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Management and Control of Smart Grid Systems: Opportunities and Challenges in Morocco

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Abstract

The smart grid is an electrical network that connects decentralized renewable energy, energy distributed with high efficiency. It makes use of distributed energy product and advanced communication and control technologies to supply electricity at a lower cost by reducing green house gas emissions and meeting the needs of consumers. Typically, alternative forms of power generation combined with power management in order to balance the load of all users on the network, with small renewable sources instead of large centralized and remote source. This document provides are view of the literature and the general model on the concept and gives the expected needs and requirements of smart grids and the problems of families for the management an optimization of intelligent electrical grids, and potential of smart grid development in the case of Morocco.

Keywords

Smart Grid Systems, Optimisation Methods, Case Study

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1. Introduction

The smart grid is an intelligent network that uses new information and communications technologies to optimize the entire production, transportation and distribution chain, and electric power consumption. It is an evolution of the current grid to meet the growing demand for electricity, especially in peak periods, to meet the challenges of integrating decentralized and intermittent generation sources, and to increase the production of targets reduction of emissions of carbon dioxide related to renewable energy. The term smart grid or intelligent network refers to the new generation of energy systems. The smart grid is needed in response to changes in the electricity market. In fact, energy demand increases dramatically in both developed and developing countries. By 2030, a 50% and 40% increase in energy consumption is expected in the United States and Europe, respectively. It is expected to triple in China and India and doubling globally [1].

Therefore, there is now a worldwide consensus on the need to increase energy efficiency, increase the use of renewable energy sources and reduce the emissions of carbon dioxide. Therefore, we want to introduce electric vehicles to the market and the proliferation of the use of renewable energy sources, such as wind, solar and tidal power. Guidelines adopted by the EU in 2008, in particular, require that renewable energy by 2020 be 20% of all energy and the solution to comply with these guide lines are implementing a more flexible intelligent network capable of easily integrating new energy sources [2].

However, the integration of electric vehicles will increase the demand for electricity, while renewable energy will require efficient management of heterogeneous sources of production o meet this demand. This is, in fact, part of the challenges facing smart grids.

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From an architectural point of view, the smart grid is super imposed on the physics-line communication network using the tools of the ICT (Information and Communication Technology) field. The grid becomes the communication with the elements not only physically connected by high, medium and low voltage, but also virtually through measurement and other smart devices.

This includes, am on got hers, a utility and its consumers to control and constantly adjust energy consumption.

The smart grid is also characterized by a number of features and applications that is made possible by the use of ICT and that value added to the network.

2. Definition and General Model of the Smart Grid, Review of the Literature

The ultimate go all of the smart grid is to control power consumption in order to make the most of the electricity generated.

The European Technology Platform defines smart grid as an electrical network that can intelligently integrate the behaviour and actions of users that the producers connected to it, consumers as well as advanced users (those who provide these functions at the same time) to effectively provide a sustainable, affordable and secure supply of electricity3]

According to Veolia, a smart grid and intelligent network can be defined as a networked electrical communication, components of which are not only physically connected by high, medium and low voltage, but al so virtually through meters and other communication devices [1].

The smart grid involves passing a highly interconnected computer network between consumers and electricity providers, including transportation, distribution and production. In short, in this transformation, energy network s evolve from a static infrastructure to the design of a dynamic infrastructure through proactive management of supply and distribution.[4]

Smart grid refers to a power transmission and distribution network that incorporates traditional and innovative components of energy engineering, advanced technology detection and tracking, as well as information and communication to improve performances kills and support business processes of another operator, especially customer service. Generally, smart grid should not be defined by the technologies it incorporates, but rather by what it can do and does for operators and their customers [5].

The list of criteria for a smart grid compiled by ABB focuses on general characteristics rather than specific functions. In this model, the smart grid is:

-Adaptive, with a lower vis-à-vis addiction operators, particularly by demonstrating the responsiveness to changing conditions-predictive, for the purposes of operational data to practices of maintenance of equipment or identification of failures before Of potential occurrence;

-Integrated with real-time communication and regulatory functions;

-Interactive with customers and markets;

-Optimized for maximum reliability, availability, efficiency and economic performance;

-Ensure against at tacks and interruptions of natural origin [6].

