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Mathematical Models to Support the Issue of Electrical Blackouts in the Context of Smart Grid

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***Abstract*—This paper aims to provide knowledge to understand the impacts of the integration of information and communication technologies (ICT) in the conventional power network giving birth to a smart energy grid. We have developed the attributes of combining smart systems with renewable energy resources to mitigate the occurrence of blackouts. Two main issues were investigated from mathematical models point of view: First, we have considered time series analysis and forecasting models to understand the occurrence of the blackouts and consequently the behaviour of the power system. Second, we have modelled the restoration process of the system after the blackout using Markov method. This work has highlighted the dominance of ARMA model in forecasts and that the smart systems can mitigate the blackouts occurrence thanks to the information given online looking to the weather conditions and to the load demand. Using Markov method we have highlighted the importance of decentralized clean resources in the reduction of the downtime during the restoration of the power network.**

***Index Terms*—ARMA models, blackouts, interruption modeling, renewable energy, smart grid**

I. INTRODUCTION

The integration of the technologies of information and communication combined to the insertion of renewable energy resources are giving birth to a smart energy grid. These smart systems allow mitigating the cascading events, from one hand and accelerating the network reconstruction in the case where those events were not prevented, from the other hand. A typical large blackout has an initial disturbance or trigger events followed by a sequence of cascading events [1]. The progression of blackout can be divided into several steps as shown in Fig 1, such as: precondition, initiating events, cascade events, final state and restoration.

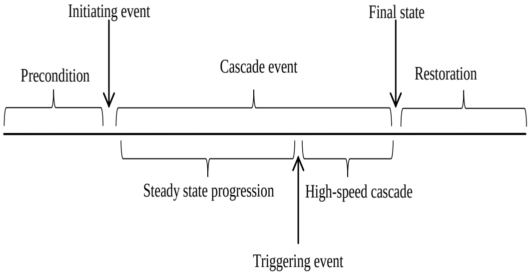

Figure 1. Phases of blackout

Among these five steps, cascade events can be further divided into three phases in the process of some blackouts [2]: steady-state progression, triggering events and high-speed cascade. In reference [3] the authors have analyzed a 15 years, of North American electric power system blackouts for evidence of self-organized criticality. They have proposed three measures tools, such as: the energy unserved in MWh, the a000000mount of power losses in MW and the number of customers affected. They have given the proportion of the contribution of weather in blackouts occurrence, estimated to 50% of the total number. This phenomenon takes into account the intensive operation of both cooling and heating systems. To reduce the risk of major blackouts trough improved power system visualization, Overbye and Wiegmann [4] describe several visualization techniques that can be used to provide information and control at time using automation system. They have stated that it is possible to mitigate blackouts through corrective and extreme control; such as: quickly load shedding at right location and opening tie-lines. Many researchers were interested in the problem of blackouts, and more works were conducted on the deterministic side. Nevertheless, the stochastic aspect has been addressed with the introduction of several probabilistic models highlighting the risk of blackouts occurrence. After reviewing about 200 works on the blackouts, and based on the synthesis work conducted by the IEEE PES Task Force [5] and while having ideas about what can make smart systems, we have introduced forecast models to show the evolution of the latter in the future and to predict the behavior of the conventional

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network if ever information systems are integrated and in the case it becomes better communicating.

Using box and Jenkins models for North American blackouts forecasting, where the trend is quite constant, we have demonstrated that the ICT integration performs both power system operation and some reliability indices, such as: interruption duration, failures frequency and subsequently the non-deserved energy. With smart meters, a smart grid is able to collect real-time information about grid operations, through a reliable communication networks deployed in parallel to the power transmission and distribution systems.

The occurrence of a blackout can be modeled using the Markov method. A competing failure process is proposed gathering the degradation process (due to the normal operation of the system subject to aging and to the wear of equipment) and the shock process (due to the loss a generator or a main line) as shown in Fig. 2.

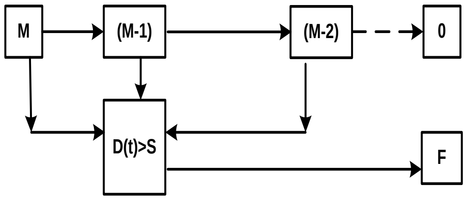

Figure 2. System states diagram subject to two failures processes where M, (M-1) are degradation states, O is a degradation failure state and F is a catastrophic failure state.

