CHAPTER for the book on AI and the Ubiquitous City

Smart cities: grids, homes and the workforce: challenges and prospects

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ABSTRACT

The chapter explores specific developments and opportunities in smart technology in cities as well as the interface with the workforce. The first part of the chapter looks at technological development in smart grids and smart homes: integration of new Information and Communication Technologies (ICT) such as Internet of Things and advanced algorithms based on Artificial Intelligence (AI) to manage energy in urban areas and support user awareness or operator observation. The "smartness" of smart cities is defined. The enablers including AI and ICT, and their applications and benefits for users are discussed. The interoperability layers of smart grids architecture model are presented, and the importance of multidisciplinary ex-ante analysis of newly developed technologies and distributed intelligence is highlighted. The second part relates to the urban workforce. This is distinctive as most literature on smart cities looks at the impact on people as residents/users—not as workers. This part starts by discussing the overall impact of the development of smart grids and homes in the workforce across the sectors of the urban economy. Following, it concentrates on workers in trades related to the built environment. It argues that technological developments need a restructuring of vocational training, which may lead to a more skilled workforce with better working conditions. At the same time, it may reduce the quantity of employment, therefore part of the wealth generated by economic growth derived from technological advancements should be used to strengthen social protection. The chapter makes proposals to address current challenges, reaching a win–win situation.

INTRODUCTION

There are several projects across the world to develop smart cities and systematically shift them from digitalisation toward Ubiquitous Cities. London Smart Vision [1], Amsterdam Smart City [2], Singapore Smart Nation [3] or San Francisco Environment Project [4] are some examples of such initiatives. Ubiquitous Cities integrate novel technologies and advanced methodologies to distribute intelligence across the society. The key applications include smart transportation, smart public health, smart environment, smart grids and smart buildings. Digitalization is the first stage of creating ubiquitous cities. Anthopoulos and Fitsilis in [5] review several digitalised cities in their early stages. Kyoto and Amsterdam started using web and Virtual Reality for managing streets, malls, etc.[6], [7]. Copenhagen in Denmark used public database to cover local needs [8]. Smart city of Brisbane in Australia added AI to the decision-making services. And in Digital City of Craigmillar in Scotland, groups of citizens shared knowledge and social services [8].

As one of the main objectives of smartening the cities is sustainability improvement and green modernisation, the focus of this chapter is on the energy sector including distribution and consumption premises. The two application domains, smart grids and smart homes, are discussed from two aspects: technological aspect with a review of enablers and their applications, and workforce aspect including the workers' benefits and challenges.

Smart grids and homes integrate novel Information and Communication Technologies (ICT) with bidirectional data exchange capability and embedded intelligent algorithms. To develop ideas and improve the smartness of these systems, standards are essentials. Standards, in general, improve the quality of life, encourage innovation and competition, and promote international trades. There is a high demand to develop frameworks for the standards. In smart grids, there have been several developed frameworks to define standards, including NIST (National Institute of Standards and Technology) [9], Smart Grid Interoperability Panel (SGIP) [10], or IntelliGrid Architecture sponsored by the Electricity Innovation Institute (E2I) as an ICT Program [11], in the USA, Smart Grid Architecture Model (SGAM) in the EU [12], the State Grid Corporation of China (SGCC) Smart Gid Framework in China [13], and Japanese Industrial Standards Committee (JISC) in Japan [14]. In these frameworks, a set of descriptions are provided to make a basis for analysing the assets, use cases, interfaces, and standards of smart grids. Such reference models allow for shifting existing paradigms to "smart" systems systematically through maximising reuse of the in-place assets and off-the-shelf technologies.

Understanding the enablers of smart grids and homes allows for developing new use cases. And mapping the newly developed use cases to reference models help identify the gaps and analyse the interoperability of different technologies to deploy the new devices or schemes more efficiently. This would support for reviewing the benefits and challenges of new deployments for the users, especially the workers in the smart society. Therefore, in this chapter, the first section introduces the evolution enablers of smart grids and smart homes with some applications. Then, the impacts on the workforce in urban societies are discussed in the second section.

In the first section, two common enablers including Artificial Intelligence (AI) as methodological enabler and ICT as technological enabler are reviewed. The key applications of these enablers to smart grids and homes are discussed with some examples. Internet of Things (IoT) solution is introduced as an ICT-based approach to facilitate creation of ubiquitous cities with a focus on smart grids and homes. The direct benefits of emerging technologies in smart grids and homes on human, especially the operators and workers, are presented with some illustrative examples. These benefits are discussed in twofold: advantages of new ICT-enabled approaches to support ex-ante safe test and verification of new use cases, and benefits of ICT and AI in improving operators' efficiency and satisfaction.

Section 2 is based on key research by academics and institutions, notably the comprehensive studies of WBCSD [15] and Goger et al. [16], the presentation of Yuson (a key leader of the construction workers) [17] and related references. The section is also informed by the experience of one of the authors (Werna) during 16 years at the International Labour Office including the opportunities to discuss the future of work with workers, employers and governments, to prepare and take part on meetings and to implement projects on the ground, also informed by the literature quoted herewith.

1. SMARTNESS IN UBIQUITOUS CITIES

Prior to any discussions on the so-called smart society, smart grids, smart home, etc. the definition of "smartness" and the reason such environments are called "smart" should be noted. According to the Cambridge Dictionary, "smart" means intelligent or able to think quickly or intelligently in difficult situations [18]. Any device or system which is capable of independent and seemingly intelligent actions is called "smart" [19]. The question is how a society or system becomes smart. There are two means to make them smart: a) enabling them to communicate bidirectionally using sensors and actuators, and b) through embedding elaboration systems to run mathematical computations and logical operations to make decisions. For example, in smart grids, the digital technology allows for two-way communication between the utility and its customers, sensing along the transmission lines, and actuating physical elements [20],[21].