The transition to a smarter network promises to revolutionize the industry-wide business model and its relationship with all stake holders: operators, regulators, service providers, and energy and automation technology providers [7].

Demand management provides are posit or y for rewarding economic performance. It offers the advantage of efficiency by allowing the best possible interconnection configurations [8].

Smart grids incorporate bi-directional computing and communication capabilities with existing electrical infrastructure. They cover all levels of the energy value chain and are not limited to smart meters...they make use of sensors, integrated computer systems and digital communications to make the electrical network observable (measure capacity and display (Ability and optimization), automated (adaptability and self-correction) and fully integrated (total interoperability with existing systems and the ability to incorporate a diverse mix of energy sources manipulation)[9, 10]. Smart grids are virtually the future of energy systems and electricity worldwide [11, 12]. As noted [13], two main approaches to smart grids can be identified to define the technology.

The US approach is more for use doesn’t him development of smart grids to improve security of supply and network efficiency. Pilot implementations in several states show all experiences a head of their objectives to improve efficiency and security of supply and reduce the economic losses associated with transmission and distribution activities through the renewal of networks. Some states, such as California, complete this upgrade dimension by major efforts to limit maximum effects and ensure system reliability.

The European approach is substantially different from the US approach to the main reason that networks are therein better condition, more meshed and operators in smaller numbers and therefore easier to control. There is a tendency to concentrate more on the integration of all the stake holders in the electricity chain, i.e. the centralized, but also decentralized, classical agents (consumers, decentralized units of production and storage operators);this in order to meet the dual purpose of developing an integrated market and low car bon transition. The most notable difference with the North American approach found in many Europe a projects is the explicit goal of integrating intermittent energy sources and the development of distributed generation. Several projects of German and Danish in rural or urban area activate the development of these production methods.

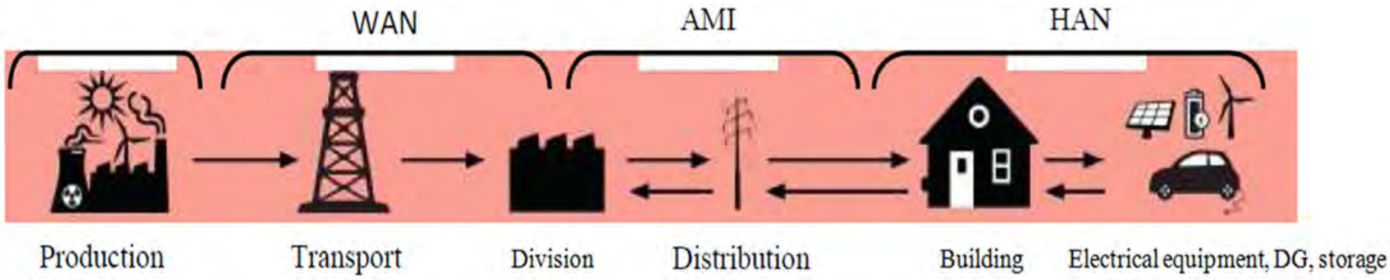
The first approach refers to the problems of technology design where ICT is applied to the activation of networks and consumers. Therefore, from a technical point of view, smart grids are composed of sever allayers that each includes different technologies and systems in the fields of communication, information and energy.

Advanced communication services are the back bone of smart networks. It is from these devices that various actors can be integrated and that the information, key to an optimal management, can happen dynamically.

In general, the definitions used to describe smart grid technology will vary depending on the policies and industries, but are brought together by increased use of digital technologies, communications and remote control systems for both low voltage electrical networks as well than with places of consumption with intelligent measuring equipment. According to [14] it has resumed twelve definitions of smart grids from various institutions and concludes that they can be addressed from two main approaches. According to the approach of the technical components or as the approach of the mobilized capacities.

One canal so represent the architecture of intelligent energy networks by adding ICT technologies to the electrical infrastructure (Figure 1). Operators and producers of the transport network have long been equipped with local communication networks (LAN for local area network) and distance (WAN Wide Area Network). These networks allow the communication and collection of data from production lines and transit to distribution networks.

