Challenges for citizens in energy management system of Smart cities

Ary Mauricio Burbano, Antonio Martín, Carlos León, Enrique Personal

***Abstract*— Much has been written about the rapidly emerging, the disruptive impact being detected on every aspect of how machines and their operational technology communicate with one another, with the underlying information technology platforms. Within the smart city exists an infrastructure of interconnected objects, people, systems, and information resources together with intelligent services to allow them to process information on the physical and the virtual world. In this paper, the authors talk about the advantages and the uses of these technologies in the smart city and the new challenges of citizens to reduce energy consumption and global warming.**

This paper attempts to address these new approaches and the requirements involved and to articulate it in a concise and concrete way. The aim is to assist decision makers, architects, developers, and implementers in changing the character of the smart city initiatives from ones based on simple transformation to ones involving play shifts in the way that devices are identified, management and controlled.

***Index Terms*— Smart city, energy efficiency, smart citizen, energy management system, Microgrid**

I. INTRODUCTION

THE energy is very important for the operation the smart city. All cities need a huge quantity of energy every day for transport, homes, business, public service, education, industry, etc. Our capitalism system increasingly needs more energy because now there are more people can buy electronic devices that need energy. Recent statistics show that 50% of the world´s population is now in or around cities. These cities are responsible for three-fourths of the world´s energy consumption and greenhouse emission.

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By 2050 the world´s population will grow by another 30 % and the number of people living around cities will jump to 70 % [1]. Ten years ago, families had a minor energy needs due principally the change of lifestyle. For example, few years ago children went to parks and gardens to play, but now there are more children that play video games in their houses. The middle class is increased around the world and also they need more energy, for example in China, thousands of people have money to buy whole that the markets offer. Citizens in developed countries use renewables energies, recycling, re-use, use bicycles and others habits that make the difference. But while these citizens created a green culture, at developing countries there are many people coming out of poverty and now they need more energy than a few years ago. All the habits that save energy are welcome, but looking around the world, we need other forms to reduce our energy consumption. If the technology created all the elements that need energy, technology also can give us the solution to reduce energy consumption and protect the environment.

The energy efficiency could be the key to reduce energy consumption together with electronics and artificial intelligence. For the smart cities, many of the current technology trends contribute to its expansion such as Internet, which is thought to reduce the digital divide for citizens and smart cities. Some researchers have working about the collective knowledge of the citizen in the smart city; for example, Guelzim and Obaidat talk about smart city challenges, introducing concepts like smart environment and smart people [2]. The magazine for the metropolitan world, editing by Siemens, center the attention in cities for people but from the point of view of urban planner [3]. Other magazine called “Metering and smart energy” focus on Smart grid and data and analytics [4]. Akgul have researched in green network management for Smart cities and homes [5]. Organizations like Greenpeace with the help of Delft University, has enouncing the potential of the citizen to produce renewable energy [6]. All these works have good information about the smart city but don´t focus in the challenges of the smart citizen.

In this paper, the authors talk about the advantages and the uses of these technologies that any person or family can use to reduce energy consumption and prevent the global warming. Then, the authors talk about the energy efficiency and energy in the smart city. Finally, the authors defined the challenge of citizens in the smart city.

II. ENERGY EFFICIENCY IN SMART CITY

The present society uses different sources of energy. Electric energy is produced by means of renewable and non-renewable sources. Renewable sources like the sun and the wind are becoming more and more important in the global energy market. The European Union has set itself the goal of reaching 20% of its total renewables by 2020, and the United States has become one of the leading countries in solar and wind energy. Developed countries, for their part, are beginning to create policies that encourage the use of these energies. According to the Energy International Agency (EIA), the preference for green policies is bolster because the oil and gas extraction is each most expensive every day, while renewables costs and technologies more efficiently still down [7]. The human being has found several ways to produce electrical energy in a sustainable way, reducing waste to the environment and using renewable resources, however, the problem is not only finding the way to produce energy but also how to use it. Currently, energy is wasted in our cities; the energy efficiency in this sense is undoubtedly a challenge for our society, from the implementation of technologies that allow reducing energy consumption until the challenges and duties of citizens. The authorities must make efforts to save energy with the community, thinking in saving money and in the protection of the environment.

