Gasification survey country: Norway
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Date: November, 2015

1 Policy

1.1 White Paper on Energy Policy

In the 2013 Government platform, the Government stated that it wants Norway to be a pioneer in environmentally friendly energy use and production, both in hydropower, wind power, bioenergy and other renewable forms of energy.
The Norwegian Government is currently in developing a White Paper on energy policy. The Government has signaled that the White Paper will be published in in 2016.
In 2012, an expert commission nominated by the Government in order to assess and provide policy recommendations for the further development of the energy system in Norway delivered its report[1]. The report offers some assessment of the potential of biomass for energy purposes in Norway (chapter 11.8) and will probably represent an important reference for the White Paper on energy policy.

1.2 Bioeconomy strategy and SKOG22

The Norwegian government established an expert panel in 2013 in order to provide recommendations for an improved resource management and increased industrial activity related to Norwegian forest resources. SKOG22 (Forest22) is a national strategy for forestry and wood industries. Innovation Norway was responsible for the development of the strategy, and the work was conducted in four workgroups:

- Building materials
- Chemistry
- Fiber
- Energy

The work in SKOG22 considered both short and long term measures to increase the added value that can be generated by the forestry industry. Bioenergy and biofuels were mentioned as growth areas, as Norway has large unused forestry resources.

The strategy document (available in Norwegian only) can be found at
http://www.innovasjonnorge.no/PageFiles/1219801/Skog_22_rapport_DEL1.pdf

SKOG22 will likely be an important input into the Government's efforts with a national bioeconomy strategy.The Norwegian Government has decided that a national strategy for bioeconomy should be developed. The bioeconomy strategy will be developed in a partnership with all relevant ministries as well as funding agencies, businesses, organizations and research institutions. The strategy is scheduled to be completed by 2015.

[1] NOU 2012:9: Energiutredningen – verdiskaping, forsyningssikkerhet og miljø, Oslo: Norges offentlige utredninger.

1.3 Klimakur 2020[2]

Klimakur 2020 is a report that was prepared for the "Ministry of the Environment" by several groups, among these are, "Norwegian Water Resources and Energy Directorate", "Norwegian Petroleum Directorate", "The Norwegian Public Roads Administration", "Statistics Norway" and "The Climate and Pollution Agency". The report aims at mitigating the climate changes by reducing CO_2 emissions to the atmosphere. Conclusions are as follows:

- The Norwegian emissions of climate gases shall be reduced by 15 – 17 million tons of CO_2 equivalents by the year 2020.
- It is taken into account that Norway will be credited 3 million tons of CO_2 equivalents through CO_2 capture by forest. The aim is therefore reduced to 12 – 14 million tons of CO_2 equivalents.
- The target is set relative to the baseline scenario of future greenhouse gas emissions as expressed in the national budget for 2007.
- The klimakur 2020 has only investigated measures that are adding to the expected emission reductions which are in the baseline scenario.
- The klimakur assessment will be the basis for the government's evaluation of the Norwegian climate policy, which will be presented to the parliament in 2011.
- The agencies behind the report should show existing opportunities without selecting or recommending any measures.

The Klimakur report mentions the transport sector as one of the easiest sector for the reduction of climate gas emissions. The potential is 3 – 4.5 million tons of CO_2 equivalents within the year 2020 where the contributors are comprised of road traffic, civil air traffic, ships traffic, railroad and other mobile sources (tractors, etc.). Klimakur recommends biofuels as a part of the solution and estimates potential CO_2 reductions of 1.7 – 1.9 million tons in 2020 and 3.8 – 7.7 million tons in 2030.
Other sector that contributes to the increase of biomass utilization is inland production of heat and electricity. This sector is already blessed with high share of renewable energy due to the hydropower situation in Norway. The climate emissions from this sector were calculated to 0.6 million tons of CO_2 equivalents in 2007 which constitutes of one percent of the national emissions. Most of these emissions come from natural gas heat and power generation which are already accounted for under the section dealing with CO_2 capture and storage. The rest of the contributors come from small scale heat production units based on fossil fuels. Measures for CO_2 reduction from these units are will be solved by the replacement of fossil fuels with biomass.

