

## WP6 Dissemination activities DONG Energy

### Introduction to the task

As the region of Jutland is relative small, and as the conclusion from the previous WP's was that the fuel cells all should be based on pure hydrogen feed either from an electrolyser or ethanol/methanol or biogas reformers it makes no sense, that the various partners in the region of Jutland carries out parallel dissemination activities, addressing the same people in the same small region. Hence DONG Energy has focused on promoting the development of 2G bio-ethanol, and the reformation of ethanol into pure hydrogen, as this might be the fastest way of introducing a renewable feed into the fuel cells. 2G bio-ethanol has a much larger CO<sub>2</sub> reduction potential than 1G Ethanol, and is furthermore characterized by not using human food as feedstock. So far there is no commercial technology for production of 2G Ethanol, and support for the development is needed. In the near future it will still be more expensive to produce 2G ethanol than 1G Ethanol, and if 2G ethanol has to succeed it's important that the decision makers set some sustainability criteria's, that favors 2G biofuels. The major driver for 2G ethanol is however the transportation sector and not the RES-Fuel Cell business.

The most important issues for the fuel Cell Business with respect to ethanol, is the reformation of ethanol into hydrogen. No commercial ethanol reformers are on the market, and have to be developed. In the concept of a centralized ethanol reformer delivering hydrogen to a cluster of Fuel Cells, one must dilute the ethanol with water in the reformer. Hence for such applications it makes sense not to remove all the water from the ethanol product in the final steps of an ethanol plant. Energy can be saved by only distilling the ethanol-water mixture up to 50-70%, and then reform this mixture into hydrogen. This mixture will however contain some impurities which require further development of the catalyst to be used in the ethanol reformer. DONG Energy has tried to encourage catalyst experts to test and develop new catalysts based on real 2G ethanol-water mixtures with real impurities, in order to increase the application possibilities of ethanol. Furthermore this development is needed before ethanol can have a breakthrough in fuel-Cells.

### Summary on sector dissemination activities carried out

DONG Energy has been developing the technology for 2G Ethanol in the last 6-8 years, and recently they founded the company Inbicon, who will market and mature the technology, and make it ready for commercial operation. Hence focus in the last 1-2 years has been to establish a network of future potential customers and investors, in order to secure an incoming cash flow to cover for the development cost associated with up-scaling a technology. Furthermore focus has been on cooperation with universities and other knowl-

edge providers, in order to support the technological development. The right framework conditions from a political point of view, has also been an important goal of the dissemination activities. The purpose with the dissemination activities has often been to demonstrate that the IPR, Technology and business plan was superior compared to foreign competitors, and hence to demonstrate a potential export niche for the associated industry.

Inbicon has presented 2G Ethanol in the following sectors during the last year.

- In Private Sessions for invited potential investors, primarily private companies
- In Private Sessions for invited Knowledge Providers, as universities and other companies doing research in the same field.
- In Private Sessions for invited key persons, mainly manageable due to personal relationships
- In Public Sessions for various Authorities in the Agricultural and Energy Sectors
- In various public conferences with focus on the ethanol Market
- In Various public conferences with focus on the development of the technology.
- In Scientific Journals, both on ethanol production and ethanol reforming

## **The Results of disseminating the 2G ethanol production Technology**

In order to speed up the commercialization of the knowledge gathered from working with biomass for several years, DONG Energy has formed the company Inbicon who will market and mature a technology for production of 2G ethanol. Inbicon (**I**ntegrated **B**io **C**onversion) is 100% owned by DONG Energy and has a permanent staff of employees and associated consultants from DONG Energy. Most of the employees have been involved since the beginning of the IBUS project in 2002, however, within the past years the staff has been expanded with several new employees. At the moment, we are 24 employees: 16 permanent employees, 8 external consultants (mainly from DONG Energy) and a committed board. These employees are actively involved in establishing Inbicon, further development of the technology, operation of test plant, marketing and business development, establishment of partnerships and procurement of financing, see [www.inbicon.com](http://www.inbicon.com)

Inbicon has a patented technology for production of 2G ethanol based on biomass consisting of lignocelluloses and is operating a pilot plant able to convert 1 ton of straw per hour into ethanol.



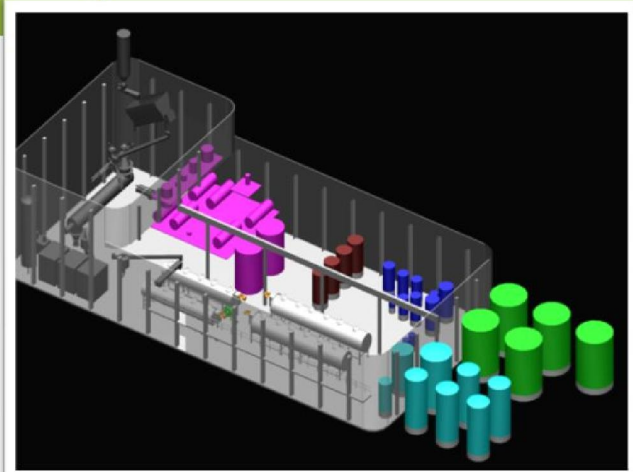
Inbicon pretreatment pilot plant

Before the technology can be commercialized it is however important to demonstrate, that the process can be up-scaled and prove long time operation. Such a task requires the construction of a demonstration plant, which is capital intensive.

