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Renewable Energies in MOROCCO: Situation of the Sector, Development Potential of the Sector

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Abstract - **A smart grid is an electrical grid linking electricity production, consumption and storage and coordinating them autonomously. This type of network therefore makes it possible to switch from a demand-driven production system to a supply-based consumption system, which will have to adapt in future to the random variations of the production of wind and solar energies. Combined with other technologies such as pumped storage or gas combined cycle facilities, particularly flexible, this network must contribute to improving security of supply, reducing costs related to the distribution network and the to integrate renewable energies into the grid and to improve the efficiency of the entire system. A smart grid combines the existing electricity grid with information and communication technology applications. However, if several current technologies can already be used, they must first be tested in the form of individual components, since the technical implementation depends on the stability and effectiveness of their interaction. Indeed, except in some research projects, no smart grid ensures a fully automated control consumer devices and production facilities exist in the world: it is still a concept. The current tests on smart meters, already deployed on a large scale in some countries, are a first step in the implementation of these smart grids. This technology should encourage final users to save electricity and encourage decentralized injection control. However, their introduction in Switzerland is hampered by data protection issues, lack of standards in this field and a lack of clarity in the allocation of roles and costs. The success of smart grids will depend in large part on the economic interests of the various stakeholders. Once this happens, the likelihood of a change in our existing grid in smart grid will also emerge.**

Keywords - **Smart Grid, Renewable Energy, Energy Transition, Innovation, Energy Consumption**

1 .Introduction

A smart grid is an electricity network connecting the production, consumption and storage of electricity and coordinated them centrally .Within smart grids, fast and bidirectional communication between the various components of the networks and production, storage and consumption systems makes it possible to harmonize management [1]. As a result, these networks are able to ensure more efficient operating of the system (both in terms of energy and costs) for future requirements (Figure 1).

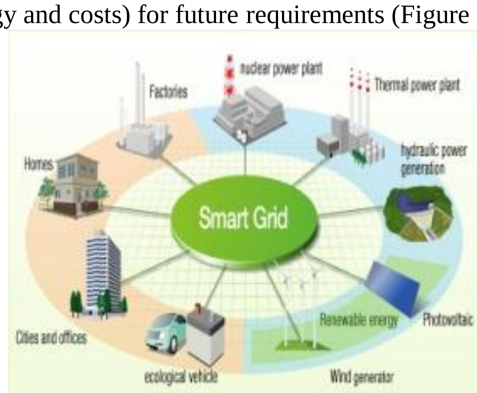

Figure 1: Schematic representation of a smart grid

The electricity continues to circulate and therefore cannot be stored at the cost of very complex processes. It is however possible to convert it into another form of energy: for example it can afford to pump water from a reservoir and thus be stored as potential energy [2]. We can also accumulate energy in chemical form in a battery and then convert it back into electricity. This process however can store that tiny amounts and causes losses [1].

The production of electricity is constantly adapted to the consumption in order to ensure that the amount of energy available on the network is constantly equal to that consumed, with short-term differences between supply and demand being offset by energy adjustment. However, within smart grids , an algorithm in a data center can quickly coordinate and in a fully automated way, supply and demand by actively switching between the load and the production, or by powering the accumulation system. Depending on its design, the calculation center can cover a decentralized service area or a transport network [3].

Smart grids are used not only to control production facilities but also to connect or disconnect loads depending on the requirements. The demand management (demand side

management, DSM), for example, can adapt the demand to the production, thereby reducing storage requirements in case of increase of the injection of stochastic renewable energy [4].
The current system and smart grids are characterized by the following differences:

Traditional system:
- Hierarchical structure.
- Stations usually large.
- Low number of large central facilities for storing energy (turbine pumping central).
- Non-widespread use of information and communication technologies (ICTs).

Smart grid:
- Many components of different sizes
- Integration of decentralized production facilities (DEG: distributed energy generation)
- Integration of many small decentralized storage facilities (electric vehicles)
- Smarter components
- Constant use of ICTs until final consumers.

This intelligent network management must ultimately help to preserve or increase security of supply, reduce distribution system and control energy costs, integrate renewable energies into the grid and improve the efficiency of the entire system [5]. These requirements are taken into account by the various projects launched in different countries and incorporating smart grids, the priorities and the main elements vary according to the local initial situation. In the United States, the network being partly outdated, security of supply is paramount; In Europe, on the other hand, the increasing share of renewable energies in production leads to the integration of decentralized and random production facilities into the electricity grid [6]. In all cases, a calculation unit must autonomously manage production, load and storage, and optimize the entire system via the flow of electricity, so far not controlled [7].