Different energy saving initiatives have been developed in the last 10 years, the citizens and the companies that want to save energy have begun to use the ISO 51001 standard that refers to save and use of efficient energy. Several companies have decided to have a business alternative energy management that uses measurement, telemetry, and the Web as tools to inform users how they are consuming their energy. In work and home, energy efficiency plays a key role in limiting global energy demand growth by a third by 2040, while the world economy is growing by 150 % [7]. In the United States, the Energy Service Company's (ESCOS) was created twenty years ago in charge of energy audits of its clients, who make proposals for energy solutions that represent an initial investment. ESCOS provides energy services of improving energy efficiency in the installations or infrastructure of one user and they face economic risk to do. They assume necessary investment to improve the energy performance and operated in the base of contracts which payment is based on the improvements in energy efficiency and accomplish of the rest performance of the commitment requirements [8].

On the other hand, if the customer, for example, has a renewable installation, the solar devices like the voltage regulator and inverter can show information in real time about the state of the system. The user can look the behavior of current, voltage and power and with this information the final user could be his own energy manager. This primary information can be simple but it´s the beginning of the smart energy. This system of monitoring could be installed in home, offices, government, hospitals, schools etc., and work with a set of devices. So in this moment, the technology can use this information to prevent possible failures and show in real time the behavior of the energy system. However, the real question is if the citizen is prepared to use this technology and if is proficient to assume its role in energy systems. As it´s can see in the next figure, the solar system can be controlled with data of consumption, current, voltage, power, temperature and solar radiation. With this information, the user can infer the functioning of the installation but he always has to go the panel to check this information and eventually take a decision, however, with the smart devices, users can forget this revision because technology allow the data visualization in a smartphone or the machine can take the decision without the human intervention.

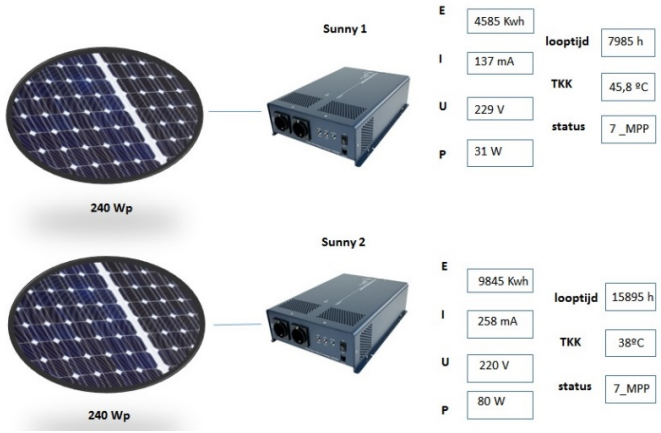

Fig. 1. Electricity production monitoring

A. ICT for Smart City

Technology is one of the key tools for the development of the smart city, the level of the advance of the Information and communication technologies (ICT) affect in the strategy of planning for development of the smart cities. With ICT is possible to have digital platform whole interconnected that support applications and private and public services. The objective is to improve the performance, thus the reduction of the energy consumption and the emission of greenhouse gasses [8]. The cities tend toward models that allow reducing the personal and global energy consumption, that support the big imbalance between energy generation capacity and municipal energy consumption.

There are many key enabling technologies that have played and are playing a great role in building and developing smart homes and cities. Among these are: the internet, wireless networks, and systems such as Wi-Fi, Bluetooth, and Zigbee; Smart Phones including LTE, 3G, 4G, and 5G cell systems; body area sensor networks, smart grids and renewable energy, optical fiber systems and high-speed networks, Internet of Things (IoTs), wireless sensor networks (WSNs), Vehicle Ad Hoc Networks (VANETs), global positioning systems (GPSs), geographical information systems (GISs), wireless navigation systems, world wide web (WWW), social networks, smart TV, radio frequency ID (RFID), sensor-enabled smart objects, actuators and sensors, cloud computing systems, intelligent transportation systems (ITSs), biometric systems, e-based systems including e-commerce, e-government, e-business and e-service systems, network infrastructures, data management systems, analytics, cyber security [2]. Besides, Wireless power

transfer (WPT) is used to transfer power over short distances by magnetic fields [9].

