



Pellets instead of coal in thermal power plants

Camilla Løhre



UNIVERSITY OF BERGEN





Who am I?

Camilla Løhre

Born and raised in Stavanger

Educated at the University of Bergen

PhD thesis defence January 2017

Employed as researcher at the
Department of Chemistry (UoB)



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Picture 1: <http://www.andershusa.com>

Picture 2: <http://stavanger-forum.no>



Outline

Pellets instead of coal in thermal power plants

- I. The company
- II. The product
- III. Ongoing research

Who is Arbaflame?

A political decision in Ontario, Canada, November 2013

Ontario's government decided to **close all coal-fired power stations** and replace them with more healthy and environmentally-sound alternatives

Ontario Power Generation (OPG) had two coal-fired power plants

Who is Arbaflame?

Atitokan Generating Station (205 MW) has converted to use traditional white pellets as fuel

The conversion project took 18 months and cost 170 million Canadian dollars

Thunder Bay Generating Station was used to manage peaks in the energy supply, so an equal investment was not an option

Alternative 1: close down the station

Alternative 2: find a cheaper way

From fossil fuel to renewable in four months

Only minor modifications, in a very short period of time, was necessary to switch to fully renewable power generation

- The Thunder Bay Generating Station was converted with **only two months down-time**
- To a facility running on Arbacore wood pellets
- It maintained power generation capacity at 170 MW, equal to when it was coal-fired

Arbaflame's black pellets – Arbacore

The pellets share many of the same properties as coal:

- Transported, stored and handled the same way
- Exterior film that make the pellets water resistant
- No risk of explosion or spontaneous combustion
- Same equipment for pulverising and combustion can be used
- Energy dense → 76 % of the heat value of coal
- Reducing CO₂ emissions with more than 90 %

“The next generation of wood pellets!”

*"Keep the power station,
lose the coal"*

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Picture: <https://www.arbaflame.no>



Steam explosion

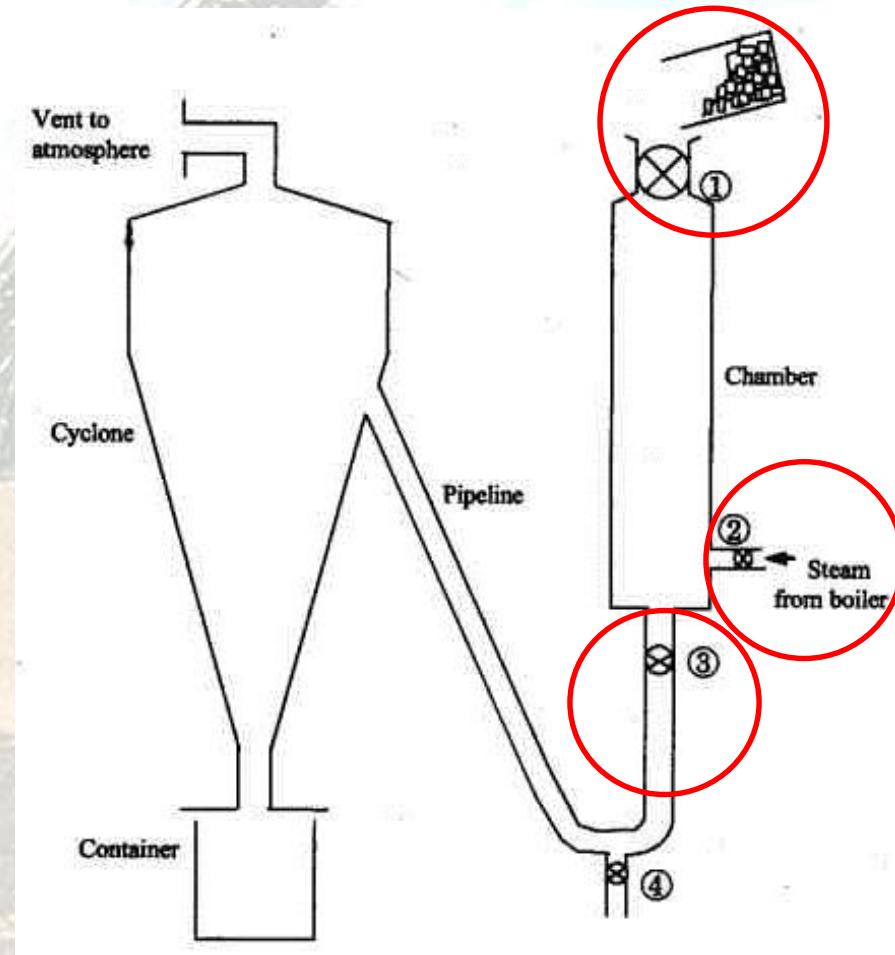
Production of brown pellets by biomass pre-treatment using

