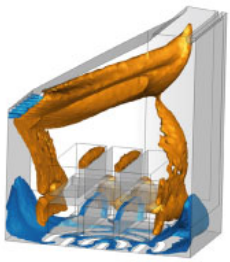
WoodCFD

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



Newsletter 2-2016

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:

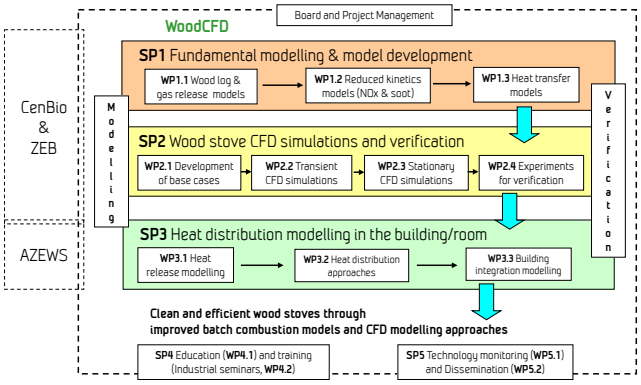
- Model development: improved transient wood log and gas release models, transient heat transfer and storage models, reduced kinetics models (NOx and soot), and transient models and approaches for heat distribution in the building; and verification of these
- Simulations: transient and stationary CFD 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 2016

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. The work with the sub-models, also for stationary CFD simulations, is continued in 2016. The employed PhD candidate in the project focus on

- a Knowledge-building Project for Industry (KPN) co-funded by the Research Council of Norway through the ENERGIX-programme.
Contact: oyvind.skreiberg@sintef.no

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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.

WoodCFD in Energy

A WoodCFD work, Dampening of wood batch combustion heat release using a phase change material heat storage: Material selection and heat storage property optimization, has been published in Energy. The abstract is given below:

"The use of wood stoves for space heating in energy effective residential buildings can be problematic due to the batch combustion giving a highly transient heat production and the limited regulation of the combustion process. Increasing the heat storage capacity and lowering the maximum heat release from the stove has been proposed to improve the utility of wood stoves. Latent Heat Storage (LHS) solutions will lower and even out the heat release from stoves. However, finding a suitable Phase Change Material (PCM) for a LHS solution can be problematic. In this work an analytical method for ranking PCM candidates for LHS solutions is proposed. The method takes into account PCM properties, in addition to LHS properties that have to be tailored to the selected PCM. The method is validated with numerical models using realistic heat production profiles from wood stoves. The numerical results show significant benefits of using PCMs in LHS solutions over traditional solutions. There exists significant work on PCMs and their properties, but little work on how to select a PCM for a given application. This work contributes to a more efficient selection process, decreasing the work required to select the optimum PCM for a LHS."

WoodCFD in the Journal of Building Performance Simulation

A WoodCFD work, Simple Modelling Procedure for the Indoor Thermal Environment of Highly Insulated Buildings Heated by Wood Stoves, has been published in the Journal of Building Performance Simulation. The abstract is given below:

"Space heating using wood stoves is a popular solution in many European countries. The nominal power of the state-of-the-art stoves is oversized compared to the needs of highly insulated buildings, leading to a risk of overheating. A modelling procedure is here developed in order to investigate the indoor thermal environment generated by wood stoves in such buildings. This procedure is kept simple to perform all-year detailed dynamic simulations (e.g. using TRNSYS) at an acceptable computational cost. A specific experimental set-up has been developed for validation, essentially regarding the interaction between the stove and the building. The largest source of error appears to be the thermal stratification in the room where the stove is placed. The experiments prove that the model gives a fair insight into the global thermal comfort. Therefore, it is possible to investigate the conditions required for a stove to be properly integrated in a highly insulated building."

WoodCFD at ICAE 2016

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 been accepted for publication in Energy Procedia.

WoodCFD at 24th European Biomass Conference & Exhibition

A WoodCFD work, Computational Fluid Dynamics as an Efficient Design Tool for Wood Stoves, was presented by Øyvind Skreiberg at the 24th EUBCE conference in Amsterdam, 6-9 June 2016.

WoodCFD at CLIMA 2016

Joanna Polak, a master student connected to the WoodCFD project, presented a paper with the title "Experimental study of the airflow distribution inside and between two zones with temperature differences with an air curtain system" based on her master thesis work at the conference CLIMA 2016, 22-25 May 2016, Ålborg, Denmark.

WoodCFD at Indoor Air 2016

Guangyu Cao presented a joint CenBio and WoodCFD paper with the title "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, at the conference Indoor Air 2016, 3-8 July 2016, Ghent, Belgium.

WoodCFD at the upcoming 25th European Biomass Conference & Exhibition

Four WoodCFD or connected works have been accepted for presentation at the 25th EUBCE conference in Stockholm, 12-15 June 2017:

1) Transient CFD simulations of wood log combustion in a wood stove
2) Numerical simulation of devolatilization of wood logs and pressure generation in the wood log center
3) Performance evaluation of a modern wood stove when using charcoal
4) Coupled ventilation system and wood logs-stove for use in low energy dwellings: an investigation using dynamic energy simulations

