Project summary

(February 2011)

Project acronym:	Bioliquids-CHP
Project name:	Engine and turbine combustion for combined heat and power production
Call:	FP7-ENERGY-2008-RUSSIA
Activity code:	ENERGY.2008.2.2.1: Enhancing strategic international cooperation with Russia in the field of power generation from biomass
Keywords:	Cooperation with Russia in the field of power generation from biomass; combustion, bio-liquids, engine, turbine, combined heat and power (CHP), cogeneration
Duration:	January 2009 – December 2011 (36 months)
Total cost:	4,309,696 Euros
Commission funding[1]:	1,602,319 Euros
Project website:	www.bioliquids-chp.eu

Project partners:

- BTG Biomass Technology Group BV (NL)
- EnConTech BV (NL)
- University of Florence, CREAR (Italy)
- Boreskov Institute of Catalysis, Siberian Branch of Russian Academy of Sciences (Russia)
- Federal State Unitary Enterprise 'Central Scientific Research Automobile and Automotive Engines Institute' - FSUE 'NAMI' (Russia)
- Aston University (United Kingdom)
- The Likhachev Plant (AMO ZIL) (Russia)

Project management

Overall coordination:
John Vos
BTG Biomass Technology Group BV
Tel. +31-53-486 1186
Email: vos@btgworld.com

Technical issues:
Bert van de Beld
BTG Biomass Technology Group BV
Tel. +31-53-486 2288
Email: vandebeld@btgworld.com

[1] In addition, 72 million Rubles are made available by the Ministry of Education and Science of the Russian Federation.

Project Context

Whereas the EC had set the target to increase the share of combined heat and power (CHP) in the European energy supply to 18% by 2010, CHP currently accounts for only 11% of it[2], and substantial efforts remain to be done. Biomass CHP could greatly contribute to the effort needed and account for 44% of CHP in Europe by 2050[2]. Small-scale (50 to 1000 kW_e), direct biomass-to-electricity CHP-systems could contribute to this potential, particularly in remote regions. However, the implementation of such systems has been rather limited for different reasons, including:

- Relatively high investment costs for small-scale systems
- High running costs
- Poor reliability and availability
- Low acceptance by end-users

The factors causing these intrinsic problems are manifold, but main causes include:

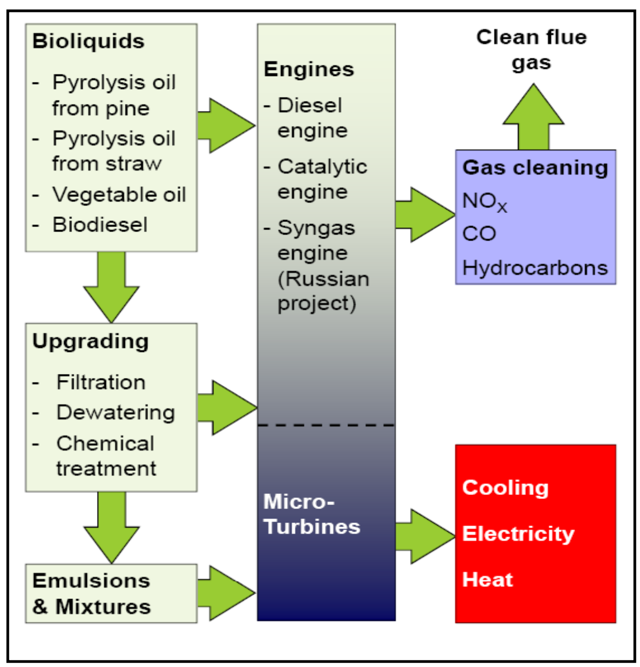
- The presence of contaminants in the biomass (apart from ash, oxygen and water can also be considered this way)
- The limited availability of uniform types of biomass
- The non-uniform appearance of biomass
- Its general low energetic density (especially in terms of GJ/m^3), requiring huge volumes of biomass stocks to be stored near the electricity production unit

Converting biomass into bioliquids[3] can solve these problems in different ways. Amongst others, it increases the acceptance by end-users, as they are uniform and easier to use. Also, the energetic density of bioliquids is higher than that of the biomass used to produce them. The Bioliquids-CHP project was set up to break down the technical barriers preventing the use of bioliquids in engines and turbines.

Project objectives

The aim of the project is to adapt engines/turbines to enable operation on a variety of bioliquids, including pyrolysis liquids.

On the one hand, the project is modifying the design of a diesel engine and a micro gas turbine so that these can run efficiently on bioliquids such as biodiesel, vegetable oil and pyrolysis oil. On the other hand, bioliquids will be upgraded and blended in order to facilitate their use in engines and turbines. Thus, the most economic and reliable engine/turbine-bioliquids combinations will be developed in order to make the system attractive. In addition, the project is developing methods and techniques to control exhaust emissions (NO_x, CO, particulates), which will improve the environmental sustainability of the engine/turbine-bioliquids combinations.