III. ENERGY MANAGEMENT

Every day we can see more cities around the world that want to have an energy management system. The governments have realized that with the saving energy the costs of energy production and the impact of environmental reduce considerably. A few cities have energy management system from the energy production to distribution. Some cities are starting to build a smart grid to prevent failures, as Malaga that with the project MONICA (Advanced Monitoring and control), are testing and assessing a series of powerful monitoring tools that perform real-time diagnostics in medium and low voltage distribution grid. Siemens have a project "SIESTORAGE" in a Portugal smart grid, this consists of a pilot project based on a storage system that will be integrated into a medium-voltage power distribution grid connected to Evora University. This solution will have a power of 472 Kilowatts and a storage capacity of 360 kWh [4]. Helsinki plans to meet this predominantly through to supply of cleaner electricity and heating. In Spain, the Spanish technological platform of Electrical Grids (FUTURED) was created for the purpose of integrating all of the agents involved in the electricity sector. Amsterdam smart city is a public–private partnership initiated in 2009 to transform the Amsterdam Metropolitan into a smart city. The Amsterdam smart city platform is composed of many initiatives like "Nieuw West", that is one of the most advanced grids in the world that has advanced features such as self-healing [10]. Digital Birmingham in the United Kingdom, was launched in 2014 with a defined 49 actions, one of these, is involves digitalizing the social care, improving energy efficiency, as well as smart mobility [11].

The management solution should focus on the installation of measurement equipment based on signal acquisition equipment that registers energy consumption of energy in real time. As said Akgul: one of the most important aspects of the smart cities is improving the quality of the user life [12]. In order to manage this aspect the involvement of the users to the network management is necessary by presenting specific data and necessary feedbacks. Human involvement in the intermediate steps would make the control framework open for failure and slow down the optimization process [12]. These equipment registers consumption in configurable time bands and sends it to management data system (MDS) with daily frequency. The MDS analyze the consumption, in a list or as graphic allows generated alarms that send SMS or email. That indicated, for example, the consumption of the hours of installation used or the defaults or excess. Besides, is used units of local control; it can work with the data of consumption a real time, can detect and correct problems of functioning, even before it generated costs or extra faults. Many of the actual applications are based on solutions management from the cloud.

The average saving after the implementation of this systems, oscillate between the 10% and the 30% according to the application, the use and the state of the installations and the spaces. The challenge brings out the necessity of simplicity in management.

Moreover, smart city devices (SCDs) can demand specific applications or routines. Design and implementation process of SCD network management devices is also challenging [5]. The author's talk about the importance of the user in the energy efficiency, so in this case, if the people don't change their habits, whole the saving energy actions are for nothing. The ESCOS can provide the user´s multiples devices to control his energy consumption also with domotics, but the maybe the people will not aware about the energy and delegates all their energy duties for electronic devices. The principal step to reduce the energy consumption is that the people save energy at home; other reason is the citizens care the environmental, or they want to save money. As can see in figure 5, the Master center control the whole system since the generation until the consumption; the generation could be renewable, the transformation and distribution could be smart and users should choose the energy management system. When the cities have a huge participation of renewables in the energy matrix, the distribution could be in direct current through grids or micro grids with superconductors.

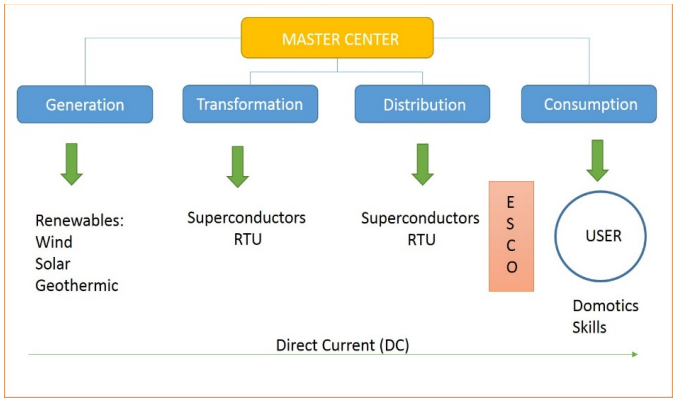

Fig. 2. Ideal energy management system

When energy is produced, it has to transport for substations and them to final users, the energy does a long trip to arrive our homes. In whole travel exists losses in the cable by the joule effect, in the power transformers and all the devices that work in the energy system have a little consumption. The cables still use aluminum, copper or steel to conduct energy, however, researchers are finding superconductors that improve the generation and transport the energy without losses. In the future will use a Pottery of yttrium, barium and copper oxide that it´s a superconductor at 93 Kelvin, this material could refrigerate with liquid nitrogen that have an accessible price, The superconductors that are used now, have losses with alternating current (AC), however, these losses decrease when energy is transported in direct current (DC).

