPR to all companies processing the personal data of data subjects residing in the Union, regardless of the company's location and regardless of whether the processing of personal data takes place in the EU or not;
2. penalties, up to 4% of annual global turnover or €20 mill., whichever is greater;

3. consent, where conditions have been strengthened and companies will no longer be able to use long illegible terms and conditions full of legalese, as the request for consent must be given in an intelligible and easily accessible form – with the purpose for data processing attached to that consent – using clear and plain language; in addition, it must be as easy to withdraw consent as it is to give it;
4. breach notification, that becomes mandatory, within 72 hours, in all member states where a data breach is likely to "result in a risk for the rights and freedoms of individuals";
5. right to access, i.e. the right for data subjects to obtain from the data controller confirmation as to whether or not their personal data is being processed, where and for what purpose. Furthermore, the controller shall provide a copy of the personal data, free of charge, in an electronic format, which dramatically increases data transparency and empowerment of data subjects;
6. right to be forgotten, entitling the data subject to have the data controller erase his/her personal data, cease further dissemination of the data, and potentially have third parties halt processing of the data. The conditions for erasure, as outlined in article 17, include data no longer relevant to original purposes for processing, or data subjects withdrawing consent;
7. data portability, i.e. the right for a data subject to receive personal data concerning them, which they have previously provided in a 'commonly use and machine readable format' and have the right to transmit that data to another controller;
8. privacy by design, calling for the inclusion of data protection from the onset of the designing of systems, rather than as an addition;
9. Data Protection Officers, who are mandatory only for those controllers and processors whose core activities consist of processing operations which require regular and systematic monitoring of data subjects on a large scale or of special categories of data. The introduction of this professional figure avoids controllers notifying their data processing activities with each local Data Protection

Box 2.4 Data protection in the digital society. The European GDPR framework

Society's digitalization, internet usage and IoT's deployment are producing a huge amount of data. In this context it's very important to set rules able to ensure an effective protection of personal data.
European institutions are aware of this requirement and the importance to create a trusted climate.
On April 27, 2016 the Parliament and the Council adopted the Regulation 2016/679 setting the rules on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, repealing Directive 95/46/EC (General Data Protection Regulation).

This Regulation recognizes that the protection of natural persons in relation to the processing of personal data is a fundamental right – even if it isn't an absolute right and it must be considered in relation to its function in society and be balanced against other fundamental rights, in accordance with the principle of proportionality – and to ensure a consistent and high level of protection of natural persons and to remove the obstacles to flows of personal data within the Union. The level of protection of the rights and freedoms of natural persons with regard to the processing of such data should be equivalent in all member states. Therefore, the Regulation's purpose is to contribute to establishing an area of freedom, security and justice and economic union, to economic and social progress, the strengthening and convergence of the economies within the internal market, and the well-being of natural persons.

This Regulation applies to the processing of personal data in the context of the activities of an establishment of a controller or a processor in the Union, regardless of whether the processing takes place in the Union or not, to the processing of personal data of data subjects who are in the Union by a controller or processor not established in the Union – where the processing activities are related to: (a) the offering of goods or services, irrespective of whether a payment of the data subject is required, to such data subjects in the Union; or (b) the monitoring of their behavior as far as their behavior takes place within the Union- and to the processing of personal data by a controller not established in the Union, but in a place where member state law applies by virtue of public international law.

The Regulation sets out some key principles on the processing of personal data and consent aspects. In particular, personal data shall be processed lawfully, fairly and in a transparent manner in relation to the data subject, collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes; adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed; accurate, kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the personal data are processed; and processed in a manner that ensures appropriate security of the personal data, including protection against unauthorized or unlawful processing and against accidental loss, destruction or damage, using appropriate technical or organizational measures.

Art. 6 sets the lawfulness of processing providing that processing shall be lawful only if and to the extent that at least one of the following applies: (a) the data subject has given consent to the processing of his or her personal data for one or more specific purposes; (b) processing is necessary for the performance of a contract to which the data subject is party or in order to take steps at the request of the data subject prior to entering into a contract; (c) processing is necessary for compliance with a legal obligation to which the controller is subject; (d) processing is necessary in order to protect the vital interests of the data subject or of another natural person; (e) processing is necessary for

the performance of a task carried out in the public interest or in the exercise of official authority vested in the controller; (f) processing is necessary for the purposes of the legitimate interests pursued by the controller or by a third party, except where such interests are overridden by the interests or fundamental rights and freedoms of the data subject which require protection of personal data, in particular where the data subject is a child. Point (f) of the first subparagraph shall not apply to processing carried out by public authorities in the performance of their tasks.
Art. 7, instead, sets the conditions for consent requiring that the controller shall be able to demonstrate that the data subject has consented to processing of his or her personal data and the request for consent shall be presented in a manner which is clearly distinguishable from the other matters, in an intelligible and easily accessible form, using clear and plain language. The same article identifies the right of the data subject to withdraw the consent at any time.
The Regulation fixes the information to be provided where personal data are collected from the data subject (art. 13) and where personal data have not been obtained from the data subject (14) and defines the rights of the data subject providing, in particular, the right of access by the data subject (art. 15)[19], the right to rectification (art. 16), the right to erasure ('right to be forgotten') (art. 17) and the right to restriction of processing (art. 18).
The right to erasure is the right of the data subject to obtain from the controller the erasure of personal data concerning him or her without undue delay. The controller shall have the obligation to erase personal data without undue delay where one of the following grounds applies: (a) the personal data is no longer necessary in relation to the purposes for which they were collected or otherwise processed; (b) the data subject withdraws consent on which the processing is based according to point (a) of Article 6(1), or point (a) of Article 9(2), and where there is no other legal ground for the processing; (c) the data subject objects to the processing pursuant to Article 21(1) and there are no overriding legitimate grounds for the processing, or the data subject objects to the processing pursuant to Article 21(2); (d) the personal data have been unlawfully processed; (e) the personal data has to be erased for compliance with a legal obligation in Union or member state law to which the controller is subject; (f) the personal data has been

19 Article 15 Right of access by the data subject
1.The data subject shall have the right to obtain from the controller confirmation as to whether or not personal data concerning him or her are being processed, and, where that is the case, access to the personal data and the following information: (a) the purposes of the processing; (b) the categories of personal data concerned; (c) the recipients or categories of recipient to whom the personal data have been or will be disclosed, in particular recipients in third countries or international organizations; (d) where possible, the envisaged period for which the personal data will be stored, or, if not possible, the criteria used to determine that period; (e) the existence of the right to request from the controller rectification or erasure of personal data or restriction of processing of personal data concerning the data subject or to object to such processing; (f) the right to lodge a complaint with a supervisory authority; (g) where the personal data are not collected from the data subject, any available information as to their source; (h) the existence of automated decision-making, including profiling, referred to in Article 22(1) and (4) and, at least in those cases, meaningful information about the logic involved, as well as the significance and the envisaged consequences of such processing for the data subject.

collected in relation to the offer of information society services referred to in Article 8(1).
Art. 20 sets out the right to data portability, another very important right, providing that the data subject shall have the right to receive the personal data concerning him or her, which he or she has provided to a controller, in a structured, commonly used and machine-readable format and has the right to transmit that data to another controller without hindrance from the controller to which the personal data has been provided under certain circumstances provided for by the Regulation.
The same Regulation defines the responsibility of the controller introducing a very important rule, the *"data protection by design and by default"* providing that taking into account the state of the art, the cost of implementation and the nature, scope, context and purposes of processing as well as the risks of varying likelihood and severity for rights and freedoms of natural persons posed by the processing, the controller shall, both at the time of the determination of the means for processing and at the time of the processing itself, implement appropriate technical and organizational measures, such as pseudonymization, which are designed to implement data-protection principles, such as data minimization, in an effective manner and to integrate the necessary safeguards into the processing in order to meet the requirements of this Regulation and protect the rights of data subjects. The controller shall implement appropriate technical and organizational measures for ensuring that, by default, only personal data which is necessary for each specific purpose of the processing is processed. That obligation applies to the amount of personal data collected, the extent of processing, the period of storage and accessibility. In particular, such measures shall ensure that by default personal data is not made accessible without the individual's intervention to an indefinite number of natural persons (art. 25).
The Regulation also encourages the drawing up of codes of conduct (art. 40) and the establishment of data protection certification mechanisms and of data protection seals and marks, for the purpose of demonstrating compliance with its rules of processing operations by controllers and processors (art. 42). It sets the rules on the transfers of personal data to third countries or international organizations introducing the principle of "adequacy" of the level of protection(art. 45), defines the features of the international cooperation for the protection of personal data (art. 50) and of the independent supervisory authorities (art. 51-59), encourages the cooperation between the lead supervisory authority and the other supervisory authorities concerned (art. 60-67), institutes the European Data Protection Board (art. 68) fixing its jurisdiction and powers and sets remedies, liability and penalties (artt. 77-84).
On January 10, 2017 the European Commission submitted a proposal for a Regulation on the processing of personal data and the protection of privacy in the electronic communications sector and repealing Directive 2002/58/EC

(Regulation on Privacy and Electronic Communications).
These measures aim to update current rules, extending their scope to all electronic communication providers, to create new possibilities to process communication data, reinforce trust and security in the Digital Single Market and align the rules for electronic communications with the new world-class standards of the EU's General Data Protection Regulation.
The Commission's proposal, in particular, provides for the extension of privacy rule applicability to new providers of electronic communications services (such as WhatsApp, Facebook, Messenger, Skype, Gmail, iMessage, or Viber), stronger rules to ensure that all people and businesses in the EU will benefit from one single set of rules, the same protection for communications content and metadata, more opportunities for operators to use data and provide additional services, simpler rules on cookies (no consent is needed for non-privacy intrusive cookies improving Internet experience), protection against spam banning unsolicited electronic communication by any means and more effective enforcement setting the enforcement of the confidentiality rules in the Regulation on the responsibility of national data protection authorities.

Authorities (DPAs), with only internal record keeping requirements.

Furthermore, on 6 July 2016, the Directive on security of network and information systems (NIS) was adopted. It provides legal measures to boost the overall level of cybersecurity in the EU by ensuring:

- member states preparedness by requiring them to be appropriately equipped, e.g. via a Computer Security Incident Response Team (CSIRT) and a competent national NIS authority;
- cooperation among all member states, by setting up a cooperation group, in order to support and facilitate strategic cooperation and the exchange of information among member states. They will also need to set a CSIRT Network, in order to promote swift and effective operational cooperation on specific cybersecurity incidents and sharing information about risks;
- a culture of security across sectors which is vital for our economy and society and, moreover, relies heavily on ICTs, such as energy, transport, water, banking, financial market infrastructures, healthcare and digital infrastructure. Businesses in these sectors that are identified as operators of essential services will have to take appropriate security measures and to notify serious incidents to the relevant national authority. Also key digital service providers (search engines, cloud computing services and online marketplaces) will have to comply with the security and notification requirements under the new Directive.

In his annual State of the Union Address on 13 September

2017, the President of the EU Commission, Jean-Claude Junker, revealed the EU roadmap to fight cyber threats and to improve the ability of member states to respond quickly and efficiently to cyber attacks. There are two pillars of the COM(2017) 477 aimed at considerably reducing the exposure of EU institutions, enterprises and citizens to cyber-crimes.

The first proposal is to strengthen the EU Cybersecurity Agency, giving the existing European Agency for Network and Information Security (ENISA) more tasks and resources to improve coordination and cooperation across member states and EU institutions, agencies and bodies. The Agency should build a common strategy to improve capabilities and expertise, for instance on the prevention of and response to accidents and attacks and makes an important contribution to cooperation within the framework of Computer Security Incident Response Teams (CSIRTs).

The second pillar is represented by the proposal for a common certification framework to ensure that products and services are cyber secure. Just as food or energy labels, the EU cybersecurity certificates will ensure the trustworthiness and quality of the billions of IoT connected devices and related digital services that will be market ready in the near future. Cybersecurity certificates will be recognized across member states, thereby cutting down on the administrative burdens and costs for companies and consumers.

PART 3

DIGITAL MEDIA AND ENERGY CONSUMERS

3. DIGITAL MEDIA AND ENERGY CONSUMERS

3.1. INTERNET USE AND DIGITAL SKILLS IN EUROPE

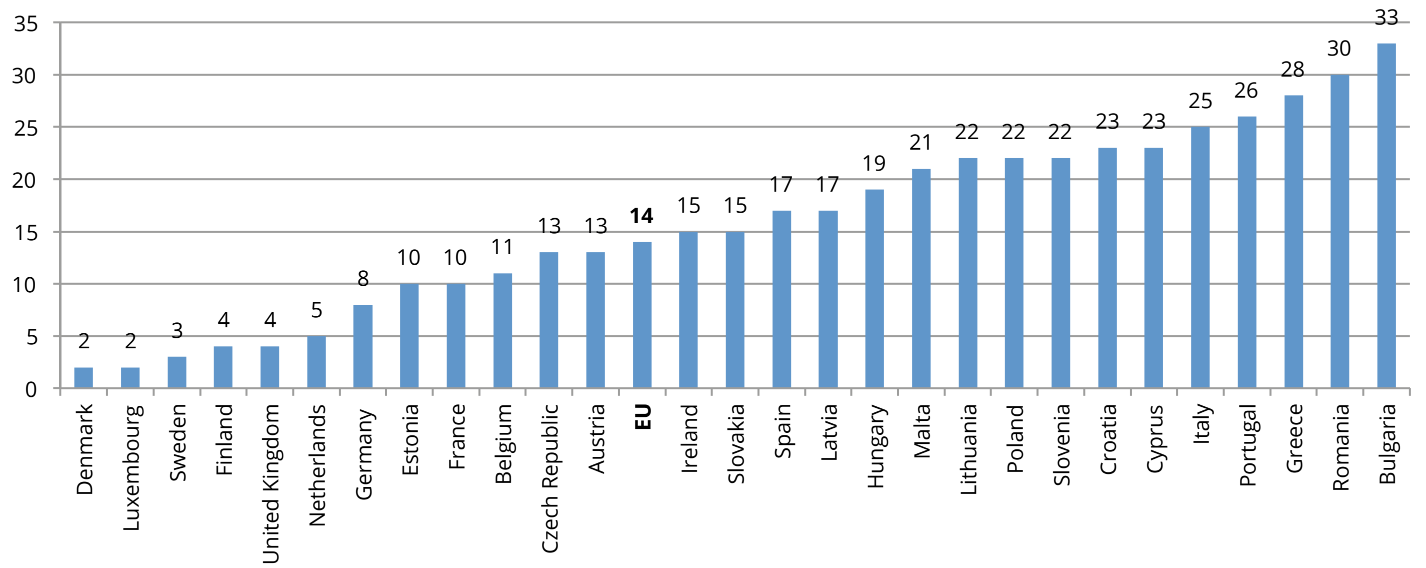
Internet and digital technologies are revolutionizing our lives, transforming traditional communication techniques, research, exchange of information and goods and service purchases. In fact, the network is becoming the privileged place where people communicate, search for information, buy goods and services, interact with public administrations and conclude transactions.

Each socio-economic field and each national context is taking on these new challenges to seize on digital opportunities and as well, to deal with potential weaknesses connected to the digital revolution. Focusing on the European context, data shows that in the different member states EU citizens and companies have a different level of computer skills and, more generally, a different sensitivity to the advent of the digital age, so they access available digital services with different intensity and interest.

In particular, the following figures and sections describe Internet usage, skills and digital service penetration in the EU underlining that the Northern Europe leads in the field of digitization.

Fig. 3.1 % of individuals who never used the Internet in 2016

Source: I-Com elaboration on Eurostst data



Regarding Internet usage by individuals, in 2016, the best performers were Denmark and Luxembourg (2%), Sweden (3%), Finland and the United Kingdom (4%) where only a tiny percentage of individuals didn't use the Internet. The worst results, on the other hand, are registered in Bulgaria, Romania and Greece, where the percentage of individuals never accessing the Internet in 2016 was 33%, 30% and 28%, respectively (Fig. 3.1). Also relative to daily Internet use, Luxemburg and Denmark registered the best performance with 93% and 89% of individuals accessing the Internet in 2016 (Fig. 3.2).

There is a reverse relationship between age and internet usage. In fact, analyzing EU data, younger people are more inclined to use Internet (97% of 16-24 year olds, 96% of 25-34, 93% of 35-44) while older people – due the lack of skills and digital culture and different habits – reveal more difficulties (86% for 45-54 year old group, 72% for 55-64 and 51% for 65-74). This is a general trend that, however, is weaker in the more digitally mature nationalities. In fact, in Denmark and Luxembourg, 97% and 95% of people aged between 55 and 64 years and 87% and 91% of those aged 65-74 used the Internet in 2016 (Fig. 3.3).

