



Potential and status of bio gas production in rural areas: A case study of ghumarwin development block in district Bilaspur Himachal Pradesh, India

Rajender Kumar^{1*}, Jagdish Chand²

¹ Research Scholar, Department of Geography, CPU Kota, Rajasthan, India

² Assistant Professor, Geography Govt College, Sangrah, Sirmour, Himachal Pradesh, India

Abstract

Energy plays an important role in the modern society and can serve as one of the vital parameters of socio-economic development. Despite developments in technology, over three billion persons living in rural parts of the low- and middle-income countries continue to cover their energy needs for cooking through traditional ways by burning biomass resources and fossil fuels. Central and state Govt. ensure LPG connection to every households through various schemes in India, but there is a great hue and cry on the price of LPG during last few years. This paper as a case study focuses on to assess the potential of bio gas production in rural areas of Himachal Pradesh. A comprehensive survey regarding use of energy resources, agricultural land and cattle strength was conducted across the study area. Total 528 households among ten selected villages surveyed for this purpose. It is observed that the manure of the livestock farms is not used efficiently and area have good potential and feasibility of bio gas production. The benefit of biogas production would therefore be manifold: (1) local energy source, (2) mitigation of environmental impacts, (3) reducing CH₄-emissions, (4) producing organic fertilizer as a side product (5) additional earnings/ savings for farmers. (6) organic waste management.

Keywords: biogas, agriculture, organic waste management mitigation

Introduction

In rural areas people are still using traditional and conventional methods for heating and cooking, these methods are either inefficient or costly and are not using other easily available alternative energy resources like solar, biogas, residue and household wastage. In addition to these problems the poverty line in rural area is 20 rupees per day income and in urban area is 28 rupees per day income according to Tendulkar Committee set up by Planning Commission of India in 2009, so buying costly technology like an LPG and PNG for daily practices like cooking is beyond the budget of poor people. There are various studies and research is available on this topic, many people have already produced good results, including the development of solar cookers or biogas plants. Devices like solar cooker are costly and have some drawbacks such as food is needed to be cooked for a longer time and weather conditions play an important role in it.

These techniques should be easy to use, cheap and available to everyone. They shouldn't have any adverse effects on ecosystem and support the theory of sustainable development. To improve upon the existing technology and find a mean which contribute in socio, economic and sustainable development of society. According to 2011, census there are 6.1 million villages in India and more than 60% of all population is employed in primary sector like agriculture, animal husbandry, fisheries and horticulture, plantation, pastoral activities. Conventional methods used by people for cooking and heating (for example LPG, kerosene, coal and wood are going to end in near future and are damaging the environment in form of deforestation and excess mining, furthermore they are expensive for people of rural areas. That is why it is needed to find ways to utilise local energy resources efficiently for cooking and heating.

There is ample potential of setting up biogas plants considering the livestock population of 512.06 million, which includes about 300 million (299.98 million) total population of bovines (comprising of cattle, buffalo, mithun and yak). The livestock sector contributes about significantly to India's GDP and will continue to increase. The dissemination of biogas technology is a boon for Indian farmers with its direct and collateral benefits. ^[1]

Literature review

The poor management of livestock-derived waste can lead to multiple environmental problems like nutrient accumulation in soil, water eutrophication, and air pollution. The aim of this work is to establish a replicable geographic information system (GIS)-based methodology for selecting priority sites in which to implement anaerobic digestion units. These units will use multiple parameters that evaluate environmental risks and viability factors for the units themselves. A weighted overlay analysis was used to identify critical regions and, based on the results, clusters of individual livestock production units (LPUs) across the state were selected.. The results indicate that Jalisco has the potential to generate 5.5% of its total electricity demand if the entirety of its livestock waste is treated and utilized in centralized anaerobic digestion units. Additionally, 49.2 and 31.2 Gg of nitrogen and phosphorus respectively could be valorised, and there would be an estimated total reduction of 3012.6 Gg of carbon dioxide equivalent (CO₂eq). ^[7] This paper as a case study focuses on the AralSea region of Uzbekistan, possessing a well- developed agricultural production with high livestock numbers and intensive crop production. The manure of the livestock farms is not used efficiently and the energy supply of the farms depends primarily on centrally produced gas and