1.4 Strategy For increased expansion of bioenergy - 2008[3]

The main target the strategy is to increase the biomass utilization with "new" 14 TWh by the year 2020. It is estimated that the total use of biomass in Norway was about 14.5 TWh in 2006. A slightly over 7 TWh was used in homes and 4.4 TWh in the industry. 2.7 TWh was

[2] Statens Vegvesen Climate cure 2020 Chapter 10, Sector analysis of transport, in the Norwegian report Climate Cure 2020, Measures and Instruments for Achieving Norwegian Climate Goals by 2020 www.klimakur2020.no
[3] http://www.regjeringen.no/nb/dep/oed/dok/rapporter/2008/strategi-for-okt-utbygging-av-bioenergi.html?id=505401

converted into heat and power in large systems, of which 1.4 TWh was generated in district heating plants, 1 TWh in cogeneration plants and 0.3 TWh in thermal power plants. As it can be seen, the power generation based on biomass which is relevant from the biomass gasification point of view is quite limited in Norway. Profitability for such systems depends on the utilization of the generated heat. The strategy for increased utilization in biomass for heating is by substituting oil based systems. Calculations has shown that the annual consumption of bioenergy in residential, commercial buildings and heating plants can be increased by 14 TWh if oil prices are still expected to remain at a high level (70-90 USD / barrel) and if the quota price of CO_2 increases to 500 NOK/ton. Norway introduced a CO_2 tax in 1991, as one of the first countries in the world. In 2008, the CO_2 tax was 207 NOK per ton of CO_2 for light fuel oil and 175 for heavy fuel oils.

As for biofuel the strategy states that Norway shall increase the biofuels turnover to approximately 7 % from 2010 whereas the second sets the ambitious target of reaching a 20 % share of energy from renewable sources by 2020 and a 10 % share of renewable energy specifically in the transport sector, with a significant contribution from biofuels.

The Climate and Pollution Agency (klif) is attempting at achieving these ambitious targets by putting in motion a new proposal for the utilization of biofuels.[4] A deadline for proposal modification was set to January the 10th 2011. In addition, the EU directive on fuel quality will be also implemented in Norway. As from July 2011 a new law for the trade of biofuels was introduced. The share of biofuels in the total quantity of traded fuel was increased from 3.5 % to at least 5 %. A greater care will also be taken at ensuring a sustainable production in line with EU directives. The following goals are hoped to be achieved in regards to emissions:

- Emissions of greenhouse gases from fuel should be reduced by 6 % (relative to energy content in the fuel) by the end of 2020.
- The substitution of fossil fuels by biofuels should lead to a reduction of greenhouse gas emissions by at least 35 %.
- As of January the first 2017 the emission reduction should be at least 50 percent.
- Biofuels produced on plants that start up after January 2017 should have an emission reduction of at least 60 % after January 2018.

2 Research programs

The Research Council of Norway serves as strategic adviser, funding agency and network builder and bases its activities on national research policy and guidelines established by the Norwegian Government. The Norwegian research policy is laid down in Report No. 30 (2008-2009): Climate for Research, which identifies areas of research expected to play a crucial role in meeting key challenges facing society.

- Upholds the Government's long term ambition that total R&D expenditure will constitute 3 per cent of GDP
- Emphasizes the need to focus on major global challenges relating to energy, climate, poverty and health

[4] http://www.klif.no/no/Tema/Klima-og-ozon/Biodrivstoff/

- Incorporates perspectives relating to the northern areas
- Sets clear targets for the role of the public sector in industry-oriented research
- Signals a desire to increase investment in basic research
- Suggests a new funding model for infrastructure
- Sets clear targets for increased recruitment
- Advocates greater focus on internationalization
- States that resource use throughout the research sector will be evaluated

2.1 ENERGIX (2013-2022)

The new Large-Scale Programme for Energy Research (ENERGIX)[5] was launched in 2013 and covers a ten year period. The ENERGIX programme is funded by the Ministry of Petroleum and Energy, the Ministry of Transport and Communications, the Ministry of the Environment, the Ministry of Agriculture and Food, the Ministry of Education and Research, and the Ministry of Fisheries and Coastal Affairs. The thematic priority areas are presented on Figure 1.

