European Commission

Biofuel-burning Microturbine

Opportunities for Biofuel-burning Microturbines in the European Decentralised-generation Market (BIOTURBINE)

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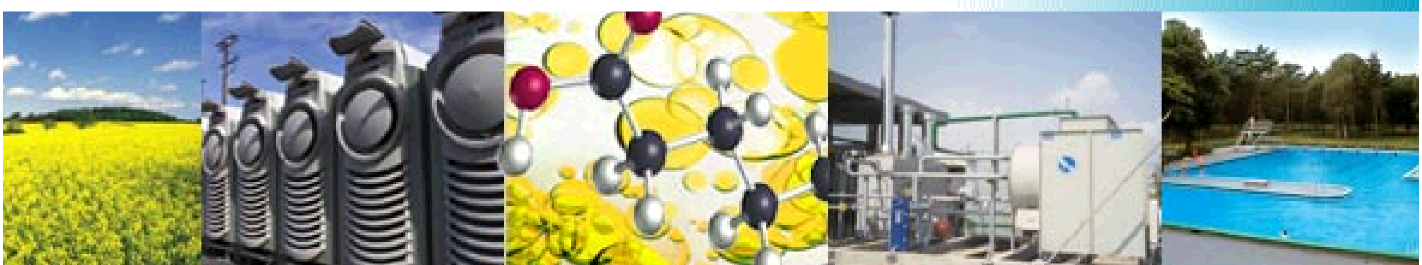

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The Bioturbine Project

The BIOTURBINE project, short for “Opportunities for Biofuel-burning Microturbines in the European Decentralised-generation Market”, is co-funded by the European Commission (AL-2002-11) in the framework of the ALTENER programme.

The project is coordinated by WIP-Renewable Energies (Munich, Germany) and the partners are EUBIA - European Biomass Industry Association (Brussels, Belgium), ETA-Renewable Energies (Florence, Italy) and Energidalen Sollefteå (Sollefteå, Sweden).

The aim of the project is to assess the technical feasibility and the market potential of microturbines that run on liquid biofuels (bioturbines) for power and heating applications (CHP).

These are considered a viable option for the short term future to promote an innovative, efficient and environmentally friendly technology for distributed power generation. It has the additional benefit of developing the biofuels market in Europe.

The opportunities for bioturbines have been evaluated through:

- Assessment and review of the current utilisation, technological development, technical / environmental performance of microturbine systems;
- Analysis of the liquid biofuels market and applications for power systems and the current state of development of bioturbines;
- Assessment of the potential market in Europe for bioturbines by means of identification of distributed-generation and niche electricity markets, comparison with competitive technologies, identifying the critical factors linked to technical and institutional barriers.

More information on the BIOTURBINE project can be found at:
www.bioturbine.org

Overview of Microturbine Technology and Market

Microturbine characteristics

During the last few years microturbines in the range 20-300 kW have been developed as a promising technology for distributed power generation having interesting characteristics like:

- Low maintenance;
- Very compact;
- High reliability;
- Low emissions;
- High flue gas temperatures useful for cogeneration;
- Flexible to use different fuels.

Microturbines are very simple systems having only one moving component: the high speed shaft (over 60.000 rpm and up to 105.000 rpm) supporting the compressor, turbine wheel and generator. The shaft is mounted on air bearings rather than lubricated bearings, which are commonly used in conventional turbines. This reduces maintenance and technical complexity.

Cogeneration units include additional components such as heat exchangers to produce hot water or steam. Heat exchangers serve also to increase electrical efficiency (heating inlet air).

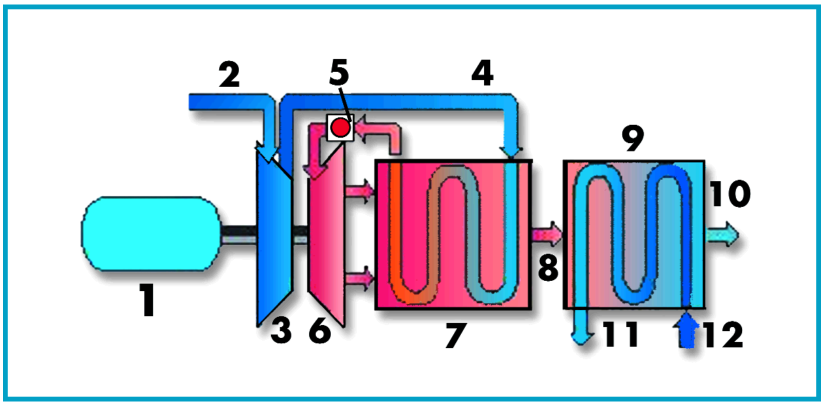


Fig. 1: Basic Microturbine elements
1 - Generator
2 - Air Inlet
3 - Compressor
4 - Air to recuperator
5 - Combustion Chamber
6 - Turbine
7 - Recuperator
8 - Exhaust gases
9 - Heat exchanger
10 - Exhaust gas outlet
11 - Hot water outlet
12 - Water inlet

