THE OPPORTUNITY OF CONNECTING SMALL SCALE WOOD GAS GENERATOR PLANT TO GREENHOUSES

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Abstract

The biggest difficulties of the Hungarian horticultures are caused by the high energy prices and the fluctuating and decreasing vegetable prices. In order to solve this we outlined a concept which will be implemented at the Termo Energo System Ltd.'s research site. The most important subsystem of the concept is the small scale wood gas generating power plant with 45kW electric and 90kW thermal output. The power plant's waste heat is utilized in the heating system of the greenhouse while its exhaust (CO_2) is used to fertilize the land.

Keywords

Gasification, pyrolysis, greenhouse heating,

Introduction

The importance of an efficient utilization of biomass as a renewable energy in terms of global warming and resource shortage are well known and documented. Biomass gasification is a promising CHP technology, due to its high electrical efficiency compared to other CHP systems in the lower and middle range of power. This power class has high potential with respect to heat demand, and hence, biomass gasification is predestined for decentralized energy systems.

In case of the modern greenhouse cultivation technology we already met the utilization of heat generated by natural gas fueled cogeneration unit to heat greenhouse. With this technology the cost of heating can be decreased. CO_2 fertilizing has major importance considering the Hungarian circumstances, since the amount of heat leaving the installation due to ventilation in case of early plant growing can be decreased, since the amount of CO_2 needed by the plant's photosynthesis is not provided by the cold ambient air. Generally the CO_2 does not originate from a natural gas fueled furnace's exhaust, but from expensive fluidized CO_2 stored in tanks. The reason behind this is the danger of pollutants possibly present in the exhaust gas (hydrocarbons due to incomplete combustion, and other pollutants originating from the sulphur content of natural gas).

Method

A three-way R+P work was pre-made before planning the connection of the small scale gasifier plant to the greenhouse.

- The development of low-temperature heating system for greenhouses, utilizing the waste cooling water of combined cycle power plant
- The effects of CO_2 fertilizing on the tomatoes' average yield and composition
- Development and analysis of gasifier creating low tar content wood gas

The following steps induced the connection:

- The increasing gas prices make the operation of horticultures impossible (high energy prices)
- The decreasing vegetable prices and uncertain merchandizing (e.g.: german vegetable scandal in 2011) renders the earnings uncertain
- The beneficial effect of CO_2 fertilizing on the vegetables' composition and the opportunity of price reduction of CO_2 fertilizing utilizing the wood gas generator's exhaust
- The electricity generated indicates a constant income for the horticulture, increasing the stability and sustainable development of it.

Low temperature heating system for greenhouses

The combined cycle power plant, powered by natural gas, recently built in Vásárosnamény induced the development of the low temperature greenhouse heating system. During the process of research and development a modular concrete panel was researched, which is able to utilize the cooling water at 30-35°C to heat greenhouses without complementary heating. With aid from tender financing we built two greenhouses with an area of 780 m² each. One of these installations acted as a reference greenhouse with conventional hot water heating system with steel pipes, while in the other greenhouse the developed concrete panels' thermal parameters were analyzed. These systems were heated with natural gas fueled furnaces.

Parameters of the experimental greenhouses:

- Greenhouse area: 780 m²
- Greenhouse outer surface: 1417 m²
- The ratio of the greenhouse area and outer surface: 1 : 1.816

Figure 1. Greenhouses and service buildings

We measured a U-value of 4.1 W/m^{2}K for the greenhouses. Due to this measurement the daily, monthly and annual energy requirements of the installations can be precisely calculated. Near the two greenhouses with an area of 780m^2 each four 10 m x 30 m solo greenhouses were built. We intend to connect their heating system to the planned scale gasifier plant. In the following tables we can find the calculated energy requirements based on measured U-values, illumination and the average temperature values of the last 40 years.

Table 1.: The energy requirement of the heating system of a 780 m^2 large greenhouse during heating season.

	Daily energy [MJ]	Monthly energy [MJ]
October	1330	41245
November	3923	117685
December	6866	212835
January	8091	250826
February	5043	141213
March	3081	95503
April	1286	38565
Annual energy [MJ]		897873

Table 2.: The energy requirement of the heating system of a 300 m^2 large greenhouse during heating season.

	Daily energy [MJ]	Monthly energy [MJ]
October	590	18296
November	1822	54646
December	3112	96479
January	3679	114052
February	2367	66287
March	1437	44535
April	570	17107
Annual energy [MJ]		411402

Figure 2. The Hydroponic growing in the experimental concrete panel heated 780 m^2 greenhouse.

Development and analysis of gasifier creating low tar content wood gas

The gasification technology, which was first utilized on industrial level in the 19th century, only spread in the 20th century due to the fuel shortage occurring after the world war. The interest in biomass appeared, mainly in developing countries where waste (e.g.: by-products of agriculture, forestry and wood industry, like: straw, chips, waste-wood, trimmings) was utilized to save energy for a short time during the energy crisis of the 80's. In this way import of expensive petroleum products could be avoided.