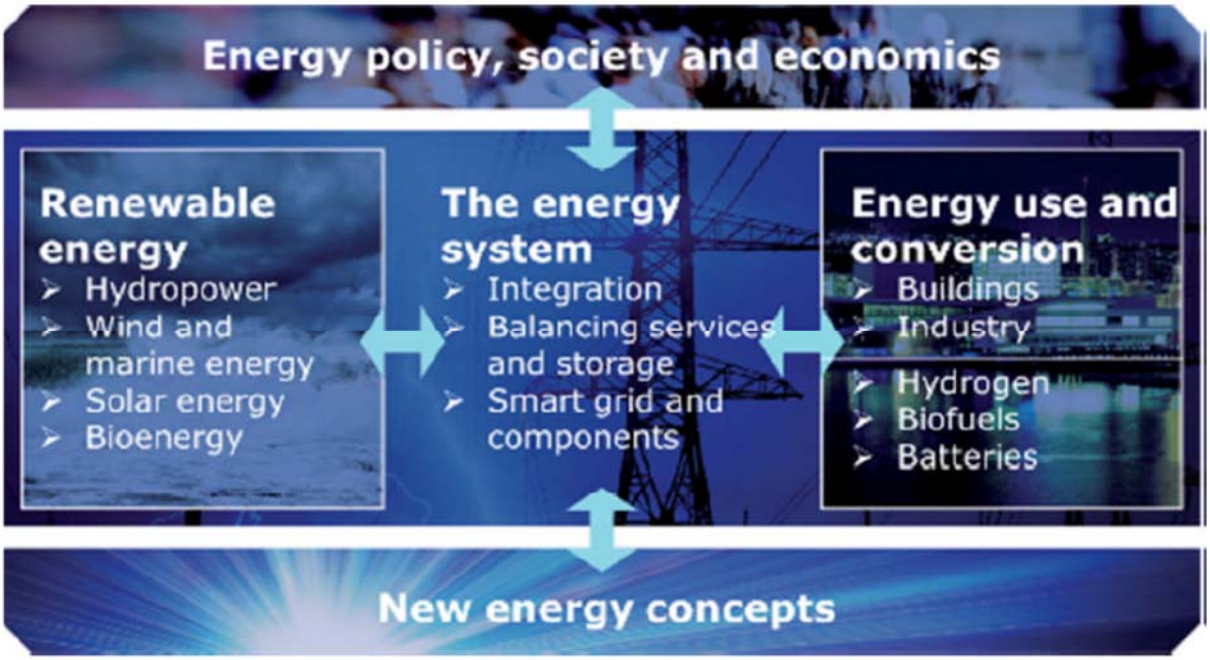

Figure 1 Thematic priority areas in ENERGIX Programme (Figure source: Research Council of Norway)

The ENERGIX programme includes both stationary energy and transport. The ENERGIX programme aims at helping to achieve energy and industrial policy objectives and is a key instrument in the implementation of Energi21, Norway's national RD&D strategy. The programme will also promote the broadest possible range of research activities strengthen innovation. The programme is targeted towards Norwegian companies and research and educational institutions.

[5] http://www.forskningsradet.no/prognett-energix/Home_page/1253980140022

2.1.1 Primary objective

The primary objective of the ENERGIX programme is to provide support for the long-term, sustainable restructuring of the energy system in order to accommodate a greater supply of new renewable energy, improve efficiency and flexibility, and facilitate closer energy integration with Europe.

2.1.2 Secondary objectives

The secondary objectives for the programme are:

- To achieve sustainable utilisation and consumption of renewable energy resources;
- To reduce Norwegian and global emissions of climate gases;
- To ensure Norway's security of supply;
- To strengthen innovation in Norwegian trade and industry;
- To further develop Norwegian research communities.