IV. AUTO GENERATION OF ENERGY

Exist another strategy to implicate the users in the whole energy cycle. Recently, foundations or companies with renewable energy and micro grids (MGs) offer a solar or wind installation and also the possibility to connect your house with other houses. For example at a neighborhood, citizens could interchange excess of energy between their homes. Perhaps this technology is the democratization of the energy, where now the user is the generator, distributor, and consumer.

Hence, the option of having MGs and can share the energy into houses will be a social thing. MGs achieves that energy will be democratized, that means user don't need big companies to supply energy. In a Research, Suryanarayanan and other authors expect a proliferation of MGs in future power systems, and in particular of customer driven micro-grids, which will be established through contractual agreements among residential customers [13]. The empowered end user can actively participate in the system in multiple ways. With micro-generation, investment in own or community-owned electricity generation facilities becomes more commercially attractive for the consumer compared to grid-delivered electricity. Users may replace primary energy with more sustainable electricity for such needs. The regulators and policy makers should removal of barriers for the end users access to various electricity markets [4].

The MGs comprise low voltage (LV) distribution systems with distributed energy resources (DER) (micro turbines, fuel cells, PV, etc.) together with storage devices (flywheels, energy capacitors and batteries) and flexible loads [14]. These MGs can be connected to the main grid or could be isolated from the grid; it depends on the client requirements. The geography, and the environmental are also significant, the user perhaps live in a town, village or a city. In order to use the MGs, it should have a mechanism for its management. The MGs besides of the cable line, and electric devices, it should have electronic devices to control, supervision and solution the problems in real time, so the exact term is "Smart Microgrid".

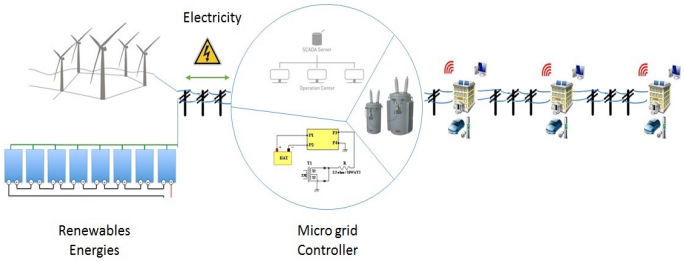

Fig. 3. Microgrid

The smart Microgrid combine hardware, communication systems and software for the bidirectional interaction between final consumer and the energy companies to reduce and optimize the energy consumption. In the MGs is possible measurement the current and voltage to analysis the quality of energy. Normally grids are very large and they need more money to check the energy in all phases. Maybe if grids were shorter like MGs, the management of energy could be easier. According to the report "The potential of energy citizen in European Union", more of 264 million of Europeans Could produce its own energy by 2050 and cover 45% of the EU's electricity demand. Figure 7 shows the potential number of EU energy citizens for the various technologies assessed, in 2050. With the assumptions used, we estimate that about 115 million EU households will have an electric vehicle in 2050, 70 million may have a smart electric boiler, 60 million may have solar PV on their roof and 42 million may have stationary batteries on their premises. Another 64 million households could participate in renewable energy production through energy collective [6].

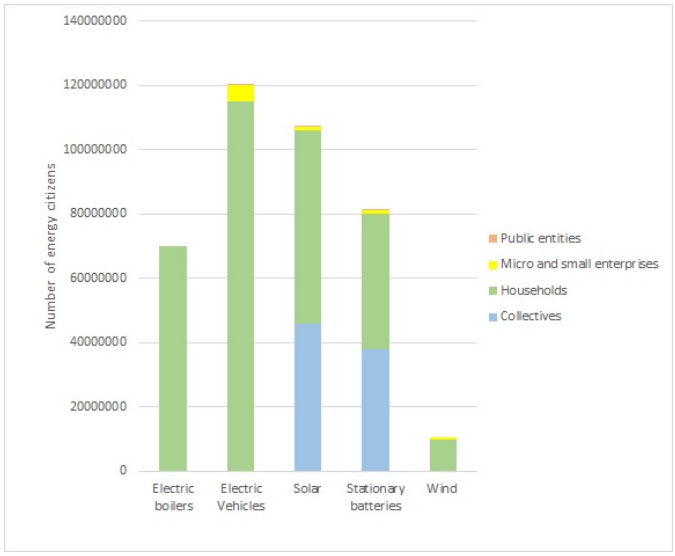

Fig. 4. Number of energy citizens for the various technologies assessed, potential to 2050 for the EU28.

