Negative CO_2

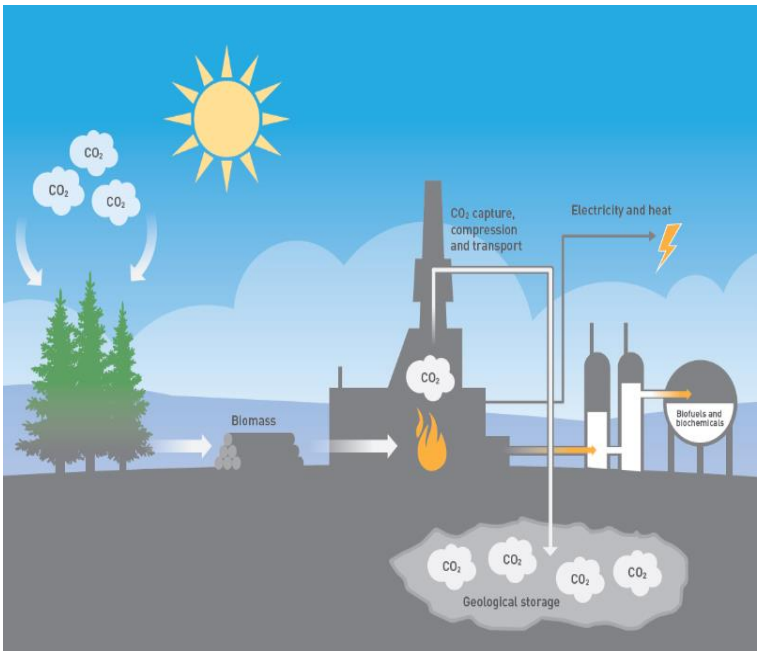
Negative CO_2 Emissions with Chemical-Looping Combustion of Biomass

Negative CO_2 newsletter #1
24 February 2016

The Nordic Energy Research Flagship Project "Negative CO_2 Emissions with Chemical Looping Combustion of Biomass" has set sail, cruising gently towards the future shores of negative CO_2 emissions.

The Paris Agreement adopted by consensus on 12 December 2015 within the framework of the United Nations Framework Convention on Climate Change stipulates that the increase in the global average temperature should be limited to well below 2°C above pre-industrial levels, and pursue efforts to limit the temperature increase to 1.5 °C. In order to meet this target there is a remaining CO_2 budget corresponding to less than thirty years (for 2°C) or as little as ten years (for 1.5°C) of today's emissions. In practice, these stringent emission limits means that technology capable of generating negative CO_2 emissions will need to be developed and deployed in grand scale in the coming decades.

Biomass is a renewable energy source that extracts CO_2 from the atmosphere during its growth. It is affordable and widely available and the Nordic countries are world leading in biomass utilization. If CO_2 generated during biomass combustion is captured and brought to a geological storage, the result will be a net decrease of CO_2 in the atmosphere (see figure). The concept is referred to as Bio-Energy with Carbon Capture and Storage (BECCS) and offers a very realistic method for effectively removing carbon dioxide from the atmosphere, making also the most ambitious CO_2 targets achievable.



Schematic description of BECCS from: *Removing CO_2 from the atmosphere, Christina Benjaminsen, Gemini 2016-02-11*.

The ultimate goal of the Negative CO_2 project is the development of

new competitive technology that:

- enables CO_2 capture and negative CO_2 emissions with the lowest possible cost and energy penalty
- is able to produce power and/or steam for industrial and other applications
- utilizes Nordic expertise and competence in fluidized bed technology
- eliminates thermal NO_x emissions and has potential to achieve more efficient fuel utilization compared to ordinary biomass combustion.

The technology capable of achieving these goals is **Chemical-Looping Combustion of biomass (Bio-CLC)**, a unique and innovative combustion technology that will be studied and developed in the project. Chemical-Looping Combustion (CLC) involves oxidation of fuels with oxygen provided with solid oxygen carrier particles rather than with air and both the high energy penalty and the high capital cost associated with gas separation can be avoided. Because of this CLC is expected to have at least 50% lower energy penalty and cost than any other CO_2 capture technology.