2.1.3 Budget

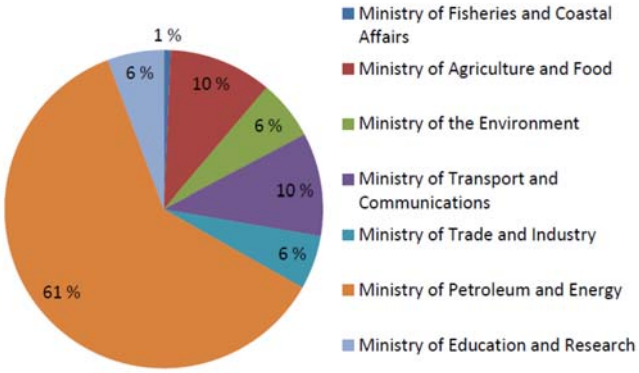

Figure 2 FinancingfortheENERGIXprogramme (Figure source: Research Council of Norway)

2.1.4 Centres for Environment-friendly Energy Research (FME)

The FME centers play a key role within the research and innovation system in achieving renewable energy targets. The centers bring together leading research groups and relevant industry players in selected priority areas, and focus on long-term research, with clear objectives and work packages. Centre activities are intended to open up new opportunities for innovation, raise new questions and identify new research needs.

CenBio is one of the FME's and is dealing with research within bioenergy. CenBio is co-funded by the Research Council of Norway. The host institution is the Norwegian University of Life Sciences (NMBU), our center leader is SINTEF Energi AS. CenBio aims at enabling sustainable and cost-efficient bioenergy. CenBio will address the entire value chains of virgin biomass and biodegradable waste fractions, including their production, harvesting and transportation, their conversion to heat, power and biogas, and the handling and upgrade of residues to valuable products. This is a formidable task, requiring knowledge and

competence from numerous research disciplines and industrial sectors. This complex task is divided into six subprojects (SP), each subproject is itself divided into several work packages (WP), see figure below for details.

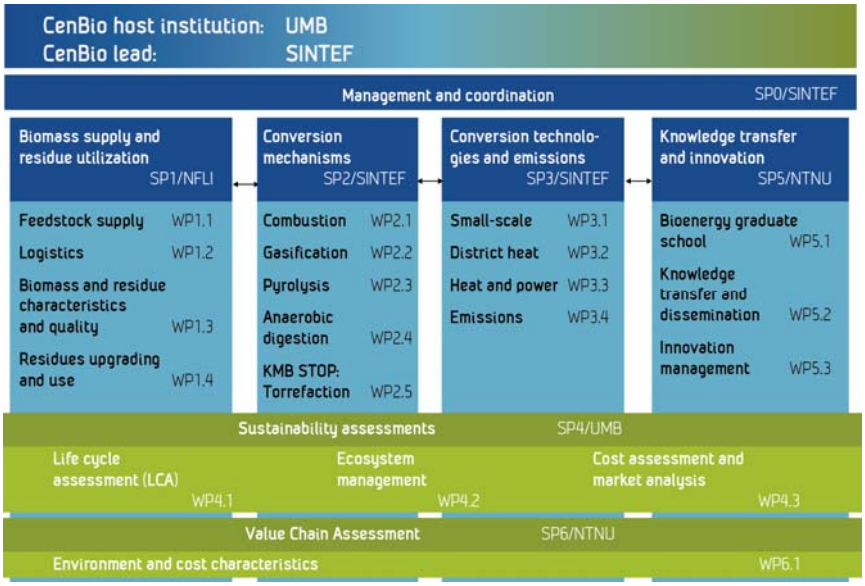

Figure 3 CenBio Work Breakdown Structure (Fugure source www.Cenbio.no)

