Global Gateway

GET.transform
Transforming Energy Sectors Globally

Powering Peru's Future: Smarter Forecasting for Reliable Renewable Integration

From Theory to Implementation

IMPACT CASE STUDY

GET.transform is co-funded by

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Norway

Ministry of Foreign Affairs of the Netherlands

Sweden
Sverige

Austrian Development Cooperation

Prepared by
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

GET.transform
Friedrich-Ebert-Allee 32 + 36
53113 Bonn, Germany
T +49 228 44601112
E info@get-transform.eu
I www.get-transform.eu
I www.giz.de

Place and date of publication
Bonn, September 2025

Author
Daniel Cumpa Exebio, GET.transform

Photo credits
Cover © COES

GET.transform is a European programme which offers developing and emerging countries comprehensive advisory services to advance their energy sector transformations. It is hosted on the multi-donor platform GET.pro (Global Energy Transformation Programme), and co-funded by the European Union, Germany, Norway, the Netherlands, Sweden and Austria.

Table of Contents

Introduction

In this series of **Impact Case Studies**, GET.transform sheds light on the tangible and lasting results of advancing energy transitions in partnership with high-impact countries and regions. Focusing on both policy and technical reforms, each case explores how tailored advisory, collaborative dialogue, and hands-on implementation have translated into real-world progress. More than snapshots of success, the case studies surface valuable lessons on what has worked and what has not—insights that may inform future strategies for enabling clean, affordable, and reliable energy systems. Together, they aim to capture how targeted support can create ripple effects far beyond individual interventions.

This case study illustrates Peru's efforts to ensure the stability of the power system and an efficient integration of variable renewable energy (vRE) into the electricity supply. The Peru's power system operator, did so by improving the operational conditions related to the forecasting framework of weather dependent power production. GET.transform is grateful for COES' trust and leadership in jointly working towards that goal, and congratulates the operator on the significant results yielded, with enhanced predictions for the short-term operation (hours/days/weeks) from wind and solar plants.

Partner Testimonial

"For us as the System Operator, precision in the forecasting of demand and production is of the uttermost importance. Maximum precision will allow to assign resources in an optimal way to cover the needs of electrical energy of the country on a day-to-day basis."

César Butrón

President of the Board of COES (Power System Operator), Peru

1 The Challenge

Peru has been one of Latin America´s fastest growing economies over the past decade. The emerging economy has spurred the electricity demand, and the power supply has been historically dominated by hydro and natural gas power plants. Given the increasing competitiveness of variable renewable energies (vRE), Peru has taken additional steps to promote investment in solar and wind power plants. With excellent wind resources and very high solar irradiation levels, the country has enormous potential to exploit both technologies.

Peru has set the target to increase its non-conventional renewable share to 20%[1] by 2030. In 2024, the participation of vRE in the energy matrix was 8.6%. Varying wind speeds and solar irradiation directly translate into rapid and significant changes in electricity generation, and can create new operational challenges. Peru’s power system operator, COES (Comité de Operación Económica del Sistema Interconectado Nacional), had been particularly affected since its role is to maintain the stability of the electricity network.

Over the last years, COES has recognised the need to introduce adjustments in the operational regulation to effectively integrate weather dependent production from variable renewable energies, specifically on enhancing the accuracy of solar and wind generation forecasts. COES saw an increasing need to balance power at low shares of vRE penetration. With the expected significant rise in solar and wind installed capacities, reliable power forecasts became indispensable to keep balancing cost in check and maintain system stability.

According to the regulation in Peru, COES must use the best available information which, in practice, has historically meant relying on the power forecasts provided by the vRE plant operators as the only source of predictions. While the generators were obliged to send these predictions, there was no prescribed level of quality. Consequently, forecasts sometimes came in late, lacked data or were a replication of the previous day generation profile. The concept of portfolio forecast, which is more accurate than individual plant forecasts, was never applied. Yet, as the energy landscape evolved, the

[1] Supreme Decree N° 003-2022-MINAM (2022), the Ministry of the Environment set a target of 20% by 2030, includes wind and solar power plants, excludes the hydroelectric.

demand for higher accuracy in wind and solar generation forecasting became vital to uphold optimal system frequency control.

