

### I. IDENTIFICATION DATA

<b>Thesis name:</b>	<b>Co-Simulation of distributed flexibility coordination schemes</b>
<b>Author's name:</b>	<b>Markus Stroot</b>
<b>Type of thesis :</b>	<b>master</b>
<b>Faculty/Institute:</b>	<b>Faculty of Electrical Engineering (FEE)</b>
<b>Department:</b>	<b>Department of Control Engineering</b>
<b>Thesis supervisor:</b>	<b>Thomas Offergeld, M.Sc.</b>
<b>Supervisor's department:</b>	<b>Electrical Engineering</b>

### II. EVALUATION OF INDIVIDUAL CRITERIA

<b>Assignment</b> <i>Evaluation of thesis difficulty of assignment.</i> Markus was asked to implement a simulation environment for coupling multi-domain simulations of energy systems with control and optimization structures. The topics covered by his thesis were very diverse and ranged from evaluating software architectures to mathematical optimization of energy systems. Overall the thesis comprised of several challenging tasks, each of which required expert knowledge in its domain.	<b>challenging</b>
<b>Satisfaction of assignment</b> <i>Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.</i> Markus fulfilled the assigned tasks to full satisfaction. Markus displayed exceptional creativity in developing solutions to the challenges encountered during realization of the designed simulation environment. Markus showed particular interest in extending the simulation environment with valuable additional functionality while also implementing a potential use case for demonstration of the environment.	<b>fulfilled</b>
<b>Activity and independence when creating final thesis</b> <i>Assess that student had positive approach, time limits were met, conception was regularly consulted and was well prepared for consultations. Assess student's ability to work independently.</i> Markus presented his work at regular intervals in a comprehensible way and always offered his own ideas of how to tackle specific challenges during consultations showing a great deal of independence. Markus could improve upon his time scheduling, however there were no major discrepancies between planned and actual completion of intermediate thesis milestones.	<b>B - very good.</b>
<b>Technical level</b> <i>Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.</i> Markus' thesis topic was a combination of several domains of electrical and software engineering. Markus researched relevant literature diligently, identifying state of the art of similar concepts in scientific publications. He assessed the solutions outlined in these publications and chose sensible approaches of integrating existing knowledge into his work.	<b>A - excellent.</b>
<b>Formal and language level, scope of thesis</b> <i>Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.</i> Markus' thesis shows excellent command of the English language in a scientific context. His phrasing was well chosen throughout the thesis and the thesis showed no shortcomings in formal aspects.	<b>A - excellent.</b>
<b>Selection of sources, citation correctness</b> <i>Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished</i>	<b>B - very good.</b>

## SUPERVISOR'S OPINION OF FINAL THESIS

*from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.*

Markus based his thesis upon different comparable concepts that were published in the scientific community during the last few years. He screened the very high number of publications on the topic of energy system simulation and identified a sufficient number of sources that were most relevant to his own thesis, however he could have identified a wider variety of sources overall. He correctly distinguished his own work from existing related work and cited his sources to full satisfaction.

### **Additional commentary and evaluation**

*Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.*

The goals of the thesis were achieved to full satisfaction. In some aspects the work done during the thesis goes beyond the expectations formulated in the task description. Markus showed particular proficiency in the software engineering aspects which were at the center of the thesis while also developing a good understanding for the domains of energy system simulation and mathematical optimization. Markus was always determined to identify good solutions to the issues he encountered and required minimal aid from his supervisors.

He confidently defended his thesis in a comprehensible way with excellent command of English in front of his peers and supervisors.

### **III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION**

Overall Markus proved to be a very capable and motivated student with the ability to quickly acquire expert knowledge in topics new to him. The degree of independence Markus showed in overcoming challenges of high complexity along the way is a commendable virtue.

I suggest the classification grade **A - excellent**.

Date: **26.8.2020**

Signature:

## I. IDENTIFICATION DATA

<b>Thesis name:</b>	<b>Co-Simulation of distributed flexibility coordination schemes</b>
<b>Author's name:</b>	<b>Herrn Markus Stroot</b>
<b>Type of thesis :</b>	master
<b>Faculty/Institute:</b>	Faculty of Electrical Engineering (FEE)
<b>Department:</b>	Department of Control Engineering
<b>Thesis reviewer:</b>	Daniel Wagner, MSc.
<b>Reviewer's department:</b>	Department of Control Engineering

## II. EVALUATION OF INDIVIDUAL CRITERIA

### Assignment

**challenging**

*Evaluation of thesis difficulty of assignment.*

Linear programming in of itself is a straight-forward topic. However, virtualization and co-simulation for smart energy grids for homes is not so straight forward. I believe that the topic of this thesis is sufficient in its complexity.

### Satisfaction of assignment

**fulfilled**

*Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.*

I believe the author has demonstrated his mastery of the topic worthy of an advanced degree. The main contribution was the development of co-simulation tools of smart grid entities. The main results are simply not achievable without the completion and implementation of these tools.

### Method of conception

**outstanding**

*Assess that student has chosen correct approach or solution methods.*

The theoretical preliminaries to this thesis were well organized. Figures worked well in highlighting the novel features of Mosaik and simulation architecture. Even someone unfamiliar with the topic could come understand the main highlights after a reading.

### Technical level

**B - very good.**

*Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.*

This thesis specializes in model predictive control and co-simulation of smart grid entities. With the introduction of smart-grids, the need for control schemes and simulation environment that describe the changes in the power grid throughout the day are becoming more prescient. The powerful tools provided within this thesis provide users with an easily

### Formal and language level, scope of thesis

**A - excellent.**

*Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.*

The author has demonstrated a mastery of the English language. The English in this document is perfect and the results are straight forward. The optimization problems and the notations used therein are well done and easy to read. The main results section, albeit compact, is well written and each graph is readable.

### Selection of sources, citation correctness

**B - very good.**

*Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.*

The sources used this thesis are equal parts immediate and relevant. This bibliography is well organized, but I feel like the amount of abbreviations can be reduced. The technical achievements of this author do not infringe on any sources contained therein.

**Additional commentary and evaluation**

*Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.*

The language in this thesis presents a difficult topic (for example, mixed integer linear programming) in a straightforward way that enables someone who doesn't specialize in the topic to understand. Every sentence in this document has its unique merits. I commend the author for his mastery of grammar for elucidating the main results. On page 21 the figure goes slightly outside the page margin, but I found no other issues.

**III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION**

*Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.*

Here are some of my additional thoughts:

Is the noise for power usage truly Gaussian? If so, why 700 W and 1 kW?

Some additional remarks on localized control vs. coordinated control of a neighborhood may be useful.

I evaluate handed thesis with classification grade **A - excellent**.

Date: **18.8.2020**

Signature: