CADDETT Renewable Energy Newsletter

DOMESTIC, STIRLING ENGINE BASED COMBINED HEAT & POWER

by Jeremy Harrison, Sigma Elektroteknisk AS, Norway

A 3kWe micro CHP is about to enter production in Norway. A project funded under the EU THERMIE programme is in progress to demonstrate the reliability, performance and operating costs necessary to prove commercial viability. The micro CHP unit will allow the production of electricity without the need for central power plant, transmission systems and at virtually zero marginal CO_2 production.

Combined Heat and Power (CHP) has significant potential for the more efficient use of fossil fuels and the reduction of CO_2 and other polluting emissions. It also offers the possibility of reduced infrastructure requirements, (and consequent environmental impact) both in terms of large-scale generators and the associated transmission and distribution facilities, by the nature of "embedded" generation.

Generally, economic considerations limit existing CHP technologies to the size range of 30kWe and above, although tax and other artificial incentives make smaller units viable in some countries. This is due to the high unit maintenance and capital costs of equipment. The internal combustion engines generally applied are of limited durability, reliability and efficiency and produce relatively high levels of noise and air pollution.

The smallest units commercially available are over 8 kWe (although smaller units as small as 5.5kWe are available for some applications) and at this size are of questionable economic benefit. They use spark or compression ignition internal combustion engines adapted from automotive versions in order to minimise initial cost. Consequently they have short service intervals, high maintenance costs and limited life. Due to their combustion characteristics they also produce high levels of CO_2, SO_2, and NOX as well as being relatively noisy and are therefore unsuitable for domestic installations.

STIRLING ENGINES

Stirling Engines, being external combustion machines, have a number of advantages in terms of reliability and performance and ultimately should have a cost between that of spark and compression ignition automotive units. They offer better energy efficiency and reliability, lower exhaust emissions and noise levels. They also permit a greater flexibility than internal combustion engines in the choice of fossil fuels and alternative renewable energy sources. Service intervals of between 3,500 and 5,000 hours (equivalent to more than one year's economic operation) are expected compared with 750-1000 hours for IC engines. Life expectancy should be 50-60,000 hours compared with 10,000 hours for an ICE.

THERMIE DEMONSTRATION PROJECT

Sigma Elektroteknisk AS has begun work to manufacture energy converters as the central component of a micro CHP unit suitable for the requirements of the European residential and small scale commercial market.

A consortium comprising Scottish Hydro Electric (UK), NESA (Denmark), Sigma AS (Norway), TEM (Sweden) and EA Technology (UK) has been established to demonstrate the commercial and technical viability of the Sigma PCP (Personal Combustion Powerplant) energy converter in this micro CHP application. The project is supported under the EU THERMIE programme.

The objective of this programme is to install five PCP based CHP units in representative European installations. Two of the installations will be in public sector housing in Scotland, two in Denmark and one in Norway. It is anticipated that this will identify any technical, commercial or legislative issues in a European context and enable the experience to be transferred throughout Europe.

The specific objectives are:

- to demonstrate the technical and commercial viability of the Stirling engine micro CHP system when applied to domestic/small commercial installations

- to determine the matching of electrical and thermal load profiles in these applications

- to evaluate the user reaction to the micro CHP unit and the effect on the building and unit performance

- to evaluate the implications of integrating micro CHP systems with different electricity distribution system (e.g. single phase in UK, three phase in Denmark) particularly with regard to the potential DSM benefits

THE MICRO CHP SYSTEM

The Sigma PCP is a development of the proven TEM SCP 1-75 unit that was developed over 10 years as a range extender for hybrid vehicles. The unit consumes 12.5 kW (gross calorific value) of natural gas and delivers 9kWt of useful heat and 3kWe of electricity, giving an overall conversion efficiency of 95%. The thermal conversion is similar to that of a conventional modern gas boiler so that it could be argued that the electricity is effectively a "free" by-product of the heating system, both in cost and environmental terms. (The comparison could also be made with higher efficiency boilers with higher capital and lower running costs. However, at least 80% of boilers sold today are for replacements of conventional boilers in existing systems so that the flow temperature and other parameters lead most customers to select conventional boilers as the most cost-effective solution. This is therefore the selected base case for comparison.)
The majority of the heat is in the form of hot water that is pumped through the radiators of the central heating system of the house. The flow temperatures are

compatible with existing high flow temperature central heating systems, so that the Sigma PCP unit is able to act as a "drop-in" replacement for obsolete gas boilers. In order to optimise the performance of the system and to standardise production, a supplementary flow boiler is included in the system.

The operation of the unit is led by thermal demand, so that there are occasions when surplus electricity generation is exported to the grid and others when some import must take place. The economic viability of the system is therefore a function of the marginal investment cost (compared with a replacement gas boiler) and the value of the electricity generated. In the UK where there is an established competitive market, the import price is around 8p/kWh and an anticipated export price of 2.8 p/kWh. Optimising controls are therefore used to maximise the use of own generation, although the highly variable demands of the domestic system mean that utilisation is normally between 40-50%. Further work on, for example, stand-alone systems can increase this figure to 100%, but with obvious capital cost implications.

IMPLICATIONS FOR UTILITIES

There are, however, significant opportunities for utilities (such as avoided costs) as the aggregate value of exported units is enhanced by the fact that the majority of generation occurs, by definition, during peak pool price for electricity, i.e. during the early evening in winter.

There are also strategic benefits both in terms of avoided network reinforcement costs and, in countries with developing infrastructures, the avoidance of large scale, centralised generation. Distributed or "embedded" generation offers benefits of capital cost and environmental impact avoidance both of the generating plant and the distribution network. It also maximises the utilisation of primary fuel. Indeed, distributed generation is a natural evolution from central plant, through large scale to small scale CHP. The extent to which it can be extended is dependent on the availability of small, reliable and cost effective energy converters.

Future developments

Sigma Elektroteknisk is now seeking partners in a number of countries to develop system expertise and establish an installation and service network. It is anticipated that the micro CHP packages will be available commercially in two years time.

Further information:
Sigma Elektroteknisk AS
PO Box 58
N-1550 Hølen
Norway
+47 64 98 24 03
http://www.sigma-el.com