In this section, the two main technical drivers of smart cities including technological and methodological enablers are firstly introduced as "evolution enablers". The focus of this chapter is on smart grids and smart homes. The services and applications are elaborated with some examples for novel ICT schemes as technological enablers and AI as methodological enablers. Regarding the ICT-based schemes, Internet of Things applications in smart grids and homes are briefly addressed as well. This part is entitled "application of enablers". The section will conclude with reviewing some opportunities that these technologies and methodologies would bring to the system operators and users. This part is presented as "direct benefits for human". The impacts on the urban workforce will be then detailed with challenges and prospects in the second section of the chapter.

1.1. Smart Grids and Smart Homes: Evolution Enablers

Smart grid is defined as electricity networks that can efficiently integrate the behaviour and actions of all users connected to it to ensure an economically efficient, sustainable power system with low losses and high quality and security of supply [22]. The drivers toward smart grids, however, are not limited to technological drivers. There are public policy drivers including restructuring, deregulations and national security, as well as market drivers including consumer demands, privatisation and competition [23].

The smart revolution to form intelligent cities requires two important enablers: technologies and methodologies. The enabling technologies cover a wide range of devices, software, systems, function and standards to digitalize the cities and reshape control and management of societies. The technologies include physical devices like sensors and actuators which are widely distributed, exchanged information management through signal processing, efficient and reliable communication networks, and data analytics and distribution. The methodologies add smart functions to better manage the digitalized systems. They include programming and simulation techniques and tools, optimization methods, and system modelling (Figure 1). In this chapter, Information and Communication Technology (ICT) from the technologies, and Artificial Intelligence (AI) from the methodologies are elaborated with application focus in smart grids and homes [24].

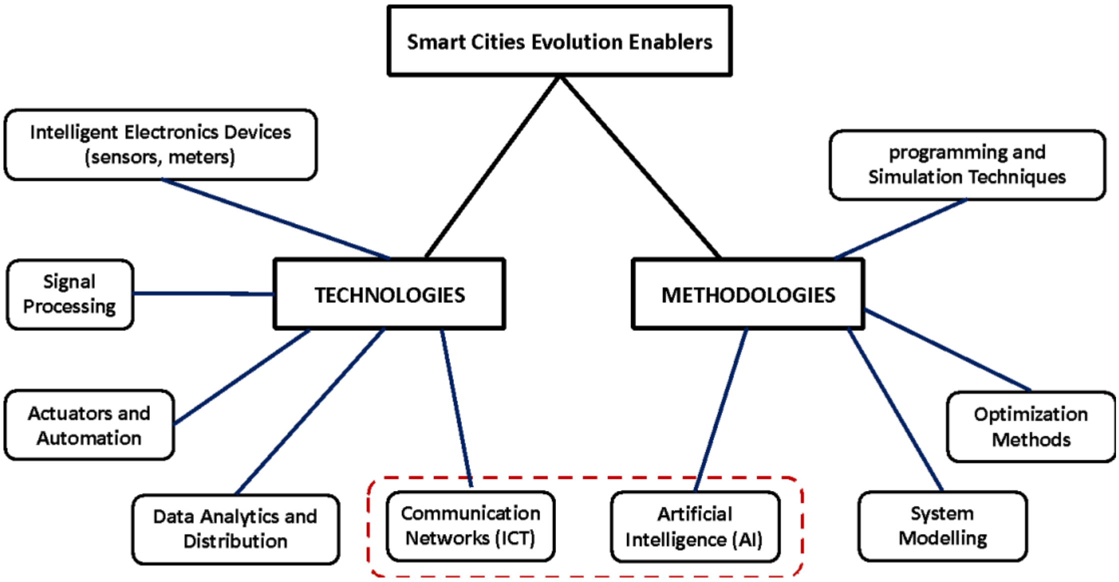

Figure 1 Smart Cities Evolution: technological and methodological enablers

1.2. Smart Grids and Smart Homes: Applications of Enablers

There is a wide range of technologies and methodologies which enable evolution of smart grids and smart homes, but the two enablers are more common and vital nowadays: Artificial Intelligence (AI) and Information and Communication Technologies (ICT). The former is more on *methodologies*, while the latter brings novel *technologies* to establish ubiquitous cities.

AI Applications: Growing capability of computation machines allows for practicing and improving some old data and operational methods to develop more efficient tools. Machine learning (ML) algorithms are among those methods whose basis could be found in older scientific and engineering literature, however the implementation of most of those methods required high performance computation (HPC). Today's opportunity of advanced HPC brings them to life and support developing more advanced techniques. For example, most of Deep Learning algorithms are based on multi-layered Neural Networks with more nodes and layers which increase the accuracy of the outcome. For example, [25] uses deep learning with loss ensembles for solar power prediction in smart cities.

Load forecasting has improved a lot in the recent decades for the accuracy and performance of the techniques, but new smart city applications demand for more advanced methods. For instance, emerging smart homes require smart energy management, which implies embedding technologies and algorithms exchanging data through home communication network (HAN). Applying the same forecast tools used in power grids would not capture the fast dynamics of volatile loads of a single residential household, hence new methods need to be developed. [26] presents a novel model based on deep learning and image encoding techniques to forecast loads in single residential homes.

Bringing smartness to individual assets of the society such as energy components, homes, vehicles, and people accessories mean coordination and management of a large amount of data. This is challenging even if the communication networks grow, as processing and analysing such big data would demand very high-performance computation with advanced AI. Therefore, in the *transition toward ubiquitous cities*, digitalization is not sufficient, and the intelligence should be distributed [27].

