AVERAGE INCREMENTAL COST PRICING IN ELECTRICITY AUCTIONS

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Overview

Since the restructuring policies that led to the liberalization of the electricity sector and to the existence of a market for power, electricity markets have been organized in a highly centralized fashion, relying on uniform-price auctions. These auctions typically include non-convex bids. The main implication of these non-convexities is that they impede the existence of a uniform "market-clearing" price. Therefore, what the electricity price should be under these settings is an open question, which has attracted the interest of both academics and practitioners over the past thirty years. In this paper, we study one particular pricing method called Average incremental cost (AIC) pricing, introduced by O'Neill in several articles (O'Neill et al., 2023; O'Neill and Chen, 2023; Chen et al., 2024).

Methods

Stevens et al. (2024) recently proposed a theoretical framework and methodology to comprehensively analyze different pricing methods which have been proposed for electricity auctions. In this paper, we apply this framework to the study of Average incremental cost (AIC) pricing.

We provide a theoretical analysis of AIC pricing: we clarify its definition, its main property—that is, it eliminates the need of make-whole payments—and we establish several other properties, in particular regarding the outcome of AIC pricing in presence of a network. These properties are illustrated on numerical simulations that rely on realistic auction datasets. More specifically, we illustrate and study these properties on two different datasets: the "FERC dataset" (public data, but without a network) and the "CWE dataset" (non-public data, but including a network).

Importantly, our analysis also provides a comprehensive comparison of AIC pricing with other pricing approaches, such as marginal pricing and convex hull pricing. In particular, we discuss how AIC pricing compares with some other pricing proposals which also eliminate the need for make-whole payments. Such a comparison is critical to correctly appreciate the relative merits and drawbacks of AIC pricing.

Finally, Unlike marginal pricing or convex hull pricing, which admit a single unequivocal definition, average incremental cost pricing admits some slight variants: in a multi-commodity settings, the notion of "average cost" indeed let some freedom. The paper discusses these variants. Our objective is not to be exhaustive—we rather highlight some important tradeoffs and choices that an auctioneer might want to consider when implementing AIC pricing.

Results & conclusions

One objective of this paper is, by studying some properties of AIC pricing, to clarify its objectives: "what does AIC pricing exactly do compared to another approach that also minimize revenue shortfall?" Our conclusions are:

- AIC pricing ensures zero revenue shortfall for suppliers which have possibility of inaction, thus eliminating the need for make-whole payments. This is the cornerstone property of AIC pricing, which we formalize and observe in our numerical simulations.

- However, the suppliers which do not have possibility of inaction may bear some revenue shortfall under AIC pricing. This should be kept in mind for some auction models, for instance when they rely on a unit commitment model involving must-run constraints or initial conditions.

- AIC pricing guarantees locational price consistency, i.e. zero "lost opportunity costs" for the network. This property is similar to marginal pricing, which also ensures network price consistency. This is in contrast with ELMP or CHP, which are well-known not to hold such property (Stevens et al., 2024). It is also significantly different from various "Minimal make-whole payment" (MMWP) schemes analysed in the literature (cf. Stevens et al. (2024)). These approaches are similar to AIC pricing, in the sense that they aim at minimizing the revenue shortfall. However, these MMWP approaches fail to treat the network properly and therefore lead to poor incentives in presence of a network. AIC pricing overcomes this issue. This locational price consistency is certainly an important asset of AIC pricing.

- AIC pricing aims at eliminating make-whole payments. This is in contrast with an approach such as convex hull pricing, which aims at minimizing the so-called "lost opportunity costs". In Stevens et al. (2024), we highlight an important asymmetry: while minimizing the lost opportunity costs (somewhat focusing on the self-scheduling problem), as convex hull pricing does, leads to moderate revenue shortfall (thus low make-whole payments needed), minimizing the revenue shortfall, as AIC pricing does, may exacerbate the lost opportunity costs dramatically thus creating significant opportunities for the market participants to self-schedule.

- AIC pricing outcome are observed to be sensitive to some modelling choices, which we analyse in the paper.

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