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Electricity Networks:

Technology, Future Role and Economic Incentives for Innovation

Executive Summary

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The power grid needs to adapt to its changing operating environment as it is at the centre of decarbonisation, digitalisation, and decentralisation trends in the electricity sector. Furthermore, the electrification of the heat and transport sectors, which are currently being pursued as a default strategy by many European countries, has serious implications for grid infrastructure. Without intervention, the combined electrification of heat and transport can cause the peak electricity demand of a developed economy to grow as much as 1 GW per year post 2030 (ENA, 2017). This means the electricity networks require more agility, control, automation, new regulatory models, and innovative business models, both at transmission and distribution network levels. The problem is even more critical at low voltages, because this is a place where most disruptive technologies are located and this area has traditionally been managed in a passive manner.

In recent years, efforts at the level of the low-voltage grid have largely been focused on dealing with issues such as renewable intermittency, congestion, load shifting, and bidirectional flow. In the future, technological innovation at the grid edge will facilitate the development of markets for distributed resources, service-oriented business models, and end-to-end integrated grid management. This implies the role of the grid is evolving beyond just supplying electricity to consumers. There are multiple pathways here but one scenario envisions the electricity network as a platform that also maximises the value of grid edge technologies such as distributed generation, storage, energy efficiency, demand response, and electric vehicles. Therefore a new paradigm (including a technical, regulatory, and business model) is required at grid level to integrate disruptive technologies, find new ways of operating to meet customers' expectations, and facilitate grid edge transformation.

However, network companies are regulated natural monopolies; this means that they hardly ever undertake innovation activities in the absence of sufficient incentives. Traditional regulatory models of network utilities are designed to incentivise cost efficiency, with the assumption that network business is costly and the task of regulation is to lower these costs, subject to achieving a certain level of reliability. The main challenge of incentivising innovation is that it is not only costly but also risky. Therefore, an innovation-oriented regulatory model needs to factor in uncertainty in the outcome of innovation efforts.

The costs and risks of innovation effort can be borne by firms, be passed to consumers, or shared between these two. If the regulator were able to observe the firm's effort, incentivising innovation would be simple because the regulator could set the remuneration at a level equal to the cost of the efficient level of effort. However, in practice there is information asymmetry between the regulator and the firm, which means that the remuneration of firms needs to be linked to the performance of the firm. But this is not straightforward. On the one hand, the regulator wants the firm to undertake innovation, but for this to happen he needs to remunerate the firm for its costs when undertaking risky activity. On the other hand, the regulator does not want to distort the firm's incentives by giving it full insurance for activities whose risks are actually manageable by the firm. The task of regulation is, therefore, to devise a scheme which balances risk sharing with incentives.

We show that incentive mechanisms that do not take into account the risk profile of innovation activities divert the attention of the network utilities from innovation to normal efficiency gain. This indicates the importance of differentiating between cost efficiency and innovation in designing the regulation of electricity networks. A shift from traditional models of network regulation to new models – where innovation is the key part of the incentive structure – is crucial to facilitate the transition of the power sector. In relation to the design of an innovation-friendly regulatory scheme, the regulator needs to differentiate between types of innovation activities, as there is a different level of risk involved at each stage of innovation. When network companies engage in R&D and piloting, an input-based regulation (whereby the costs of these activities are transferred to consumers) has proved to be an effective approach. For less risky activities, such as the introduction of established technologies and processes, an output-based regulation that uses costs sharing or revenue cap adjustment leads to a more efficient risk-sharing mechanism.

The issue of risk in regulating innovation is not confined to the actual risk of outcome. The risk attitude of network companies is also decisive. If the scheme does not take this into account, a heterogeneous risk attitude among bidders can distort the outcome of a competitive allocation of innovation funds. We demonstrate that a firm with a greater level of risk tolerance but a less valuable project can win a contest for innovation funds in competition with a risk averse firm which has a more valuable innovation project. The risk of losing their initial investment because of the uncertain outcome of competition can discourage network companies from entering into competition or spending resources to make a case for their project. An approach to address this issue is to adopt a two-stage competition process in which an initial evaluation provides an early indication of eligible projects before companies are invited for full submission. Regulator can also offer smaller funds to be used for projects whose technical/economic results can then be used in larger-scale innovation proposals. This eliminates the risk of losing the upfront capital and puts network companies with different levels of risk tolerance on the same level in the competition process.