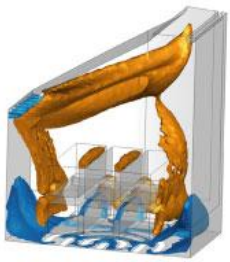
WoodCFD

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



Newsletter 1-2015

Introduction

The overall objective of WoodCFD is development of clean and efficient wood stoves through improved batch combustion models and CFD modelling approaches through:

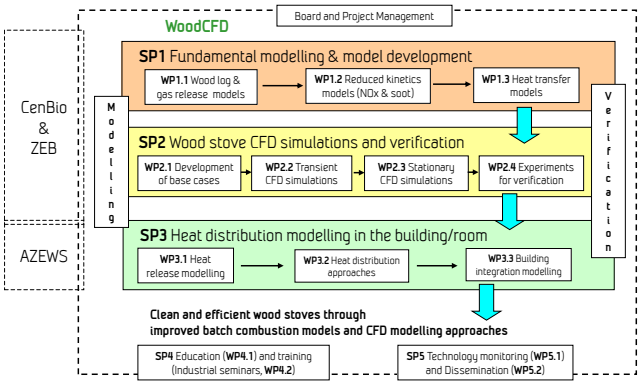
- Model development: improved transient wood log and gas release models, transient heat transfer and storage models, reduced kinetics models (NOx and soot), and transient models and approaches for heat distribution in the building; and verification of these
- Simulations: transient and stationary CFD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

The WoodCFD consortium

The project consortium covers all the necessary aspects, and includes large and central industrial players in the bioenergy area in Norway and Denmark.

SINTEF ER will lead the project and will focus on the wood stove modelling and experimental side. NTNU (Norwegian University of Science and Technology) will supervise the PhD and Master candidates, lead the room/building modelling activities and participate in additional selected activities.

The industrial partners will contribute with finances and their extensive industrial knowledge generated through their commercial activities within wood stove development and production (Jøtul AS, Dovre AS, Norsk Kleber AS (former Granit Kleber AS), Morsø Jernstøberi A/S).

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

The constellation of project partners is very strong, bringing together leading research organisations within the field and major industrial players.

Project background

Several new national strategies points out the importance of bioenergy in the future energy supply for Norway. Wood log combustion has long traditions in Norway and currently constitutes as much as 50% of the current use of biomass for energy purposes. The national target is a doubling of the use in 2020.

Three central documents are defining the current national bioenergy strategy: Klimameldingen, Energi21 and Strategy for increased expansion of bioenergy - 2008. The latter states that Norway shall double the bioenergy production from 14 to 28 TWh by 2020 and that the major single contributor of new bioenergy production shall come from bioenergy use in small-scale heating appliances for space heating, meaning in practise the use of wood log combustion in wood stoves and fireplaces (~50% of the increase, which equals 7 new TWh).

Using wood logs is important as a part of security of supply in Norway, where we today rely heavily on the electricity grid to deliver the needed heating for our houses. Close to 80% of the domestic heating is by electricity and 15-20% by wood log combustion, while district heating accounts for only about 2% and heating with gas is close to zero. This makes Norway quite special compared with other European countries.

Wood log combustion has long traditions in Norway, constituting almost 50% of the use of biomass for energy purposes. Increasing electricity prices, colder winters and increasing renewable energy awareness are factors that contribute to an increased use of wood log combustion. However, this is not enough and new solutions and technologies that enable a more widespread and extensive use of wood log combustion are clearly necessary to reach these ambitious targets. New houses, as well as retrofit/upgrading of old houses, have increasingly focused on improved insulation (e.g. the Norwegian passive house standard, the future TEK15 regulation and nearly-zero energy buildings in 2020). The space-heating effect (power) required for these highly-insulated buildings is drastically reduced, which means that wood stoves should be able to deliver a constant heating effect to the building as low as ~1 kW.

Norwegian houses are mainly wooden houses, which have two important implications; they cannot support large heat storing stoves (due to weight restrictions on the wooden floors) and the building itself is not able to store much heat compared to a concrete/brick building. The consequence of the above is that we need to develop new solutions and technologies that, while giving a stable heat release and distribution at a heat release effect as low as 1 kW, also reduce the emission levels and improves the thermal efficiency.

Combining heat production, storage and distribution in an optimum way makes it possible to achieve a substantially more stable heat release and distribution in wooden houses than the current solutions and technologies can offer. It opens up for a groundbreaking shift; enabling a substantially longer wood log heating season due to solutions that can operate at low and more stable effect early and late in the heating season, and thereby also increasing the total wood log use through the heating season due to the increased heat comfort. This will result in an increased number of operational hours per unit and also more units in active operation.

Low load wood stoves and fireplaces in buildings with new insulation standards demand new technologies and solutions with an increased focus on the combustion process and its control, the combustion quality and optimum design to ensure low emissions and high energy efficiency. To minimize the negative effects of the batch combustion process (compared to a continuous combustion process), a more stable heat generation and heat release is needed. This was the focus of the KMB StableWood project (2011-14), the predecessor to the proposed KPN WoodCFD, where a number of studies were carried out in a broad range. These studies confirmed that wood stoves have a place in future's buildings. However, it also clearly showed the need for a more concentrated effort on the development of improved models and the use of advanced modelling approaches to be able to further improve wood stoves and especially low load wood stoves with respect to emissions and energy efficiency, as well as combustion stability and optimum room and building integration.

Project overview

The project is divided into 5 subprojects (SP), each subproject is itself divided into several work packages (WP).

- Fundamental modelling & model development - SP1
- Wood stove CFD simulations and verification - SP2
- Heat distribution modelling in the building/room - SP3
- Education and training - SP4
- Technology monitoring and dissemination - SP5

Fundamental modelling & model development - SP1

The major objective of SP1 is to develop improved sub models to be included in the CFD simulations in SP2.