The first step in launching a smart grid is to measure consumption very precisely using smart meters, the values being transmitted in an automated way. For current applications such as remote reading of meters or prognoses of production of renewable energy sources, a measurement of data every quarter of an hour and a daily dispatch to the operators of the distribution network are sufficient. The future allocation of supply and demand by a computer center requires a high temporal resolution and a very fast exchange of data [8].

The smart meters are therefore essential to the implementation of a smart grid, but are not enough. A bidirectional communication with the central management unit is essential, as well as the measurement of consumption. The smart meters can not only send measurement data but also receive control signals and control consumer devices when they have the right equipment [9]. Reliable communication between the measuring devices and the calculation center is therefore paramount. Today it is made possible by modern information and communication technologies [6]. The rest of the paper is divided into five parts .The second part is devoted to the study of Intelligent electrical networks: such as Definition, Electrical management and distribution in a home, Supply and demand management, Access and remote control and Industrial platforms .The third part is dedicated to the Advantages and disadvantages of the Smart Grid .The The innovations of the Smart Grid are the subject of Part 4. Part 5 is reserved to the Morocco on the path of smart grids .The conclusions are in the last part.

2-Intelligent electrical networks

2.1 Definition:
An intelligent power grid can be described as a combination of systems that revolve around three types of systems (Figure 2) [10]:
- Conventional and renewable energy production systems, which make up all the electrical production capacities.
- Systems consisting of distribution and transport networks driven by energy supply and demand.
- Local systems for the integration of renewable energies and storage systems, and even electric vehicles.

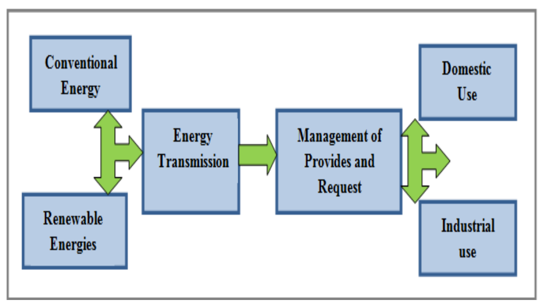

Figure 2: Components of a smart distribution system

The advent of this type of electricity network has created a harmony between the production, distribution and energy management environment and that of new information and telecommunications technologies [11].
The infrastructure for setting up a grid consisting of three levels:
- The level of sensors and advanced devices of the electrical network.
- The level of applications for data presentation and decision making.

- The level of communication networks and integration platforms (Figure 3).

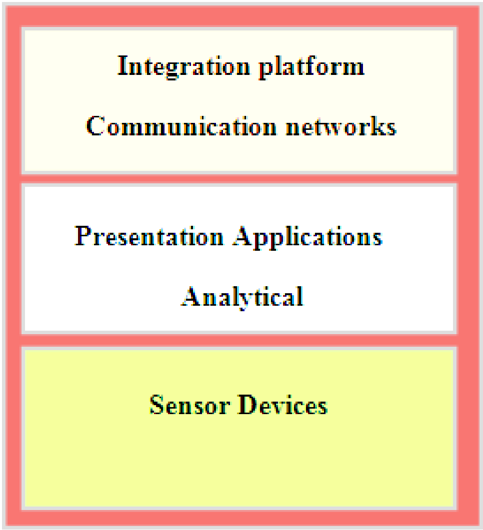

Figure 3: Infrastructure of an electric Smart Grid

2.2 - Electrical management and distribution in a home:
The energy production in this model based on smart grids is decentralized. It includes classically produced energy and renewable energy. A zone is powered by high voltage lines; This energy will be transformed in order to power the local network and in case of overload, the extra energy will be stored for later use [7]. The adjustment of the voltages at the network level is managed by control modules equipped with wireless communication interfaces and remotely controlled by a control center. The integration of electric vehicles into the network has also been taken into account in this type of network. Electric charging stations are installed at several points in the network. These stations feed these vehicles in common stations and even in homes [12].