Based on the three experiences of the Algerian, Italian and American blackouts occurred in 2003, a lot of efforts may be made to reduce restoration times. Regarding the delays of turbines starting, it is demonstrated that renewable sources can play an important role in this issue, thanks to the instantaneous delivery assured using batteries storage. A particular interest is given to the contribution of both integration of smart systems and insertion of renewable sources to better manage the peaks of demands, to reduce power losses and to increase the availability of electricity. The rest of the paper is organized as follows: section 2 is devoted to time series modelling, using Box and Jenkins method. To highlight the dominance of the ARMA models in the field of electrical engineering, we have made four different applications with real cases. In this section, a particular attention is given to cascade degradation processes modeling where we have introduced competing failure processes including both degradation and a shock processes. In the case of a blackout occurrence, a particular interest should be granted to the restoration process. This issue is developed in section 3 with applications for three special cases of blackouts occurred in year 2003. Section 4, is devoted to conclusion and discussions.

II. TIME SERIES MODELING

A. Formulation of Models

There are two types of models to account for time series. Initial works consider that the data is a function of time $y_t = f(t)$. This category model can be adjusted by the least squares method, or other iterative methods. The model analysis by Fourier transform is a sophisticated version of this type of model. A second class of models seeks to determine the value of each series based values which proceed a $y_t = f(y_{i-1}, y_{i-2}, \ldots)$. This is the case of ARIMA models (Auto-Regressive - Integrated -. Moving Average), this class of models has been popularized and formalized by Box and Jenkins [6].

ARMA models: The general Auto-Regressive Moving Average (ARMA (p, q)) model for a univariate stationary time series can be presented analytically as:

$$\begin{aligned} Y_t &= \phi_1 y_{t-1} + \phi_2 y_{t-2} + \ldots - \phi_p y_{t-p} \\ &+ \mu_t + \theta_1 \mu_{t-1} + \theta_2 \mu_{t-2} + \ldots - \theta_q \mu_{t-q} \end{aligned} \tag{1}$$

where: ϕ and θ are polynomial functions of degrees p and q respectively.

ARIMA models: A no stationary series is provided by the ARIMA (p,d,q) processes, it has the general form:

$$\Delta^d Y_t (1 - \phi_1 L - \phi_2 L^2 - \ldots - \phi_p L^p) = (1 - \theta_1 L - \theta_2 L^2 - \ldots - \theta_q L^q) \mu_t \tag{2}$$

SARIMA models: We use the Seasonal Autoregressive Integrated Moving Average processes when we have to deal with time series with trends, seasonal pattern and short time correlations.
If we denote:

- Y_t , The number of events passing through the observed link during the time interval $\left[(t-1)\Delta; t\Delta\right]$ of duration $\Delta \rangle 0$ for t=0, 1, 2, …

- B , is the backshift operator which affects the time series y_t given by $(B^d y)_t = y_t - d$ for all integers d.

The $SARIMA(p,d,q) \times (P,D,Q)_s$ process y_t is given by the following equation:

$$\phi_p(\mathrm{B}) \Phi_p(\mathrm{B}^d)(1-\mathrm{B})^d (1-\mathrm{B}^s)^D y_t = \theta_q(\mathrm{B}) \Theta_Q(\mathrm{B}^s) \varepsilon_t \tag{3}$$

where: ε_t is a white noise sequence, Φ and Θ are polynomial functions of degrees P and Q respectively.

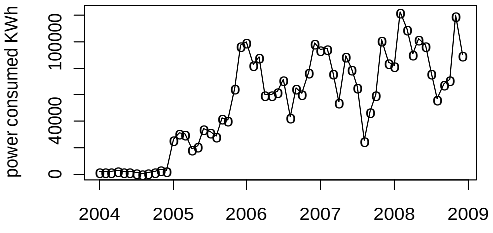

Figure 3. Plot of the original series

B. Applications

Energy consumption: The objective of this application is to provide a novel strategy for internal power system operation. Initially, the power distributor has installed mean voltage / low voltage sub-stations (MV/LV), and some utilities are secured by oil engines made at disposal and managed by the services of the university. When we have evaluated moral and financial prejudices caused by the loss of the power, we have demonstrated that it is beneficial to the distributor to provide the emergency sources securing MV/LV stations. This investigation was conducted taking into account the annual evolution of the load. The plot of the original series is given in Fig. 3.

