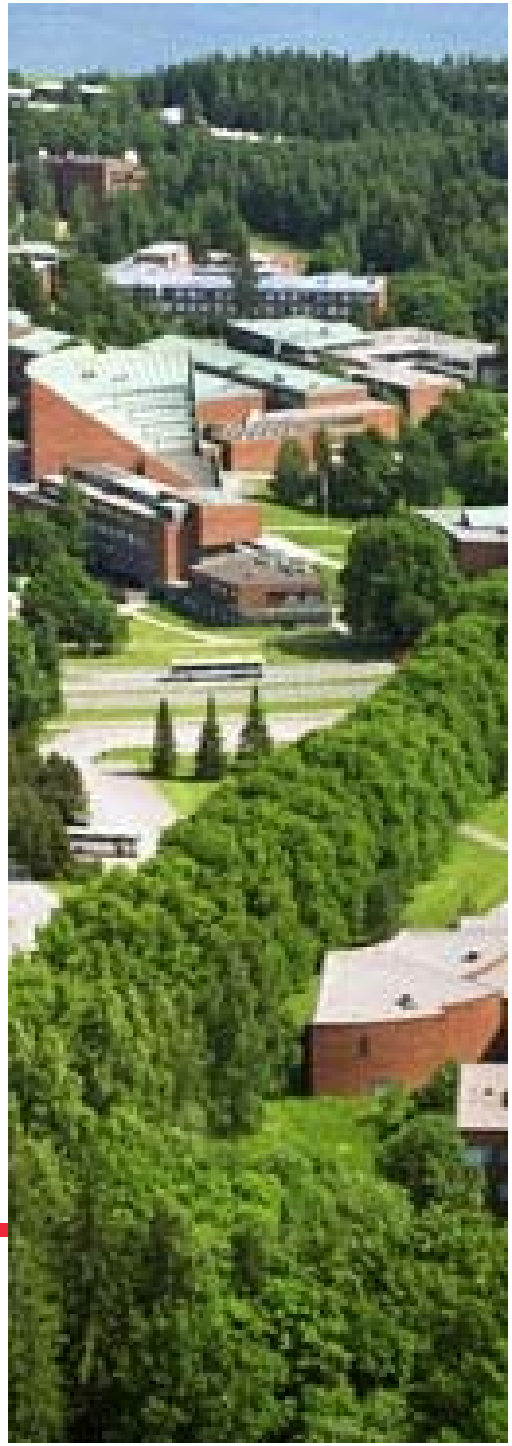
Aalto University
School of Engineering

Innovative Sustainable Energy Engineering (ISEE)

Bio Energy Track

Aalto University
Mika Järvinen



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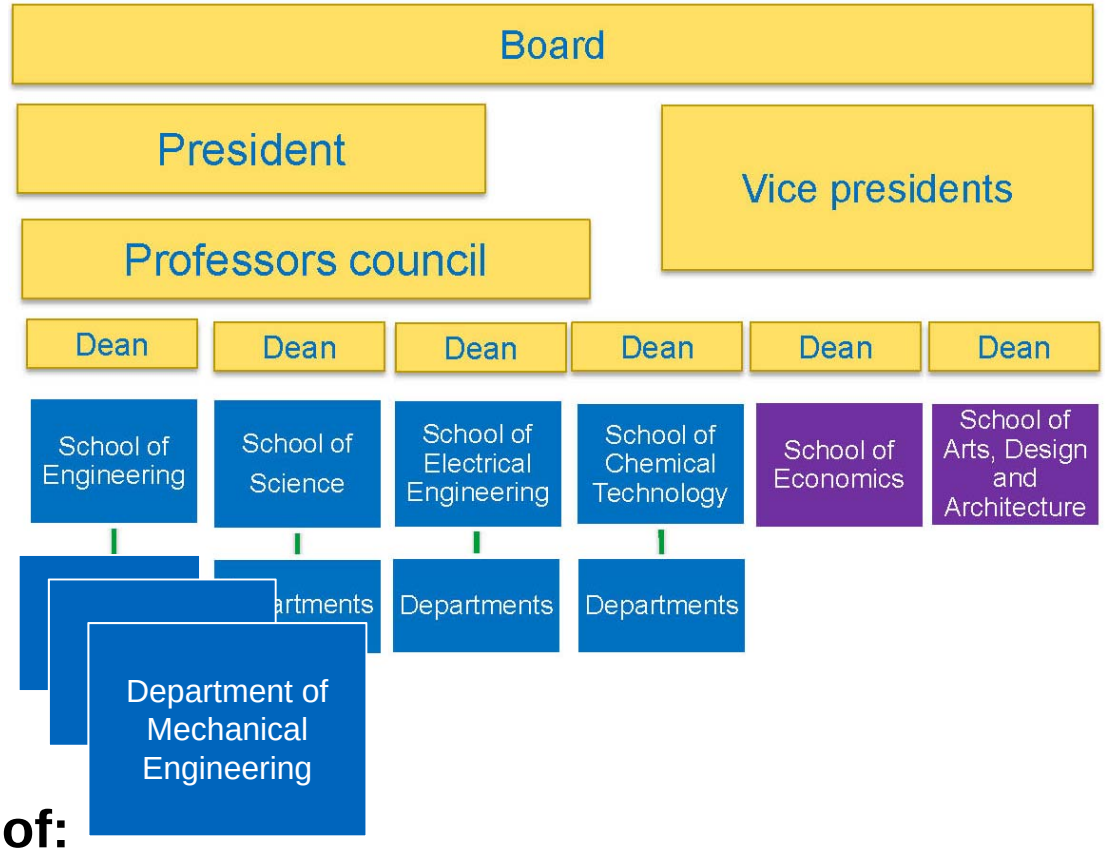
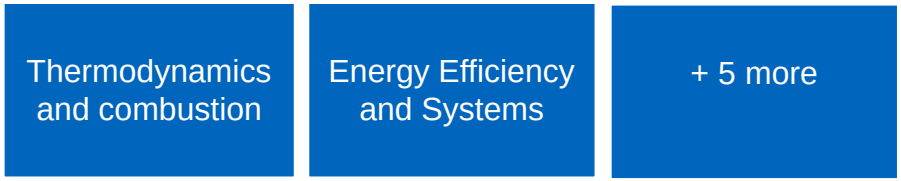