Steam explosion

Violent boiling/flashing of water into steam and filling the reactor with wood chips

Exposure of wood chips (200-700 sec) to high-pressure steam (160-260 °C)

Process termination by explosive decompression



Steam explosion

The wood fibers are broken down:

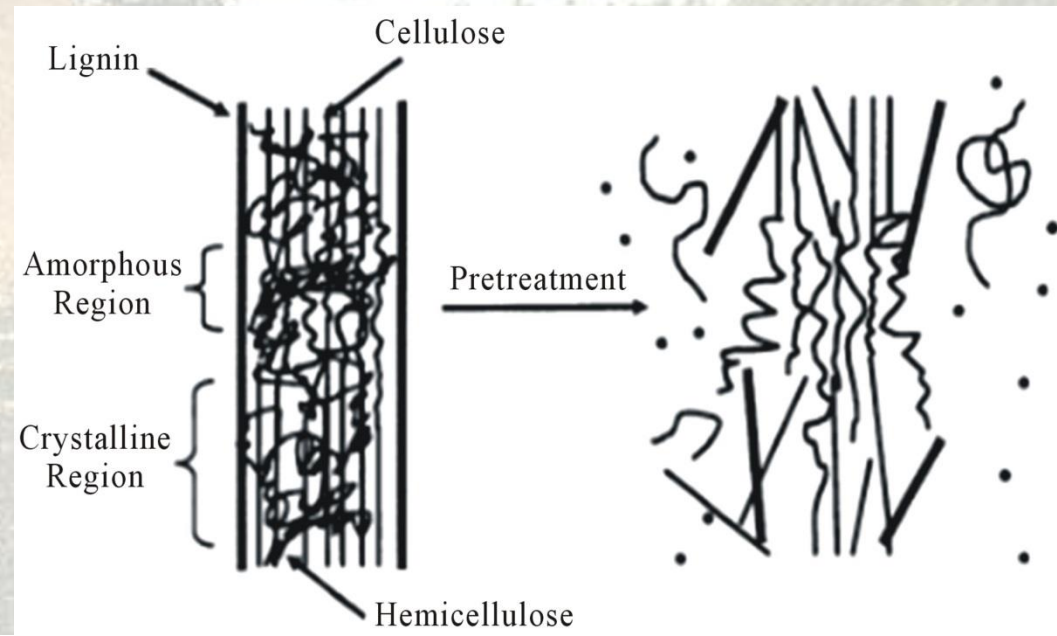
Steam penetrates within the structure of the material

Steam condenses and wets the material

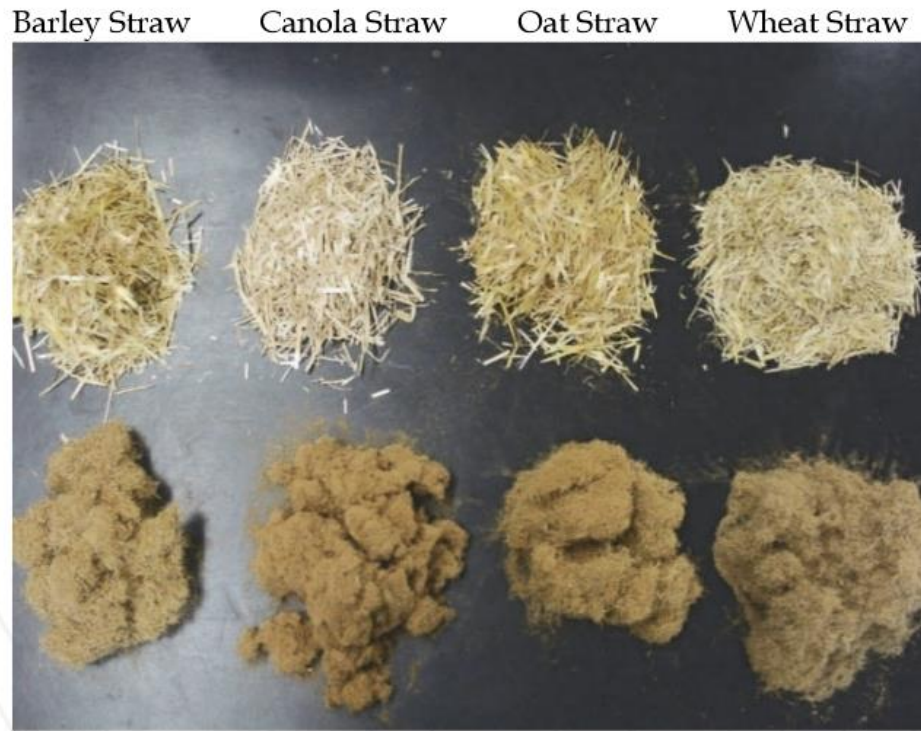
Condensed water and high temperature initiates hydrolysis and the release of acid groups attached to hemicellulose

Hemicelluloses are removed by hydrolysis, lignin (the binding agent in wood) softens, and depolymerises

Released organic acids catalyse the depolymerisation of hemicelluloses



Steam explosion



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Picture:

Lope, T., A. Phani, and K. Mahdi, *Biomass Feedstock Pre-Processing – Part 1: Pre-Treatment*. Biofuel's Engineering Process Technology. 2011.

