COGENERATION

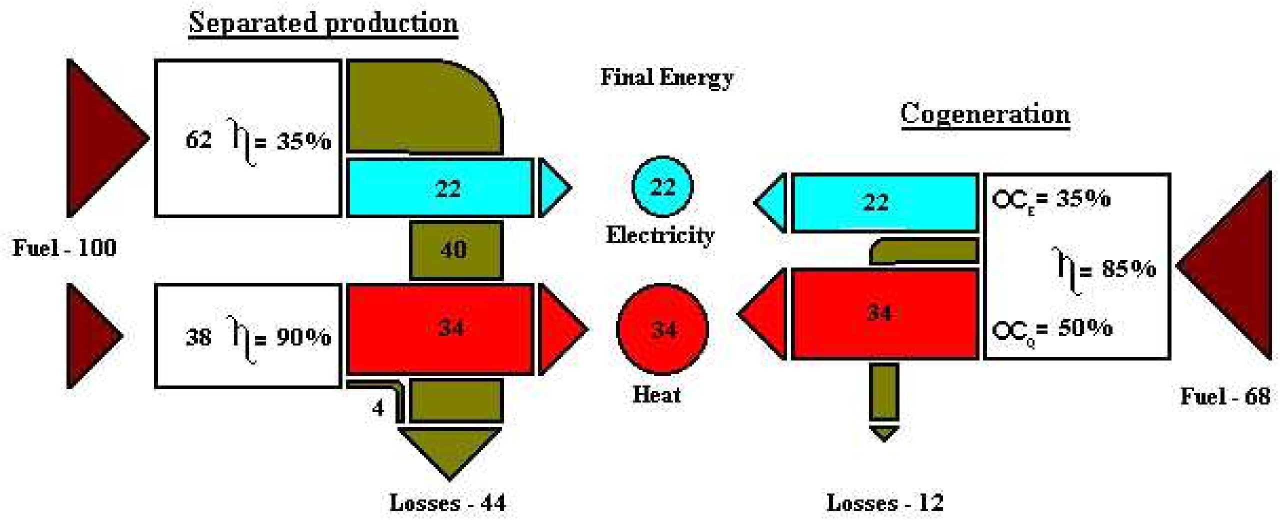
Main Facts

What is cogeneration (CHP)?

Cogeneration is on-site generation and use of heat and electricity. In the cogeneration system a turbine or engine is connected to a generator to produce electricity while the exhaust heat is used to produce steam or hot water.

With traditional methods of electricity generation in thermal power plants a huge amount of valuable heat is wasted as emission of condensing heat of the steam. Co-generation produces heat and electricity in a combined heat and power process (CHP) making use of this rejected heat and therefore more efficiently, at lower prices and with less pollution than the conventional method.

The figure below presents schematically the main principle of CHP and its advantage compared to separate production of electricity and heat:



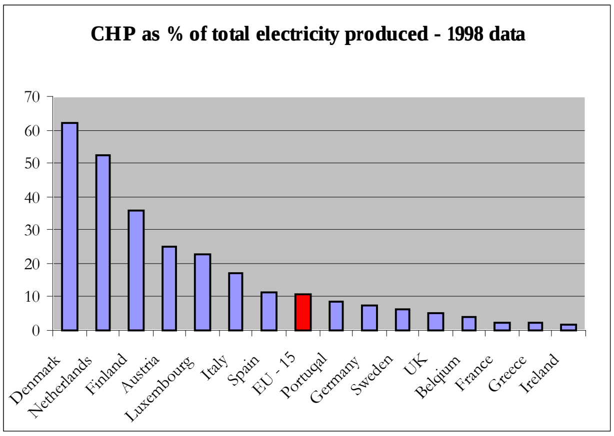
Why invest in CHP?