There are many local or small-scale AI-based controllers and agents which are designed and deployed for specific applications with limited amount of data. User awareness of energy consumption and generation at home is an example of applying AI in smart homes. New algorithms can be embedded in modern smart meters to support home energy management, reduce costs and emission, and improve user comfort. Demand Side Response (DSR) algorithms [28], [29], Non-intrusive appliance load monitoring (NIALM) [30], battery management systems [31], lighting and thermal control [32] are some examples of enablers to which AI would add values.

ICT Enablers: ICT related systems are technological enablers to deploy *ubiquitous* city projects. In this subsection, the role of ICT in smart grids with respect to the traditional power systems is reviewed as an example of technology applications to smart cities.

The common terms in most of smart grid definitions are efficiency integration of actions, incorporation of digital technologies, information exchange and two-way communication technologies. Therefore, the communication is a key element in smart grids. This is not only the glue to interconnect physical devices, but also market actors, operation centres, enterprise entities, energy producers and users, and other business premises. The ICT layer covers *i) information to be exchanged, ii) communication protocols and standards, iii) media and iv) control or supervisory systems*. In electricity utilisation premises the protocols like IEEE 802.11, IPv4, IPv6, IEC 61850, the media like ZigBee, HomePlug, Z-Wave (HAN), and the control or supervisory systems such as Building Area Network (BAN), OpenADR (price responsive) and energy management system are used.

In distribution domain, the ICT allows for introducing many new services that enhance energy network operation and efficiency. It supports distribution management systems in 3 parts: data acquisition, system modelling, and system operation.

Data acquisition: ICT interconnects many Remote Terminal Units (RTUs) distributed across the network and buildings with centralised or decentralised data gateways such as Supervisory Control And Data Acquisition (SCADA) system [33]. Device status, energy data and user information are periodically exchanged thanks to well-established ICT network. Any data storage, event log and reporting are performed in this part. The ICT supports smart payment of bills, customer complaint handling and outage affected customer identification [34], [35].

Modelling: ICT enables modelling applications such as state estimation [36], fault analysis [37], route optimization for field crew and power flow calculations. This is through providing prompt information and distributing the intelligence to enhance computation power and modelling performances.

System operation: the existing services would be automatized and enhanced when ICT is integrated. Network real-time monitoring of distributed renewable generation, user energy consumption and topology reconfiguration are facilitated by appropriate deployment of an ICT-enabled system [38], [39]. In this application, smart metering infrastructure like Advanced Metering Infrastructure (AMI) utilizes ICT and widely distributed smart meters to improve monitoring. Protection coordination, network reconfiguration, power loss minimisation, automated mapping, fault and outage management [50], and operator training are some of other examples of the ICT-enabled system operation [51].

Internet of Things: IoT-based approaches are among popular and common novel ICT-based enablers. IoT aims to interconnect numerous heterogeneous devices through the internet. This is performed through a layered architecture in which the devices, the people and cloud-based services are integrated to support an application [40]. IoT outperforms other ICT based approaches especially in use cases where large number of distributed devices should communicate bidirectionally. Smart grids require a lot of services that involve numerous widely distributed devices, such as smart meters. In an urban area, there may be over millions smart meters both in customer premises and field substations. They should periodically send signals to report alarms, status or measurements, and receive signals of actuation commands. The signals may be used by several services, for instance fault location [37], thief detection, energy balance, power quality monitoring, demand side response [41] and state estimation [36]. IoT enables interactions between the same devices with many services.

The performance of IoT-enabled schemes for smart grids depends on several parameters including the number of deployed intelligent electronic devices (IED) in the network, the cloud protocols (e.g. MQTT, REST, etc.), interoperability, and fast bidirectional communication [27]. Smart meters are low-cost multi-purpose IEDs that can be widely utilized by an IoT-based architecture. The architecture collects real-time data from large number of different meters and sensors to provide actual information for the services. The services should have appropriate Application Programming Interface (API) to access data. This allows for integrating novel services and distributed applications with minimum effort and a plug-and-play fashion. It is important to ensure interoperability among different existing communication protocols. This requires some middleware to abstract hardware functionalities from different low-level technologies through uniform interfaces. For some services, near real-time data exchange is needed that implies an asynchronous communication. This is often implemented by using the publish/subscribe approach [42].

1.3. Smart Grids and Smart Homes: Direct Benefits for Users

The benefits and opportunities provided by smart grids and smart homes can be reviewed from different aspects. In this section, the direct benefits of integrating new technologies and methodologies for the system operators and users in smart grids and homes are discussed. In the next section, the benefits and challenges of this evolution for the urban workforce and built environment workers are elaborated in detail.

1.3.1 Improving ex-ante interoperability analysis: software and hardware in-the-loop

Ex-ante analysis of newly developed technologies and methodologies is crucial to verify the performance and efficiency of them [43]. This is normally done by modelling and simulation; however, the multidisciplinary nature of modern systems requires new sophisticated tools and methods for reproducing the behaviour of the real system in the lab [44].

In each application domain of ubiquitous cities including smart grids and homes, the actors and actions which form use cases may belong to different disciplines. For example, in smart home applications, users and devices are some of the actors and home energy management is an action; users' behaviour is a social output which is an input to define the function of appliances and their status, the appliances are electrical or thermal physical devices, and the home energy management is a smart function integrating ICT and AI. Multidisciplinary systems like this example, multi-vector energy systems like interconnected gas and electricity networks [45], and multi-level hierarchical systems like utilisation-distribution-transmission networks [46], imply the fact that multidisciplinary modelling and analysis is needed. The new modelling approaches should be able to study the interoperability layers - including physical, information, communication, function and business layers (Figure 2 [47]) of smart grids and homes. Reviewing literature and project reports shows a growing interest in developing new schemes which are ubiquitous, general purpose, scalable and flexible. The new management or operation schemes integrate different modules from different disciplines. Most of recent investigations and implementations proved Internet of Things (IoT) to be an efficient and low-cost approach to improve the ex-ante modelling and analysis of smart grids.

