NORTH ATLANTIC UNIVERSITY UNION

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Recent Advances in Energy, Environment and Financial Planning

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Proceedings of the 5th International Conference on Development, Energy, Environment, Economics (DEEE '14)

Florence, Italy, November 22-24, 2014

Mathematics and Computers in Science and Engineering Series | 35

Provide knowledge to assist stakeholders in smart energy grid management: decision making using Analytic Hierarchy Process

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Abstract: - Customers' requirements in terms of availability of supply and quality of energy are increasingly growing and the enterprises of electricity distribution are asked to meet them and to provide a high quality of service. This paper aims to provide knowledge and to assist decision-makers to understand the impacts of information and communication technologies (ICT) integration in the conventional power network giving birth to a smart energy grid. We have investigated multi-criteria decision making methods that allow aiding managers of enterprises in developing countries to take the opportunity of exploiting advancements of developed countries in the fields of ICT and renewable energy resources (RES) insertion. The analytic hierarchy process (AHP) is the method of our choice, as it is judged a transparent process and a useful tool in conflict resolution. We have made an application to the Algerian case and the obtained results are very significant, promising and opening the way to an excellent research topic as well as electricity sustainability.

Key-Words: - Electric power systems, smart grid, decision making, AHP

1 Introduction

For decades, the managers of companies were accustomed to monitor and to manage conventional and centralized systems. Nowadays, it is demonstrated that the integration of ICT in the conventional network and the insertion of RES provide a transition towards cleaner and environmentally sustainable technologies. This work deals with the impacts of societal, environmental and economic indicators on both decision-makers attitudes and the customers reactions towards these decisions. The integration of these technologies in conventional networks gave birth to smart grids which co-ordinate the needs and capabilities of all generators, grid operators, end-users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimizing costs and environmental impacts while maximizing system reliability, resilience and stability [1]. Two concepts are distinguished: the first one oriented system reliability, managing peak

ISBN: 978-960-474-400-8

demand, minimizing losses for long-distance transport, is mainly advocated by the U.S., China, India, etc., however the second one oriented sustainable development and therefore sustainable electricity is much advocated by European countries, like Germany, Denmark, Sweden, Italy and others. If we are in the case of developing countries, what kind of smart grid can - we suggest? We worked for a long time in this direction and we ended up with a compromise solution. For developing countries, the urgency is marked by the availability of electricity for all because it is a staple. This decision will be accompanied by educational measures and moral struggle against the waste from one hand and the transformation of some state supports in the form of prepaid amount of electricity for poor households on the other hand. It will be developed at first stage, the smart meter to facilitate the implementation of this measure. So in the short and medium terms, the high priority is given to the reliability and to the safety of supply, however sustainable electricity, is under measures established on a long term. The outcome of these decisions was based on multi-criteria decision making methods (MCDM), especially AHP using pair wise comparisons between criteria and between alternatives fixed a priori against the assigned objective. For applications we have considered the case of the Algerian national electricity and gas distribution enterprise (SONELGAZ) acting in a monopoly environment where the main shareholder is the Algerian state. The case of Algeria is very striking in terms of transition to smart grids and renewable energy development; given that the country admits a significant solar resources and political decision is very supportive and even incentive as stipulated by various finance laws signed in recent years. It is also shown by the ambitions of the enterprise SONELGAZ willing to play an important role in DESERTEC project. The rest of the paper is organized as follows: An overview of advancements in smart grids topic is given in section 2. Among panoply of multi-criteria decision making methods, AHP is developed in section 3. The section 4 is devoted for the application, how to choose an adequate smart grid for an enterprise issued from a developing country using AHP method. The conclusion and the discussions are given in section 5.

2 State of the art of smart grids and electricity sustainability

The development of the smart grids concept will be built around two separate definitions, namely: the European one oriented towards sustainable development and the American one oriented towards reliability and security. Numerous studies and various investigations have stated that the strengthening and the modernization of the existing power grids are imperative. These measures will enable the integration of an increasing amount of renewable energy, improving network security and finally achieve energy efficiency. To attempt these objectives, it is necessary not only to build new lines and sub-stations, but it is essential to make the system more intelligent and overall electricity through the integration of ICT [2]. Algeria is moving towards sustainable development, and the country has already taken steps to modernize the national network and to produce tools for collecting and processing data on the energy sector, more particularly electrical energy. This commitment is supported by the SONELGAZ group which has already made considerable progress in the installation of supervisory control and data acquisition (SCADA) systems and communicant meters for high voltage (HV) level energy counting and the acquisition of solar panel technology. A research work emanating from IBM confirms the diversity of concepts of smart grids, depending on the country and on the objectives of each utility.

