Case Study 1

Lahti Gasification Facility, Finland

Case Study for Zero Waste South Australia

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Case Study 1 Lahti Gasification Project

Overview

A new combined heat and power (CHP) waste gasification plant (**Kymijärvi II)** opened in May 2012 replacing the previous biomass gasifier built in 1998. The plant uses 250,000 tonnes per year of Solid Recovered Fuel, which consists mainly of plastic, wood and paper products unsuitable for recycling. The plant is a result of a successful pilot project delivered by a partnership between Lahti Energy and Metso Corporation. Lahti Energy is a corporation which 100% owned by the City of Lahti.

Outcomes

- Successful demonstration of the gasification of waste
- The power plant produces 50 MW of electricity and 90 MW of district heat
- The plant uses 250,000 tonnes of per year Solid Recovered Fuel (SRF) which is equivalent to 170,000 tonnes of coal
- The plant supplies power to 87,000 costumers mainly in the Lahti area
- District heating is supplied to 7,600 costumers mainly apartment blocks and industry

Benefits

- The use of the fuel, which is produced from waste that is not suitable for recycling, saves on the use of natural resources and reduces CO2, NOx and SO2 emissions.
- The supply of district heating has reduced heating and electricity bills for local customers.
- Lower environmental impact as the gasification of biofuels and co-combustion of gases in the coal-fired boiler cuts CO2, SO2 and NOx emissions.

Success Factors

- Pilot scale plant was developed and proven before full scale commercialisation.
- Pilot stage helped to determine optimum fuel characteristics
- Project has been successful where others have failed, due to stringent fuel specifications
- Long term contracts guarantee security of supply of fuel
- Technical barriers of gas cleaning overcome

Background

The city of Lahti in Finland has a population of approximately 102,000 inhabitants. There has been a power plant in the city since 1907. In 1976, the Kymijärvi power plant was constructed which provides electrical power (167 MW_e) and district heating (240 MW_{th}). This plant was followed by Lahti Energy's first Kymijärvi biomass CFB (Circulating Fluidised Bed) gasifier which started commercial operations in March 1998. Constructed by Foster Wheeler, the gasifier was connected to the pulverized

coal fired power plant and replaced approximately 15% of the coal burned in the main boiler with biofuels. A further plant began incinerating waste in 1969.

In 2006, a new project – 'LahtiStreams' began with the aim of demonstrating a complete waste management chain including waste processing, material recovery, Solid Recovered Fuel (SRF)/Refuse Derived Fuel (RDF) production, and the gasification of these fuels in an advanced, high efficiency W2E plant as in a large scale gasification project.

The aim of the Lahti gasification project was to demonstrate direct gasification of wet bio-fuels and the use of hot, raw and low calorific gas directly combusted in the existing coal-fired boiler.

Subsequently, a joint pilot plant was built with Foster Wheeler to study cleaning of product gas. The target was to develop a new concept for a full scale gasifier-based power plant. The pilot plant testing showed that the gas could be cleaned sufficiently to be utilised to produce electricity at high efficiencies (higher than 35% in some instances).

The first small scale gasification plant and the pilot test was a success, prompting Lahti Energy, in partnership with the Finnish-based Metso Corporation, to build a new full scale gasification plant, Kymijärvi II, which was officially opened in May 2012.

Metso supplied the gasification reactors, gas purification systems, and the boiler of the power plant. Lahti Energy had the overall responsibility for the construction project.

The new technology enables a more efficient utilisation of solid recovered fuel than before. The facility produces 50 MW_e and 90 MW_{th} and is superior in terms of its heat-to-power ratio.

Feedstocks

Solid Recovered Fuels are sourced from preferred fuel suppliers in southern Finland.

The quality of the SRF is pre-specified and the raw material is mainly collected from industry, retail trade, construction sites and households. It consists of plastics, wood and paper waste materials that are unsuitable for material recycling. The waste is collected from a 200km radius of the site. That is a significant area in Finnish terms, as it includes Helsinki, 100 km away, where 10% of Finland's 5.2 million inhabitants live. Fuel supply has been ensured with long-term contracts.

After separating the waste, suppliers to the Kymijärvi II are required to shred it to a particle size of about 6 cm and reduce any moisture content to below 20–30%. A sample from each truckload is tested by a laboratory at the entrance to the power plant's weigh station. Processed waste is delivered to the plant's fuel depot.

