

## MAIN SUPERVISOR



**Roger Renström**  
Associate Professor at  
Karlstad University

## EXAMINER



**Jonas Berghel**  
Associate Professor at  
Karlstad University

## ASSISTANT SUPERVISOR



**Lars Nilsson**  
Professor at Karlstad  
University

## ABOUT KARLSTAD UNIVERSITY

As one of the youngest universities in Sweden, we hope to be more adventurous in challenging the established and exploring the unknown.

Our ambition is to contribute to the development of knowledge at international, regional and individual levels. Thanks to our openness, creativity and multidisciplinary, we have already attained a significant level of academic achievement. All our education and research is underpinned by a close dialogue with private companies and public organizations.

16 000 students and 1 200 employees make the University an inspiring place to work and study. We offer approximately 40 Bachelor's degree programs, 30 Master's level degree programs and 900 courses in the humanities and fine arts, social and economic sciences, natural sciences, engineering and technology, health care and teacher training.



VIPP VALUES CREATED IN  
FIBRE-BASED PROCESSES  
AND PRODUCTS

## VIPP INDUSTRIAL GRADUATE SCHOOL

A PARTNERSHIP OF 14 COMPANIES IN THE PAPER AND PULP INDUSTRY AND KARLSTAD UNIVERSITY

VIPP stands for values created in fibre based processes and products and is a unique partnership in Swedish higher education. This is a long-term project financed by the Knowledge Foundation and the partner companies. The partnership was launched in 2011 and presently 18 doctoral students are busy with as many research projects. Three strong industrial graduate school environments:

- pulp, paper and graphic technology
- environment and energy
- service innovation and customer satisfaction

Here the disciplines of chemistry, chemical engineering, environmental and energy systems, physics, mechanical and materials engineering and the Service Research Center (CTF) at Karlstad University are collaborating.

The doctoral students share their time between Karlstad University and their respective company. Their academic supervisors and industrial mentors participate actively throughout the whole process.

## BOARD

**Louise Törnefalk Svanqvist**, Resultat Effekt AB, Chair  
**Erik Sundström**, SP Technical Research Institute of Sweden  
**Ivica Crnkovic**, Mälardalen University  
**Niclas Andersson**, BTG Instruments AB  
**Eva Söfting**, BillerudKorsnäs AB  
**Patrik Larsson**, Karlstad University  
**Thomas Nilsson**, Karlstad University



VIPP VALUES CREATED IN  
FIBRE-BASED PROCESSES  
AND PRODUCTS



**CHRISTER GUSTAVSSON**  
DOCTORAL THESIS DECEMBER 08, 2016

## ADDED VALUE FROM BIOMASS BY BROADER UTILIZATION OF FUELS AND CHP PLANTS

# CHRISTER GUSTAVSSON



## CONTACT INFORMATION

**Mail:** christer.gustavsson@kau.se

**Tel:** 054 700 1571, 070-584 46 68

## BIOGRAPHY

Christer Gustavsson is working as a senior process consultant for Pöyry Sweden AB with engineering and technical business development in foremost energy- and forest industry. His work focuses on novel utilization of woody biomass and on integration aspects when such utilization is co-located with existing industrial structures.

## ADDED VALUE FROM BIOMASS BY BROADER UTILIZATION OF FUELS AND CHP PLANTS

DOCTORAL THESIS  
DECEMBER 08, 2016

### ABSTRACT

Bioeconomy has been identified to hold a great potential for reducing fossil fuel dependence and for maintaining and creating economic growth. Large parts of the combined heat and power (CHP) sector, which successfully have contributed in the transition towards a fossil free society, are at present facing stagnation. District heating actors are facing challenges due to warmer climate, better insulated buildings and competition from heat pumps. The forest industry where CHP plants supplies processes with heat is facing structural changes foremost in the graphic segments.

The emerging bioeconomy and the stagnation for the existing business models in large parts of the CHP sector form the background for the examination of additional value-creating processes in the existing CHP structure presented in this thesis. The technical viability for integration of fast pyrolysis, gasification and leaching with existing CHP plants has been analysed as well as the motivation and ability of the CHP incumbents to participate in a transition towards the bioeconomy by developing their plants to biorefineries.

**ISBN nr:** 978-91-7063-727-8

**Webb:** <http://kau.diva-portal.org/smash/record.jsf?pid=diva2%3A1040047&dswid=9597>

## LIST OF PUBLICATIONS

### List of publications

- I. Gustavsson, C., Nilsson, L. (2013) Co-production of Pyrolysis Oil in District Heating Plants: Systems Analysis of Dual Fluidized-Bed Pyrolysis with Sequential Vapor Condensation. *Energy & Fuels*, 2013, 27, 5313-5319. DOI: 10.1021/ef401143v  
Addition/Correction: DOI: 10.1021/ef401966m
  - II. Gustavsson, C., Nilsson, L., Renström R. (2014) Syngas as additional energy carrier in the pulp and paper industry: A mill-wide systems analysis of a combined drying concept, utilizing on-site generated gas and steam. *Energy & Fuels*, 2014, 28, 5841-5848. DOI: 10.1021/ef5010144
  - III. Fridén, M., Jumaah, F., Gustavsson, C., Enmark, M., Fornstedt, T., Turner, C., Sjöberg, P., Samuelsson, J. (2015) Evaluation and Analysis of Environmentally Sustainable Methodologies for Extraction of Betulin from Birch Bark with Focus on Industrial Feasibility. *Green Chemistry*, 2015, 18, 516-523. DOI: 10.1039/C5GC00519A
  - IV. Gustavsson, C., Hulteberg, C. (2016) Co-production of gasification based biofuels in existing combined heat and power plants - Analysis of production capacity and integration potential. *Energy* 111 (2016) 830-840. DOI: 10.1016/j.energy.2016.06.027
  - V. Gustavsson, C., Hellsmark, H. (2016) The Role of Incumbents in the Transition towards a Bioeconomy: Motivation and Abilities of the Combined Heat and Power Sector  
Submitted for publication
- Other work by the author**
- I) Gustavsson, C., Nordgren, D., Lindberg, K. (2015) Integrering av termokemiska tillverkningsprocesser med kraftvärmeproduktion. Swedish Energy Research Centre, report 2015:111, ISBN 978-91-7673-111-6
  - II) Nilsson, L., Andreasson, R., Axelsson, B., Gustavsson, C., Malutta, R., Ottosson, A., Paulsson, P., Zottermann, C. (2016) Fossil free tissue drying. Swedish Energy Research Centre, report: 2016:231, ISBN 978-91-7673-231-1