As stated in the Smart Grid Gotland pilot project [3], smart grid technology is developed for increased network hosting capacity for consumers' utilization of RES and the consumers' integrated Demand Participation (DP). By implementing smart grid technology, improved system control, energy storage, utilization of RES and consumer DP may be coordinated and subsequently will facilitate for optimization of implementation and generation of renewable in the selected networks and consequently reduce the CO_2 footprint. Aligned under the energy efficiency and electricity technologies program, the Oak Ridge National Laboratory's (ORNL) sustainable electricity program develops technologies to create a cleaner environment, a stronger economy, and a more secure future for the nation [4]. The program is committed to expanding energy resource options and to improving efficiency in every element of energy production and use, and to ensure a reliable and secure grid that fully integrates central generation with distributed resources, manages power flows, and meets the nation's need for increasing electric power. ORNL actively develops innovative electricity delivery technologies to improve grid reliability, efficiency, security, energy storage systems, and prevent cyber infiltration. The Electric Power Research Institute (EPRI) describes electricity as a solution, an essential foundation for a sustainable world. Modernization of the electric system will increase productivity, contribute to economic growth and the transition to cleaner technologies and environmentally sustainable. Modernization of power infrastructure can also increase the reliability and safety of food while reducing the risk of failure or dangerous electrical disturbances as stated by NERC [5]. The infrastructure put in place for the smart grid has essentially three levels. The first one is composed of sensors and advanced devices from the mains, the median one is made up of networks of communication and integration platform, and the top level combines analytical applications and systems required for presentation of data and decision making. So we say that the smart grid is different from traditional network because it is instrumented, interconnected and informed. The future of energy production is dominated by renewable sources. But the success of integrating power from wind and solar sources depends on the ability of mastering the challenges due to their volatile and decentralized natures and to the mitigation of investment expenditures of their insertion to transport and distribution networks. The smart grid is a global concept with multiple perspectives, namely: technical, commercial, legal and societal. Many economists agree that the smart grid industry is experiencing a considerable growth with an annual rate approaching 23% and the back of the last five years will revolve around U.S. $ 13 billion [6]. Smart grid projects have contributed to the emergence of other services like computer security development, because the field of data transfer and communication has often been the target of terrorists and hackers. How about sustainable electricity? Direct electricity generation from solar power has been less successful, mainly due to high capital costs. Solar power has a major advantage, in that it is produced most abundantly at times when power is needed most. The way towards sustainable use of electricity involves three main steps: Reduce, Replace and Generate. Reduce the amount of energy used, replace old inefficient appliances, and then cover the remaining need with renewable electricity generated on a small scale. Sustainable electricity can be highlighted by acting at the three levels of the power system, namely: production, distribution and consumption. The actions are resumed as: clean energy development and environment protection, optimization by automation and regulation, monitoring maintenance and improvement of system performances and finally the mastery of basics. This point is usually supported in energy efficiency target.

3 Problem: Analytic hierarchy process overview

The AHP is a tool for decision support. It allows managers to structure the complex problems they face in issuing judgments based on their experience and informal available data. The approach consists on: the identification of the goal (find an optimal smart grid project for a developing country), the development of potential scenarios that can meet the desired objective, the identification of the criteria and sub-criteria that influence the decision. In the following are developed the potential scenarios highlighted by the visions of different countries such as: the USA, Europeans and some emerging countries. The decomposition of the problem in a hierarchy process is given in figure 1.

3.1 AHP development

The use of AHP is summarized as follows [7]:

- Model the problem as a hierarchy containing the decision goal, the alternatives for reaching it, and the criteria for evaluating the alternatives.
- Establish priorities among the elements of the hierarchy by making a series of judgments based on pair-wise comparisons of the elements.
- Synthesize these judgments to yield a set of overall priorities for the hierarchy.
- Check the consistency of the judgments. The consistency index of a matrix of comparisons is given by CI. The consistency ratio (CR) is obtained by comparing the CI with the appropriate random index value [8].
- Come to a final decision based on the results of this process.
- Analyze the sensitivity to changes in judgment to study the margin of stability and the decision. Sensitivity measures are developed to determine the robustness of the consistency ratio and the principal right eigenvector to perturbation in the group judgments of the pair-wise comparison matrix [9].

