ICSC
Institute for Climate and Sustainable Cities

REQUEST FOR PROPOSALS

Efficient integration of wind and solar power in the Philippines

A quantitative analysis of the Philippine power system: Transmission expansion needs and flexibility options

Background

The operation and planning of a power system with high shares of variable wind and solar power are quite different from the practices prevailing in power system consisting of large, centralized thermal power plants. Indeed, the technical, operational, and planning challenges associated with integrating large shares of variable renewables into the grids are often referenced as major barriers to wind and solar power expansion.

Over the recent years, renewables development in the Philippines has been dominated by hydropower and geothermal energy, which together generate about 20% of the electricity in the country. Wind and solar power, which is still marginal today, will need to play an increasing role to meet the fast-growing electricity demand at lower costs and facilitate the decarbonization of the power system in line with the Philippines' renewables objectives (shares of 35% by 2030 and 50% by 2050) and climate commitments.

Given the country's archipelagic nature and limited interconnectivity between its three main grid areas, integrating variable renewables in the Philippines is more challenging than in a large interconnected system. In addition, the coal moratorium, potentially laying the foundations for a gradual phase-out of coal in the country, would profoundly shift how the system is planned and operated. This transformation will put the grid infrastructure at the forefront of the discussion. The Philippines will need to move towards new planning and investment practices for the grid to ensure it can integrate variable renewables at lower costs for consumers while maintaining the security and reliability of the overall system. Additional flexibility options in the system (such as demand side response, battery storage, and electric vehicles, among others) will also be required.

Detailed power system and power grid modeling are important tools that allow for the quantitative mapping of system integration challenges incurred by high variable renewables shares on transmission and distribution grid operations. Using such tools allows for an evidence-based analysis to highlight priority areas and inform energy planners, system operators, decision-makers, and key market players of the consequences of higher shares of renewables and what they would mean for transmission investment and integration strategies in the Philippines.

Objectives

The project "Efficient integration of wind and solar power in the Philippines", led by the Institute for Climate and Sustainable Cities (ICSC), with the support of Agora Energiewende, aims to inform discussions around the Transmission Development Plan (TDP) of the National Grid Corporation of the Philippines (NGCP).

To best inform this discussion, the project's partners are seeking the support of technical experts (one consultancy or a group of consultancies) who will develop a techno-economic analysis of the power system of the Philippines. This analysis aims to explore the various options to cost-efficiently integrate wind and solar power into the Philippine power system. It should allow for the quantification of the challenges ahead and explore how grid planning, management, and operations can help minimize the potential grid-related costs of wind and solar deployment.

A load-flow-based simulation of the transmission system shall, in the first step, quantify what amount of additional wind and solar generation can be integrated into the current system without major changes to the system or its operations.

In a second step, and using the same load-flow simulation model, the transmission expansion needs should be explored for a set of defined scenarios that incorporate a significant scale-up of wind and solar generation. Within this analysis, interventions to optimise transmission system investments should also be explored. The scenarios should focus on major milestone years referenced in the Philippines Energy Plan, i.e., 2030, 2040, and 2050.

Finally, existing and future flexibility options shall be assessed. This assessment should consider the existing generation fleet, exploring in particular the expansion of flexibility in existing hydropower and thermal generators, interconnections between the Visayas, Mindanao, and Davao grids, energy storage, and the potential for demand-side response.

The results of this analysis shall support public authorities and the system operator in planning for a resilient transmission grid and setting adequate incentives for improving the flexibility of the Philippine energy system. The identified policy window of opportunity is the 2024 update to the NGCP's Transmission Development Plan, which is expected to be published in September 2024.

Scope and work packages

The following questions are at the core of the requested analysis:

1. How much additional wind and solar generation can be integrated in the Philippines' transmission system as it exists today?
2. What are the required expansions to the transmission grid for a set of defined scenarios with varying shares of RES by 2030, 2040, and 2050 while considering current planning rules?
3. What are the consequences of technological (i.e., wind and solar) and regional distribution of renewable energy deployment for the expansion of the transmission and distribution grid? How would this be impacted by the addition of system flexibility assets introduced to the Philippine system?
4. What planning and operational strategies could help reduce transmission expansion needs, considering state-of-the art operational strategies, intelligent smart-systems or even modifications to the electricity market while ensuring security of supply.
5. What are the flexibility options and barriers in the Philippines' power system, considering the country's current electricity generation fleet, existing regulations, and potential adjustments?