Fig. 3.2 % of individuals who accessed the Internet daily in 2016

Source: I-Com elaboration on Euroststdata

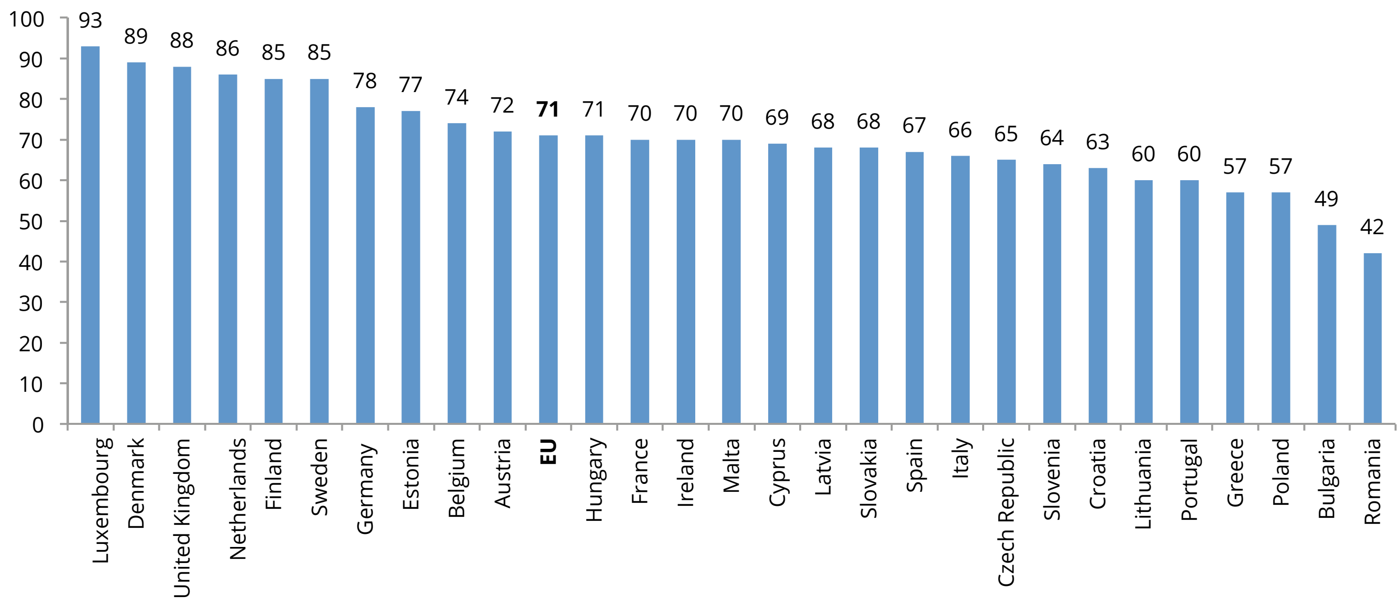


Fig. 3.3 Internet usage in the last 12 months – age bracket 2016 (% of individuals)

Source: I-Com elaboration on Eurostst data

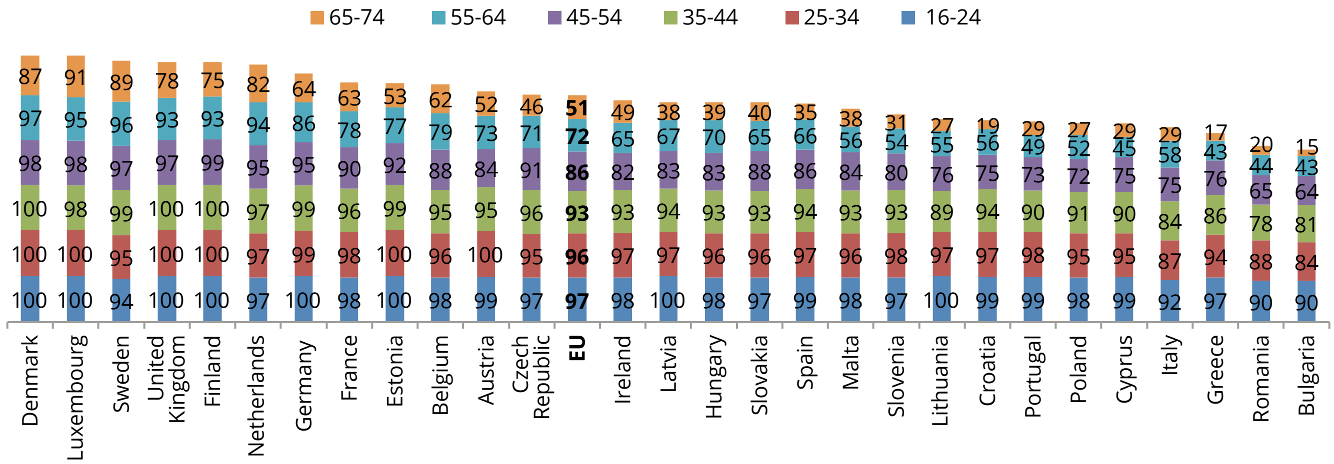
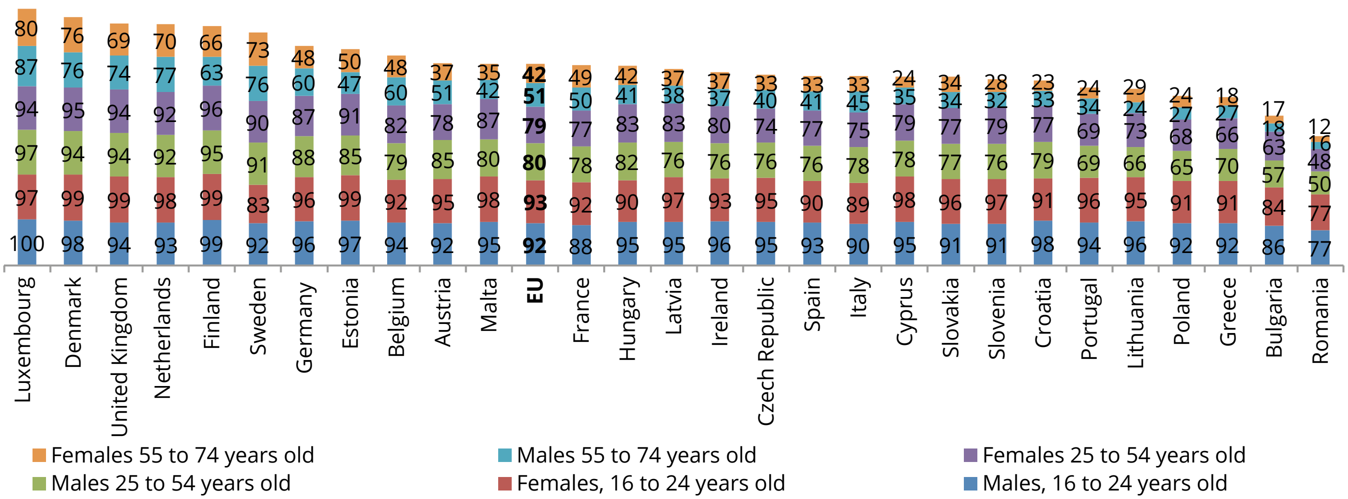


Fig. 3.4 Internet access on a daily basis (% of males and females) – 2016

Source: I-Com elaboration on Eurostst data



Analyzing Internet access by gender, the data shows that in 2016 there was no gender difference in Internet access at a European level. In fact, in each age range access percentages are similar (only for individuals aged from 55 to 74 years was there a difference of 9% – (males 52%, females 42%) (Fig. 3.4).

Countries with the highest percentages of Internet usage are also those where the highest percentages of households connected to the Internet and individuals having above basic digital skills. In fact, in Luxembourg and the Netherlands, Denmark and Sweden and United Kingdom 97%, 94% and 93%, respectively, of households are connected to the Internet (Fig. 3.5) and in Luxembourg, Denmark and Netherlands, 54%, 53% and 45% of individuals have digital skills above average (Fig. 3.6).

Analyzing the various activities carried out online, at a European level, the most popular are the sending and receiving of emails (71% of individuals) and the search for information about goods and services (66%), followed by participation in social networks and phone calls or video calls that concerned 54% and 32% of Europeans respectively in 2016 (Fig. 3.7).

Fig. 3.5 Level of internet access (% of households)

Source: I-Com elaboration on Eurostst data

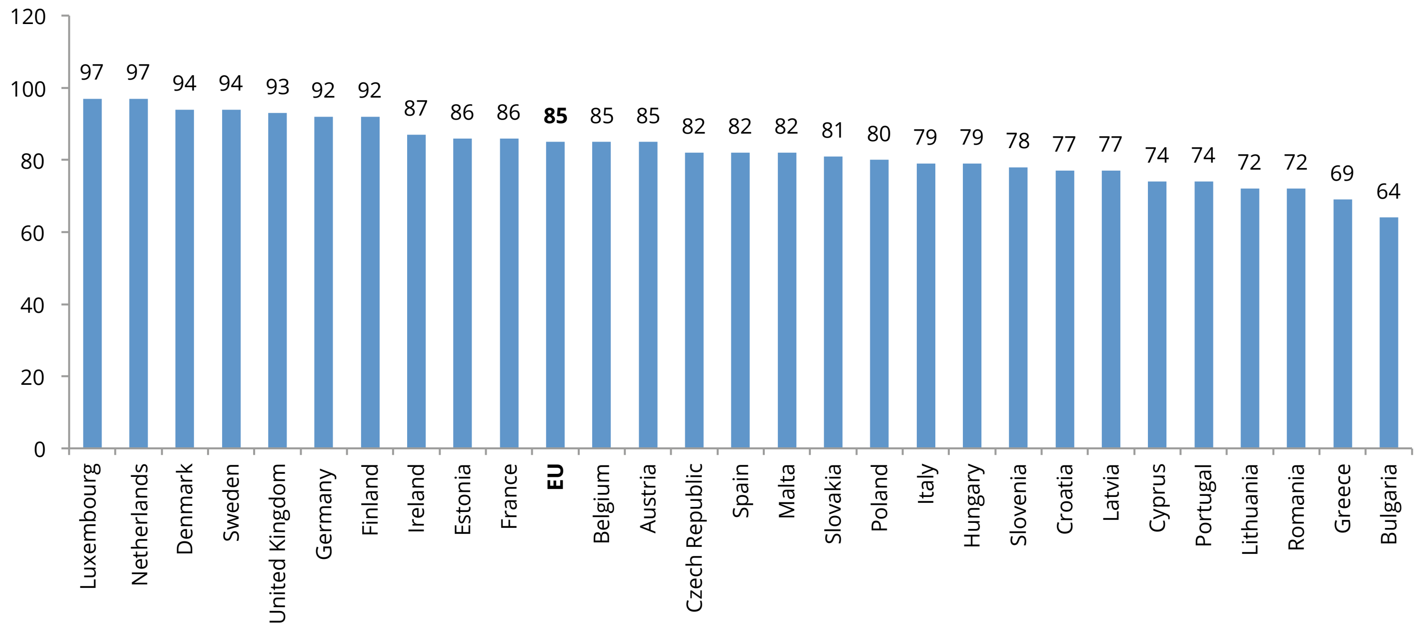


Fig. 3.6 Individuals' level of digital skills (% of individuals)

Source: I-Com elaboration on Eurostst data

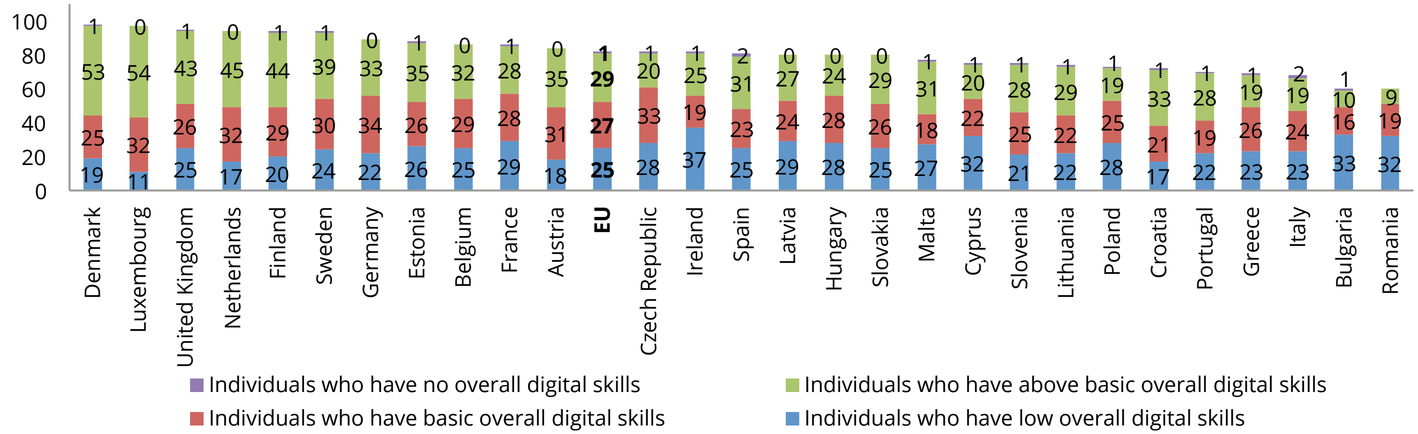
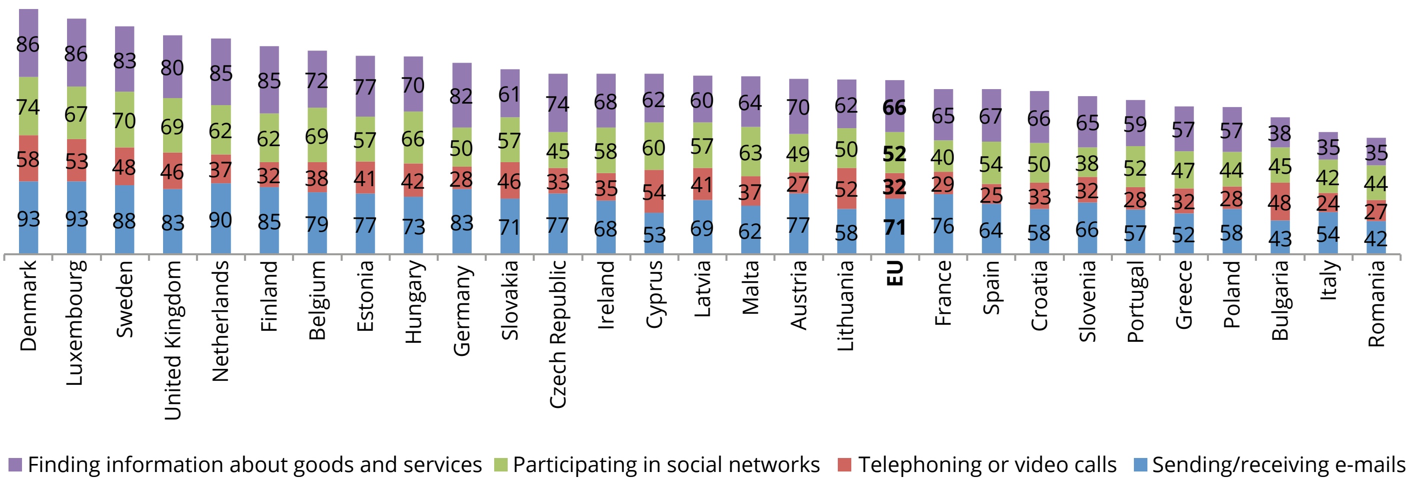


Fig. 3.7 Internet use and activities (% of individuals)

Source: I-Com elaboration on Eurostst data



3.2. DIGITAL SERVICE PENETRATION IN EUROPE. SOCIAL NETWORKS, E-COMMERCE AND INTERNET BANKING IN CITIZEN HABITS AND ENTERPRISE BUSINESS

Among the digital services, it is interesting to analyze social networks. Regarding social network penetration, the report, Digital in 2017, highlights that more than 2.8 billion people use social channels at least once a month, and + 91% of them using mobile devices. Facebook is the most widely used platform with 1.871 billion users (Fig. 3.8). More than a third of the world's population access mobile social platforms (2.5 billion people, +581 million compared to 12 months ago).

Also in Europe, citizens are quite active on social networks. 52% of European citizens, in fact, used the Internet for participating in social networks in 2016. Northern Europe shows the best performance – in Denmark, Sweden, Belgium and the United Kingdom, the percentage of individuals accessing the Internet to participate in social networks was 74%, 70% and 69%, respectively. The worst results are registered by Italy, France and Slovenia, where the percentage of individuals was 42%, 40% and 38%, respectively (Fig. 3.9).

At a European level – but also in individual countries – the highest percentage concerns the younger age groups, and in particular, individuals aged between 16 and 24, 25 and 34, 35 and 44 (Fig. 3.10).

Connected to the search for online information, is the online purchase of goods and services.

Fig. 3.8 Active users of key global social platforms – January 2017 (mill.)

Source: Digital in 2017, We Are Social

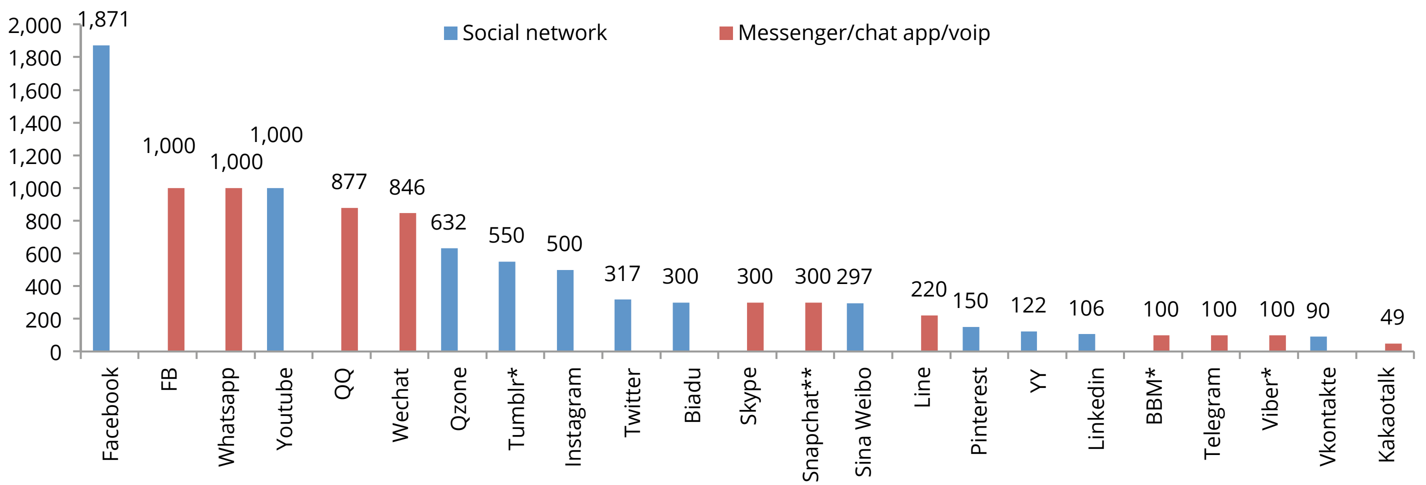


Fig. 3.9 Individuals using the Internet to participate in social networks – 2016 (% of individuals)

