Skoltech
Skolkovo Institute of Science and Technology

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: Prof. Keith Stevenson

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Signature:**  **Date: 30-12-2019**

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
I am writing this letter to provide an evaluation of Timur Saifutdinov on his original creative work (i.e. thesis) entitled “OPTIMAL SITING, SIZING AND TECHNOLOGY SELECTION OF ENERGY STORAGE SYSTEMS FOR POWER SYSTEM APPLICATIONS,” in the completion of PhD requirements at Skoltech. Overall, his thesis contains original and forefront work on the optimal siting, sizing, and technology selection of energy storage systems for power system applications by applying the formal optimization methods. His thesis is arranged into main components: Introduction, literature review, energy storage options, models for siting, sizing and technology selection, models overview, optimization problem formulation, results and analysis and conclusions. The scientific outcomes are reflected in 4 publications and 4 conference proceedings. Most are published in high impact factor journals and conferences and his contributions to the work are clearly outlined in the beginning of the thesis. What is represented in the thesis is a significant body of work given complexity of the power systems modeling and simulation field especially with regard to selection of energy storage options in this rapidly emerging field. First with regard to the introduction part of the thesis. The background literature, methods, and basic description of field is well described and documented. In fact, given the subject of the thesis to review the whole energy storage field is perhaps too broad and should have been limited to primarily electrochemical based energy storage as pumped hydro, etc represents quite different set of constraints and challenges. The literature (references) overviewed is fast moving and several new works are being published on a daily basis so what is presented is very thorough. The most significant part of the thesis focuses on optimization problem formulation and resolution, presentation of case studies and specific choice of a model with presentation of results and discussion. These main sections are well done with regard to applying the mathematical formulations with specific parameterization of key inputs for various energy storage options especially for lithium ion batteries. A broad range of problems and models are considered with the ultimate choice to develop a thesis topic and formulism based on energy storage problem that accounst for self-discharge, charge-discharge efficiency, operational and calendar lifetime, investment cost, and degradation, as well as environment models. This is a bold undertaking. While the extension of this approach for most applications is somewhat in the infancy stages it is understandable that the approach described in this thesis could offer a proposed solution based on specific constraints with regard to the use of lithium ion batteries for larger scale energy storage applications. I particularly liked the fact that the actual commercialized battery parameters are used in the development of the optimization problem. This is the first model that I am aware of that uses LFP, NMC in particular. I think the publications will become highly cited with regard to various scenarios analyzed and discussed. In reading over thesis there are noticed here and there small typos and grammatical miscues. Theses should be corrected in the final version of the thesis. Overall this thesis work, highlights the essential importance of coupling both fundamental science with pragmatic optimization models to establish new algorithms in siting, sizing and

technology selection for energy storage applications. Timur has done outstanding original work and addresses many challenges of this field.

Considering his performance in original research achievements, I wholeheartedly recommend the acceptance of his PhD thesis with possible consideration of slight modifications especially with regard to formatting of his thesis.

Provisional Recommendation

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

☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*

☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*