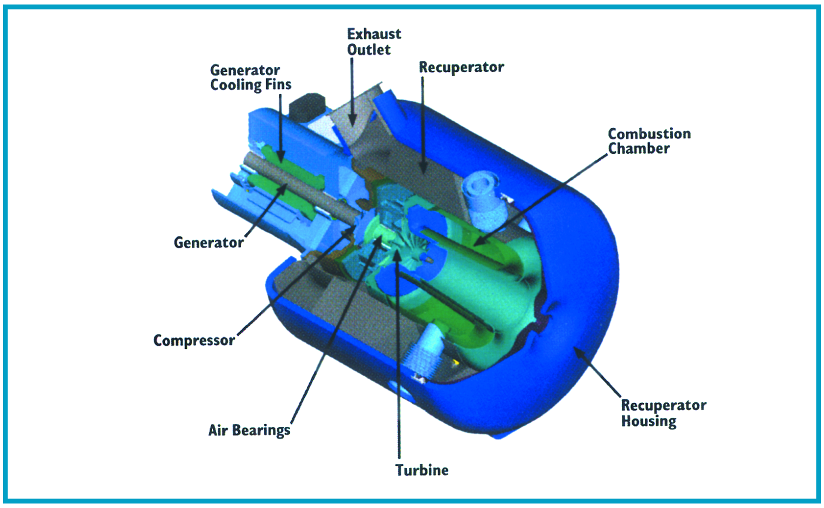


Fig. 2: Capstone Microturbine (by courtesy of Capstone)

Microturbine market in Europe

In spite of all the advantages offered, a microturbine market in Europe is hardly existing. In 2003 the total for the microturbine market has been estimated at about 300 installed units corresponding to a generation capacity of approximately 18 MW_e.

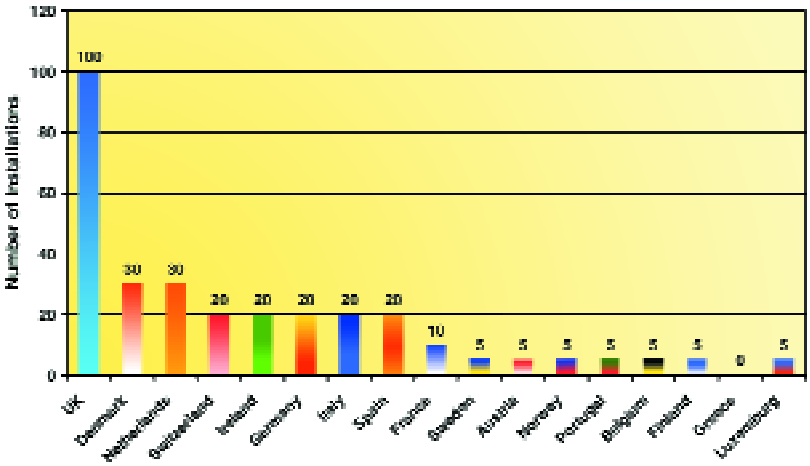


Fig. 3: Estimated microturbine market in the EU-2003

It can be seen that only in the UK a significant microturbine market has evolved, whereas in all other EU countries the market is in its very early stages. Nevertheless it is possible to distinguish EU countries with almost no microturbine market such as Austria, Sweden, Norway, Portugal, Belgium, Finland, Greece and Luxembourg, from countries having started to commercialise microturbine systems and having already gathered significant operational experience such as Denmark, the Netherlands, Ireland, Germany, Italy, Spain and France.

The main reasons for this unsatisfactory current market are lack of knowledge, high investment and high energy production costs, that make them not competitive compared to conventional power supply, and a need of further research to improve their performances, especially using biofuels. Actually microturbines have not reached their technological targets as reported in the Table below.

Performance targets	**Up to now**	**In a few years**
Efficiency of fuel to electricity conversion	30%	> 40%
Investment costs	900-1200 Euro/kW	< 500 Euro/kW
NO_x emission	Tens of ppm	< 7 ppm

The market share by microturbine producers indicates that Swedish Turbec has the first place, closely followed by Bowman Power Systems, while Capstone, the world leader holding 85% of the market worldwide, accounts for lower sales in the EU than expected.

With respect to the type of fuel used, up to now the large majority of microturbines run on natural gas. Nevertheless activities are ongoing in several EU countries to test the performances of microturbines running on landfill gas, digester gas and biogas.

Microturbine Applications

Possible applications

Microturbines offer opportunities for a variety of customers and applications in the residential, commercial and industrial sector.
They can have several potential applications, such as:

- **Continuous generation** (>6000 hrs operation/year)- to succeed microturbines will have to be able to generate electricity at costs competitive with grid connected power;
- **Peak power** (< 1000 hrs operation/year) for peak shaving: users can run on-site units to avoid paying high prices caused by peaks;
- **Backup power** (less than 100 hrs/year)- factors influencing microturbines application are their costs compared to diesel generator sets, their ability to start up rapidly, their reliability and the low expected operation and maintenance costs;
- **Premium power** where the process requires power with a higher quality (availability, constant voltage and frequency, no voltage dips, no harmonic distorsions) than provided from grid to avoid damages to machines, loss of data, loss of production;
- **Remote power** for far off grid applications;
- **Co-/Trigeneration systems** for applications requiring thermal energy (heating and/or cooling) as well as electric power need for development of distributed generation.

Microturbine applications in the commercial/residential sector

A large market share in the microturbines market is currently occupied by the commercial/residential sector. The main reasons are that a large number of this kind of locations have suitable heat and electricity demand profiles, the gap between cost for electricity and gas is larger than in the industrial sector and there is a lower demand for return of investment than in the industrial area.
The major market potential in the commercial and residential sector is traditional CHP (combined heat and power) applications.

