

Decision Making Method Based on Fuzzy Logic for Powering Sensitive Sites in Case of Electric Failures

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ABSTRACT: The electrical network is part of larger systems designed by man. The legitimacy of the distributor of such a network as a dealer depends heavily on its ability to minimize recovery time in case of failure on the network and to control problems of service quality perceived by users. Despite such a system is considered as stable and reliable, it is not immune to the daily disturbances (cuts, power surges, harmonics, voltage drops ...).

The frequency of these failures and their direct impact on consumer satisfaction show the need for better post-incident management. And in particular, the implementation of an interim solution for powering sensitive sites pending final restored.

In this work, we propose a method for decision-making based on fuzzy logic, a tool that will allow operators to optimize their emergency rules face unplanned outages. These rules were obtained in cooperation with working group of experts in electrical distribution. They are fruit of human experience.

KEYWORDS: Fuzzy logic, Distribution network, Fault on a power grid, Temporary power, Sensitive sites.

I. INTRODUCTION

Since 1965, numerous power outages (or "blackout") marked the world. The number of people affected varies from a few hundred thousand to millions of people. The biggest failure in the history of the number of individuals involved is the one that struck India in 2012 [7].

Power failures are particularly critical at sites where the environment and public safety are at risk. Institutions such as hospitals, sewage treatment plants, mines, and the like will usually have backup power sources such as standby generators, which will automatically start up when electrical power is lost [8].

Interrupt management on the electricity distribution network is made by a dispatching room attached to the company responsible for the distribution. The goal is to identify in real time the system disturbances and execute the maneuvers needed to restore service promptly; including the precise fault location and isolation for repair. For an efficient distributor these operations take less than 15 minutes for 75% of customers cut off [1]. In some cases, the recovery time can be up to 4 hours; or even more. During this period the operator may decide to temporarily power sensitive customers by generators. This decision was taken after consulting experts in different farms.

In this paper, fuzzy logic is introduced to take account of the weaknesses displayed by the existing decision tools in terms of their responsiveness in an imprecise environment and the variables are not homogeneous. Specifically, with fuzzy logic we are able to obtain a single value (output) from the imprecise data (input).

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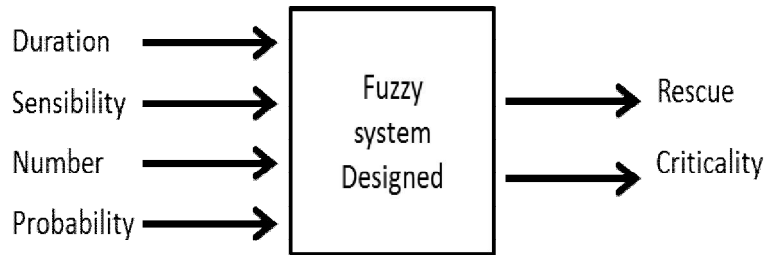


Fig.1. General diagram of the system.

This paper proposes the application of fuzzy logic to evaluate the level of emergency to be given to sensitive customer after a service interruption. This emergency level is combined with the probability of occurrence of the switching incident, to evaluate its criticality.

This paper is organized as follows: section II, gives a description of a proposed system based on fuzzy logic. Section III presents the simulation on Matlab of the system. And the conclusions are given in section IV.

II. SYSTEM DESCRIPTION

The proposed model is divided on two parties that are based on Mamdani fuzzy inference [2] [3] [4]. The first bloc uses as input variables: the duration of the interruption, the customers' sensitivity and the number of clients to restore. The output is the net value of the emergency level.

This variable is re-injected in the next block as input variables; which is matched with probability of occurrence in order to get a level of criticality [6]. It allows us to determine the severity level of interruption, if it is acceptable or not, in order to better control risks and manage priorities. Once complete analysis, we will have all the information necessary to decide the type of rescue to be made.