The emergence of smart grids extends the communication layer downstream of the electrical system to include distribution network coverage through advanced metering infrastructure (AMI for advanced metering infrastructure) and coverage of Sale to the consumer through the domestic communications network (HAN for the domestic area network). The integration of the SCADA (Supervision Control and Data Acquisition) systems for the automation of distribution networks is required. These systems collect and vary voltage levels and other data flows, load levels, equipment status, etc. They allow operators to activate certain technical features remotely and contribute significantly to both better asset management and the realization of a quality energy route.



Avec LAN: Local Area Network: WAN: Wide Area Network; AMI: Advanced Meter Infrastructure; HAN: Home Area Network

Source: GTM Research

Figure 1. Architecture of smart grid.

The second approach proposed by [14] to identify the economic characteristics of smart grids and determine the efficiency gains that can be expected. This approach is also adopted by regulators and from which the Smart Grids European technology platform gave a definition of smart grids at European level, "smart grids are electrical grids that can integrate the behaviour and actions of all connected users-Producers, consumers and those who are smartly two to effectively provide electricity that is sustainable, economical and safe".

Residential and commercial sites represent deposits of considerable energy efficiency, given their importance in the evolution of demand and advanced features. The development of intelligent measurement systems is a prerequisite for the development of demand management programs. Currently there are several definitions of an intelligent grid [15] and also several objectives for the definition of a smart grid. However, all definitions agree that two- way communication is a key to future smart grids.

The Institute of Software Engineering at Carnegie Mellon University defines smart grid and intelligent network as a term used to refer to a grid whose operations were raised an analogue technology is the use of digital technology built for communication, detection, Prediction and control [16]. Smart grid technology defines as an electrical network capable of intelligently integrating the behaviour and actions of the users (producers and consumers) connected to it, this technology in fact al lows to effectively provide the electrical energy Sustainable, Sauer and economic [17].

A smart grid will be considered as a set of micro-network interconnections [18]. Definitions vary but it is still possible to arrive at a general definition. In short, the smart grid concept can be defined as any set of applications aimed at modernizing energy networks and optimizing the production, distribution and consumption of electricity through the integration of information technology and Communication (ICT) [19, 20]. In this sense, the smart grids can be considered a process of informatization of the electrical networks [21].

SGs witness the migration of a unidirectional flow of electricity grid to a bidirectional flow of electric power grid and information. Figure 2 shows a general model of OS. It shows the integration of renewable energies such as wind and solar to medium voltage transmission networks and low voltage distribution.