2.1.5 Coordination with other national instruments

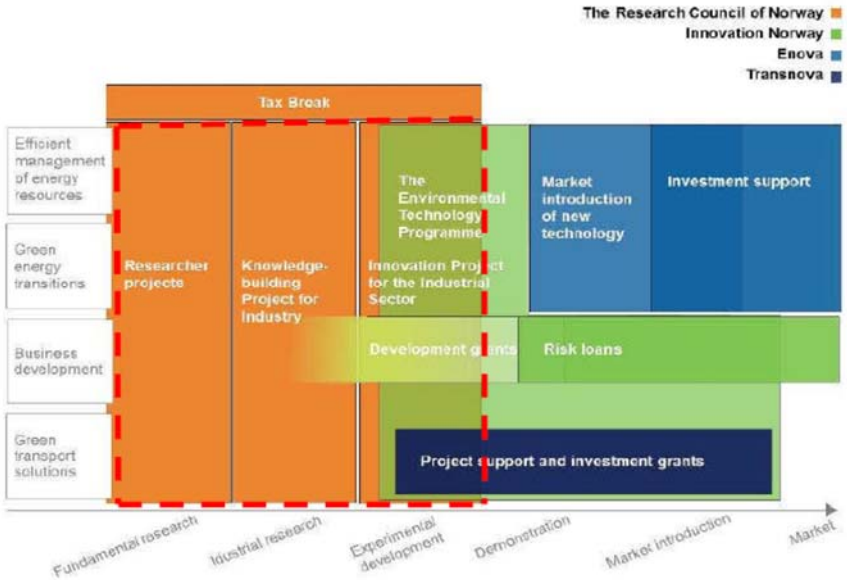

Figure 4 National funding instruments in Norway (Figure source: Research Council of Norway)

In Figure 4, the research and innovation funding system in Norway is presented. The Norwegian Research Council funds research in the renewable energy field via the ENERGIX programme (red dotted frame) and the FME centre scheme. The ENERGIX programme administers Researcher Projects, Knowledge-building Projects for Industry and Innovation Projects for the Industrial Sector (orange field).

2.2 Clean Energy for the Future (RENERGI) (2004 – 2013)

2.2.1 Primary objective

The primary objective of the RENERGI program is to develop knowledge and solutions as a basis for ensuring environment-friendly, economically efficient and effective management of the country's energy resources, a highly reliable energy supply and internationally competitive industrial development related to the energy sector.

2.2.2 Secondary objectives (5-10 years perspective)

- New technologies, systems and solutions that facilitate energy restructuring by improving the efficiency of energy production, transmission and use, making more energy available and improving system security and flexibility.
- Environment-friendly energy systems that reduce emissions of greenhouse gases and other air pollutants, improve land use, etc.
- New, internationally competitive goods and services related to the energy sector.
- Knowledge and analysis as the basis for the authorities' and industry's long-term energy strategies, public debate and design of public policy instruments.
- Internationally competitive research communities in high-priority fields that collaborate extensively with international researchers and various types of users.

2.2.3 The objectives for a 20-30 year perspective

The objectives for a 20-30 year perspective encompass these same elements. Research activities are intended to create a foundation for societal development based on a high degree of innovation in which the development of the energy sector development is consistent with ambitious environmental goals.
Important secondary objectives in this context include:

- Energy systems and management that can be adapted to comply with the next generation of climate agreements and the EU's long-term objectives for security of supply, the environment, renewable energy, etc.
- Energy policy that paves the way for value creation in the energy sector and enables the energy-related supplier industry to continue to play an important role in the Norwegian economy
- When laying down objectives and designing strategies in such a long-term perspective, research efforts will have to be adaptable to changes in the needs of society and in framework conditions, and include:
- Knowledge-building in fields relevant to the exploitation of Norwegian energy resources and energy efficiency
- Recruitment to research communities
- Establishing good cooperation between research communities, trade and industry and other users
- Broad participation in international research programmes
- Encouraging innovation and a long-term perspective in trade and industry
- This programme/activity normally accepts grant applications from: Trade and industry, independent research institutes, and universities and university colleges.

2.3 Program for Power Generation with Carbon Capture and Storage (CLIMIT)

The program is managed by Gassnova in cooperation with the Research Council of Norway. Responsibilities have been divided: whereas the Research Council of Norway is in charge of the research projects, Gassnova is responsible for the prototype and demonstration projects. By supporting testing and demonstration projects, Gassnova shall help to develop cost-efficient and future-oriented technology concepts for CO_2 management. This includes the development of know-how and solutions for:

- CO_2 capture before, during or after power production
- Compression and handling of CO_2
- Transport of CO_2
- Long-term storage of CO_2 and other areas of application

Gassnova shall focus on co-funding projects seen as having an obvious commercial potential and which include a market-oriented business plan. Please also refer to the Program Plan and the CLIMIT "road map".

