# Ni Ketut Caturwati-Ketut_2019_IOP_Conf._Ser.__Mater._Sci._Eng._494_012068

*by* Ni Ketut Caturwati

**Submission date:** 02-Feb-2022 08:09PM (UTC+0700)
**Submission ID:** 1753409347
**File name:** Ketut_2019_IOP_Conf._Ser.__Mater._Sci._Eng._494_012068.pdf (779.15K)
**Word count:** 1924
**Character count:** 9668

IOP Conference Series: Materials Science and Engineering

PAPER · OPEN ACCESS

# Improved performance of CS 100l LPG fuel generator with the addition of biogas

To cite this article: Caturwati Ni Ketut *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **494** 012068

IOP Conf. Series: Materials Science and Engineering **494** (2019) 012068 doi:10.1088/1757-899X/494/1/012068

# Improved performance of CS 100l LPG fuel generator with the addition of biogas

**Caturwati Ni Ketut[1], Agung Sudrajad[2], Heri Haryanto[2]**

[1]Mechanical Engineering Department, Universitas Sultan Ageng Tirtayasa, Cilegon, Indonesia
[2]Electrical Engineering Department, Universitas Sultan Ageng Tirtayasa, Cilegon, Indonesia

E-mail: n4wati@yahoo.co.id

**Abstract**. Biogas is one of the new renewable energy sources that can be obtained through anaerobic degradation process of organic materials. Utilization of household waste, agricultural waste and livestock as the main ingredient of biogas production in addition to generate new renewable energy sources can also minimize the negative impact of waste to the environment. In this research, the performance test of CS 1000 L LPG generator engine and compare it with the use of LPG fuel added a little biogas. With a slight addition of biogas into the generator's engine chamber (0.6 Nl / min) obtained an effective engine power increased by an average of 2.4% of the generated power generator with LPG fuel. In addition, the results of the test of emissions when no load (idle) to reduce the CO content in the exhaust gas reaches 89% and the decrease of 99% of HC content. Thus, the addition of a small amount of biogas into the combustion chamber of the genset machine can avoid significant exhaust gas pollution as required by the Regulation of the Minister of Environment of Indonesia No. 05 of 2006.

Keywords: biogas, performance test, generator engine, test of emission.

## 1. Introduction

The scarcity of fossil fuels and limited fossil energy reserves forced the Indonesian government to issue a policy to convert the use of kerosene in households to gas (LPG) in 2007, this policy is expected to reduce government subsidies in the use of fuel oil up to Rp. 197 , 05 trillion. But the simultaneous migration of LPG makes LPG gas price increasing. To overcome this need to make efforts to utilize renewable energy resources that exist around us such as biogas.

Biogas is a renewable energy source that can replace conventional fossil-based energy sources and is highly applicable to rural and developing countries with abundant cellulosic biomass resources (such as cow dung, agricultural waste, industrial waste etc.) [1], [2][3][4][5][6][7]. Biogas is an anaerobic decomposition of organic material by methanogenic bacteria. The main ingredients of biogas are methane about 40-70% , 25-40% of carbon dioxide and other gases in small quantities as shown in Table 1. Biogas is 20% lighter than air with flame temperature 650-750 ˚C. The characteristics of the biogas flame are similar to the flame generated by LPG gas with a heat value of 20 MJ / m3 and the combustion efficiency reaches 60 percent in conventional gas stoves [2][8]

**Table 1.** Composition of biogas [1]

| Substance | Symbol | content (%) |
|---|---|---|
| Methane | $CH_4$ | 40-70 |
| Carbon Dioxide | $CO_2$ | 25-40 |
| Hydrogen | $H_2$ | 0.1-0.5 |
| Nitrogen | $N_2$ | 0.5-2.5 |
| Ammonia | $NH_3$ | 0.1-0.5 |
| Hydrogen Sulphide | $H_2S$ | 0.1-0.5 |

Initially the study was directed to use biogas as a substitute for LPG gas in CS 1000 generator set, but this did not work well. This is probably caused by higher biogas flame temperatures than LPG gas which has a flame temperature value ranging from 410-580 ˚C. So the research in this paper is done through testing the performance of CS 1000 L LPG generator set with a slight addition of biogas. Engine performance to be tested includes: Output power (VA), Specific Fuel Consumption (SFC) value and waste gas emission test of engine.

***Output Power (VA)***
The output power for each load variant is determined from the multiplication value between the rated current (A) and the measured voltage (V) at the installed load.