Wood stove CFD simulations and verification - SP2

The major objectives of SP2 are to 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.

Heat distribution modelling in the building/room - SP3

The major objectives of SP3 are to 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 and training - SP4

The major objective of SP4 is to strengthen the education within this field through MSc and PhD students. The objective is also to increase the competence level in the industry. The long-term goal is competence building and strengthening of the education within combustion of wood in wood stoves and fireplaces.

Technology monitoring and dissemination - SP5

The major objectives of SP5 are to monitor the latest research and technological developments and to disseminate research results.

WoodCFD deliverables

In the first year of WoodCFD focus will be on initial theoretical studies and model development that will form the foundation for the succeeding studies to be carried out.

PhD position announced

The PhD position within "Numerical simulations of the transient behavior of wood log decomposition and combustion" has been announced. A number of applications have been received, the applicant evaluation process is completed, and the PhD position will soon be filled.

Collaboration with ZEB

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

New publications

WoodCFD in the media

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.

StableWood modelling publications:

Øyvind Skreiberg, Morten Seljeskog, Laurent Georges. 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. Predicting NOx emissions from wood stoves using detailed chemistry and computational fluid dynamics. Manuscript presented at ICAE2015, 28-31 March 2015, Abu Dhabi, United Arab Emirates. To be published in Energy Procedia.

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). Modeling of the Indoor Thermal Comfort in Passive Houses heated by Wood Stoves. Proceedings of System Simulation in Buildings 2014 (SSB2014), 10-12 December, Liege, Belgium. (Co-publication with ZEB).

Øyvind Skreiberg (2014). Biofuels of the future, and modelling implications. Keynote presentation at the 1st International Workshop on CFD and Biomass Thermochemical Conversion, 30th September, 2014, DBFZ, Leipzig, Germany. (Co-presentation with CenBio).

Mette Bugge, Nils E. L. Haugen, Øyvind Skreiberg, Morten Seljeskog (2014). CFD modelling of NOx emissions from wood stoves. 1st International Workshop on CFD and Biomass Thermochemical Conversion, 30th September, 2014, DBFZ, Leipzig, Germany, pp. 51-56.

Morten Seljeskog, Øyvind Skreiberg (2014). Batch combustion of logs in wood stoves – Transient fuel models and modelling of the fuel decomposition and products composition as input to CFD gas phase calculations. 1st International Workshop on CFD and Biomass Thermochemical Conversion, 30th September, 2014, DBFZ, Leipzig, Germany, pp. 39-44.

Øyvind Skreiberg, Morten Seljeskog, Laurent Georges (2014). Batch combustion of logs in wood stoves – Transient modelling for generation of input to CFD modelling of stoves and thermal comfort simulations. 1st International Workshop on CFD and Biomass Thermochemical Conversion, 30th September, 2014, DBFZ, Leipzig, Germany, pp. 45-50. (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 (2014). Simulation of the Indoor Thermal Environment in Passive Houses heated using Wood Stoves. BUILDSIM-NORDIC, 25-26 September 2014, Espoo-Finland. (Co-presentation with ZEB).

Mette Bugge, Nils E. L. Haugen, Øyvind Skreiberg (2014). NOx emissions from wood stoves – A CFD modelling approach. Proceedings of 22nd European BC&E, 23-26 June 2014, Hamburg, Germany, pp. 674-679.

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 Integration of Wood Stoves in Norwegian Passive Houses: Investigations Using Dynamic Simulations. Proceedings of Clima 2013, Prague, 16-19 June 2013. (Co-publication with ZEB).

Øyvind Skreiberg, Morten Seljeskog, Laurent Georges (2013). Transient wood-log stove modelling integrating detailed combustion physics. Oral presentation at 21st European Biomass Conference and Exhibition, 3-7 June 2013, Copenhagen, Denmark. (Co-presentation with ZEB).

Kolbeinn Kristjansson, Erling Næss, Øyvind Skreiberg, Marie Seltveit Haugen (2013). Stable heat release and distribution from batch combustion of wood. Proceedings of 21st European Biomass Conference and Exhibition, 3-7 June 2013, Copenhagen, Denmark, pp. 568-572.

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).

Morten Seljeskog, Øyvind Skreiberg (2012). Transient fuel models for wood log combustion. Oral presentation at 20th European Biomass Conference and Exhibition, 18-22 June 2012, Milan, Italy.

Morten Seljeskog, Øyvind Skreiberg (2012). Transient fuel elemental composition models for wood logs. Renewable Energy Research Conference 2012, 16-17 April, Trondheim, Norway.

Other news

IEA Task 32 Biomass Combustion and Co-firing

A Task 32 meeting was arranged in UK June 11-12. Planning of activities for the next triennium (2016-18) was on the agenda. Also in the new triennium wood stoves will receive significant attention, and a workshop dedicated to wood stoves is planned. This year a similar workshop is planned in connection with the IEA Bioenergy conference in Berlin October 27-28.

EERA Bioenergy - Stationary Bioenergy

An EERA Bioenergy - Stationary Bioenergy Sub-Program workshop was arranged at ECN in the Netherlands June 15-16. The goal of this workshop was to align efforts towards joint proposals, to e.g. H2020, within the stationary bioenergy area. However, as the H2020 calls are not in favor of small-scale biomass combustion, but rather focusing on medium- to large-scale units, wood stove proposals within the current H2020 calls seems not realistically possible.

RHC technology platform

The activity level of the RHC platform is currently limited, as new financing solutions are sought for and the originally planned strategy documents have been delivered. A decision regarding the path forward can be expected in the autumn.

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