- **SRF consists of plastic, wood and paper products unsuitable for recycling**
- **Annual usage of SRF is 250,000 tonnes which is equivalent to 170,000 tonnes of coal in terms of calorific value**
- **In one hour, 360 m^3 of SRF is gasified (two lorry loads)**

Technology

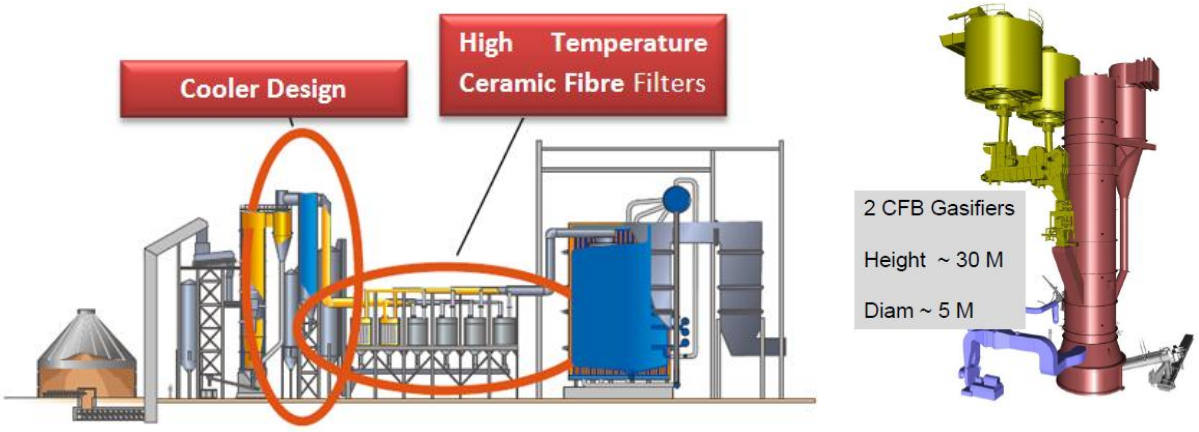
Hot Gas Cooling

Once approved, the SRF is fed into two 7,500m^3 silos from where it is conveyed into one of the two Circulating Fluidised Bed (CFB) reactors. The gasifiers contain hot sand and

limestone that is fluidised with air blown from the bottom of the gasifier. The SRF is mixed with the fluidised bed at a temperature of 900°C. The fuel will not burn as there is insufficient oxygen, but instead will be broken down into a gas.

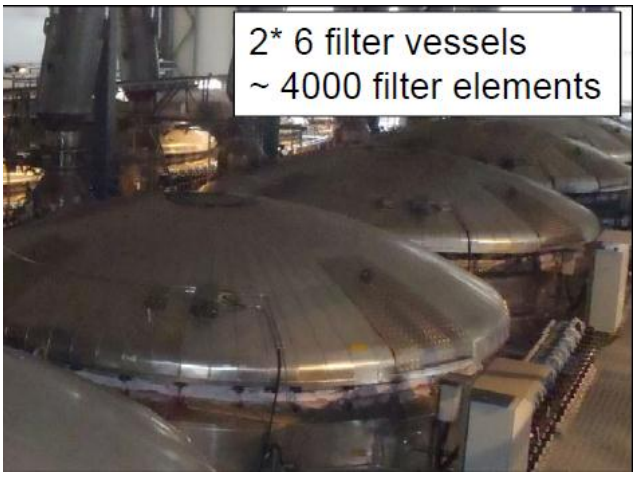
The hot gases rise to the top of the gasifier and then into a cooling system where the gas temperature falls to 400°C. When cooling, impurities in the fuel return into a solid state (ash).

Cooling is necessary prior to cleaning the gas of unwanted particles. Metal compounds and alkalis re-solidify and fall to the bottom of the cooling system and are removed.



Hot Gas Cleaning

Corrosion from hot waste gases is a common problem with a feedstock of waste-based SRF. However, the new Kymijärvi power plant claims to have resolved this issue.



Gasification of waste-derived SRF has not previously been done at this scale. The cooling and cleaning components, supplied by Metso Corporation, are unique to the Kymijärvi II plant. The system purifies the gas produced during gasification so that emissions are close to zero, except for carbon dioxide.

By cooling the gas to 400°C, impurities in the fuel, such as alkali chlorides, Pb and Zn, turn to solid form and are more easily removed. The gas impurities are removed inside 12 cooling chambers containing 300 high temperature ceramic candle filters, each collecting unwanted particles while allowing the gas to pass through. A nitrogen pulse every minute ejects collected dust, which falls to the chamber floor for removal.

The resulting gas is equal to natural gas in terms of its purity and is fed into the power plant boiler. Due to the efficient gas cleaning, there are few impurities to cause corrosion in the boiler. Additionally, the steam temperature and pressure are high, and therefore provide efficient and high electricity generation.

Outputs

Energy

The production capacity at Kymijärvi II is 50 MW of power plus 90 MW of heat, from a boiler operating at 540°C under 121 bar, achieving nearly 90% overall efficiency.

The plant supplies power to 87,000 customers nationwide, although mainly in the Lahti area. District heating is supplied to 7,600 customers, with almost every building in Lahti connected to the district heating network.

The district heating network has been developed across Lahti since the 1960s; therefore, the heat from the power plant was an ideal solution. The balance of heat and power needs to be weighed up with the infrastructure and the needs of a city.

