

# Load shifting versus manual frequency reserve: Which one is more appealing to flexible loads?

Peter A.V. Gade<sup>\*1,2</sup>, Trygve Skjøtskift<sup>2</sup>, Henrik W. Bindner<sup>1</sup>, and Jalal Kazempour<sup>1</sup>

<sup>1</sup>*Department of Wind and Energy Systems, Technical University of Denmark, Kgs. Lyngby, Denmark*

<sup>2</sup>*IBM Client Innovation Center, Copenhagen, Denmark*

December 12, 2022

## Abstract

## 1 Introduction

## 2 Conclusion

## Acknowledgement

The authors would like to acknowledge the financial support from Innovation Fund Denmark under grant number 0153-00205B for partially funding the work in this paper. The authors would also like to thank Christian Ahn Albertsen (IBM Client Innovation Center) for all our discussions and his feedback which has been particularly valuable regarding practical challenges faced for demand-response. The authors would also like to thank Bennevis Crowley (DTU) for reading the paper and providing feedback on corrections, figures, and phrases. The authors would also like to thank the Centre for Utilities and Supply at Energistyrelsen (Danish Energy Agency) for allowing us to present our work to them while also elaborating their perspective on Market Model 3.0 and their intentions.

## Author Biographies

**Peter A.V. Gade** is an Industrial PhD researcher at IBM and affiliated with the Technical University of Denmark, Kongens Lyngby, Denmark, in the Energy Markets and Analytics Section within the Power and Energy Systems division at the Wind and Energy Systems Department. His research focuses on demand-side flexibility and the revenue streams from utilization of demand-side flexibility. He holds a M.S. in Mathematical Modelling and Computing and a B.S. in Biomedical Engineering, both from the Technical University of Denmark.

**Trygve Skjøtskift** is an Associate Partner at IBM Denmark, with focus on energy transformation and demand-side flexibility. His solid experience and deep knowledge within intelligent energy systems, buildings, and civil infrastructures makes him a leading figure, strategic advisor, and a first mover in the flexibility market with a strong track record to find and deliver new

---

\*Corresponding author. Tel.: +45 24263865.

Email addresses: pega@dtu.dk (P.A.V. Gade), Trygve.Skjotskift@ibm.com (T. Skjøtskift), hwbi@dtu.dk (H.W. Bindner), jalal@dtu.dk (J. Kazempour).

cutting-edge solutions. He holds an MBA in Strategy from Universitat Pompeu Fabra, and a Master of Export Engineering from Copenhagen University, College of Engineering.

**Henrik W. Bindner** received the MSc in Electrical Engineering from Technical University of Denmark in 1988. He is currently a senior researcher with the Department of Wind and Energy Systems, Technical University of Denmark. He is heading the *Distributed Energy Systems* Section and his research interests include control and management of smart grids, active distribution networks, and integrated energy systems.

**Jalal Kazempour** is an Associate Professor with the Department of Wind and Energy Systems, Technical University of Denmark, where he is heading the *Energy Markets and Analytics* Section. He received the Ph.D. degree in Electrical Engineering from the University of Castilla-La Mancha, Ciudad Real, Spain, in 2013. His research interests include intersection of multiple fields, including power and energy systems, electricity markets, optimization, game theory, and machine learning.