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Strategies for regional integration of electricity supply in West Africa

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Abstract

To improve peoples' living conditions in West African countries national governments have to considerably reinforce the electricity supply infrastructures. Rehabilitation of the existing installations and construction of new power generation facilities and transmission lines require substantial resources which are tremendously difficult to raise due to the region's specific economical and political conditions. This paper examines the long-term prospects for integrated development of the regional electricity industry and evaluates its advantages by using PLANELEC-Pro, a "bottom-up" electricity system expansion planning optimisation model. The evolution of regional electricity market is analysed on the basis of two strategies. The "autarkical" strategy consists in adequate expansion of national power generation systems and the exchanges of electricity between the countries in sub-zones. Another approach referred to as "integration" strategy is recommended in this article. It leads to fast retirement of the obsolete power plants and the integration of new investment projects at the level of whole West African sub-region. The main finding is that the regional integration strategy is capable to bring about additional benefits in terms of reduced capital expenditures, lower electricity supply cost and the enhanced system's reliability compared to the autarkical strategy.

Keywords: West Africa; Electricity market; Regional integration

1. Introduction

For several decades, the majority of West African countries have suffered from the electricity shortages, which constitute a serious handicap for their socio-economic development. The situation has been worsened during the last years due to several reasons: obsolescence of the electricity generation and transmission infrastructures, unfavourable hydrological conditions and difficulties to attract the investments for construction of new facilities required to satisfy the increasing energy demand. Under the pressure of donors, the reforms in electricity industry have been gradually undertaken in the region. The principal characteristic of the reforms consists in privatisation of public electricity companies. The goal is to raise the necessary funding from private sector investors. Recently, a regional strategy has been promoted seeking to reinforce the undergoing reforms, to exploit new primary energy resources and to improve the electricity supply security. However, the dominant vision is largely influenced by the historical models of regional interconnection, whereas the emphasis should be put on a wider and longer-term prospect. Thus, the objective of this paper is to contribute to a new strategic reflection on the nature and direction of the reforms in electricity industry in West Africa.

The advantages of regionally integrated energy sector development have been highlighted in several international studies and political initiatives. So, the report of World Energy Council identified four major benefits, such as: improved security of supply, better economic efficiency, enhanced environmental quality and facilitation of renewable energy projects (WEC, 2005). According to Hammons (2006) the joint operation of electric power systems in Africa can improve significantly their economical, ecological and technological efficiencies due to system effects, scale economies and massive exploitation of previously untapped hydropower resources. Srivastava et al. (2003)

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analysed the utility planning as well as environmental and economic effects of integrated power sector development at the national level in India. It was shown that integrated development and operation of the power system could reduce the total cost, total capacity additions, atmospheric pollution and improve the overall system reliability. The increased interdependence resulting from energy sector integration can be also seen as a factor contributing to the enhancement of regional peace and stability.

To promote regional integration via energy trading and the investments in least-cost electricity generation options regional power pooling agreements have been concluded in Africa (Davidson, 2005). Southern African Power Pool (SAPP) provides the most advanced example of such initiative which embarks nowadays on the creation of a competitive regional electricity market (Sparrow et al., 1999; Musaba, 2005). The study of Bowen et al. (1999) using linear programming model demonstrated that the benefits from centralized and competitive dispatch in SAPP could reach US$ 100 million per year compared to the existing bilateral electricity trade agreements. These benefits emanate primarily from the increased use of hydropower under integrated operation conditions. Another study on SAPP compared the costs of integrated regional development with those of the independent development, where each country follows a strategy of self-sufficiency. It showed savings of US$ 785 million, or 20%, over 1995–2010 (O'Leary et al., 1998). In a recent study of Graeber et al. (2005) the benefits from optimisation of regional generation and transmission expansion planning within SAPP are estimated at US$ 2.2 billion over 20 years (2000–2020).

Following the establishment of Southern African Power Pool, a similar initiative was launched by 14 countries of the Economic Community of West African States (ECOWAS) [1] with the cooperation of US Agency for International Development and the methodological support of Purdue University (Plunkett, 2004). It aims at coordinating the electricity generation and transmission in the sub-region (Fig. 1). Although the future market structure has not yet been clearly specified, it appears that the pool will be limited to the electricity exchanges among the member states based primarily on long-term contracts and allocation of the surplus electricity production. An independent regulation authority will be established to supervise the implementation of these exchanges (Manley, 2002).

To simulate the effects of regional pooling and cross-boarder electricity trade within West African sub-region, the study group of Purdue University developed a least-cost optimisation model which minimises the discounted total cost of the power generation system while satisfying

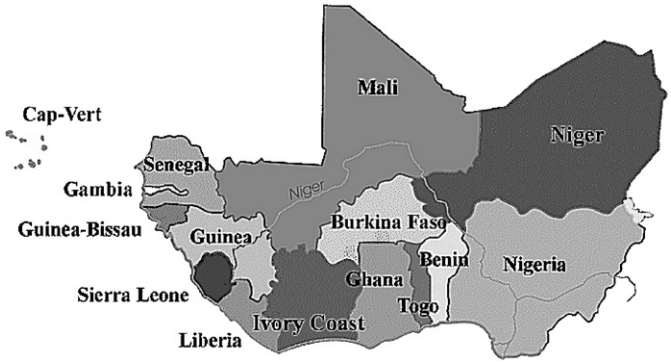

Fig. 1. Countries of West Africa sub-region.

each country's electricity demand (Sparrow et al., 2000). An energy autonomy factor (ENAF), i.e. the minimum percentage to be generated from own capacity, is defined for each country. The remainder of energy is traded within the sub-region. In this deterministic model a preset reserve is added to each type of power plant (19% for thermal power plants and 10% for hydropower plants). The results of this study show that during the study period 2001–2020 the regional electricity trade, with nevertheless a self-sufficiency of at least 50% per country, allows a 27% reduction of the total costs compared to the autonomous development strategy (Sparrow et al., 2001). Another interesting finding is that in the case of regional trade strategy the share of transmission grid adaptation costs accounts only for 3% of the total system cost.

Another study limited to the member states of UEMOA[2] was carried out by the researchers of the University of Quebec using the same methodology as that of Purdue University. This study compared two strategies: the first one consists in maintaining the transmission capacities at their current level, and the other one postulates unlimited interconnection capacities among the countries. The study indicated a reduction of the objective function between 48% and 54% according to different electricity demand scenarios, showing a net benefit from the strategy of reinforced regional trade (Salifou and Lafrance, 2002). These results obtained with a deterministic linear programming model demonstrate the advantage of complete regional interconnection in the sub-region.

This paper proposes a model of electricity sector restructuring, which allows for integrated development of the electricity supply industry at regional level in West Africa. Two strategies are compared. The first strategy is based on adequate expansion of the national power systems and the electricity exchanges among the countries in sub-zones. It aims at optimising the management of national electricity generation systems. The second strategy, recommended in this article, leads to a fast retirement of obsolete power plants and integration of electricity

[1] The Economic Community of West African States (ECOWAS) consists the following countries: Benin, Burkina Faso, Cap-Vert, Ivory Coast, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. The research of Purdue University did not consider Cap-Vert but took into account Mauritania, previous member of ECOWAS.

[2] Members of the "Economic and Monetary Union of Western Africa" (UEMOA): Benin, Burkina Faso, Ivory Coast, Guinea-Bissau, Mali, Niger, Senegal and Togo.