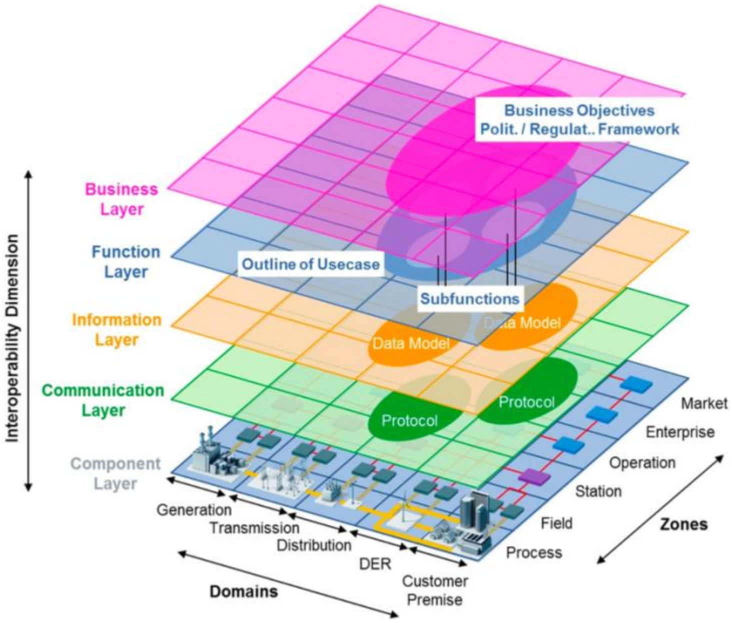

Figure 2 Smart grid architecture model (SGAM) with interoperability layers [47].

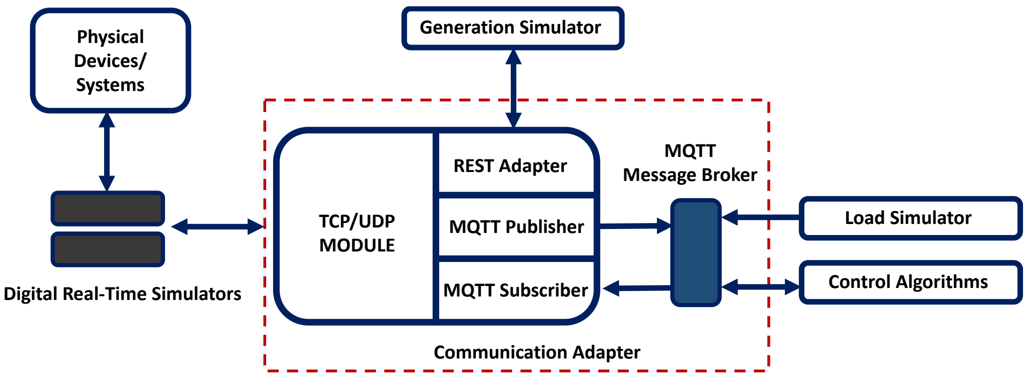

Figure 3 An IoT-based proposed scheme for real-time co-simulation in smart grids [43]

1.3.2 Improving real-time efficiency of system operators: human in-the-loop

All technological and methodological enablers aim at evolving smart grids and smart homes through digitalization and automatization. Nevertheless, human would remain in the loop. Not only in planning phase, but also in operation the technicians, engineers, regulators, policy and decision makers are closely involved in running the systems. In the following, some examples of the role of ICT in increasing the efficiency of human operation in smart grids are introduced.

SCADA in electricity distribution networks provide appropriate data from pre-processed analysis and classification of events to the operators via Human-Machine Interface (HMI). Measuring consumption or generation is performed remotely and the bills are delivered via various methods automatically. New systems provide facilities for the customer service operators to log the complaints and map the customers. In case of scheduled maintenance, the customers would be notified in proper time.

Route optimization for technical crew who are dispatched to field is another example of ICT and AI application for human satisfaction. The terrain conditions and information of the streets reaching the filed are stored in database to be used in transportation models aiming at optimizing crew travel. In some restoration or repair missions, the time is crucial as it impacts on the reliability of the distribution system [48], [49].

Most of electricity outages are due to distribution network fault. When a fault in network disconnects the circuit or triggers the protection relays to interrupt the electricity, the faulted lines are isolated to restore the rest of system. This process traditionally should take around an hour (40-80 minutes) in an urban area. Figure 3(a) summarizes the whole restoration process in a conventional outage management system. In this process, the human (the electrical engineer or technician) should firstly localize the outage based on trouble calls or breaker alarms. The repair crew is dispatched to travel to the field. They need patrolling and investigating the problem, and finally isolate the fault. In practice, this is a challenging and time-consuming process. There may false or fake reports, patrolling is demanding specially during adverse weather conditions, and the night darkness or fewer reports make the outage identification longer.

AI can support localizing faults and outage faster [50], Intelligent Electronic Devices (IED) can provide data over communication system, and automatized actuators can receive commands to isolate the fault before human arrives. Figure 3 (b) shows the importance of ICT in reducing the restoration time to less than a minute. This would significantly improve system reliability [52], [53] and human satisfaction at both operator and customer sides.