electricity. Some areas are not yet connected to the gas grid. [8] An experimental study worked on a model biogas production unit which has 0.5 m3 fermentation tank capacities of a breeding farm in the Urla district of Izmir/Turkey. The farm animal quantity is 70 cattle and 1400 chicken. Animal wastes (poultry manure and bovine animals manure) were anaerobically fermented in the tank. In this respect, experimentation was performed at summer season and average regional temperature was 307 K and so reaction does not require the extra heating for the optimization of process. Biogas production potential from bovine animal and poultry manure was separately studied. Results showed that daily 6.33 m3 and 0.83 m3 biogas productions were obtained from fermentation of bovine animal manure and poultry animal manure. [9] Successful implementation of biogas projects in developed countries for agricultural waste-motivated biogas has occurred in a range of low- and middle-income countries, such as China, India, Nepal, Kenya [2]. Most of the household biogas plants installed in China started providing energy for its rural areas and strengthening the biogas-based economy in 1974 [3] Agricultural-based projects gave a stimulus for improvement in biogas implementation in China, and biogas production is growing because of the industrial-scale digesters. Despite the impressive number of achievements, there are still several challenges regarding policy, poor industrial chain and technical problems caused by low-quality digesters [4]. In the case of India, government programs such as the National Biogas and Manure Management programme (NBMMP) served as a base in biogas implementation to enhance the energy service status of the people [5]. Most biogas plants consist of reactors that are intended to treat food wastes, cow dung, human excreta and mixed feedstock [6].

The study seeks to investigate the following research questions:

1. What is the status of bio gas production in the study area?
2. Is there any potential of bio gas production in the study area?
3. Is there any feasibility of bio gas production in the study area?
4. What are the benefits of bio gas production?

Methodology

The present study is based on primary and secondary data. The primary data is generated through comprehensive survey of the household. A questionnaires/ schedules is prepared for household to collect the data. Considering the geographic spread the purposive random sampling technique is used for collecting the primary data. In total, 10 sample villages named Galyana, Ladhyani, Bum, Seu, Machhwan, Kothi, Bhadrog, Patta, Niun and Majhasu and about 528 households surveyed for the present study. A comprehensive survey regarding education level, occupation, use of energy recourses for cooking, agriculture

land and cattle strength, types of cattle and perception regarding bio gas was conducted across the study area. In the present study, data analysis is done through various statistical, cartographic and tabular methods. All the responses represented through simple percentage method.

Study Area

Ghumarwin Block (CD) lies in the Bilaspur District of Himachal Pradesh. Total area of Ghumarwin CD block is 228.66 km² including 225.556 km² rural area and 3.10 km² urban area. According to Census 2011, Ghumarwin has population of 102023 persons. There are 261 inhabited villages and 01 urban centre in Ghumarwin block.

Table 1

Population type	Male population	Female population	Total population
Rural	45873	48251	94124
Urban	4,175	3,724	7,899
Total	50048	51975	102023

Results and discussions

Educational level and Occupational structure Table 1.1 and Fig1 and Fig 2 depict the picture of educational level and occupational structure of the study area. In the study area only 7.7 percent persons are illiterate and 92.3 percent are literate.

76.9 percent persons have education qualifications up to metric and above. About 33 percent of population is above 10+2and above in their qualification. So we can say that educational level of the study area is high in comparison to the national level. More than half of the working population is engaged in agricultural and associated activities as 55.9 percent population engaged in cropping and animal husbandry. Skilled labour 9.8 percent, non-skilled labour, 4.3 percent, Govt. sector 4.3 percent, private sector 20.8 percent and others 4.5 percent of the population. It is clear that most of the population is working in the fields and rearing the cattle in the study area, which is first requirement for bio gas generation.

Table 1.1: Educational level and occupational structure of the study area.

Educational Level	Age (%)	Occupation Structure	Age (%)
Illiterate	7.7%	Agriculture & Share cropping	29.6%
literate	15.4%	Animals & Port Farming	26.3%
Metric	44.6%	Skilled Labour	9.8%
12th	16.4%	Non-skilled labour	4.3%
ITI/Diploma	3.5%	Govt. sector	4.3%
Graduate	8.3%	Private sector	20.8%
Post Graduate	4.1%	others	4.5%

Source: Compiled by author based on primary survey 2021.