Aalto University is made of:

- **Helsinki University of Technology**
- **Helsinki School of Economics**
- **University of Art and Design Helsinki**



A? Suomeksi Search

Aalto.fi / School of Engineering / Department of Mechanical Engineering

Department of Mechanical Engineering

- Research
  - Engineering Design
  - Engineering Materials
  - Production Engineering
  - Marine Technology
  - Solid Mechanics
  - Energy Efficiency and Systems
  - Thermodynamics and Combustion Technology
  - Publications
- Studies
- ADD
- Design Factory
- AIC

Department of Mechanical Engineering

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STUDIES

Greater freedom of choice with new master's degree programmes

#Aalto:n alumnit kehittivät yhdessä Finlaysonin, @VTTFinland:in ja Flexbright Oy:n kanssa mahtavan

RESEARCH

Heat treatment improves the cracking resistance of nickel-based alloy

Energy at Aalto ENG

Mission

- To develop environmentally friendly processes that have a **higher energy & material efficiency** and to **reduce the end-use of energy**

Strategic focus areas, two larger research units

- A. Energy efficiency and systems EES, 4 professors
- B. Thermodynamics and combustion technology TCT, 3 professors

ENERGY RESEARCH

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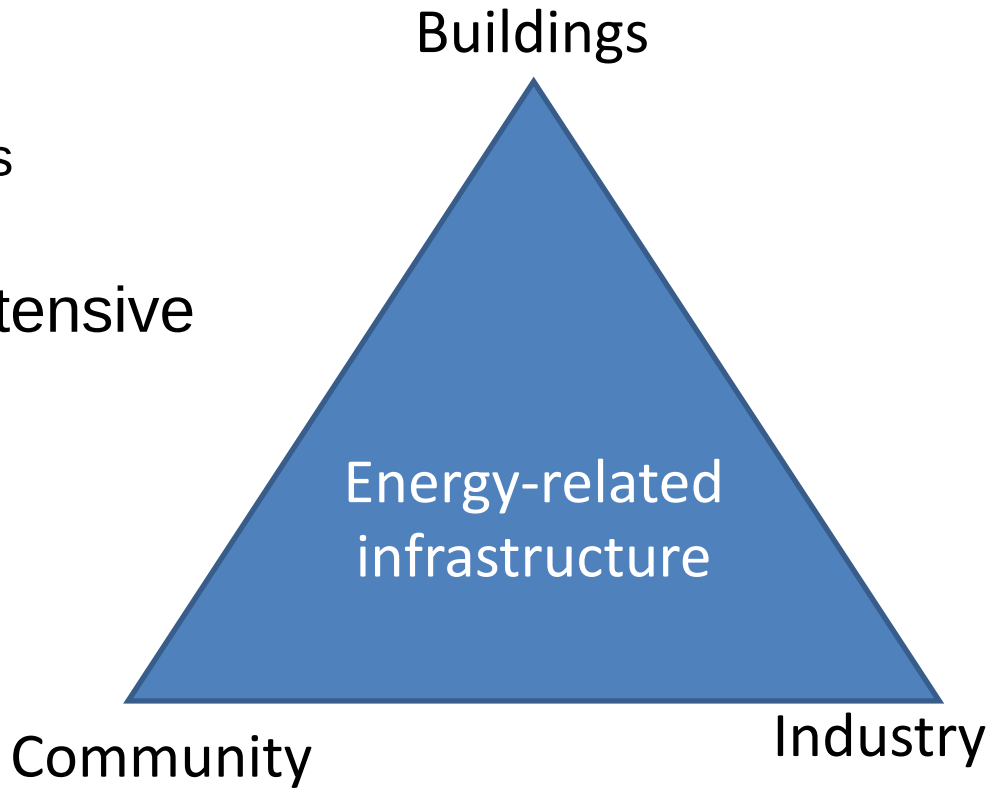
A. Energy efficiency and systems (EES)

