

## Jury Member Report – Doctor of Philosophy thesis.

**Name of Candidate:** Timur Saifutdinov


**PhD Program:** Engineering Systems

**Title of Thesis:** Optimal siting, sizing and technology selection of energy storage systems for power system applications

**Supervisor:** Prof. Janusz Bialek

**Date of Thesis Defense:** 20 January 2020

**Name of the Reviewer:** Louis Wehenkel

I confirm the absence of any conflict of interest	<b>Signature:</b>  <b>Date: 18-12-2019</b>
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*The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.*

*If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.*

### Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

The PhD thesis of Timur Saifutdinov considers the problem of designing decision aids to help in optimally investing into storage systems within the context of electric power systems, with a focus on modern Li-Ion batteries. The mathematical formulation and algorithmic resolution of the resulting family of very complex (CAPEX + OPEX) optimization problems (under uncertainty) is addressed both from a theoretical and from a practical viewpoint. The writing style and the organization of the manuscript are clearly of good quality. The title of the dissertation is perfectly coherent with the contribution of the thesis.

The methods used in the thesis are threefold: synthesis of relevant physical and mathematical models of storage systems, of their environment, and of the family of optimization problems addressed; design of a scalable algorithmic scheme, by leveraging discretization, relaxation, parallel computations, and iterative schemes; experimental validation thanks to an academic test system (of moderate but relevant size) and various computer simulations. All these methods are suitable and relevant to the research context. The thesis also provides a rather complete overview of existing energy storage technologies and of the types of practical electric power system problems they can contribute to solve.

The problem addressed is a very timely and difficult one, and to my best knowledge the thesis brings a true contribution by enabling the incorporation within the optimization problem formulation of a suitable model of battery ageing in a way that correctly accounts for the planned charging-discharging policies of the different storage systems. It also proposes a non-trivial and scalable numerical resolution scheme that is able to exploit massively parallel computing architectures, so as to compute a near optimal solution without making overly gross approximations. The potential economic and reliability gains that could be obtained in practice by using the proposed methods are in my opinion very important, and the proposed approach is already shown to be better than state-of-the-art methods on a relevant case study carried on the chosen 39-bus academic test system.

The research work has produced already a good number of publications, both in peer-reviewed conference proceedings and in high-level scientific journals, many of them being 'first-authored' by Timur Saifutdinov. Beyond the realized work, I believe that the thesis and these publications open and motivate a number of further research directions within the general theme of this research.

In my opinion the proposed manuscript is of very good technical and scientific quality, and makes a quite significant contribution to the state of the art. I therefore propose to authorize the public defense without further modifications.

#### **Provisional Recommendation**

*I recommend that the candidate should defend the thesis by means of a formal thesis defense*