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Contractual Framework for the Devolution of System Balancing Responsibility from the Transmission System Operator to Distribution System Operators

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Authorities in many jurisdictions, especially in Europe, California, and New York, have been eagerly trying to integrate more renewable electricity sources (RES) into the power grid to realize their dream of a low carbon society in the near future.

The future power system with a high penetration of RES can be regarded as a system which is decentralized in terms of energy production. The increase in the number of distributed RES facilities in terms of production may cause some local problems in the distribution system such as over/under voltage phenomena and thermal overload on certain distribution lines. To manage these problems, the distribution system operator (DSO) needs to evolve into a more active entity with regards to governing its distribution system, which acts in some way analogous to a local autonomous entity. This gives rise to an inevitable co-dependence with the transmission system operator (TSO) who currently takes the balancing actions for system reliability and the DSO who undertakes the local management of distribution system. System balancing actions could include, for example, the procurement of local frequency response services and voltage support within the distribution system.

In the future power system, there may therefore be some conflicts between traditional TSO balancing actions and a DSO's local management actions. The DSO may be best place to manage balancing in its own area and to hence reduce total system balancing costs across a TSO area. This would also mean that a TSO can only interact indirectly with the users connected to the distribution system via the DSO. Under this ***devolution principle***, each DSO with high penetrations of renewable distributed generators (RDGs) manages and tries to reduce its variability and uncertainty within its own control area. It can do this through various kinds of actions such as more advanced forecasting, active scheduling and control of generation/demand, using energy storage systems or voltage control equipment actively in short-term, while encouraging efficient long-term investment and not disrupting system balancing at the transmission level.

In many jurisdictions balancing costs are allocated on the basis of energy use (kWhs), under what we call an energy amount related cost allocation scheme (EA-CAS). In line with the previous paragraph, we propose a cost causality allocation scheme (CC-CAS) where costs are allocated to DSOs on the basis of their area contribution to total system balancing costs across a single TSO area.

This research suggests two things about cost allocation schemes (CASs) for balancing costs. We prove the economic efficiency of the CC-CAS. In world of rising distributed RES, DSOs should be designated as the entities who have primary economic responsibility for system balancing cost to give them the motivation to reduce or manage variability and uncertainty from their own distribution networks. Second, the system balancing cost allocation scheme should be transformed from an EA-CAS to a CC-CAS. To avoid the side effect that the DSO with a large amount of RES may face a high and risky balancing payment under the CC-CAS, this research also proposes an optimal design framework for a balancing payment insurance (BPI) contract which helps DSOs hedge the risks associated with uncertain balancing payments. The DSO can hedge the risk in its balancing payments by paying a BPI contract price to the TSO ex-ante. With this proposed hedging instrument, the DSO can achieve an optimal risk adjusted operating strategy minimizing its net operating cost. This cost includes the original operating cost of its distribution system, the balancing payment, the purchase price of the BPI, and the rebate amount through the BPI.

The proposed contractual framework can induce DSOs to reduce variability and uncertainty that is leaked on to the transmission system via interface flows. It is expected that a significant part of the system balancing responsibility of TSO can be handed over to a number of DSOs under the proposed contractual framework. In addition, the TSO can conduct system balancing actions more efficiently based on better partial ex-ante information on estimated variability and uncertainty arising from the local distribution system via its signed BPI.

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