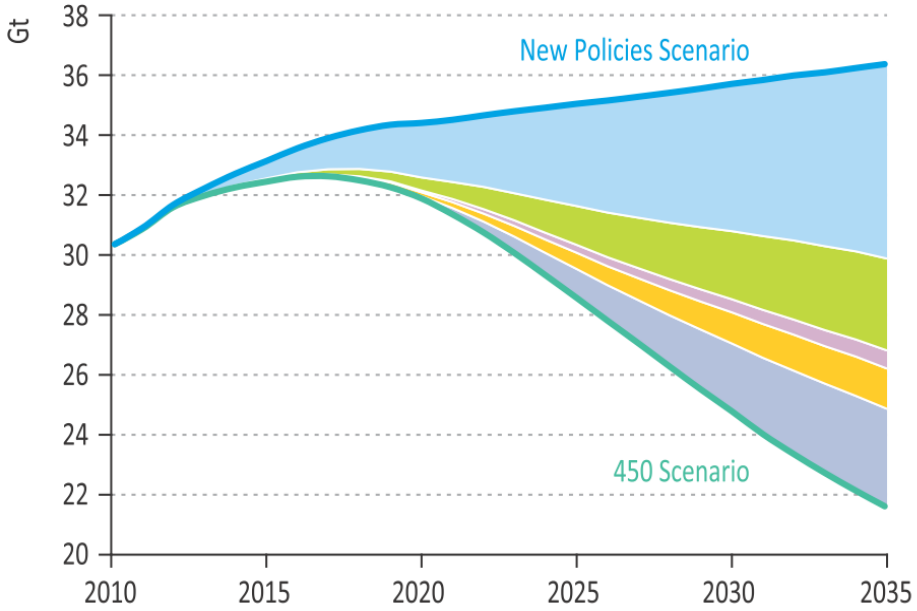
- Energy efficiency must be improved on all sectors
- A systemic approach
  - not just isolated solutions
- Integration of energy-intensive processes in
  - buildings
  - communities
  - industry, and
  - across them



EES – Research challenges

- Improving the energy efficiency is by far the most important means for CO_2 emission abatement

World energy-related CO_2 emissions abatement in the 450 Scenario relative to the New Policies Scenario



	Abatement	
	2020	2035
Efficiency	72%	44%
Renewables	17%	21%
Biofuels	2%	4%
Nuclear	5%	9%
CCS	3%	22%
Total (Gt CO_2)	2.5	14.8

Energy efficiency and systems

- Research topics
  - Drying in industrial processes, mainly drying of biofuels
  - Combined heat, power and cooling production (poly-generation)
  - Integration of energy solutions for industry and communities
  - Zero-energy buildings, HVAC
  - National and global energy system modelling and optimization

- Major activities
  - Doctoral Program on Energy Efficiency and Systems (EES)
    - Aalto, UH, VTT, ÅA, JYU, LUT, TUT, UO, UVA
  - Aalto Energy Efficiency Initiative
    - Several projects

B. Thermodynamics and combustion (TC)

Relevance of research

- Significant part of world energy is based on combustion and gasification, we need to improve these further.
- Emission reduction and increased energy efficiency.
- Promoting the use of new bio-based/renewable fuels.

The research combines theoretical, experimental and computational methods

- Theory basis lays in thermodynamics.
- Computational fluid dynamics (CFD) and advanced process simulators are necessary tools for analysing the complicated physical phenomena of combustion technology.
- Advanced experimental methods.

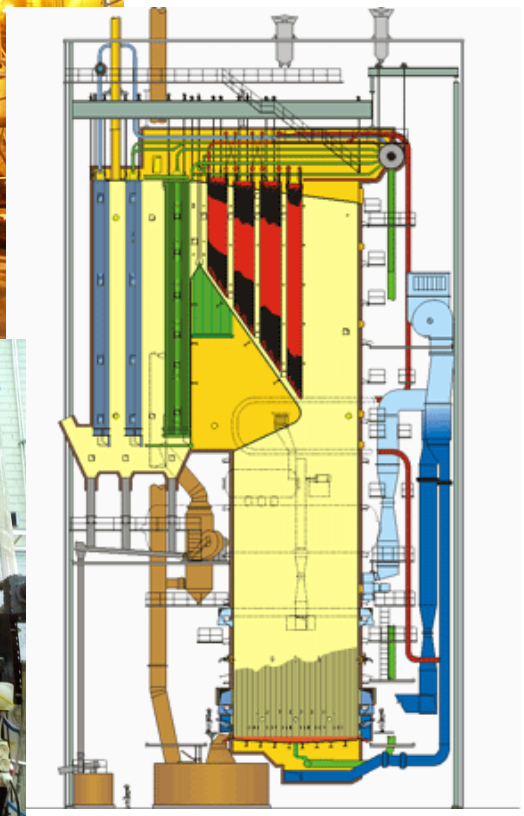
Energy engineering and environmental protection

Topics

- Black Liquor Spraying and Combustion in **Recovery boilers**, **Biomass** and **Waste** and **CSS**
- Simulation and optimization of different conversion processes, power plants, combustion, metallurgy

Resources

- 1 Professor (M. Järvinen)
- 2-3 Post-docs, 4-6 doctoral students, 2-4 Master's thesis workers