ISBN: 978-960-474-400-8

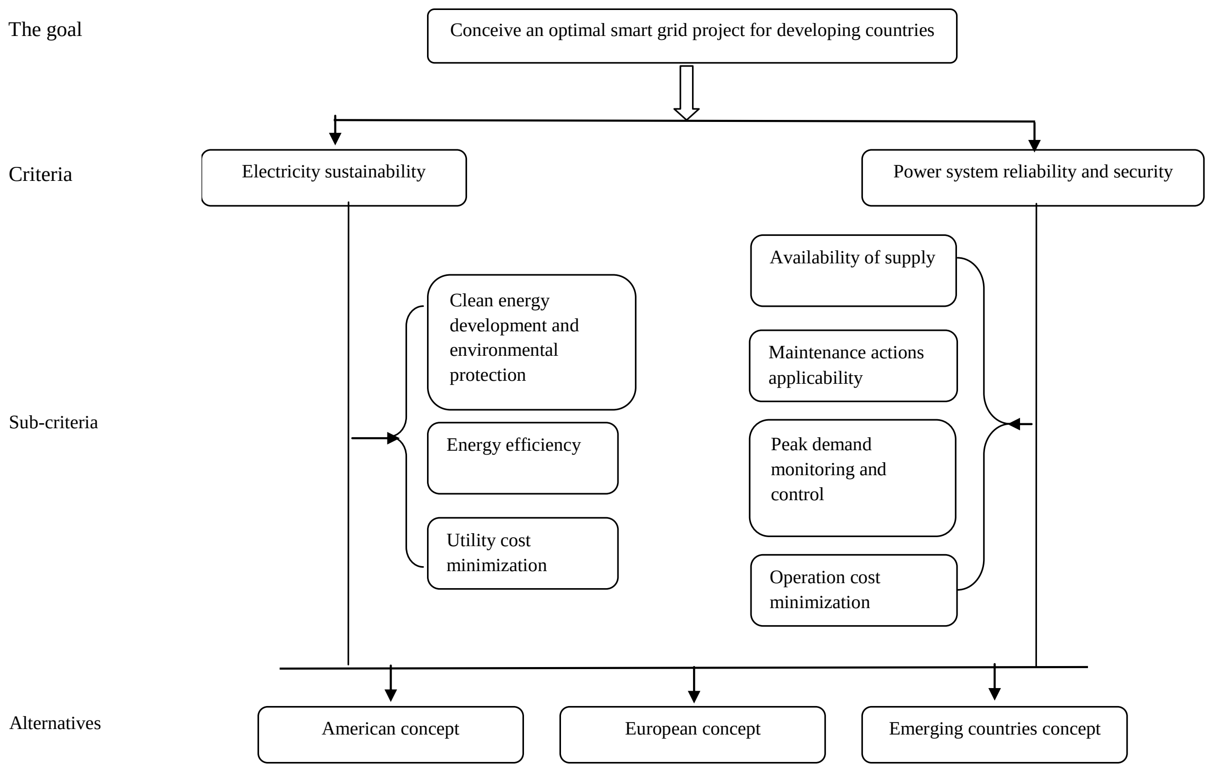

Fig.1. Decomposition of the problem into hierarchy process.

Let consider A the matrix of elements aij representing a quantified judgment on a pair of elements Ci, Cj. In the matrix A, the problem becomes one of assigning to the n elements C1, C2, …, Cn a set of numerical weights W1, W2, …, Wn that reflects the recorded judgments.

