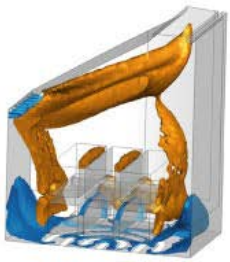
WoodCFD

Clean and efficient wood stoves through improved batch combustion models and CFD modelling approaches



Newsletter 1-2017

Introduction

The WoodCFD project is proceeding as planned, focusing on achieving the overall objective, which is development of clean and efficient wood stoves through improved batch combustion models and CFD modelling approaches through:

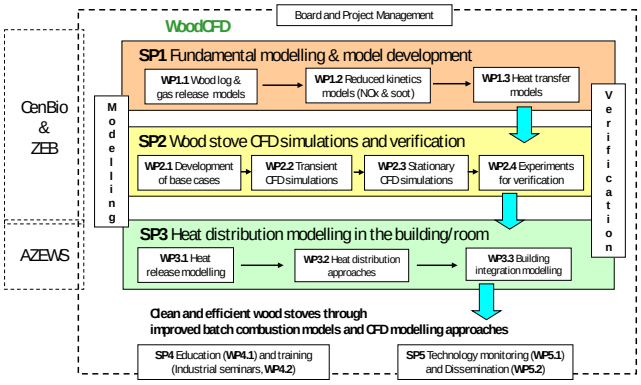
- Model development: improved transient wood log and gas release models, transient heat transfer and storage models, reduced kinetics models (NOx and soot), and transient models and approaches for heat distribution in the building; and verification of these
- Simulations: transient and stationary CFD simulations of wood stoves, and room and building integration simulations; and verification of these

The sub-objectives are:

- Develop improved sub models to be included in the CFD simulations
- Develop a numerical tool that is suitable to study concept improvements for wood stoves and to recommend new improved concepts with respect to high energy efficiency and low emissions based on simulation results
- Develop improved transient heat distribution models - giving reliable prediction of the effect of various heat transfer concepts in buildings and providing design guidelines for optimum wood stoves for tomorrows (energy efficient) buildings
- Education of highly skilled candidates within this area and training of industry partners
- Monitoring of activities and state-of-the-art within this area and dissemination of knowledge to the industry partners, and other interested parties when applicable

The anticipated results of the project are clean and efficient wood stoves through improved batch combustion models and CFD modelling approaches. Improved models and modelling approaches, in combination with targeted experiments, are keys in the development of future's downscaled clean burning and energy efficient wood stoves. This will have a potentially huge impact on the most important bioenergy value chain in Norway today, targeting key bottlenecks in the value chain, i.e. reducing today's still relatively high emissions from wood stoves and improving their energy efficiency, especially in low load wood stoves, as well as ensuring optimum room and building integration.

The Work Breakdown Structure of WoodCFD is:



WoodCFD will run for four years (2015-2018) and has a total budget of 17.5 million NOK which is 80% financed by the Research Council of Norway through the ENERGIX program and 20% financed by the industrial partners Jøtul AS, Dovre AS, Norsk Kleber AS, Morsø Jernstøberi A/S.

Progress in 2017

In 2017 the work has focused on testing of developed sub-models in CFD simulations, and the PhD candidate focus on further development of the decomposition model for wood logs. The thermal comfort work so far in 2017 has focused on experimental activity to provide detailed data for further development and validation of models.

- a Knowledge-building Project for Industry (KPN) co-funded by the Research Council of Norway through the ENERGIX-programme.

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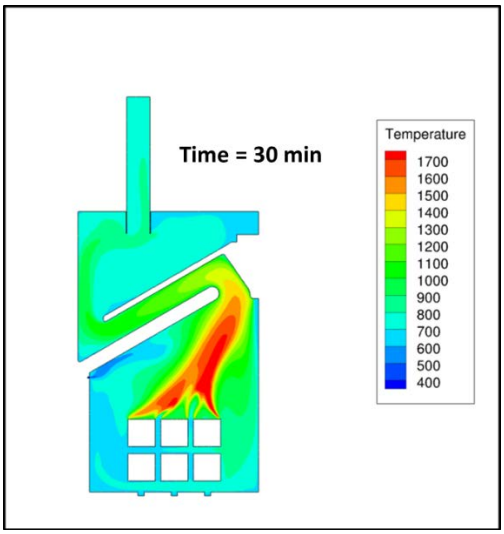
The work with the sub-models, also for stationary CFD simulations, was continued in 2016. The employed PhD candidate in the project focus on development of a thermal decomposition model for wood logs. In parallel work is ongoing regarding improvement of models and tools used for simulation of thermal comfort in energy effective buildings with wood stoves. In 2015 the scientific focus was on initial studies and establishment of sub-models for use in transient CFD simulations, as well as modelling of heat transfer in stoves and analysis of heat distribution to other rooms in a building.