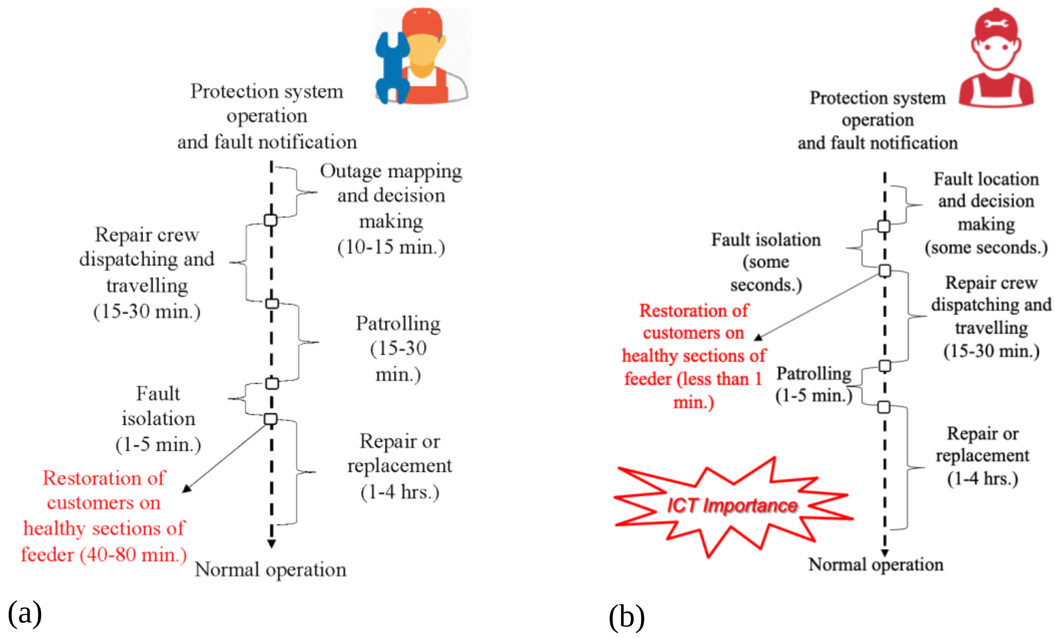

Figure 4 Example of technician efficiency improvement using AI and ICT in smart grids [49]

2. SMART LABOUR

Despite important developments already accomplished, smart grids and smart homes still have a long way to go. As explained in the abstract and introduction, urban technology has a meaning if it contributes to human development – as residents but at the same time as workers. One needs to have a decent income to live decently in a city or town. The actual impact on the workforce is still a subject of inquiry, as the technology is still unfolding. The title of the section is an allusion to the overall use of the word 'smart' (as applied in cities, homes and grids).

This section will discuss trends, potential consequences and provide insights into the future. First, the session discusses the overall impact of the development of smart grids and homes in the urban workforce in general (i.e. across the sectors of the urban economy). Following, it concentrates on workers in trades related to the built environment – i.e. the sector of the economy which encompasses the grids and homes. In each case, the section will discuss existing and potential opportunities and challenges, paving the ground for conclusions and recommendations.

1.1. Urban workforce

2.1.1. Opportunities

Starting with the broad picture. Smart grids accelerate communication and the transmission of energy, which, in turn, pave the ground for a more efficient economy in the localities where they are placed. When the economy is more efficient and grows, it has more potential to generate new employment and to improve job quality. From this perspective, smart grids are potentially good news for the workers in such areas. Naturally one cannot guarantee that the economy will indeed benefit workers, as there are cases in which surplus is unevenly distributed, sometimes to the extreme. But at least a growing economy has more prospects than a stagnated or shrinking one.

Faster and better communication has a great impact on online working. It opens many possibilities. Those whose work can be done online are able to offer their services to clients literally all over the world. Those who have limited mobility are particularly benefited – e.g. workers with disability, those who live in neighbourhoods badly served by public transport, those who live in far away suburbs.

WBCSD [15], in its research about future trends in work, noted that where once physical proximity was required for people to get work done, the advancements of digital communication technologies and collaboration platforms have allowed for an accelerating trend of remote working –a phenomenon known as telecommuting –and created the opportunity for more distributed teams.

According to a survey conducted by IWG [54], over half of professionals worldwide already work remotely at least 2.5 days per week. Moreover, in the past two years alone, there has been a 78% increase in LinkedIn job posts advertising flexible work arrangement. These statistics indicate that remote work is here to stay and is not only a temporary trend in the labour market. [55], [56], [57].

Faster electricity contributes to the development of the gig economy, immersive tech, IoT. IoT is also instrumental for the grids themselves. They will be analysed in turns. The gig economy is defined as [15]:

… "a labor market that brings together supply and demand for a set tasks or projects... Distinct from times when workers and employers had to find each other through job adverts and recruitment agents, so-called online gig workers are on-boarded by independent platform businesses and then matched to work opportunities by the platform, who typically also handles the rate, service delivery standards, cash collection and payment" …

Many gig workers want to work in this way. Self-perceived benefits include the flexibility, lack of monopolization of time, the earnings potential, and the lack of management overhead. For many, a gig is not a career, but a 'side hustle', an opportunity to generate revenue [58].

Virtual reality (VR), augmented reality (AR) and mixed reality (MR) –three immersive technologies that fall under the category of extended reality (XR) –have been expanding throughout the past decade. In recent years, their presence began to be increasingly felt beyond the fields of gaming and entertainment, where they initially gained popularity. According to a global survey by WEF [56], [59], more than half (58%) of companies are likely to adopt VR and AR by 2022.

There are already some interesting case studies in the use of immersive technology in the world of work. In job advertising (Jaguar Land Rover / Gorrilaz), in job assessment (Lloyds Banking Group) in job training (Walmart Black Friday simulator), in employer branding (WeWorkAR video) and in even in the creation of an entirely virtual organization (eXpRealty virtual office island).

"The Internet of things (IoT) is a network of physical objects —devices, vehicles, appliances —embedded with sensors, software, network connectivity and computing capability that enable them to collect, exchange and act on data, usually without human intervention" [15]. It accelerates the economy. It will be beneficial for those who have access to it, as it increases efficiency. It is not clear if it will increase or decrease employment. For sure, it will need re-skilling (such as the ones above).

