Modelling Non-Conventional Renewable Energy: A Case of Study of the Peruvian Power Supply sector

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Overview

In the global energy landscape, the remarkable decrease in renewable energy technology costs has positioned renewable projects as pivotal components of sustainable development. This trend is particularly evident in Peru, where our research delves into the dynamics of Non-Conventional Renewable Energy Resources (RER). Against the backdrop of diminishing costs and a growing environmental consciousness exhibited by both governmental bodies and private enterprises, our methodology focuses on estimating the entry and impact of RER projects within the Peruvian power sector. Our study seeks to articulate that RER projects have the potential to contribute significantly, up to 30% of the total energy production by 2040, under a politically and economically stable environment.

The primary objectives of our research encompass an assessment of the feasibility and profitability of RER projects to foresee the evolution of the power capacity additions in the long term. Through a microfounded model, our aim is to unravel the investor decision-making processes and project implementation dynamics. The study endeavors to provide comprehensive insights into the potential increase in RER participation in Peru's power generation landscape, considering factors influencing such a transformation.

Methods

First, we forecast electricity demand. This analysis encompasses two key stages: the vegetative demand and special loads demand (major consumers). The former, primarily driven by economic growth (GDP), is modeled through an econometric time series model, covering the household, commercial and smaller free-market consumers. For the latter, major consumers in sectors such as mining, agriculture, and transportation are identified to forecast demand based on current consumption and the start date of each major demand load project based on the latest Transmission Plan developed by the Peruvian electricity market operator. Accurate macroeconomic information and precise details on future projects gathered directly from private sources and public open databases, ensure a reliable demand projection.

Second, on the power supply side, our projection considers existing and future generation projects, the availability of the hydric resource, and the dispatch order based on the variable costs of power plants. Initially, the entry of new projects is evaluated, emphasizing the significant role RER power stations, which have priority on the dispatch order according to the legal framework, to encourage sustainable production. Subsequently, the availability of hydric resources is examined, critical for hydropower plants. The power plants costs are projected, considering variables such as international CAPEX trends, natural gas prices, state royalties for hydropower, and the international oil price for fossil fuel-based power plants. RER power plants, devoid of variable costs, are dispatched first. This strategic approach highlight the prominent place for sustainable energy sources in the power market.

We propose a dual-pronged analysis to assess thoroughly how RER and conventional technologies will be included: (i) a granular evaluation of the feasibility of RER projects through a multi-stage implementation process and (ii) a detailed assessment of their profitability over their operational lifespan. Feasibility considerations extend to regulatory approval intricacies, construction planning nuances, and meticulous execution timelines, based on data regarding the development of previously developed projects. The profitability aspect involves the calculation of the expected Net Present Value (NPV), intricately considering projected revenues from spot markets, power contracts, and potential regulatory changes.

Results

The findings derived from our methodology paint a promising picture. Under conducive conditions, RER projects could increase their share in energy production by up to 10 percentage points, reaching a substantial 30% of total production by 2040.

Conclusions

In the current regulatory and electricity market landscape in Peru, coupled with the cost dynamics of Non-Conventional Renewable Energy Resources (RER) technology, investors are increasingly inclined towards the development of RER generation plants. Consequently, RER is poised to emerge as the fastest-growing technology in the coming years, reflecting a strategic alignment with the nation's regulatory priorities and economic considerations.

Nevertheless, our study reveals three limitations that warrant careful consideration. First, the geographical distribution of spaces rich in renewable resources is finite, posing a potential constraint on the expansion of RER projects. Second, the pace at which the transmission systems can adapt to accommodate the growing influx of RER projects may present challenges, potentially impacting the efficiency of energy distribution. Third, ensuring a consistent energy production capacity remains a challenge, particularly given the inherently variable nature of RER technologies.

Taking these limitations into account, our projection of the energy market yields precise estimations. By 2040 RER technologies are projected to constitute 30% of the national power generation. This forecast incorporates a comprehensive understanding of the regulatory framework, market dynamics, and the nuanced intricacies of RER technologies. It emphasizes the need for strategic planning and adaptive measures to harness the full potential of renewable energy while addressing the identified challenges. This forecast not only underscores the transformative trajectory of Peru's energy landscape but also emphasizes the imperative for continued regulatory support and adaptive infrastructure development to facilitate a sustainable energy paradigm.

Additional Discussions

Our model incorporates a foresighted analysis of the anticipated impact of regulatory changes from 2026 onwards. We envision pro-RER measures fostering enhanced project profitability, with RER projects becoming financially more attractive from 2029 onwards. Interestingly, the sustained profitability of non-RER projects, such as thermoelectric plants, persists until 2040, highlighting the imperative need for a balanced and diversified energy mix to ensure the overall stability of the energy system. This nuanced discussion of the temporal dynamics and potential trade-offs in the evolving energy landscape contributes to a comprehensive understanding of the complex interplay between renewable and non-renewable energy sources.

Overall, this study offers nuanced and comprehensive insights into the potential evolution of non-conventional renewable power generation in Peru, emphasizing the need for proactive policies to drive sustainable energy transitions in the region while considering the multifaceted dimensions of the energy landscape.

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