WoodCFD at 25th European Biomass Conference & Exhibition

Four WoodCFD or connected works were presented at the 25th EUBCE conference in Stockholm, Sweden, 12-15 June 2017:

1) Transient CFD simulations of wood log combustion in a wood stove, presented by Øyvind Skreiberg
2) Numerical simulation of devolatilization of wood logs and pressure generation in the wood log center, presented by Inge Haberle
3) Performance evaluation of a modern wood stove when using charcoal, presented by Alexis Sevault
4) Coupled ventilation system and wood logs-stove for use in low energy dwellings: an investigation using dynamic energy simulations, presented by Axel Cable



Transient CFD simulations of wood log combustion

WoodCFD at CenBio Final Conference

Øyvind Skreiberg gave a presentation at the CenBio Final Conference in Ås, Norway, 13-14 March 2017. The title of the presentation was "The ultimate wood stove".

WoodCFD at ICAE 2016. Papers now published in Energy Procedia

WoodCFD related work was presented at the 8th International Conference on Applied Energy in Beijing, China, 8-11 October 2016. Two papers were presented by Morten Seljeskog, with the titles "Variables affecting emission measurements from domestic wood combustion" and "Recommended revisions of Norwegian emission factors for wood stoves". The papers have now been published in Energy Procedia.

WoodCFD at the upcoming 9th International Conference on Applied Energy

Three WoodCFD works have been accepted for presentation at the 9th International Conference on Applied Energy in Cardiff, United Kingdom, Aug 21-24, 2017:

1) Performance Evaluation of a Modern Wood Stove Using Charcoal
2) Comparison of numerical efficiency of the thermal and the kinetic rate drying model applied to a thermally thick wood particle
3) Wood stove material configurations for increased thermal comfort

WoodCFD at the upcoming Cold Climate HVAC 2018

Two WoodCFD works have been accepted for presentation at Cold Climate HVAC 2018 in Kiruna, Sweden, 12-15 March 2018:

1) Validation of a zonal model to capture the detailed indoor thermal environment of a room heated by a wood stove
2) Assessment of the effects of using wood stoves on indoor air quality in two types of Norwegian houses

PhD work

The PhD work "Numerical simulations of the transient behavior of wood log decomposition and combustion" is progressing. The candidate, Inge Haberle from Austria, has good progress in her research work, focusing on modelling of the thermal decomposition of thermally thick biomass particles.

WoodCFD publications

Mette Bugge, Nils E. L. Haugen, Øyvind Skreiberg (2017). Transient CFD simulations of wood log combustion in a wood stove. Presented at the 25th European Biomass

Conference & Exhibition (**EUBCE**), 12-15 June 2017, Stockholm, Sweden.

Inge Haberle, Øyvind Skreiberg, Nils Erland L. Haugen (2017). Numerical simulation of devolatilization of wood logs and pressure generation in the wood log center. Presented at the 25th EUBCE.

Alexis Sevault, Roger Khalil, Bjørn Christian Enger, Øyvind Skreiberg, Franziska Goile, Liang Wang, Morten Seljeskog, Rajesh Kempegowda (2017). Performance evaluation of a modern wood stove when using charcoal. Presented at the 25th EUBCE.

A. Cablé, L. Georges, P. Peigné, Ø. Skreiberg, K. Chetehouna (2017). Coupled ventilation system and wood logs-stove for use in low energy dwellings: an investigation using dynamic energy simulations. Presented at the 25th EUBCE.

Morten Seljeskog, Alexis Sevault, Asbjørn Østnor, Øyvind Skreiberg (2017). Variables affecting emission measurements from domestic wood combustion. Energy Procedia 105(May 2017):596-603.

Morten Seljeskog, Franziska Goile, Øyvind Skreiberg (2017). Recommended revisions of Norwegian emission factors for wood stoves. Energy Procedia 105(May 2017):1022-1028.