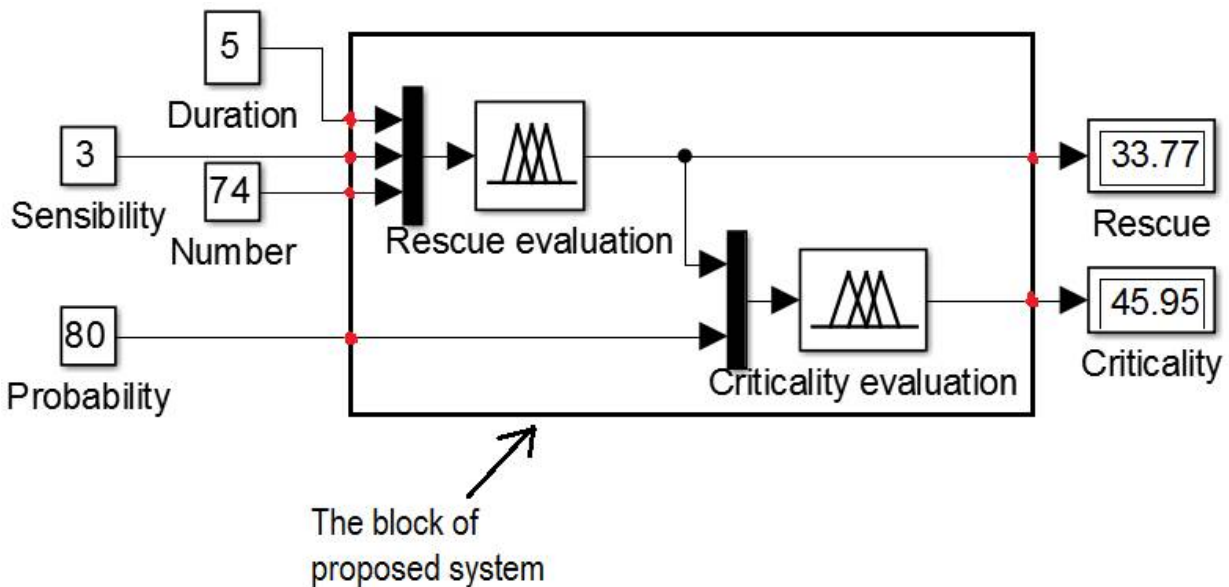


Fig.2. Detailed diagram of the system.

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III. INPUT AND OUTPUT VARIABLES

A) Rescuevaluation

We use as input variables: The sensitive customers, the number of clients to restore and duration of the interruption. The output is the net value of the emergency level.

a. Input variable interrupt duration

As shown in Figure 4, in the proposed model, the variable duration is divided into 3 levels: short (short <4 h), the long-term (2 h <Long <8 hours) and very long (very long > 6 h).

These levels are given here as an indication. But it is quite possible to imagine a different process that aims to estimate these periods in function of other variables; such as SAIFI and SAIDI indicators, the cause of the failure, the nature of the failure, duration of response and repairs, etc.

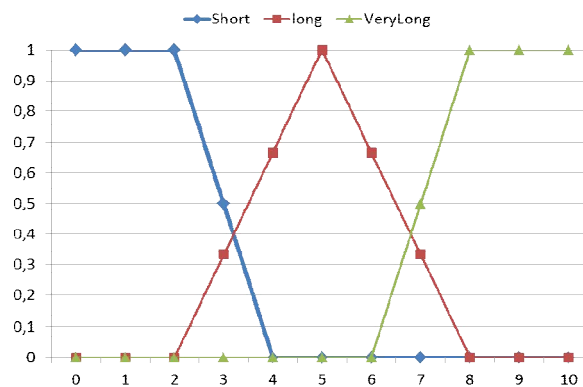


Figure 4: Membership function of the input variable failure duration

b. Customer input variable sensitivity

As shown in Figure 5, in the proposed model the input variable sensitivity is divided into 5 levels [5]: Normal, Sensitive (hospital, school), Large (office building), Critical (water tank) and Strategic (Royal Palace).