Fig. 4: Residential CHP-Turbec T100 (by courtesy of Turbec)

Some of the most important markets are expected to be hospitals, hotels, apartments or clusters of houses, residential homes, office buildings, schools, sport centres, supermarkets, swimming pools and sewage treatment plants.
District heating, using microturbines adopted in clusters, could be an attractive market, too.

Fig.5: Turbec T100 installed in a boiler room (by courtesy of Turbec)

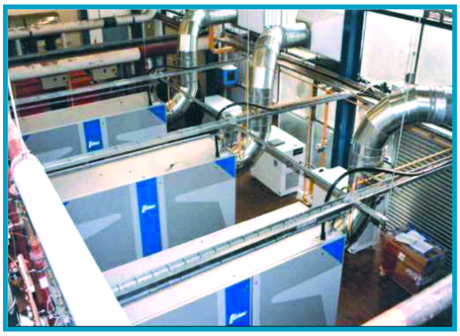


Fig.6: Turbec T100-Hospitals heating (by courtesy of Turbec)

Microturbine applications in the industrial sector

Microturbine market shows a lower potential in the industrial sector due to the short payback time for investments required by industrial companies. The main markets for CHP microturbines in this sector are expected to be: greenhouses, industrial laundries, SMEs (Small Medium Enterprises) having a certain heat demand, special process integrated industrial applications that need premium power.

Applications in greenhouses exploit another advantage of microturbines: Fertilisation with CO_2 from exhaust gas (with very low harmful content) as well as the drying potential.

Fig. 7: Greenhouses CHP- Turbec T100 (by courtesy of Turbec)

Microturbine applications in the transport sector

A very interesting application for microturbines could be the transport sector, especially when cooling is required and if trucks have an urban traject (hybrid trucks). It can also give a contribution to pollution control in urban areas and to urban emissions control in hybrid cars, being a good candidate for on board electricity generation. Hybrid cars are seen as the solution to comply with emission standards.

Liquid Biofuels

Environmental benefits from biofuels

Biofuels are liquid or gas fuels, produced from biomass through thermal/chemical processes.

Biomass denotes organic materials that are part of a short carbon cycle.
Biofuels can be considered "climate neutral" because the CO_2 balance shows that carbon dioxide (CO_2) released during combustion is absorbed from the air by crops for their growth through the photosynthesis process. No net CO_2 emissions are released to the air besides production and transport of biomass and biofuels (if not done with biofuels).

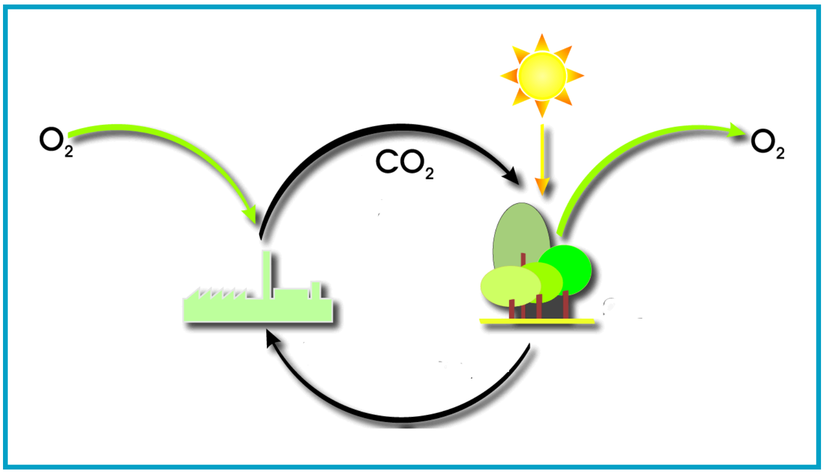


Fig. 8: Carbon Cycle

Liquid biofuel production

Biomass can be transformed into a biofuel by means of a biochemical process, involving anaerobic digestion or alcohol fermentation, or a thermochemical process, involving carbonization, gasification or pyrolysis.

The biofuels that have gained commercial potential are biodiesel and bioethanol. Other liquid biofuels under research are biomethanol, dimethylether, Fischer-Tropsch diesel, pyrolisis oil and Hydro Thermal Upgrading oil.

Main conversion processes are:

- Extraction of vegetable oils from oil crops (in Europe mainly from rapeseed), followed by esterification to produce biodiesel;
- Fermentation of sugar rich crops, such as food crops (corn, wheat, beet, sweet sorghum and barley) and the newly experimented woody biomass, followed by distillation to produce bioethanol;
- Pyrolisis of wood obtaining pyrolisis oil (diesel equivalent);
- Hydro Thermal Upgrading (HTU) of wet biomass obtaining HTU oil (diesel equivalent);
- Gasification of biomass using synthesis gas to produce biomethanol, DME and Fischer-Tropsch diesel.

The biomass feedstock necessary for biofuels production, taking into account only species with commercial potential:

Biofuel [1 ton]	Feedstock	Tons of biomass
Bio-ethanol	Grains	3
Bio-ethanol	Dry wood	3
Biodiesel	Rapeseed	2,5

Liquid biofuel market

Currently only bioethanol and biodiesel are applied on a commercial scale.
The global biofuels production is estimated at about 15 million tons per year and Europe has still a small share, about 6% of the total production.