Source: I-Com elaboration on Eurostst data

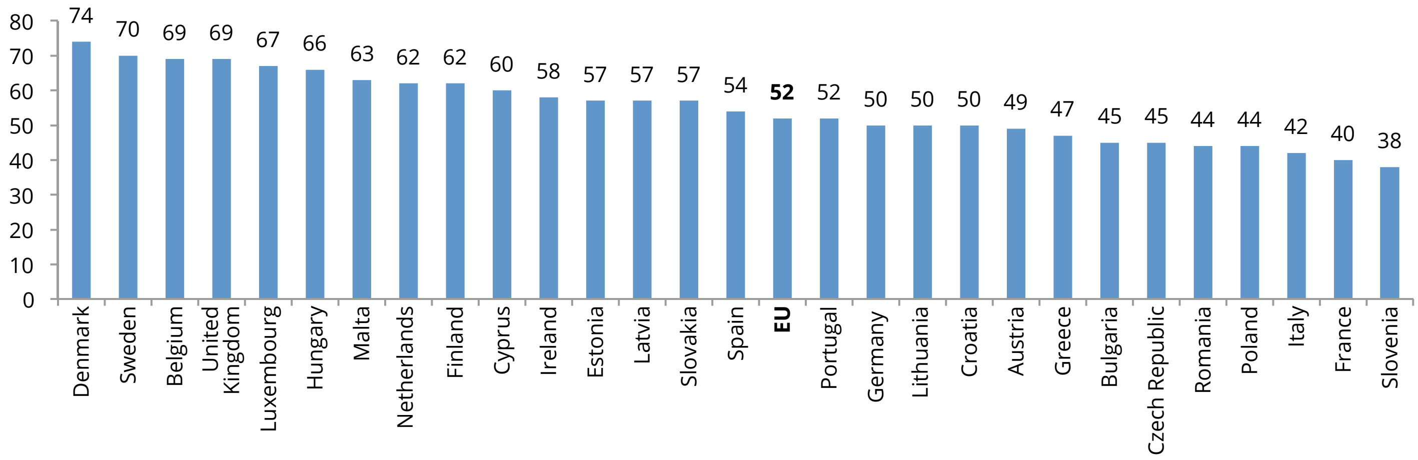
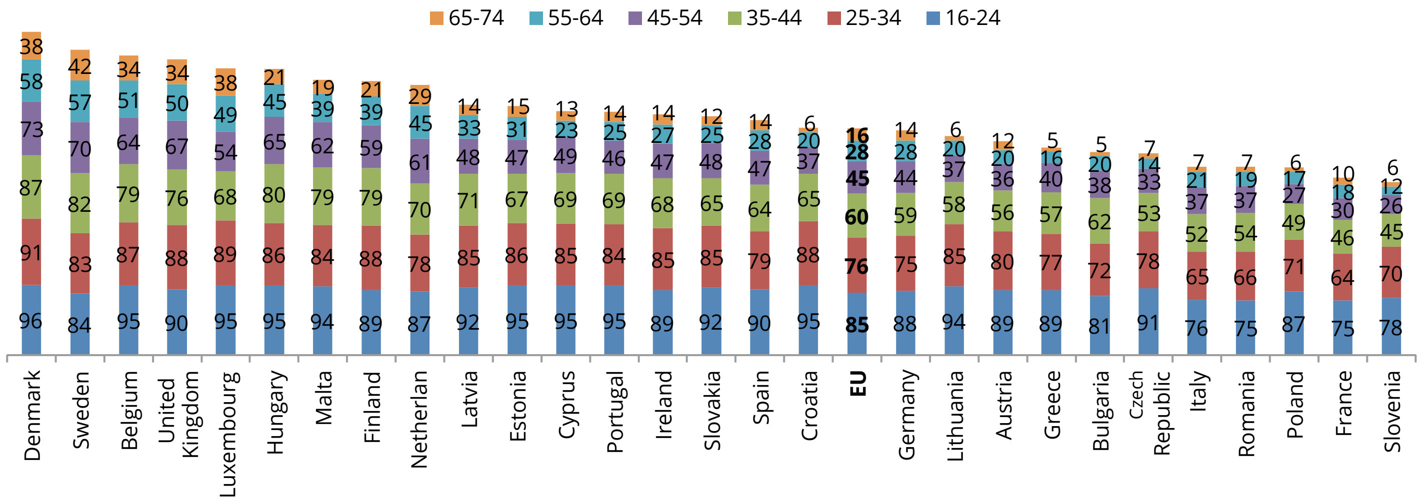


Fig. 3.10 Internet use: participating in social networks – age bracket 2016 (% of individuals)

Source: I-Com elaboration on Eurostst data



E-commerce rates vary greatly from country to country, from 12% in Romania to 83% in the United Kingdom (Fig. 3.11).

The individuals aged between 25 and 34 years are more active in online shopping, with European data showing that 72% of individuals aged between 25 and 24 years bought goods or services online in 2016 (Fig. 3.12).

Analyzing male and female online purchases, in 2016, there was no big difference between them. At European level in each age bracket – with the exception of individuals aged from 55 to 74 years – males and females show the same interest in online purchases (Fig. 3.13).

For types of purchases, sporting goods and clothing primarily concern Europeans (34%), followed by travel and holiday accommodation (29%) and event tickets (21%) (Fig. 3.14).

Where problems encountered by individuals are concerned when buying/ordering over the Internet, delivery costs or final price higher than indicated, wrong or damaged good/services delivered, problems with fraud, difficult complaints and redress or no satisfactory response were some difficulties underlined by individuals (Fig. 3.15). The percentage is quite low at a European level – and also in member states – demonstrating that e-commerce works well.

For e-commerce, it is very interesting to analyze its impact

Fig. 3.11 Internet users who bought or ordered goods or services for private use over the Internet in the previous 12 months (% of individuals)

Source: I-Com elaboration on Eurostst data

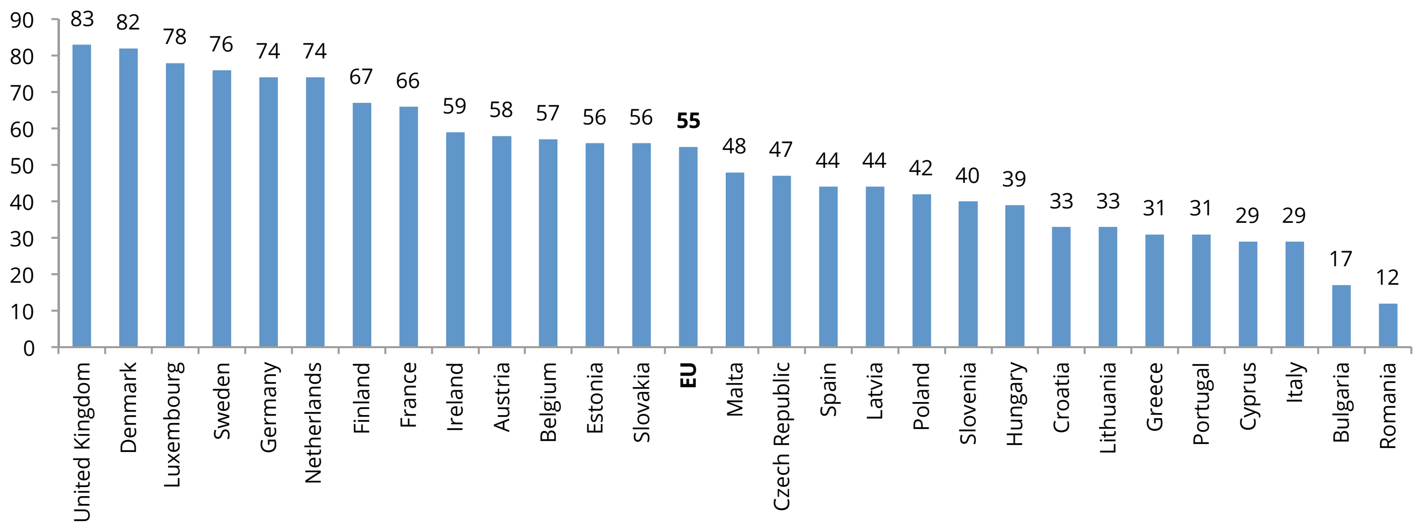


Fig. 3.12 Online purchases – age bracket (2016)

Source: I-Com elaboration on Eurostst data

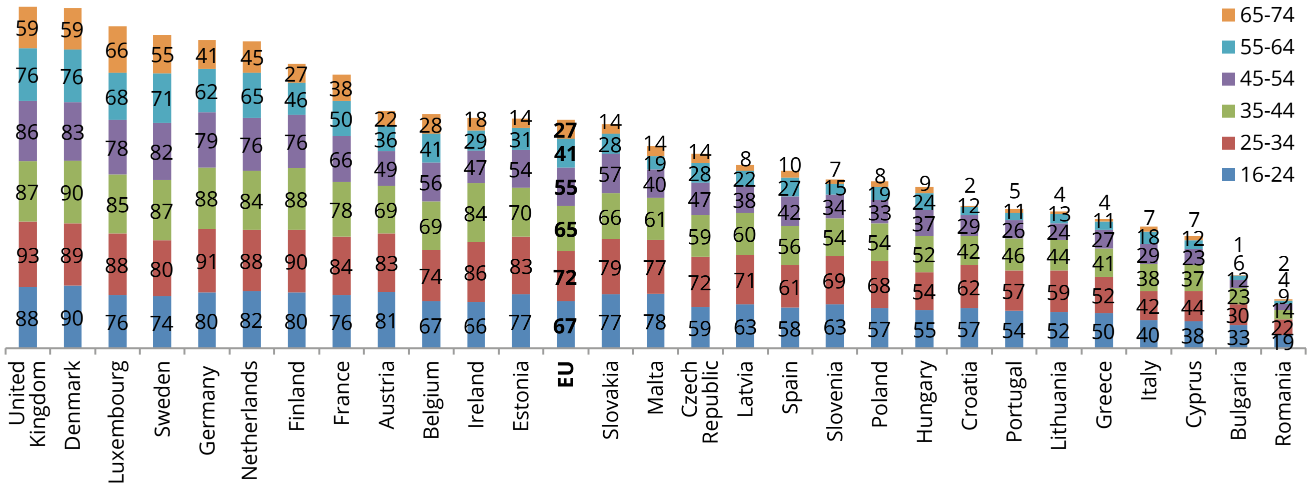


Fig. 3.13 Males and females online purchases (2016)

Source: I-Com elaboration on Eurostst data

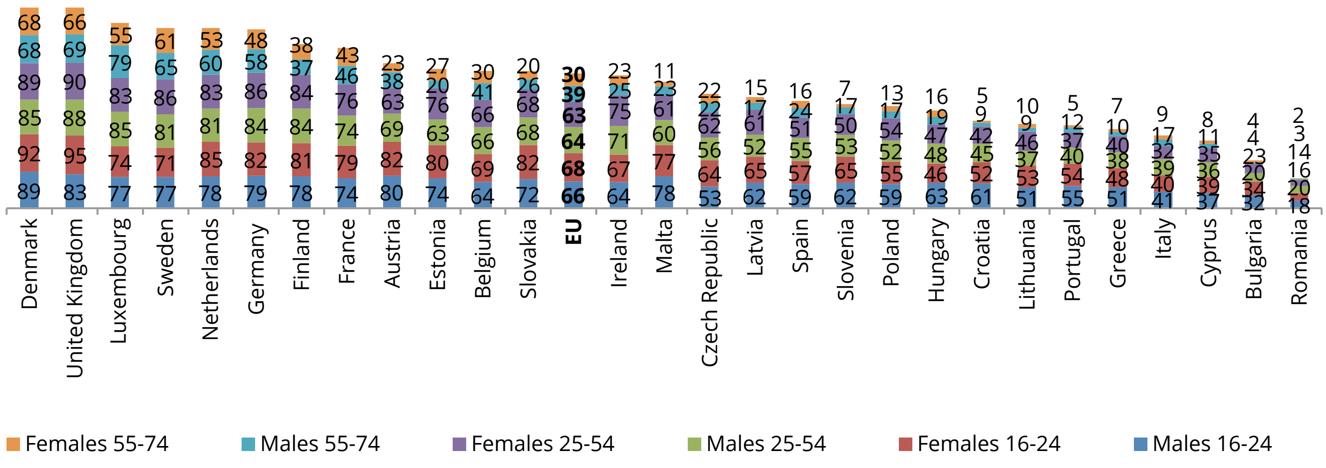


Fig. 3.14 Online purchases (2016)

Source: I-Com elaboration on Eurostst data

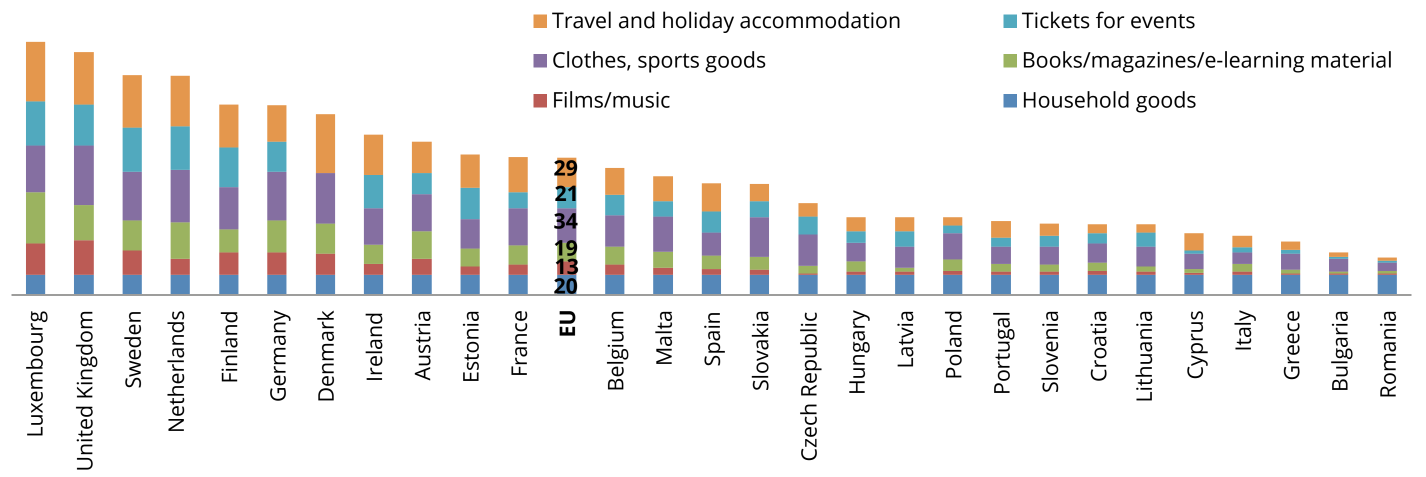


Fig. 3.15 Online purchases: problems encountered by individuals (2016)

Source: I-Com elaboration on Eurostst data

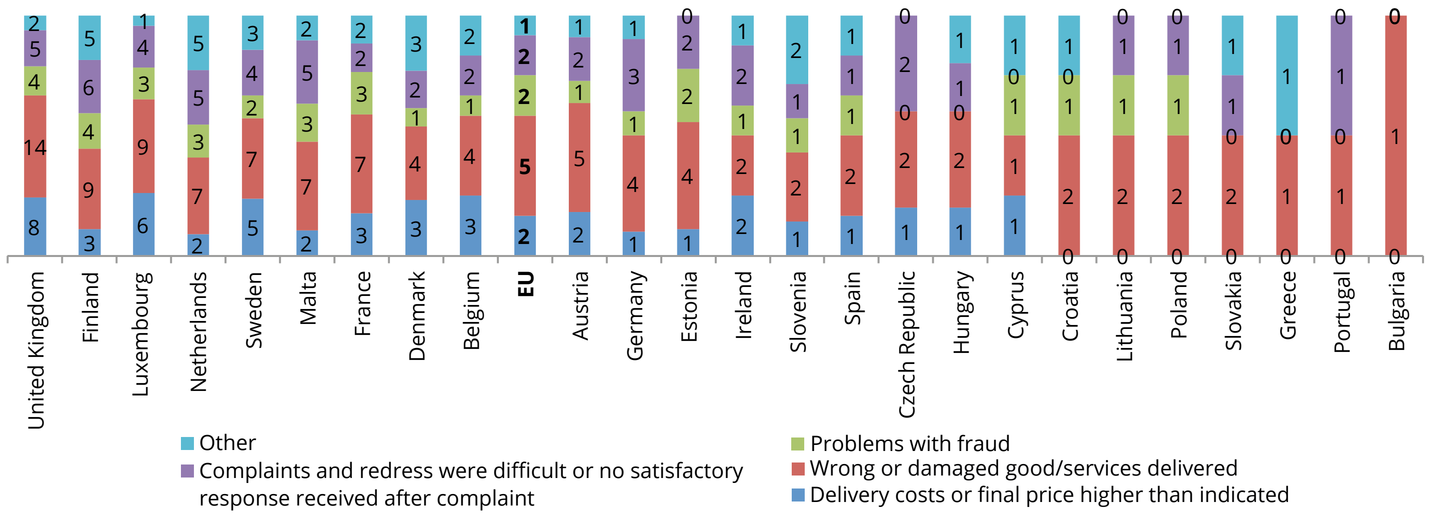
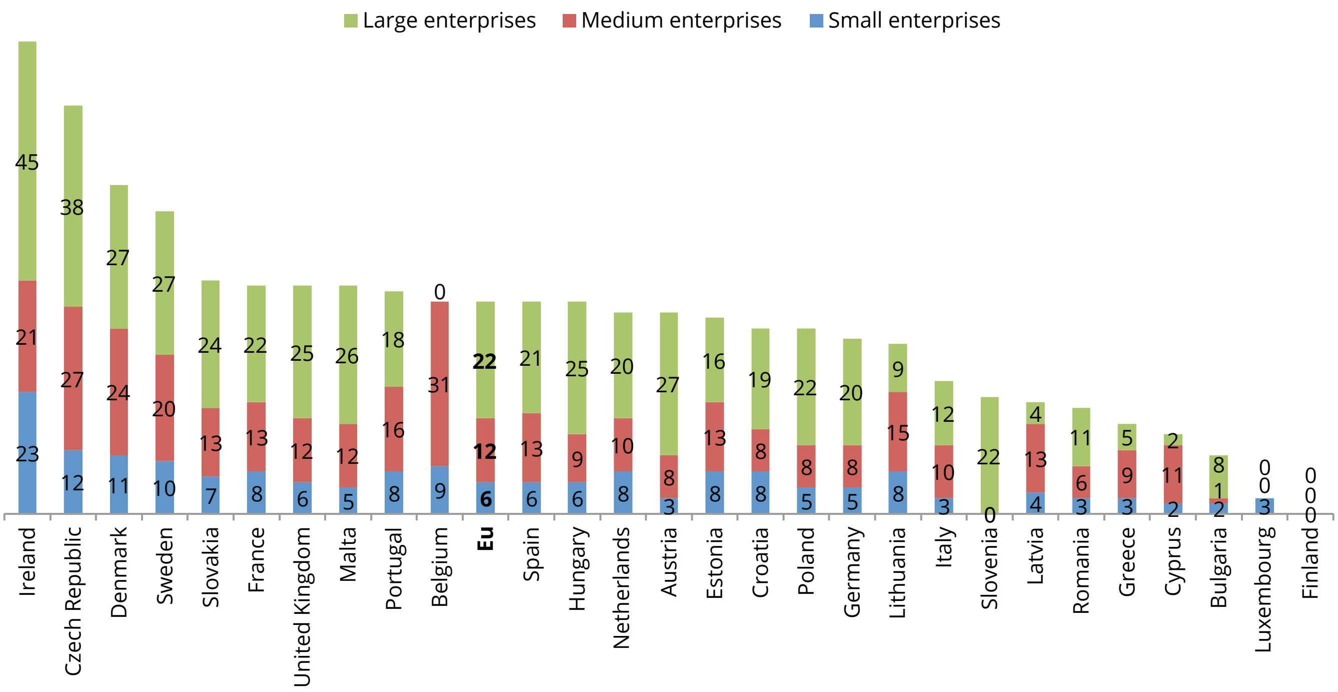


Fig. 3.16 Total enterprise turnover from e-commerce (2016)

Source: I-Com elaboration on Eurostst data



on total enterprise turnover in Europe. The data shows that especially large enterprises, having more resources to invest in digital canals and being more aware of e-commerce opportunities, benefit from e-commerce (22%). In this regard, Ireland is the most advanced country with 45% of Irish large enterprise turnover being due to e-commerce (Fig. 3.16).