Future of building regulation in Europe and Norway

The recast of the Energy Performance of Building Directive (EBPD) 2010/31/EU introduced the concept of *nearly zero-energy building* (NZEB). A NZEB is defined as a building that has a very-low energy use that is covered to a very significant extent by renewable sources. While the directive includes this general definition of NZEB, it is up to the EU member states to set up detailed national application of this definition. The EPBD directive also requests that all new buildings should be NZEB by 31 December 2020. The current Norwegian building code (TEK10) essentially focuses on the performance of the building envelope. In practice, the TEK10 regulation indeed either sets requirement on the building envelope (and ventilation) components or on net energy needs. By definition, it does not take the energy efficiency of heating systems into account and does not distinguish between energy carriers for buildings below 1000 m² (for example, wood, electricity, district heating). Even though, the definition of NZEB is not yet established in Norway, these two aspects (energy efficiency and energy carriers) need to be integrated in the future building regulation. The way they will be integrated will have a significant influence on the competitiveness between heating technologies. Regarding wood stoves, the energy efficiency that will be given to this space-heating technology within Norwegian standards will be important, such as in the NS3031 standard used to evaluate the energy use of buildings. Another aspect is the so-called primary energy factors (or alternatively CO_{2eq} factors) given for each energy carrier which play a major role in the NZEB definition. These factors are presumably relatively low for “green” energy carriers such as wood, which would result in lower required investments in other energy measures and thereby increase their competitiveness.
WoodCFD will monitor the progress of implementation of the NZEB concept in Norway (for example by supporting equal and fair treatment for all energy carriers), especially its influence on wood stoves in NZEB buildings.

How to operate your wood stove

The firing season has started again, and each year the same subject is coming up in the media, i.e. how to operate your wood stove in the best way. We therefore here points towards earlier popular science articles, published in connection with last year's heating season, providing information that might make even you a better wood stove operator. The articles are:

Her er "vedfyringens ABC"

Ja, dette fjerner sotet fra peisen (February 6, 2016)
Så mye bedre er nye vedovner (January 28, 2016)
Vil forby disse ovnene (January 23, 2016)
Foreslår å forby gamle vedovner (January 22, 2016)
Vil forby gamle vedovner (January 22, 2016)
Ekspertenes beste vinterråd (January 21, 2016)
Nå kan vedfyring være helsefarlig (January 21, 2016)
Nå kan dette være helsefarlig (January 21, 2016)
Her ser du hvorfor du IKKE skal brenne juletreet i peisen (January 4, 2016)
Farlig å fyre med juletreet (January 3, 2016)
Ikke brenn juletreet – og hvordan du blir kvitt det (January 2, 2016)
Slik tar du helsesjekk på vedovnen (December 29, 2015)
Her er forskerens tips til sikker og miljøvennlig vedfyring (October 21, 2015)
Sjekk om du bør ha feier på besøk (October 20, 2015)
Sjekk om du bør bytte vedovn (October 15, 2015)

These articles are in Norwegian, but good advices in English can be found in the Guidebook Effective and environmentally friendly firing of firewood.

In a nutshell:

1. Plain and simple, as the operator and control system, you significantly influence the performance of your wood stove, with respect to both emissions and efficiency. Become a more educated wood stove user, and by that also contribute to reduced environmental impact from your stove.

2. If you have an old wood stove, pre 1998, replacing this with a new one will be very wise both from an emissions and efficiency point of view. Why? Because the new wood stoves implement measures for improved combustion that do not exist in the old stoves.

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.

Collaboration with ZEB

As in the StableWood project, the predecessor to WoodCFD, there is an active collaboration with The Research Centre on Zero Emission Buildings (ZEB).

A new wood stove project has received funding from the Research Council of Norway

The innovation project for the industry "Almost zero emission wood stoves" (AZEWS) has been running for 3 years, and will be completed in 2016. At 15 December, a new project with the same industry partners received funding from the EnergiX program at the Research Council of Norway. The new project, "The universal wood stove combustion chamber" (The One), is also an innovation project for the industry.

WoodCFD publications

Thalfeldt M., Georges L., Skreiberg Ø. Measurement of plumes created by wood stoves. Accepted for presentation at Healthy Buildings Europe 2017, 2-5 July 2017, Lublin, Poland.

Mette Bugge, Nils E. L. Haugen, Øyvind Skreiberg. Transient CFD simulations of wood log combustion in a wood stove. Accepted for presentation at the 25th European Biomass Conference & Exhibition (**EUBCE**), 12-15 June 2017, Stockholm, Sweden.

Inge Haberle, Øyvind Skreiberg, Nils Erland L. Haugen. Numerical simulation of devolatilization of wood logs and pressure generation in the wood log center. Accepted for presentation at the 25th EUBCE.

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

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

Morten Seljeskog, Alexis Sevault, Asbjørn Østnor, Øyvind Skreiberg. Variables affecting emission measurements from domestic wood combustion. Accepted for publication in Energy Procedia.

Morten Seljeskog, Franziska Goile, Øyvind Skreiberg. Recommended revisions of Norwegian emission factors for wood stoves. Accepted for publication in Energy Procedia.

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.

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 Switzerland in connection with the 20th ETH-Conference on Combustion Generated Nanoparticles, 13-16 June. This was the first meeting in the new triennium (2016-18). The second meeting in 2016 was arranged in Japan. For more 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 - Stationary Bioenergy

The effort this year has been focused on arranging workshops in Brussels connected to issue papers, on bioenergy and biofuels, and coordination of efforts to establish joint EU proposals. The annual EERA conference was arranged 24-25 November in Birmingham, UK. More info is available here. For more info on EERA Bioenergy, visit the website, and see the newsletters.

RHC technology platform

The activity level of the RHC platform is picking up, after a period where new financing solutions have been sought and the originally planned strategy documents have 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. Two workshops were arranged 27 and 28 June. The first one was an industry workshop while the second one was a technology workshop. The aim was to support to key activities of the RHC-ETIP and to discuss the successful contribution of the RHC-sector to the fifth dimension of the Energy Union.

Further 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.

Øyvind Skreiberg from SINTEF Energy Research is a member of the Biomass Panel Steering Committee.

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