

Biomass gasifier Stirling engine based tri-generation system in United Kingdom

Introduction

The new low carbon energy centre developed by strategic outsourcing and energy services company Management Incentive Through Investment Equity (MITIE) uses locally-sourced sustainable wood chip to power, heat and cool the store. The centre, built at a Waitrose supermarket in Bracknell, helps the store to cut carbon emissions by over 750 tonnes per year – equivalent to almost 1,500 transatlantic flights. It also helps in reducing the amount of grid electricity the store uses by 69% and the amount of grid gas it uses by 84%, making it almost completely independent of the national grid.

PROJECT AT A GLANCE	
Project Title	Biomass Stirling engine based tri-generation system
Project Site/location	Waitrose Super Market, Bracknell, United Kingdom
Owner/ developer	MITIE Group/Waitrose
System capacity	35 kWe, 140 kWth, absorption chiller 280 kW
Biomass fuel source	Woodchips from woodland management
Project installation	2012
Project cost	Approximately £ 3,000,000
Payback period	12 years

The biomass tri-generation system at Waitrose (Bracknell) comprises a biomass gasifier, an absorption chiller and a Stirling engine to convert woodchip energy into three types of energy - heat, cooling energy and electricity. The Combined Heat and Power (CHP) unit uses the Stirling engine manufactured by Stirling DK of Denmark.



Typical tri-generation plant

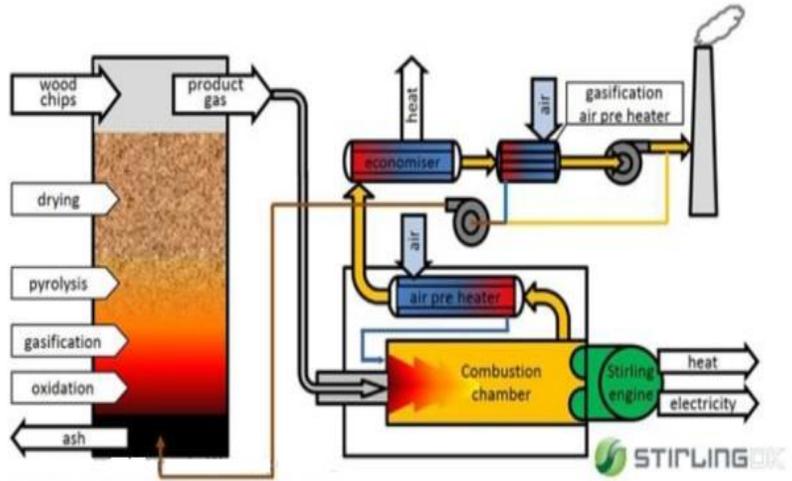
MITIE is a British strategic outsourcing and energy services company providing infrastructure consultancy, facilities management, property management, energy and healthcare services.

System details

The CHP unit has four modular units each rated at 35 kWe (electricity) and 140 kWth (heat), giving a total capacity of 140 kWe and 560 kWth. Fuel (producer gas) needed by the Stirling

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engine is provided by a biomass gasifier, which generates combustible mixture of gases, known as product gas, from biomass/woodchip through gasification reactions. The Stirling engine produces electricity as well as process heat, which in turn is used in the absorption chiller used for cooling the store building. Additional process heat is obtained using economizer, placed in the flue gas path of Stirling engine, and preheated air is obtained that is supplied to the gasifier as well as to the Stirling engine to enhance its operating efficiency.



Schematic diagram to explain the basic processes involved in tri-generation system

System performance

MITIE group has installed an identical sized system on Waitrose's premises in Isle of Wight. Considering the average envisaged system availability of 80%, Bracknell site has been generating about 980 MWe and 3,920 MWh_{th} since 2012 at rated power.

RHI payments

The Bracknell site falls under a medium size biomass system for the purpose of Renewable Heat Incentive (RHI) in the country. As such, the site will receive Tier 1 rate of 4.7p/kWh for the first 1,314 hours of operation and Tier 2 rate of 1.9p/kWh thereafter. The 1,314 hours of system operation equates to about 735 MWh of heat generated by the system installed at Bracknell site. Considering the site operation for 80% of the year i.e. 7000 hours/annum, RHI payment will be approximately £95,000 per annum. Commercial sites with CHP system may also be exempt from Climate Change Levy (CCL) (currently at 0.177p/kWh for gas and 0.5p/kWh for electricity) depending on Department of Energy and Climate Change (DECC's) assessment of the site under the Combined Heat and Power Quality Assurance (CHPQA) programme.

Annual Energy Generation (Table from manufacturer and Bracknell site)	
No of Stirling engines	4
Efficiency (system)	89.2%
Electrical output	4 x 35 (140) kW _e
Heat output	4 x 140 (560) kWh _{th}
Estimated annual operation	7,000 hours
Annual power production	980 MWh _e
Annual heat production	3,920 MWh _{th}
Hourly fuel consumption (@42%MC)	280 kg/hour
Estimated annual fuel consumption (@ 2.80 kWh _e /kg)	2,200 (t/year)
CO ₂ emissions avoided	1,390 (t/year)

Annual operation and maintenance cost

The approximate operation and maintenance cost of the plant is £100,000 per annum. The manufacturer recommends regular service of the plant at intervals of every 4,000-6,000 hours of operation. The servicing involves a complete overhauling of the system (at least twice per year).