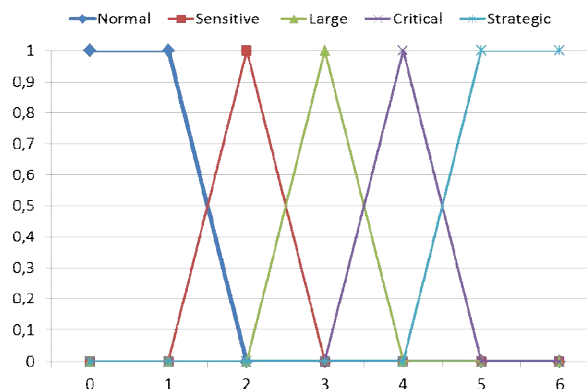


Figure 5: Membership function of the input variable customer sensitivity

NB: These levels are given here as an indication. But it is quite possible to imagine a different process which aims to estimate these levels depending on other variables; such as customer segments, contract requirements, etc.

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c. Input variable number of customers cut off

As shown in Figure 6, in the proposed model, the input variable number of customers cut is divided into 3 levels: low (<100 customers), small (50 to 200) and high (> 150).

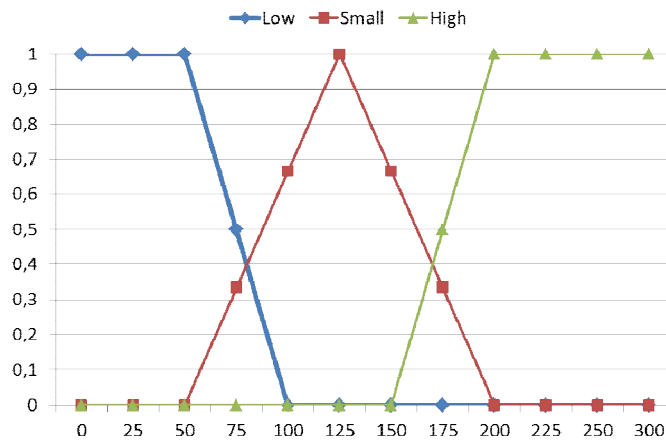


Figure 6: Membership function of the variable number of customers cut off

d. Output variable rescue level

As shown in Figure 7, in the proposed model, the output variable "rescue level" is divided into 5 levels on a scale of 10: Rescue unnecessary (NON <3), local rescue by means of the Direction (1 <Local <5) strengthening by the neighboring Direction (3 < neighbor <7), strengthening by other Directions (5 < other <9) and the crisis level (7 < crisis) when the means of all departments are no longer sufficient; and must be called possibly outsourcing to strengthen.

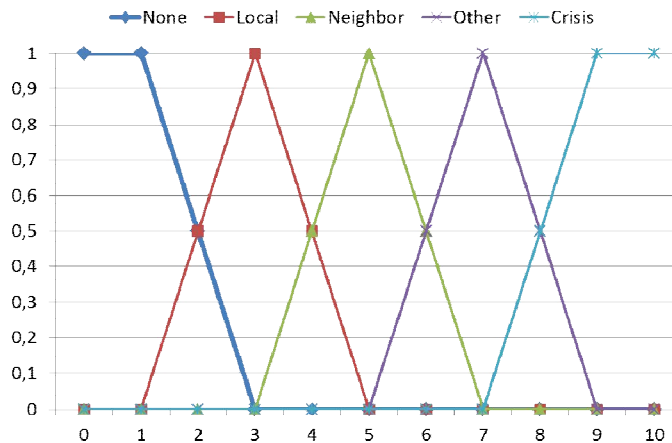


Figure 7: Membership function of the output variable rescue

B) Criticality evaluation

We use as input variables: The probability of occurrence and the rescue level. The output is the net value of the criticality.

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a. Input variable probability

As shown in Figure 9, in the proposed model the input variable probability is divided into 5 levels [5]: Rare (when value is under 25%), Occasional (when it's between 0% and 50%), Medium (when it's between 25% and 75%), High (when it's between 50% and 100%) and Continuous (when > 75%).

