TRIGENERATION

Description of technology

Tri-generation technology is a technology that can provide simultaneously three forms of output energy; electrical power, heating and cooling. Trigeneration is also known as CCHP (Combined Cooling, Heating and Power) or CHRP (Combined Heating, Refrigeration and Power). In essence, trigeneration systems are CHP (Combined Heat and Power) or co-generation systems, integrated with a thermally driven refrigeration system to provide cooling as well as electrical power and heating.

CHP systems consist of a power system which can be an internal combustion engine driven by a fossil fuel or a biofuel, an external combustion engine or other thermally or chemically driven systems coupled to a generator which produces electricity. A heat recovery system recovers heat from the power system and exhaust gases to be used for heating applications. Effective operation of CHP systems requires maximum utilisation of both electrical power and heat. Where there are seasonal variations in heat demand, the utilisation efficiency of CHP systems can be increased if the excess heat is used to power thermally driven refrigeration technologies. Trigeneration systems can have overall efficiencies as high as 90% compared to 33%-35% for electricity generated in central power plants

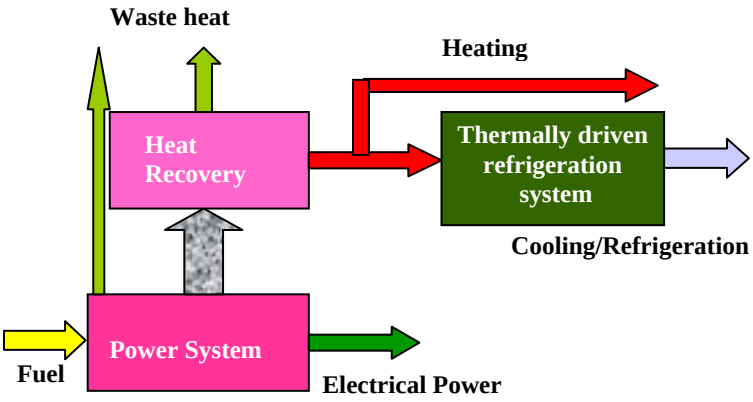

Figure 1. Schematic of a trigeneration system

State of Development

Trigeneration systems have been in operation for many years. Developments in recent years have mainly concentrated on individual subsystems such as the power system, heat recovery system, thermally driven refrigeration machines and system integration and control.

On the power systems front the main developments have been on: i) improvement of the efficiency of internal combustion engines, particularly gas and diesel engines and the development of engines that can operate with biofuels; ii) development of microturbines that enable the availability of reject heat at a much higher temperature than internal combustion engines; iii) development of fuel cells that offer higher electrical power generation efficiencies than internal combustion engines and microturbines. Progress in thermally driven cooling machines has mainly been on the development of adsorption cooling systems and multi-effect absorption systems to improve efficiency. Advances in heat transfer and heat exchanger technology now enable the manufacture of more compact heat recovery systems.

Applications in the food sector

There are a number of examples of application of trigeneration plants in the food industry. The majority of these are large plants in the MW range in food factories where bespoke ammonia plant are linked to gas turbines, or internal combustion engines. More recently, application of trigeneration has been extended to supermarkets with a very small number of installations in the USA, the UK and Japan. These systems are mainly used for space cooling applications and are based on internal combustion engines or microturbines and Li-Br/H_2O absorption refrigeration systems. A pilot installation is currently planned in the UK of a system employing an adsorption chiller.

Barriers to uptake of the technology

The main barriers to uptake of tri-generation technology are:

- application range of off the shelf systems is currently limited to temperatures above 0 ^{o}C,
- insufficient experience and performance data from applications in retail food stores to provide confidence in the application of the technology,
- economics are very sensitive to the relative difference between the price of grid electricity and fuel used by the trigeneration system. This makes it difficult to project accurately energy savings.

Key drivers to encourage uptake

The main drivers to encourage uptake of the technology in the food sector are:

- legislation that limits or prohibits the use of HFCs.
- greater availability of biofuels and legislation that requires significant reductions in emissions from food manufacturing and retailing.
- policies to encourage local/embedded power generation through subsidies and other instruments.

Research and development needs

To increase the attractiveness and application of trigeneration systems research and development work is required to:

- increase efficiency and reduce cost of power systems (engines, microturbines and fuel cells) and sorption refrigeration machines (absorption, adsorption)
- develop packaged systems for low temperature applications below 0 ^{o}C.
- develop design, and integration strategies for trigeneration system components.
- develop strategies and controls for the optimum integration of trigeneration systems with other power and thermal systems for applications in food manufacturing, retail and storage facilities.