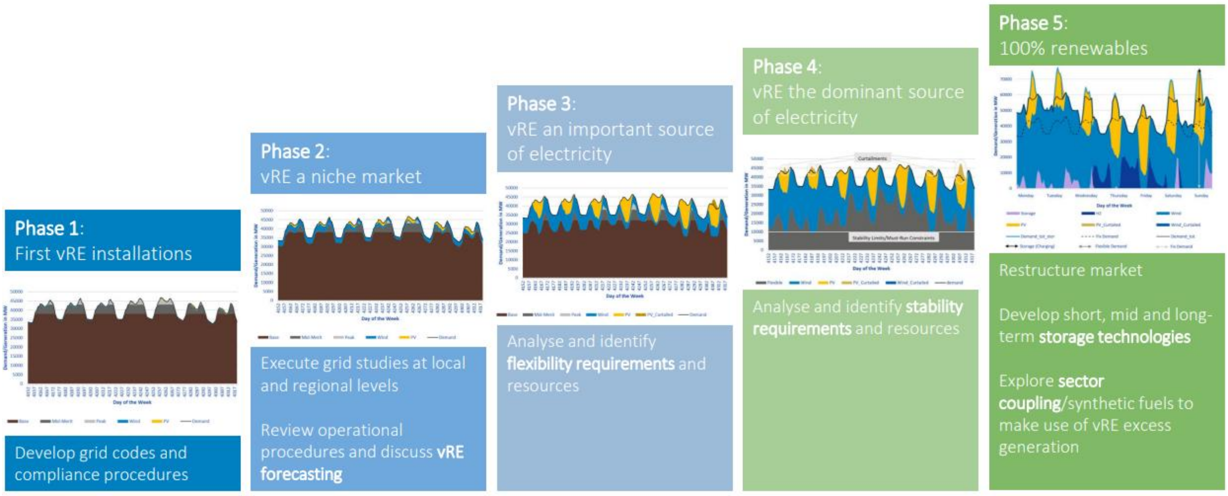

Figure 1: System Impact of vRE in the Different Phases of the Energy Transition
Source: own elaboration based on Energy System Transformation Guide, GET.transform 2022

As visible in **Figure 1** , the increasing penetration of variable renewable energies has an impact on system operations. Depicting the energy transition across five phases, the figure shows a high-level overview of the main technical challenges that have to be managed in each phase. While it took a considerable amount of time for Peru to reach Phase 2, the increasing competitiveness of the solar and wind powerand excellent availablility of primary energy for renewable generation are likely to result in a speedy transition from Phase 2 to Phase 3. Centralised vRE forecasting thus arises as one of the critical levers to secure a smooth operation of the power system.

2 The Approach

The power system operator, COES, decided to partner with GET.transform in 2021. The goal was to assess national conditions and current regulations and provide recommendations to improve the requirements and the regulatory framework for vRE forecasting. Through improving the short-term forecasting for solar and wind power plants, the partners aimed to pave the way for a smooth and cost-efficient integration of vRE expansion in the Peruvian power system.

A two-stage approach was applied to prepare the power system operator for higher shares of vRE

- Research: studying the existing forecasting framework and providing specific recommendations
- Pilot: test a centralised forecast system against those of individual plant operators

For the first stage, **Figure 2** shows a summary of the specific recommendations proposed. The short-term measures are the ones that can be implemented in less than a year, while the long-term measures are likely to require more time for their implementation.

Period	Recommendation
Short-term	Enforce the daily submission of forecasts (penalties)
Short-term	Introduce a standardized format for power forecasts
Short-term	Introduce regular forecast quality assessment and dialogue with plant operators
Short-term	Implement an automated mutual data exchange
Long-term	Implement a (digital) national plant register
Long-term	Require a weather-model based forecasting approach
Long-term	Require combination forecast combining several NWP models
Long-term	Implement centralized forecasts with external service provider
Long-term	Work with higher forecast update frequency based on real-time data
Long-term	Work with higher temporal resolution (15 minutes)
Long-term	Incorporate model-spreads in power forecasts

Figure 2: Recommendations for the vRE Forecasting System
(Source: GET.transform)

Drawing on the data analysis and international experiences and trends, a forecast brief was developed to provide an overview of best practices in power forecasting and share global experiences on predicting solar and wind power production. The brief informs on fundamental techniques and data requirements to set up and improve power forecasts and delves into the most important factors that influence prediction accuracy levels.

To ensure best possible results and sector alignment, key public sector stakeholders were consulted in the process. The Peruvian Ministry of Energy and Mines and the national energy regulator OSINERGMIN were involved to validate the findings in a dedicated workshop in July 2022.

