



Operating and Planning Electricity Grids with Variable Renewable Generation: Review of Emerging Lessons from Selected Operational Experiences and Desktop Studies (World Bank Studies)

Marcelino Madrigal, Kevin Porter

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The paper ‘Challenges and Approaches to Electricity Grids Operations and Planning with Increased Amounts of Variable Renewable Generation: Emerging Lessons from Selected Operational Experiences and Desktop Studies’ focuses on analyzing the impacts of variable renewable energy on the operation and planning of the the power system (mostly, generation system). It is aimed at informing stakeholders in power utilities, regulatory bodies and other relevant audiences, on the fundamentals of technical challenges and approaches to operate electricity grids with renewable energy. It covers renewable energy as a whole, but in particular, focusses on wind and solar energy. It also presents three case studies of countries, including China, Gemany and Spain.

The total worldwide installed capacity of wind and solar projects is growing rapidly, and several countries are noticing increased penetrations of wind and solar in their electricity generation mix. In addition to operating experience being gained from adding wind and solar capacity, several grid integration studies have been performed that assess potential grid and operating impacts from adding higher amounts of wind and solar capacity. Perhaps just as important, the electric power industry and those that conduct research on grid integration have not found a maximum level of variable generation that can be reliably incorporated, and it is clear that it is as much an economic question (how much cost in additional reserves or grid impacts is acceptable) as a technical question regarding grid operators’ ability to adapt to the new challenges.

In addition, while their contributions to capacity or “firm” power and associated costs are different from those of conventional power sources, variable renewable generation technologies can contribute to long-term system adequacy and security. The paper describes on the contribution of variable power sources to long-term supply adequacy requirements, i.e. how much sources like wind and solar power contribute to “firm supply” in a system. It also describes methods to find out to what extent they contribute and at what cost. It also aims at providing indicative answers to how costs to system operations be determined and when and how an integration study be done to estimate the short-term reserve costs of renewable energy.

The concepts in the paper should be of interest, especially to grid planers. For grid operators, the paper summarizes a menu of strategies that the operational practices and desktop research tell about managing wind in a system at different levels of penetration. It also elucidates available strategies, amongst other crucial questions of operational impacts and challenges that operators need to be aware of, to integrate variable generation.

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