Homes

Moving from smart grids to smart homes, the latter also offer a number of existing or potential opportunities to workers. Overall, it saves time for domestic chores. Such time can be used for gainful work, or to rest.

There is ample evidence that home-based enterprises have provided livelihoods for large numbers of workers, both in the Global South and Global North. A large number of people are not able to find employment and have to resort to self-employment. Out of these, several work from home for different reasons. It is not only the sophisticated online workers, able to tele-work. It is also a large number of self-employed blue-collar workers or entrepreneurs who cannot afford to open an office elsewhere, and/or – especially in the case of women – have to combine work with home/children care. Many also want to spend more time with family. For those who are or plan to work at home, smart homes provide an added value as some of the appliances may be used for work as well. Or, as said before, save time. This is in normal conditions. When crises strike, such as COVID19 has shown the world, work from home for many people turn out to be the only option – and therefore smart homes become even more important.

2.1.2. Challenges

To recap, smart electricity contributes to the adoption and/or development of the gig economy, immersive tech, IoT. It also contributes to 3/4 D printing and blockchain (the latter is a key connector across a massive flow of data list of evolving records which use sophisticated cryptography to link back to each other and contain transactional data allowing market participants to execute transactions without the need for a centralized third party - i.e. a bank [15]. These developments, together with smart homes, bring challenges to workers. One cannot lay the blame on smart grids and/or smart homes for all the challenges noted below. The point is that such challenges are connected to technological developments which are facilitated by smart grids / homes, therefore they are mentioned here.

ILO [60] and WBCSD [15] also noted that the unprecedented pace of development and adoption of such new technologies are raising concerns of mass job displacement and job losses while rapidly changing tasks and work patterns and challenging how companies and commerce function.

While such technologies may be beneficial for the workers who use them (session 2.1.), there are overall challenges for the urban workers, including increase in inequality, increase in casualization of work, lack of social dialogue, job losses and lack of socialization. They will be analized in turns.

The first one is the potential increase in inequality between those who have access to such technologies and those who do not. By and large, industrialized countries are well ahead of developing ones in technological innovation. Considering the level of poverty specially (but not only) in developing countries, but the race for the new technologies is also likely to increase the inequality gap, unless policies to help those who do not have access are put in place.

Second, the types of professional work aligned with the aforementioned technological advancements tend to be temporary or project-based. Workers are hired to complete a particular task or for a certain period of time. This means that workers have to be constantly on the look-out for the assignments, and there is no job security. While this was already been escalating since the 1970s, the power of the new technological developments can take it to a much greater level [15].

Third, social dialogue with employers and governments has traditionally been a powerful means for workers to collectively bargain for better wages and working conditions [61], [62]. However, in such type of work arrangements explained above, social dialogue is very difficult or almost impossible. Contrary to traditional industrial factories, where there was a clear employer, in the new arrangements it is difficult or impossible to determine who and where is the employer. This makes it practically impossible to establish social dialogue to improve labour conditions. As an anecdote: the title of an internal ILO study on the mining sector in Turkey was "*Who is the Employer*"? The title says it all. The structure of the sector was so intricate with layers of sub-contracting and several modalities of contract, that in the end it was not clear who would be responsible if an accident happened.

The fact that workers under such arrangements are far from each other also conspire – at least in a first instance – against social dialogue. In other words, when workers are physically in the same worksite and know each other, it is much easier for them to discuss collectively and organize themselves to dialogue at least with the government – and with the employer if there is one that can be identified and located. There is less synergy among workers who work online, especially those who do carry out collective assignments. When a given group of workers is spread among different countries, it is difficult to find a common ground to dialogue with the government.

Having said the above, it is also important to note that workers may benefit from ICT to speed up exchange of information, online dialogue among them and decision-making. It may be more realistic to explore potential benefits of technological development rather than to fight them.

The fourth point is that such technologies can lead to job losses for being (highly) capital-intensive. This links to the traditional debate regarding labour- versus capital-intensive techniques [63]. Labour-intensive techniques may create more jobs during a certain period as opposed to capital-intensive ones, but it is regarded as slowing down economic growth. If capital-intensive techniques have a sound effect on economic growth, in the end it will create more jobs in absolute terms. For example, while a house built with 3D printing will cut down jobs needed to build it in a traditional way, the massive manufacture of 3D printing and the consequent massive production of housing in such a way may in the end generate more jobs. It is difficult to make a conclusive prediction. But one way or another, given the impact of industrial growth in the planet, it is important to bear in mind that economic growth is finite, and one cannot rely on it forever to generate jobs via ever-expanding capital-intensive techniques. This is an important debate, that must continue to bring new findings.

During a few decades, industrialized countries have set up production unit in developing countries. Despite of many debatable practices, this has created many jobs in the latter set of countries. By and large, industralized countries are well ahead of developing ones in skills training for technological innovation. The race to digitalization may lead to a counter shift. I.e. jobs migrating back to the North, a fact which may exacerbate unemployment in the South [17]

If or where job losses take place, unemployment benefits are needed. But unemployment also have other consequences, even if the unemployed has financial compensation. Having a professional activity is an important element in one's insertion in society. There is evidence of mental health problems (such depression) derived from unemployment [64].

The fifth challenge noted here concerns both the unemployed and those who work online. Socialization is one of the important elements of collective work. To work in isolation (or not to work) has a toll on one's health [65]. Also, according to WBCSD [15], disconnected workplaces have been linked to nearly 40% higher rates of absenteeism, 50% higher rates of bodily accidents and 60% higher rates of avoidable errors. Further studies have shown that a connected and engaged workplace fosters higher rates of self-reported job satisfaction, improved job performance and increase rates of retention.

