# Skoltech
Skolkovo Institute of Science and Technology

## Jury Member Report – Doctor of Philosophy thesis.

**Name of Candidate:** Andrey Churkin

**PhD Program:** Engineering Systems

**Title of Thesis:** Game-theoretical approach to cooperation stability analysis in cross-border power interconnection planning

**Supervisor:** Professor Janusz Bialek, Skoltech

**Co-advisor:** Assistant Professor David Pozo, Skoltech

**Name of the Reviewer: Javier Contreras**

| | Signature: |
|---|---|
| I confirm the absence of any conflict of interest<br><br>(Alternatively, Reviewer can formulate a possible conflict) | <br><br><br>Date: 08-10-2020 |

*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 thesis presents a study on a game theory approach to determine the cross-border interconnections planning in power systems. It is clearly an important problem and the way to solve it is clearly innovative. The quality of the text is high and the chapters included introduce the state of the art on game theory and its applications to power systems, in particular power systems planning.

One of the sections that I consider outstanding is the huge amount of effort devoted to classify the state of the art literature on the subject. The classification method is based a tool named citation network analysis and its results are impressive. From the initial amount of papers revised (thousands!), it can be seen how there are several clouds of connections where all pivotal or seminal works are at their roots. Thus, the reader can verify which works are of true importance and how they are related to other works after them.

After that, the thesis enter into a section that describes the transmission expansion planning (TEP) formulation, in which a classical mathematical formulation is presented. It is necessary to include it together with the game theoretic approach.

Next, a detailed background on cooperative game theory (CGT) is provided. All CGT solutions, such as the Shapley value, kernel, nucleolus, core, etc. are clearly described and the theorems proving their existence included or references to them.

The next chapter is clearly the core of the thesis, where there is a bilevel model in which the upper level consists of the upper level consists of the TEP problem and the lower level represents the constraints of the CGT approach, in terms of surpluses of the players. Bilevel models are at the forefront of mathematical programming and are sophisticated tools to solve complex problem, such as TEP under cooperation among the players. The model is then illustrated with two small examples, where we can see the solutions and the effect of player manipulations. This is a completely new way to study the problem, since previous works made the TEP first and calculated the allocation of costs/benefits ex-post. Because of this, I consider that the thesis is of great interest and deserves publication.

The final chapter before the conclusions shows aa real-life application to interconnect several countries in North East Asia. As an application does not completely succeed due to the complexity of the problem posed and the need of a huge computational effort. Nevertheless, the author is able to adequately remedy this issue by proposing realistic solutions to the case study. This has been also part of a Journal paper.

All in all, I find the thesis well-written, extremely informative for CGT readership and with a bilevel model that is able to introduce the concept of cooperation in the problem itself, and find an optimal solution bounded by the cooperation, parameterized in various degrees

**Provisional Recommendation**

X *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*