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A Systematic Literature Review of Electricity Distribution in Smart Grid Scenarios

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Abstract

This paper aims to survey the main contributions related to the application of intelligent solutions in the process of electricity distribution. Through a systematic literature review, a comparative analysis of the most relevant work on the target topic is performed considering the application of Smart Grid principles. The methodology adopted in the literature review and the main results are presented by means of a six group categorization, namely: communication in electrical structures, computational modeling, load control, microgrids, energy storage, and economic viability.

1. INTRODUCTION

➤ Expansion of electricity generation carried out by the inclusion of sustainable sources (photovoltaic, wind, biogas, among others) through Distributed Generation (DG).

➤ As an alternative to dealing with this challenge, it is increasingly noticeable the inclusion of innovative communication and information technology solutions generating what is known as the Smart Grid (SG).

➤ One of the main goals in SG is to converge technologies for the control and balancing of grids with DG. As a result, optimizing the distribution and use of smart grids will increase the efficiency of electrical systems.

➤ More efficient distribution of electricity will no longer require excessive use of resources, optimizing those already employed.
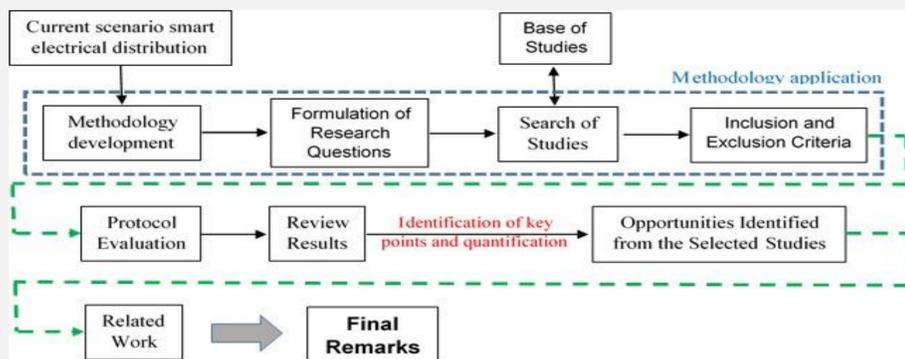
2. METHODOLOGY

Fig. 1. General flowchart of the methodology.

➤ Formulation of Research Questions:
   # RQ1: What SG-based methods/tools/techniques are used to improve electricity distribution?
   # RQ2: What is the scope of each selected study in relation to:
      i) Distributed generation;
      ii) Scalability of the solution;
      iii) Self-healing mechanisms; and
      iv) Solution validation.

➤ Automated searches were performed in the following scientific bases: CAPES CAFe, Google Scholar, IEEE Xplore e SciELO, which are common sources used for systematic reviews in engineering areas and offer reasonable confidence to cover relevant publications.

➤ The searches were performed using the following search string considering the papers' titles and abstracts (* stands for the wild card):
   # ("electrical energy" OR "power grid*") AND "distribution" AND "smart grid*"

Table I. - Paper Selection Stages

Stage 1	Apply the query to all sources and get the results
Stage 2	Remove duplicates and invalid results
Stage 3	Apply inclusion/exclusion criteria to papers titles
Stage 4	Apply inclusion/exclusion criteria to abstracts and conclusions
Stage 5	When necessary, apply inclusion/exclusion criteria to the whole text

3. RESULTS

➤ By applying the inclusion/exclusion criteria to the 30 papers selected from each source in March 2019 was obtained a total of 18 papers.

➤ Table II presents the number of papers returned in each data source, as well as the number of selected papers. It can be seen that by applying the proposed methodology the CAPES CAFe base offers a higher level of accuracy of results.

Source	Total	Filtered	Selected	Precision (%)
CAPES CAFe	705	30	7	38.9
Google Scholar	275	30	5	27.8
IEEE Xplore	519	30	6	33.3
Scielo	1	1	0	0

➤ The year of publication of the selected papers was analyzed. The result is shown in Figure 1. As can be seen, the publications were concentrated between 2011 and 2017, with the growth of published papers from 2012 to 2014.

➤ Regarding the publication vehicle, 66.7% of the papers were published in event proceedings, and the others were published in journals.
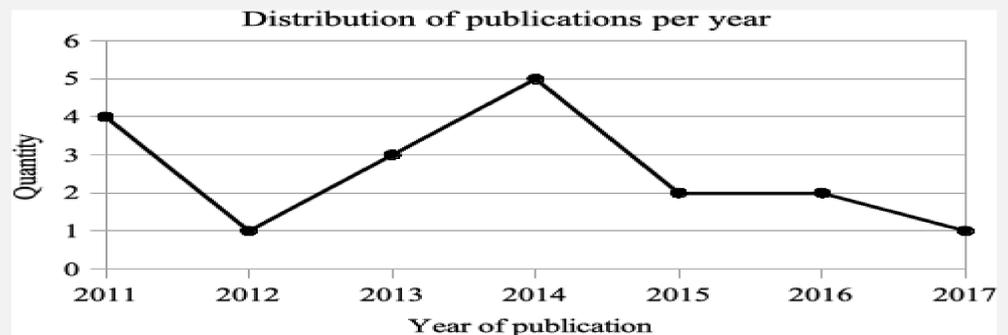

Fig. 2. Validation of the random variable ethanol production.

➤ As a way to answer RQ1 and RQ2, the selected papers were divided into categories, taking into account their main theme.

➤ Table III presents the identified themes, as well as the distribution of the selected work. A discussion of the studies based on this classification is presented following.

Table III. - Distribution of Studies per Focus

Category	Quantity	%
Communication in electrical structure	4	22.22%
Computational modeling	4	22.22%
Load control	4	22.22%
Microgrid	3	16.67%
Energy storage	1	5.56%
Economic viability	2	11.11%
Total	18	

4. OPPORTUNITIES IDENTIFIED FROM THE SELECTED STUDIES

➤ Through the analysis of the selected studies, it was possible to extract some limitations and gaps that constitute opportunities to be explored in future research. These limitations are related to meeting demand, generation from renewable sources, storage and distributed generation.

➤ Regarding computational structures, the specifications of the structure required for the implementation of systems for the development, analysis, and monitoring of electrical systems are not described.

➤ More than 65% of the selected studies use empirical research, which is not surprising since smart grid distribution efforts require a high level of analysis prior to implementation in real-world scenarios.

5. RELATED WORK

➤ As in this paper, there are other systematic literature reviews related to the distribution of energy in SM. Discuss relevant research in smart grid analysis for rural service companies.

➤ In general, related work addresses revisions with a smaller scope than proposed in this work. In this paper, the theme was discussed in a more general and comprehensive way, seeking results that include small and large electrical structures.

6. FINAL REMARKS

➤ This paper has presented the results of the application of a systematic literature review seeking to analyze the main contributions related to energy distribution using SG concepts.

➤ Currently, the methods used to improve the distribution of electricity are related to the application of SG in order to meet the particularities of each case. The main bottlenecks for these applications are related to the economic viability, connectivity, and suitability of existent structures.

➤ With regard to self-healing mechanisms, technologies are already in operation. What still limits the progress of this application is the connectivity requirements of electrical systems for the performance of SG. Another important result is that we note that there are few contributions focused on the Brazilian scenario.

➤ It is possible to observe that there is a growing trend in the number of papers published in the last five years and that because it is a still-emerging topic some significant works may have been eliminated by applying the sorting by relevance.

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