As far as the spread Internet banking in Europe is concerned, the best performer is Denmark with 88% of individuals using Internet banking in 2016, followed by Finland (86%) and the Netherlands (85%), instead, the lowest percentages were registered in Greece, Romania and Bulgaria,19%, 5% and 4%, respectively (Fig. 3.17).

The most relevant age groups are, in general, 25-34 year olds and 35-44 year olds. The best performers are Denmark, Finland and the Netherlands, the worst, Greece, Romania and Bulgaria (Fig. 3.18).

Fig. 3.17 Individuals accessing Internet banking in 2016 (% of individuals)

Source: I-Com elaboration on Eurostst data

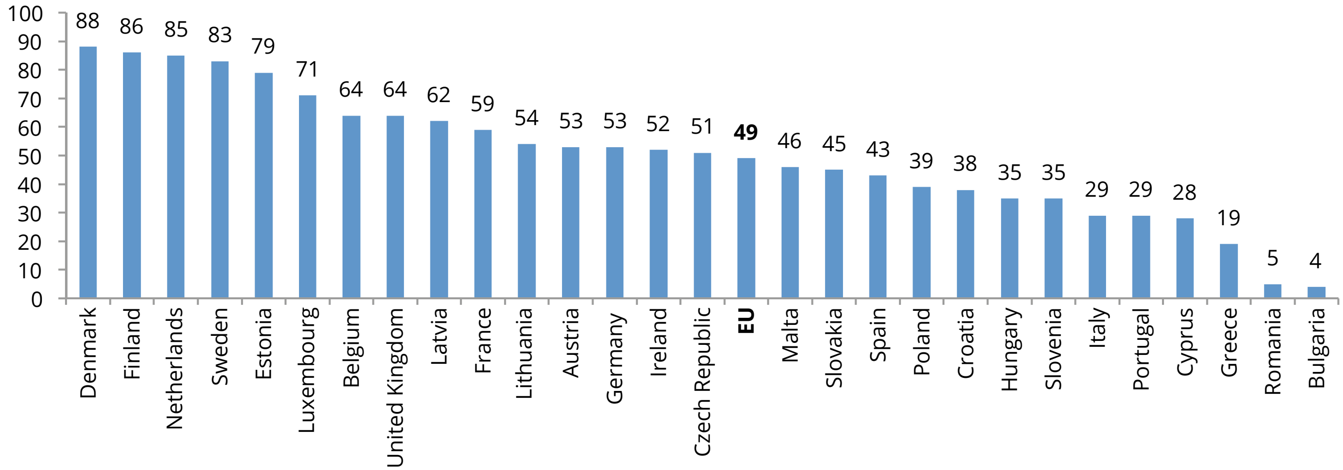
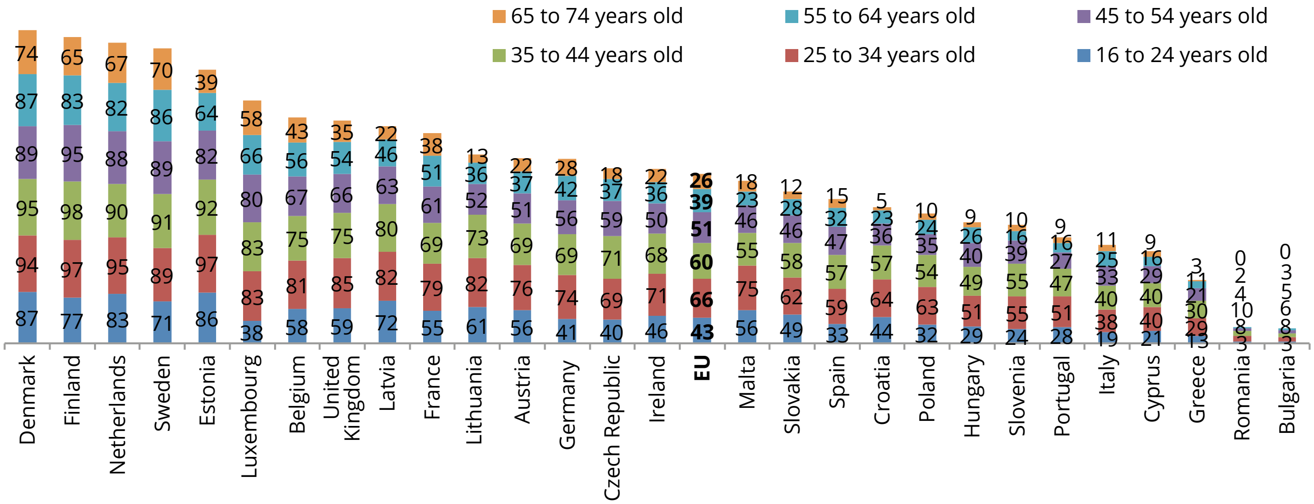


Fig. 3.18 Individuals accessing Internet banking in 2016 – age bracket (% of individuals)

Source: I-Com elaboration on Eurostst data

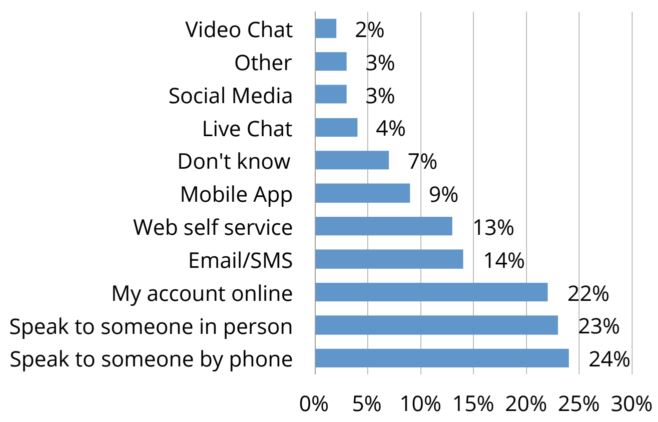


3.3. DIGITIZING ENERGY CONSUMERS

Digitalization has reshaped the customer's view. On the one hand, customers embrace innovative technologies and take on new roles as both buyers and sellers of energy. On the other hand, they expect, high-quality products, more tailored experiences, 24/7 services and more digital access. The Internet, smart technologies and connected home appliances have changed energy systems. The new energy model should be more focused on the customer. Although the opportunities and challenges vary across regions, all providers should reformulate their strategies for understanding, reaching and engaging energy consumers. As mentioned above, the conventional energy customer, who only consumes electricity, and the traditional provider, who mostly sells kilowatt hour, is an obsolete model. Digitalization has disrupted customer service delivery, as well as product and service development, and customers are now more demanding. Currently, also in the energy sector, consumers are going digital for service, for comparing and switching providers. Energy providers should shift to services, because some private and commercial customers will want to produce independently a share of their own energy.

Fig. 3.19 Consumer preferred communications channel with businesses (2016)

Source: I-Com elaboration on Verint data



According to the Verint survey[20], thanks to the growing number of digital communication and social media tools, the demand for customers to communicate with businesses through multiple channels has grown. Even though, today customers consider email and company websites as basic level service channels, the most popular options to interact with companies are picking up the phone (24%) and going in store (23%), followed by online accounts (22%) and emails (14%). Despite the huge popularity of the social media communication channels, Facebook and Twitter are not among the preferred customer options with only 3% of consumers expressing a preference for these types of contacts (Fig. 3.19).

On investigating the specific sectors, online platforms are more popular with banks and credit card providers. The telephone is preferred in the insurance sector, home telephones, broadband and cable, as well as electricity, gas and water companies.

20 The research was conducted from July to September 2016, interviewing 24,001 consumers in the following countries: Australia (2,000), Brazil (2,000), India (2,000), France (2,000), Germany (2,000), Japan (2,000), Mexico (2,000), Netherlands (2,000), New Zealand (2,000), South Africa (2,000), UK (2,001) and US (2,000).

In the new scenario, energy management will become an essential topic for many companies. Accenture tracked consumers' interest in value-added products and services. What emerges from the 2015 survey is the general attention to the potential (energy and money)saving. In fact, 76% of digital users and 57% of non-digital users are interested in products and materials to make simple improvements in their own homes in order to save electricity; 72% of digital users and 53% of non-digital users are interested in home energy audits to identify opportunities to save electricity. Moreover, 70% of digital users and 48% of non-digital are interested in devices or services to automate home energy management based on customer preferences.
In the new model to be defined, consumer trust and satisfaction is increasingly a key factor of success.

Fig. 3.21 Consumer trust in utilities/energy providers (% of respondents)

Source: I-Com elaboration on Accenture data

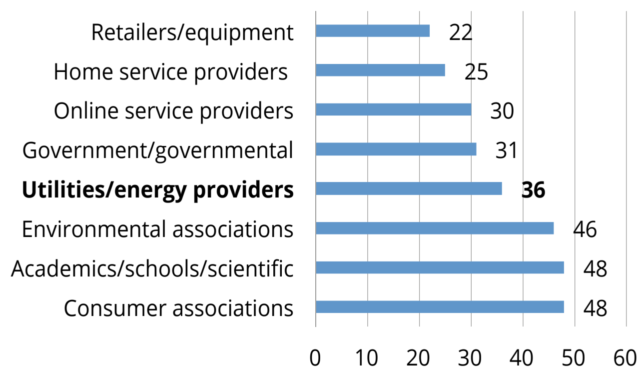
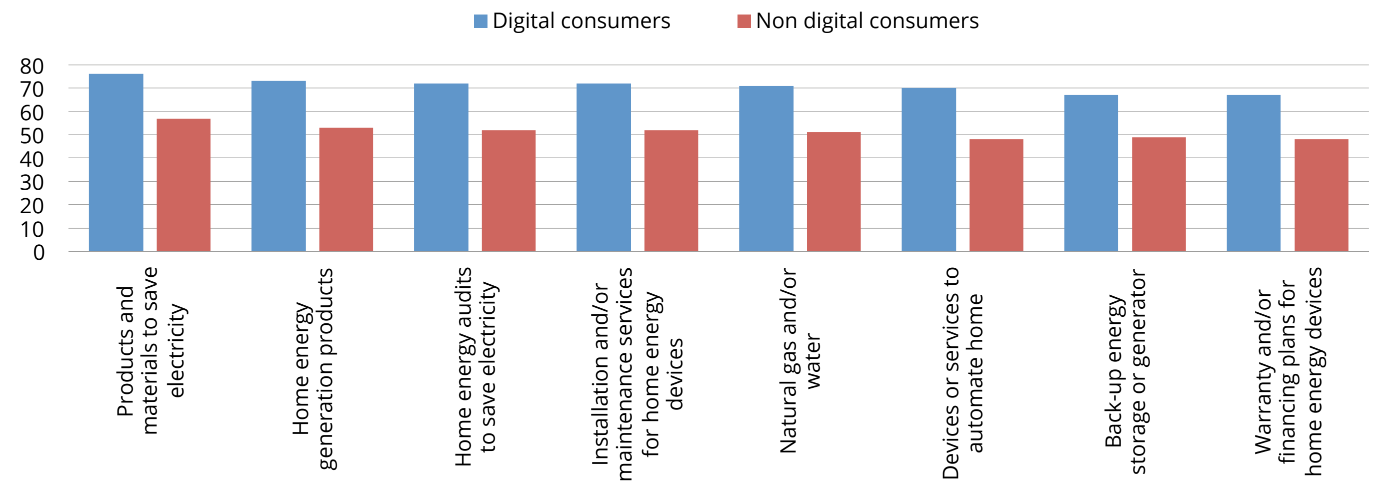


Fig. 3.20 Consumers interested in energy-related products or services (%, 2015)

Source: I-Com elaboration on Accenture data



Accenture's research also shows that energy providers are landmarks in terms of customer trust related to information about energy consumption optimization (Fig. 3.20). In 2015, 36% of the survey respondents trusted in energy providers in order to optimize energy consumption. With reference to the other organizations, energy providers ranked third, following consumer associations and academic bodies/schools/scientific associations (48%), and environmental associations (46%). Trust could be a valuable asset providing strategic advantages over new market entrants. Moreover, energy providers could be potential strategic partners for retailers, equipment manufacturers and other home service providers that have lower levels of consumer trust.

Box 3.1 The Italian energy data platform (by Acquirente Unico)

With the full opening-up of the electricity and natural gas markets, the number of operators involved in the switching process increased from a few dozen to about 1,000 among distributors, traders, sellers, etc.

Indeed, every single operator was using its own system for managing their processes, with around 350 different standards working together. Therefore, a major communication issue arose between distributors and suppliers. In particular, the most relevant problems were:

- unavailability or incompleteness of consumer identification data;
- potential anti-competitive behaviors by vertically-integrated distributors.

In order to address these criticalities, in 2010, Italian legislation assigned to Acquirente Unico the design, development and operation of an Integrated Information System (Sistema Informativo Integrato – SII) – a tool devoted to foster transparency and competition in the electricity and natural gas retail market.

Functioning

The system is a set of technological infrastructures and technical rules for sharing, integrating and exchanging data and supporting the processes associated with the functioning of electricity and gas markets. The main purpose of this infrastructure is the following:

- ensure uniformity of treatment for all operators;
- certify and guarantee data flows, permitting the correct execution of the related market activities;
- allow simplification of processes and costs reduction for operators and, therefore, for consumers;
- monitor the compliance of processes with a direct impact on the consumers;
- strengthen the unbundling process.

The Integrated Information System facilitates the exchange of data flow among distributors and sellers, thus making the switching process more efficient and swift (from an average 3 months to the 3 weeks envisaged in Directive 2009/72, with current technology capable to shrink it up to 1 day). The System activities also reduce entry barriers for new suppliers, creating a level playing field in the complex energy markets.
Moreover, the essential development from hundreds of standards of communication to one common standard allowed suppliers to save a significant amount of money.
The added value of the SII regards the neutrality and openness of the infrastructure: standards and workflows have been shared with operators, thus allowing for identify clearly responsibilities of all parties.
SII is not just a technological infrastructure, but something with a wider scope and complexity – it is a focal point of connection for the several systems in the market.
Among the activities processed, we can count flows of around 20 billion metering data to the actors of the sector; aggregation of metering data for settlement; supply transfer and, of course, switching. The System indeed is in charge of collecting and managing metering data of all customers.
The potential for using this database for a wider scope has already been exploited by the Authority. Due to the SII, now the National Regulatory Authority, it has the ability to better control the whole energy system, so to foster the monitoring of activities and preventing market abuses. There is a wide range of opportunities to exploit the SII for the advantage of customers.

What's next?
The current activities of this System have already improved market functioning, as is the case of switching processes.
Italy is currently undergoing a smart meter replacement plan, the objective being to replace current first-generation smart meters with more technologically advanced ones (2G). The deployment of new smart meters will allow a daily meter reading for billing, with a reading content of 96 quarter-hours per day. Availability of data, thanks to the System, will empower consumers to fully understand their consumption path, thus allowing them to be active market players and shape the offers according to their needs. Furthermore, this data will enable authorities to better shape energy policies, e.g. for supporting vulnerable consumers.
In order to strengthen the System's role in the energy markets, Energy Authority and the Government are already cooperating for a balanced development. In such a context, the task of SII is to represent a driver of change, creating opportunities for both suppliers and customers to enjoy a more functional market

3.4. WHAT DIGITALIZATION MEANS IN THE ENERGY SECTOR

As for the power sector, the digital revolution has changed market dynamics and the business model. Due to the disruptive technologies such as increasingly cheaper solar technology, storage systems and improved smart grids, the historical trends can no longer be applied. A large variety of new opportunities are now (and more increasingly in the future) available to companies and consumers. From fundraising to final payment through the provision and the exploitation of services, all of these phases could benefit from digitalization.

Demand Response

Natural variations in energy needs and the intermittent supply of specific renewable sources can make the integration of renewable energy in power systems difficult. Adopting an active behavior, energy consumers can contribute to keeping the network in balance in a context characterized by a growing variable production share. Indeed, a better balance between supply and demand can support grid management and maintenance, leading to a reduction in energy infrastructures and backup generation.

In this context all flexibility models such as demand flexibility, distributed energy sources and storage are becoming increasingly important and require a strong and close cooperation between and among Transmission System Operators (TSO) and Distribution System Operators (DSO).

Demand Response implies end-consumers provide flexibility to the electricity system by voluntarily changing their usual electricity consumption responding to price signals (manually or automatically) or to specific request and benefiting from doing so. This requires temporarily decreasing or increasing normal consumption patterns.

Demand response can be implicit (also known as price based) or explicit (also known as incentive based).

Implicit demand response refers to consumers choosing to be exposed to time-varying electricity prices, which reflect the value and cost of electricity in different times. Consumers can decide to shift their consumption away from times of high prices and reduce their bills. Electricity suppliers offer time-varying prices that encompass simple day and night prices to more dynamic prices based on hourly wholesale prices (e.g. time-of-use pricing – ToU –, critical peak pricing – CPP –, real time pricing – RTP). Some countries are also examining time-of-use distribution tariffs in order to avoid grid constraints.

In explicit demand response, resources are traded in the wholesale markets, directly or through an aggregator (supplier or third party). Consumers receive a specific reward to change their consumption based on market prices and electricity system needs.

Dynamic pricing has a different degree of penetration across Europe. Barriers to its spread are mainly weak consumer motivation due to the limited awareness of the possible benefits of dynamic pricing and the popularity of fixed contracts among household consumers in the Union.

In 2016, ACER conducted a survey among NRAs to investigate the state of dynamic pricing in Europe. The ToU was applied in 17 countries, generally split into day/night differentiation, also with the possibility to cover higher time periods (e.g. Italy set 3 periods). Critical peak pricing was used extensively in Estonia, Romania and Spain (less in Sweden and UK). Other dynamic pricing methods applied to electricity consumers in Denmark, Norway and Sweden, where consumers most often incurred spot-market pricing through the monthly average wholesale price. Finally, real time and critical peak pricing applied to a small portion of households in the UK, Lithuania, Portugal, Romania and France (Fig. 3.22)

The state of art regulatory framework on explicit demand response across Europe in 2015 is shown in Fig. 3.23. Today, in countries where Demand Response has traditionally been almost non-existent (Estonia, Spain, Italy) there has been at least some regulatory interest in exploring its potential. Germany and Denmark, from 2015 to 2017, passed from “orange” to “yellow”. Although these markets are in principle open to the active participation of demand, they are not yet operational from the point of view of market opening due to regulatory barriers.