***Specific Fuel Consumption (SFC)***
Shows the rate of fuel consumption to produce one unit of power (kg / kWh)

$$SFC = \frac{\dot{m}_f}{N_e} \quad (1)$$

The mass flow rate of fuel, can be determined from equation (2)

$$\dot{m}_f = \rho_f . \dot{Q}_f \quad (2)$$

Where :
$\dot{m}_f$ = mass flow rate of fuel (kg/s , kg/h)
$N_e$ = output power (Watt)
$\rho_f$ = density of fuel (kg/m$^3$)
$\dot{Q}_f$ = flow rate of fuel (m$^3$/s , m$^3$/h)

**Waste Gas Emissions Test of Engine**
The waste gas emission test is performed by measuring the component composition: CO, CO2, O2, HC and λ. This value is compared with the Regulation of the Minister of Environment of Indonesia - Number 05 Year 2006 with the condition of emission limits in accordance with Table 2.

**Table 2.** Emission Limits according to the Indonesian Ministry of Environment's Regulation of 2006

| category | production | Parameter | | Test method |
|---|---|---|---|---|
| | | CO (%) | HC (ppm) | |
| Two stroke motorcycle | < 2010 | 4,5 | 12000 | idle |
| Four stroke motorcycle | < 2010 | 5,5 | 2400 | idle |
| Motorcycle ( two – four stroke ) | ≥ 2010 | 4,5 | 2000 | idle |
| Internal combustion machine | > 2007 | 4,5 | 1200 | idle |

## 2. Experimental Methods

Research on the addition of biogas as engine fuel has done on genset machine with the following specifications:

| | |
|---|---|
| Type | : CS1000L |
| Generator | |
| Rated Wattage | : 850 W |
| Rated Voltage | : 230 V |
| Rated Frequency | : 50 Hz |
| Phase | : Single Engine |
| Engine type | : 4- stroke OHV single cylinder with forced air cooling system |
| Fuel | : Use clean, fresh, regular LPG 0.03 – 0.4 Mpa. |
| Dimensions | : 18.7" x 15.6"x16.7" (480x400x420 mm) |

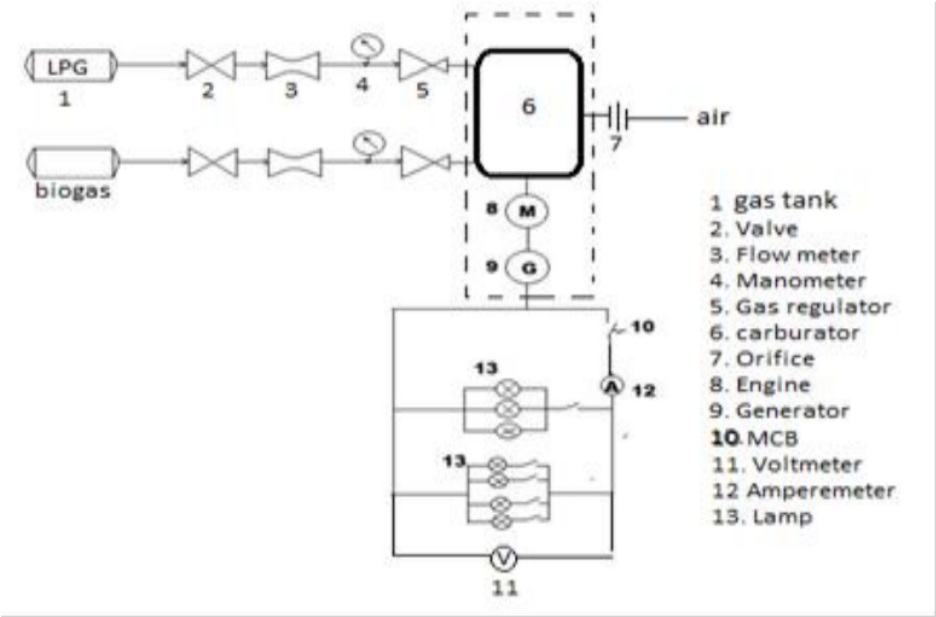


**Figure 1.** Scheme of test equipment.

The main fuel of this machine is LPG gas, in this study added one channel to add biogas fuel 0.6 Nl / min into the combustion chamber. The main load of the generator can be varied with the variation of installed lamp power at number 13 in Figure 1. The lamp loads in this study vary from: 200 W, 400 W, 600 W, 700 W and 725 W. Testing the performance of engines with biogas additional fuel can't be done until the maximum load of the machine, testing with a 800 W lamp causes the engine stoped (overload) so that the engine test is done with a maximum load of 725 W.

## 3. Results and Discussion

*3.1 Output Power*

The measured output power is obtained from the measurement of the current (amperemeter) and voltage (voltmeter) through the load circuit (lamp). The measured output power in the lamp circuit shows a

higher value than the total installed lamp load: 24.45% in the generator using LPG + biogas fuel; 21.06% in generators using LPG fuel, as shown in Figure 2.