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & . & . & . & a_{1n} \\ 1 & 1 & . & . & . & a_{2n} \\ . & . & . & . & . & . \\ .. \quad . & . & . & . & . & . \\ . & . & . & . & . & . \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & . & . & . & 1 \end{bmatrix} \tag{1}$$

If A is a consistency matrix, the relations between weights Wi and judgments aij are simply given by:

$$a_{ij} = \frac{W_j}{W_i}$$

(for i,j=1,2,…,n). The largest eigenvalue λmax is given by:

$$\lambda_{\max} = \sum_{j=1}^{n} a_{ij} \frac{W_j}{W_i} \tag{2}$$

If A is a consistency matrix, the eigenvector X can be calculated by:

$$(A - \lambda_{\max} I)X = 0 \tag{3}$$

The consistency index (CI) and consistency ratio (CR) were proposed to verify the consistency of the comparison matrix. It is adopted that:

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{4}$$

In the AHP, the pair-wise comparisons in a judgment matrix are considered to be adequately consistent if the corresponding CR is less than 10 % [10].

3.2 How to use AHP in the context of smart grid project?

The answer is quite sharp and target system’s reliability and security, and electricity sustainability. These two targets constitute the main criteria. The first criterion obeys to the American definition, however, the second criterion is inspired from the European one, dealing with sustainability development. To the system reliability and security are associated some sub-criteria, such as: Availability of the supply, system maintainability (in fact, this concerns the applicability of maintenance actions highlighted by both their efficiency and the easy of their implementation), the mastery of the peak demand monitoring and its control and at least and not the last, operation cost minimization due to interruptions and losses. As the sustainability development is large and encloses a lot of fields of humanity activities, in this work, this criterion is limited to electricity sustainability. It includes the following issues: clean energy development and environment protection, energy efficiency (encloses optimization by automation and regulation, monitoring maintenance and improvement of system performances and the mastery of basics) and minimization of utility costs. It will be noted that the evaluation of priorities for these two main criteria depends on the period of planning. For short and medium terms, a high priority is attributed to reliability and security, however for the long term, the high value is assumed for electricity sustainability. As for scenarios, three competing concepts are considered, such as: European countries, USA and some emerging countries, as developed in the following.

3.2.1 Case of European countries

The European Commission supports numerous research and development on technologies for smart grids. Many projects have been funded and a large proportion of them was dedicated to the study of the integration of renewable generation and diffuses networks. In 2009, the European Commission has established the Smart Grid Taskforce working group bringing together all stakeholders in the smart grids (regulators, network operators, power producers, energy suppliers, equipment manufacturers).

Germany: focuses on research and development. The German government decided in 2006 to invest 15 billion euros in the project "E-Energy: ICT-based system Energy of the Future" to develop intelligence and networking technologies necessary to enable smart grids. In this context, three lines of thought have been identified: the creation of a marketplace E-Energy to facilitate transactions and the award of contracts between the different actors of intelligent systems, information transfer and execution of transaction in real time, and the development of interfaces between the different technical systems and components to allow independent verification, the sharing of the maintenance and development of regulations covering the entire system.

Denmark: focuses on the development of electric vehicles. The project Edison (Electric vehicles in a distributed and integrated market using sustainable energy and open networks), launched in late February 2010 on the island of Bornholm, aims to develop an intelligent infrastructure required for large-scale adoption of electric vehicles powered with renewable energy. According to the researchers, the development of infrastructure that would allow electric vehicles to communicate intelligently with the grid is essential. Danish officials said the cool down would depend on fluctuating input power into the grid from renewable energy sources, "as well as the cumulative demand on the network at any time." In the near future, an estimated one-tenth of the entire Danish fleet will be electric or hybrid with investment plans implemented in the northern state.

Spain: Iberdrola will invest 22 million euros in the STAR project, which will focus on the modernization of over 600 transformer substations and replacement of over 100,000 meters of 175,000 inhabitants of the city of Castellan. It will be the first Spanish city to integrate a smart grid. Therefore, 175,000 customers have a service improving power quality and reducing incidents. To achieve this, Iberdrola renew more than 100,000 meters currently serving its customers. In addition, it will adapt the processing centers of the city to provide services remotely, take readings on metering devices and manage registrations, cancellations or changes of power purchased.

Netherlands: Amsterdam Smart City project, launched in 2009, has a series of bold pilots could extend to the entire city and 700 units were equipped with smart meters, which measure energy consumption and CO2 emissions. Another example, an office tower will have an energy management system based on sensors that provide detailed information. Boats can be connected to electrical connection points, instead of running diesel generators. The municipality also intends to promote the electric car with the installation of recharging points. Amsterdam aims to satisfy, in 2020, 30% of its energy needs through renewable energy, while the proportion is 6%.