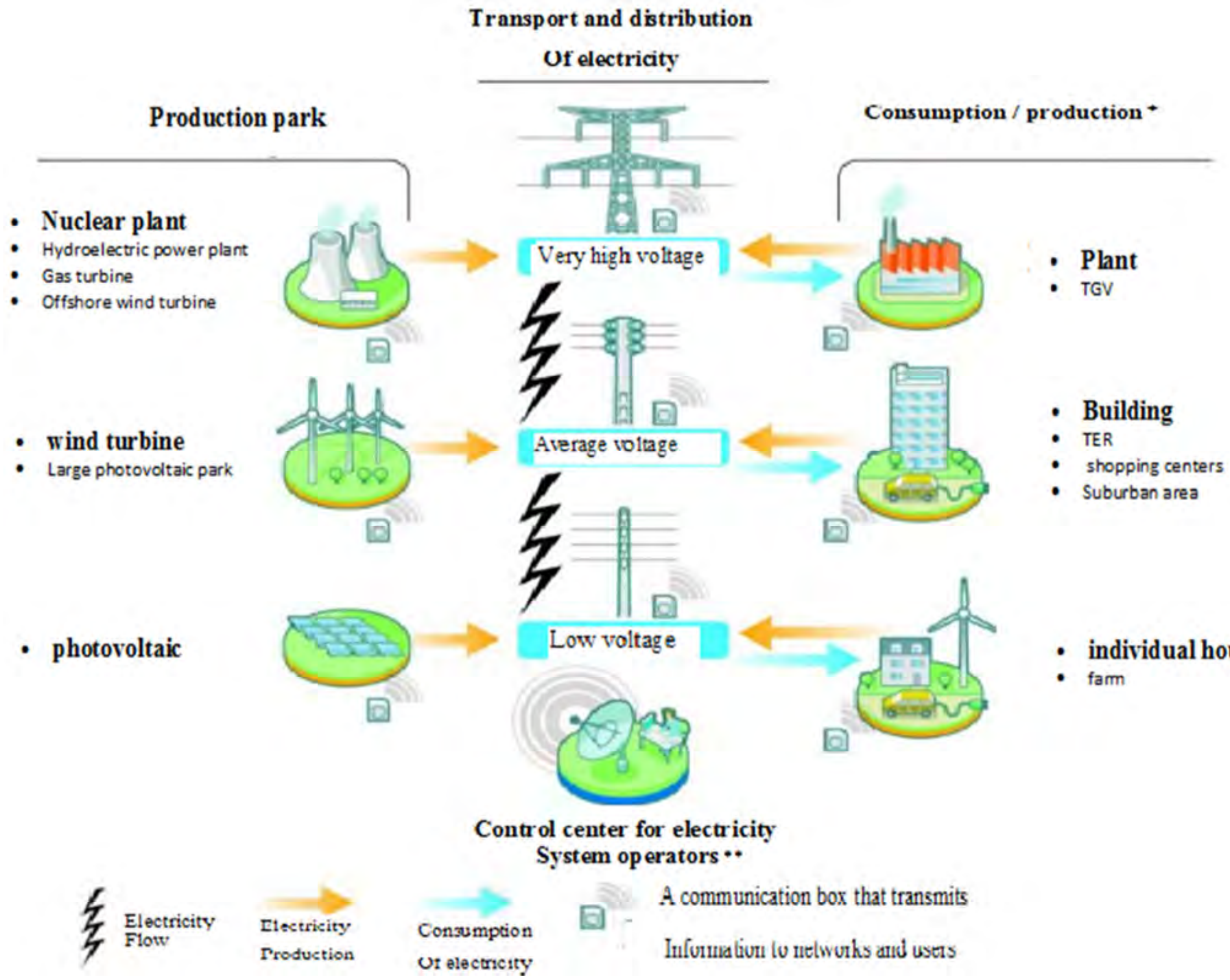


Figure 2. General model of the smart grid [22].

In addition to large power plants, consumers come in to play such as large factories, malls, houses, electric vehicles, etc. These consumers can in turn become producers of energy if they have their own generators.

Thanks to new information technologies, network administrators detect and easily locate net work failures. The maintenance operations, the succession and the driving distance will be carried out. Electricity centres operators of the control system will also be informed real-time power consumption needs: Then distribute the correct amount of electrical power to the grid [22]. The operation of the smart grid is based on the possibility of interaction between entities through communication networks. As callable and invasive communication infrastructure is a key problem in the operation of smart grids [23].

3. Needs and Expectations of Smart Grids

According to the National Energy Technology Laboratory (NETL) [24], the transition from the existing grid to smart grid should be based mainly on progress towards the following aspects: Stability: a more stable grid provides power with the required quality for any moment. He warned of the growing problems and is resistant to disturbances, without decomposing. Corrective action is needed before most users are affected. Security: Secure grid resists physical and cyber attacks and protects the privacy of your customers. It is also less vulnerable to natural disasters and recovers quickly after a disturbance. Efficiency: amore efficient grid at all levels, the application of cost control, reduction of losses in the transmission and distribution network and optimization of electricity production. Respect for the environment: an electricity grid reduces the average of its negative impacts on the environment by using a higher percentage of sustainable energy sources. The economy: an economic energy network offers fair prices and adequate supply. To achieve these objectives, the vision of the smart grid is based on the key concepts that will be discussed in the next section.