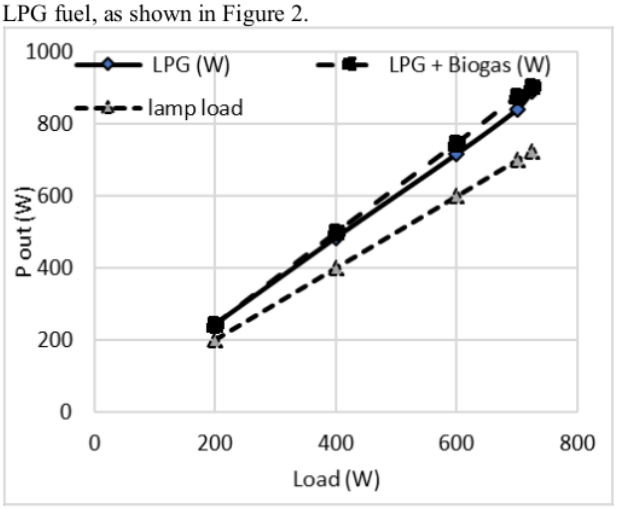


**Figure 2**. The measured output power in the lamp circuit vs the installed load

*3.2 Spesific Fuel Consumption*

The measurement of SFC values is determined based on the amount of fuel consumed compared to the output power generated. The fuel mass rate of gases are determined by Equation (2) with the density of gases:

$\rho_{LPG}$ = 2.26 kg/m$^3$

$\rho_{biogas}$ = 1.2 kg/m$^3$

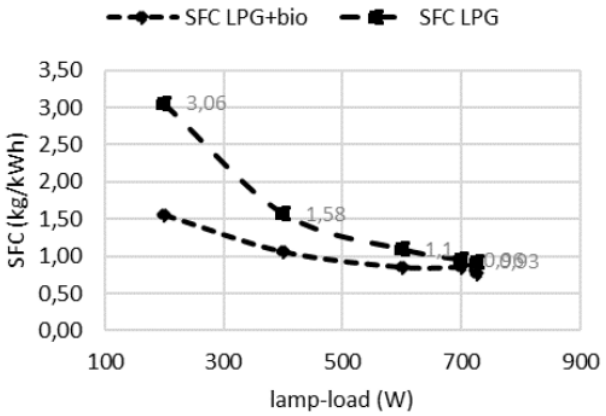


**Figure 3.** Specific Fuel Consumption Genset LPG and LPG + biogas fuels.

While the SFC value is determined as in equation (1). The result of testing of generator machine with LPG and LPG + biogas fuel usage is shown in Figure 3. The value of SFC Genset with LPG fuel is higher than LPG + biogas with an average value of 26.5%. The highest difference was obtained at the

lowest lamp load of 200 W at 48.9%. Thus the results of this study indicate the addition of biogas into the engine combustion chamber produces significant savings in the amount of fuel used.

*3.3 Waste Gas Emissions Test of Engine*

In accordance with the Indonesian environment minister's regulation in 2006 the CO gas content in the waste gas for Idle conditions is a maximum of 4.5%. Figure 4 shows the CO gas content for the genset gas with LPG + biogas fuel having a value below the required maximum limit, with a value of 0.53% under idle conditions. On the other hand, waste gas of genset with LPG fuel has CO content above the required maximum limit, idle operation condition produces exhaust gas with the element content of CO reaches 5.39% almost 10 times compared to gas content of CO generated by generator with LPG + biogas fuel .