V. CITIZENS IN SMART ENVIRONMENTAL

It´s important that people understand the technology, they should use it well and obtain results from it. The human being has taken the capacity of adapt in the environmental, now our body and mind have a great challenge; use the technology to improve the quality of life, minimize the resources holding of the earth, and preserve the nature. The new environmental that will offer the technology implies the responsibility of humans in the new smart system. As said Weiser "The most profound technologies are those that disappear, they weave themselves into the fabric of everyday life until they are indistinguishable from it" [15]. The smart environment is a concept that emerged in the early 1990s where city residents are continuously interacting with objects and sensors seamlessly to better their lives. The humans will have more time to use in other activities more essential for our evolution, machines will make the job for the humans, like house cleaning, check the energy consumption, pay taxes and everything machine can do it. They may recover time and could be used for example to raise the children and spend time with the family. Maybe the machines will connect the humans to live more in the community. As the concept of "The smart city house" [16] is a framework that relies on to create value for the society. This model is composed of two parts: data and networking as the basis for the smart city endeavor on top of which sits three pillars whose role is to enable good governance, transform the social organization, and inform or guide residents in their day-to-day choices.

VI. SMART CITIZEN

For smart cities to thrive, the human factor has to be accounted for [17]. In this setup, city residents have to possess additional technological skills that allow them to interact and benefit from their smart city as well as to improve it. Technology requires people to have primary skills in order to use this technology but also to follow on the advances in the day to day activities. The majority of public policies on energy efficiency are based on the public areas of cities, where governments want to increase their efficiency based on the concept of "Smart Cities", focusing on the “Public” and not to end users. But if the policies do not include training about energy efficiency and a direct relationship between users and generators is complicated achieve the goal. So the end users are the principal actor in any smart energy system. If the user has to propose itself save energy, first he has to change his habits. If the final users take concrete actions and change a little bit his style life the energy saving increase and it’s no necessary appeal to energy companies. But the reality is other, the citizen live in a fast society where much of time is spend at work, is very difficult that citizens have time to change habits and save energy. ESCOS and energy companies that offer this service, have a huge market with the people that live in their work and have a modern life. The users can choice the strategy of saving energy as we can see in figure 8. He could take an agreement with ESCO but if he changes his energy habits could have a better energy efficiency. For example, turn off the light in a space where nobody stays, or turn off the devices when not need these, have solar energy and connected the electric car to the home energy storage. The traditional electricity delivery model of the grid-connected system will change significantly. In a more distributes environment with both generation and consumption at all levels, system operators would need to agree on a number of initiatives to ensure that, despite this complexity, end-users can still benefit from affordable, high quality and safe services delivered by energy providers [4].

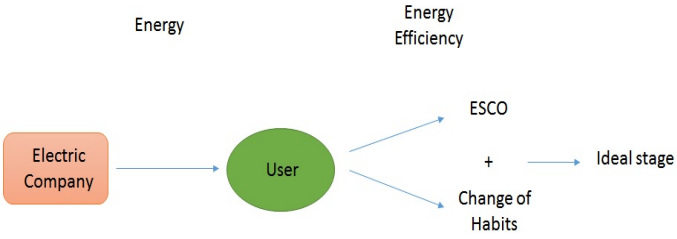

Fig. 5. User and energy efficiency

Collecting information about the customers and the way they use products and services can allow the identification of problems that were previously hard to find to ESCOS. This is not useful only for city officials that want to understand how citizens live and move in the city, or how they use the city services, but it is also helpful to the citizens themselves because it offers them some aggregated information about their lives.

VII. CHALLENGES OF CITIZENS IN THE SMART CITY

The life in a smart city brings challenges for citizens. The education in informatics is important to understand the computer knowledge and to have technological skills. Twenty years ago the informatics were new in college and university. But starting the 90´s, the computers had a great expansion and ten years ago many people around the world had a computer. Whereby the authors can infer that adults with 35 years or minus they have good skills in informatics. Perhaps for older adults, it´s more difficult understand and operate the hardware and software. Imagine in twenty years most of the citizens will have great skills in informatics and understand the information that gives the energy system, in this instant apparently the users have everything under control, but as authors say before, if the users do not change the energy habits is difficult to achieve a great energy efficiency. For that, is significant that the users as we can see in figure 9 decide where to get the energy, if they have an isolated system or connected to the grid, the energy will be stored or sold? It´s important program their home appliances? If the house is connected to the grid, how can the renewables installations interact with the grid?