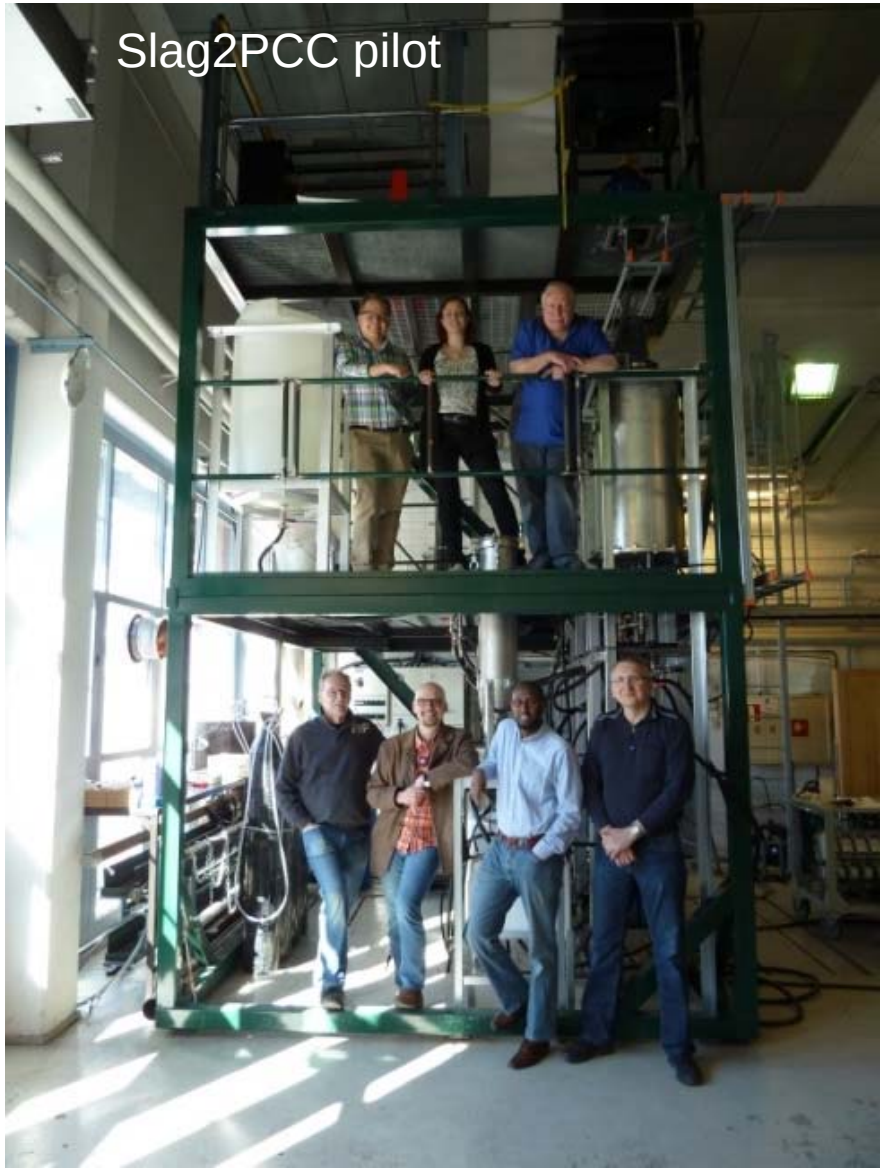


Main Partners

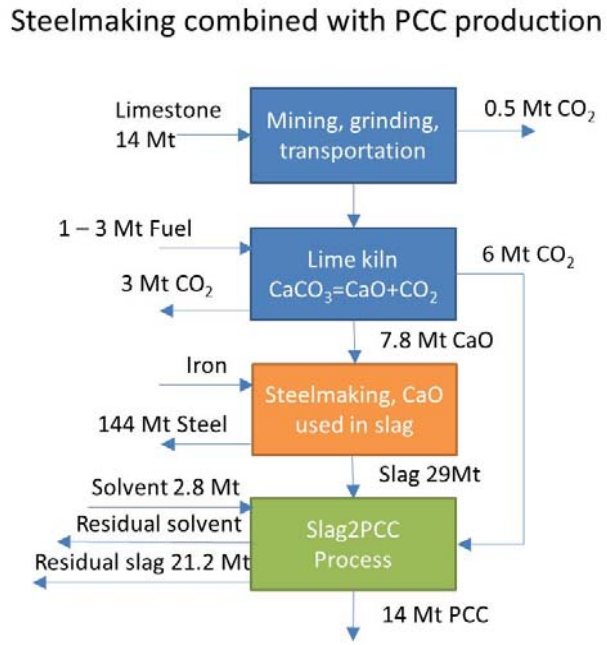
- Fortum, Andritz, Valmet, Outokumpu, SSAB, Energy industry
- ÅA, TUT, JYU, VTT, Univ. Oulu, etc.

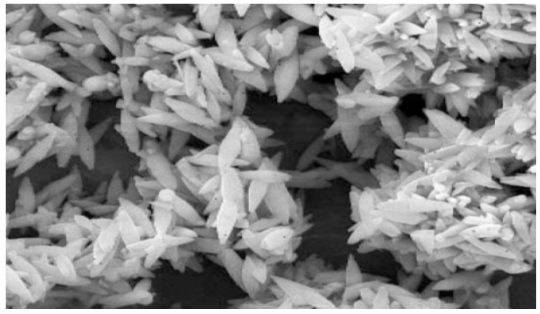
Infrastructure

- **Slag2PCC** pilot plant, **CFB Waste gasifier**, spraying chambers etc.
- Image Analysis systems, High Speed video and Thermal Cameras



Principles of Slag2PCC process





- Ammonium chloride water solution is used to dissolve calcium from the slag or other Ca-containg powder with 0.25 mm particle size.
- Filtering of the mixture to get a clean solution.
- CO_2 is bubbled through this clean calcium rich solution and as product of reaction we get precipitated calcium carbonate PCC.
- Produced PCC can be sold to paper, plastic or medical industry.
- Annual global PCC need 14 Mt heavily increasing.

RESONATE AWARD 2015

http://resnick.caltech.edu/awards-winners2015.php

Caltech

RESNICK INSTITUTE
science + energy + sustainability

Mika Järvinen

Resonate Award recipient for pioneering a CO2 sequestration process that converts a low-value steel-manufacturing by-product into a valuable resource for industry.