There are several models of electrical distribution like IDAPS (Intelligent Distributed Autonomous Power System). In order to increase the reliability of electrical services, Distributed Energy Resources (DER) has been installed in electrical distribution arteries. IDAPS allows customers to buy electricity from their neighbors; the final user customer will have the option to purchase a portion of their electricity from DER units available locally if the offers have competitive prices and interesting features (such as green energy)[13].

2.3 - Supply and demand management:
Given that in a smart electricity grid, supply and demand of electric energy are not centralized, a household can sell electricity to its neighbor through a supply and demand procedure. On this subject, several proposals proposing different solutions have been published. An Autonomous Power System Area Demand (ADAPS) is defined as a segment of the distribution system connected to the transmission system linked to the high voltage [14].This system maintains stability and reliability of supply for a long time. A control module and power distribution is installed in each household and treats the supply and demand of energy, the charge storage batteries using communication techniques [8].

In this model, a household can inject its energy production on the network, as it can receive, through a centralized information system, data that will be processed by the supply and demand procedure. In IDAPS, a mechanism for managing supply and demand on the network is also proposed. If a user sends a power purchase request, each agent on the network receives a copy of the request [15]. Each agent will send its responses to these recipients and create a copy of the data sent to a centralized database. This database is accessible in real time by all agents.

2.4 Access and remote control:
With remote control systems in a smart grid, the customer can see its energy consumption, or even control its electrical and household appliances. A system that uses web services. This system includes a configured residential gateway that has a CPU, a GSM module, a network interface and a switching module. All components used are linked together in an intelligent Ethernet channel at the household level [16]. A client sends a command from the mobile to the GSM gateway. The latter receives this request and transfers it to the local network as a SOAP (Simple Object Access Protocol) message to a terminal. In the terminal, there is command functions declared as services. The request received by the terminal initiates a function to execute a control task that will be sent to a standard interface to a switch. Since each household appliance in the fireplace is connected to this switch, the control message will be received by the appliance for which it is intended to change its state [17].

2.5 - Industrial platforms:
In the industry, several equipment and software manufacturers have proposed environments to model, manage and monitor power grids. We will cite three examples of this type of solutions [5]. Cisco Smart Grid is a combination of products and services with a global architecture consisting of four main areas:

- Creation, transmission, distribution and production management (centralized or decentralized) of energy.
- Consumption management at the level of households, industries and businesses.
- Management of the electrical network: installations and maintenance of the elements of the network.
- Monitoring: invoicing, data management, etc.

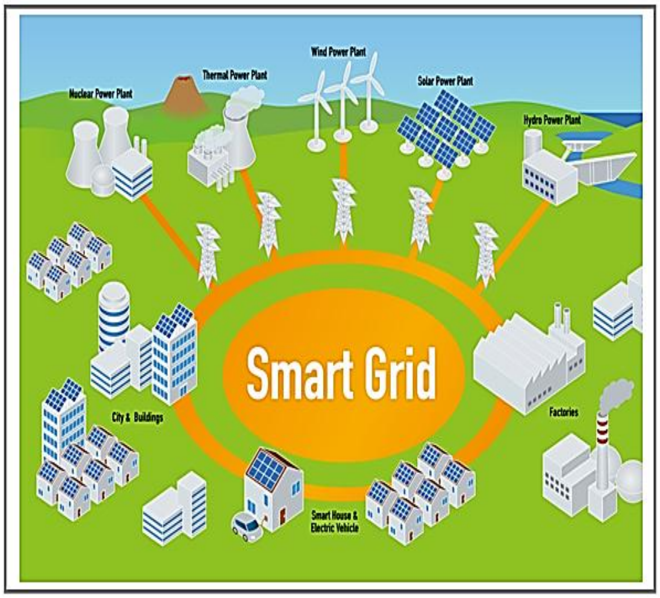

Figure 4: The Smart Grid Industrial Platform

Services provided to businesses are represented by six levels:

Level 1 includes energy infrastructure such as cabling, sensors, transformers, connectors, electrical meters, storage units, etc.

Level 2 represents the different types of communications (WiMax, fiber optic, cellular, Wifi, ZigBee, etc.).

Level 3 represents the data storage platform.

Level 4 represents operational systems such as automated metering infrastructure (eg, geographic information), electrical metering information, and customer personal data.

Level 5 contains commercial applications using the communications counters, data on locally produced energy, etc.