Project news (November 2015 – February 2016)

Scientific and technical progress

In the project an experimental campaign in a semi-commercial facility (Chalmers Research Boiler) is scheduled for 2018. However, already in November 2015 an opportunity arose to make preliminary experiments in the said facility. During 3 days the gasification reactor of Chalmers Research Boiler was successfully operated as a CLC fuel reactor, although it should be noted that the gasifier is not designed for this purpose. Wood pellets corresponding to a thermal power of up to 2.4 MW was top-fed to the gasification reactor. The oxygen carrier was a pre-calcined manganese ore. Fuel powers up to 2.4 MW was examined and the fuel conversion was in the order of 60-70% at 820°C. Much higher conversion is attained in CLC pilot reactors and is also expected in full-scale boilers. For the 2018 campaign, improvements with respect to fuel feeding and temperature of operation are planned. Nevertheless, these experiments constitutes a considerable leap forward and has potential to contribute greatly on many issues that is to be examined in the project.

A number of key decisions have been taken with respect to planned experimental work. This includes selection of two reference fuels (Finnish White Wood Pellets and Norwegian steam treated Arbapellets) and a number of oxygen carrier materials for examination(three manganese ores and three ilmenite sands available via the project partner Sibelco, one sintered manganese product provided by advisory board member Alstom and rock ilmenite provided by advisory board member Titania).

Samples of fuels and oxygen carriers are currently being distributed among parties involved. Initial experiments are being planned and performed at SINTEF MC and Åbo Akademi.

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About Negative CO2

Negative CO_2 is a multi-partner and cross-disciplinary project funded by Nordic Energy Research that runs from November 2015 to October 2019. The research topic is CO_2 capture during biomass combustion by means of an innovative and potentially revolutionary technology. The project partners are:

- Chalmers University of Technology
- The Bellona Foundation
- Sibelco Nordic AB
- SINTEF Energy Research
- SINTEF Materials and Chemistry
- VTT Technical Research Centre of Finland Ltd
- Åbo Akademi University

Associated with the project is also an advisory board, consisting of industrial stakeholders with interest in the project:

- Alstom Power AB
- Andritz Oy
- AKZO Nobel
- Elkem AS
- E.ON Sverige AB
- Fortum Oyj
- Foster Wheeler Energia
- Göteborgs Energi
- Titania A/S

Experimental facilities at SINTEF ER and VTT is currently being commissioned. Rock ilmenite will be used as oxygen carrier during the first campaigns.

Dissemination to the scientific community

During the winter a number of abstracts related to the project has been send to conferences considered important to the field. This includes:

- *Rydén M, Lyngfelt A, Langørgen Ø, Larring Y, Brink A, Teir S, Havåg H, Karmhagen P. Negative CO_2 Emissions with Chemical Looping Combustion of Biomass – a Nordic Energy Research Flagship Project.* Abstract send to the 13th Conference on Greenhouse Gas Control Technologies in Lausanne, Switzerland.
- *Rydén M, Thunman H, Lind F, Lyngfelt A. About the use of Circulating Fluidized Bed (CFB) boilers for demonstration of Chemical Looping Combustion (CLC).* Abstract send to the 4th International Conference on Chemical Looping in Nanjing, China.
- *Hanning M, Corcoran A, Zhao D, Lind F, Rydén M. Characterization of Oxygen Carriers during Combustion and CLC Conditions in a 12 MW_{th} Circulating Fluidized Bed Biomass Boiler.* Abstract send to the 4th International Conference on Chemical Looping in Nanjing, China.
- *Berdugo Vilches T, Lind F, Thunman H, Rydén M. Experience of more than 1000h of operation with oxygen carriers and solid biomass at large scale.* Abstract send to the 4th International Conference on Chemical Looping in Nanjing, China.

Public awareness

- Mario Ditaranto of SINTEF ER and Marika Andersen from Bellona Europa are interviewed about Negative CO2 emissions by the Norwegian popular science journal Gemini 11 February. This article was also posted on ScienceNordic.
- Bellona gave a Pecha Kucha presentation about Bio-CCS in Oslo 21 January.

Beyond the science news

The Guardian, 10 Feb 2016: Europe's climate change goals 'need profound lifestyle changes'

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Business Green, 19 Jan 2016: Bioenergy is still a low-carbon 'game-changer' despite CCS cuts

On Twitter: Pascoe Sabido from Corporate Europe Observatory

Pascoe Sabido @pascoesabido · Feb 18
The #EU takes a serious look at 'negative emissions' technology despite enormous social & environmental risks #**BECCS**
theguardian.com/environment/20…

Other project-related news

A new industrial partner has been recruited to the advisory board of the project: Arbaflame is a world leading Norwegian company with a world leading patented process (steam treatment) for producing Advanced Wood Pellet ("AWP" or "Arbapellets").

Contacts

For general questions about the project please contact the coordinating party which his Chalmers University of Technology:

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A project website will be launched soon.