Mika Järvinen is an Associate Professor in the Department of Energy Technology at Aalto University and an Academy of Finland Research Fellow. His team's Resonate Award winning process sequesters CO2 by mineral carbonation using steel slag (a by-product of steelmaking) as raw material. Järvinen's Doctoral student Arshe Said worked as the main researcher on this project. Using waste slag and CO2 flue gas as resources, the team's process yields high valued precipitated calcium carbonate (PCC), which is useful to many industries. Järvinen is a graduate of the Department of Energy Technology at Lappeenranta University of Technology. Prior to his postdoctoral studies in the Aalto University, he worked at the Ahlstrom Machinery Corporation as a research engineer. In addition to carbon capture and storage by mineral carbonization, Järvinen's group researches biomass combustion, circulating fluidized bed gasification of waste, and advanced modeling of industrial processes, mainly for energy and metallurgical applications.

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Research in engines by CFD and experiments

Topics:

- Engine Combustion Technology
- Sprays and Jets & Mixture formation
- Future Fuels
- Simulation tools (LES)

Resources:

- 2 Professors (Larmi, Vuorinen)
- 3 Post-docs/ several doctoral students

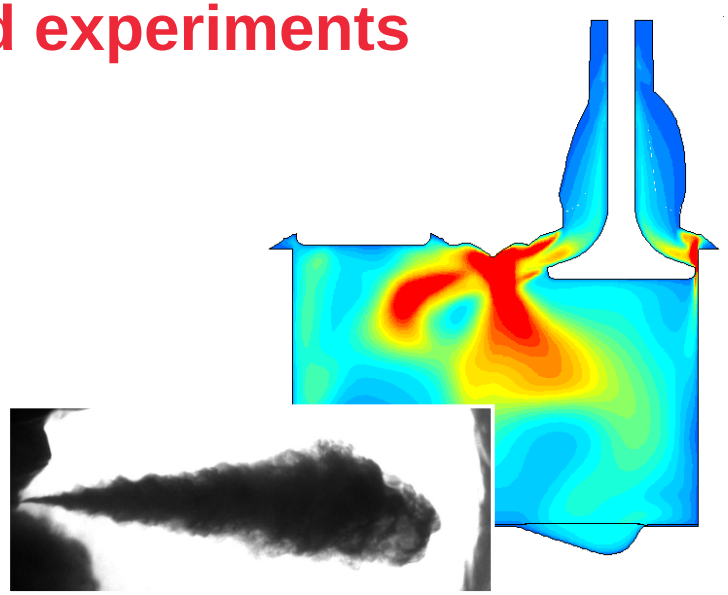
Main Partners:

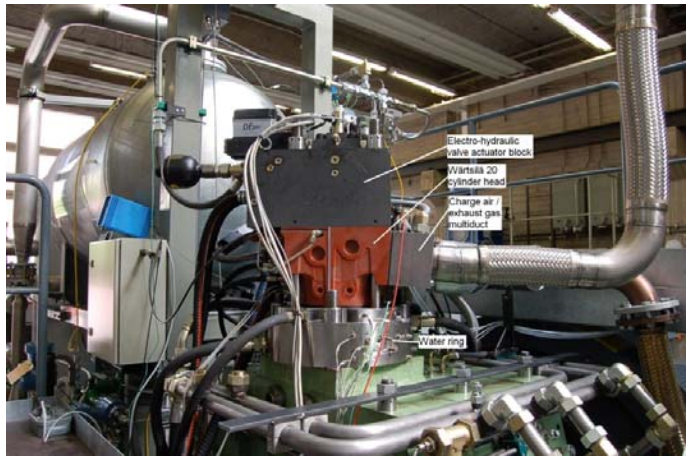
- Swiss and Swedish Universities
- Engine industry, Marine and Off-road

Infrastructure:

- Optical engine, Spray bombs
- Single cylinder research engines
- Laser diagnostics tools

Other: IEA Combustion Agreement Activity





Applied Thermodynamics

Research topics

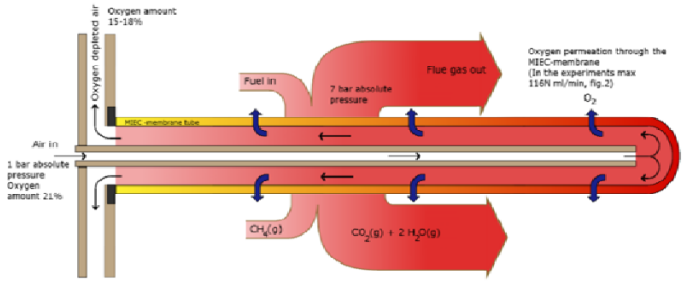
- Theory of exergy analysis for complex systems
- Nanofluids in heat transfer and in heat storages
- Nanotechnology in heat isolation
- Glucose driven fuel cell
- Intensified oxidation processes with effective power generation
- District heating systems