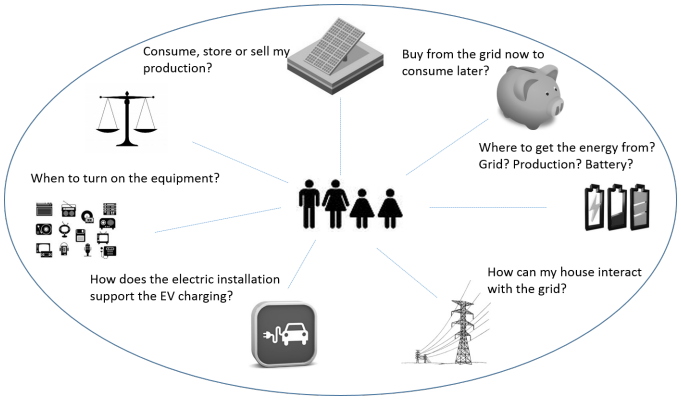

Fig. 6. Question to ask the user

Besides Citizens they have to understand the information that brings the energy systems to have technological skills. The citizens must have time flexibility, take the time to their families and organize the actions for energy efficiency. This flexibility can arrive for two ways; the first is the possibility that family wants to hire an ESCO. The second way is the "conscience", this comes when the citizens believe that they should collaborate with the city for decrease environmental impact and believe that changing their habits they are cooperating with other people. As can see in figure 10, when the information arrives at the user, the user should understand the indicators about current, voltage, solar irradiation, power, the level of batteries etc. The user should have skills and take flexibility to understand and process this information to take a decision about their energy consumption. Once the users take actions as reducing the temperature of calefaction, or turn off some home appliances, lights, the management system, changes the configuration, stores the new information and learn new cases. So not only the users learn about their consumption, the machine also learns the habits of the users.

The citizens should have a new sense of life in the community and in smart environmental. So maybe the most important challenge is to take the time to thinking as reduce the energy consumption, learn integrate other people in my habits, being aware that all my actions in the city affect other inhabitants.

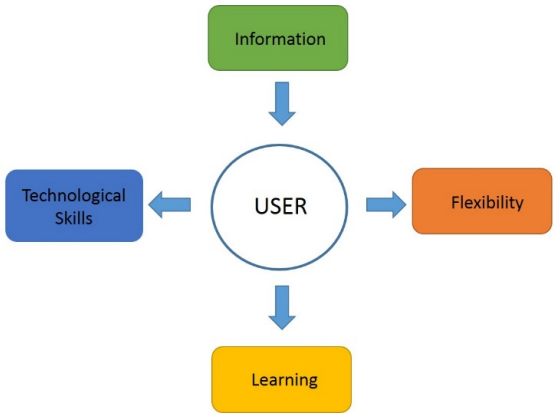

Fig. 7. Challenges of the user

VIII. Conclusions

It´s essential the empowerment and capability of the final user interact with the energy system; have a green energy is a new culture that is possibly created with sustainable habits, innovation, and creativity. The digitalization of city infrastructure is already a fact and is opening a world of opportunities in which all the stakeholders are called to be positioned and create value from that. For example, the development of the Smart Grids passes to adapt the regulatory framework and do big investment in the grids, thus as implement monitoring equipment of consumption and smart meters in the consumer´s installations.

A smart city of the future has to take more percent of renewable energy than hydro and fossil fuels. In this city the transport and distribution it does through superconductors, all the energy system is supervised for a master center that analyzes the information that arrives from de sensors and remote terminal units (RTU). This expert system solves the problems and failures, inform to the operators if is necessary to fix a point of the line. The Master learns the new cases and storage the cases for futures problems. So when the energy arrives the homes, come with a few losses and now the obligation in the efficiency line is for the user.

The citizen will have various challenges to live in a smart city. The new citizen called smart citizen or smart user should know the technologies that operate in the city, adapted the new devices for having efficiency energy and learning constantly as works the IoT in an energy domain. Besides, they should change the life habits for adopted the new requirements for the consumers and the energy restrictions.

The governments and energy companies have to inform the users the changes in the energy technology and offer the alternative of self-consumption energy for the users. The policies should give the tools for the smart citizen to choice the source of his energy. The challenges for the smart energy systems are for the citizens, technicians and the politicians because when new energy laws are produced, it should take into account whole the involved actors.

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