Level 6 represents CISCO Commercial Services.

3. Advantages and disadvantages of the Smart Grid

In addition to measuring, the real-time communication of consumption on the client screens and websites enables him to analyze and monitor, and so manage load and save electricity. These immediate information should encourage them to better manage their consumption, and thus to reduce it [18].

Rates depending on the time per day already exist in Switzerland for a long time: most electricity providers indeed offer a high price and a low price. With the introduction of smart meters, evolutionary rates based more on the wholesale price could even be offered. This financial incentive may encourage the consumer to quickly adapt its needs to the network load. It is necessary that the consumption must be postponed, but also reduced to actually save money [3].

The smart meters can also help control the decentralized injection, ensuring two-way communication: the data sent but also the received control signals can be used to drive production facilities spread and consumer devices. Systems which a cost price to reward and have an installed capacity of over 30 kVA are equipped with a smart meter. This is currently used to calculate the load, used to provide daily production. Theoretically, it should also enable power to order the use of the facility [19].

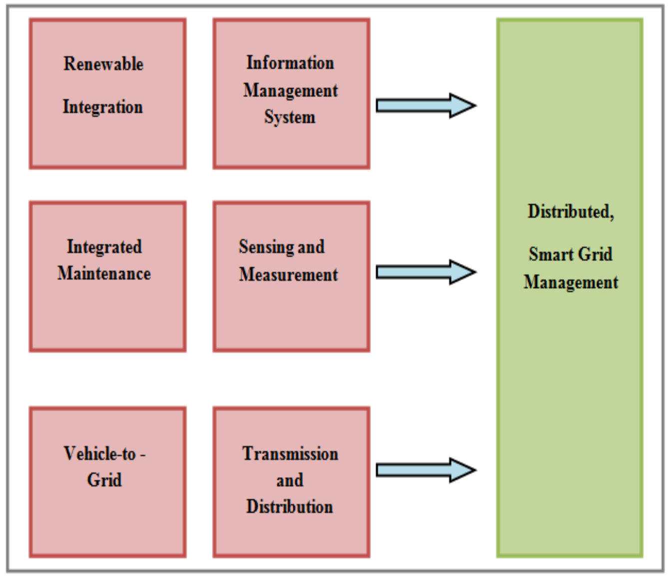

Figure 5: Some advantages of smart grids

If these systems offer advantages, they also present a number of risks and disadvantages. Therefore dissemination is quite slow, at least in Switzerland. With the current regulatory system, the distribution system operator is not able to pass on the costs of smart meter, although the final customer as the supplier can take advantage [13]. According to the Federal Electricity Commission, the costs cannot be passed on to end customers that when they contribute to improve the efficiency or security of the network. Without the establishment of a smart grid, smart meters are nothing but measurement devices not automatically obtaining the mentioned effects. For the investment pays off, the legislature must determine who bears the costs.

Moreover, technical standards ensuring that the various components needed to operate the system, such as meters and remote reading software, will not be associated with each other randomly, are lacking. Distribution system operators then run the risk of being dependent on system suppliers [10].This dependence is of strategic importance when the technique is not developed and the investment required is huge. The need for standardization, however, was recognized in the meter and electricity sector. This is why the Swiss

Smart Grid Association's priority is to ensure interoperability and compatibility of devices and smart grid systems via standard open Swiss branch, independent from manufacturers.

Finally, economic incentives are too weak to cause the dissemination of smart meters. Low energy costs hardly encourage consumers to conserve and demand for smart meters with inciting the consumption fails [20].

Through centralized remote control, the Swiss distribution system operators already have a way to handle the load by driving consumer appliances such as electric heating, electric water heaters and heat pumps. The charging points are thus smoothed and load balanced network. Most electricity suppliers already offer financial incentives to ease the load with the high price / low price. The benefits of a smart grid are already partially exploited today.

A smart grid could also generate additional advantage since the smart meters and modern communication techniques give the possibility to individually control different devices, thereby refines the burden of management. The integration of small distributed generation facilities would be easier for the network manager, which could convince him to introduce a smart grid [21].

4. The innovations of the Smart Grid

Many innovations lead us to important prospects. The electrical network is more powerful every day with advances in the field of materials, applied mathematics, advanced computing, telecommunications or power electronics. Further integrating communications and technologies in the network; Smart Grids are a key lever of transformation. Ultimately, smart grids enable optimal interactions between all actors in the electricity market.