For the second stage, a pilot project was carried out in 2023 to demonstrate that higher levels of accuracy in operational power forecasting were achievable within the Peruvian context. The following activities were implemented to reduce forecasting errors in operational power system management in Peru:

- 16 large solar and wind power plants covered.
- Implemented updated forecasts with 30-minute resolution in line with COES schedule.
- Used historic data and real-time production data for forecast improvement.
- Provided aggregated forecasts for wind and solar, as well as regional aggregations.

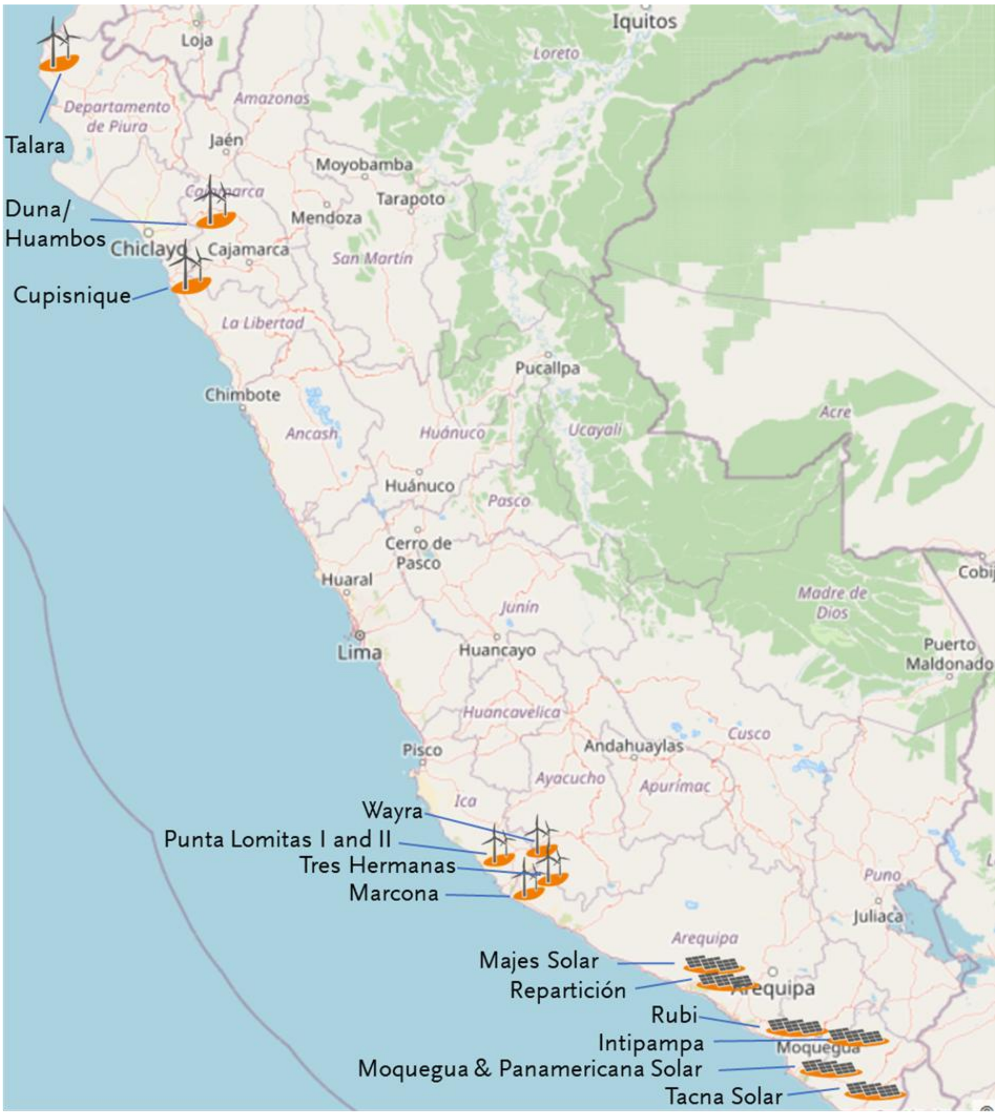

Figure 3: Wind and Solar Plants Comprised in the vRE Forecasting Pilot in Peru

Source: COES

In case of the participating wind parks, the forecasting deviation (Root Mean Squared Error, RMSE) was reduced by approximately 20%, and for some plants by up to 45%. Only in the case of two parks, Wayra and Tres Hermanas, the improvement was smaller than 10%.

For the solar parks, it was possible to reduce the RMSE between 10% (Intipampa, Rubi) and 40% (Moquegua, Panamericana, Tacna).

The improved forecast accuracy (Root Mean Squared Error, RMSE) for individual plants is illustrated in the following charts.