Proposed work packages

Work Package 1: Model set-up & data gathering

The consultant will set up a load-flow based model of the Philippine power system suitable to answer the key questions required for the analysis (see above). The model should incorporate information including the topology and physical properties of the transmission system (e.g., 500kV and 230 kV lines and transformer stations, impedance of the lines, thermal limits on transmission capacities), as well as the technical and economic properties of all generators and loads connected to the system in at least hourly steps (for a full year run), at a level of disaggregation relevant for a robust analysis. The modelling framework should facilitate a load-flow analysis that ensures grid performance remains within its standard operational parameters, taking into account factors such as bus voltage magnitude profiles, active and reactive power flows, transmission line loading, bus voltage stability, N-1 contingency analysis, and other relevant aspects.

An important criterion for the selection of the consultant will be their ability to develop such a model by accessing and working with existing data on the Philippine power system, both in the public domain and potentially beyond it.

Work package 2: Scenario definition

Based on discussion with and input from the clients, a set of scenarios (a priori four) will be defined for the Philippine power system in 2030, 2040, and 2050. The scenarios will differ in the overall level of renewable energy, the regional distribution of variable renewable sources, and additional investments in system flexibility services (e.g., energy storage, interconnecting grids, or even large-scale demand-response). Additional sensitivity analyses would be expected to explore the impact of individual assumptions and variables.

For each scenario, overall capacity relating to the feed-in points to the transmission system of the PV and wind sites, as well as load at each node, are to be defined, and time series based on available meteorological data and load patterns on an hourly basis are to be calculated. Also, hydropower power plant capacities, availabilities and operation are expected to be adequately represented. To set up distributed / best resource scenarios, an estimation of the wind and solar potential in different geographic regions is to be performed. The consultant, in their proposal, shall explain in detail how wind, solar and hydro generation, as well as load patterns, will be represented in the model.

Ideally, one scenario should accurately reflect the government's targets in terms of generation mix and expansion plans for the transmission and distribution grids. The scenarios should differ in terms of the growth of wind and solar as well as their geographical location. For example, at least two scenarios should compare the impacts on transmission system operation when the location of newly deployed wind and solar is optimised for bulk generation (i.e., sites with the best available resource), versus when they are deployed in a more distributed fashion to optimise grid operations and planning (i.e., reducing grid congestions, reducing T&D investments, increasing security of supply).

Work Package 3: Load-flow simulation: identification of congestions and investment needs.

Step 1: Market simulation: Modelling of generation dispatch will need to consider the current market regime and dispatch regulations (i.e., priority dispatch) as an input for the load-flow simulation.

Step 2: Load-flow simulation: load-flow simulations should be run on an hourly basis (or potentially even at a lower time resolution) for an entire year for each scenario. They should allow for the identification of congestions and the magnitude of overload and non-transmittable power on the level of line and/or transformer. This should consider the operational principles of the TSO (in particular ‘n-1’ safeguards).

Step 3: Transmission expansion proposal: proposal for the reinforcement and expansion of the transmission system to relieve identified congestions and ensure ‘n-1’ stable operation of the system based on current TSO rules and regulations.

Work Package 4: Identification of potential for reducing transmission investment for each scenario

Several operational and technical improvements have been developed that help reduce the need for T&D expansion while ensuring a secure operation of the grid, especially for systems with large shares of variable renewables. In this work package, options for reducing grid investments, thanks to these best practices, are to be identified and assessed for the Philippine power system.

In terms of optimising grid operations, allowing for a certain level of renewable energy curtailment can be viewed as beneficial from a cost-benefit approach as it could avoid overinvestments into grid infrastructure. At the same time, the option of regional balancing to alleviate congestion over a line could be achieved through the redispatch of thermal generators. The options of curtailment and thermal redispatch should be assessed and integrated into the model to assess how such techniques can reduce grid congestions during moments of very high renewable energy generation.

On the technical side, options have also been developed that can help mitigate grid congestions without requiring the expansion of new transmission lines. Such measures include, e.g., allowing higher loads on high-voltage lines at times of high-wind feed-in (as high winds help cool lines and avoid line sag), and the introduction of high-temperature conductors.