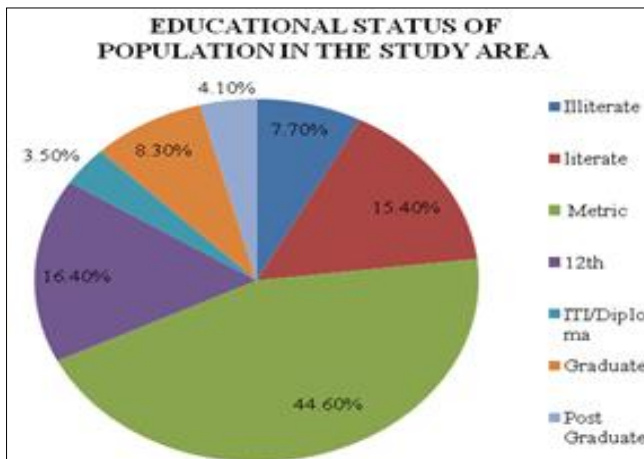


Fig 1

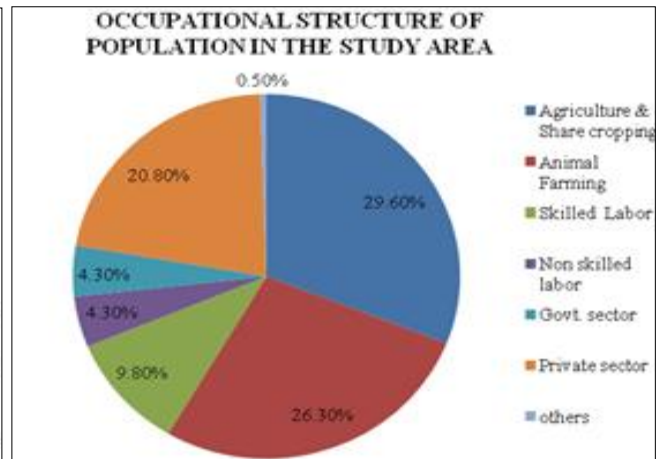


Fig 2

Use of Energy Resources for cooking: At present, in India, people rely on old methods for cooking and heating. These methods consume huge amounts of energy, which leads to overutilization of resources. The procedure of making dung cakes and burning them are both uneconomical and unhygienic. This brings us to understand the current consumption rate of energy and analyse other available resources so as to secure resource sustainability. In the present study it is very much important to know about the status of households using energy resources for cooking. The data in this regard is shown in Table 1.2. The table clearly depicts that LPG and wood are the main energy resources use in 99.2 percent and 92.4 percent households respectively. Government try to provide clean energy

resources through various schemes in the study area but still 92.4 percent households using wood as source of energy for cooking, which is unhygienic and problematic from environmental point of view. Most of the households use both of these energy resources simultaneously. 20.73 percent households use electricity, 13.67 percent use solar energy for cooking in the study area. It is observed during the study that most of the households use multiple energy resources for cooking. In some households people are using three energy resources like LPG, wood and electricity simultaneously as per their need. It is matter of concern that only few households (1.69%) have bio gas as energy resource for cooking in the study area.

Table 1.2: Status of households regarding use of types of different energy for cooking among selected villages (%)

Name of village	LPG	Wood	Electricity	Cow Dung	Biogas	Kerosene	Solar
Galyana	100	82	26.5	12.3	1.92	5.4	00
Ladhyani	98.00	92	19.21	9.6	9.45	8.3	6.3
Bum	100	95	21.21	12.4	5.55	7.5	5.2
Seu	98.00	94	15.6	15.4	00	6.2	4.5
Machhwan	96.00	94	19.26	19.8	00	9.0	00
Kothi	100	89	25.6	9.6	00	5.4	00
Bhadrog	100	94	22.4	12.8	00	7.6	00
Patta	100	96	16.9	14.4	00	4.6	4.2
Niun	100	92	22.42	15.6	00	00	2.5
Majhasu	100	96	18.24	14.8	00	5.6	00
Total	99.2	92.4	20.73	13.67	1.69	5.96	2.27

Source: Compiled by author based on primary survey 2021.