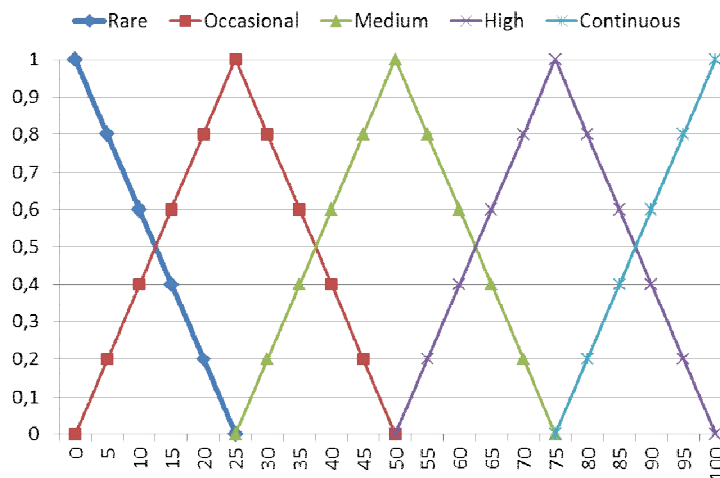


Figure 9: Membership function of the input variable probability

b. Output variable criticality

As shown in Figure 10, in the proposed model the input variable criticality is divided into 4 levels [5]: Acceptable (when value is under 33%), Possible (when it's between 0% and 67%), Moderate (when it's between 33% and 67%) and Unacceptable (when > 67%).

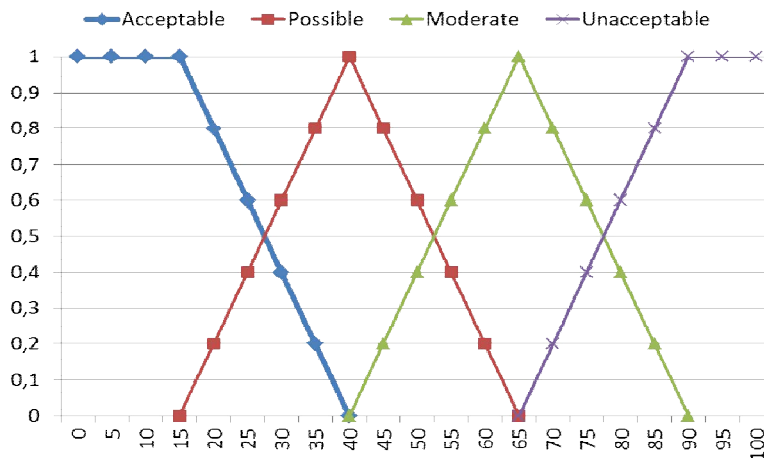


Figure 10: Membership function of the output variable criticality

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IV. THE FUZZY INFERENCE

The fuzzy inference is a system that uses fuzzy logic to map input to output variables. The fuzzy rules are gained by doing interviews with experts and operators in different plantations. As it can be seen in Table 1; three input variables gives a maximum of $(5 * 3 * 3) = 45$ rules for the inference system.

In table 2, we can see that two input variables give $(5*5) = 25$ rules for the inference system.

Tableau 1: Fuzzy rules for rescue evaluation

| Duration of intrruption | Number of customers cut off | Sensibility of customers is | | | | |
|-------------------------|-----------------------------|-----------------------------|-----------|----------|----------|-----------|
| | | Normal | Sensitive | Large | Critical | Strategic |
| Short | Low | Non | Non | Non | Non | Non |
| | Small | Non | Non | Non | Non | Non |
| | High | Non | Non | Non | Non | Non |
| Long | Low | Non | Local | Local | Local | Local |
| | Small | Non | Local | Neighbor | Neighbor | Neighbor |
| | High | Non | Local | Other | Other | Other |
| Very Long | Low | Local | Neighbor | Other | Crisis | Crisis |
| | Small | Other | Other | Crisis | Crisis | Crisis |
| | High | Crisis | Crisis | Crisis | Crisis | Crisis |

Tableau 2: Fuzzy rules for criticality evaluation

| Probability of occurrence | Level of rescue | | | | |
|---------------------------|-----------------|------------|------------|--------------|--------------|
| | None | Local | Neighbor | Other | Crisis |
| Continuous | Acceptable | Possible | Moderate | Unacceptable | Unacceptable |
| High | Acceptable | Possible | Moderate | Unacceptable | Unacceptable |
| Medium | Acceptable | Possible | Moderate | Moderate | Moderate |
| Occasional | Acceptable | Acceptable | Possible | Possible | Possible |
| Rare | Acceptable | Acceptable | Acceptable | Acceptable | Possible |

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V. SIMULATION ON MATLAB

The type of the proposed model is based on Mamdani fuzzy inference [2] [3] [4]. The method used to transform the fuzzy outputs from the systems to crisp values (defuzzification) is the center of gravity (COG).