2.4 Program for user-driven research BIA

The BIA program is targeted at industry. Companies may apply for partial funding of R&D projects which are based on their own strategies and challenges, regardless of branch of industry or thematic area. The projects must result in substantial value creation for the companies as well as for society-at-large, and must take an international perspective. The projects are organized in consortia whereby companies and R&D communities cooperate on achieving results.

2.4.1 Background

The level of national investments in R&D is lower than desired, and it is vital that Norwegian trade and industry is encouraged to increase its investments in research. Moreover, the ability to exploit the economic potential of R&D investments still needs to be enhanced significantly. The Research Council has launched a strategy for user-driven research based on the following assumptions:

- Public investments in user-driven research will trigger significant new R&D initiatives in Norwegian trade and industry.
- Public investments in user-driven research will lead to increased national value creation in the long-term.
- User-driven research needs to be targeted to meet important challenges and support company strategies.

Report no. 20 to the Storting (2004-2005) “Commitment to Research” stresses the importance of mobilizing Norwegian trade and industry with a view to achieving greater R&D investment. However, the report also states that too great a focus on user-driven research in narrow segments of industry may result in too little funding for projects that would be profitable in a more socio-economic perspective. Based on this reasoning, the Norwegian Government has recommended that the competitive arena for funding be expanded within

the established budgetary framework. Consequently, several specific, industry-oriented user-driven research programs have been consolidated into a new, more general Program for User-driven Research-based Innovation (Norwegian title: Brukerstyrt innovasjonsarena, abbreviated BIA).

2.5 SkatteFUNN

The primary objective of the SkatteFUNN scheme is:

- To provide support to R&D projects carried out by companies.
- To enhance innovation in Norwegian trade and industry, and services.
- To foster the development of good business ideas.
- To motivate Norwegian companies to make their R&D efforts more strategic and targeted.
- To encourage greater use of development and research as strategic instruments to improve competitiveness.

The SkatteFUNN scheme is an indirect funding scheme. Support takes the form of a tax deduction up to 20% of the costs related to R&D activity. Expenses must be documented and recorded in the project accounts. The tax deduction is awarded on top of the ordinary deductions. Tax deduction under the SkatteFUNN scheme are based on the following annual limitations per project per company:

- NOK 5,5 million R&D conducted by the company itself (internally or in collaboration with others). 20 % deduction = maximum NOK 1,1 million for SMEs and 18 % for larger companies.
- With a budget framework of over NOK 5,5 million (and maximum NOK 11 million), all expenses between NOK 5,5-11 million must be related to the procurement of R&D services from an approved R&D institution. Up to 20 % deduction = maximum NOK 2,2 million for SMEs and 18 % for larger companies.

Only projects that have been approved by the Research Council (the SkatteFUNN scheme) are eligible for tax deductions. The deduction itself (which may be considered project funding) is taken at the time of the annual tax assessment, and is based on the deductions itemized by the company and verified by an auditor on the RF 1053B tax form. SkatteFUNN normally accepts grant applications from all business enterprises subject to taxation in Norway.

3 R&D institutes

SINTEF Energy Research
Department of Thermal Energy
NO-7465, Trondheim
Norway

Norwegian University of Science and Technology (NTNU)
Department of Energy and Process Engineering
NO-7491, Trondheim

Norway

Norwegian University of Science and Technology (NTNU)
Department of Chemical Engineering
NO-7491, Trondheim
Norway

Institutt for Energiteknikk (IFE)
NO-40, 2027 Kjeller
Norway

Paper and Fibre Research Institute (PFI)
NO-7491, Trondheim
Norway

4 Industries

ENERGOS AS
Kvenildmyra 5
N-7072, Heimdal
Norway

Fiborgtangen Vekst AS
N-7620, Skogn
Norway

Agder Biocom AS
Industriveien 2
N-4484 Øyestranda
Norway

5 Projects

5.1 Gasification and FT-Synthesis of Lignocellulosic Feedstocks (2015-2018)

The project Gasification and FT-Synthesis of Lignocellulosic Feedstocks (GAFT)[6] is aiming at accelerate the introduction of liquid biofuels production in the Norwegian market through local production.