Arbacore

The solid product is dried and pressed into brown, almost black, pellets





Steam explosion

Condensed steam vaporizes upon explosive decompression

Hemicellulose products follow the steam fraction

A side stream *condensate* is produced

- Small/negligible quantities in laboratory scale
- Large quantities in industrial scale

Research project – part I

Condensate Identification

Main components

TOC-measurements reveal high carbon-concentration in condensate
– Potential environmental hazard?

High value side stream products?



Laboratory facilities

Cooperation with Lund's University

- Small scale steam explosion (SE)

Increased resource efficiency

Testing the influence of:

- Comparability between large scale and small scale
- Raw material/ wood species
- Reaction conditions during SE (residence time and temperature)



Pilot plant

Pilot plant at **Grasmo**

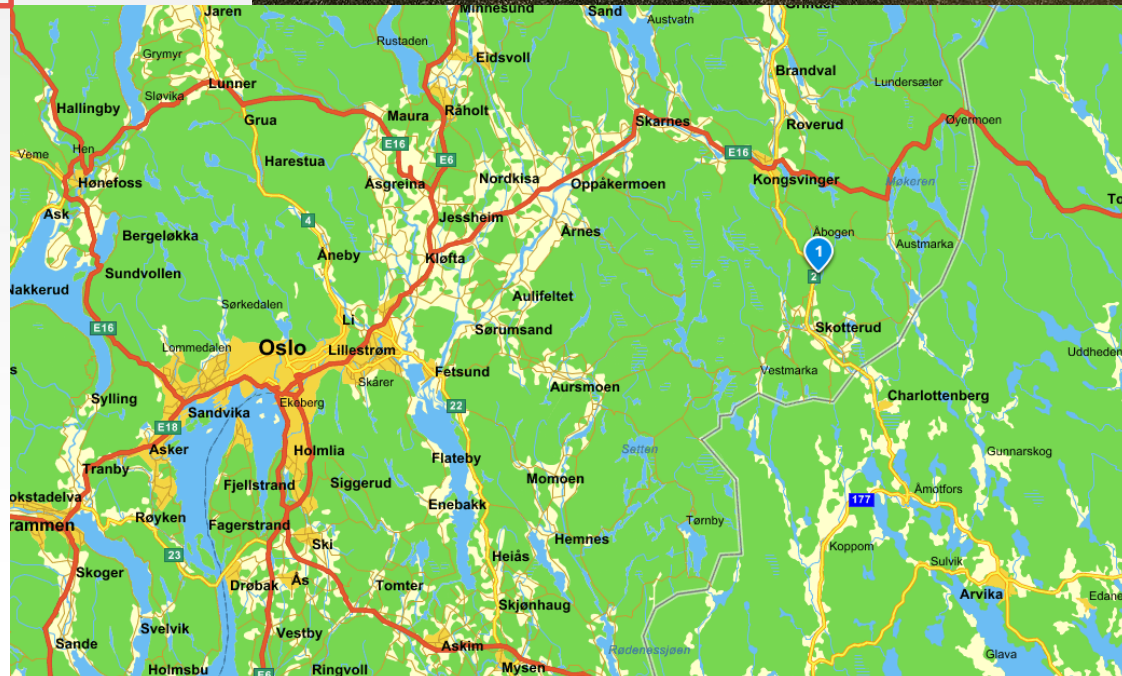
- Industrial scale steam explosion (SE)

The plant producing Arbacore pellets for export to Canada



Confirming research results and upscaling:

- Confirm the influence of species
- Confirm the influence of reaction conditions during SE



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Map: <https://kart.gulesider.no>

Picture: <https://www.arbaflame.no>

Analytical procedures – NNP

Condensate analysis by NMR
(Nuclear Magnetic Spectroscopy)