Øyvind Skreiberg (2017). The ultimate wood stove. CenBio Final Conference, 13-14 March, Ås, Norway.

Øivind Lie, Simen Gjølsjø, Øyvind Skreiberg (2017). Maks varme av veden. Hytteliv 1/2017:46-48.

Kolbeinn Kristjansson, Erling Næss, Øyvind Skreiberg (2016). Dampening of wood batch combustion heat release using a phase change material heat storage: Material selection and heat storage property optimization. Energy 115:378-385.

Jacob Hadler-Jacobsen (2016). A model for pyrolysis of thermally thick wood particles. SINTEF Summer Job Project report. Supervisors: Nils Erland L. Haugen, Øyvind Skreiberg

Eivin Dyvik Sellevold (2016). Modeling of indoor environment of building heated using wood stoves. NTNU Master thesis. Main supervisor: Laurent Georges, Co-supervisor: Øyvind Skreiberg

Guangyu Cao, Laurent Georges, Øyvind Skreiberg, Morten Seljeskog (2016). An experimental study on how a wood stove affects the indoor air quality when used as the main source of heating in two representative Norwegian dwellings, one modern and one old. Indoor Air 2016, 3-8 July 2016, Ghent, Belgium.

Morten Seljeskog, Alexis Sevault, Birger Rønning, Magnus Rishaug, Asbjørn Østnor, Øyvind Skreiberg (2016). Variables affecting particulate emissions from residential wood combustion – simultaneous sampling on hot and ambient filter. 20th ETH-Conference on Combustion Generated Nanoparticles, 13-16 June 2016, Zurich, Switzerland.

Øyvind Skreiberg, Mette Bugge, Morten Seljeskog, Nils Erland L. Haugen, Inge Haberle, Laurent Georges (2016). Computational Fluid Dynamics as an Efficient Design Tool for Wood Stoves. 24th European Biomass Conference and Exhibition, 6-9 June 2016, Amsterdam, The Netherlands.

Joanna Polak, Guangyu Cao, Laurent Georges, Øyvind Skreiberg (2016). Experimental study of the airflow distribution inside and between two zones with temperature differences with an air curtain system. Proceedings of CLIMA 2016, 22-25 May 2016, Ålborg, Denmark.

Laurent Georges, Øyvind Skreiberg (2016). Simple Modelling Procedure for the Indoor Thermal Environment of Highly Insulated Buildings Heated by Wood Stoves. Journal of Building Performance Simulation 9(6):663-679.

Joanna Lazar, Nils Erland L. Haugen, Jonas Kruger, Andrzej Szlek (2016). Numerical Study of Hydrogen Inhibition of Char Gasification Using Detailed Hetero- and Homogeneous Chemical Kinetics. Energy & Fuels 30(6):4411-4418.

Philipp Betchart (2015). Viscosity measurements. NTNU Project thesis. Main supervisor: Erling Næss, Co-supervisor: Kolbeinn Kristjansson

Eivin Sellevold (2015). Modelling the indoor thermal environment in passive houses heated by wood stoves. NTNU Project thesis. Main supervisor: Laurent Georges, Co-supervisor: Øyvind Skreiberg

Joanna Polak (2015). Experimental study of the airflow distribution in a room with heating equipment. NTNU Master thesis. Main supervisor: Guangyu Cao, Co-supervisors: Laurent Georges, Øyvind Skreiberg

Laurent Georges, Morten Seljeskog, Øyvind Skreiberg (2015). En balansert kombinasjon av stråling og konveksjon gir best komfort. Varmenytt 4-2015, p. 22.

Øyvind Skreiberg, Mette Bugge, Morten Seljeskog, Nils Erland L. Haugen, Laurent Georges (2015). CFD as an efficient design tool for wood stoves. Expert workshop on Highly efficient and clean wood log stoves, IEA Bioenergy Task 32, 29 October 2015, Berlin, Germany.

Laurent Georges, Øyvind Skreiberg (2015). Wood stoves for future's energy efficient buildings. Expert workshop on Highly efficient and clean wood log stoves, IEA Bioenergy Task 32, 29 October 2015, Berlin, Germany.

WoodCFD in the media

Benjaminsen, Christina; Skreiberg, Øyvind; Seljeskog, Morten. Her er "vedfyringens ABC". Gemini 3 desember 2015. Reprodusert på forskning.no. NRK radio intervju med Morten Seljeskog.