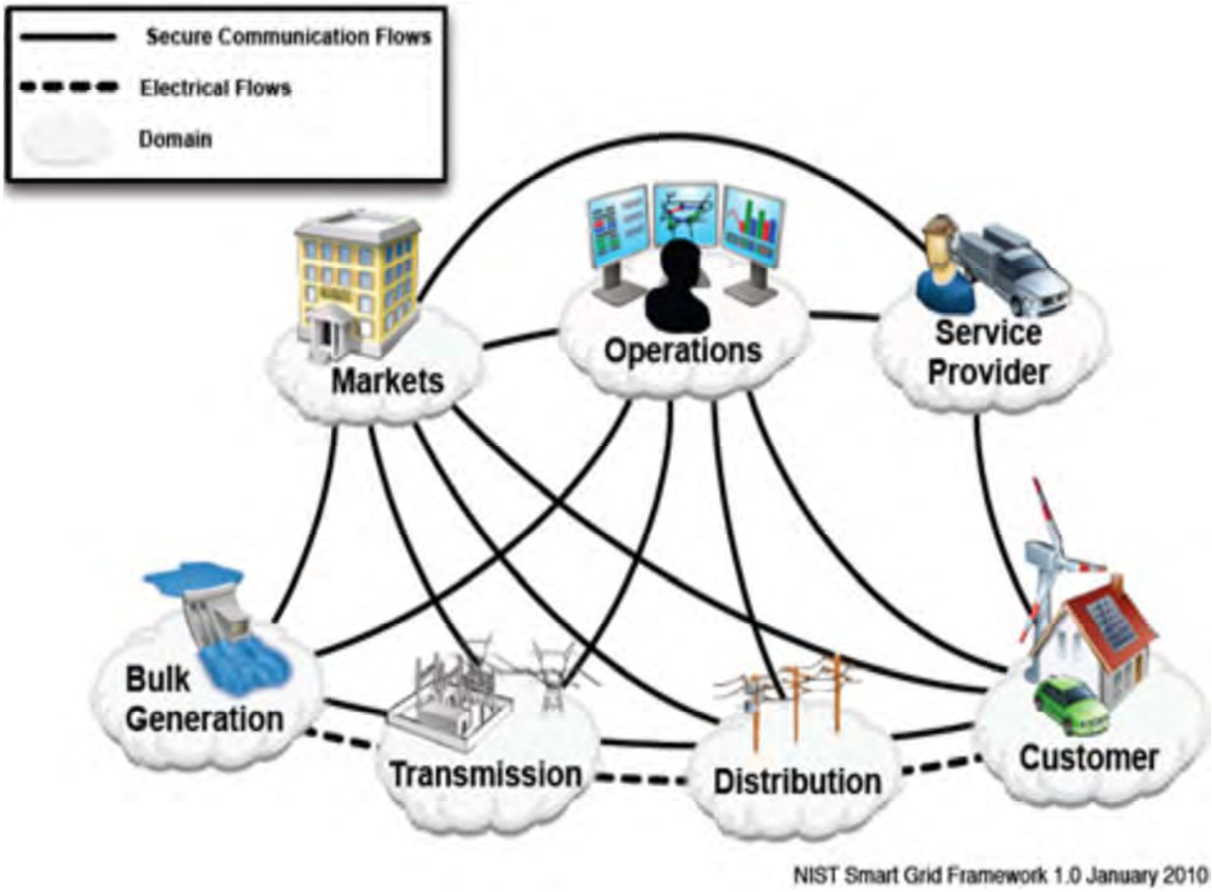


Figure 3. Relationships and interactions between the domains of a smart grid [25].

4. The Families of Problems for the Management of Smart Grids

The smart grids raise a number of important challenges in the field of artificial intelligence [26]. Indeed, new concepts and techniques will be needed to solve the many problems that cannot be solved on current energy networks. These problems include network stability, reliability of supply, and management of new distributed energy sources, integration of new heterogeneous and distributed actors, self-healing of networks. Some problems a real ready particularly studied and there for a better formulated, Here is an on-exhaustive list of these: Unit Commitment (UC); Demand Side Management (DSM); Demand Response (DR);Supply and Demand Matching, (SDM); Vehicule to Grid (V2G), Virtual Power Plant (VPP); HOMEBOTS; Periodic Value Reporting (PVR); Level Crossing Sampling (LCS); Priority based Value Reporting (PBVR); Priority Based cooperation (PBCOOP); ABCON (Agent Based Control); CoDA; PriBaCC; Value Reporting (VR) is given in Table 1. The methods for the management of smart grids are given in Table 2. The Families of problems and methods for the management of smart grids is given in Table 3.