During the last years fix bed gasification technologies developed rapidly. Due to this technological advancement the tar content of the wood gas created decreased, which increased the technology's accessibility and the simplicity of the gas cleaning system, therefore increased the technology's economic efficiency.

We started to develop our own gasifier after studying these modern staged systems. The most important aspect of the research was to create a gasifier which is able to generate synthesis gas with low tar content.

The reactor design is moving bed, co-current, downdraft and throatless. The fuel feed is on the top and in the middle of reactor, with the help of a double sluice feeding device. The feeder is flushed with fresh air. The reactor has double walls, so the hot producer gas preheats the fresh air, which is very important to reach the low tar content of the generator gas. The zone of reduction is sheathing is isolated with fire-bricks. The grate is rotating to promote constant ash removal from the reduction zone. The measurements done during the operation of the gasifier gave positive results. The tar content under 50 mg/Nm^3 and the cold gas efficiency reaching almost 80% makes possible to operate a gas engine continuously with the gas generated.

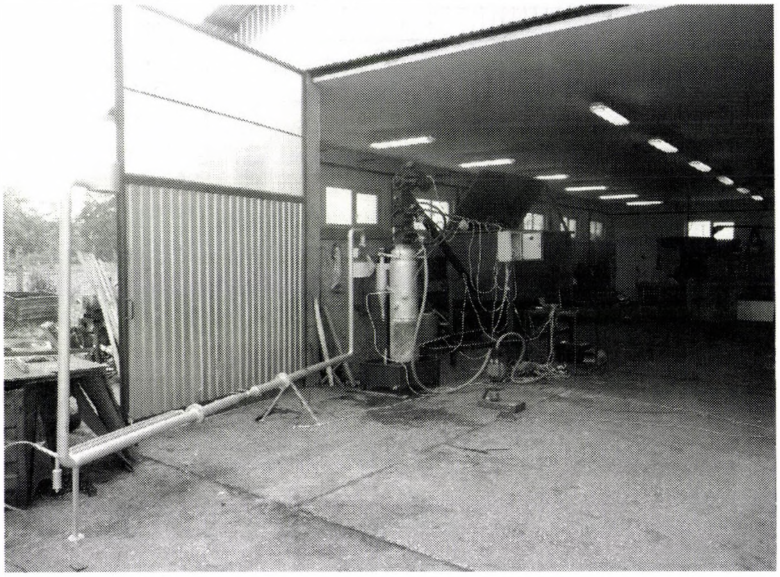

Figure 3. The gasifier prepared for measurements with the woodchips container and the measurement system.

The effects of CO_2 fertilizing on tomato average yields and composition

During tomato growing we analyzed the effect of increased CO_2 in the greenhouse on growing and quality. The growing took place in two greenhouses at once. One of these greenhouses was treated with CO_2, while the other was used as reference. The CO_2 concentration in the greenhouses was around 800-900ppm, which means around 50-70 kg/ha CO_2 gas consumption hourly.

Based on the harvested amount the treated greenhouse has a larger yield. The amounts harvested from both sources indicated distribution. More significant differences appeared during the early and the final periods to the advantage of the treated greenhouse.

Results

The greenhouses' annual energy requirement is 3441 GJ (calculated with 212-day-long heating season). The energy output for this period of the small scale power plant is 1648 GJ (7.776 GJ daily), which less then half of the amount of energy needed. This ratio is worsened by the increasing demand during the cold months (e.g.: in January the daily energy requirement of the heating system is 30.89 GJ). For this reason the greenhouse should be involved in growing gradually to improve the occupancy of the power plant, which has a major effect on its economic efficiency. The maximum thermal requirement of the two 780 m^2 greenhouses is 390 kW, therefore to supply the blockhouses a 300kW biomass furnace should be installed. A 30 m3 puffer tank should be installed together with the power plant, which is able to store 4.4 GJ heat, which allows the small scale power plant to supply the complete heat demand of the whole installation. With this design the utilization of the heat generated by the power plant is close to 100% during heating season, which means an operation time of 4500 hours.

The gasifier power plant generates 42kg of CO_2 hourly. The total surface of the heated greenhouses is 2760 m^2, which means a CO_2 consumption of 19.32 kg/h while maintaining the concentration of CO_2 used during the experiments, around 800 ppm. For this reason higher CO_2 concentration might be reasonable if it has a positive effect on the plants and not harmful on the employees.

Conclusions

The fuels of the small scale wood gas generating power plant are chips of energy plants or wood. In contrast to conventional biomass power plants, not only a closed CO_2 cycle develops, but it is consumed. Since the fertilized plants absorb ambient (exhaust) CO_2 and since these plants will not be burned, but composted the CO_2 accumulated in them will not return to environment. The amount of CO_2 absorbed a year is almost 150 tons in case of a power plant with 45kW electric output.

If the small scale gasifier plant replaces gas heating and tanked CO_2 fertilizer, then in case of a 2500 m^2 heated culture the price of fuel used during 7000 hours of operation can be saved. The investment is recovered after 4 years from the price of the electricity generated during 7000 hours of operation annually and after this it continuously generates a well calculable income.

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