As noted by Werna and Klink [66], a dystopian scenario would entail masses of unemployed workers. Unless the wealth generated by those who work would be evenly distributed, there will be alarming problems. The ethical and social toll would entail an increase in poverty, riots and crime. In terms of the economy, one can ask: who will buy the products made by machines, if nobody has cash?

Above are the challenges to urban workers brought up by technological developments, which are facilitated by smart grids and/or brought up by smart homes. One issue that cuts across most of the challenges is disaggregation: workers in a same project but in different locations; the end of the physical workplace as we know it; production, exchange and purchase of goods without the need for human contact. This changes the perspective not only of urban work specifically, but also the concept of the 'urban' itself. A basic distinctiveness of cities and towns is gathering, and economies of agglomeration is one of its crucial features. Therefore, if economic activity does not need agglomeration any more, this may have a significant impact in urban morphology.

Those who are able to work from online (especially in smart homes, or even elsewhere), may opt to live in the countryside or small villages, which is already happening to some extent. This is still incipient if one takes into account the number of settlements and people in the planet, but is a trend or a desire at least for part of the urban workers. COVID19 came to exacerbate the dispersion trend.

There are still many people who like to live in urban areas because of the social and cultural life, which is a counter-trend. We do not know yet which trend will prevail. So far there has been a steady and constant growth towards urbanization. It is important to monitor this, think about the possible consequences for each one of the alternatives and how to best design the human settlements of the future.

1.2. **Built environment workers**

The built environment encompasses the very trades which produce grids and homes. Therefore, out of all urban workers, those in trades related to the built environment are particularly impacted by the technological innovations noted in Section 1 of this chapter.

1.2.1. Opportunities

BWI (Building and Wood Workers International) is the one and only international confederation of trade unions in construction-related (and forestry-related) trades. Mr. Ambet

Yuson, BWI's Secretary General, is optimistic in relation to advancements in artificial intelligence, also informed by a study commissioned by BWI [16]. In a recorded interview [17], the Secretary-General notes that such technological developments are welcome. They are likely to be safer, provide new training and new working opportunities specially for women and youth, pay better, need less working hours (meaning more time for the family) and have more sustainable production methods.

The points made by Yuson [17] and Goger et al. [16] are valid at least as premises and relate to (i.e. address) key current challenges of construction workers. They will be analysed in turns.

Construction is one of the most dangerous occupations. Approximately 17 per cent of fatal accidents reported globally take place in the construction sector, amounting to 60,000 fatal accidents per year. Worldwide, around 22 construction workers die annually for every 100,000 construction workers. The construction industry accident fatality rate stands at more than double that of the 'all-sector' average. It is estimated that fatality rates in the least developed countries may be more than double the rates in developed economies [66], [67], [68].

A substantial part of the safety and health deficits is due to the hazardous nature of the construction work. This is likely to improve with digitalization in general, including smart grids and smart homes. The nature of the (so-called) 'smart' work is less hazardous.

As smart grids and smart homes entail technological innovations in many places around the world, they will bring new training and job opportunities for workers. The specific groups signaled by the Secretary General of the Building and Wook Workers International (the trade union confederation for construction) [17] (youth and women) are indeed priority beneficiaries. First, there is ample evidence about the difficulties for a large number of young people to enter the labour market, with grave forecasts for the increase in poverty, alienation and insecurity [69]. Smart grids and homes provide an opportunity for the youth. Senior workers do not have an advantage because, as the technologies are novel, they do not have the professional knowledge already. In addition, young people usually deal better with digital innovations than older generations. On the other hand, this may also create challenges for senior workers, which will be discussed later.

In regard to women, according to the latest publication of the ILO on labour in construction [67], despite some increases, the participation of women in such sector remains low, and lower than in many sectors. Equal opportunities have not been achieved. Women are sometimes employed as part of a family work unit, often without receiving direct payment. The percentage of all women paid workers in construction - which denotes the share of paid women working in the construction sector, out of female workers in all sectors – is between 5.5 and 14.6 percent according to the geographical region. The share of women workers out of all workers in the construction industry is between 0.5 and 7.5 percent according to the region.

At least a significant part of the exclusion of women is due to the traditional view of construction as a sector which requires heavy physical work, regarded as task for men. This has created an entrenched culture. As the type of work that smart grids and homes require is more sophisticated than traditional "heavy load carrying" construction, it helps to counteract this routed view.

The next point is better salaries. Construction is a pyramidal sector, with a large number of low-paid workers at the bottom. Moreover, although payments below what the law stipulates and /or longer working hours without proper compensation are illegal, such practices do happen given the high numbers of informal or casual workers, and/or lack of control. Delays in payment are also an extended practice [70], [71]. Given the innovativeness and sophistication of smart grids and smart homes, their implementation will need highly skilled workers, who are likely to be better paid. The impact on the unskilled and semi-skilled workers remain uncertain, and will depend on a number of variables (such as the capacity of the workers to negotiate, or/and - considering the scenario of social anomie - a social pact for a better world with the commitment of entrepreneurs and governments).

The premise of less working hours, and therefore a better work-life balance, addresses another challenge of the sector. In many countries, piece-work is the predominant wage form for temporary workers. Many are forced to work long hours. Others choose to do so, either because the rates of pay are low or because they want to earn as much as possible while work is available. This is particularly so in the case of workers who have migrated from the countryside or from overseas. A ten to 12-hour day, for six days per week, is the norm. Even in the United Kingdom, research revealed that self-employed construction workers are paid per shift (rather than per hour) and the shift is normally 10 to 12 hours per day for six days a week [66], [72]. In sum, if the technologies under scrutiny in this chapter increase productivity and reduce the working time (without reducing wages), this will obviously have a beneficial impact for the workers.