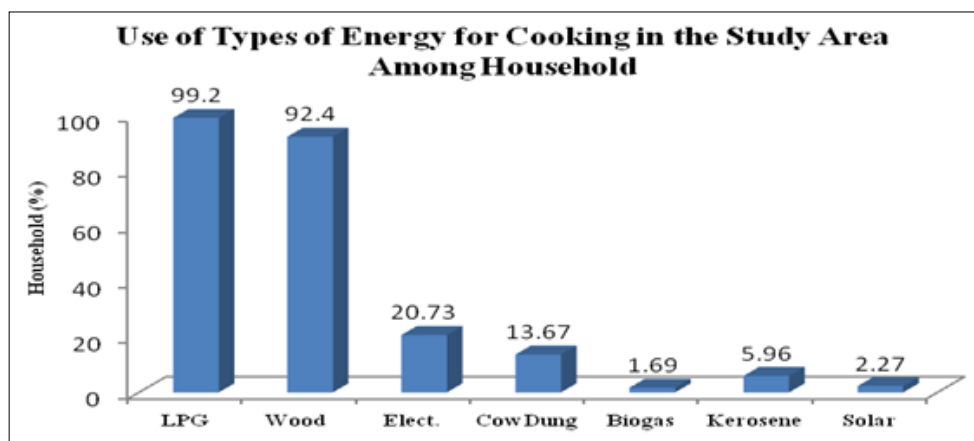


Fig 3

Cattle strength and status of cowshed in the study area: Status of household regarding cattle, type of cattle, Bio gas plant and cow shed is presented in table 1.3 and clearly show that 79.4 percent of the household have cattle and only 20.57 percent do not have the cattle wealth in the study area. Among the cattle strength 91.84 percent cattle are buffaloes and cows and only 8.15 percent are of other category. 71.70 percent households have pucca cow shed in the study area. A survey was conducted from January 2005 to July 2006 in 1500 households. It showed that excreta collected per cattle was about 3–7.5 kg per adult cattle, excreta per buffalo was about 12–15 kg, excreta of stall-fed buffalo was about 15–18 kg, and excreta of hybrid variety was about 15–18 kg. By taking the minimum values (such as 3 kg dung / cattle / day and 12 kg dung / buffalo / day), the total excreta obtained

per day per village was calculated. With the assumption of 0.036 m³ of biogas produced per kg of dung of cattle / buffalo, the total amount of biogas produced was calculated. It gave the quantity of biogas produced per village [16]. Similarly, on taking the maximum values, that is 7.5 kg dung / cattle / day and 15 kg dung / buffalo / day, the total biogas was calculated per village per day, by assuming 0.042 m³ of biogas produced per kg of cattle / buffalo excreta. It was presumed that the per capita demand of biogas for the domestic purposes was about 0.34–0.43 m³ / day. The biogas need was calculated by multiplying the adult equivalent of the village population by the per capita biogas demands. Need of 0.34–0.43 m³ per day could be considered for estimating the minimum and maximum values of biogas required in the village [15].

Table 1.3: Status of household regarding cattle, type of cattle, Bio gas plant and cow shed among selected villages (%)

Name village	Have Cattle	No Cattle	Cow / Buffalo	Other	Biogas plant	Cow shed		
						Pucca	Kucha	Open
Galyana	75.0	25.0	94.87	5.12	1.92	71.79	20.51	7.69
Ladhyan	76.28	23.71	94.59	5.40	9.45	70.27	20.27	9.45
Bum	79.41	20.58	92.59	7.4	5.55	47.07	20.51	7.69
Seu	82.81	17.18	90.56	9.43	00	75.47	18.86	5.66
Machhwan	88.48	11.53	95.65	4.34	00	65.21	26.08	8.69
Kothi	68.42	31.57	92.30	7.69	00	56.41	38.46	5.12
Bhadrog	83.72	13.95	86.11	13.88	00	69.44	30.55	5.55
Patta	83.33	16.66	84.0	16.0	00	76.0	20.0	4.0
Niun	80.0	20.0	90.0	10.0	00	80.0	15.0	5.0
Majhasu	83.78	16.21	90.92	6.45	00	87.09	12.90	3.22
Total	79.42	20.57	91.84	8.15	1.69	71.70	20.38	6.23

Source: Compiled by author based on primary survey 2021.