Britain: The installation of 27 million meters was announced. The British project includes a number of high meters, due to the deployment of smart meters for both electricity and gas, allowing for better absorption of fixed costs of the project. Ofgem has decided to set up a working group to determine a pattern where the customer could keep the same meter despite its switching and develop a standard for interoperability of counting.

Portugal: Inovgrid project, led by EDP approximately 6.1 million customers. Portugal receives steady winds and strong sunlight, so that some days, more than 90% of the electricity is

ISBN: 978-960-474-400-8

produced from renewable energy sources. Inovgrid combines smart meters and smart grid. This project is implemented by creating a dedicated structure, reporting directly to the general direction of EDP and combines several trades. EDP readily integrated all the elements necessary for the information system. This project started in 2007 and led to experiments in different geographical areas. Today, more than 50,000 points of consumption are managed by smart grids in the country.

Sweden: is an exception compared to other countries. Since 2001, studies on smart metering were conducted. The feature of this meter deployment is that it has not been regulated by law: indeed, the introduction of compulsory monthly billing based on actual consumption data from 1 July 2009 has created a strong incentive processing parks meter, low voltage, by Swedish operators. Indeed, at that time, 5.3 million smart meters have been deployed, mainly used for remote reading. The government does not exclude the possibility that some of the investments to be financed by an increase in the rate of the use of networks (regulated) and the measurement of benefits perceived by end users. In January 2011, 8 million smart meters were installed in Sweden. It aims to have a transport independent of fossil fuels by 2030, and for that, the park aims to develop electric vehicles. At present, only 317 electric cars are in circulation, whereas by 2020, 600,000 ones are planned. Builders have nonetheless begun to develop models. Saab has built a hundred test vehicles on the end of 2011, while Volvo plans to launch a plug-in hybrid.

Switzerland: The research in electrical systems is operating in a relatively narrow landscape; the new agreement provides an essential contribution to a more intensive collaboration with its neighbors in the research. It allows for example the transfer of knowledge from large research projects such as the flagship E-Energy developed by Germany or enhanced coordination for norms and standards taking place soon enough. In this sense, it complements the international activities that Switzerland has in these areas from the International Energy Agency (IEA) and the European Union. In November 2009, the Swiss Federal Office of Energy (FOE) has compiled a list of recommendations for the implementation of advanced metering systems AMR: the system should allow a return frequent consumption data, provide additional information and let consumers choose their means of information (SMS, Internet, etc.). Counters will allow communicating additional functions support (remote display, device control, measures) and advanced metering systems will ensure interoperability of equipment and technologies (meters, concentrators and systems).

Italy: Enel began installing the first smart grid in Italy, part of the impetus to develop the technology needed to manage the flow of electricity decentralized and fluctuating renewable energy sources. It said that several thousand customers will take part in 10 million euros pilot project in the southern region of Molise. Smart grids use data from the production, transmission and consumers effectively providing reliable power at the lowest cost. Network intelligent driver includes systems for estimating the power produced from renewable resources, advanced sensors for monitoring network volumes and interaction with generators to provide advanced regulation of input streams. It also includes a repository using technology lithium-ion batteries with a capacity of 0.7 megawatt to modulate the flow of electricity. Enel is currently implementing a restructuring 10 years of its distribution network of more than 1 million kilometers, coordinated with programs to encourage the development of smart grids launched by the European Commission.

France: French energy mix is dominated by nuclear with minimal CO2 emissions. The adoption of smart grids in France obeys to the following objectives: energy efficiency and service quality, seeking the adoption of a citizen attitude for reducing consumption and anticipating the success of the electric vehicle deployment with a large-scale renewable energy. France advance step by step in the smart grid, by developing new business models, assessing the capacity of consumers to adapt their consumption to the production of renewable energy and reducing annual consumption and delay outside the period of peak demand. It is optimizing the management of residential users. The project to replace the existing meter by a communicating one was launched with the ambition of making 29,000 substitutions as first step in a project driven primarily by Siemens. Some regions set specific targets, such as reducing consumption of 15% by 2013 and reach a production-based renewable for about 25% of the total consumption mainly with their involvement in competitive clusters.