As example, it is shown in Figure 11, for input values (duration outage = 5h; customer sensitivity level of cut = 3; number of customers cut = 74); a single value of 33.8, is obtained for the output variable “level of rescue”.



Figure 11: output variable rescue

And, as shown in figure 12, with input value probability = 80, we obtained 49.5 for the output variable criticality.

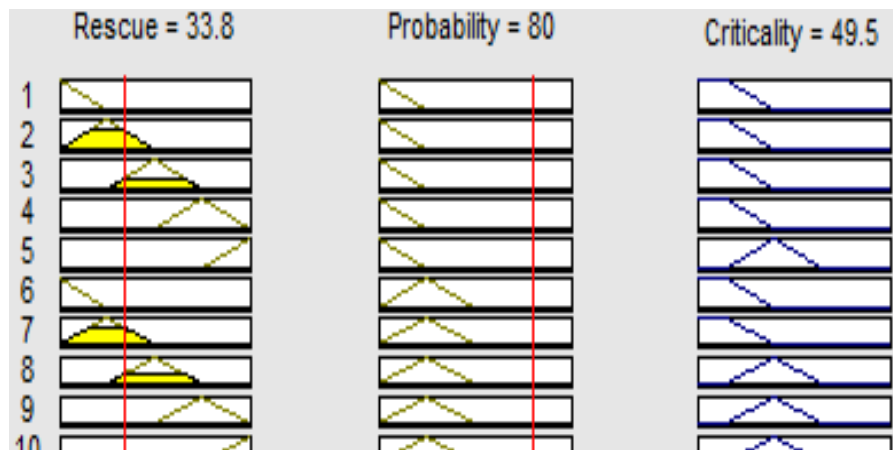


Figure 12: output variable criticality

NB: Reducing criticality can be improved by reducing the number of faults (SAIFI measurement) and reducing the repair time (SAIDI measurement) by means of various design and maintenance strategies [7].

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VI. CONCLUSION

Fuzzy logic has been introduced in various technical fields of electrical distribution, whether for decision making and automating the operation of a power device. However, the use of this method for improving the quality of service and in particular to reflect the customer's relief level is original.

Using fuzzy logic allows to formally model the aggregates needed for decision making in a possibilistic field and allows to integrate the non-palpable character of the desire to provide better service to customers. It is then to find compromises guaranteeing a possibility of more accurate decision.

On perspective we can try to experiment the presented approach. The implementation of this method to real cases of power outages will compare the different assumptions expressed.

REFERENCES

- [1] Lydec company, "Annual activity report 2010"
- [2] F. Deroncourt, "introduction to fuzzy logic"
- [3] Schneider Electric. Cahier Technique ECT 191 "Fuzzylogic"
- [4] Saric, M. (2014, November). "Fuzzy approach for evaluating risk of service interruption used as criteria in Electricity Distribution Network Planning". In Neural Network Applications in Electrical Engineering (NEUREL), 2014 12th Symposium on (pp. 79-84). IEEE.
- [5] The Union of Quebec Municipalities, the Quebec Federation of Municipalities and Hydro-Québec, "Planning of civil protection at the municipal level". Power Outages.
- [6] Criticality index from Wikipedia. https://en.wikipedia.org/wiki/Criticality_index.
- [7] Important Power outages from Wikipedia. https://fr.wikipedia.org/wiki/Liste_des_pannes_de_courant_importantes.
- [8] Power outage from Wikipedia. https://en.wikipedia.org/wiki/Power_outage.