4.1 Adapt the demand for more efficiency:
Shares of electricity demand can be conducted in two ways: reducing demand or time lag.

Improving energy efficiency:
To improve energy efficiency, there are three main levers:
Installation of automatic control systems, consumer information, consumer appliances standards and building isolation. Control devices such as motion sensors connected to the switch, automate some useful gestures and sometimes forgotten as turning off the light when leaving a room. Consumer awareness and beyond, from providing a more detailed information on consumption and cost, as permitted by section "Home" smart grid aimed at consumers contribute to the awareness and generalization of saving reflexes. The acceptability of automation is also better when they facilitate and increase the flight home during moment’s presence of household members, and they reduce waste during the time of absence. The devices use standards and building insulation allow for their act at the root, by drastically reducing the energy consumed by the devices during operation or in standby mode or the amount of energy required To maintain the temperature of a building [7].

The time offset of electrical uses:
So touched upon in the first part, consumer tips are for the power system are a major source of costs, risks of failure and emissions of greenhouse gases. To reduce them, we must be able to shift in time some consumptions (as, for example, the launch of a washing machine). These uses are then carried at times when demand is lower, allowing a reduction of peak electricity demand. Many technical solutions are already available for all uses related to temperature [2]. It is for example possible to reduce the heat of a room during peak periods by having more heated during the previous peak period, for district heating trigger before leaving his workplace. In the same way, it is possible through the thermal inertia of maintaining an acceptable temperature in a refrigerator or in a freezer with micro cuts of a few minutes, which replicated on a large scale and in a coordinated way, can relieve the networks. Intelligent networks have a key role to play in enabling large-scale deployment of such technical solutions and to coordinate their implementation [22].

4.2 Increase the transfer of information through ICTs
The transformation of existing networks in intelligent networks result in a sharp increase in information flow to collect, record, process. In the traditional model, the amount of information exchanged between the networks and consumer sites remains low for two reasons: Firstly, the frequency of feedback of the information is low because it is expensive, since it is carried out essentially via a manual reading of the meter; secondly, the information collected is aggregated because the counter displays cumulatively the electrical energy consumed. Thus, the actors have very low visibility on actual consumption.

The dynamic demand management requires such knowledge. This will cause an exponential growth of data, a few measurement points per year on a consumption site at a rate of quarter of an hour, or even minute. The exchanges will be automated. Beyond consumption, real-time transmission will be done at once on the state of the networks, the updating of weather forecasts, on the influence of the past on intermittent production [12].

With more information, more players, more complexity, the advent of smart grids will rely extensively on information and communications technology (ICT) on the development of new data collection tools, Storage, transmission and analysis. It is therefore not surprising to see the major ICT players get into the industry of smart grids [9].

4.3 Out of the national framework:
Today, networks stops by the entry of consumption sites. Beyond the electric meter, they have no visibility or means of action on the use of different equipment (heating, water heater, refrigerator, etc.). In the new model, the demand management requires to actually interact with the home network for real-time consumption of housing, to provide or operate, solutions to reduce or offset in time. Upstream, the increasing shares of intermittent sources require to go beyond national borders. For three reasons. First, some abundant renewable sources are located or will be located outside French territory (large offshore solar wind resource in North Africa). Next, interconnect the countries can smooth demand, because the tips do not always occur at the same time in each country. A report by the European Climate Foundation and shows that at European level, electricity demand peaks are compensated partially. This is because the rhythms of life as lifestyles, so the power consumption profiles are different, with a peak around 19 h in France against 21 h in Spain. Finally, the same smoothing effect is achieved when one aggregate the wind production profiles at European level [23].The diversity of renewable resources and can enjoy a variety of weather conditions (12 windy corridors in Europe instead of 3 in France). More coordination, and in the transport and energy markets, could also help to share reserve capacity, the total need which could be reduced by 40%, avoiding redundant and unprofitable investments. Thus such a network development, which marks a break with the current investment rates, requires ad-hoc funding be mobilized but also the institutional framework surrounding the development of network infrastructure is taken into account to mobilize necessary investments [24].