3.2.2 Case of USA

The USA are currently at the forefront of green technologies and the country has committed to transform its antiquated electrical system "smart grid", a network full of computers and modeled on the architecture of the Internet. America takes an early lead in this area, which attracts huge investments and giants like IBM, Google, Cisco, Accenture General Electric and Siemens. Smart grids are expected to reduce electricity demand by 10% in the integrated network decentralized sources of renewable energy and reduce consumption peaks generators breakdowns and pollution. These technologies could avoid power outages that cost annually $ 80 billion in the United States and reduce the energy bill of $ 150 billion per year. Criteria highlighted to justify smart grid project are the reliability and security of supply. The blackout of 2003 was one of the most severe in a series that revealed the fragility of the U.S. network to support the demand peaks and a particular attention is given to its control. In terms of regulation and regulatory, it was developed and implemented standards grouped into six areas, namely: security, curves semantic models and software, visualization and continuous monitoring of the network, demand management, energy storage and electrification of transport.

3.2.3 Case of some emerging countries

Case of China: The economic growth in China has doubled its production capacity of electricity between 2004 and 2008. Even such growth has been unable to keep pace with demand, and there have been periodic shortfalls. This has been one of the drivers for smart grids in China [11]. The renewable energy is experiencing a major boom which is happening in major centers that connect directly to the transmission network. The Chinese network is back, and requires the concentration of all efforts to promote efficient transmission. China plans to build a strong smart grid for a value of around 60 billion euros. Its network is remarkably different from the American and French networks, it is highly centralized and the Chinese smart grid is moving in a context of accelerating energy needs.

Case of India: Smart grids in India have been implemented to improve energy efficiency. One example is to equip the substations with automatic recording systems equipped with advanced electrical test capabilities. For the processor, the system monitors the level of oil and temperature. Communication occurs through cellular networks with a central control and data acquisition. It should also minimize energy losses estimated at 30% of the total energy supported by the current Indian network. The blackout in September 2012 with its disastrous economic effects, gives a concrete way to the acceleration of the implementation of the smart grid project.

4 Case study: An adequate smart grid to SONELGAZ conditions

Algeria is not immune from a new blackout and the terrible event of 2003 can be repeated. So we ask the recurring question: what is the space reserved to smart grids? The triggering event of a blackout remains uncertain; it may be due to a high peak in demand, to the loss of a generator, to the loss of a transmission line or to a fault on a main distribution station. Current technology without smart tools provides solutions but judged to be expensive. So when a cascading degradation is initiated, the question asked is: What is the decision to take in a very short time and without notice? The recommended solution is the downloading, but in many cases the solution is prejudicial from both economic and moral points of views. The other alternative is to let running automatic mechanisms such as compensators. But in case of a mismatch, it appears the worsening of the degradation with the collapse of the frequency and the voltage levels. In the case of a blackout, the reconstruction of the network takes a lot of time which increases the damage consequences mentioned earlier. The solution may come from smart grids. Based on the earlier overview, smart grids highlight the following features:

- Ability to perform forecast peak demand and to ensure its management,
- Anticipation of the start of the emergency,
- Risk assessment of equipment failures,
- Management of shedding their workforce at the appropriate times,
- Select the consumer prior to relieve via current carriers.

SONELGAZ group had launched the installation of SCADA systems and smart meters for HV level counting across the country. These systems are connected to the national dispatching center for the acquisition of relevant data in a timely manner thus helping to better network management. In recent years, several millions of dollars have been invested in the modernization and the automation of the network, as highlighted by the contract signed between this group and ABB for the installation of 05 dispatching sites connected using a computer system technology. The load dispatch centre coordinates the flow of energy within the permissible limits of transmission lines. It is also to improve the monitoring and to control the power generation sources. SONELGAZ suffers from the problem of the unpaid bills recovery. From one hand, to solve this problem in conjunction with illegal connections, it can enjoy the experience of

ISBN: 978-960-474-400-8

Enel, which states that the invoice installation of smart meters was amortized using financial resources earned by limiting fraud. From the other hand, as it has the characteristic of public company, it is called to think on solving the problem of the most diminished household bills. It can sign an agreement with the government for the transformation of certain aid granted to electricity rations using prepaid cards that work on the smart meter or communicating counter. This can also help in counting the produced energy following the government decisions adopted to encourage individuals to produce their own clean energy.