The European countries that currently provide the

Fig. 3.22 Implicit demand response – state of art in Europe

Source: ACER/CEER (2016)

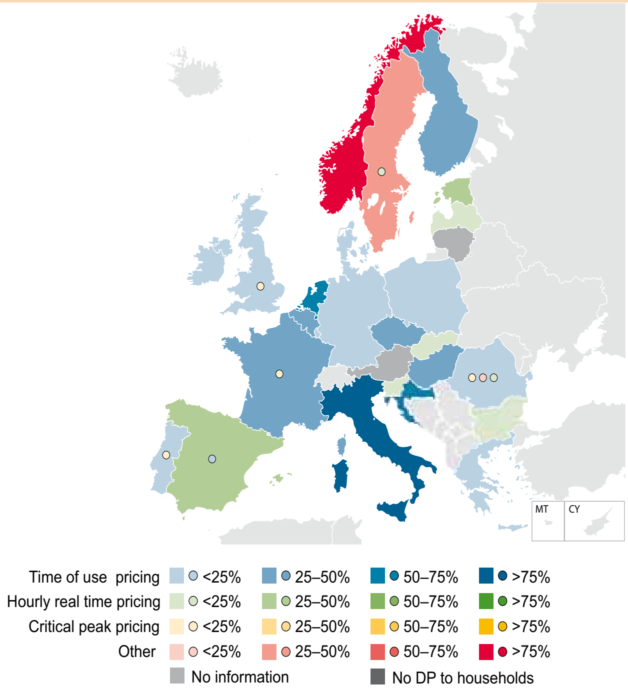
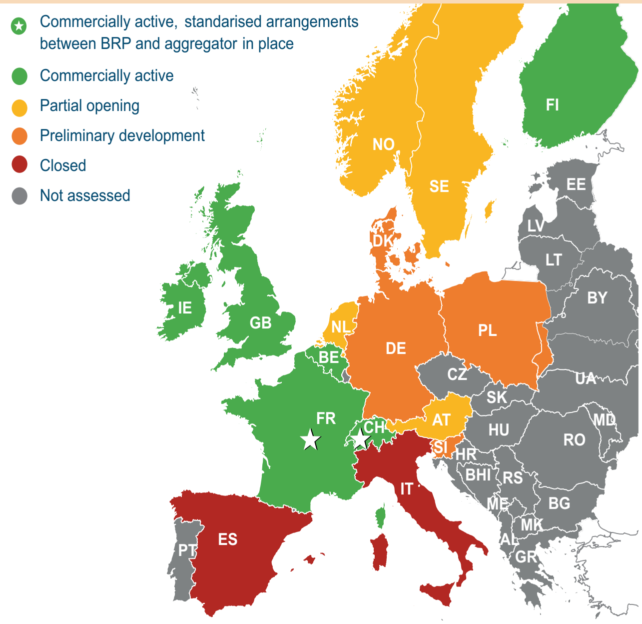


Fig. 3.23 Explicit demand response – state of art in Europe

Source: SEDC (2016)



most favorable framework for the development of Demand Response are Switzerland, France, Belgium, Finland, Great Britain and Ireland. Nevertheless, some issues on market design and regulatory context remain unresolved. Switzerland and France have detailed frameworks in place for independent aggregation, including standardized roles and responsibilities of market participants.

There has been no progress in regulation in Poland and Slovenia in the past couple of years, while Estonia, Portugal and Spain do not admit demand to the market. Despite being still in the red category, regulation in Italy is evolving towards a progressive market opening to demand through specific pilot projects[21].

Demand response, as well as storage, are a critical resource in order to achieve a low carbon efficient electricity system at reasonable costs, making it more flexible for market participants and helping to handle peak demand.

Apps for energy consumers

Digital technologies could play a key role in the new service-oriented energy system, responding to new customer expectations for high-quality, personalized services available every time and everywhere.

Only a few years ago, in the energy sector, the supplier-consumer relationship was based on the contract involving service delivery and payment. Digitalization has made this paradigm obsolete. Consumers are now more demanding and expect a more personalized experience and more digital access. Indeed, consumer awareness has increased due to the spread of the smart meter that allows consumers to check their consumption rate. Therefore, utilities should be more focused on customers' needs in order to create a real value and unlock additional opportunities.

Automation and control systems, on the one hand, allow consumers to accurately monitor their consumption, and on the other, allow companies to better track consumer behavior and improve their products and services.

Currently, many tools are available in the market and below are shown a few examples that can boost energy efficiency and improve consumer empowerment.

In order to improve energy management in the home, three interesting cases are presented below.

The first, recently acquired by Google (2014), Nest is more than a simple thermostat, in fact it automatically adjusts the temperature according to real needs and turns off heating in the case of long absences.

Another interesting case, useful for consumption management, is the Swedish Watty. A single sensor tracks the energy consumption of each appliance in the house. The Watty app shows in very simple graphics how much energy each appliance uses in real time, helping people make smart decisions about their consumption.

The third, the Italian Elemize will promote energy efficiency through cloud analysis and communication in real time of a building's energy consumption, resulting in an energy saving strategy. This technology enables customers to take advantage of all the benefits of

21 In Italy the ancillary services market is in the process of being amended, aiming also at demand and aggregator participation.

distributed energy sources using Artificial Intelligence and Internet of Things, and redefining the way that energy is distributed and consumed.

With the purpose of helping customers to understand the energy sector and make them more conscious of their consumption, costs and footprint, two other interesting apps are presented below.

The US Energy cost calculator is a simple equation-based system that calculates energy costs. The app uses several equations to calculate the cost of an electronic item. The app shows users their energy usage per day, week, month and year as well as the carbon emission per year.

The Asian Lotus greens carbon calculator. A web and mobile application that can track and measure the carbon footprint and suggest ways to reduce. The app helps people's understanding of how different aspects of their lifestyle and consumption habits affect their personal carbon emissions.

The interconnection and the possibility to record and share information represent the real strength of the new technologies. From a consumer perspective, these tools can result in energy and economic savings. From a company perspective, however, these appliances and apps allow for a better knowledge of customer routines, improving their products and services.

The spread of ICT has deeply changed the relationship between customers and suppliers, especially in customer relationship management. The traditional call center and paper bill are outdated. Borders between contact channels have become blurred due to the convergence on single social media platforms of chat, e-mail and additional features and new device availability strongly encourages this convergence. Therefore, power companies should (maybe must) move from being energy-oriented to customer-oriented, using increasing data accessibility to better track habits. A tremendous opportunity comes from the development of innovative digitally enabled products and services to provide an integrated customer service. Energy suppliers should also adopt a holistic approach, with a special focus on an actual "mobility", self-service systems for transactions and on direct interaction in order to increase customer satisfaction.

Gamification

In the near future, the development of solutions allowing consumers to remotely manage home-appliances (i.e. air conditioning, heating, etc.) will be an increasing reality. The social media will also play a key role here. Indeed, many consumers are interested in this tool to follow and interact with suppliers for a faster and easier service. Integrating the social media with traditional channels is an opportunity for energy suppliers aiming at increasing customer satisfaction and consumer behavior can also be influenced by the social media, an invaluable tool in cross-selling and up-selling. Moreover, an organized and well-designed gamification strategy could change the interaction model between utilities and customers, especially in addressing social and ethical issues such as energy efficiency.

Gamification use the elements that traditionally operate in the game world converting them into actual situations (e.g. classroom, office, hospital, home, etc.) to accomplish real world objectives, transforming everyday activities in game-like experiences. The huge amount of data available through smart meters can be used to plan gamification strategy related to energy use, management and storage.

Gamified solutions encompass community-based games that encourage saving energy as one activity among many others and utility-sponsored energy challenges that reward customers for reducing their energy use as much as possible. The introduction of a reward mechanism can trigger a virtuous circle of energy-efficiency behavior. This is the case of Opower which launched a program with Facebook, that involves clients on a voluntary basis in a "competition" with other customers and friends to consume less energy. Thanks to the sharing of consumption data, customers can compare their consumption with national public benchmarks and receive advice on how to better manage energy. Therefore, the gamification potential is enormous, however, it is very important to have an appropriate planning and strategy to identify the key factors of success and to encourage virtuous behavior.

Crowdfunding

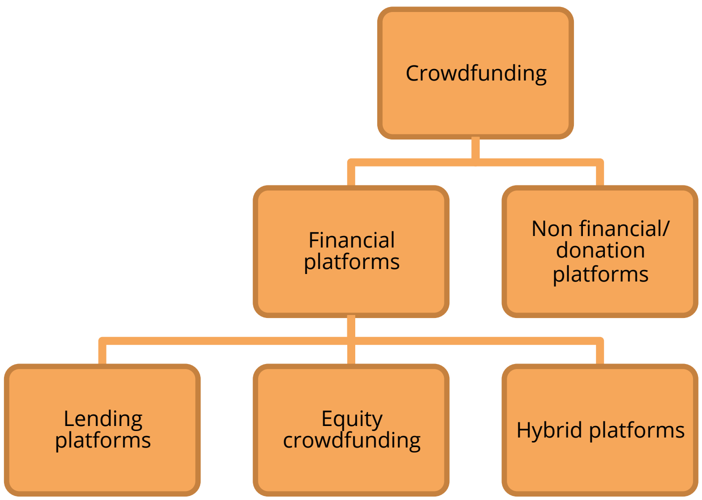
In relation to fundraising, a new opportunity emerged from the 2008 financial crisis and the resulting obstacles to credit access. In fact, the widespread dissemination of information and communication technologies enabled crowdfunding to take off. It uses Internet in order to raise money through public participation, the idea being a small amount of money from many people. Crowdfunding is most common for startup companies or growing businesses as a way of accessing funds. Projects are presented on dedicated platforms and people can donate or invest money.

Crowdfunding represents not only an alternative way to raise the money, but also a communication tool, that allows transparency and open communication on projects, enables investors to engage with the projects proponents and track progress over the time. Crowdfunding is a form of democratization, due to the consumers and investors involvement in online communities and sharing information and suggestions.

Crowdfunding platforms can be financial or non-financial (Fig. 3.24). The financial platforms can be classified as lending, equity or hybrid crowdfunding models.

On lending platforms money is raised online and investors

Fig. 3.24 Main crowdfunding platform types

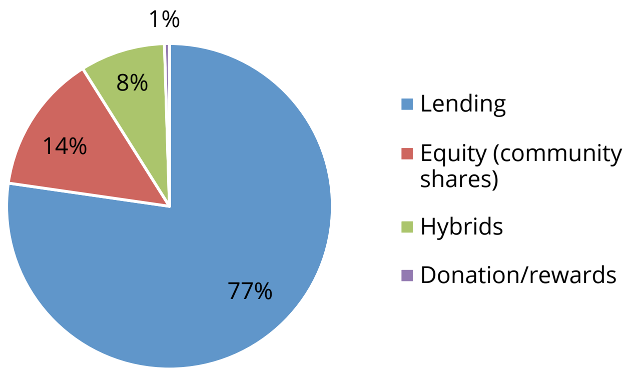


are repaid and remunerated over time based on the project revenues. The equity crowdfunding platforms are similar to common stocks that are bought or sold on an exchange with investors becoming partners in the new organization. Most of these platforms focus on community projects aiming at boosting the participation of local populations in renewable energy investment. Finally, hybrid platforms that allow investors to combine elements of different solutions as debt instruments, bonds, company equity, or share in local cooperatives.

Through the non-financial platforms – donation or reward based – people donate money without any expectation of financial return. These kinds of platforms are the most socially oriented, supporting renewable energy projects for communities in developed countries and rural electrification in developing countries.

Fig. 3.25 Energy Crowdfunding performance (2012-2015)

Source: Crowdfunding in the energy sector: a smart financing and empowering tool for citizens and communities (2016)



In 2012, as result of the decrease in investments in the transition to decarbonized energy systems, crowdfunding began to be used in the energy sector. In October 2015, twenty-nine energy crowdfunding platforms were active. According to Candelise, up to October 2015, energy crowdfunding had raised a total of € 165 million. Despite the relatively small size of the market (roughly 0.75% of overall crowdfunding funds and the very limited impact on energy investments), the energy crowdfunding campaigns are on average more successful than others.

Roughly 60% of financial platforms adopted the lending model, 25% the equity model, and 15% the hybrid model. Platform performance differs in terms of the number of projects and amount of money raised. The lending model is the more frequently applied in energy crowdfunding platforms and it is also the best performing. Indeed, lending projects have been the highest in number (219), raised the largest amount of money (127,555,407 €) and with the largest average project size (Candelise, 2015[22]). The donation/reward model follows in terms of the number of projects (93) but are the last in terms of capital raised (814,883) (Fig. 3.25).

Crowdfunding is attracting a growing interest from citizens and institutions alike as it is an enabling factor for SME access to capital. Moreover, crowdfunding, both financial and non-financial, could also play an important role in promoting the growth of the renewable energy industry especially in developing nations. The energy crowdfunding segment emerges as a quite dynamic

22 Smart financing and empowerment: the use of crowdfunding in the energy sector.

sector, making use of all the tools available, from lending to donations, and with a strong focus on clean energy projects and the environmental impact.

Crowdfunding in the energy sector allows people to invest in green energy projects even with a small amount of money. This opportunity combined with the environmental aspect could make energy crowdfunding one of the best tools in the transition towards a low-carbon energy system.

Blockchain

A block-chain is a digital contract permitting an individual party to conduct and bill a transaction (e.g. a sale of electricity) directly (peer-to-peer) with another party. The peer-to-peer concept means that all transactions are stored on a network of computers involving the computers of the provider and customer participating in a transaction, as well as of the computers of many other network participants.

Generally, in transactions, a third party acts as a guarantor and is responsible for data management. The blockchain involves a paradigm shift towards a more distributed mechanism, where transaction data is stored on a peer-to-peer database. Disintermediation is the key word for the mechanism. The blockchain is a widespread, digital peer-to-peer register, which stores every transaction between two connected agents in a ledger that is globally distributed. All of the users of a blockchain system act as witnesses to every transaction between two parties, and can provide confirmation of the transaction, because the data is distributed on the network and stored locally on the users' computers.

The first application of the blockchain was developed in the financial sector, but several new applications have recently been emerging. In the energy sector, especially, the blockchain technology could enable decentralized energy supply and simplify the system by a direct linking between producers and consumers.

As mentioned above, today, but increasingly in the future, the energy system will be more decentralized and everyone could provide electricity. Moreover, the IoT will support smart devices to generate, manage, communicate and share data. On the one hand, such devices can potentially make it possible, to buy and sell distributed electricity, on the other hand, the blockchain peer-to-peer technology enables, tracks, verifies and records digital transactions, and allows the automatic startup of the transactions through smart contracts (digital protocol which automatically carries out a transaction based on individually defined rules).

The spread of the blockchain could boost the empowerment of the final consumer – that could become autonomous in contracting power – and promote the network reliability as the system needs are continuously tracked.

Currently, the blockchain is a very niche area, but energy companies are becoming aware of the technological potential. In February 2017, energy and blockchain experts met in Vienna to analyze the potential of this technology in the energy sector. Some experts believe that blockchain technology could play a significant, potentially game-changing role in the global electricity system transition to a more secure, resilient, cost-effective and low-carbon grid (Rocky Mountain Institute, 2016).

An interesting experience is the Brooklyn MicroGrid project of LO3 Energy and ConsenSys that shows the potential of blockchain technology for local peer-to-peer energy trade. The aim of the project is to test how renewable energy producers can sell surplus power directly to their neighbors without intermediaries, using apps and smart meters to empower consumers and purchase the required electricity at a negotiated price.

The project implementation required smart mete sr, that record the quantity of energy produced, and blockchain technology with integrated smart contract functionality to execute and record the transaction automatically and securely.

Another example of the use of the blockchain in the energy sector was developed by Oneup, from the Netherlands. As in the Brooklyn case, households located within the same neighborhood that generate solar energy, can deliver the surplus to their neighbors and bill them using a blockchain system.

All transactions are made based on smart contracts. Each building has a smart meter that is connected to a mini computer (Raspberry Pi), which is connected to a network. The software automatically initiates the energy transfer and corresponding payments using its own cryptocurrency.

Due to the early stage of development, it is difficult today to predict how exactly the blockchain will change the energy business. Some of the existing rules and roles might become obsolete by supporting the development of the new ones. Probably, the blockchain will become part of the answer to updating and improving centralized systems, with a distributed hybrid system made up of both large power plants and micro-grids powered by distributed energy resources such as solar power. Such a decentralized energy system could deliver efficient, reliable renewable energy.

PART 4

SYSTEMIC BENEFITS OF DIGITAL ENERGY AND THE POTENTIAL ROLE OF ADVANCED TELECOMMUNICATION INFRASTRUCTURES

4. SYSTEMIC BENEFITS OF DIGITAL ENERGY AND THE POTENTIAL ROLE OF ADVANCED TELECOMMUNICATION INFRASTRUCTURES

4.1. SYSTEMIC BENEFITS

Technological progress and data analytics are transforming all economic sectors. Digitalization is bringing about changes in the way we live, produce, and consume and synergies between traditionally different sectors are developing. Processes are becoming more efficient and new services and businesses are becoming more and more commonplace.

Digitalization is transforming the business architecture of the energy sector, redrawing structures and redefining relations between consumers and suppliers. As well, several other fundamental changes need to be taken into account. The power generation model has evolved from fully centralized based conventional thermal power plants, to a more decentralized and renewable based system. Decentralization also evolved the ownership paradigm, from large power plant utility-owned to small (generally) renewable plants owned by individuals or local communities.

Currently, Distribution System Operators (DSOs) and suppliers are no longer the only players in the market. Indeed, thanks firstly to liberalization and then digitalization, new players (e.g. aggregators, technology companies, etc.) have progressively entered the markets, competing to offer services to consumers. Furthermore, consumers are no longer passive entities. The new energy consumers are becoming more active as they are increasingly interested in value-added services beyond energy and more aware of environmental issues.

The digitalization of the energy system can bring benefits to all energy players. With the smart meter widespread, in the short term, consumers can better control their consumption and benefit from additional services. Suppliers can optimize their business, come up with new offers and target their communications. Finally, system operators can use new tools to manage their grids more efficiently and integrate an increasing amount of variable renewable energy in the system.

In the long term, increasingly distributed energy and progressively smart technologies (e.g. smart appliances, smart grids and home platforms that interact with each other) will lead in a new age with radically different production and consumption patterns.

Despite the huge amount of benefits, digitalization in the energy sector is moving more slowly than in other areas. This is due to the slower than expected smart meter roll-out at the EU level[23], as well as data privacy and security concerns and because, for some consumers, digital appliances and services may not yet be attractive enough.

