UDC 621.311

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# TOPOLOGICAL APPROACH TO ANALYSIS OF ELECTRICITY MARKET DESIGN

**Introduction.** In the systems theory, a topological approach is widely used as a research method to analyze the elements and their interconnections in complex systems. This approach is also a part of mathematical modeling in investigating the functioning of electric power systems. Regarding the analysis of electricity market models, this approach was applied in [1-3]. Due to the proven capabilities of the method to study specific properties, processes, and phenomena in the energy sector, it has been chosen to analyze Senegal's electricity market design. As Senegal is a developing country, electricity consumption is low but a strong tendency towards increasing electricity demand is observed in recent years caused by economic and demographic growth. However, there is a disparity in access to electricity grids between different types of consumers, for example, this access is difficult or absent for consumers in the rural and remote areas. For small communities connected to grids, the most typical problems are outages and recurring electricity shortages. Senegal's electricity industry still faces a set of challenges including power stations rehabilitations, upgrading the electricity infrastructure and electricity source diversification [4-5]. The growing electricity demand and developing renewable energy need a more competitive environment and liberalization of the electricity market in Senegal.

**The purpose of the research** is to define electricity market design by using a topological approach for analyzing the composition and structure of the electricity sector on Senegal's example that will contribute to designing a more competitive electricity market environment.

**Results and discussion.** To achieve the purpose of research, the topology of the infrastructure of the electricity market has been considered through the construction of directed structural graphs for market system components. According to [2-3], the infrastructure system consists of the technological system, including the technical and production system, and the commercial system, including the trade and contract system. The electric power system of Senegal is divided on one regional system with the transmission and distribution network and six local non-connected electric power systems with their own distribution networks. The graphs (Fig. 1, a, b) reflect the structure of the regional and local technical system including different types of physical assets and their interconnections. Further, there will be only considered the regional system in the research.

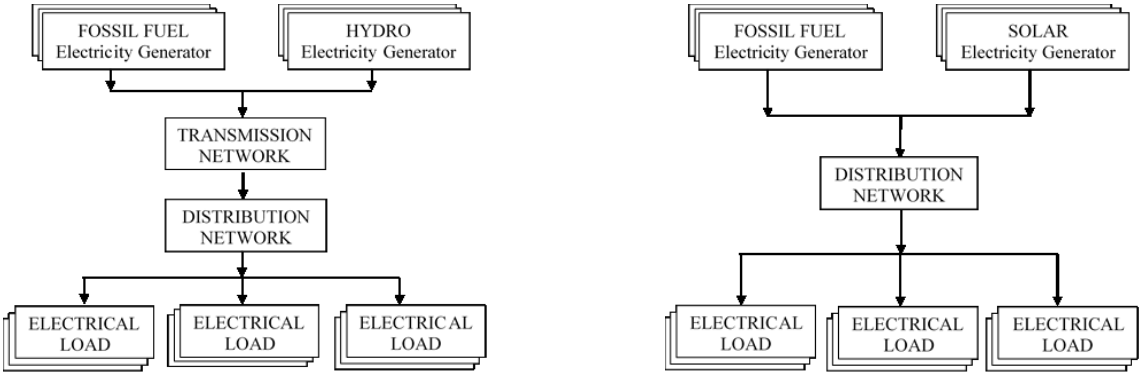


Figure 1 – Directed structural graphs of the regional technical system (a) and the local technical system (b)

The owners of physical assets of the regional technical system are presented in the directed structural graph of the production system of the electricity market (Fig.2, a). SENELEC is the vertically integrated state-owned enterprise. This is a multiproduct company that generates, transmits and distributes electricity. This enterprise is also the operator of transmission and distribution systems. Other electricity producing companies presented in the graph have various forms of ownership and management. The directed structural graph of the commercial system of the electricity market is given in Fig. 2, b. The graph shows that the electricity generation is subject to competition and all the electricity must be sold to SENELEC. This enterprise holds a tender at the electricity auction, where obtains supply offers from primary sellers. After conducted tender SENELEC signs contracts for the purchase of electricity. As a result, this enterprise has respectively a monopsony on the purchase of wholesale electricity and a monopoly on the sale of retail electricity. All final buyers have no right to choose an electricity supplier. SENELEC is also the operator of wholesale and retail markets.

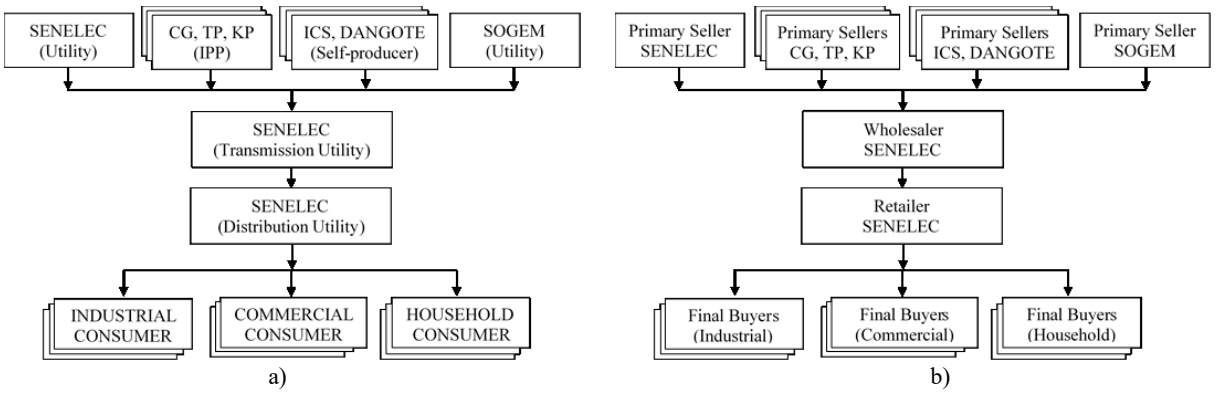


Figure 2 – Directed structural graphs of the production system (a) and the commercial system (b): IPP - independent power producer; CG – Contour Global; TP - Tobene Power; KP - Kounoune Power; ICS - chemical industry; DANGOTE - cement industry

Comparative analysis of the constructed graphs of the technical, production and commercial systems has shown the similarity of their topological structures, which is the attribute of the wholesale monopsony model. Considering that SENELEC is a single buyer that has delegated rights to buy and sell electricity, the electricity market in Senegal operates as the purchasing agency, which is a version of the wholesale monopsony model. Since SENELEC is a vertically integrated company, this model is also an integrated version of the wholesale monopsony model.

**Conclusions.** Due to the applied topological approach, the structural graphs of technical, production and commercial systems of the electricity market in Senegal were constructed. The comparative analysis of their structural graphs has shown the electricity market design in Senegal corresponds to the wholesale monopsony model, in particular, the integrated version of the purchasing agency. This type of design has sufficient background to develop a more competitive market environment by dividing the SENELEC into three specialized electricity companies for generating, transmitting and distributing electricity, increasing the number of electricity producers and implementing the electricity pool as a version of the existing model.

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