Benjaminsen, Christina; Skreiberg, Øyvind. Cheaper heating using environmentally-friendly wood-burning stoves. Gemini 9 February 2015.

Benjaminsen, Christina; Skreiberg, Øyvind. Miljøvennlig vedfyring gir deg billigere varme. Gemini 3 februar 2015. Reprodusert på Adresseavisen nett.

Skreiberg, Øyvind. Vi skal gjøre det mer effektivt og miljøvennlig å fyre med ved. blog.sintefenergy.com 2 februar 2015.

Selected **StableWood modelling publications:**

Øyvind Skreiberg, Morten Seljeskog, Laurent Georges (2015). Solutions and technologies for wood stoves in future's energy efficient residential buildings. Oral presentation at 23rd European Biomass Conference and Exhibition, 1-4 June 2015, Vienna, Austria. (Co-presentation with ZEB).

Mette Bugge, Øyvind Skreiberg, Nils E. L. Haugen, Per Carlsson, Morten Seljeskog (2015). Predicting NOx emissions from wood stoves using detailed chemistry and computational fluid dynamics. Energy Procedia 75:1740-1745.

Øyvind Skreiberg, Morten Seljeskog, Laurent Georges (2015). The process of batch combustion of logs in wood stoves - Transient modelling for generation of input to CFD modelling of stoves and thermal comfort simulations. Chemical Engineering Transactions 43:433-438. (Co-publication with ZEB).

Laurent Georges, Øyvind Skreiberg (2014). Simulation of the Indoor Thermal Environment in Passive Houses heated using Wood Stoves: comparison between thermal dynamic simulations and CFD. 1st International Workshop on CFD and Biomass Thermochemical Conversion, 30th September, 2014, DBFZ, Leipzig, Germany, pp. 57-61. (Co-publication with ZEB).

Laurent Georges, Øyvind Skreiberg, Vojislav Novakovic (2014). On the proper integration of wood stoves in passive houses under cold climates. Energy and Buildings 72:87-95. (Co-publication with ZEB).

Laurent Georges, Øyvind Skreiberg, Vojislav Novakovic (2013). On the proper integration of wood stoves in passive houses: Investigation using detailed dynamic simulations. Energy and Buildings 59:203-213. (Co-publication with ZEB).

Other news

IEA Task 32 Biomass Combustion and Co-firing

An IEA Bioenergy Task 32 meeting was arranged in connection with the 25th European Biomass Conference and Exhibition in Stockholm, Sweden, 12-15 June 2017. For information about IEA Bioenergy Task 32 activities, see this newsletter, and for IEA Bioenergy news, see this newsletter. Øyvind Skreiberg from SINTEF Energy Research is the Norwegian participant in IEA Bioenergy Task 32.

EERA Bioenergy – SP5 Stationary Bioenergy

The effort this year has been focused on revising the SP focus and the description of work. For more info on EERA Bioenergy, visit the website, and see the newsletters. Berta Matas Güell from SINTEF Energy Research is leading SP5 Stationary Bioenergy in EERA Bioenergy.

RHC technology platform

The activity level of the RHC platform has picked up, after a period where new financing solutions were sought and the originally planned strategy documents had been delivered. The "new" European Technology and **Innovation** Platform on Renewable Heating & Cooling (RHC-ETIP) brings together stakeholders from the biomass, geothermal and solar thermal sector - including related industries such as District

Heating and Cooling, Thermal Energy Storage, Hybrid Systems and Heat Pumps - to define a common Research, Development and Innovation strategy for increasing the use of renewable energy technologies for heating and cooling.

Previously concrete work has been carried out by the Biomass Panel in the RHC-ETIP connected to giving input to the SET-plan issues paper on renewable fuels and bioenergy, as well as work connected to the Implementation of the biomass technology roadmap of the Biomass Panel. The aim of the latter was to update the progress in R&I priorities identified by the Biomass technology roadmap.

This work continues through different efforts, whereof a Biomass Panel steering committee meeting was arranged 20 June in Brussels.

Øyvind Skreiberg from SINTEF Energy Research is a member of the Biomass Panel Steering Committee and the leader of Issue group 2: Residential/small scale heating devices and building integration.

See the RHC newsletters for other news.

Links (click on the links or logos to get there)

StableWood
SKOG22
Energi21
Renewable Heating and Cooling technology platform
EERA Bioenergy
IEA Task32 Biomass Combustion and Cofiring