ENERGY CURTAILMENT REGULATION IMPACT ON DISTRIBUTED GENERATION INTEGRATION

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Overview

The increasing amount of distributed generation (DG) of all sizes, types, and with the unexpected sites for the grid operators is adding complexity to distribution grid. This is especially challenging for renewable energy due to their high fluctuations in generation. The grid investment can be based on accommodating the energy produced from renewables without curtailment; however, a part of these investments is only relevant for a few hours annually when the generation is too high compared to the demand. Therefore, energy curtailment in some situations is an option to decrease the investment. However, curtailed producers suffer economic losses. Furthermore, curtailing renewable energy is intuitively viewed as a waste given the low marginal cost of it. Therefore, curtailed producers receive compensation according to energy curtailment regulation, which defines the compensation rules in the terms of the price, the quantity and the payer. Energy curtailment can be due to network constraints, security constraints in the grid, low electricity price and strategic bidding (Jacobsen och Schröder 2012). The curtailment of DG due to network constraints is the focus of this paper.

A qualitative analysis of different nowadays energy curtailment regulations in EU countries is presented in (Ropenus, o.a. 2009). It explains the interplay between the curtailment costs and network investment. Energy curtailment regulation combined with a new active network management is proposed in (Kane och Ault 2014). By accepting curtailment in combination with active control more renewable generation capacity can be accommodated in a distribution grid. Paper (Brandstätt, Brunekreeft och Jahnke 2011) argues that the use of voluntary curtailment agreements is a good approach to efficiently integrate large-scale renewables in Germany. Pros and cons of different compensation rules, nowadays and newly proposed, for renewable curtailment are discussed in (Jacobsen och Schröder 2012) with statistics for some countries. It points out that equilibrium between network investment and energy curtailment is reached when the marginal network investment cost due to DG is equal to the marginal expected compensation for the curtailment over the lifetime of the network investment. However, these costs have not been quantified in the reviewed studies.

The challenge to quantify the equilibrium lies in estimating the marginal cost of reinforcing and expanding the grid to accommodate the energy and the marginal value of the curtailed energy under different energy curtailment regulations.

This paper addresses the challenge from engineering and economic points of view. The engineering perspective tackles the network constraints and the amount of curtailment in the grid. The economic perspective contains the regulation regarding compensation for curtailed energy and network long-term investment.

Methods

The impact of energy curtailment regulation is evaluated by applying different curtailment regulations on the same distribution grid with different amounts of wind generation. Optimal level of curtailment is calculated considering the cost of avoiding network investment. Case studies of German and Swedish as well as recommended energy curtailment regulations are performed. All the costs are obtained by a network investment model, which considers network constraints, fluctuations of generation and load and regulatory settings. The reference total social cost is assumed to be the minimum of the combined grid investment and energy curtailment costs.

Results

The expected results are listed as follows:

- Optimal network investment and energy curtailment is obtained under different energy curtailment regulations;
- The deep connection charge scheme for DG sends out locational incentives and decreases the total cost;
- The compensation rules for curtailment has big impact on the optimal curtailment level;
- The compensation rule to protect the DG integration level may increase the total social cost.

Conclusions

This paper concludes that the energy curtailment regulation has to strike a balance between the grid investment and the curtailed energy compensation. In order to evaluate the balance, the cost analysis from the grid operator's and the generator's perspective is necessary. Furthermore, the DG or renewable energy support regulations should be consistent with the curtailment regulation to send out incentives for DG and grid operators to minimize the total social cost. Last but not the least, the compensation rules for curtailment has big impact on the optimal curtailment level. However, whether the regulation is optimal or not requires further studies. In future work, short-term benefits from energy curtailment, for example from up-regulation and down-regulation prices, can be added in the analysis.

References

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