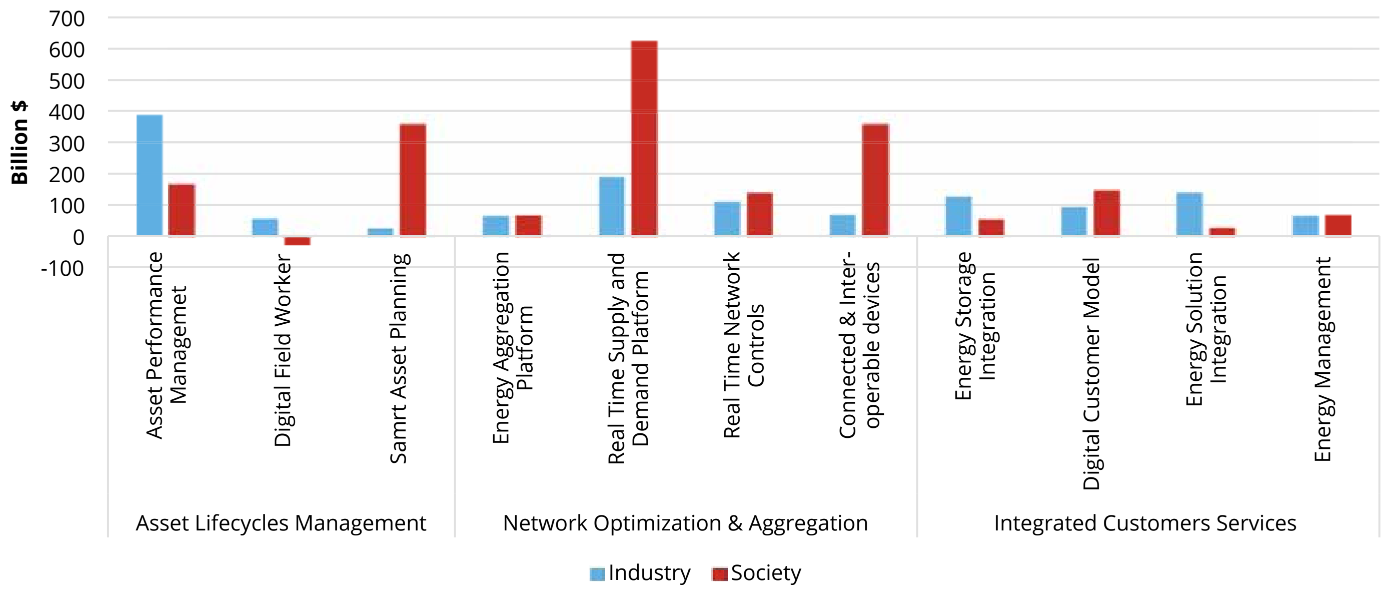
On the businesses side, the lack of standardization and interoperability may slow down the commercialization of new appliances and the learning process to convert

23 Because of varying cost-benefit analysis outcomes across European countries.

a mass of unstructured data into real action hesitates.
On the one hand, markets and innovation will solve some of these issues, on the other, the regulatory framework should be fit for the purpose. Indeed, as larger sets of data are becoming available and boundaries between sectors are fading, the regulatory framework should ensure that all data – be it energy related, telecoms-related or from online platforms – is covered by consistent and appropriate regulation. Moreover, that privacy and security, including cyber security, are safeguarded.
The smart energy model is becoming predominant. All phases of the energy chain are affected by the energy system revolution, from production to the exploitation of the service, through distribution and new consumption patterns.
In all sectors, the role of digital technology has shifted from being an efficiency and innovation driver to an essential tool in order to remain in the market because digital applications have become increasingly important in everyday life.
According to the 2016 Accenture estimates, electricity industries are ready to realize on value from the ongoing digitalization that could reach $1.3 trillion worldwide from 2016 to 2025, deriving from asset management

Fig. 4.1 Total potential value at stake for digital initiatives (2016-2025)

Source: I-Com elaboration on Accenture data



initiatives ($477 billion), network optimization and aggregation ($445 billion) and integrated customer services ($438 billion). The value at stake for society exceeds $2 trillion. The most promising initiatives for society are network optimization and aggregation and specifically, the real-time supply and demand platforms, which account for $623 billion (Fig. 4.1).

Integrated customer service initiatives globally (both industry and society) have reached $749 billion. The digital customer model totals $248 billion, $151 billion for society and $97 billion for industry.

Although there are many analyses on the impact of digitalization on the global job market (and not always perfectly consistent with each other), it is always interesting to give an idea of the potential growth of the market in the period from 2016 to 2025. According to Accenture data, integrated customer services could generate 1.3 million new jobs. Energy storage integration is the initiative with the greatest potential (1.08 million new jobs), followed by smart asset planning (925,000) and asset performance management (596,000).

4.2. LOCAL COMMUNITIES

As mentioned above, the energy system is undergoing a revolution. Decarbonization of the economy and the global financial crisis – that resulted in a general reduction of energy consumption – has led the evolution of the previous paradigm towards new models of production, consumption and business management. Decentralization is the key word. Consumers become more involved in the energy system. They can now respond to system requirements and, in order to save money, they can produce, store, use (also shift use in time) or sell their own electricity.

Technological progress has made the supply of new services possible, which have changed daily live (home automation, connected cars, etc.). The huge amount of data now available has shifted the competition to the online channel opening up the way to new risks, as well as new opportunities.

Decentralization and renewable energy have brought back to the surface an old production and consumption model – the energy communities.

Energy communities could be an efficient way of managing energy. Renewable energy production and small cogeneration, combined with the possibility of selling part of the energy produced through local micro-grids, could promote the spread of technologies such as photovoltaic energy without using incentives.

Self-production, energy exchange through smart micro-networks and local networks and energy storage are the pillars on which energy communities are based.

The idea is to efficiently manage an articulated system of different plants, minimizing energy losses. Such a structure enhances distributed generation by reducing the gap between production and demand, cutting management costs, intermediation and the inefficiencies of traditional generation plants.

Different heterogeneous subjects, interested in different achievable benefits, can develop energy communities.

For example, hospitals are interested in the certainty of supply, residential buildings in the reduction of energy spending, while industrial districts want a mix the above. The energy community can also be useful in emergencies, continuing to provide energy supply.

The consumption transformation requires the adoption of advanced technologies for distributed energy production, for the management, control and monitoring of energy flows, and finally for the distribution of energy flows and information.

The main barriers to the spread of energy communities are misinformation and the lack of resources and organization, which is why it is crucial to identify new funding methods.

Although energy communities represent an important system and market innovation with significant aggregate benefits (for the electricity system and for citizens), they will hardly be able to spread through a bottom-up process. In order to develop these communities several actions are crucial. These involve defining a clear legislation and regulation framework, spreading technologies and best practices, simplifying the fundraising and creating an energy culture that is an essential issue for consumers.

Local energy communities can be an efficient way of managing energy at a local community level, with or without a connection to distribution systems.

Last November, the European Commission presented a legislative package, which aims at encouraging active consumer participation in the energy market. The Commission's proposals provide opportunities for newer technologies and for newer commercial models such as aggregation or community energy schemes. The European Commission acknowledged that energy communities – such as co-operatives – have a fundamental role to play in Europe's energy transition.

Energy communities are mentioned in two proposals –: in the revised "Directive Internal Market for Electricity[24]" and in the revised "Renewable Energy Directive[25]". In the first one, local energy communities are defined as organizations "effectively controlled by local shareholders or members, generally non-profit driven or generally value rather than profit-driven involved in distributed generation and in performing activities of a distribution system operator, supplier or aggregator at local level, including across borders". Member states should adopt a legal framework that ensures the possibility for local energy communities to own, create or rent and manage networks autonomously. Furthermore, they should allow these communities access to all organized markets, directly or through aggregators. Energy communities that consume electricity from an external network will be subject to appropriate network charges.

In the Renewable Energy Directive renewable energy communities are essentially held to be locally based entities that are either SMEs or not for profit organizations, which are to be allowed to generate, consume, store and sell renewable electricity, including

24 Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal market in electricity (art. 16).

25 Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the promotion of the use of energy from renewable sources (art.22).

through PPAs (power purchase agreements).
The Wisegrid Project is an interesting case. Wisegrid is a project of 17.6 million euros largely funded under the Horizon 20-20 program. The projectpursues the European Commission's ambition to put the consumer at the center of the energy system, to promote and support sustainable energy communities.
The initiative aims at an optimal win-win solution for the network and consumers by leveraging sustainable business models, regulatory recommendations, and a variety of technologies (smart metering, smart appliances, batteries, electric vehicles, etc.). Clearly focused on consumers, the project aims to make a difference in the market by providing tools that boost the creation of an open market where not only traditional users but also electricity cooperatives and SMEs can play an active role, thus contributing effectively to the transition to energy democracy.
The Wisegrid model is based on the existence of a sustainable energy community – a SME or non-profit organization – where shareholders or partners cooperate in generating, distributing, storing or supplying energy from renewable sources.
Launched in November 2016, the Wisegrid involves 4 countries with different technical, climatic, regulatory, legislative and social conditions (Belgium, Italy, Spain and Greece), involving more than 1,700 users, 60 batteries – for a total of more than 300KWh of installed capacity –, 50 heat pumps – for a total of over 160kWh of installed capacity –, 180 electric vehicles, 40 recharge stations and more than 70MWh of RES-FV, wind and hydroelectric.

4.3. COMPANY INNOVATION POTENTIAL

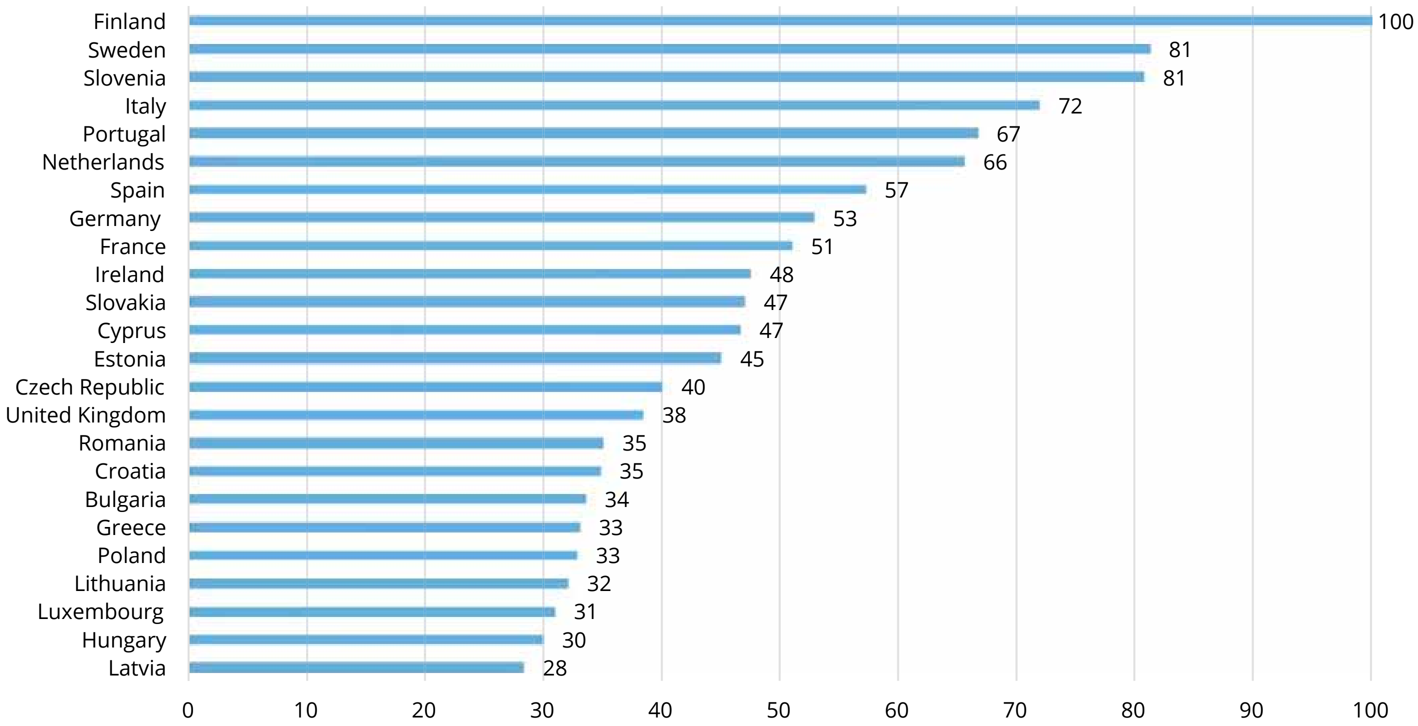
The spread of Internet and mobile devices has changed the context in which citizens, consumers and companies traditionally operate, introducing new ways to communicate, make deals, and exchange information. Indeed, the massive digitalization of services has transformed the network into a privileged place in which consumers interact and transact with companies, providing a huge amount of data and, consequently, new business models.
Technological progress and the availability of sensors able to measure virtually everything are revolutionizing every industrial sector, boosting research in new technologies, advance devices and telecommunication networks.
In order to give an idea of the progress achieved in the digitalizationof the energy sector, I-Com has developed an index, based on five variables (Fig. 4.2), specifically:

- Enterprises analyzing big data from any data source
- Enterprises using cloud computing services
- Enterprises sending invoices suitable for automated processing
- Enterprises using software solutions like Customer Relationship Management (CRM);
- Enterprises with a formally defined ICT security policy (as of 2015).

Each variable was weighted and for each country a variable average was calculated. The values obtained were normalized regarding the best performer country, so as to establish a ranking from 0 to 100. Austria,

Fig. 4.2 2017 I-Com index on energy company digital readiness

Source: I-Com elaboration on Eurostat data



Belgium, Denmark and Malta are not considered in the analysis due to a lack of values.

The most prepared countries are Finland, Sweden and Slovenia (equal footing), and Italy and Portugal.

Despite it being extremely interesting that companies analyze big data, much more interesting is the way they are analyzing it, in-house or outsourcing. At a European level, 16% of the analyses of energy enterprises gain data from any source (e.g. smart devices or sensors, geolocation of portable devices, social media, etc.), and among these companies analyzing big data, roughly 80% perform this activity in-house. It is an obvious sign there is room for specialized companies. Indeed, the big data analysis is becoming an increasingly important issue for companies and startups in order to innovate and remain in the market.

A sustainable energy sector needs new products, new solutions and new services. But often technical expertise, commercial awareness and access to a variety of skills and resources are critical.

According to the European Commission vision, businesses support, especially at the early stages, is an essential driver of innovation. The high-growth firms, create many more new jobs compared to others. Startups make up a big share of these businesses. They increase EU innovation and competitiveness, strengthening the economy.

The EU Commission will look at how to make the Single Market more efficient for startups and scale-ups. Indeed, improving the ecosystem for these types of companies in Europe will have a direct effect on jobs and growth.

A number of initiatives have contributed to job creation and growth as the European Fund for Strategic Investments (EFSI), the Single Market Strategy, the Digital Single Market, and the Capital Markets Union have also provided a framework for further improvement.

The outcomes of the Commission's public consultation, launched in early 2016 highlights that:

- startups looking to scale up still face too many regulatory and administrative barriers especially in a cross-border situation;
- for both start-ups and scale-ups, too few opportunities exist to find and engage with potential partners in finance, business and local authorities;
- accessing finance is one of the biggest barriers to scaling up.

Market fragmentation could be a significant barrier to startup and scale-up growth. Regulatory and administrative burdens often reduce the incentive for these companies to innovate, make the best use of their intangible assets and scale up, EU-wide.

European public authorities, start-ups and their business partners should act collectively to avoid that the valuable efforts of start-ups are wasted. A partnership with national, regional and local authorities, and especially with the startups themselves, is needed. This involves authorities promoting conditions that ensure startups can scale up. In return those startups can create jobs, compete on the market and be socially responsible.

The Commission believes that member states could further simplify the life of startups by supporting them in: connecting with the right partners (e.g. investors, business partners, universities, research centers); accessing commercial opportunities (especially procurement contracts); and recruiting employees with the right skills, including from outside the EU.

The European Institute of Innovation and Technology (EIT) has set up a number of Knowledge and Innovation Communities (KIC) in the thematic areas of ICT, Energy, Climate Change, Health etc. with 25% of public financing, the rest being private investment. The EIT is helping on a number of fronts with entrepreneurship skills, mentoring-, and start-up accelerators.

In order to promote innovation in the sustainable energy sector across Europe an interesting case should be mentioned. Supported by the European Innovation Technology, InnoEnergy is the innovation engine for energy industry, investing in businesses and helping develop innovative products, services, and solutions that have high commercial potential. InnoEnergy provides access to a vast pool of complementary skills and resources, and connect them to markets and commercial opportunities across Europe. Involving universities, research centers and businesses, the organization promotes innovation, entrepreneurship and education in the field of sustainable energy.

InnoEnergy is the only accelerator in Europe specializing in sustainable energy. Among the different services for entrepreneurship, there is also the Highway® program that supports the creation and the development of startups, turning innovative ideas into commercial solutions that together will change the way of producing and consuming energy. Some of them may lead to incremental changes in one part of the energy value chain, while others may lead to much larger transformations. The start-ups supported become members of the Europe-wide network of industrial partners, potential customers, and technology experts. The power of the community opens up opportunities across the continent to connect ideas and investors, entrepreneurs and enterprises, products and markets.

According to InnoEnergy Highway® figures, from 2012 to 2016, a total of 171 startups were supported through the Highway® program (Fig. 4.3). After the peak in 2015 (52), in 2016, the number of startups supported was just above the 2014 level (38 and 36, respectively).

Looking at the sectors of the supported startup activity, energy storage emerged as the first sector (31%), followed by smart efficient buildings and cities (28%).

InnoEnergy Highway® registered that the total amount of capital raised from 2013 to 2016 was €47.34 million.

Fig. 4.3 Number of startups supported

Source: I-Com elaboration on InnoEnergy, Highway®

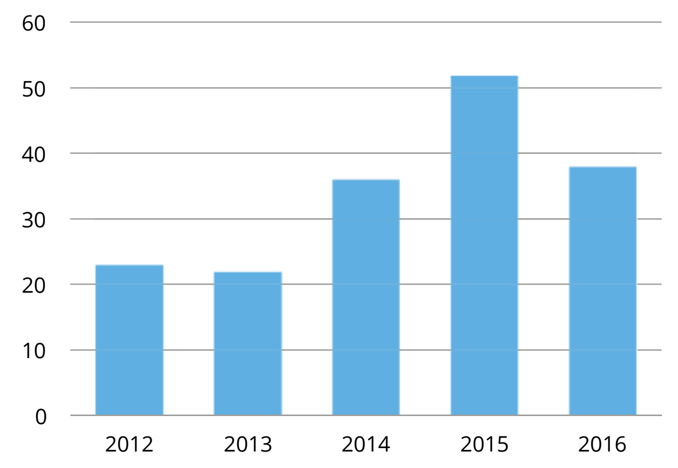
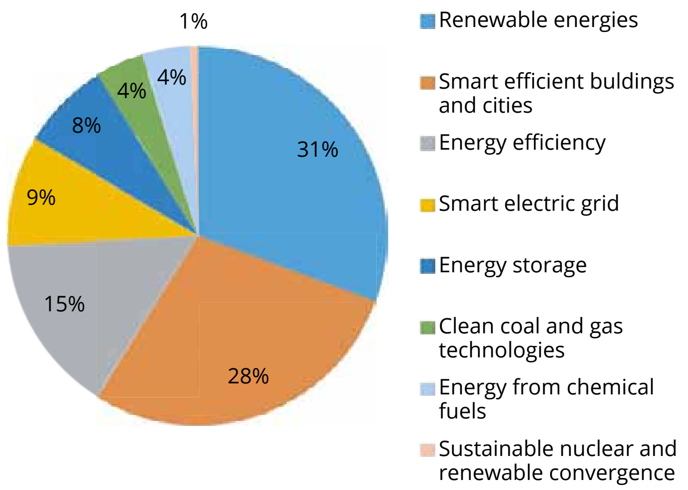


Fig. 4.4 Startups supported per sector (2016)

Source: I-Com elaboration on InnoEnergy, Highway®



4.4. THE FIXED AND MOBILE TLC NETWORKS IN EUROPE

Digital service deployment and penetration requires not only the individuals' interest, but also high-performance networks. Focusing on Europe and, in particular, on the fixed telecommunications networks, Fig. 4.5 shows the percentage of households connected to the broadband. At a European level, the percentage is 83%, with Northern Europe in first place with Luxembourg, the Netherlands, Denmark and the United Kingdom at 97%, 95% and 92%, respectively, of households connected to broadband.