From the time plot it appears a linear trend on average, and a seasonality of order 12.

Two transformations were needed such as: a differentiation of order 1 to eliminate the trend and a seasonal differentiation of order 12 to eliminate the seasonality. Since these transformations are aimed, the corresponding ACF and PACF correlograms are given in Fig. 4 and Fig. 5 respectively.

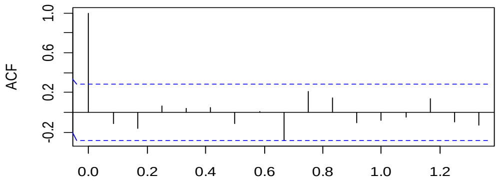

Figure 4. ACF of the transformed series.

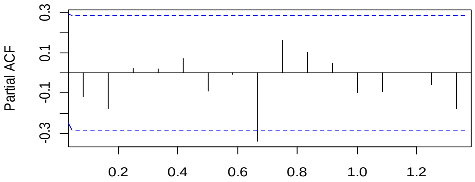

Figure 5. PACF of the transformed series.

The analysis of the autocorrelation and the partial autocorrelations of the original series bring up a significant peak that exceeds the significance bounds at lag1 for partial autocorrelation and no significant peak for the autocorrelation. Based on these results, we propose the model SARIMA (0,1,1) $(0,1,0)_{12}$.

$$Z_t = Z_{t-1} + Z_{t-12} - Z_{t-13} + \varepsilon_t - 0.4428\varepsilon_{t-1}$$

The Forecasts for the next twenty-four months are shown in the fig. 6.

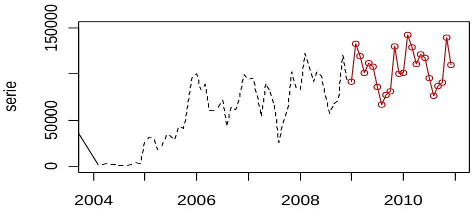

Figure 6. Result of forecasting.

TABLE I. COMPARISON BETWEEN REAL AND FORECASTING DATA FOR THE FOUR MONTHS OF 2009

Real consumption (Kw)	Forecasting with SARIMA (Kw)
138791.00	92769.34
141133.00	133429.34
106746.00	120634.34
95797.00	102282.34

Those of the last four months were compared to the real values recorded using power meter and shown in Table I. We observe a good correlation with an acceptable error.

Why this investigation is of interest?

What is the relevance of smart system use?

This work could be generalized to the whole universities of the country and the consequences contribute surely to the customer satisfaction and to enterprise profitability. The results encourage the distributor for future investments in providing emergency resources at his account.

In the cases of low supply or high demand, smart systems can able the distribution company to manage the load shedding using the national file of institutions powered by emergency sources, and consequently reduce the unavailability time to the balancing time only.

This solution can also help to mitigate partial or global blackouts.

Forecasting the production of a hydroelectric power plant: Pay special attention to the hydroelectric power plant of Darguina, located in a mountainous region of Bejaia, obeys to a twofold objective. Firstly, it is to mark the commitment of Algeria in the production of clean energy, mainly the solar one, as the country has a large deposit in the Saharan region. Secondly, the north of the country must rely on the hydroelectric plant, but this latter is considered obsolete because its construction dates back to the colonial period, during forty's years. So the forecasts provided in this work may justify investments expenses in both its renovation and its maintenance. From a supply point of view in the context of smart systems, it can be a tool of decentralization that may have a direct effect on the local consumption if at any time a strong regional demand is requested. So, the time series analysis and the forecasting modelling concern the peak load demand on monthly intervals. The ARIMA model (0, 0, 3) is validated and formulated as follows:

$$Z_t = (1 - 0.8618\varepsilon_{t-1} - 0.7473\varepsilon_{t-2} - 0.6748\varepsilon_{t-3} + 3.9757)$$