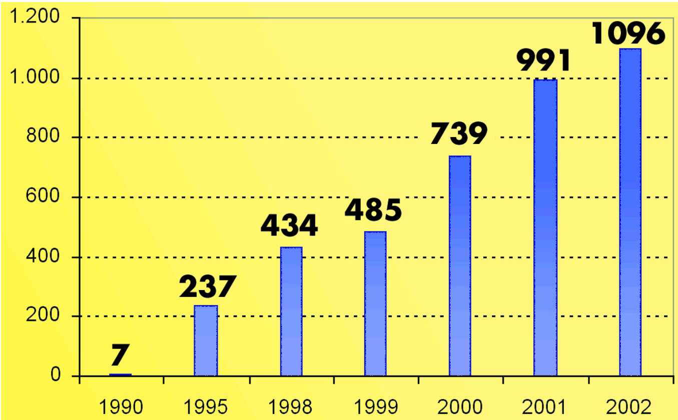
Most of the global production consists of bioethanol. The main producers are USA and Brazil, while Europe is the most important producer of biodiesel. Ethanol is, since short, quoted at the world commodity market.

Biofuels production is increasing. Biodiesel production increased from 80.000 tons in 1993 to 860.000 tons in 2001 (by eleven times), bioethanol production for automotive fuel application has grown by a factor three, passing from 47.500 tons in 1993 to 136.000 tons in 2001.

The countries producing the largest amounts of biodiesel are Germany (46%), France (40%), Italy (10%) and Austria (4%), while countries producing the largest amounts of bioethanol are France (42%), Spain (37%) and Sweden (21%).

The following table shows the trend for biofuels production for primary energy in Europe. The first producer (for primary energy utilization) is Germany (500.000 tons in 2001), followed by France (389.000 tons in 2001) and Spain (80.000 tons in 2001).

Fig.9 : Liquid biofuels for primary energy in EU. Source: IEA Statistics 2003



Current production costs of liquid biofuels depend on the used biomass prices and on the size (investment costs are higher for smaller plants) and type of production plant. For example the average production costs of bioethanol in Germany are 0,56 Euro/l for a 500.000 hl plant and 0,5 Euro/l for a 2.000.000 hl plant, if the used feedstock is wheat or sugar beet.

Liquid Biofuel Burning Microturbines

Current situation

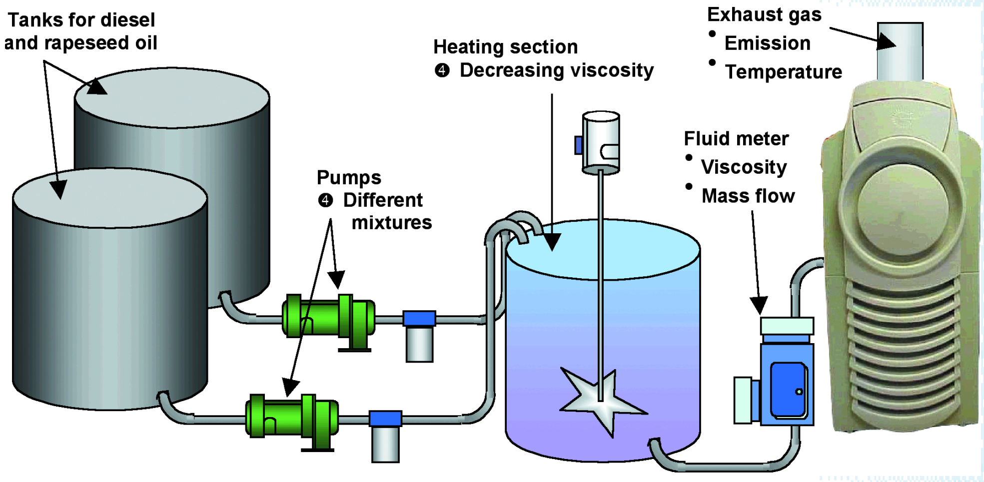
Although in general all commercially available microturbine systems have the potential to be operated with liquid fuels, currently only one microturbine type does exist which is specified by the producer for the use of liquid fuels, namely the Capstone C30 (Liquid Fuel) unit. Thereby, the term 'liquid fuel' only refers to fossil fuels such as diesel and methanol, and no explicit specifications exist for liquid biofuels.

Currently no liquid fuel burning microturbines are used for commercial applications in Europe. However, several research and demonstration units investigate the technical and emission properties of liquid fuel systems. Two Turbec T100 units are operated on methanol (produced from natural gas) by the Norwegian oil and gas company Statoil ASA. This demonstration project is implemented in the framework of the EC co-funded project 'Optimised Microturbine Energy Systems – OMES', and its main aim is to introduce methanol (as innovative energy carrier) to the fuel market for distributed electricity and heat production.

With respect to liquid biofuels use in microturbines, at the Institute of Mechanical Engineering and Marine-Technology, University of Rostock, a study was performed on the utilisation of bio-oils in microturbines. Laboratory tests using a T216 microturbine from Deutz were carried out on rapeseed methyl ester, sunflower methyl ester, animal fat methyl ester, rapeseed oil, false flax oil, waste edible oil, pyrolysis oil as well as ethanol. This research study concluded that a variety of bio-fuels may be used in microturbines after system adjustments have been made which are necessary due to different physical and chemical properties.