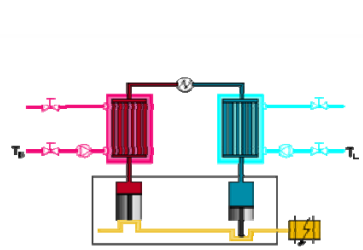
Resources

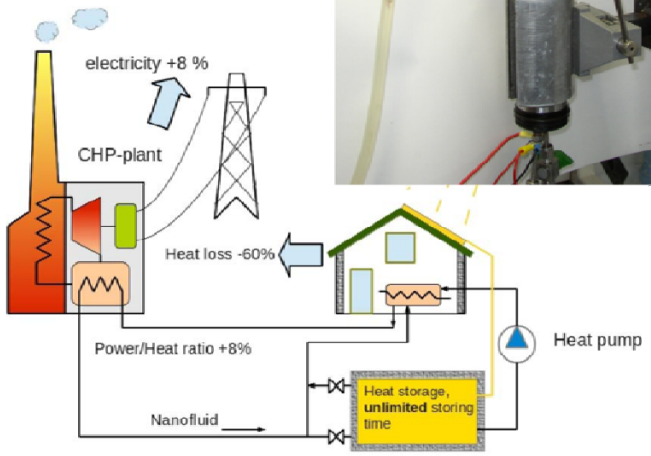
- Professor (Lampinen)
- 3 Post-docs/ several doctoral students

Main Partners

- Fraunhofer Institute, Germany
- Arrhenius Laboratory, Stockholm
- Oy Outotec, Finland







STUDIES

Bio Energy Track in the ISEE Program

	Possible Study Tracks for the new ISEE Program					
Nr.	**Study track name**	**Responsible University for the planning phase**	**The first year** Basic master courses, Specializations		**The second year** Specialization courses, Master thesis	
			Where?	What?	Where?	What?
1	*Solar Energy?*	**NTNU**	DTU	Sustainable Energy – Energy Savings, Solar Energy	NTNU	Solar Energy Materials
2	*Wind Energy?*	**DTU**	NTNU	Sustainable Energy – Smart Grid	DTU	Wind Energy
3	*Heat and Power engineering?*	**Chalmers**	HI	Sustainable Energy – Thermal Energy	Chalmers	Heat and Power Engineering
4	*Geothermal Energy?*	**HI**	Chalmers	Sustainable Energy – Power Generation	HI	Geothermal Energy
5	*Bio Energy?*	**Aalto**	KTH	Sustainable Energy – Power Generation	Aalto	Bio Energy
6	*Energy Systems?*	**KTH**	Aalto	Sustainable Energy – Energy Systems	KTH	Energy Systems/ Energy Efficiency

Bio Energy track (Aalto University)

Bio Energy track at Aalto University for second year includes following topics:

- ***The basics of bio-fuel production principles***
- ***Sustainable production of power from biomass***
- ***Principles, planning, structure and operation of bio-boilers***
- ***Combustion and gasification techniques in different types of boilers***
- ***The use and usability and combustion of bio-derived fuels in transport***
- ***On-road, off-road and marine transport***

Goal of Bioenergy track (Aalto University)

The goal of bio energy track is to provide state-of-the-art education in the fields of:

- **Biofuel production, use, combustion and relevant environmental aspects.**
- **Sustainable power generation from biomass and waste**
- **1st year in KTH, 2nd year in Aalto**

Sustainable Energy-Power Generation in KTH

First Semester (Autumn term):

Essential Courses: (33 cr)

MJ1402 Introduction to Energy Technology (3 ETCS)
MJ2411 Renewable Energy Technology (6 ETCS)
MJ2405 Sustainable Power Generation (9 ETCS)
MJ2407 Sustainable Energy Utilization (9 ETCS)
MJ2413 Energy and Environment (6 ETCS)

Elective courses (list 1):

MJ2438 Modeling of Energy Systems-Heat and Power Generation, 6 ECTS
MJ2470 Climate Change Mitigation Tools, 6 ECTS
MJ 2473 Energy Policy Design, 6 ECTS

Sustainable Energy-Power Generation in KTH

Second Semester (Spring term):

Essential Courses: (24 ETCS)

MJ2424 Computational Methods in Energy Technology (6 ETCS)
MJ2410 Energy Management (6 ETCS)
MJ2426 Applied heat and power technology (6 ETCS)
MJ2412 RET Advanced course (6 ETCS)

Elective courses (list 1):

MJ2438 Modeling of Energy Systems-Heat and Power Generation, 6 ECTS
MJ2470 Climate Change Mitigation Tools, 6 ECTS
MJ 2473 Energy Policy Design, 6 ECTS

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School of Engineering

Bio Energy Track (Power Generation from Biomass module), Mika Järvinen

Third Semester (Autumn term): (30 ECTS)

Mandatory Courses: (25 ECTS)

EEN-E2005 Bioenery I (5 ETCS), I
EEN-E2006 Bioenery II (5 ETCS), II
EEN-E2007 Energy, Environment and Emission Control (5 ECTS), II
EEN-E1050 Renewable Energy for Communities and Industry (5 ECTS), I
EEN-E3007 Process Integration and Energy Optimization (5 ECTS), II

Elective courses: (5 ECTS)

PHYS-C6370 Fundamentals of New Energy Sources (5 ECTS) (I-II)
EEN-E1010 Power Plants and Processes (5 ECTS) (I-II)
EEN-E3006 Energy Markets (5 ECTS), (I)
EEN-E9010 Energy Project (5 ECTS) (I-II)
Kie-98.1114 Communicating Technology (3 ECTS) (I-II, III-IV, IV-V)
Kie-98.1115 Persuasive Communication (3 ECTS) (I-II, III-IV, IV-V)
Kie-98.1410 Industrial Communications (3-5 ECTS) (III)