4.1 Specific actions on renewable energy production

Several laws have been passed in relation to the energy conservation and the promotion of renewable energies in the context of sustainable development. The integration of the 'Rouiba Lighting' company, specialized in the production of solar panels, as a subsidiary of SONELGAZ, informs about the attachment of this group to this aspect, and responds to a strategy of developing a real solar industry. The latter enters into production at the end of 2013 with an annual production capacity estimated to 116MWc. More recently, the 2010 Finance law has spent the creation of a national fund for renewable energy [12].

4.2 The decision criteria

The principles of AHP method are: the hierarchical structuring, priorities structuring and logical consistency. The method includes the sensitivity analysis that gives the decision maker the possibility to change weights values of criteria or to eliminate whatever criteria it deems relevant. The main criteria and sub-criteria are:

- Power system reliability and security (PSRS);
- Availability of supply (AS),
- Maintenance actions applicability (MAA),
- Peak demand monitoring and control (PDMC),
- Operation cost minimization (OCM)
- Electricity sustainability (ES);
- Clean energy development and environment protection (CEDEP),
- Energy efficiency (EE),
- Utility cost minimization (UCM).

4.3 Results and discussions

This application constitutes a technical tool that can assist decision-makers to choose the best scenario to adapt to the conditions of SONELGAZ depending on its ambitions in smart grids project and electricity sustainability. For the assessments, we have developed a computer program LAMOS laboratory implemented under MATLAB software package and the application was made by distinguishing criteria between short and medium terms and long term periods.

4.3.1 In short and medium terms

The main objective is to ensure high availability of supply, to mitigate risks of catastrophic failures and to reduce power losses in transportation system. These points are supported in the PSRS criterion. For this, a high priority is allocated to this latter. The considered values are: PSRS priority is 0.8750 and ES priority is: 0.1250 (as shown on the first line of table 3.

Energy efficiency and renewable energy are said to be the twin pillars of sustainable electricity. The results dressed in table 1 showed that energy efficiency owned the highest priority given to its immediate result. However, the returns of investment, in the case of development of renewable energy, are much longer and cannot be effective and consequent only with long term.

Table1.Pair-wise comparisons matrix of the sub-criteria with respect to electricity sustainability (short and medium terms)

	CEDEP	EE	UCM	Priorities
CEDEP	1	5	7	0.7306
EE	1/5	1	2	0.1884
UCM	1/7	1/3	1	0.0810
CRI=0.0559	CI=0.0324	λmax= 3.0649		

USA and India are the most familiar with blackout event which cause social and economic damages. It occurs mostly when there was a high electrical demand (summer peak and winter peak). Then, a high priority is given to peak demand monitoring and control as shown in table 2. It is followed by maintenance actions applicability which takes into account the congestion of the system and the efficiency of the operations. These two sub-criteria are important to maintain an available supply of electricity.

Table2. Pair-wise comparisons matrix of the sub-criteria of the sub-criteria with respect to power system reliability and security (short and medium terms)

	AS	MAA	PDMC	OCM	Priorities
AS	1	½	1/3	2	0.1519
MAA	2	1	½	4	0.2826
PDMC	3	2	1	6	0.4896
OCM	½	¼	1/6	1	0.0759
CRI=0.038	CI=0.0035	λmax= 4.0104			

After a series of standard calculations, namely pair-wise comparisons between criteria and sub-criteria in relation to the goal, we have developed a synthesis, where the results are dressed in table 3.

Table 3. Final results using synthesis (short and medium terms)

	ES			*OCM*				Priorities
Weights	0.1250			0.8750				
Sub-criteria	CDEP	EE	UCM	AS	MAA	PDMC	OC	
Weights	0.3764	0.4742	0.1494	0.1519	0.2826	0.4896	0.0759	
American concept	0.1220	0.1047	0.1168	0.6250	0.5584	0.6910	0.3196	0.5525
European concept	0.6483	0.2583	0.6833	0.2385	0.1220	0.2176	0.1220	0.2218
Emerging countries concept	0.2297	0.6370	0.1998	0.1365	0.3196	0.0914	0.5584	0.2257

The American concept won the highest priority followed by the emerging countries and finally the European concept. This is justified by the immediate need of developing countries to meet the needs of billions of people who still lack access to basic, modern energy services. The access to reliable, reasonable and socially acceptable energy services are a pre-requisite to alleviating extreme poverty and meeting other societal development goals.