A further project investigating the use of bio-diesel and vegetable oil (rapeseed oil) in microturbines is currently performed by the University of Applied Sciences Aachen in cooperation with the German Capstone distributor E-Quad Power Systems. This project focuses on combustion properties as well as the identification of required adaptations of the fuel supply system. With the two tanks of the test rig displayed in Figure 10, a mixture of diesel and rapeseed oil is produced. In a heating section both fuels are heated to a constant level and mixed with a stirrer. Tests started with running the turbine on 100% diesel and the amount of rapeseed oil will be increased by 10% steps to evaluate effects on turbine emissions and efficiency. First test results are expected for late 2004.

Fig. 10: Microturbine Bio Fuel Test Rig



Liquid biofuel properties and microturbine adaptations

Today natural gas, bio-gas, diesel and kerosene are used as fuel to operate microturbines. For liquid biofuel based operation, adaptations of the microturbine system are necessary, due to the different physical properties and chemical composition of biofuels with respect to liquid fossil fuels. Important fuel properties for biofuel applications are presented below.

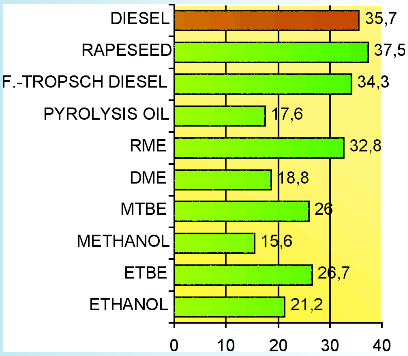


Fig. 11: Calorific Value of Liquid Bio-Fuels in MJ/Litre

Calorific value

Most biofuels have lower heating values by volume than fossil fuels.

In order to obtain an equal output and run-time between refilling, in some cases the flow rate and the fuel storage volume has to be increased. Some fuels like methanol, ethanol and their derivates have calorific values less than 50% of those of fossil fuels, thus demanding twice the storage capacity.

Biodiesel (RME), Fischer Tropsch diesel and most vegetable oils have a similar energy content as fossil liquid fuels (> 30 MJ/l).

Fuel viscosity

The viscosity of a fluid is a measure of the fluids adhesive/cohesive or frictional properties. The viscosity of vegetable oils can be ten times higher at room temperature than that of fossil diesel. This makes it difficult, uneconomical or even impossible to pipe and pump vegetable oils at ambient temperature. High viscosity may also lead to cold start problems and prevents a fine fuel/air mixture in the combustion chamber, due to its negative effect on fuel injection properties.

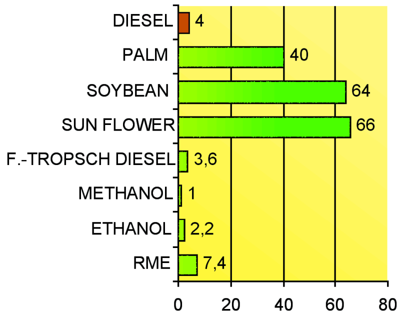


Fig. 12: Kinematic Viscosity of Liquid Bio-Fuels in mm^2/s

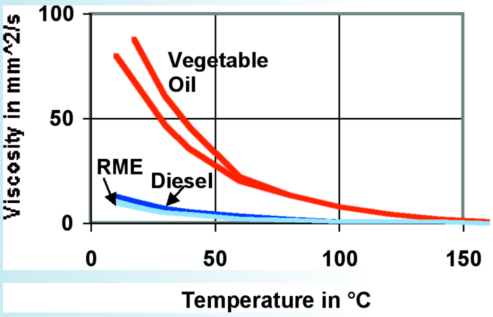


Fig. 13: Temperature vs. Viscosity for RME and Diesel Fuel

These problems can be solved in the following two ways:

Blending

A fuel with a high viscosity is blended with a fuel of low viscosity. Depending on the mixture ratio, the viscosity can be adjusted to the requirements (e.g. using alcohols with a very low viscosity of 1 – 2 mm^2/s).

Preheating

In this case a fuel heating system is installed, that tempers the fuel to 50°C to 80°C. Figure 13 shows the decrease of viscosity for vegetable oil, RME and diesel with increasing temperature.

Impurities

In general, substantially higher contents of ashes are found in biofuels. The relatively high ash content in some biofuels can cause microturbine malfunction, through corrosion, erosion and deposits.

In case of **erosion**, the impact of hard and small particles causes damage on the surface of the turbine blades.

Ash fractions within the fuel can form **deposits** under certain physical and chemical conditions. They cause a reduction in the performance of the microturbine by increasing surface friction losses reducing the flow area and clogging of the heat exchanger. The heat transfer in the heat exchanger is obstructed which reduces the efficiency.

Corrosion of the hot gas path depends on the prevailing temperatures, the compounds present or formed in the hot air as well as the component materials. Compounds in biofuels that lead to corrosion are alkali salts, such as sulphates and chlorides (Fig. 14).

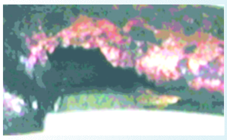


Fig. 14: Corrosion damage on a pipe

The problem of contaminants can be addressed by fuel pre-treatment, such as fuel cleaning, washing and filtration. Also an adapted material choice and proper engineering can eliminate these problems.