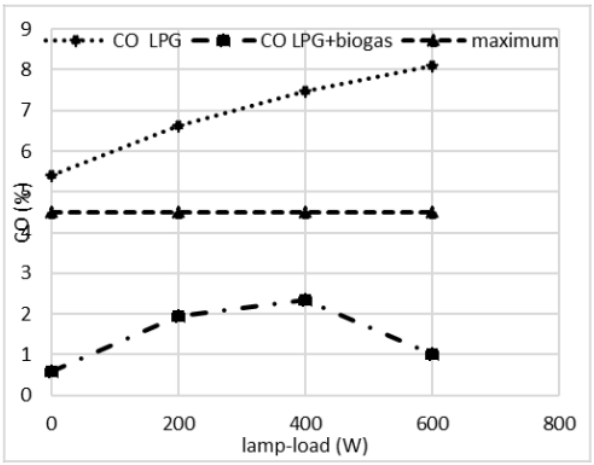


**Figure 4.** Content of CO gas in waste gas of genset with LPG and LPG+biogas as the fuels

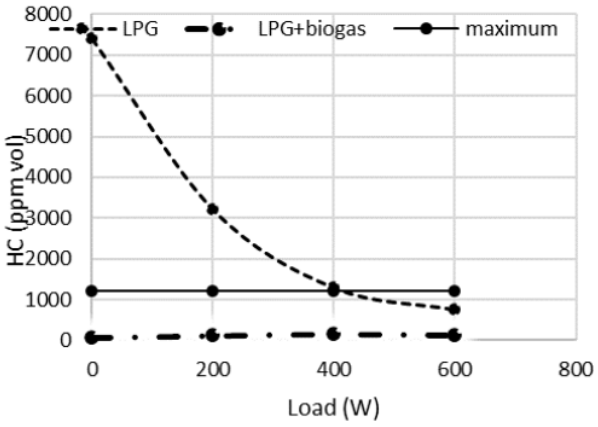


**Figure 5**. The content of HC elements in waste gas of genset.

## 4. Conclusions

1. The addition of biogas into the combustion chamber of gas generated LPG generator can give the following effect.
2. Increased power generated by the machine from 21.06% above the installed load to 24.45% above installed load.
3. Decrease in the value of Specific Fuel Consumption on average 26.5% so that the generator is more fuel efficient.
4. More environmentally friendly exhaust emissions with CO and HC elements below the maximum permissible conditions.

## ACKNOWLEDGMENT

The authors would like to thank the Ministry of Research and Higher Education of Republic of Indonesia for the financial support under PTUPT Research Grant.

## REFERENCES

[1]. R. Arthur, M. F. Baidoo, and E. Antwi, "Biogas as a potential renewable energy source: A Ghanaiancase study," *Renew. Energy*, vol. 36, no. 5, pp. 1510–1516, 2011.
[2]. S. Amini, P. Ordoney, and I. Khuzestan, "Investigation of biogas as renewable energy source.," *Int. J. ...*, pp. 1453–1457, 2013.
[3]. C. N. Ketut, A. Sudrajad, M. Permana, and H. Haryanto, "Experimental study of anaerobic digester biogas method using leachate from landfill municipal waste," *Int. J. Appl. Eng. Res.*, vol. 12, no. 19, pp. 9112–9115, 2017.
[4]. P. McKendry, "Energy production from biomass (part 3): Gasification technologies," *Bioresour. Technol.*, vol. 83, no. 1, pp. 55–63, 2002.
[5]. J. Valerie, "BIOGAS : a Bright Idea for Africa," no. May, 2006.
[6]. T. Zhang *et al.*, "Biogas Production by Co-Digestion of Goat Manure with Three Crop Residues," vol. 8, no. 6, pp. 1–8, 2013.
[7]. L. G. a Potts and D. J. Martin, "Anaerobic digestion, gasification, and pyrolysis," *Waste Manag. Minimization*, 2011.
[8]. C. N. Ketut, S. Agung, P. Mekro, H. Heri, and Bachtiar, "The flame characteristics of the biogas has produced through the digester method with various starters," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 299, p. 012091, 2018.

# Ni Ketut Caturwati-Ketut_2019_IOP_Conf._Ser.__Mater._Sci._Eng._494_012068

ORIGINALITY REPORT

| 18% | 16% | 14% | % |
|---|---|---|---|
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

PRIMARY SOURCES

| | | |
|---|---|---|
| 1 | umpir.ump.edu.my<br>Internet Source | 4% |
| 2 | kyutech.repo.nii.ac.jp<br>Internet Source | 3% |
| 3 | lintar.untar.ac.id<br>Internet Source | 2% |
| 4 | www.matec-conferences.org<br>Internet Source | 2% |
| 5 | sintadev.ristekdikti.go.id<br>Internet Source | 2% |
| 6 | C. N. Ude, O. D. Onukwuli, C. Nwobi –Okoye, O. E. Anisiji, C. U. Atuanya, M. C. Menkiti. "Performance evaluation of cottonseed oil methyl esters produced using CaO and prediction with an artificial neural network", Biofuels, 2017<br>Publication | 1% |
| 7 | docplayer.net<br>Internet Source | 1% |

| | | |
|---|---|---|
| 8 | mafiadoc.com<br>Internet Source | 1 % |
| 9 | www.5vie.ch<br>Internet Source | 1 % |
| 10 | digilib.uinsgd.ac.id<br>Internet Source | 1 % |
| 11 | pertambangan.fst.uinjkt.ac.id<br>Internet Source | 1 % |
| 12 | gulfstormsupply.com<br>Internet Source | 1 % |
| 13 | www.science.gov<br>Internet Source | <1 % |
| 14 | Caturwati Ni Ketut, Agung Sudrajad, Mekro Permana, Heri Haryanto, Rizka Khaerani. "The Comparison of Genset Machine CS 1000 L Performance Between LPG and Methane Gas Usage as The Fuel", MATEC Web of Conferences, 2018<br>Publication | <1 % |

| | | | |
|---|---|---|---|
| Exclude quotes | On | Exclude matches | < 5 words |
| Exclude bibliography | On | | |