- CHP will **reduce** your energy **costs**
- CHP can **improve** your **profit** margin and give your company a competitive edge
- CHP can offer **security** against **energy price** fluctuations
- CHP provides a **secure supply** of energy to your site
- CHP can help your business **comply** with **environmental** legislation

Current CHP situation and perspectives in EU

In Europe, the use of CHP or cogeneration is a well established energy supply option. In the current energy market, cogeneration supplies around 10% of European electricity production, 10% of the European heat market and a small amount of the cooling demand. Cogeneration plants are found in all European countries and range in size from as small as a few kilowatts to greater than 500 MWe. Cogeneration is used in all sectors of the economies of Europe, from individual buildings to heavy industry and large district heating schemes. Finally, cogeneration utilizes all types of fuels from coal, gas and oil to biofuels and even solar energy.

The following graph shows the contribution of CHP to generated electricity in the EU member-states.



Today, cogeneration saves Europe around 350 million tones of CO_2 and reduces the dependence on energy resources by 1200 PJ per year, equivalent to the energy consumption of Austria. Cogeneration is thus an excellent energy supply option and this is why it has been identified as a key technical solution to improving European environment, by reducing the impact of global climate change and reducing local emissions, such as particulates, sulphur and nitrogen oxides.

In 1997, the European Commission brought forward a strategy paper to double the amount of cogeneration in the European market place. The implications of this strategy are that cogeneration would grow to provide 18% of European electricity by the year 2010 (at 10,9 % for 1998). This in turn would save a further 180 million tones of CO_2 and 1000 PJ per year. The strategy also proposed ways to remove barriers to the development of cogeneration.

The picture for cogeneration in Europe is one of great diversity, both in terms of the share of the electricity market enjoyed by cogeneration, and the applications and plant options deployed. In some countries, namely the Netherlands, Finland and Denmark, cogeneration supplies more than 30% of electricity requirements whilst in others it is a marginal electricity supply source. The status of cogeneration in the various EU countries is a result of a number of important factors:

- the structure of the energy sector
- the policy framework
- long-term governmental priorities
- climatic conditions
- the structure of the economy.

By far the most important factors are the policy framework and incentives, or otherwise, in the energy sector to support cogeneration.

In the past couple of years, the cogeneration market has been under serious threat due to:

- partial liberalization of the electricity market
- predatory pricing by incumbent utilities
- poor regulations that do not ensure fair treatment
- gas markets that have not been liberalized
- gas prices that are linked to world oil prices.

This has resulted in a downturn in the European cogeneration market.

If the European target for CHP is to be met, then the Member States will have to deliver substantial growth in cogeneration over the next few years.

At the time of writing, the European Commission is preparing a proposal on a European CHP Directive with the aim to define specific policy mechanisms for the wider use of CHP. Yet, this Directive is not the only piece of European legislation with relevance to CHP. Rather, a whole plethora of European Directives is under preparation, which in a number of ways will affect CHP in European Member States and candidate countries alike. Some of the provisions contained in these Directives are targeted specifically at CHP, whilst the implications in other cases are rather of an indirect nature. The contents and processes of these forthcoming legislative measures will set an important framework to the development of CHP in the years to come.

Countries overview

Bulgaria

Large scale CHP has been implemented in Bulgaria for a long time. At present the share of co-generation plants is 16 % of the total installed capacity and 31 % of the TPP capacity. Regardless the fact that during the past years the heat consumption has decreased significantly due to the economic recession, which by all means influenced also co-generation, nowadays 6 to 6.5 billion kWh electricity or 15 % to 16 % of the total gross electricity consumption of the country is produced by co-generation.

With the forthcoming energy market liberalisation and increase of de-centralised energy production, the objective is to demonstrate the economic and environmental benefits by using also small-scale CHP applications (up to 2 MW) in the industry and in the building sector.

Romania

The total installed capacity in cogeneration plants in 1999 was 6,164 MW which represented about 38% of the total installed capacity of the thermal power plants.