Table 1. The families of problems for the control and management of smart grid.

N°FB	The Families of problems	Definitions
1	Unit Commitment (UC)	The problem of the UC is to distribute energy production through a number of known sources that meet the demand for a minimum cost.
2	Demand Side Management (DSM)	Demand management involves changing the demand of energy consumers through various methods such as financial incentives or education.
3	Demand Response (DR)	The Demand Response for Smart Grid (DR) can be defined as changes in the consumption of electricity by the final consumers of their normal consumer habits in response to the evolution of electricity prices over time.
4	Supply and Demand Matching (SDM)	The SDM allows simultaneous control of production and consumption to improve the whole network
5	Vehicule to Grid(V2G)	The idea behind theV2G concept is to use the energy (both in charge and discharge) of an electric vehicle.
6	Virtual Power Plant (VPP)	The VPP problem encompasses a set of decentralized production devices (such as micro turbines, PVs, wind turbines, small hydropower plants, etc.) that act as a centralized power plant to sell power to the grid.
7	HOMEBOTS	HOMEBOTS is an approached Ealing with Intelligent Equipment Management distributes inside a home. It is based on a multi-agent system, the agents being directly linked to a specific hardware.
8	Periodic Value Reporting(PVR)	The authors of this approach propose architecture for monitoring power in Smart Grids using a Wireless Sensor Network (WSN) The approach defines the policy of communication between then odes of the network.
9	Level Crossing Sampling (LCS)	The authors propose an approach based on Level Crossing Sampling (LCS). In this approach, the nodes only transmit data collected by the sensors when the collected valueschange by a predetermined amount compared to Previous values
10	Priority based Value Reporting (PBVR)	The authors define intervals for the collected values of the sensors and assimilate to each interval a priority according to the importance or not of the detected value.
11	Priority Based COOPeration (PBCOOP)	The authors define intervals for the collected values of the sensors and assimilate to each interval apriority according to the importance or not of the detected value. The authors thus propose that a detected value of high priority is sent directly to the Sink, while a detected value of average priority leads to the application of a cooperation algorithm.
12	ABCON (Agent Based CONtrol)	The electrical network consists of generators, transmission and distribution lines, and consumers. We propose an approach where each agent is embedded in a sensor which will be placed at the level of one of the components of the network to follow the behaviour of this component.
13	CoDA (Correlation-based Data Aggregation)	Data Aggregation Approach in Smart Meter Infrastructure
14	PriBaCC	Priority Based Cooperative Communications: Data aggregation approach in deployed With wireless sensor net work(WSNs)for monitoring and control applications)
15	Value Reporting (VR)	This approach is used to monitor an urban electrical network.

Table 2. The methods for the management of smart grids.

Methods	Description
1	SWOT"*"
2	Fuzzy Logic (FL)
3	Neural networks(NN)
4	Genetic algorithm (GA)

"*": The term SWOT is an acronym derived from English:strengths, weaknesse, opportunities, threats

Table 3. The Families of problems and methods for the management of smart grids.

Authors	TheFamiliesofproblems															Methods			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4
Salam 2007	*															*			
Padhy 2004	*																		*
Gellings et al 2008		*																	
US Department of Energy (2006)			*																
Basso et al.,2013				*															
Clement-Nynsetal.,2011					*														*
Asmus,2010						*													
Ygge et al.,1996							*												
Yerra et al2011								*											*
A.Nasipuri et al 2010									*										*

