EFFECTS OF PLANNING LEAD TIMES IN GENERATION AND TRANSMISSION PROJECTS ON THE EVOLUTION OF THE ELECTRICAL SYSTEM

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Overview

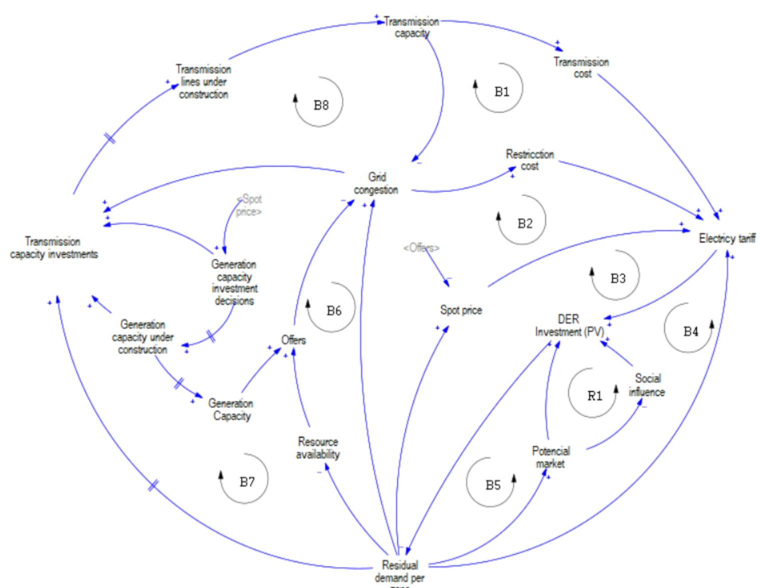
Most countries have implemented incentives to increase their energy generation capacity, prioritizing the adoption of renewable energy sources. However, the development of electrical transmission infrastructure has lagged behind, resulting in a negative impact on established goals for new renewable capacity and discouraging new investments. Additionally, current planning and development timelines, along with potential delays in transmission and generation projects, could create gaps between needs and planning, distort market signals, and alter the expected evolution of the electrical system. The objective of this study is to analyze the dynamics of project development timelines in the evolution of the Colombian electrical market, using System Dynamics.

Methods

In order to model the the electricity market, the planning times and delays were based on the models proposed by De Zubiría Arango, 2023 and Herrera et al., 2018, where the long-term expansion of the electric system is addressed through system dynamics. System dynamics is a methodology that aids in understanding the electric system by examining the causal relationships involved, feedback loops, and delays, allowing for a coherent simplification of a complex system (Ford, 1998).

The following figure illustrates the balancing and reinforcing feedback loops of the simplified causal diagram of the model. It demonstrates how generation needs are influenced by residual demand and price but are regulated by distributed generation. Additionally, both generation needs and constraints contribute to an increase in transmission requirements in the system. However, both generation and transmission expansion experience delays from the identification of the need until they are commissioned in the system. Taking the above into account, the model was calibrated to the Colombian case, without considering planning times, meaning that when new projects are needed, they are installed. Currently, efforts are underway to incorporate these times to assess their effects on the system's evolution.

Figure 1.Simplified causal diagram



Results

The model considers the installed capacity, resource availability, demand, hydrology, transmission lines between zones, and distributed generation within the country. It conducts an ideal dispatch, generates an average price for the country, and installs new capacity in generation and transmission as needed. The following figures illustrate the main variables of three different scenarios: a baseline scenario without generation expansion, a scenario with centralized expansion, and another scenario with centralized expansion and distributed energy resources (DER).

Figure 2. Total Generation Capacity

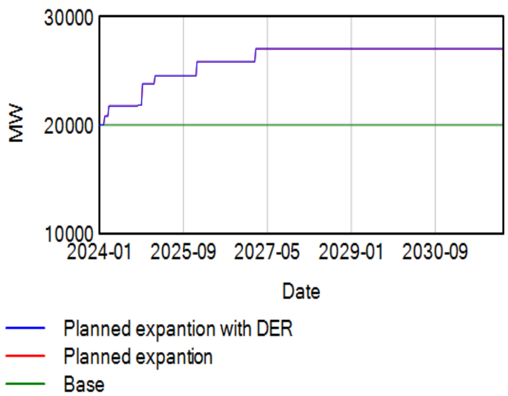


Figure 3. Electricity Tariff

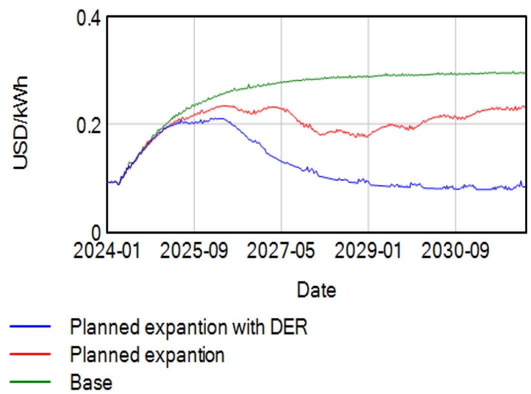


Figure 5. Mean avalaibility margin

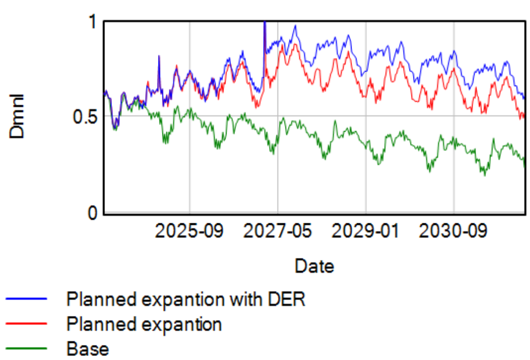
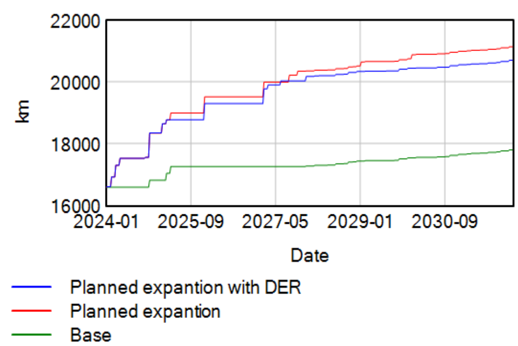


Figure 6. Total transmission



Conclusions

The current results show that the model can accurately represent the Colombian electrical system and display long-term generation and transmission needs. However, the model expands resources based on immediate system needs, so when incorporating planning and project development timelines, other dynamics may arise that alter the technologies required by the system. With the current state of the model, various scenarios have been explored, allowing for an analysis of the effects of battery integration, resource complementarity, and high penetration of renewable energies into the system.

References

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