Fourth Semester (Spring term): (30 ECTS)

Thesis work

ISEE Program - Energy System Track

Possible Study Tracks for the new ISEE Program						
Nr.	**Study track name**	**Responsible University for the planning phase**	**The first year** Basic master courses, Specializations		**The second year** Specialization courses, Master thesis	
			Where?	What?	Where?	What?
1	*Solar Energy?*	**NTNU**	DTU	Sustainable Energy – Energy Savings, Solar Energy	NTNU	Solar Energy Materials
2	*Wind Energy?*	**DTU**	NTNU	Sustainable Energy – Smart Grid	DTU	Wind Energy
3	*Heat and Power engineering?*	**Chalmers**	HI	Sustainable Energy – Thermal Energy	Chalmers	Heat and Power Engineering
4	*Geothermal Energy?*	**HI**	Chalmers	Sustainable Energy – Power Generation	HI	Geothermal Energy
5	*Bio Energy?*	**Aalto**	KTH	Sustainable Energy – Power Generation	Aalto	Bio Energy
6	*Energy Systems?*	**KTH**	Aalto	Sustainable Energy – Energy Systems	KTH	Energy Systems/ Energy Efficiency

Academic year (2017-2018) - Aalto University
ISEE - Energy Systems Track

First Semester (Autumn term): (30 ETCS)

Mandatory Courses: (20 ETCS)

EEN-E1050 Renewable Energy for Communities and Industry (5 ECTS), I

EEN-E2007 Energy, Environment and Emission Control (5 ECTS), II

EEN-E1010 Power Plants and Processes (5 ECTS), I-II

EEN-E3007 Process Integration and Energy Optimization (5 ECTS), II

MS-E2140 Linear programming (5 ECTS), I

Elective courses- list 1: (10 ETCS)

PHYS-E6572 Advanced Wind Power Technology (5 ECTS) (I-II) (alternate years, lectured in autumn 2016)

PHYS-C6370 Fundamentals of New Energy Sources (5 ECTS) (I-II)

EEN-E2005 Bioenergy I (5 ECTS) (I)

EEN-E2006 Bioenergy II (5 ECTS) (II)

EEN-E3006 Energy Markets (5 ECTS), (I)

Academic year (2017-2018) - Aalto University
ISEE - Energy Systems Track

Second Semester (Spring term): (30 cr)

Mandatory Courses: (20 ETCS)

EEN-E3002 Power process simulation (5 ECTS), III

EEN-E3001 Fundamentals of industrial energy engineering (5 ECTS), III

PHYS-E0483 Advances in New Energy Technologies (5 ECTS), III- IV

31C01300 Energy and Environmental Economics (6 ECTS), V

Elective courses- list 2: (10 ETCS)

EEN-E3004 District heating and cooling (5 ECTS), V

PHYS-C1380 Multi-disciplinary energy perspectives (5 ECTS), III-V

PHYS-E6570 Solar Energy Engineering (5 ECTS), III- IV, (alternate years, lectured in spring 2016)

CHEM-E5145 Materials for Renewable Energy P (5 ECTS), III–V

EEN-E3005 Exercises in Energy Technology (5 ECTS), IV-V

ISEE Program – Heat & Power Track

Possible Study Tracks for the new ISEE Program						
Nr.	**Study track name**	**Responsible University for the planning phase**	**The first year** Basic master courses, Specializations		**The second year** Specialization courses, Master thesis	
			Where?	What?	Where?	What?
1	*Solar Energy?*	**NTNU**	DTU	Sustainable Energy – Energy Savings, Solar Energy	NTNU	Solar Energy Materials
2	*Wind Energy?*	**DTU**	NTNU	Sustainable Energy – Smart Grid	DTU	Wind Energy
3	*Heat and Power engineering?*	**Chalmers**	**Aalto**	Sustainable Energy – Thermal Energy	Chalmers	Heat and Power Engineering
4	*Geothermal Energy?*	**HI**	Chalmers	Sustainable Energy – Power Generation	HI	Geothermal Energy
5	*Bio Energy?*	**Aalto**	KTH	Sustainable Energy – Power Generation	Aalto	Bio Energy
6	*Energy Systems?*	**KTH**	Aalto	Sustainable Energy – Energy Systems	KTH	Energy Systems/ Energy Efficiency

Academic year (2017-2018) - Aalto University
ISEE – Heat & Power Track

First Semester (Autumn term): (25 ETCS)

Mandatory Courses: (15 ECTS)

EEN-E2005 Bioenergy I (5 ETCS), I
EEN-E2006 Bioenergy II (5 ETCS), II
EEN-E2007 Energy, Environment and Emission Control (5 ECTS), II

Elective courses- list 1: (10 ETCS)

EEN-E1050 Renewable Energy for Communities and Industry (5 ECTS), I-II
EEN-E3006 Energy Markets (5 ECTS), I
EEN-E9010 Energy Project (5 ECTS), I-II
PHYS-E6572 Advanced Wind Power Technology (5 ECTS) (alternate years, lectured autumn 2016), I-II
PHYS-C6370 Fundamentals of New Energy Sources (5 ECTS)

Academic year (2017-2018) - Aalto University
ISEE - Energy & Power Track

Second Semester (Spring term): (36 ECTS)

Mandatory courses: (26 ECTS)