Two specific markets are targeted:

- bio-jetfuel for the aviation sector
- bio-diesel for the heavy road transport sector

Biomass, which is the starting point of the energy conversion route, will be a mixture of mostly low by-products that are available in the Norwegian market and some high quality products.

[6] http://www.sintef.no/en/projects/gaft-gasification-and-ft-synthesis-of-lignocellulo/

Key areas that have been identified as crucial for the success of the project are:

1. The plant scale should be in the medium range (100-500 MW) which will help to keep the fuel transport costs in check
2. The entire process will be optimized with the idea of having three separate sub-processes
    - A decentralized feedstock pre-treatment sites using torrefaction
    - A centralized gasification and FT for bio-crude production
    - The use of existing refineries for further upgrade of the bio-crude into transport fuels

Partners:

- Avinor
- Silva Green Fuel AS
- Viken Skog SA
- CAMBI ASA
- ECOPRO AS
- The Research Council of Norway

International partners:

- Johnson Matthey
- SP Energy Technology Center

5.2 Gasification for Biofuels (2010-2014)

Future production of Second Generation Biofuels in Norway requires building of long term competence in thermochemical biomass conversion (i.e. gasification). GasBio aims to fulfill this national need. This project adresses key elements of processes for large scale production of synthetic diesel from wood and forest resources, as well as processes for smaller scale production of biofuels from forest, household and industrial waste fractions. The proposed project is backed by the most central Norwegian industrial enterprises planning to establish future liquid biofuels production plants in Norway, and will be carried out in close cooperation with these. The research group behind the proposal has a solid track record in research on related issued with focus on combustion of biomass, including the leadership of NextGenBioWaste, EUs largest biomass research project ever, as well as the leadership of the recently established National Bioenergy Innovation Centre - CenBio.

5.3 Technology development for integrated SOFC, biomass gasification and high temperature gas cleaning - Up-scaling and long term testing (2005 – 2008)

The EU strategies for Renewable Energy Sources (RES) involve an increase of the use of these resources from 6% (1997) to 12% (2010) and the Electricity from Renewable Energy Resources (RES-E) is subject to an increase from 14% (1997) to 22% (2010). A major part of this increase is planned to come from biomass. The rapid increase in renewable electricity put focus on gasification technologies in particular. To increase the electric efficiency in future gasification plants, a shift from gas engines and gas turbines to high temperature fuel cells is needed. The biomass gasification process must yield highest possible hydrogen

content in the producer gas. Hence, steam gasification is the ideal gasification process in combination with fuel cells. However, other compounds in the producer gas, such as H2S, are damaging for the SOFC, depending on their levels. This proposal is a continuation of an ongoing project funded by the Research Council of Norway that includes both novel fundamental and applied studies, including laboratory tests of high temperature filtration and SOFC operation performance as well as onsite testing in connection with biomass steam gasification. As such, the novelty of the ongoing project is quite unique, and will contribute to future development of high efficiency electricity production from biomass. The new project proposes an up-scaling from the 1 kW to a 10 kW SOFC including continuous high temperature filtration. The most problematic compound identified so far is H2S and particular attention must be paid to removal of this component. A total system in operation has to be thermally integrated to reduce losses and increase the total efficiency; hence a detailed system study for optimization of the gasifier-high temperature filtration-SOFC system is proposed.