Forecasting failures of components of an electrical distribution network: After treating the case of consumption and clean energy production, we granted a particular interest to the distribution part of the electrical system by treating failure forecasts of the Bejaia city network. As stated in several recent publications, 90% of the total failures are recorded in the distribution part. It is essential to recall that actually power systems are modelled as both multi-components and multi-degraded systems. It is useful to distinguish and to classify failures based on their origins and by the components where it concern. To this end, using Box and Jenkins method, we formulate forecasting models for such equipment as follows:

- Overhead lines forecasting failures model

$$Y_t = 0.34851Y_{t-1} + 0.77956Y_{t-2} + 0.83544\varepsilon_{t-1} + \varepsilon_t$$

- Underground cables forecasting failure models

$$Y_t = 0.29148Y_{t-1} + 0.83538Y_{t-2} + 0.85063\varepsilon_t$$

- Joint nodes forecasting failures model

$$Y_t = 1.01066Y_{t-1} + 0.06623Y_{t-2} + 0.33257\varepsilon_{t-1} + \varepsilon_t$$

MV/LV sub-station forecasting failures models

$$Y_t = 0.04987Y_{t-1} + 0.75822Y_{t-2} + \varepsilon_t$$

- Mean voltage feeder forecasting failures model

$$Y_t = 0.30520Y_{t-1} + 0.21176Y_{t-2} + 0.30099Y_{t-3} + \varepsilon_t$$

The time series analysis was done on annual intervals and the data were collected on a period of ten years. The models are generally ARMA (p, q) and the forecasts show that failure evolve in increasing manner with the exception of the last two years due to the renewal of some aging sections of cables during the recent years.

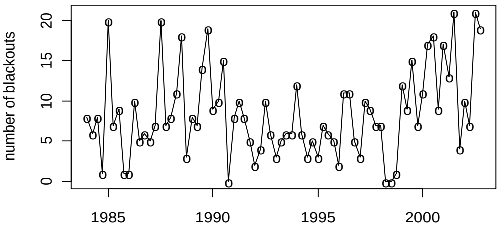

Figure 7. Plot of the original series

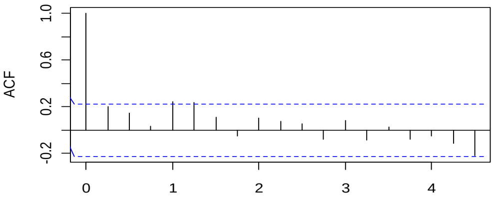

Figure 8. ACF Original series

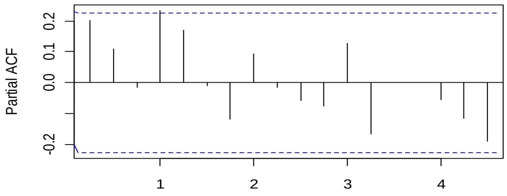

Figure 9. PACF Original series

Forecasting the number of blackouts of northern USA: After confirming the dominance of the ARMA model forecasts on local events, it was given to us the idea of popularizing the model for events abroad. The phenomenon which binds several countries in the field of power systems is the blackout. Just look at the spectacular events of 2003, where Algeria has shared the same adventure with the Italians and Americans. America is very striking this phenomenon because it is repetitive and a database has been created in this way, and where several research works have exploited it. To this end, we wanted to use it to establish forecasting models. We have reported the events as an original time series plot in Fig. 7. We can see from this plot that there seems to be seasonal variation. So we need to introduce the differentiation of the series.

Both of ACF and PACF show a single spike at the first lag. An ARMA (1, 1) model is indicated. The analysis of the autocorrelation coefficients and the partial autocorrelation of the transformed series of Fig. 8, Fig. 9, Fig. 10 and Fig. 11 bring up a significant peak delay 1 for the autocorrelation peak and a significant delay 2 for the partial autocorrelation.

