The Economics of Demand-side Flexibility in Distribution Grids

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The Clean Energy Package (CEP) Directive (EU) 2019/944 calls on the Member States to develop regulatory frameworks that incentivize Distribution System Operators (DSOs) to consider the use of flexibility as an alternative to network expansion. DSOs will have to develop and publish network development plans that consider the trade-off between flexible resources and system expansion. The CEP also includes demand-side flexibility as a new network code area, recognizing the need to elaborate on a regulatory framework for demand-side flexibility.

Demand-side flexibility can be implicit, i.e., reacting to pre-defined price signals to which all consumers are subject, or explicit, i.e., flexibility, offered by a consumer or requested by the DSO, is paid a given price. This paper focuses on mandatory curtailment by the DSO with compensation. We develop a long-term bi-level equilibrium model. In the upper level, the regulated DSO optimizes the social welfare by deciding on the network investment and/or curtailing consumers, as well as setting the network charge level to recover network and flexibility costs. Consumers, prosumers or passive consumers, maximize their own welfare in the lower level. The DSO anticipates the consumers' reaction when investing in the network and when setting the flexibility level.

We assess to what extent explicit demand-side flexibility mechanisms can complement the implicit incentives. If network tariffs are somewhat cost-reflective, prosumers investments in PV and batteries internalize the cost of network investments. Explicit demand-side flexibility, used in combination, allows the realization of higher welfare gains. If network tariffs are too imperfect, it can become relatively cheaper to overinvest in the network than to correct the resulting consumer profiles with curtailment. We also found that it will be challenging for regulators to set an appropriate level of compensation for curtailment. When the compensation is below the Value of Lost Load (VoLL), passive consumers are only partly compensated for their loss. If the compensation is increased towards the VoLL, it becomes so attractive for prosumers that they game the system. They start to use their batteries against system needs, anticipating that they will get curtailed and compensated.

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