By-products

Leachability tests are performed on both the ash from the main boiler and gasifier bottom ash. The leachability of trace metals is low. Gasifier bottom ash is disposed of but ash from the main boiler is used in construction projects such as road building. Permission is needed from the authorities on a case by case basis.

Costs

The LahtiStreams demonstration projected lasted over 6 years and had a total budget of €23.5 M. This included funding from the European Commission of €8.7 M.

The construction of the Kymijärvi II plant itself was €160 million. This included a €7 million grant from the European Union and €15 million as a 'new technology' subsidy from Finland's Ministry of Employment.

Loans from the European Investment Bank (€70 million) and the Nordic Investment Bank (€50 million) made up the bulk of remainder of funding.

Benefits

The plant's lower environmental impact was a key driving force for its development. The gasification of biofuels and co-combustion of gases in the coal-fired boiler cuts CO_2, SO_2 and NO_x emissions.

Much of the reduction in the SO_2 emissions is due to the inherently low sulphur content of biofuels. The plant's boiler does not use a sulphur removal system as the sulphur content of the coal is so low.

By contrast, NO_x is reduced via plant design. The burners are provided with flue gas circulation and staged combustion to cut NO_x emissions. The limit values for the emissions are NO_x 240mg/MJ (as NO_2) and SO_x 240mg/MJ.

The project won Finland's Ilmastoteko 2011 prize for its contribution to countering climate change. The plant will also help the country meet the EU's 2020 green energy targets of cutting greenhouse gases by 20%, improving energy efficiency by 20%, and raising renewable energy consumption to 38%.

Annual carbon dioxide emissions from Kymijärvi I and II operating together will total 230,000 tonnes, down from 410,000 tonnes with just Kymijärvi I.

The use of the fuel, which is produced from waste that is not suitable for recycling, saves on the use of natural resources and reduces CO_2, NO_x and SO_2 emissions.

The supply of district heating has reduced heating and electricity bills for local customers. The area has been using district heat since the 1960s, so local infrastructure and industry has been adapted to take advantage of this.

Practical barriers and solutions

Obtaining an environmental permit has been challenging and caused delays to the construction of both Kymijärvi I and II. It took 8 years to obtain the final environmental permit for Kymijärvi I. When it came to the Kymijärvi II, delays were also encountered as, at the time, gasification of waste was a relatively new technology and authorities were sceptical.

The local environmental authority was supportive and open-minded about the new facility. However, the Finnish Association for Nature Conservation appealed against the permit for Kymijärvi II first to the Vaasa Administrative Court, then to Supreme Administrative Court. The grounds for the appeal were not in protest against the environmental effects of the project itself, but opposition against the principle of incineration of waste in general. The Finnish Ministry of Environment opposed gasification technology as a solution to utilise Waste, whilst the Finnish Environment Institute took a favourable view.

The fact that the technology was unproven and unfamiliar increased the uncertainty and opposition to the project. The main issue was that gasification technology had not been widely demonstrated at the time the Waste Incineration Directive was implemented. This created an issue in the interpretation of the directive on burning a gas produced from waste, which itself would still be considered a waste product. Originally, Kymijärvi II was designed as a plant that used a clean, waste derived gas as its feedstock, as opposed to a waste. However, learning from the difficulties experienced with Kymijärvi I, Lahti Energy designed and permitted Kymijärvi II so that it will meet the stringent emission requirements of the Waste Incineration Directive. This meant that even if the clean gas was still determined to be a waste stream, the facility would still be permitted to use it as a fuel.

Success Factors

One of the overriding factors in the success of the Kymijärvi II facility is the stringent quality standards for the SRF by Lahti Energy. In February 2012, the Finnish Standards Association SFS published a new standard: *SFS-EN 15359 Solid Recovered Fuels. Specifications and Classes*. Lahti Energy has specified its own quality standards for solid recovered fuel in line with the standard's policy.

The Lahti regions have a long tradition of waste sorting, including source separation, and using waste-to-energy technology at the previous Lahti Energy power plant. Source-separated waste has been produced for 12 years in co-operation with the local waste management company Päijät-Hämeen Jätehuolto. During this period, both companies have been able to accumulate their know-how in waste management and waste-based energy production. Households have adopted waste sorting as a natural part of the daily life, while sufficiency in fuel supply is ensured by the nearby industry and trade. Combined, these factors have contributed to the success of the plant.

Kymijärvi II has a unique design and contains several innovative technical solutions that lead to its success. The gasifier produces biogas with close to zero impurities as a result of the process of cooling and cleaning. No impurities causing corrosion end up in the boiler, allowing the steam pressure and temperature to be kept high. This allows for a more efficient electricity generation rate. In addition, as there are no corrosion problems, less expensive materials can be used in the boiler structures. This has a positive effect on the investment price even with a gas cleaning line.