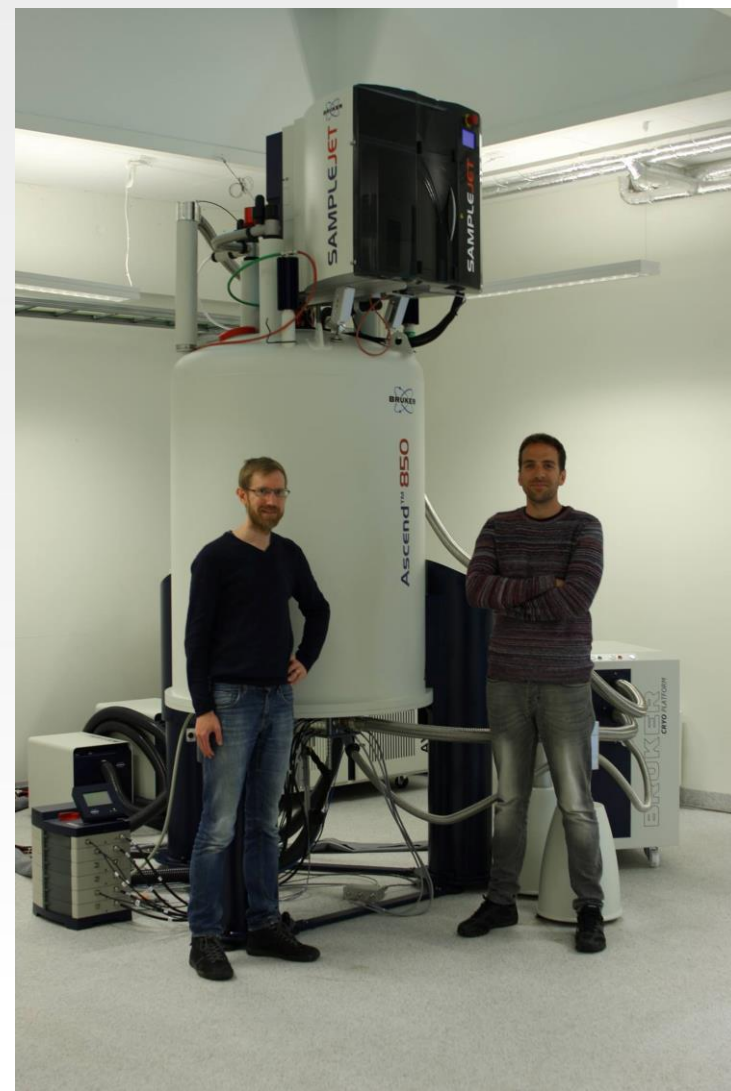
Close collaboration with the Norwegian NMR
Platform (NNP) at UoB

Developing and establishing a method for
frequent and efficient composition/structure
analysis

Thormøhlensgate 55 A,
Bergen, Hordaland
<http://nmr.uib.no>

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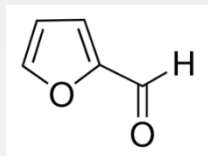
Picture: <https://www.facebook.com>



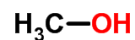
Analytical procedures

Main components identified by NMR

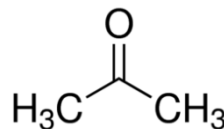
Furfural



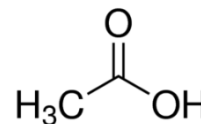
Methanol



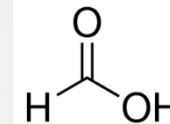
Acetone



Acetic acid



Formic acid



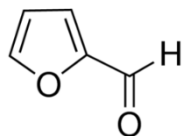
- Other components present
- Identification and quantification and comparing it with wood species and experimental SE parameters



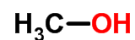
Analytical procedures

High value platform chemical
Increases product value with 7-10% compared to just pellet production

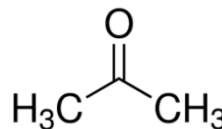
Furfural



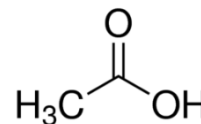
Methanol



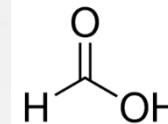
Acetone



Acetic acid



Formic acid



Similar composition

Concentration differences between species

} Tuning of experimental
conditions

Separation technology

Separation of SE condensate
Product and compound isolation

Distillation in laboratory scale

Development of industrial scale
separation techniques:

ANDRITZ

SULZER



**LUNDS
UNIVERSITET**



Research project – part II

Increasing ash fusion temperature

- Deposits in combustion furnace
- Ash condensation causes slagging and fouling
- Inefficient heat transfer
- Reduced electricity production
- Wear and corrosion

The power plant cannot maintain its function



Ash fusion temperature

Influenced by the raw material's mineral composition

- High ash content in fast growing crops/tropical species

Adjust combustion mechanisms

Prevent/cause reaction mechanisms during combustion by mineral addition or material pretreatment

Analytical procedures:

DEPARTMENT OF EARTH SCIENCE

Combustion experiments:



Future plan

October 2017:

NFR-application for extended research period
– awaiting response in December

Targeting a complete production plant at Follum (Hønefoss):

“If year-round production of biocoal at Follum replaces the fossil coal used by one coal-fired power plant, CO₂ emissions will be reduced by 400,000 tonnes”

- Bjørn Knappskog,
Arbaflame’s board chair and majority shareholder



Thank you!



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