In Romania, the share of heat supply (steam and hot water) from centralized systems amounts to about 30% of the final energy consumption. From the total amount of heat provided from centralized supply systems, the former Romanian Electricity Authority supplied in 1995 about 42% from its own cogeneration and heat plants of which about 94% is from cogeneration plants. The remaining 58% was produced in the cogeneration and heat plants owned by industrial enterprises or autonomous companies of municipalities (self producers). From this, 33% was provided in cogeneration plants and 67% in heat plants.

Greece

As it can be seen on the graph on the first page, Greece has a poorly developed cogeneration sector with less than 20 facilities, held back in the past by the monopoly of the electricity utility. The electrical installed capacity of cogeneration units makes up the 2.5% of the total electrical installed capacity and is currently supplying approximately 3% of the country's needs.

Since most Greek industry is in the small and medium sized sector, small to medium sized installation will be the principal growth area. The technical potential for Cogeneration has been estimated at 400 MWe in the food, beverage, textiles, wood, paper mills, chemicals, metals and mineral sector. The market potential will be for installations in the range of 5-10MW. In the tertiary sector, total potential is estimated at 90 MWe, primary in hotels, hospitals and commercial and public administration buildings. This growth is likely to be in the range of 500 kW-1.5MW units. District heating systems are expected to become viable in the north of the country.

Here It Works

A pilot installation of a prototype microturbine CHP solution in the small southern Swedish community of Kävlinge was set up. Participating in the project were Sydgas, Southern Sweden's natural gas utility, the Kävlinge Municipal Housing Authority (KKB), and Turbec AB, a Southern Swedish manufacturer of microturbine CHP solutions for on-site power that now has more than thirty operating commercial installations.

WHY MICROTURBINE CHP?

For Sydgas, the project represented an attractive opportunity to investigate a promising application for natural gas. Sydgas contributed by installing the unit, providing funding for doing so and helping to monitor the installation.

The KKB agreed to provide the site for the installation. They were interested in small-scale power generation and attracted by the environmental benefits offered by the Turbec prototype, which produces low levels of emissions. They were also interested in anticipated long-term economic benefits. While the current price ratio between gas and electricity makes microturbine CHP an expensive alternative in Sweden today, this is expected to change in the future. Low installation and maintenance costs expected for Turbec's future commercial units were other decisive factors.

Turbec was looking for a first on-site test environment for its 100 kW microturbine CHP prototype unit. Turbec's work with microturbines is based on pioneering research by Volvo on gas-turbine powered vehicles. Encouraging results of the research led to a decision to start a new company to commercialize the technology. Volvo brought in ABB as a partner and formed the independent company Turbec AB in 1998. Commercial considerations led Turbec to focus on a 100 kW unit. The trial installation in a working environment fitted in well with Turbec's strategy of solving potential technical challenges before launching a commercial product. In 1999, a prototype product was ready for just such an installation.

Turbec contributed to the Kävlinge project by covering 50% of the cost of the unit and sharing in its maintenance. The Delegation for Energy Provision under the Swedish Department of Energy (set up in June 1997) covered the remaining 50% of the unit cost.

THE KÄVLINGE PROJECT

The prototype unit was installed in Kävlinge in late 1999 after an initial viability study followed by a more thorough analysis. The analysis examined, among other things, the economic viability of the installation and the suitability of the site.

As mentioned earlier, the price ratio between gas and electricity in Sweden today is not favourable for microturbine CHP. In addition, because the unit to be installed in Kävlinge was a prototype and therefore not mass-produced, it was considerably more expensive to produce than a commercial unit. However, analysis based on costs associated with mass-produced units in markets with conditions similar to those anticipated in Sweden show clear economic benefits.

The Kävlinge site, which is part of a complex of apartments, schools and institutions with district heating, proved to be particularly suitable for the installation. The unit could be installed in a boiler room with easy access for air intake and an exhaust gas stack. Ambient air could be provided through an opening in the boiler room wall and there was no need for special noise reduction on the outside.