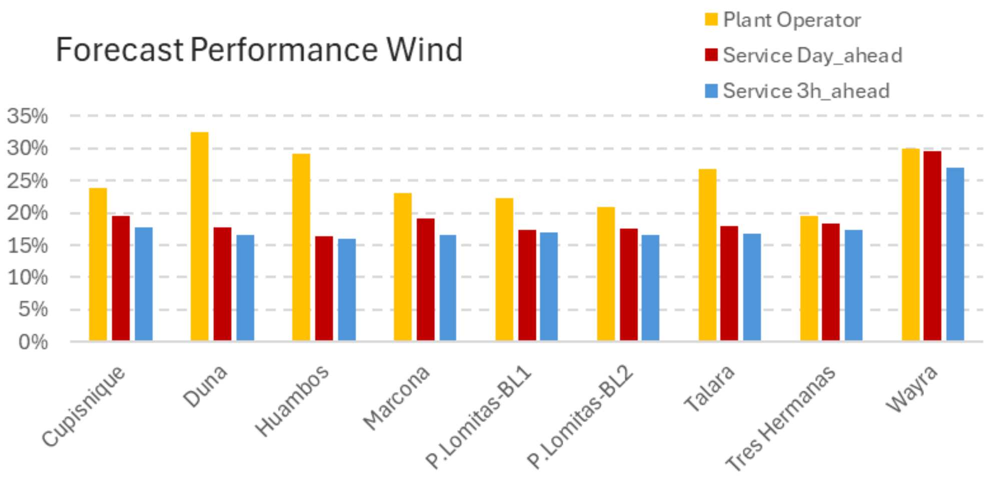

Figure 4: Forecast Performance - Wind

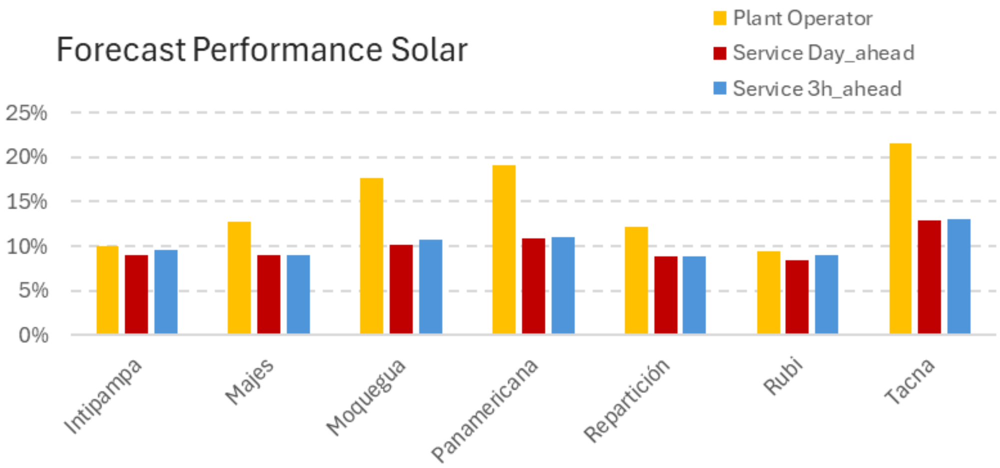

Figure 5: Forecast Performance - Solar

There was a continuous improvement process driven by the stakeholders involved in the activity. Additional opportunities to improve forecast accuracy even further were identified, for example with longer data history or by reducing the delays in transferring real-time production data.

3 The Impact

The main impact was to strengthen the system operator's ability to precisely predict the output of more than 1GW of capacity from solar and wind power plants in Peru. Because of the higher accuracy in the vRE generation forecasting, the level of operational optimisation in the electricity system will increase, and the power plant owners will be able to use this information for improving their technical and commercial short-term decisions. The key findings from the pilot are summarised across three reports. A summary of the main benefits the system operator identified in their operational processes is listed in Figure 6.

