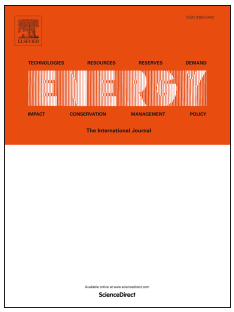
Accepted Manuscript



Implementing flexible demand: Real-time price vs. market integration

Florian Kühnlenz, Pedro H.J. Nardelli, Santtu Karhinen, Rauli Svento

PII: S0360-5442(18)30252-4

DOI: 10.1016/j.energy.2018.02.024

Reference: EGY 12324

To appear in: *Energy*

Received Date: 7 September 2017

Revised Date: 2 February 2018

Accepted Date: 7 February 2018

Please cite this article as: Kühnlenz F, Nardelli PHJ, Karhinen S, Svento R, Implementing flexible demand: Real-time price vs. market integration, *Energy* (2018), doi: 10.1016/j.energy.2018.02.024.

Implementing Flexible Demand: Real-time Price vs. Market Integration

Florian Kühnlenz[a,*], Pedro H. J. Nardelli[b], Santtu Karhinen[c], Rauli Svento[c]

[a] *Centre for Wireless Communications (CWC), University of Oulu, Finland*
[b] *Laboratory of Control Engineering and Digital Systems, School of Energy Systems, Lappeenranta University of Technology, Finland*
[c] *Business School at University of Oulu, Finland*

Abstract

This paper proposes an agent-based model that combines both spot and balancing electricity markets. From this model, we develop a multi-agent simulation to study the integration of the consumers' flexibility into the system. Our study identifies the conditions that real-time prices may lead to higher electricity costs, which in turn contradicts the usual claim that such a pricing scheme reduces cost.

We show that such undesirable behavior is in fact systemic. Due to the existing structure of the wholesale market, the predicted demand that is used in the formation of the price is never realized since the flexible users will change their demand according to such established price.

As the demand is never correctly predicted, the volume traded through the balancing markets increases, leading to higher overall costs. In this case, the system can sustain, and even benefit from, a small number of flexible users, but this solution can never upscale without increasing the total costs.

To avoid this problem, we implement the so-called "exclusive groups". Our results illustrate the importance of rethinking the current practices so that flexibility can be successfully integrated considering scenarios with and without intermittent renewable sources.

*Corresponding author
Email address: Florian.Kuhnlenz@oulu.fi (Florian Kühnlenz)