Conclusion

Microturbine systems have to be modified in order to be operated with liquid biofuels. All necessary modifications are feasible and can be done on basis of common technologies in the short term. Due to the large variety of liquid biofuel physical and chemical properties, system adjustments have to be done for each different biofuel or at least for biofuel groups.

With respect to their physical and chemical properties, vegetable oils, alcohols and Fischer-Tropsch Diesel are best suited for applications in microturbines.

Environmental performance

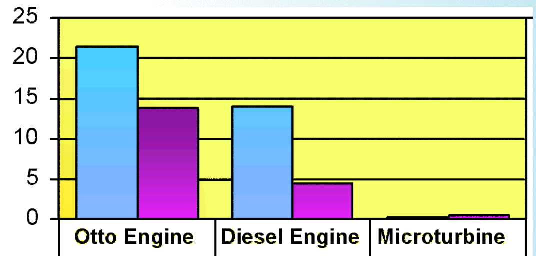
Avoidance of hazardous agents

Due to the use of air-bearing, microturbines require no petroleum-based lubricants. This avoids potential soil and ground water contamination. Additionally, the use of toxic coolants (such as glycol) is avoided, because microturbines can be air cooled.

Low emission

Carbon monoxide is a poisonous gas that can be harmful in very low quantities, whereas sulphur and nitrogen oxides cause “acid rain”. This “acid rain” affects vegetation and leaches into lakes and drinking water sources. Additionally, nitrogen oxides are a precursor to the formation of ozone in the atmosphere, which causes smog.

Microturbines achieve low emission levels through its lean-premix combustion technology, operating at a high air to fuel ratio, that results in a low flame temperature.



	Otto Engine	Diesel Engine	Microturbine
NOx [s/kWh]	21,35	14	0,29
CO [g/kWh]	13,9	4,5	0,42

Fig. 15: Average emission values for competing technologies. Value range for Otto: NO_X: 0,7-42, CO: 0,8-27; Diesel: NO_X: 6-22, CO: 1-8; Microturbine: NO_X: 0,23-0,36, CO: 0,22-0,62 in g/kWh

The pollution referred to as NO_x is a mixture of mostly NO and NO_2 in variable composition. The predominant NO_x formation mechanism associated with gas turbines is thermal NO_x formation. The rate of thermal NO_x formation increases rapidly with flame temperature. The lean-premix combustion in microturbines therefore leads to low NO_x levels, i.e. < 9 - 15 ppm for natural gas and < 35 ppm for liquid fuels.

Incomplete combustion results in both CO and unburned hydrocarbons. CO emissions occur when there is insufficient residence time at high temperature. In order to achieve low levels of CO with low NO_x levels, the air and fuel mixture is retained in the combustion chamber for a relatively long time period. This allows for more complete combustion of CO and C_xH_y. CO emission values of about 35 ppm for liquid fuels can be achieved without reduction by exhaust gas treatment (i.e. selective catalytic reduction and particle traps). Average emission values are presented in Figure 15.

Electricity Market within EU

European electricity market

The European electricity market is involved in a process of fundamental change. The previous regional and national supply monopolies are being dismantled. The EU Directive 92/96/EC concerning common rules for the internal market in electricity laid the basis for the electricity market within the EU. On 26 June 2003, the European Parliament adopted the Directive 2003/54/EC, establishing the common rules for the generation, transmission, distribution and supply of electricity. The resulting benefits may be in terms of efficiency gains, price reductions, higher standards of service and increased competitivenesMtoeata is provided by Eurostat and IEA about the energy consumption and production in Europe in 2003:

Mtoe = Million tons oil equivalent

- Overall energy consumptions in Europe: 1504,8 Mtoe (52,3% imported, mostly as fuels);
- Primary input to electricity generation: 591,7 Mtoe. Nuclear energy contributed with 39,3% followed by coal (28%), natural gas (19%), renewable sources (8,3 %) and oil (5,4%);
- Electricity generation: 2723,6 TWh. Conventional thermal plants contribute with 53,3 %, nuclear with 33% and renewable sources with 13,7%;
- Greenhouse gases emissions: 3213 Mt CO_2.

Electricity prices in Europe

Examining the electricity prices in Europe, using data taken from Eurostat updated to July 2003:

- For domestic consumers Denmark shows the highest prices, having the highest electricity production costs and the highest taxes, while the lowest prices are for Greece
- For industrial consumers electricity prices are the highest for Ireland and Italy, having very high electricity production costs and taxes, while the lowest prices are for Sweden.

Annual consumption	***600 kWh***		***1200 kWh***		***3500 kWh***		***7500 kWh***	
Countries	*Including taxes*	*Without taxes*	*Including taxes*	*Without taxes*	*Including taxes*	*Without taxes*	*Including taxes*	*Without taxes*
Austria	17,3	12,4	15,5	10,9	13,4	9,2	12,9	8,8
Belgium	18,3	14,8	17,0	13,8	13,8	11,2	13,3	10,7
Denmark	32,5	17,0	26,2	12,0	22,1	8,7	20,9	7,7
Finland	19,4	15,2	13,9	10,6	10,6	8,0	9,0	6,6
France(A)	16,2	12,6	14,0	10,9	11,2	8,9	10,9	8,6
Germany(A)	26,0	20,4	20,9	16,0	16,9	12,5	15,5	11,3
Greece	8,2	7,6	7,7	7,1	6,5	6,1	7,4	6,9
Ireland	23,9	19,1	18,0	14,9	11,8	10,1	10,9	9,4
Italy(B)	9,6	7,8	10,0	8,1	19,8	14,7	19,3	14,3
Luxembourg	23,7	21,7	17,9	16,2	13,4	11,9	12,2	10,9
Norway	42,5	33,2	24,9	18,9	13,3	9,6	10,1	7,0
Netherlands	20,4	24,0	18,8	16,1	17,8	10,9	17,4	9,3
Portugal	13,7	12,9	15,5	14,7	13,2	12,6	11,8	11,2
United Kingdom	16,7	15,9	13,4	12,8	9,4	9,0	8,5	8,1
Spain	13,6	11,2	13,6	11,2	10,6	8,7	9,8	8,0
Sweden	30,2	21,8	20,3	13,8	13,7	8,6	12,7	7,7
European average(C)	20,0	16,3	16,2	12,8	13,5	10,3	12,5	9,4

