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The importance of nuclear energy for the expansion of Brazil's electricity grid

Ricardo Luis Pereira dos Santos *, Luiz Pinguelli Rosa, Maurício Cardoso Arouca, Alan Emanuel Duailibe Ribeiro

Energy Planning Program, Federal University of Rio de Janeiro, RJ, Brazil

HIGHLIGHTS

- The expansion of the power capacity is essential to support the economic growth.
- The increase through hydropower cannot benefit from storage reservoirs.
- It will be necessary to increase the capacity thermal power.
- Nuclear power has significant comparative advantages in Brazil.
- Brazil has institutional base, uranium reserves and nuclear technology.

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ABSTRACT

This article analyzes the thermal energy options available in the country to support the expansion of Brazil's electricity grid capacity. The country's electricity mix consists primarily of renewable sources of energy and this configuration will be maintained throughout the 21st century. However, grid expansion can no longer benefit from hydroelectric power plants with large reservoirs leading to a greater participation of thermal power plants. Among the thermal sources available in the country, nuclear power has important comparative advantages. Recognizing these benefits, the Brazilian government has established that expanding electricity grid capacity will amount to up to 8000 MW through nuclear energy by 2030.

The use of nuclear technology for electricity generation has historically been a controversial issue worldwide and some countries have decided to review their nuclear programs in the aftermath of the 2011 Fukushima nuclear accident.

This article shows that increasing the participation of nuclear energy in Brazil's electricity grid will provide important benefits for the country by ensuring energy security, keeping Brazil's electricity mix as one of the cleanest in the world, securing electricity grid reliability and safety and reducing operating costs.

1. Introduction

This article aims to show the importance of nuclear energy as a base load[1] component for the expansion of Brazil's electricity grid. Brazil's 2030 National Energy Plan (PNE 2030)[2] has already made this issue a top priority and established that electricity grid expansion will be up to 8000 MW through nuclear energy. The use of nuclear technology for electricity generation has historically been a controversial issue with many opposing opinions. For instance, a study (Carvalho and Sauer, 2009) concluded that nuclear energy is not a priority for Brazil's electricity grid. However, this study focused mainly on cost while omitting other important factors.

Important drivers that need to be evaluated during the decision-making process by Brazil's Energy Planning Office include:

- effective participation of each energy source,
- environmental issues associated with greenhouse gas emissions,
- projections of electricity costs,

* Corresponding author. Tel.: +55 2125628761; fax: +55 2125628777.
E-mail addresses: ricardolpsantos@hotmail.com (R.L.P.d. Santos), lpr@adc.coppe.ufrj.br (L.P. Rosa), arouca@ppe.ufrj.br (M.C. Arouca), aedr@ppe.ufrj.br (A.E.D. Ribeiro).

[1] Base Load: Energy that can be used during the whole day, during the supplying period. Source: CCEE Glossary – Câmara de Comercialização de Energia Elétrica. ⟨http://www.ccee.org.br⟩.

[2] MME – Plano Nacional de Energia – PNE 2030.

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- operational challenges of the National Interconnected System (SIN)[3] due to lower regularization capacity[4] of hydroelectric power plants,
- energy security.

Although Brazil is the world's 6th largest economy in terms of nominal GDP, the country suffers deep social and regional inequalities. Expanding electricity grid capacity will provide conditions for sustainable economic growth by supporting social development and improving the quality of life.

Brazil's electricity consumption per capita per year was 2489 kWh/inhabitant[5] in 2011, which is lower than the global average and lower than that of Argentina and Chile. Consistent with the need to boost installed power capacity and provide universal access to electricity, Brazil's Ten-year Energy Expansion Plan (PDE 2020) aims to increase annual electricity consumption per capita by 2020 to a level of consumption found in Portugal.

Brazil's electricity mix has one of the world's highest concentration of renewable sources of energy. Hydropower accounts for some 70% of installed power and corresponded to approximately 90% of the electricity generated in 2011. Although Brazil's hydroelectric potential is huge, around 260 GW (ANEEL, 2012), only 80 GW, has been developed. The remaining potential of 126 GW is technically, economically, environmentally and socially feasible before 2030.