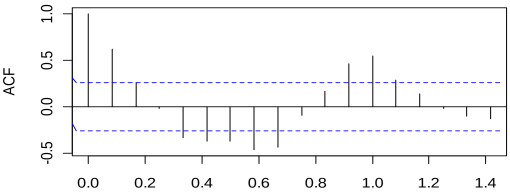

Figure 10. ACF of transformed series

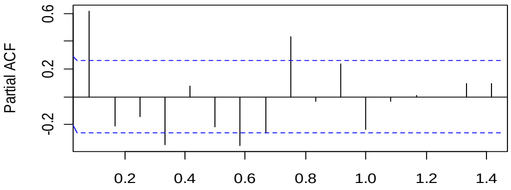

Figure 11. PACF of transformed series

Based on these results, we propose as a possible model SARIMA (1,0,1) $(1,1,2)_4$. The estimated model is given as follows.

$$Y_t = 0.9560Y_{t+1} + 0.8694Y_{t-6} - \varepsilon_t + 0.7638\varepsilon_{t-1} + 0.9999\varepsilon_{t-4}$$

The forecasting values are shown in the plot of the fig. 12, where the behavior of the future events seems to be constant, thanks to the integration of smart systems in the American power network.

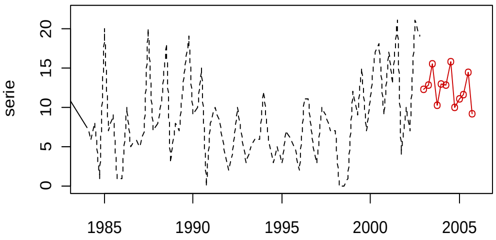

Figure 12. Result of forecasting

This country has a great advance in the development of ICT, and it is oriented towards the reliability issue and to mitigate these dreaded events.

III. CASCADE DEGRADATION PROCESSES MODELING

Power transmission networks are heterogeneous systems with a large number of components that interact with each other through various ways. When the limits are exceeded for a component, it triggers its protective device. Therefore, it becomes faulty in the sense that it becomes unavailable to transmit electrical energy. The component can also fail in the direction of misoperation or damage due to aging, or low maintenance. In any case, the power will be redistributed to other network components, according to the laws of the mesh nodes and electrical circuits, or by manual or automatic redistribution. This power will be added to the already existing power carried by these components. Therefore, their overload is inevitable if they are at their operating limits. So, this scenario leads to the propagation of failures through the network. This propagation can be local or it may be general, if the overload caused by the first degradation is very important. Any future deterioration comes to instantly change the configuration and operational parameters of the network. It makes the system unstable and the seat of transients very violating the majority of cases, such as the collapse of voltage and frequency and the loss of synchronism. Usually, the system can be pulled back to normal condition by its protection and control system. But, sometimes, the system cannot return to normal condition in good time and some new events can trigger the cascade incidents, which may interact and rapidly worsen the situation. Finally, blackout can happen. Then, every disturbance triggers a next one, and so on; the system will pass from state i to state $i-1$ due to gradual degradations or to state F due to random shock as given in Fig. 2.

Let us consider a repairable system connected to a load, where the system available capacity (SAC) and hourly system load (HSL) are shown in Fig. 13 [7].

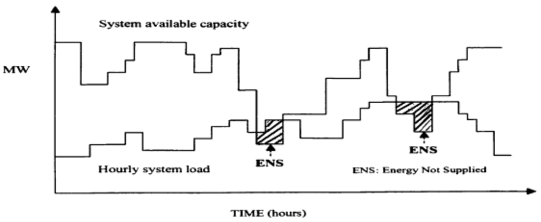

Figure 13. Superimposition of the system available capacity and the load model

The behavior of SAC curve shows that the generating system follows several states. These states can involve partial or total failure of a simple unit or of several units. The appearance of dips in the same curve reflects units' breakdowns and the resumption to the initial level of capacity indicates that repairs were made. The shaded area under the curve indicates the energy not supplied (ENS) and their corresponding time intervals denote durations where the consumption exceeded the production. They learn about the times when the expected production is actually not available in its entirety. If the study period is 24 hours, we will talk about the unavailability of the system for about 3 hours. Each decreasing in the SAC curve behavior corresponds to a degrading state, subsequently to a decreasing level of system reliability. Load points are linked to supply resources by electric lines that have their own physic characteristics. The increasing of demand implies: the increasing of the current transit, the decreasing of voltage level, the increasing of reactive power consumption and etc. After the activation of system defense (compensators), regarding physic characteristics of lines, when thresholds values are reached, the protections operate and isolate the line. If the studied system is in looped configuration (supposed more reliable and more flexible in faults conditions), there is a load transfer to another line which at its turn becomes loaded and the line opening's scenario is repeated leading to cascade degradation in the lines of the system. The final results become the loss of load. Another scenario is probable; it is the luck of coordination between the items in the system defense. The problem stay in the physics category and the system loading can deal to voltage and frequency collapses. The persistence of the phenomena during a lap's time causes generating units stopping or stall. These are scenarios of several blackouts. When a failure occurs in generating units, the standby units are connected and activated. If their contribution is insufficient, the supply becomes lower than the consumption. When the polar angle of the engine reaches a certain threshold, they drop and consequently we have loss of load independently on the reliability of the connection between the supply system and the load point.