Electricity prices (eurocent/kWh) for domestic consumers updated to 1st July 2003.
(A) Arithmetic average of prices in different regions
(B) Burdens are included in the Including taxes price
(C) Average based on national domestic consumptions in 2000

Source: AEEG elaboration based on Eurostat data- www.autorita.energia.it

Annual consumption	50000 kWh (50 kW 1000 hrs)		160000 kWh (100 kW 1600 hrs)		2 GWh (500 kW 4000 hrs)		10 GWh (2500 kW 4000 hrs)	
Countries	*Including taxes*	*Without taxes*	*Including taxes*	*Without taxes*	*Including taxes*	*Without taxes*	*Including taxes*	*Without taxes*
Austria	13,1	8,9	11,5	7,6	8,4	5,0	7,2	4,0
Belgium	15,1	12,2	13,3	10,8	9,0	7,3	8,3	6,7
Denmark	11,0	6,5	11,0	6,5	11,5	6,9	-	-
Finland	8,8	6,8	8,3	6,4	7,0	5,3	7,0	5,3
France(A)	10,0	8,3	9,3	7,6	6,5	5,3	6,5	5,3
Germany(A)	17,3	13,7	14,9	11,6	10,0	7,4	9,5	7,0
Greece	9,7	9,0	9,0	8,3	6,6	6,1	6,6	6,1
Ireland	14,6	12,8	13,1	11,2	8,8	7,6	8,3	7,2
Italy(B)	14,0	10,4	12,8	9,4	11,7	8,4	11,1	8,5
Luxembourg	14,2	12,7	11,1	9,8	7,8	6,8	5,1	4,7
Norway	8,5	6,9	8,9	7,2	6,4	5,1	5,3	4,3
Netherlands	-	-	-	-	-	-	-	-
Portugal	10,6	10,1	8,8	8,4	7,1	6,7	7,0	6,7
United Kingdom	9,3	7,3	8,5	6,9	5,8	4,7	5,2	4,2
Spain	11,6	9,5	8,1	6,6	6,4	5,3	6,1	5,0
Sweden	5,8	4,6	5,5	4,4	5,2	4,1	4,9	3,9
European average(C)	12,2	9,7	10,8	8,5	8,0	6,2	7,6	5,9

Electricity prices (eurocent/kWh) for industrial consumers updated to 1st July 2003
(D) Arithmetic average of prices in different regions
(E) Burdens are included in the Including taxes price
(F) Average based on national domestic consumptions in 2000

Source: AEEG elaboration based on Eurostat data- www.autorita.energia.it

Electricity costs for liquid biofuelled microturbines

The economic efficiency is an issue of prime importance for electricity generation units. Depending on the respective application (see page 5 of the brochure), the most important requirement can be low investment costs, high temperature heat stream or low maintenance costs.

Investment costs

The investment costs of microturbine systems cover both, capital cost of equipment and installation as well as cost related to the overall project. The equipment costs differ by facility size between 800 and 1500 Euro/kW_e.

Power output of microturbine	Microturbine capital costs in Euro	Specific capital costs in Euro/kW_e
30 kW_e	46.000	1535
60 kW_e	78.000	1300
100 kW_e	120.000	1200

Investment costs vary significantly by required ducting work, mechanical installations and cogeneration installations. The installation and project costs typically add up to 50 to 60% of overall investment costs.

Heat stream

Microturbine exhaust gas temperatures range between 170 °C and 340 °C, and can be used for water heating, space heating, steam generation or other thermal needs such as drying. This thermal energy can also be used to operate cooling equipment. Revenues from heat utilisation depend very much on the individual case. For the heat sales prices, 3,3 ct/kWh_{th} is a reasonable value in Europe.

O&M costs

The operation and maintenance costs are variable costs, and microturbine manufacturers calculate between 0,015 and 0,005 Euro per kWh_e.

Electricity generation costs

An economic analysis has been performed for 30 kW and 100 kW microturbines in continuous generation for electricity-only and CHP application. The microturbine was assumed to run on bio-ethanol, produced from lignocelluloses at 0,20 Euro per litre, a value that is expected for ethanol production in the near future. Based on investment and O&M costs for actual microturbines, electricity generation costs of 14,7 - 18,5 ct/kW (electricity-only) and 9,7 - 14,4 ct/kWh (CHP) have been calculated (see Figure 16). Both figures are higher than current industrial consumer prices, that base on large-scale electricity generation facilities. In the current initial market phase subsidies for green generation, such as guaranteed feed-in tariffs (German Renewable Energy Sources Act (EEG), help to make liquid biofuelled microturbines economically feasible.