There are practical difficulties in utilizing the unexploited hydroelectric resources due to the need to create additional storage reservoirs. The main river basins of Brazil's southeastern, southern and northeastern regions have already been largely explored and more than 70% of the remaining hydroelectric potential lies in the Amazon region, where topography is not conducive for the formation of storage reservoirs. Moreover, the region poses important political issues concerning the use of land for industrial purposes.

The construction of run-of-the-river hydroelectric power plants in the Amazon region has been used as the main alternative for hydropower planning. However, these plants have suffered heightened socio-environmental restrictions that have led to capacity factors[6] of 40% (Castro et al., 2011) (Belo Monte hydroelectric power plant), while the average capacity factor of Brazil's hydroelectric power plants as a whole is approximately 55% (Veiga, 2011). Consequently, a substantially greater contribution from thermal power generation will be essential to ensure the safety and reliable operation of the National Interconnected System in the long-term (Veiga, 2011).

2. Brazil's electricity grid characteristics

The power capacity of the National Interconnected System, shown in Table 1, represents about 90% of Brazil's electricity grid. It does not include independent systems and autonomous production of electricity.

The National System Operator is the entity responsible for coordinating and controlling the operation of generation and transmission facilities in the National Interconnected System (ONS, 2012). The plants are dispatched in priority order to ensure low electricity tariffs, low system production costs and to secure short-, medium- and long-term supply. Nuclear power plants are the first thermal plants to be dispatched due to their lower comparative production costs.

Table 1
Installed power capacity of the national interconnected system.
Source: National System Operator —ONS.

Type	Installed capacity	
	MW	%
Hydroelectric	81,253	77.58
Gas	9263	8.84
Oil	4451	4.25
Biomass	4165	3.98
Nuclear	2007	1.92
Coal	1765	1.69
Wind power	1083	1.03
Others	749	0.72
Total	**104,736**	**100**

The main concern regarding the operational management of the system is whether to use stored hydraulic potential now or in the future, therefore dispatching a higher or lower number of thermal power plants. As a result of this operational strategy, electricity generation data from 2006 to 2011,[7] shown in Table 2, reveals the importance of thermal generation through nuclear energy for the system.

In 2008 and 2010, due to higher demand for thermal generation on account of hydrological conditions,[8] nuclear power plants were not enough to meet the entire need for thermal complement and the ONS dispatched more natural gas plants (ONS, 2008, 2010).

The current operational strategy of managing hydroelectric power plant regularization reservoir levels in order to ensure future energy availability cannot be sustained throughout the 21st century. In the long-term, increasing the participation of hydroelectric power plants will have to take place through run-of-the-river power plants, thus reducing regularization capacity and leading to a modification in the operation of Brazil's electricity grid (D'Araujo, 2009).

Note that the regularization capacity of the hydroelectric power plants in operation has been reduced as load demand has increased, as shown in Fig. 1 (Castro et al., 2010).

An increase in thermal generation demand has been observed in recent years (see Fig. 2) as demonstrated by the regression line obtained from the average generation data from thermal power plants. While the increase in the average load between 2006 and 2011[9] was 18.76%, the increase in thermal generation corresponded to 36.92% during the same period.

3. Analysis of Brazil's thermal energy options

The expansion of Brazil's electricity grid should ensure that the new electricity mix make-up considers a greater share of thermal energy for generating base load for the National Interconnected System, thus ensuring continuous and reliable supply to support increasing demand. The Brazilian government has already recognized this issue and the 2030 National Energy Plan (PNE 2030) has identified the need to expand thermal generation by an additional 29,415 MW when compared to 2005 installed power capacity.

[3] SIN – National Interconnected System – Installations responsible for the supply of electricity to all electrically interconnected regions of the country. Source: ONS Glossary ⟨http://www.ons.org.br⟩.

[4] Regularization Capacity is the relation between the maximum storage energy in hydroelectric plants reservoirs and Brazil's electricity grid load. Source: Castro et al. (2012).

[5] MME – Plano Decenal de Expansão de Energia 2020 – PDE 2020.

[6] Capacity factor: Relation between the energy effectively produced and the maximum energy that could theoretically be generated using all installed power (D'Araujo, 2009).

[7] National System Operator—ONS.

[8] ONS Annual Report.

[9] National System Operator—ONS.