The final point, sustainable production methods, is also welcome in a sector like construction which is known for uncertainty and periods of boom and bust, with serious consequences for the stability of employment [66], [67], [68], [72]. If the introduction of smart grids and homes lead to sustainability, it may generate steadier employment.

Smart grids entail additional apparatuses, but also have a component of substitution – i.e. replacing traditional types of grid. Therefore, the net employment generation will depend on how many jobs are gained in the new grids versus those who are lost through substitution. Smart homes entail additional apparatuses, more than substitution. Therefore, their proliferation may entail the creation of new jobs. At the same time, the methods to be used in the manufacturing and installation (capital- or labour-intensive) also play an important role.

It is important to highlight that at the moment we are dealing with scenarios, without a firm knowledge of what will actually happen, as the future depends on many variables. It is not clear if the new technologies will lead to employment generation, longstanding employment or the contrary. Nevertheless, it is useful to identify scenarios and its possible consequences.

1.2.2. Challenges

Following the structure of sub-section 2.1., the challenges will be analysed in turn, including: increase in inequality, increase in casualization of work, lack of social dialogue, job losses and lack of socialization.

There is already large inequality within the workforce in the build environment, which is pyramidal. New technologies require highly-skilled workers. This will naturally increase inequality within the industry, if the bottom of the pyramid remains with the type of semi- and unskilled work that it has now. If there is a fully-fledged increase in the skilling, inequality will diminish. A scenario is that the semi- and unskilled workers will lose their jobs – or be replaced

- as they may not be able to catch up with the new knowledge necessary to work with the new technologies.

Casualization of work, which is already high in the construction industry [66] [67] [68], may increase not necessarily because of smart grids and smart homes themselves, but due to the trends associated with them and explained in sub-session 2.1.

The present situation regarding social dialogue is somehow similar to casualization. According to the aforementioned authors, it is also a concern in the construction industry. The products of construction are fixed in space, and this would have given the opportunity to construction workers to meet more frequently and strengthen their positions – as opposed to workers who never meet each other. However, the high levels of casualization, informalization and large-scale sub-contracting chains have weakened the organization of the workers, although there resistance remains.

The tendency is that the components of smart grids and smart homes are prefabricated off-site and only assembled in-site, and in some cases with automation. This does not help social dialogue. This reinforces a suggestion made before in this chapter: workers may benefit from ICT to speed up exchange of information, online dialogue among them and decision-making. It may be more realistic to explore potential benefits of technological development rather than to fight them.

The next point, job losses, follows the analysis for urban workers in what regards the capital- versus labour-intensity. The installation of grids and the construction homes (smart or not) can be either capital- or labour-intensive (or somewhere in between). This will naturally impact on employment generation or losses. Considering the drive for digitalization, it is likely that the tendency will be towards capital-intensive methods. The example of 3 /4 D construction, made in session 2.1.2 also applies here.

It is clear that technological innovations will create new jobs in the construction industry (section 2.2.2.). But the rate between jobs creation and job losses is still uncertain. It is also clear that there is a tendency that the new jobs will migrate from the Global South to the North (section 2.1.2), and may also 'migrate' from senior workers to young ones (2.2.2). Again there is uncertainty in regard to the fate of those whose jobs have migrated away from them.

The possible effects of unemployment, already analysed for urban workers in general, also apply for construction workers in particular. This leads to lack of socialization, which can also happen with the dispersion of workers in different workplaces and lack of physical contact. The latter may be milder in the assembly of smart grids and homes because it still requires groups of workers working together. Nevertheless, it is important to monitor how the construction methods evolve and to be aware of possible consequences.

3. CONCLUSION

The Chapter analysed key technological developments which have clear potential to improve the life in cities and towns. Usually, the literature focus on the benefit of technological development to people as residents / users. But at the same time, they are workers. It is important to understand the impact on the first because one needs to have a decent income to live decently in a city or town. At the same time, the workers are the ones who produce and install the new equipment, therefore they need to be skilled and in good conditions to do so.

The actual impact on the workforce is still a subject of inquiry, as it will depend on many variables, noted along the Chapter. Still, it is possible to detect some trends, and at the same time scenario-building is important to be prepared for the consequences.

As in the case of any radical technological innovation, workers need to be trained or re-trained. In advanced economies, some level of training in such innovations are already taught in TVET (technical and vocational training) institutions for future construction workers or in retraining courses for current workers. How advanced it is, and how relevant to the needs of the labour market, is a different question, and there is large variability. In less developed countries such skills are nascent as is related training.

The Chapter analyzed the impact on the quantity and quality of employment. Those in the construction industry who are hired to work in the production and installation of the new equipment will naturally benefit. Many workers in other trades have also been able to benefit from the innovations. At the same time, dispersion have a tool on casualization, social dialogue and socialization. The recommendation is that workers should explore how ICT could speed up exchange of information, online dialogue among them and decision-making. It is more realistic to explore potential benefits of technological development rather than to fight them.

Unemployment should be carefully monitored, for all the reasons explained in the Chapter. It may happen due to substitution of humans by machines, due to 'migration' of jobs from one region to another, due to difficulties of part of the workforce to retrain (bearing in mind that the little trained 'bottom of the pyramid' in construction is vast). In a scenario of unemployment, solutions related to social protection have to be in place. Social pacts may also be important to stimulate solidarity (section 2.2.1.).

Dispersion and disaggregation have impacts not only to work practices but also to the concept of the 'urban' in general. The urban economy, heavily based on the benefits of agglomeration, has been an important driver for the way cities and towns have developed. This could change in the future, leading to more dispersed settlements.

One way or another, the sweeping changes that the new technologies are about to bring must be embedded in an environment-conscious approach. Economic growth based on the ever-expanding production of new goods is not infinite.

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