Economic competitiveness of liquid biofuelled microturbines can be achieved by overcoming initial experience problems, by reducing of investment and engineering costs, by increasing of efficiency and by scaling-up of biofuel production and biofuel infrastructure.

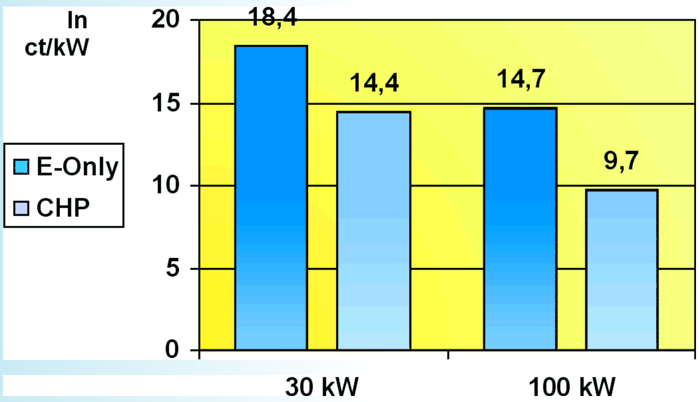


Fig. 16: Liquid biofuelled microturbine electricity generation costs

All these issues are under development and promise to make liquid biofuelled microturbines competitive in the medium term. New models, announced for 2005 show considerable efficiency improvements to prospected 34%. Microturbine manufacturers are targeting a future investment cost below 650 Euro/kW.

Today, microturbines running on various gases are already economically efficient in Europe, the USA and Asia. These applications include distributed generation with the use of essentially free fuels (e.g. at oil platforms, landfills and sewage plants), as well as co- and trigeneration applications.

Green electricity generation, intending to reduce environmental emissions and impacts, is an application that shows best opportunities for microturbines. For green electricity application microturbines offer significant advantages with respect to the existing distributed generation technologies capable of using liquid biofuels, such as reciprocating engines, Stirling engines and fuel cells. Microturbines have considerably lower emission levels than the cheaper reciprocating engines, whereas the substantially higher investment and O&M costs for fuel cell technology, today exclude fuel cells from high volume utilisation.

Thus, biofuelled microturbines offer, among all biofuelled distributed generation technologies, the best cost-performance ratio in the field of green electricity generation.

Opportunities for Bioturbines in the EU

As already mentioned the number of installed microturbines in Europe up to now is quite low, but they have a good potential market, especially if bioturbines are considered.
The most interesting applications are identified as buildings, hospitals, municipalities, hotels, food processing industries and greenhouses.
Two applications that have, after due efforts for innovation, extremely large potential, are: district heating, using microturbines adopted in clusters and the transport sector, especially if applied with hybrid technology.

The following actions are recommended in order to have the right framework for this innovative technology development, improving market chances:

- A standardisation and biofuels characterisation is necessary;
- A secure supply of biofuels will stimulate its credibility;
- Further research has to be done to improve the performances of bioturbines;
- Demonstration of the capabilities of this technology to potential private and public users;
- Increasing potential users awareness, by means of a specific information addressed to local authorities, citizens, energy companies and industries regarding distributed cogeneration and advantages of renewable energies;
- A precise legislative framework for renewable energies, energy efficiency and cogeneration promotion;
- Regulations concerning the electricity exchange with the grid and a simplifying of the authorization requirements;
- Incentives have to be put on biofuels so that an increasing demand will induce lower production costs;
- Adequate taxes differentiation between biofuels and fossil fuels;
- Acknowledgement of ultralow emissions of microturbines;
- Incentives and market stimulation for co-generation as an important energy efficiency technology.

The advantages shown by microturbines (low maintenance, being very simple and compact devices, high reliability, low noise and vibrations, low emissions, fuel flexibility) are expected to provide a successful development of this technology, especially if bioturbines are considered.
European and national environmental policies are favourable to their promotion.

The opportunities of the technology are consistent with the goals set by the EC.

Opportunity	*Corresponding EC goal*
Fuel flexibility leading to energy production from renewable sources	European countries have to get a certain contribution from renewable sources to the overall primary energy by 2010
Electricity generator for hybrid technology in transport	Directive 2003/30/EC on the promotion of the use of biofuels in transport
Reduce greenhouse gas emissions	Obligation to greenhouse gases reduction within the period 2008-2012, according to the Kyoto Protocol
Improve energy efficiency by means of distributed generation	Directive 2004/8/EC on the promotion of cogeneration based on useful demand in the internal market is pushing European countries to analyse the national potential and to define objectives to be achieved
Security in energy supply, lowering the dependence from fossil fuels, that means from non European countries, implying high electricity prices increasing in time	Green Paper on a European strategy of energy supply, 2000

Moreover, the already started process of delocalisation of power in the electricity management and the electricity market liberalisation can favour the distributed generation and also the renewable energy sources promotion.

Another favourable factor for distributed generation can arise as a consequence of the very frequent blackouts and a not very good power supply due to a distribution network not appropriate to satisfy the increasing demand of electricity. End users could get electricity with the reliability they need.

Bioturbines are therefore going to be a strategic option to face all legislative constraints and to push a sustainable energy production.

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