For the percentage of households living in areas served by NGA, the European data is 76%. The best performers are Malta (100%), Belgium (98.9%) and Netherlands (98.3%), instead, the worst, are France, Greece and Lithuania (Fig. 4.6).

Looking at the mobile network, Fig. 4.7 shows that the European percentage of LTE coverage is 84.4%. The best performers are Sweden, Denmark and Finland with 100% and 97% of LTE coverage, instead, the worst are Bulgaria (65.7%), Cyprus (64.2%) and Romania (44.7%).

Fig. 4.5 Household Internet connection type: broadband

Source: I-Com elaboration on Eurostat data, 2017

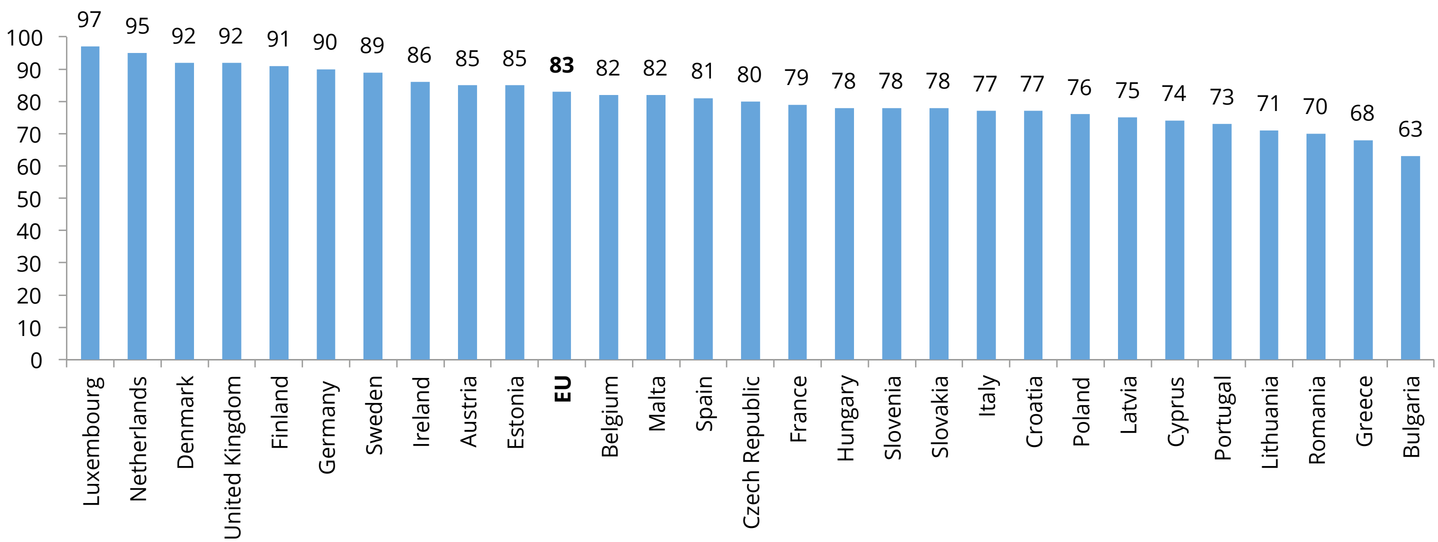


Fig. 4.6 NGA broadband coverage/availability (as a % of households)

Source: I-Com elaboration on Eurostat data, 2017

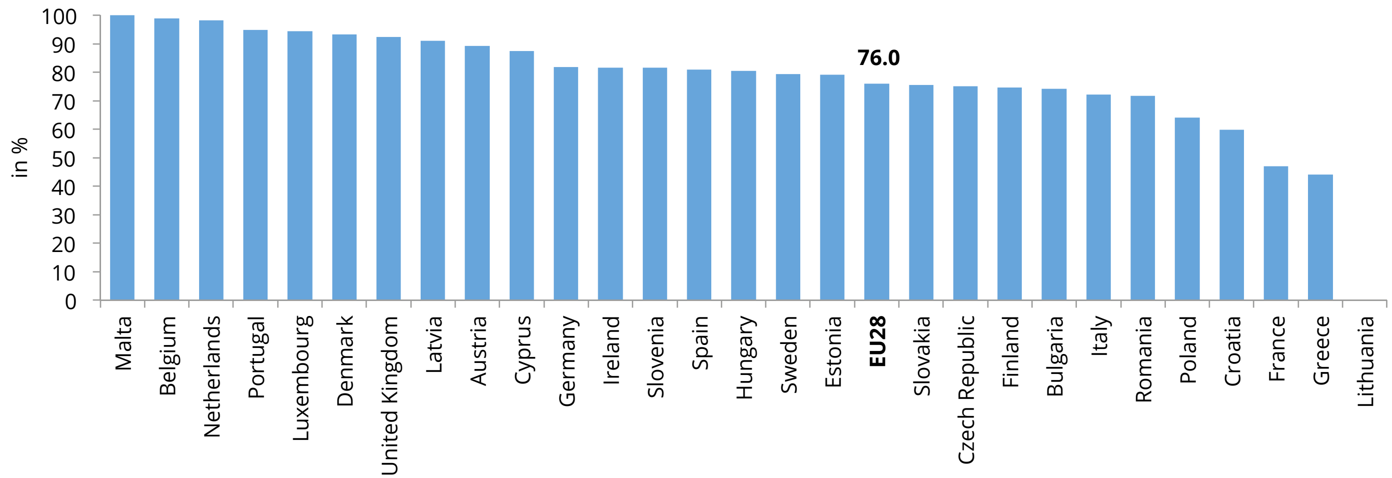
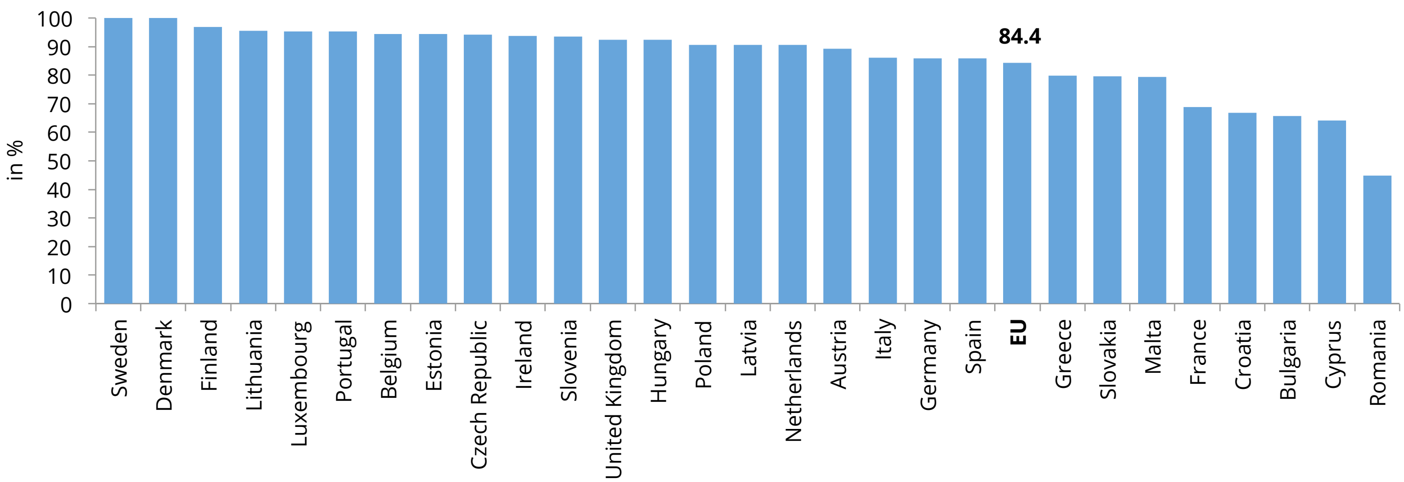


Fig. 4.7 4G mobile broadband (LTE) coverage (as a % of households)

Source: I-Com elaboration on Eurostat data, 2017



4.5. 5G PERFORMANCE. THE IMPACT ON VERTICAL SECTORS

The extraordinary growth of mobile data traffic – favored by IoT deployment and the increasing importance of contents – underlines the importance of advanced technologies and performing telecommunications network availability.

In this context, 5G deployment is one of the most important goals worldwide.

In fact, 5G is the new generation of radio systems and network architecture that will revolutionize businesses and the lives of citizens/consumers guaranteeing a more advanced and more complex set of performance requirements, being able to support more users, more devices, more services and new use cases through more efficiency and speed.

ABI research predicts that 5G revenues may reach US$250 billion by 2025, with North America, Asia-Pacific, and Western Europe being the top markets, based on revenues connected to "Machine to Machine" communication development. This is in addition to enhanced mobile broadband services and looking at the benefits for industrial sectors, summarized in the table below (Tab. 4.1).

As well, a wide range of challenges for 5G can be identified: 1) data rates up to 100 times faster (more than 10 Gbps); 2) network latency lowered by a factor of five; 3) mobile data volumes 1,000 times greater than today's; 4) battery life of remote cellular devices stretched to 10 years or more; 5) increase in the number of devices connected to the network (1 mill. per 1 sq km); 6) possibility of use of several bands from 400 MHz to 100 GHz.

Vertical industries underline the importance of 5G deployment for the future of the European Union. 5G technology, in fact, will allow for the development of new services – among them, IoT is one of the most important – that will enable the expansion of new services that will bring progress, welfare, jobs and new opportunities for businesses.

In particular, the document "*5G empowering vertical*

Tab. 4.1 5G benefits for industrial sectors

Source: ABI

Industrial sector benefits	Automotive (€ mill.)	Healthcare (€ mill.)	Transport (€ mill.)	Utilities (€ mill.)	Total (€ mill.)
Strategic	13,800	1,100	5,100	775,000	19,770
Operational	1,800	4,150	3,200	2,700	11,850
Consumer	13,900	207,000		3,000	17,110
Third Party	13,700	72,000			13,770
Total	**42,200**	**5,530**	**8,300**	**6,470**	**62,500**

industries"[26], summarizes the opportunities, the critical issues and the actions to be taken to encourage 5G development in Europe, underlining that 5G network infrastructures will be a key asset to support the revolution connected to society and industry digitization. This paper analyzes the development prospects favored by the technological evolution focusing on the transport sector, healthcare, energy and media and entertainment, showing that, in general, the digitization of factories will be a key stake for the 2020s.

With reference to the transport sector, Automated driving, Share My View, Bird's Eye View, Digitalization of Transport and Logistics and Information Society on the road are the main use cases identified in the automotive industry. 5G technology will ensure performance able to support these cases and a lot of new relevant applications to be developed, such as tele-operated driving – where a disabled individual could be driven with the help of a remote driver in areas where highly automatic driving is not possible – generating new opportunities for disabled people and improving the safety for frail and elderly people during complex traffic situations. In a context where industry will produce advanced driver assistance systems and, in an even longer perspective, completely autonomously driven cars – which will guarantee less fatal accidents, less traffic congestion, less congested cities and new important business opportunities – 5G performance (above all latency and data rates) will be essential.

Instead, regarding the health sector, considering the main use cases identified in assets and intervention management, hospitals, robotics, remote monitoring and smarter medication, 5G will be instrumental in these cases. It will ensure, for example, the mobilizing of efficiency reserves such as assisted self-management capabilities, the empowering of less qualified personnel to conduct routine tasks on behalf of higher qualified professionals, surgeon use of robots (by cutting latencies and allowing the remote use of these robots from everywhere) and personalized medicine, contributing also to cutting costs (the "European green paper on m-health" (2014) underlines a potential cut in costs for healthcare, through m-health, by 15% and an increase in the effectiveness and efficiency of care delivery).

Furthermore, in the media and entertainment sector, 5G, by integrating different network technologies – including unicast, multicast and broadcast – and capabilities, will enable at least six main families of M&E use cases in the 2020s and, in particular, Ultra High Fidelity Media, On-site Live Event Experience, User/Machine Generated Content, Immersive and Integrated Media, Cooperative Media Production and Collaborative Gaming.

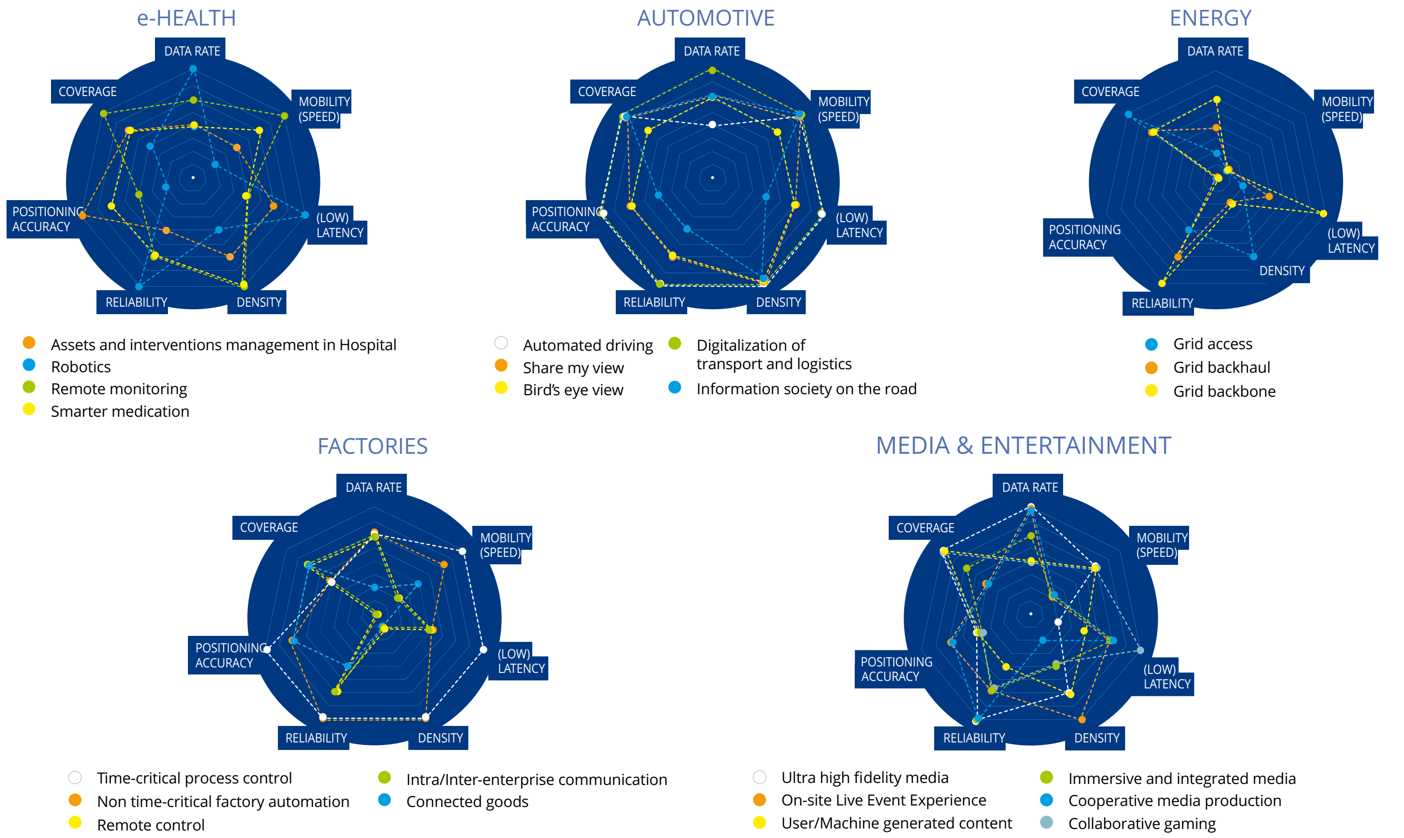
Finally, the energy sector will benefit from the opportunities related to 5G implementation. In fact, Grid access, Grid backhaul and Grid backbone are the main cases identified in the document for the energy sector. Considering that the physical infrastructure will need to support a two-way energy flow originating from the distributed energy resources, which in turn

26 This document was presented by the Commission and the Public Private Partnership on 5G (created in 2013 through an agreement between the Commission and the "5G Infrastructure Association" representing major industry players) at the Mobile World Congress 2015.

implies new needs for communication technologies, intelligence, business models and market structure, it will be necessary to introduce "Smart Grids" and 5G will be very important in achieving this goal.
The applications that will no doubt enjoy 5G opportunities will be the Smart Grid Application and the Smart Meter Application. The first, directed to network management and control, will benefit from 5G performance in terms of latency, and the second, directed to automation and data acquisition will benefit from the greater capacity, in terms of the amount of data and the large number of connected devices.
Figure 4.8 summarizes the vertical sector technical requirements.

Fig. 4.8 Vertical sector technical requirements

Source: 5G Infrastructure Association: 5G Empowering vertical industries



4.6. 5G DEPLOYMENT: THE EUROPEAN ROADMAP

European institutions have underlined the importance of 5G deployment.

On 17 December 2013, the European Commission signed a landmark agreement with the *"5G Infrastructure Association"* representing major industry players to establish a Public-Private Partnership on 5G (5G PPP) and accelerate research development in 5G technology and at the Mobile World Congress 2015, the Commission and 5G PPP presented Europe's vision of 5G technology and infrastructure. This paper specifically underlines that 5G is a new network to be designed as a sustainable and scalable technology and analyzes the development prospects favored by technological evolution focusing on the transport sector, healthcare, energy and media and entertainment, showing that, in general, the digitization of factories will be a key stake for the 2020s.