2G bioethanol developers in Denmark have during the last couple of years pushed the authorities for improved framework conditions and financial support. The wishes were accomplished, and in 2007 the Danish Government decided to give financial support in the range of 27 Mill Euro to demonstration activities regarding 2G ethanol. The Government selected an independent board of competent people, which task was to distribute the funding between various applicants. The program is named EUDP.

In December 2007 Inbicon was granted 3 mill. Euro for the design of a 2G ethanol demonstration plant, and in April 2008 Inbicon was further granted with 7 mill. Euro for the construction of the demonstration plant. The Demonstration plant will be placed in Kalundborg next to an existing Powerplant (Asnæsværket), and will be able to convert straw into both Ethanol, Animal Feed (C5 sugar sirup) and a solid biofuel, that can replace some of the coals in the Powerplant. The plant will be able to convert 4 ton of straw per hour, and will be ready for commissioning in the Autumn 2009, just in time for the Climate Summit in Copenhagen.

## Demonstration plant - 2009



Demonstration Plant, 4t/hr of straw		Tonnes/year	Tonnes DM/year	GJ/year
<b>Input</b>	<b>Straw</b>	30,000	25,000	432,000GJ
<b>Output</b>	<b>Ethanol</b>	4,300	4,200	114,800GJ
	<b>Biofuel</b>	4,300	3,900	73,100 (2900 tonnes coal)
	<b>Animal feed</b>	11,100	7,210	112,500GJ

The demonstration plant will extensively be used during the Climate Summit to disseminate the work Inbicon is doing on 2G bio-ethanol, and hopefully a successful demonstration will pave the way for the introduction of the technology to the market. Hence the demonstration plant will be specially designed to receive visitors, and will be equipped with i.e. viewing galleries.

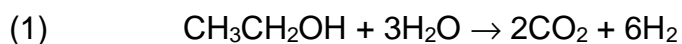
In April 2008 the construction of the plant started, and presently the foundation is being done.



The 2G Ethanol Demonstration plant in Kalundborg.

## The Results of disseminating the ethanol reformation Technology

Important factors to consider when evaluating use of bioethanol as fuel or feedstock is the overall economy of the processes involved as well as the energy-efficiency from biomass to wheel. Fuel grade bioethanol needs to be water-free, thus the production requires distillation beyond the azeotrope point, and this is one of the major production costs of fuel-ethanol. On the other hand, the ethanol reforming process requires a significant amount of water (1), which superfluous the expensive distillation. Only a simple flash distillation to some 50-70% is necessary - considerable lowering the production costs of bioethanol



Before ethanol can be used in Fuel Cells it needs to be reformed into hydrogen, and as earlier argued this requires development of new catalyst. DONG Energy has been in contact with catalyst experts from the Technical University of Denmark, in order to discuss the development of such new catalyst. The bioethanol examined was received from Dong Energy's subsidiary Inbicon's 2<sup>nd</sup> generation bioethanol pilot plant in Skærbæk, Denmark. The Ethanol-Water mixture was taken direct from the top of the stripper column, and has not been passed through the rectifier column.

The results of the test showed how steam reforming of bioethanol (1) for hydrogen production can be effectively carried out over different heterogeneous catalysts. Moreover, the university have illustrated some of the challenges for implementing this process into industrial applications.

Some heterogeneous catalysts based on ruthenium and nickel shows interesting potentials for the reforming of technical bioethanol, though some challenges still exist in e.g. reducing coke depositions on the catalysts. A major factor in limiting carbon formations is the temperature. Higher temperatures decrease the carbon formation significantly. Seeing as the activity of the catalysts are high at the temperatures used in steam reforming the most important parameter to monitor would be catalyst lifetime, the use of technical bioethanol is decreasing the lifetime of the catalysts and this must be addressed in the design of this process. As long as the deactivation issues are accounted for it is apparent that the use of fuel grade ethanol is not required; a simple flash distillation of the fibre beer to remove the sugars and other non volatile substances from the feedstock seems to be sufficient. Therefore the economics in a biorefinery can be improved by minimizing the process heat

(steam) for the energy intensive distillation along with the capital costs for the distillation equipment.

Details of the experiments will be presented in a scientific Journal, and is presently under submission

DONG Energy will continue the cooperation with the university, and hopefully it will be possible to develop some inexpensive catalyst with a reasonable lifetime, as this is needed if fuel cells based on ethanol reforming has to succeed.