4.3.2 In long term

It is expected that at longer-term, the issue of climate change must be supported by all countries. It is caused by the increasing of greenhouse and CO2 gases emissions. These problems have negative effects on developing countries. An Active participation by such countries in the efforts to de-carbonize the world's energy systems is essential as a matter of self-interest and also to help to avert a global environmental catastrophe. To highlight the importance of this issue, a high priority is given to clean energy development and environmental protection.

The results gathered in table 4 show that renewable energy development a required alternative.

This is justified by its high priority and leads to give an increasing attention to this criterion when managers are planning for long term period. Energy

Table 4. Pair-wise comparisons matrix of the sub-criteria with respect to electricity sustainability (long term)

	CEDEP	EE	UCM	Priorities
CEDEP	1	1	1/2	0.3874
EE	1	1	1/4	0.4434
UCM	2	4	1	0.1692
CRI=0.046	CI=0.0268	λ_{max}= 3.0536		

efficiency cannot be neglected when considering sustainable electricity because various criteria can be extracted, such as: economy, rational use and availability.

At least, it can be observed that the utility cost minimization is not of priority because it is obvious that in long term planning, the return of investments is guaranteed. The combination between energy efficiency and renewable energies presents a much more environmentally, socially and economically sustainable energy path.

From one side, the economics of renewable energy depend not only on the cost of designing and installing the system, which can vary considerably, but also the expense of maintaining and operating the system over the course of its serviceable lifetime, which usually spans between 25 to 30 years. From the other side, the insertion of renewable energy to the power grid can manage and control peak demand following operation cost minimization. As shown in table 5, the highest priority is given to operation cost minimization followed by the control of peak demand.

Table 5.Pair-wise comparisons matrix of the sub-criteria of the sub-criteria with respect to power system reliability and security (long term)

	AS	MAA	PDMC	*OCM*	Priorities
AS	1	1/2	1/3	1/5	0.0820
MAA	2	1	1/2	1/3	0.1569
PDMC	3	2	1	½	0.2717
OCM	5	3	2	1	0.4832
CRI=0.054	CI=0.0048	λmax= 4.0145			

After a series of standard assessments, namely pair-wise comparisons between criteria and sub-criteria in relation to the goal, a synthesis is developed, where the results are dressed in table 6. It is sorted that the European concept won the highest priority followed by the emerging countries one and finally the American concept. This is justified by the participation of developing countries in a global transition to clean and low-carbon energy systems because their emissions are growing rapidly and are contributing to environmental problems, such as climate change and poor air quality, which put the health and prosperity of people at grave risk.

Table 6.Final results using synthesis (long term)

	ES			*OCM*				
Weights	0.8889			0.1111				
Sub-criteria	CDEP	EE	UCM	AS	MAA	PDMC	OC	Priorities
Weights	0.3764	0.4742	0.1494	0.1519	0.2826	0.4896	0.0759	
American concept	0.1220	0.1047	0.1168	0.6250	0.5584	0.6910	0.3196	0.1586
European concept	0.6483	0.2583	0.6833	0.2385	0.1220	0.2176	0.1220	0.5309
Emerging countries concept	0.2297	0.6370	0.1998	0.1365	0.3196	0.0914	0.5584	0.3098

Conclusion

The information system is essential to ensure adherence of citizens to the new deployed policies providing high level of availability, a safe and economical supply and the decentralization of the system to allow the insertion of renewable energy resources. The integration of smart systems to the conventional networks recalls the necessity to otherwise manage power flows in a safe way knowing that the system becomes more vulnerable and a target for hackers. In this paper we have provided panoply of appropriate knowledge inspired from the experiences of developed countries that have a big step in the field of smart grids aiding decision-makers in developing countries to follow shortcuts, saving them time and making economic tests and subsequently increasing the chances of projects achievement. As a future work, combining the virtues of AHP method with the objectives of sustainable electricity issued from a smart energy grid management, we would like to solve the problems of unpaid bills of poor households and break down the wall of exclusion and frustration of having electricity available but inaccessible due to lack of financial means. We will try to answer the relevant question: what is the degree of acceptance towards changes made following the integration of the ICT with respect to the confidentiality of data transiting in the smart energy system?

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