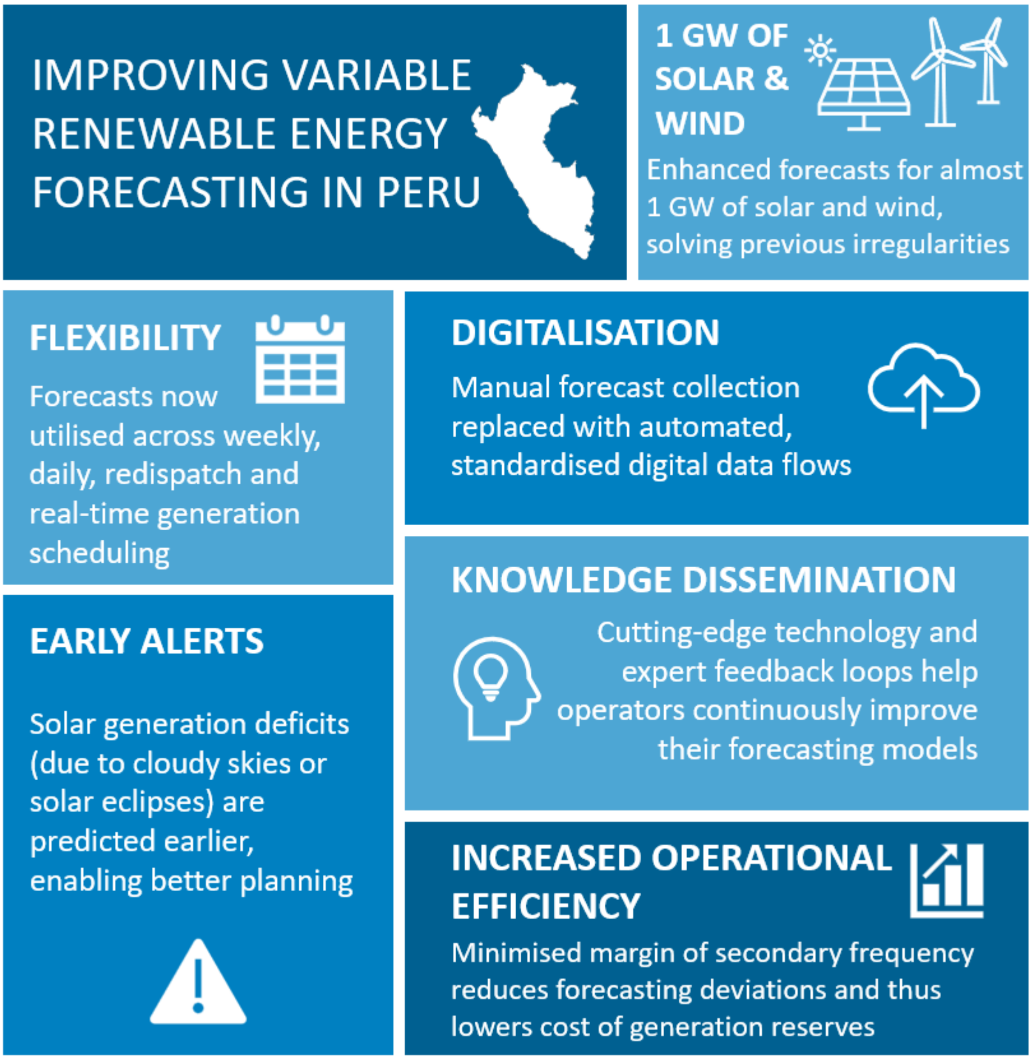

Figure 6: Key Benefits of Using New vRE Forecasting in Peru

Based on the proven advantages of the pilot project, COES initiated the proposal to update the regulation related to the forecasting procedure in 2024. At the beginning of 2025, it was modified by the regulator OSINERGMIN.

During the process, the Peruvian electricity system operator and the generation companies updated to advanced power forecasting techniques and data modelling. Private and public companies participated in the workshops and were able to benefit from this information to enhance their own internal operational and commercial procedures. The system operator is now incorporating improved forecasting data into relevant technical procedures. For instance, the cost of generation reserves required for frequency regulation is calculated based on forecasting deviations, which have now been reduced.

This improvement has been shared with other Transmission System Operators (TSOs) through regional organisations such as CIER and RELAC. The shared experience highlights the progress made in forecasting for solar and wind power plants in Peru, includes a benchmarking study with selected countries, and outlines the associated benefits—such as smoother integration of variable renewable energy (vRE) and increased efficiency in system operation.

Given the specificity of the topic and the technical processes involved, it was possible to standardise this support and take it into further contexts. A replication of the support package is currently underway with the electricity system operator in Panama.

Peru's experience demonstrates how targeted support in key technical areas of the energy transition can foster efficient and sustainable energy development. By testing and adapting to a new approach, the COES has significantly enhanced the system's operational efficiency and rendered Peru's grid future ready. GET.transform is proud and grateful to have been part of this journey.

GET.transform c/o Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH
Friedrich-Ebert-Allee 32 + 36
53113 Bonn, Germany
E info@get-transform.eu
I www.get-transform.eu
I www.giz.de

GET.transform is co-funded by