A. Restoration Processes Modeling in the Case of a Conventional System

The network reconstruction after the blackout is modeled using Markov chain method as given in fig. 14 where the degradation states are inspired from Fig. 2.

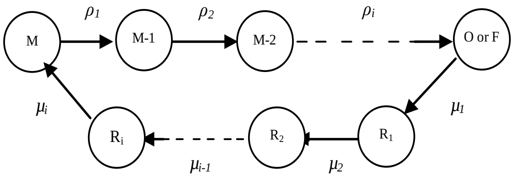

Figure 14. Transition state diagram: degradation tripping vs. restoration

Each state corresponds to a special structure of the network and to particular values of voltage and frequency. As it is not easy to master the occurrence of the blackout in the current state of the network, we have attempted to model the network restoration while suggesting the contribution of smart systems in the acceleration of the service restoration process. To this end, we have studied two cases occurred in year 2003, namely the Algerian and the Italian blackouts. A particular interest was paid to the following parameters, such as: the restoration rate, the partial power restored at each stage and finally the cumulative power restored at each stage. The Table II and Table III were filled following the stages of the fig. 14, where the Ri are the restoration states with i=6 for the Algerian case and i=5 for the Italian one. We defined the used parameters as: $\rho_i, i=1,n$ are degradation transition rates, and $\mu_i, i=1,m$ are restoration rates. In a general manner,

TABLE II. STATE RESTORATION IN CASE OF 2003 ALGERIAN BLACKOUT

States	0	1	2	3	4	5
$\mu(s^{-1})$	0.15e-4	5.0e-4	4.2e-4	2e-4	2.2e-4	2.7e-4
Power restored (%)	15	15	30	13.6	23.3	3.4
Total power restored (%)	15	30	60	73.3	96.6	100

TABLE III. NETWORK RESTORATION STATES IN CASE OF 2003 ITALIAN BLACKOUT

States	0	1	2	3	4
$\mu(s^{-1})$	4.0e-5	7.9e-5	6.9e-5	5.0e-5	6.0e-5
Power restored (%)	5	40	25	20	10
Total power restored (%)	5	45	70	90	100

We have observed inertia in the restoration processes of the networks but it is more apparent in the Algerian case. The first information about the results shows a lack of effective measures for a fast restoration. To highlight the attributes of smart systems integration regarding the three countries affected by the blackouts of 2003, we have developed a comparison presented in Table IV.

TABLE IV. PARAMETERS COMPARISON BETWEEN ALGERIAN, ITALIAN AND USA BLACKOUTS

	Algeria	Italy	USA
Power restored(GW)	5.003	27	61.8
Total restoration time(s)	15960	43200	104400

We deduce that the order of effectiveness is decreasing according to the classification as follows: USA, Italy and Algeria because the USA had firstly integrated the smart system in their conventional network to increase the reliability and the security of supply. The Italian network behavior is acceptable, however Algeria, can take this opportunity to learn from the two experiences.

The main objective of the restoration service is to minimize the number of customers faced with the interruption of power delivery by transferring them to support feeders via network reconfiguration, with respect to components operational constraints. The reaction time is a pertinent factor to take into account where disconnected areas should be restored as quickly as possible. This scenario could be considered in the case of the integration of smart grid.

B. *Restoration Processes Modelingin the Case of a Smarter System*

It will be better to simulate events which will occur in the case where smart systems are integrated in the power grid. Three scenarios are discussed in the following.