Bioliquids-CHP project overview

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[2] Source: www.cogeneurope.eu

[3] Bioliquids are defined as liquids fuels produced from biomass and used for energy purposes other than transport. Their energy purposes include electricity production, heating and cooling.

Project progress and way forward

Since the start of the project, considerable progress has been achieved with regards to (a) bioliquids production and upgrading, (b) modifications of the engines/turbine to enable the efficient use of bioliquids, (c) pollutants emission reduction, and (d) the techno-economic and environmental assessment of the developed systems.

As far as the research on bioliquids is concerned, several batches have been produced or purchased, characterised and upgraded. These bioliquids include pyrolysis oil (PO) from pine and straw, sunflower oil, and biodiesel. Research activities focus on upgrading PO and on preparing blends or emulsions that can be used in engines/turbine. For PO, different upgrading approaches have been investigated including (a) partial dewatering, (b) solids removal in a centrifuge, (c) esterification of active components with alcohol, and (d) mild hydrodeoxygenation under elevated pressure in the presence of hydrogen and a catalyst. The obtained bioliquids have been characterized and their ageing behaviour monitored. Amongst others, it has been determined that PO upgraded through mild hydrodeoxygenation presented the best ageing behaviour. In addition, a recipe to prepare PO-biodiesel emulsions has been developed and small amount have already been produced. Currently, larger amounts are being produced and will be tested in the engines/turbine along the final project year.

As far as the research on the engines/turbine is concerned, work has focused on identifying and implementing modifications that would enable the use of bioliquids. The engines/turbine considered in the project include two internal combustion (IC) engines, a newly developed external combustion engine and a micro gas turbine (MGT).

The first IC engine is a Jiang Dong 1-cylinder 20-kW_e diesel engine. After implementing different measurement equipments, BTG ran preliminary tests with diesel, biodiesel, sunflower oil, ethanol and pyrolysis oil; and characterised the engine. In addition, BTG identified the required modifications and suitable materials to manufacture PO-resistant engine parts. In 2001, the last project year, BTG will implement the different modifications and carry on engine tests with the different bioliquids.

The second IC engine is a Russian YMZ-238M2 unit that has been modified by NAMI. This engine is now assembled on a test bench with a generator, an exhaust gas cleaning system, a heat unit and a microprocessor control system; and extensive testing of the resulting CHP plant has been carried out. The exhaust gas cleaning system consists of a syngas reactor and $DeNo_x$ that were both developed by BIC in the frame of the project. For this purpose, extensive catalyst research was carried out in order to identify and select the most suitable catalysts.

The third engine is an external combustion single-piston engine developed by EnConTech and commissioned in October 2010. Preliminary tests have been carried out and allowed identifying further modifications that need to be implemented. In the last project year, the final engine modification will be implemented and further testing with different bioliquids will be carried out.

Lastly, the micro gas turbine considered in the project is a Garrett GTP 30-67. The University of Florence has identified and implemented several modifications and adaptations so that it can be operated on bioliquids. First, the engine was adapted with minor modifications for vegetable oil and biodiesel, and characterised using diesel fuel. In addition, three-dimensional computational fluid dynamic (CFD) simulations were carried out on the MGT combustor to assess the major modifications required for biofuels feeding. In 2011, UFL will conduct further tests with vegetable oil and biodiesel, before implementing major modifications allowing operation on pyrolysis oil and pyrolysis oil/biodiesel emulsions.

In addition to newly developing or modifying prime movers, the project partners will assess the developed systems in terms of economic and environmental performance, and will identify the different market opportunities. For this purpose, Aston University prepared a document discussing the performance and cost estimates for biomass CHP technologies as well as their environmental impacts. Also, they developed a model for economic evaluation, sensitivity analysis and case studies. In the final year, further work will be carried out to establish the current market opportunities for prospective users of the developed systems.

Last but not least, project results are regularly presented at conferences and made available at the website. In addition, a set a training materials targeted to Master students is being developed by the project partners and will be made available at the project website in 2011. Lastly a final dissemination event will be organised in Brussels in November 2011. More information about the event will be made available in the second half of 2011.

Expected results of the project

Strategic results of the project include:

- PO upgrading processes
- PO-bioliquids emulsions/blending processes
- Bioliquid engine concepts
- Bioliquid MGT turbine concept
- Exhaust gas cleaning system for bioliquid engines
- Techno-economic and environmental assessment of the developed systems

Expected impacts of the project

Strategic impacts of the project include:

- Increase in electricity production from biomass by reducing upgraded pyrolysis oil production prices and by improving bioliquid quality.
- Reduction of costs of electricity production from biomass.
- Optimisation of the engine-bioliquid fuel combination
- Adaptation of existing technologies (Bioliquid production, diesel engines and CHP-units) with a view to optimise the engine-fuel combination
- Improvement of the environment, the quality of life, health and safety.
- Job creation.

Acknowledgment

The project is funded through the European Commission (7th Framework Programme, Grant FP7-227303) and the Ministry of Education and Science of the Russian Federation. (Contract 02.527.11.0003).

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