Université catholique de Louvain
UCL
SECTEUR DES SCIENCES ET TECHNOLOGIES
INFORMATION AND COMMUNICATION TECHNOLOGIES, ELECTRONICS AND APPLIED MATHEMATICS

# Invitation à la soutenance publique de thèse

### Pour l'obtention du grade de Docteur en Sciences de l'Ingénieur


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## Frequency Containment Reserve from Energy Constrained Loads
## A system Perspective


Our fossil-fueled societies have to rapidly evolve towards decarbonated energy systems. Soon, we will rely on a more evanescent form of energy: the sun rays. As the morning comes and the night falls, this source of energy is intermittent, which is of particular concern to electric energy systems as electrical power cannot be easily stored. Therefore, any alternative to building new energy storage infrastructures will soon both turn lucrative and vital to safe and efficient power system operations. One of such alternative is Demand-Side Management: the actions that can be undertaken on flexible loads/processes to influence the amount and/or timing of their electrical energy consumption.

This work studies the flexible capacity offered by a group of small electric loads faced with energy constraints and providing a service known as Frequency Containment Reserves (FCR). This service is an essential part of power system short-term stability as it restores the balance between the power generation and demand within seconds.  In this work, loads adapt their power consumption autonomously (i.e., without external communication) based on measurements they can acquire in their local environment. The control framework is designed such that a certain order appears from the apparent chaos.  As a consequence of the load's energy constraints, the amount of energy that can be shifted in time by the load group is limited. This induces a specific kind of control error called energy rebound which has technical and economic consequences both in the short-term (seconds to minutes) as well as in the long-term (year-long). Those consequences are assessed through the use of aggregate models. These are simple mathematical structures that accurately represent the behavior of the group with reduced computational efforts. We propose two original families of aggregate models that are relative to two control frameworks.  Altogether, we show that load control is economically efficient when applied to the loads with adequate parameters (run time, power). Addressing only the most interesting loads is crucial for ensuring an overall positive societal impact. Yet, the expected benefits in today's context are limited. In consequence, massive implementation programs and standardization seem to be the adapted processes to access the flexibility of small electric loads. As the impact on the end-user is often imperceptible, including these controllers as a standard feature of most interesting appliances would be very well accepted.  Finally, we highlighted that the system operator's role is crucial in the overall profitability of the proposed control schemes. Its actions, and particularly the way it manages slower flexibility resources, have an important impact on the load control performances.


**Vendredi 22 avril 2016 à 15h00**

Auditoire BARB 94
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Prof. François Glineur (UCL), Promoteur
Prof. Emmanuel De Jaeger (UCL), Promoteur
Prof. Raphaël Jungers (UCL), Président
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