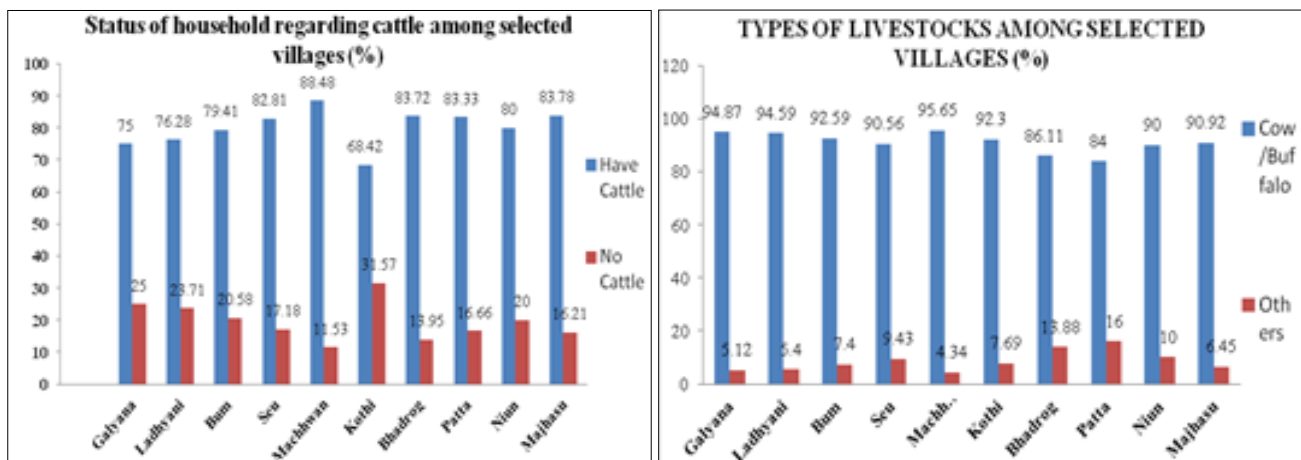


Fig 4

From these table data analyses it is clearly understood that basic requirements are available in abundance for the establishment of bio- gas plant in the study area. The study area has good cattle strength, agricultural population and very few people have explored this bio gas as energy resource.

One kg of animal excreta generates 40 L of biogas and a biogas plant that can fulfil the requirement of a small family (2–4 m³) requires 50 kg of animal excreta and the same amount of water to yield 2000 L of biogas per day. [10] A family of three members of a farmer owns 2 animals and collects 30 kg of animal waste per day. When agricultural and kitchen wastes are added to it, the mixture yields 0.8 m³ of pure biogas. This amount of biogas is sufficient to light 1

burner for almost 1.5 hours. [11] Also, the quantity of excreta yield per cattle varies from one place to another. An approximate calculation indicates that India has the capability to yield 6.38 × 10¹⁰ m³ of biogas by utilizing 980 million tonnes of animal excreta per annum. Heat value of the biogas measures 1.3 × 10¹² MJ. Also, 350 million tonnes of compost is also yielded [12]. When other feasible organic wastes such as sewage waste, municipal solid wastes, industrial wastes, and so on are used as the feedstock for biogas production, the sum total biogas capacity would further increase [13]. From the table 1.4 and Fig 1.5 it is clear that consumption Of Natural gas is increasing day by day, while India is dependable on other countries for Natural Gas. So alternate energy sources for

cooking purpose are the need of the hours. Biogas is better than other gases as it has a higher heating value compared to natural gas and coal, indicating higher consumptions. It is very cost effective and extremely convenient to use as a cooking fuel.

Table 1.4: LPG consumption (Thousand Metric Tonne)

	2019-20	2020-21
1. PSU Sales		
LPG-Packed Domestic	23,076.0	25,128.1
LPG-Packed Non-Domestic	2,614.4	1,886.0
LPG-Bulk	263.5	361.9
Auto LPG	171.9	118.4
Sub-Total (PSU Sales)	26,125.7	27,494.3
2. Direct Private Imports	204.0	64.2
Total (1+2)	26,329.8	27,558.4