Scenario 01: the initiating event is the peak demand: The smart grid concept uses smart metering which is designed to manage consumption used at peak times by encouraging more off peak power by households and small businesses, therefore shifting the load. Most outage management system and distribution management system (OMS/DMS) analyze and optimize network performance and reactively determine outage locations. Smart grid algorithms that incorporate spatial analysis will be part of a decision support system that can help determining risk and potential customer impact and recommend preventive measures by integrating real-time weather monitoring system (WMS). Note that this scenario is similar to the 2003, USA blackout.

Scenario 02: the event has already happened due to a loss of a component: This scenario is similar to the Algerian blackout (2003). The loss of generator coupled to a period of peak demand lead to a cascading event and finishes to a blackout. Smart grid via sensors and intelligent devices could avoid this undesired event by:

Integrating more renewable energy power sources to the power transmission and distribution systems. They will relieve stress by adjusting automatically their operation. Then, smart grid could switch to solar and wind mode (or energy storage) to mitigate peaks demand.

-Deciding to shed appropriate system load, by temporarily switching off distribution of energy to different geographical area proportional to the severity of power system disturbance.

Scenario 03: the system is in a state O or F of figure 2: Smart grid coordinates units, loads, transmission system, and their associated characteristics to a fast restoration of power to consumer by establishing priorities. By using location intelligence capabilities, it quickly diagnoses outages and determine the location of a fault caused by physical damage of the transmission and distribution facilities due to weather by measuring the optical distance along the fiber.

IV. CONCLUSION AND DISCUSSIONS

In a grid, even if the transportation and distribution parts are highly reliable, if the production units fail, the whole system collapses. When the load demand exceeds the production capacity, there is loss of load. To determine its proportion of time, we use loss of load probability model. A smarter power grid could be the solution to these woes. This new technologies 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 and select the consumer prior to relieve via power lines concept. This new technologies and concepts can significantly reduce barriers to the integration of renewable resources. It aims to build smart renewable-energy generation using micro-grids to enable houses, buildings, and villages to be energy self-sufficient. In the literature, it gave us to see the lack of research works in stochastic modeling of the occurrence of blackouts. To highlight our competence in the forecast, we introduced other opportunities of modeling using the concept of Box and Jenkins. We were able to prove the dominance of ARMA models in the field of energy distribution. Also in this context, the integration of smart system into the conventional one can help to exploit the weather forecasts to predict changes in consumer demand and anticipate on the main technical and organization measures. As it is necessary to consider the decentralization of the production units and encourage maintenance actions on the clean energy production units considered obsolete. Another aspect that is relevant is the provision of emergency sources of energy by the distributor and not by the customer. It was demonstrated that this decision contribute to avoid moral prejudice often felt by the customer and the financial one often sustained and supported par the distributor of the energy.

Finally, the studies done on individual cases can be generalized to all entities throughout the national territory.

REFERENCES

[1] F. Iberraken, R. Medjoudj, and D. Aissani, "Power system reliability modeling and decision making for quality of service improvement under smart system integration and renewable resources insertion," in *Proc. International Workshop Performance Evaluation and Quality of Service*, Bejaia, 2013, pp. 251-255.

[2] D. L. Ha, S. Ploix, E. Zamai, and M. Jacomino, "Prévention des blackouts grâce au système de gestion d'énergie intelligent du bâtiment," *INP Grenoble, UJF, CNRS*, 2005.

[3] B. A. Carreras, D. E. Newman, I. Dobson, and A. B. Poole, "Evidence for self-organized criticality in electric power system blackouts," in *Proc. Hawaii International Conference on System Sciences*, January 2001.

[4] T. J. Overbye and D. A. Wiegmann, "Reducing the risk of major blackouts through improved power system visualization," in *Proc. 15th PSCC*, Liege 2005, pp. 22-26.

[5] IEEE PES CAMS Task Force on Understanding, Prediction, Mitigation and Restoration of Cascading Failures; IEEE power engineering society general meeting, Pittsburgh PA, USA, July 2008.

[6] G. E. P. Box and G. M. Jenkins, *Time Series Analysis: Forecasting and Control*, Rev. ed. San Francisco: Holden-Day, 1976.

[7] J. D. Kuech, B. J. Kirby, P. N. Overholt, and L. C. Markel, *Measurement Practices for Reliability and Power Quality*, U.S Department of energy, ORNL/TM, 2004.

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