Subsequently, the "*5G Manifesto for timely deployment of 5G in Europe*" (July 2016) highlighted that standards for and coordination among European stakeholders for pre-commercial trials are very important for 5G development.

A two-phase trial roadmap, encompassing different use-cases, is being proposed: 1) before 2018, carrying out of technology trials run by independent trial consortia in various countries – involving also vertical industries – independent of the status of standardization, to demonstrate and validate new 5G capabilities; 2) around 2018, conclusion of an agree on trial specifications (use-cases, interfaces, scenarios, agreement to transfer use-cases across trial networks) among European stakeholders valid for pan-European trials to demonstrate wider interoperability and support for vertical use-cases in order to claim global public attention.

This paper highlights the importance of the spectrum aspects of the Digital Single Market – namely, harmonization and predictability of spectrum policy across member states (including spectrum availability, licensing procedures and costs, license terms, and liberalization and renewal of existing spectrums) to promote investment in the mobile sector and in 5G and, in general, the need to encourage 5G deployment synchronized across Europe to achieve the same availability both in terms of location and time (by 2020).

The 5G Manifesto identifies the actions to promote 5G development and, specifically, reduction and simplification of the rules on access to key infrastructures, deployment barrier removal, prevision of incentives for all players and, where access regulation remains, promotion – wherever possible – of long-term commercial agreements that enable competitive outcomes as an alternative to regulation. The same paper underlines the importance of creating a level playing field with equivalent and proportionate privacy requirements to innovate in data-driven markets and avoid the danger of restrictive Net Neutrality rules, regarding 5G technologies, business applications and so on.

Finally, the papers "*5G Global Developments*" and "*5G for Europe: an Action Plan*" (14.9.2016) underline the importance and the benefits for several economic and industrial sectors identifying several key elements and, in particular, the importance of aligning roadmaps and priorities for a coordinated 5G deployment across all member states. The latter should identify provisional spectrum bands available for 5G before the 2019 World Radio Communication Conference (WRC-19) and then additional bands as quickly as possible, promoting early deployment in major urban areas and along major transport paths. This will accelerate pan-European multi-stakeholder trials to turn technological innovation into full business solutions, encouraging the implementation of an industry-led venture fund in support of 5G-based innovation and supporting the promotion of global standards. In this paper the Commission identifies eight actions to promote 5G deployment: 1) promoting preliminary trials from 2017 onwards and pre-commercial trials with a clear cross-border dimension from 2018, encouraging the adoption by member states of national 5G deployment roadmaps and the identification of at least one major city to be "5G enabled" by the end of 2020; 2) identifying – in according with member states – by the end of 2016, of a list of pioneer spectrum bands for the initial launch of 5G services; 3) adopting an agreement around the full set of spectrum bands (below and above 6GHz) to be harmonized for deployment of commercial 5G networks in Europe; 4) setting roll-out and quality objectives for the monitoring of the progress of key fibers and cell deployment scenarios identifying actionable best practices to facilitate – also incrementing administrative conditions – denser cell deployment; 5) promoting by the end of 2019 the availability of the initial global 5G standard, the standardization of radio access and core network challenges and the conclusion of cross-industry partnerships; 6) planning technological experiments to be carried out as early as 2017 and presenting detailed roadmaps by March 2017 for the implementation of advanced pre-commercial trials; 7) encouraging member states to consider 5G infrastructure usage to improve the performance of communication services used for public safety and security; 8) identifying assumptions and modalities for a venture financing facility.

The Commission strategy for the Digital Single Market and the Communication *"Connectivity for a Competitive Digital Single Market: Towards a European Gigabit Society"* underline the importance of very high capacity networks like 5G as a key asset for Europe to compete in the global market. Worldwide 5G revenues should reach the equivalent of €225 billion in 2025. The study on *"Identification and Quantification of Key socio-economic data for the strategic planning of 5G introduction in Europe"*, instead, highlights that the benefits of a 5G introduction across four key industrial sectors may reach €114 billion/year.

5G deployment is a priority for Europe and, in general, for all the world. Several 5G industrial public- private partnerships were launched between 2013 and 2015 involving leading operators, vendors, universities and research institutes in the field of mobile communications. These included the IMT- 2020 (5G) Promotion Group in China (2013), the 5G Forum in the Republic of Korea (2013) and the 5G Mobile Communication Promotion Forum (5G MF) in Japan (2014) and in America (2015).

European States are also aware of the importance of

5G's deployment and there are a lot of initiatives and investments underway to achieve this goal.

In the United Kingdom, the government has created The Industrial Strategy Challenge Fund, announced by the Prime Minister at the 2016 CBI Annual Conference, which will help identify and develop UK industries that are fit for the future, driving progress in technologies where the UK can build on existing areas of industrial and research strength. A cooperation has been reached between Samsung and Arqiva to speed up 5G trials.

In France, in October 2016, Ericsson and Orange secured a partnership on the development of the new mobile network and Huawei inaugurated the new mathematical research center in Paris. The Arcep started a public consultation to identify 5G frequencies and procedures for the spectrum assignment.

The German Federal Government is also focusing on digitization. In fact, it submitted a digital strategy to accelerate digital infrastructure deployment which is divided into four phases: the first, till 2018, will have the purpose of allowing universal access to broadband of at least 50 Mbps to all households; in the second phase (until the end of 2019) the fiber will be deployed in the most difficult industrial areas; the third step is to ensure the conditions for the spread of 5G mobile technology by the end of 2020; and in the final phase, the government is aiming for a convergent Gigabit-capable infrastructure.

Sweden and Estonia are also aiming at early 5G deployment. The development will come as a result of 5G networks provided by a partnership between Swedish-Finnish telecom operator, TeliaSonera AB, and the telecommunications company, Ericsson, which are scheduled to deliver the 5G network by 2018.

In Spain, Telefonica signed a public-private partnership for 5G development with the Ministry of Industry, Tourism and Energy, the Ministry of Education of the Region of Madrid, Imdea Networks, Ericsson and AMETIC (the association representing the electronics industry, IT, Telecommunications and Digital Content) for the joint development of 5G products, services and technologies. Telefonica created the first 5G Spanish research lab (5TONIC).

As well, Italy is very interested in developing 5G. In March 2017, the Italian government published a public call for tender for pre-commercial trials of innovative 5G networks and services in the 3.7-3.8 GHz spectrum range. These trials will take place in 5 Italian cities – the metropolitan area of Milan, Prato, L'Aquila, Bari and Matera –, places where the principal aim is to experiment with the 5G network, not only from an infrastructural point of view but also with regard to the underlying services. Therefore, the call is not only catered to communication carriers but also to other national and international players who want to experience services with 5G technology and, therefore, universities and other research entities and companies from other sectors. With a public announcement on August 2, 2017, the Ministry published the list of projects submitted: Vodafone Italia for Milan, Wind Tre and Open Fiber for Prato and L'Aquila, Telecom Italia-Fastweb-Huawei Technologies Italy for Bari and Matera.

CONCLUSION AND POLICY RECOMMENDATIONS

There is a lot of uncertainty about what the energy sector will look like in the near future. It will certainly be very different from the current paradigm that is already very different from what we had experienced in the recent past. The drivers for this transition are structural and deep.

Firstly, the close interweaving between energy and human development is so clear that there is no possibility to combat global social and economic imbalances and eradicate poverty without ensuring access to affordable, reliable, sustainable and modern energy for all (UN Sustainable Development Goal Number Seven). This means ensuring access to modern power for 1 billion people, predominantly rural dwellers, half of whom live in sub-Saharan Africa, still living without electricity. Moreover, approximately 3 billion people, largely located in Asia and sub-Saharan Africa, are still cooking without clean fuel and more efficient technology. If these numbers look impressive, we have to further take into account that the world population is expected to grow by 2.2 billion units in the next 35 years, mostly in Africa and Asia.

The second main driver for the energy revolution is environmental sustainability. Human activities are putting at risk the resilience of ecosystems and depleting basic ecosystem services. Above all, human GHG emissions are almost unanimously recognized as interfering with climatic patterns. Energy, as a whole, is by far the main emitting sector.

The two aforementioned global trends can converge only if energy production as well as consumption patterns are radically reshaped. Renewable energy generation, distributed generation, energy efficiency and storage technologies are emerging as large-scale market viable applications and represent the first blocks in the energy revolution.

As well as this global trend, the European Union has decided to embark on an integration process in the energy markets among member states and even beyond its southern and eastern borders. In order to reach this target, energy market structures have undergone a deep transformation, passing from vertically integrated state-owned monopolies to liberalized markets. This has had a remarkable influence on the relations between market actors, institutions and final consumers.

The deep changes in the energy sector are intersecting yet another radical change in modern society and economy – the digital revolution. Powered by the spectacular advances in the semiconductor industry, ICT applications are spreading worldwide across all sectors and can be considered as one of the key drivers for innovation, competitiveness and growth. Improvements in communication infrastructures and Internet protocols have overcome many natural and cultural barriers, enabling impressive data flows among people, firms and institutions. At the same time, computational power has boomed and allowed for advanced data management and information mining. Artificial intelligence, machine-to-machine communication and machine learning are becoming a reality.

ICT is already influencing the evolution of the power sector and more and more interaction is expected in the near future. Power grids (both transmission and distribution) are already highly automated. Advanced monitoring and maintenance are spreading among production facilities and grid nodes. New media are changing the relationships between suppliers and consumers. Policy and regulation at EU and member state level have to pave the way for the digital energy convergence.

Below we have highlighted the following key issues to contribute to achieving this goal.

1) Data as a digital energy kingmaker

Data is at the heart of the digital revolution. In order to represent a real value for stakeholders, relevant information has to be extracted out of the mass of data generated by smart devices. In perspective, we should talk about data management as an infrastructure by itself. In order to develop this enabling infrastructure and fully grasp the benefits of digital energy, proper investments in the development of an advanced energy data management infrastructure have to be adopted at all levels. This involves investments in hardware, software and human capital.

All market actors are involved in this process. A favorable regulatory framework for regulated grid activities must be put in place. TSOs and DSOs can play an important role as data management hubs, considering the growing complexity of transmission and distribution grids (increase in cross-border interconnections, renewable energy penetration, storage, distributed generation and active participation in the demand, electric mobility). The TSO/DSO cooperation on data sharing has already started and must be further strengthened and defined in scope, responsibilities and procedures.

Market activities too have to benefit from the possibility to offer innovative and advanced energy services, especially smart metering. Energy efficiency and demand management are the simplest examples. The access to commercially sensitive data should be as open as possible, in order to create a competitive context for traditional energy retailers and new incomers. Of course, this has to be tempered with data ownership, privacy and information asymmetry between consumers and retailers/service suppliers.

However, any new data collection and exchange, as well as information elaboration burden imposed on any market actor, should be carefully studied under a cost/benefit analysis.

Costs and benefits of the implementation of the data management infrastructure should be equally distributed among the system stakeholders.

It is clear that careful data management governance has to be implemented. Probably, there is not a one-size fits all solution among member states. Different models are being implemented across Europe, in particular for handling end-user data. Some countries are opting for fully involving independent grid operators, either TSOs or DSOs, others are setting up independent regulated entities specifically devoted to smart meter data management. Centralized vs. distributed data management models are being applied. In the first case, data management is a regulated activity and smart metering data is collected by a central data hub. In the second case, data remains stored on the consumers' premises and a competitive market for energy data service is set up. Compliance with General Data Protection Regulation has to be guaranteed, and consensus on data sharing a key issue.

With the massive roll-out of IoT and, consequently, the possibility to gain insights into final energy consumption from sources other than smart meters, it is expected that the borders between these models will become less defined. Still, legal energy metering will maintain a vital role for grid operations.

However, in order to be in line with the principles of the Energy and Digital Single Market, general rules and principles should result in a level playing field and give stable and clear long-term signals to investors and consumers.

2) Cyber-security and interoperability as cornerstones for digital energy uptake

Cyber-security is surely one of the main concerns for digital energy. The massive spread of connected energy devices both at grid and consumer level widens the potentially vulnerable surface of the EU energy system. Increased interconnection between national grids extends the issue well beyond national borders. Serious security and privacy concerns are present for different digital energy applications. COM (2017) 477 poses some important priorities for setting a common EU cyber-security framework. In this sense, it would be important to create, as soon as possible, a specific working group within the EU Cyber-security Agency (ENISA) specifically dedicated to digital energy.

With the expected massive spread of energy related IoT devices, technology cyber-security certification of appliances is an important step to guaranteeing the quality of devices for consumers. In the long term, the introduction of high quality standards would bring important benefits for the competitiveness of the IoT value chain of EU enterprises and protect the market from low quality products. The energy sector has already experienced the importance of introducing high quality standards for energy devices, as was the case for the quality certification for PV and SWH technology. In new fast growing segments time is a key issue.

Certification of components and systems is as important as certification of competences and skills. Again, the energy sector has already shown the importance of taking into account this aspect as demonstrated by the experience of technicians in RES installations. We consider the introduction of a common EU framework for the certification of cyber-security skills for the different applications (e.g. data protection, asset security, etc.) a priority.

At the same time, interoperability is mandatory for a sector where standardization processes are still ongoing, where market dynamics are evolving fast and technology cycles are long, so that the contemporary presence of legacy and innovative technologies is taken into account. Digital energy interoperability will benefit from the EU Single Market and create opportunities for consumers and firms in terms of market competition and competitiveness.

3) Digital energy as the gateway to non-ETS GHG reduction targets.

Europe is putting an extraordinary effort into reducing GHG emissions to meet its long-term decarbonization goals. Projections show that emission reduction efforts in the carbon intensive industrial sectors – regulated under the Emission Trading Scheme (ETS) – have emission trajectories in line with long term goals, even if even more effort is still required. On the other hand, non-ETS sectors (e.g. transport, service, agriculture, housing – regulated under the Effort Sharing Decision - EDS) are far from reaching sustainable emission patterns. Digital energy could provide an important momentum for reorienting EDS sector emissions, putting strategic sectors like transport, services and housing on track. Electric vehicle penetration, electrification of domestic consumption and energy efficiency are just a few examples where digital energy could play a key role. Here, a coordinated initiative by the EU Commission could promote concrete actions and investments in order to increase the impact of digital energy on non-ETS emission reduction.

4) Digital energy and smart energy consumers

Consumer empowerment and awareness are real challenges for energy consumers. Indeed, digitalization in the energy sector is progressively resulting in a large variety of services. Thanks to new technologies, consumers have potential access to a huge amount of data and information, but they are not always able to take advantage of this. On the one hand, it is increasingly important to spread an energy and digital culture to empower consumers. On the other hand, in order to give value back to consumers, third parties (companies, aggregators, institutions) could help in closing the gap and support consumers in understanding and better managing their consumption patterns. Unfortunately, it should be considered that consumer awareness is not enough to fully tap into the potential of the ongoing digital transformation. Under certain circumstances, automation is a key answer. Communication between machines and prompt device reaction to signals (e.g. price signal, network needs, etc.) should be promoted by European and national regulations, while, at the same time, regularly checking that consumers are actually benefiting from it.

5) Nurturing a competitive ecosystem for digital energy players

Digital energy prompts potential spillovers outside the energy sector. The digital energy value chain involves traditional energy firms (TSOs, DSOs, power producers, retailers, etc.), traditional ICT enterprises (hardware, software and system integration) and, potentially, innovative SMEs, start-ups and scale-ups in many different sectors (data mining, behavioral analysis, advanced manufacturing, just to quote a few). The creation of an EU wide digital energy single market could create a robust demand for advanced digital energy solutions, foster strategic cross-sector fertilization and allow for a sustainable growth of a competitive “Made in EU” digital product/services offer. The sector should also aim at penetrating non-EU markets to seize worldwide digital energy investment opportunities. As already mentioned, an advanced EU framework for standardization and quality requirements are key elements to creating a sustainable digital energy value chain. Europe can play a central role also in stimulating and supporting firms in innovation and workforce qualification by specific competence and skill development programs. Also critical would be a thriving financial eco-system, funding promising start-ups and scale-ups and allowing for a rapid commercial development of technologies applied to the energy sector.

6) Converging infrastructures for digital energy deployment

The European Commission, aware of the importance of network development for new service deployment (e.g. IoT) and the future of the European Union, has proposed policy and regulatory measures to encourage network investments, setting new connectivity targets for network access and adapting the current regulatory regime to the competitive evolution of broadband markets.

Considering that fixed and mobile ultra-broadband network deployment require tremendous investments, it is very important, in general, to create a regulatory investment friendly environment (also through a stable and predictable telecom regulatory) and guarantee the respect for net-neutrality to encourage the development of new business models and new services. With regard to the regulatory framework, instead, it would be opportune to reduce and simplify rules, ensuring an EU harmonization, license timing able to encourage investments, guarantee a reasonable return on investments for network operators and, in general, respect for non-discrimination principles. Then, considering the importance of OTT and the (r)evolution of competitive dynamics, for healthy telecommunication markets it is crucial to analyze the role of platforms, promote actions aimed at shifting from ex ante to common ex post rules and ensure a level playing field where the same services are subjected to the same rules. A specific effort should be put into identifying possible synergies between energy and ICT networks.

5G will be a key enabler for IoT and new digital service deployment. Considering that Europe has a history of leading the development of mobile technology in the 2nd and 3rd generation, it is very important to take the lead also in 5G development. To achieve this goal, complying with the Commission's initiatives and planning, it is vital to step up investments, simplify and remove barriers to small cell deployment, plan a roadmap and a shared timing in Europe, ensure a harmonized and efficient spectrum management, the availability of adequate spectrum bands to 5G deployment and the strong cooperation of all stakeholders. The implementation of sustainable 5G digital energy business models could help in the development of this key communication technology.

The radio-spectrum is crucial for the increasing demand and growth of mobile services. Considering the huge increases in data traffic and the importance of investments requested by the operators, it is essential to ensure a technical spectrum harmonization, a spectrum release timing shared by member states –

to minimize cross-border interference and facilitate international roaming –, harmonized and adequate license duration (to encourage investments) and a flexible spectrum use. In fact, considering that spectrum is a scarce resource and demand is quickly increasing, it would be appropriate to foresee flexible ways of using spectrum such as Supplemental Downlink (SDL) in the lower UHF band (470 – 694 MHz) and Licensed Shared Spectrum (LSA). Finally, it's important to guarantee that spectrum auctions are efficient, based on market mechanism and not oriented to short-term fiscal targets.

7) Converging regulations for converging sectors

Digital energy means also challenging regulations. Traditionally, communications and energy have been treated separately. This legacy is clear in the architecture of most of the EU and member state institutions. The discontinuity introduced by the digital revolution imposes a change in this approach. Communications and energy could be a first example of how to innovate policy and decision-making in the digital era. The EU Commission should take the lead in this regulatory convergence and draw up one or more integrated communications and energy proposals.

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