Work Package 5: Addressing flexibility challenges

The ability of a power system to integrate larger shares of renewables in the system does not only depend on the capacity of transmission lines and transformer stations. Rather, the variability and uncertainty of variable renewables requires adequate reserves and balancing capacity to cope with rapidly changing wind and solar generation.

This work package shall identify the system flexibility demand for each scenario, including a detailed investigation of the flexibility options available. These should at minimum include:

- Hydropower and thermal generators with their potential to ramp production either up or down, taking into account technical, environmental and economic minimum generation levels.
- Energy storage options, with a particular focus on batteries and pumped storage.
- Demand side response options

Particular attention should be given to the differences between the scenarios where renewables are deployed at sites that exploit the best resources, versus when they are deployed in a more distributed fashion according to system needs.

Timeline and Deliverables

The project shall be carried out in conjunction with the consultation of an expert and stakeholder group, involving institutions such as the Department of Energy, the Energy Regulatory Commission (ERC), National Transmission Corporation (Transco), National Grid Corporation of the Philippines (NGCP), the Philippine Electricity Market Corporation (PEMC), Independent Electricity Market Operator of the Philippines (IEMOP), distribution utilities, solar and wind energy associations, project developers, researchers, civil society, etc. The consultant(s) shall make proposals for an adequate composition of this group. We plan to have two meetings, where intermediate results are to be discussed, and several meetings for assumption calibrations and scenario definition. The expert group involvement is to be considered in planning the project timeline.

The consultant shall provide a final report and the relevant data/model at the end of project duration, that will include:

Report:

- An executive summary of 3-5 pages
- Main results displayed in a PowerPoint presentation
- A detailed description and justification of the Philippines power and transmission system, the model, methodology and input parameters applied;
- A description, quantification and adequate graphic representation of the results of the scenario analysis;
- Discussion of flexibility options and barriers to renewables integration in the Philippine power system; and
- Tangible recommendations for adjusting operational, planning procedures and the regulatory framework.

Model:

- The code, as well as the input and output data used for model and scenarios, will be transferred to ICSC and Agora Energiewende.
- Knowledge on the use and interpretation of the model results will be transferred through a targeted capacity building (e.g., through a workshop on explaining and using the final model to selected participants).

Indicative timeline

The project is expected to start on 15.11.2023. Final results should be delivered by Sept. 2024 and preliminary results discussed several times with the representative group of key stakeholders mentioned above. The project proposal should suggest a precise and realistic timeline for the different work packages and show how they will unfold over the ten months period of the project. The stakeholder group will be involved at the model set-up stage (WP1 for data collection and WP2 for scenario design) but also during the analytical part (WP3, WP4 and WP5). The expert group involvement is to be taken into account in planning the project timeline. The project proposal shall also identify potential risks for not meeting the proposed timeline.

Qualifications

The consultant must be a firm or a group of firms with:

- Project experience in power system analyses methodology development, market and grid simulation model development, power system analyses, scenario development, forecasting techniques and technology assessment;
- Track record of experience regarding renewable energy, flexibility technologies and grid integration policies and regulation in the Philippines or in countries that have similar characteristics to Philippine power system;

- Proven ability to develop power sector and renewable energy technology roadmaps that encompass multiple technologies, approaches, sectors and stakeholders;
- Experience with drafting policy-maker friendly reports that draws conclusions from complex analyses.

Firms' or a group of firms' team members should have the following minimum key expertise:

- Team Leader, with preferably at least 15 years of professional experience in
    - Philippines power sector or other similar countries
    - Leading/supporting large projects with large data inputs, where multiple stakeholders with different views are involved and where the final goal is to create an impact on policy-making
    - Proven record in drafting policy-maker friendly reports from complex datasets and analytical findings
    - Proven record in the management of complex multi-stakeholders' projects
- At least two technology experts, with preferably 10 years of professional experience with
    - Proven skills in load-flow modelling and model development
    - Knowledge of power system transformation technology, strategy, policy and approaches
- One or more technology expert(s), with preferably 5 years of professional experience in
    - Data collection skills on power system characteristics, technologies, policies