The unit was installed in Kävlinge as part of a system including two boilers. The microturbine CHP unit supplements the heat provided by the boilers during periods when demand is high. When demand is low it provides all of the heat for the complex. The electricity not used at the installation site is sold to the electrical utility and supplied to the building complex through the grid. The installation is monitored remotely and controlled by Sydgas and Turbec.

FROM PROTOTYPE TO COMMERCIAL UNIT

The prototype installation provided Turbec with valuable information that it has since applied in its first commercial product, the T100 CHP, which was released to the market in late 2000. Based on experience from the Kävlinge installation, Turbec was able to make the T100 CHP more robust, and easier to install and operate, than the prototype unit. Improvements were also made in the graphical user interface, so the T100 CHP'S remote monitoring and control system is much more intuitive for users. Experience gained from Kävlinge also helped Turbec fine-tune the control system.

In May 2001 Turbec replaced the prototype unit with its commercial unit, the T100 CHP. The T100 has a very simple design with very few moving parts and only two bearings. It is therefore ideally suited for continuous operation over long periods of time at sites like Kävlinge that have relatively stable heat demands. It is designed for a 60 000-hour lifetime, with minor maintenance once a year (6000 hours) and a major overhaul after 30 000 hours.

A T100 CHP unit has now been in operation at Kävlinge for over 2000 hours. It operates at the highly satisfactory level of 95% reliability. The unit also lives up to expectations for low emission rates with a volumetric exhaust gas emission level of 15% oxygen. At 100% load, NO_2 emissions are less than 15 ppmv; CO emissions are less than 15 ppmv, and unburned hydrocarbon emissions are less than 10 ppmv.

The Kävlinge project is now in its third year of operation and reaction from the involved parties has been positive. The project has been a valuable one in terms of developing an alternative energy solution for Southern Sweden and a commercially available microturbine CHP solution.

Table 1: Summary economic analysis of a typical installation of Turbec microturbine CHP unit.

Assumptions	
Running hours/annum	6000 h
Electricity price	0,08 Euro/kWh
Fuel costs	0,02 Euro/kWh
Substituted boiler efficiency	80 %
Costs of a T100 CHP unit	80 000 Euro
Installation costs	20 000 Euro
Total costs	**100 000 Euro**
Performance data	
Electrical efficiency	30 %
Total efficiency	80 %
Thermal output	167 kW
O&M costs	0,01 Euro/kWh
Pay-back time	3,7 year

Here It Works

A number of pilot projects for installation of small co-generation units were realised in the framework of **a SAVE II international project** for promotion of small scale co-generation in rural areas. Following are summary data of these projects.

Small CHP unit installed at the sewage treatment plant of Sokolow Podlaski, Poland. This is a city of 18 000 inhabitants, situated around 100 km east of Warsaw in a typical agricultural area with intensive cattle breeding and meat industry, built its first sewage treatment plant in the 1970s. Equipped initially only with mechanical pre-treatment, the plant was upgraded 5 years later with a biological treatment stage. Subsequently, the city's expansion and the construction of meat processing factories made several upgrades and extensions of the plant necessary. Today, it has a capacity for a population equivalent of 100 000. The daily variations of the sewage flow are balanced by a series of buffer reservoirs which can temporarily accommodate excess sewage, leading to constant sewage treatment and output of cleaned water.

During the sewage treatment procedure, dried sludge is fed into a digestion tank where aerobic fermentation processes produce biogas. This gas can be used as a fuel to produce thermal energy to heat the mass of sewage sludge up to 32-34°C - which, in turn, increases the production of biogas in the digestion tank. Initially, electricity to the extensive plant came externally from the mains. In early 2000, environmental and cost saving concerns inspired the installation of a cogeneration unit, which now provides the plant with both heat and electricity. The heat production of the unit is used for the process technology and also to heat buildings.