Authors	TheFamiliesofproblems															Methods			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4
Natalie Matta et al 2012										*									*
Natalie Matta et al 2012											*								*
Dima El Nabouch et al 2013												*							*
Merghem et al 2013													*						*
Matta et al 2013														*					*
S.Ullo et al 2010															*				*
Mohammad Majid Jalali et al 2015		*																	*
Linas Gelazanskas et al 2013		*																*	
M.A.López et al 2014		*			*														*
R.Pereira et al 2014			*														*		
AshishRanjanHota et al 2013	*				*														*
Nien-CheYang et al 2014					*														*
XingHe et al 2014		*																*	
LinniJian et al 2013					*														*
Kashem M. Muttaqie al 2015		*																	*
JoyChandra Mukherjee et al 2014					*														*
ManishaGovardhan, et al 2014	*		*																*
Sandip Chanda et al 2014			*																*
SalmanKahrobaee et al 2014		*																	*
BoruiCui,ShengweiWang et al 2014			*																*
Hugo Morais et al 2014					*														*
Kashem M. Muttaqi et al 2014		*																	*
M.N.Q. Macedo et al 2014		*																*	
Mouna Rekik et al 2015					*														*

5. Potential of Smart Grid Development in the Case of Morocco

Morocco is a country where energy policy is of paramount importance like the emerging countries. The evolution of electricity demand due to several factors. Changes in the population increase domestic consumption. Modernizing life styles and rural electrification also accentuate the dependence of citizens in their every day on the power grid.

Moreover, the country should know the advantage of strong demand in the industrial plan.

The development plans and support to industrial sectors have been initiated and have generated local and foreign investment at many heavy industries with high energy consumption.

Awareness of these issues has led to strategic investments and development of laws that authorize and support the diversity of power grid in Morocco.

Projects launched at the national level for several years focused on renewable confirm an energy transition. They reduce the dependence on fossil fuels subject to huge fluctuations sector.

The existence of such infrastructure requires management efficiency technical and decisional level emergence smart grid (SG) has to provide organizations (energy authorities) of digital technologies to control, optimize, protect and anticipate actions on a power grid to diversified sources.

The SWOT analysis was done taking in to account the potential of Morocco, especially with regard to the current scenarios, the Obstacles and what needs to be achieved for a better infrastructure of the smart grid is given in Table 4.

Table 4. SWOT analysis of smart grid infrastructure in Morocco.

Strengths	Weaknesses
a. *The dynamism of the regions*	a. *The absence of major demonstrations*
b. *Strong awareness of energy issues by local institutional actors at all levels,solidity of the electricity network, energy efficiency, renewable energy*	b. *The absence of smart grid-oriented laboratories*
	c. *The lack of animation dedicated to the structuring of the ecosystem smart grid*
	d. *No major energy players*
c. *A major pole in the digital sector*	e. *Lack of diversity of reference actors*
Opportunities	**Threat**
a. *The energy intensity of the sector*	a. *The economic context*
b. *The sustainable building plan*	b. *National and international competition*
c. *The dynamic sectors of auto motive and mobility and agro-industry*	c. *The concentration of principals*
d. *The energy situation*	d. *Political and regulatory uncertainties*
e. *Involved contractors to respond to the energy context*	e. *Avery dependent public power*

6. Conclusion

This paper begins by giving the definitions necessary for the understanding of smart grids; we have introduced the general model, then the needs and expectations of Smart grids as well as the families of problems for the management of Smart Grids and ultimately the development potentialities of the smart grid in the Moroccan case. The reasons for believing in the development of Smart Grids in the Moroccan context are:

a. Morocco has for several years under taken a profound reform of its energy system, notably through programs for the mass deployment of renewable energies.

b. The energy challenges of the country are major: Morocco must meet increasing energy needs, reduce its dependence on fossil fuels and limit its carbon foot print.

c. The Smarts Grids could be one of the answers to the country's energy transition issues. Indeed, beyond their role in integrating intermittent renewable energetic production in to the electricity grid (storage, management of flexibilities...).

d. The Smart Grids are a genuine lever to reduce the losses caused by the distribution of electricity accounting for12% of the total production in 2011. Moreover, an intelligent electricity grid would allow the kingdom to improve its quality of electricity supply, to strengthen predictive maintenance and to manage new electrical uses such as electric vehicle refills.

e. The emergence of Smart Grids will be fostered by the support given to the development of renewable energies and sustainable cities. This support is provided by a favourable regulatory framework, strong and diversified financing, and by foreign partner ships in terms of research and development, innovation and training to structure sectors.

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