5. Morocco on the path of smart grids

Morocco has launched ambitious investment plans in renewable energy to reduce imports of fossil fuels. These plans require a flexible and optimized network infrastructure, like smart grids. A technology that also reduces costs and effectively manage the grid. Morocco has adopted in 2015 the smart grid technology. Defined as an electricity grid able to intelligently integrate the behavior and actions of users (producers and consumers) connected to it, this technology makes it possible to efficiently provide sustainable electrical energy, economic and safe. It is with this objective that the National Water and Electricity Authority (ONEE) have launched an international tender in 2015 to implement this technology in Morocco.

Morocco knew a significant change in terms of energy transition, as well as engaged in several colossal projects of clean energy production. The adoption of smart grid technology is a continuation of these projects. For example, a smart grid enables a better production and distribution solar energy in Ouarzazate, distribute domestically and export some to Europe. This without knowing significant energy losses, "says a source of ONEE, close to the matter. The latter reminds that the power plants of Jorf Lasfar will also feature this technology and other wind, solar and hydro. There is a complementarity between clean energy and smart grids. Renewable energy is more effective if better used thanks to this technology.

Similarly, ONEE must find ways to manage optimally the production and sale of electricity. Since 2002, electricity consumption increases at an annual average rate of 7%.
Demand is becoming increasingly important against a limited installed capacity. Similarly, because of its business model, the ONEE can not effectively meet this demand because it sells at a loss. Moreover, the agency buys electricity from the Spanish market with its interconnections with this market, as the Spanish kwh is cheaper than that produced locally. In 2012, these purchases accounted for 2.8 billion $. It is in this context that ONEE signed a performance contract with the state and pledged to adopt urgent measures to return to financial balance. These measures have included among others the launch of the tender for the smart grid in 2015. Moreover, Morocco, which imports more than 96% of its energy needs, will have to gain by adopting such technologies. In the first quarter 2014, the energy bill of Morocco was around 25 billion $, up by about 20% compared to the same period a year earlier.

If the energy mix is comprised largely of fossil energy, clean energy will grow in importance in the coming years. This will significantly reduce the country's energy bill. Similarly, with smart grids, Moroccan power consumption falls by 10 to 15%. In the US, it is estimated to fall to 12% in 2030. This drop in consumption is beneficial especially when we know that the growth rate of energy consumption is more than the GDP (Gross Domestic Product) of Morocco's growth rate in recent years.

In addition to the drops of energy bills and environmental aspect, smart grids have several advantages. The network is better managed, more efficient and reliable. The quality of customer service is also improved since the failures will be detected remotely by way of example. Similarly, operation and maintenance costs will be reduced, thus creating new sources of income.

Figure 6: About twenty kilometers from the city Ouarzazate, the largest solar plant in the world is implanted.

The city of Ouarzazate will host the largest solar plant in the world:

This mega complex, large as the capital Rabat (117km2) should be completed in 2020 and provide nearly half of the electricity of Morocco. Building four huge solar power plants, which should provide nearly half of Morocco's electricity from 2020.When the project is completed, the hydroelectric and wind complex will become the largest source of concentrated solar power in the world. For the moment, the project is in its first phase: Noor 1. It includes the establishment of 500,000 parabolic mirrors arranged in 800 rows. These glass panels of 12 meters high following the movement of the sun to capture and focus all radiation throughout the daily solar cycle (their temperature rises to 393 ° C). If this technology is less common and more expensive than conventional photovoltaic panels, it has the advantage of continuing to produce power even after sunset.

5-1 Key figures of the renewable energy sector in MOROCCO:

- 3000 hours of sunshine per year.
- 5 KWh / m2 / day of irradiation.
- More than 200 exploitable sites.

Wind Energy Plan

- 3.5 Billion $ investment.
- 2,000 MW of wind capacity to be installed by 2020.
- 6 600 GWH of electrical production.

Solar Plan

- 9 billion $ investment.
- 2000 MW of solar capacity installed in 2020.
- 4,000 MW of electricity production.

6. Conclusion

In this work, we investigated the tasks related to several aspects of smart grids. First, we formulated the problems related to this type of network while presenting various works in this area and the needs of these networks in telecommunications infrastructure and IT services. In the context of the integration of renewable energies, we studied the decentralized architecture of this new generation of power systems and aspects of supply and demand to integrate these new energies. The important role of smart meters has been demonstrated to present the functions of distribution and control it can achieve. We also studied a global architecture of smart grid that relies on smart meters, routers and wireless infrastructure.

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