**[*ASSESSMENT of REGIONAL energy storage system deployment in response to energy transITIONS in taiwan*]**

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## Overview

Owing to the scarcity of indigenous energy resources, Taiwan relies on imports for 98% of its energy requirements, which is highly dependent on fossil fuels. Considering issues of energy security, and in response to the Paris Agreement, the Taiwanese government has initiated planning for energy transitions and aims to increase renewable energy to 20% of total power generation and achieve the nuclear-free homeland by 2025. Energy Storage System (ESS) is an important option for facilitating the integration of variable renewable energy (VRE). Therefore, it is crucial to assess regional ESS requirements during energy transitions in Taiwan.

This paper develops a multi-region optimization model based on linear programming framework to incorporate the highly resolved generation data. Our model differs from previous applications of linear programming to the electricity supply planning. We explicitly address the issue of the generation technology portfolios and ESS selection from a regional perspective in linear programming frameworks, and extend the formulation to reflect regional ESS requirements. The model is utilised to simulate the daily power generation performance of multiple technologies in four seasons, which also takes the regional data into consideration, and simulates the charging and discharging operation of ESS. In other words, our model can explicitly account for ESS specification and its detailed operation in each region based on hourly temporal resolutions as well as economic and operation performances.

The paper is organised as follows: the first section is the introduction of our study. The second section gives a overview of the model description, as well as the model foumulations. The data processing of the power unit and ESS are described in the third section. The fourth section gives the results of the analysis. In the final section, there will be a conclusion and its policy implications.

## Methods

The model simulates hourly operation of all power generation technologies in Taiwan in 2025, including solar photovoltaic (20GW), offshore wind (5.5GW), and onshore wind (1.2GW). The modle minimizes the total cost of satisfying regional electricity demand in every hour of four seasons. The costs consist of capital costs and operation and maintenance (O&M) costs of each power generation technologies, which also takes the future fuel price and VRE installation fee prediction into consideration. The model constraints includes regional balanced electrical power load, the production constraint of the generators in deffirent regions, as well as policy and environmental restrictions, and the energy storage technology restrictions.

## Results

The simulation results are presented in hourly generation of various power generation technologies of four seasons in 2025. For power generation in the whole year, as much as 20% of renewable energy can be achieved. The results also indicate that the combination of Pumped-storage hydroelectricity(PSH) and chemical ESS can effectively smooth out the sharp decline of PV electricity at sunset, by storing excess solar energy at noon and release it in the evening. As a result, PSH and ESS can provide 2.6% ~3.1% of total electricity during the evening.

In terms of regional deployment recommendations, the model recommended that each of the central and southern regions of Taiwan can be installed with 100MW and 500MW lithium-ion energy storage systems, which will be able to effectively integrate solar photovoltaic, and have good economic benefits.

## Conclusions

The simulation results show that according to the current policy planning, the target of 20% of renewable energy generation can be achieved, at the same time, coal-fired power generation will be reduced to 27%, and the nuclear power will be decommissioned in the end of 2025.

The application of the ESS works well when the solar energy rapidly reduces during sunset, smoothing the drastic fluctuations of variable renewable energy generated.

Through considering regional characteristics of renewable energy, the contribution of this paper is to recommend the the ESS deployment in each region, in order to meet the energy storage goal in Taiwan.

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