5.4 Detailed studies on biomass gasification in a TGA coupled with advanced gas analysis (2008 - 2011)

Conversion of biomass to a producer gas has many advantages. A gas is easier to handle and transport, it can be cleaned before combustion (i.e. compact cleaning), and it can then be used directly in e.g. engines, gas turbines and fuel cells for electricity generation. Alternatively, it can be processed to produce fuels (e.g. 2nd generation biodiesel), chemicals (e.g. methanol) and high-value niche products (e.g. special waxes).Compared to direct combustion of biomass in boilers and subsequent electricity generation in the typical steam turbines, the achievable net electric efficiency from the producer gas used in engines and gas turbines is significantly higher than for small to medium size steam turbines of equal power output. The theoretical efficiency of a fuel cell is very high compared to the traditional competition. The proposed project includes the use of state of the art experimental set-ups to derive fundamental knowledge of importance for biomass conversion through gasification processes. This will be done mainly through two PhD studies, one on gasification fundamentals and the other on additives and gas conditioning. Important tasks will be:- Set-up, testing, refining and verification of a TGA and advanced gas analysis system- Testing of different biomass fuel types as a function of temperature and heating rate- Testing of different oxidants (steam, oxygen and air) for gasification, and reaction rates analysis- Testing of different additives (Ca and Phosphor based) to decrease the formation of harmful trace species (e.g. H2S) causing problems in downstream units (e.g. a fuel cell)- Testing of Non-Thermal Plasma (NTP) for gas conditioning- Analysis of optimum conditions for a hydrogen rich and high quality producer gas production with reduced secondary producer gas conditioning needs- Scaling effect analysis to assess the effect of increased transport limitations with increasing particle and sample size, including comparison with macro-TGA.

5.5 Biomass to liquid fuels (2009 – 2013)

Biomass is the only renewable energy possible to convert into liquid fuels that is compatible with the present infrastructure of the transportation sector. As a means for reducing the CO2 emissions from the transportation sector, biomass could play an important role in the

near future. It is of crucial importance that the biomass used for transportation fuels does not compete with biomass for food and that it is produced in an environmental friendly way. The production of 2nd generation biofuels from wood y biomass uses the whole plant including the lignocellulosic part. One promising way for producing the 2nd generation biofuels is through gasification into synthesis gas and converting the synthesis gas to liquid fuels (diesel) by the Fischer-Tropsch synthesis. Biomass also offers the possibility to produce other liquid fuels such as ethanol, methanol and even hydrogen. A number of process configurations are possible for the conversion of biomass to liquid fuels. It is, however, important for a future process to modify existing or to develop new technology for the synthesis gas production and the Fischer-Tropsch synthesis. The present proposal is based on many years of experience with similar technology for converting natural gas to liquids and contains research proposals covering crucial areas of catalyst and adsorbent technologies: The reforming of undesired biogas components, the adjustment of the biogas composition, the removal of pollutants, and the Fischer-Tropsch synthesis using biomass-generated syngas.

5.6 Lignocellulosics as a basis for second generation biofuels and the future bioreffinery (2009 – 2012)

The Lignoref project is devoted to developing fundamental knowledge about central processes for cost effective conversion of lignocellulosic materials into second generation biofuels and other value-added products. Central processes that will be studied include biomass pretreatment, hydrolysis of biomass polysaccharides, fermentation of sugars derived from biomass and thermochemical conversion of process by-products. The project will study different raw materials, ranging from wood to agro wastes (e.g. bagasse). Mechanisms involved in biomass pretreatment will be studied for three specific production routs; direct hydrolysis during pretreatment, hydrolysis after pretreatment and biomass gasification route. For the two first routs, the project aims at establishing relationships between pre-treatment conditions and the subsequent enzymatic conversion and fermentation. Furthermore, the project also aims at developing enzyme systems that will make the hydrolysis of lignocellulosic polysaccharides more effective as well as microbial strains that will effectively convert lignocellulosic sugars to ethanol. Production of value-added products from process by-products or separated biomass polymers (e.g. hemicelluloses and lignin) by chemical, thermochemical or microbial processes will also be assessed. Furthermore the LtL process for pyrolytic conversion of lignin to bio-oil will be further developed. The project aims at establishing a national knowledge platform on conversion of lignocellulosics. This platform should form a basis for future production of second generation biofuels and green chemicals in a biorefinery concept.

6 Implementations

Location	**Type**	**Capacity (thermal)/year**	**Feed**	**Status**
Ranheim	Gasification/combustion	25 GWh	Waste	Non-Operational
Averøy	Gasification/combustion	69 GWh	Waste	Non-Operational
Hurum	Gasification/combustion	105 GWh	Waste	Non-Operational
Forus	Gasification/combustion	105 GWh	Waste	Operational

Sarpsborg	Gasification/combustion	210 GWh	Waste	Operational
Sarpsborg	Gasification/combustion	256 GWh	Waste	Operational