1 Introduction

Power-to-Gas (PtG) facility is currently an alternative energy storage for a power grid with high penetration of renewable energy. The facility converts excess electricity into a gaseous energy carrier, i.e. hydrogen. The produced hydrogen can be used in different ways, e.g. it can be injected in the gas grid or sold to a mobility sector. Alternatively, it can be stored in a hydrogen buffer and later on reconverted into electrical energy using a fuel cell before selling it to a power grid. The facility overview is shown in Figure 1.

Relying on the fact that a number of PtG facilities embedded in the existing energy grids may increase, it is therefore of interest to study on how to maximize their estimated revenue from the produced hydrogen without exceeding grid capacities. The problem is solved by distributed model predictive control, allowing each PtG facility locally to decide how much hydrogen each PtG facility injects into the gas grid, sells to the mobility sector, stores to the hydrogen buffer, and/or reconverts into electricity before injecting it to the power grid, given the estimated predictions of demand patterns and selling prices in the gas grid, the mobility sector, and the power grid. As the energy grids have limited capacities, these decisions need to be coordinated with the operators of the energy grids.

2 Distributed supply coordination through prices

Inspired by [1], a dual decomposition approach combined with the projected sub-gradient method applied in the model predictive control scheme is used to solve our problem in a distributed fashion. With this approach, each operator sets extra fee for energy transport and system service utilized by PtG facilities if overloading grid is detected. In this way, PtG facilities are induced to modify their supply levels. This bidding process is illustrated in Figure 2. We provide results on how the dynamic extra fee is useful to avoid overloading grids, as shown in Figure 3 and Figure 4.

Figure 2: Interactions among PtG facilities and the operators of energy grids at each iteration $r$, $r'$, $r''$ within a time step $\tau$. Given extra fees $\lambda_i^e(\tau), \lambda_i^g(\tau), \lambda_i^c(\tau)$, PtG facilities bid their supply levels $g_i^e(\tau), y_i^g(\tau), e_i^r(\tau)$ to the operators of energy grids.

Figure 3: The decrease of supply level when the initial fee set by the operator of the gas grid is at zero level, i.e. $\lambda_{g,0}^i = 0$, and the allowable hydrogen in the gas grid is 83 $Nm^3$.

Figure 4: The increase of supply level when the initial fee is set at 0.2, i.e. $\lambda_{g,0}^i = 0.2$, and the allowable hydrogen in the gas grid is $28 Nm^3$.

References