The design and entire installation of the unit were commissioned by the operator of the sewage treatment plant, Przedsibiorstwo Usiug Inzynieryjnych I Komunalnych Ltd (PUIK), Sokolow Podlaski, Poland. In June 2000 they signed an official agreement establishing their participation in the Prosmaco project. Encouraged by the simple payback time of only 3.9 years - due mainly to the use of biogas produced by the sewage treatment plant itself as fuel and because part of the installation and design of the unit could be done in-house - they decided also to fully finance the project. No TPF arrangement was therefore required.

The cogeneration system uses a 12-cylinder engine adopted by PZL Wola, Warsaw, Poland with thermal capacity of 200 kW and electrical output of 130 kW. The heat recovery module was supplied by Gazterm, Warsaw, Poland. Overall efficiency of the system is 90%. Because on-site electricity demand is always larger than the production from the co-generation plant, no power exports had to be considered. This was an advantage because usually considerable barriers are created against power exports from small-scale cogeneration producers in Poland.

Austria, Hotel Matschner

An overhaul of the heating system in this highly frequented hotel in the Austrian region of Ramsau, combined with environmental considerations, proximity to the equipment supplier, and an attractive financing arrangement encouraged the installation of a small-scale cogeneration plant. Two LPG-fuelled Jenbacher Engines, each with thermal capacity of 120 kW and electrical capacity of 70 kW, were installed. The heat they produce is used for warm water supply, space heating, and the hotel swimming pool. The electricity output is used both on-site and exported. A leasing arrangement with Primagaz and an environmental subsidy from the bank Kommunalkredit Austria AG made the successful installation of the project possible. The two engines have payback periods of 3.4 and 5.2 years respectively.

Greece, Tagarades landfill

Within Greece, this pilot project is a real pioneer by being one and the first small-scale cogeneration units in the country, and by producing electricity from landfill gas from the Tagarades tip, which receives all the waste from Thessalonica, Greece's second biggest city. At the moment, the unit only produces electricity. Yet, the use of its heat output to cover the necessities of a nearby village is projected. 54 collectors in the landfill convey 164 m^3 of landfill gas (with a 40-45% methane content per hour) which fuels a 240 kW Deutz engine. This project has obtained co-funding under the European Community's Regional Development Funds. With a total cost of half a million Euro, and an annual income of up to 117 000 Euro the project is likely, even without additional income from heat production, to be paid off in 5 or 6 years.

Spain, wood-drying factory

The Catalonian wood-drying factory Maderas Becerra undertook a feasibility study on a cogeneration scheme and found out that it would increase their competitiveness. First, the heat would reduce the drying process for their products from 3-4 months to just one week. And secondly, additional income from avoided electricity costs and sales of surplus electricity to the grid would be created. A payback period of 6 years, calculated solely on the basis of the electricity output, was expected, but the added value from the accelerated heating process will reduce this period. The comparatively large cogeneration unit (1000 kW electrical and 1267 kW thermal) was expected to operate half of the year on full load, a quarter of the year on 50% of its capacity, and to remain switched off during the remaining time.

The TPF method chosen for this project is a type of temporary consortium agreement between the client and the supplier, where the consortium owns the plant and has the financial, operational and administrative responsibility for running the plant. The energy user, in turn, purchases the heat and electricity at grid prices. The user does not profit from energy savings, but gains a security against unexpected changes in energy prices. At end of contract, the user's share of the fund may be realized by the ownership of the cogeneration unit.

The present bulletin is issued by Sofia Energy Centre, Coordinator of Balkan OPET, within the framework of Energy Information Network at Local and Municipal Level

For information and recommendations on the content and layout of the bulletin, please contact:

Ivanka Pandelieva
Sofia Energy Centre
51, James Boucher Blvd.
1407 Sofia
Tel: (02) 96 25 158; 68 35 42
E-mail: ivankap@enpro.bg