Source: PSU OMCs (IOCL, BPCL and HPCL) 2021

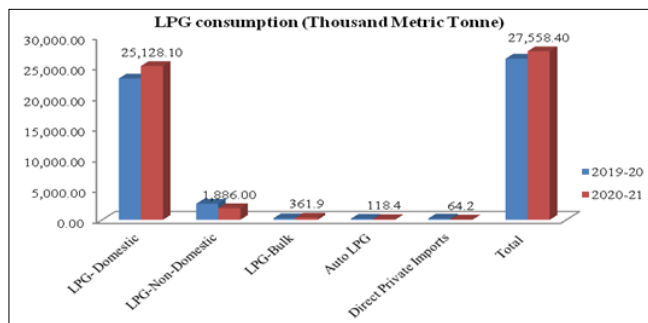


Fig 5

On the basis of its effective heat generated, a 2 m³ biogas plant could overtake fuel equivalent to 26 kg LPG (almost two standard cylinders), 37 L kerosene, 88 kg charcoal, 210 kg fuel wood, 740 kg cattle excreta in a month. Also, it does not have any bad odour, does not cause health hazards, and burns producing bluish coloured soot less flame; therefore, it is non-messy. Biogas is cost-effective and economical compared to the conventional biomass fuel (excreta or dung cakes, fuel wood, crop wastes, etc.) and LPG. Though it is costlier than kerosene, LPG and kerosene have issues related to their supply in villages. The technology of biogas increases energy supply through decentralization, thus making its access feasible in villages to meet energy demands. A comparison between using excreta directly and using it in the form of biogas showed that 25 kg of fresh excreta will generate about 5 kg dry excreta, which is almost equal to 1 m³ of biogas.

The technology used in biogas production is more useful in agro-ecosystem and can be applied to different uses. The biogas is also useful as a fuel as it is a substitute for firewood, agricultural residue, electricity, and so on, relying upon the type of work, supply circumstances, and constraints. Thus, it provides energy for both cooking and lighting. After anaerobic digestion, biogas plants also generate the residue organic waste which has greater nutrient qualities over the normal organic fertilizers and cattle excreta, as it is in the form of ammonia. The biogas can also be used to supply power to engines and help in pumping water in irrigation systems.

There are other advantages of biogas as well which are associated with renewable sources. This includes biogas having the ability to overtake the use of biomass-based fuels, especially wood. Biogas could also decrease the demand of wood from forests and establish a vacuum in

markets, which can be at the minimal for firewood. There is more than 85% reliance on bio resources to fulfil the everyday necessities of fuel and fodder in villages in many parts of India [15]. The effectiveness of transforming cattle residue and their excreta could be increased to 60% by allowing their digestion anaerobically (to generate biogas). The biogas production would also prevent the everlasting dispute between energy recovery and nutrient usage as the effluents produced by the digester could be reused in fields.

Benefits of Bio Gas Production

Biogas has been used as the most appropriate machinery for several decades, allowing suitable usage of the available resource. It has been found to be a clean, hygienic, and easy-to-use fuel at minimal cost, in addition to being completely environment friendly. Women living in villages no longer need to spend hours and travel long distances to gather firewood for cooking and burning purposes. They can now use this time for other activities. A smokeless and also a soot-free kitchen would mean that the women are not at risk of lung and throat infections and can live a longer, healthier life. Biogas has the capacity to meet all the fuel demands of houses, agricultural lands, and industries. For example, biogas can be used for cooking, heating, lighting, and so on. In farms, it can be utilized to dry crops, pump water during irrigation, and so on. A noticeable advantage of this is that it saves firewood. With the setting up of biogas plants, employment chances are also created in villages. The utilization of biogas increases as the biogas plant generates fuel and fertilizers. The most important advantage of the biogas plants is that it could digest any wet mixture of waste, fertilizer, and plant leftovers because of complicated bacterial methods. It does not cause reduction in the ammonia nitrogen content at the time of anaerobic digestion and helps in killing pathogens and weed seeds. In total, study area, has an immense capacity to produce heat from the waste as biogas. Till date, only a small part of the total capacity is used, and more investment in the field could increase the exploitation and help in realizing its true capacity in the near future.

Conclusion

Bio gas can play a major role in reducing the reliance of study area on fossil fuels by making use of it. There is utmost need to adopt a holistic approach to elevate the use of bio energy resources in the study area. It requires sound planning considering the agricultural, social, economic and technological aspects. Ap production generate local employment, promote self reliance, improve the quality of life, specially of women and rural poor. At last there is no reason to believe that if bio gas production become a mission for people and Governments, the country can make a place among the developed countries in the field of production of Green Energy.

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