EEN-E2002 Combustion Technology (5 ECTS), III
PHYS-E0483 Advances in New Energy Technologies (5 ECTS), III-IV
EN-E3005 Exercises in Energy Technology (5 ECTS), IV-V
31C01300 Energy and Environmental Economics (6 ECTS), V
EEN-E3004 District heating and cooling (5 ECTS), III

Elective courses- list 2: (10 ETCS)

PHYS-E6570 Solar Energy Engineering (5 ECTS) (alternate years, lectured in spring 2016), III - IV
EEN-E2001 Computational Fluid Dynamics (5 ECTS), III-IV
PHYS-C1380 Multi-disciplinary energy perspectives (5 ECTS), III-IV
CHEM-E5145 Materials for Renewable Energy P (5 ECTS), III-IV

EXAMPLE OF STUDENT PROJECT

GASCOW

CREATING YOUR OWN JOB

Aalto University
School of Engineering

Aalto University
School of Engineering

GASCOW

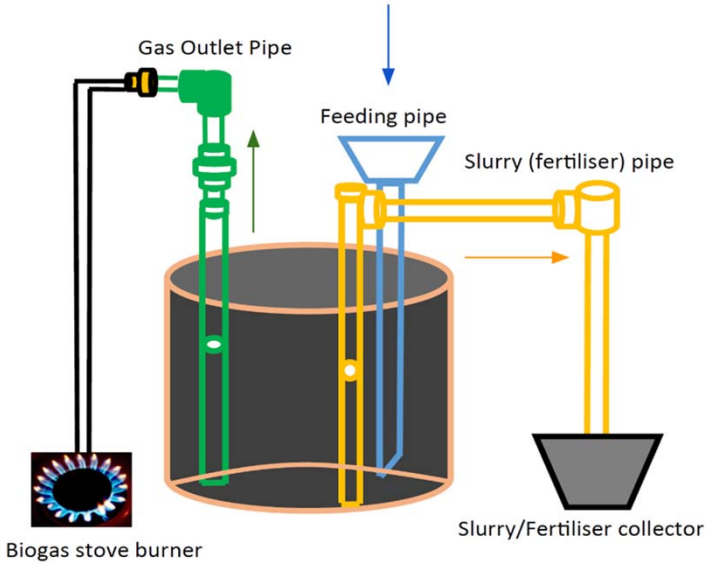
Reliable Biogas Service

hello@gascow.com

Department of Mechanical Engineering, School of Engineering

TECHNOLOGY

- Based on anaerobic digestion from local organic waste
- For small scale biogas production and service
- Prototype funded by Department of Mechanical Engineeing, Aalto University, since mid-2016



PROTOTYPE

FUTURE SERVICE

GASCOW

Service

Biogas for cooking

Organic waste

Local Restaurants/Hotels

Subscription fee

Contact information:

Academic staff:

- **Prof. Mika Järvinen (mika.jarvinen@aalto.fi)**
- **Dr. Loay Saeed (loay.saeed@aalto.fi)**

Administrative coordinator:

- **Borje Helenius (borje.helenius@aalto.fi)**

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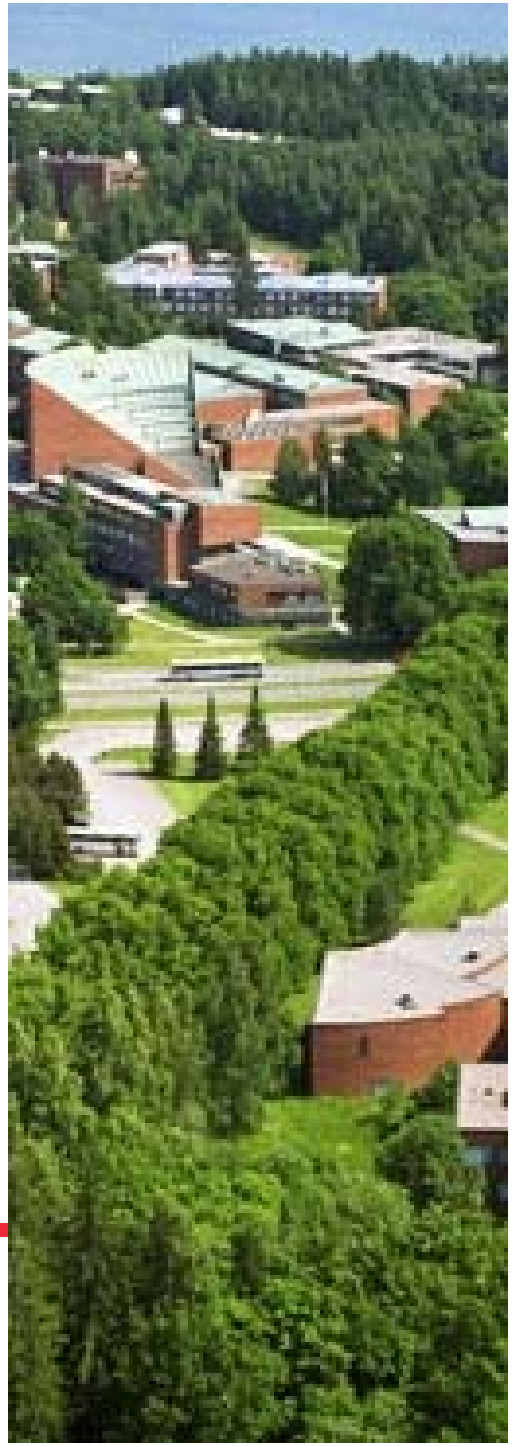
See you later at Aalto University

Thank you!



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