Electrical Energy Production from Biogas. Livestock Port, (Sudan) as an Example.

Isam Ali Salim Bazaraa[1,a] , Hashim Osman Mohamed Ahmed[2,b], Mohamed Ismail khair Allah[3]
Muhammed Osman Alameen[4] , Umbadda Bashir Gadalla Umbadda[5,c]

Red Sea University, Faculty of Engineering, Department of Electrical Engineering. Port Sudan. Sudan.

[a]ibazaraa@hotmail.com,[b]hashim2211@gmail.com,[c]UbaaddaBahir124@gmail.com

Abstract.

This paper examines the production of standby electrical energy in Livestock Port in the Red Sea State in Sudan.

The estimated power required for the (Livestock Port) is 5MW, which will be mainly produced by a hybrid renewable energy system of (solar+ wind) energies. A standby power is required to be produced from biogas and batteries to cover approximately 10% of the estimated 5MW power i.e. 500kW, out of which 250kW will be generated from a biogas plant.

Since the activity of the port is relying on exporting livestock, the biogas production will be a by – product which can be produced due to the transient stay of animals (mainly sheep) in the port.

The paper made use of the comparison of six different animal dungs in producing biogas under anaerobic conditions. Sheep dung was found to produce the greatest amount of biogas compared to the other animals.

Two types of energy production from biogas were discussed i.e. gas turbine generator and the mix of biogas with diesel in diesel engines.

The number of sheep passing the port was found suitable for the production of adequate amount of biogas to generate the required 250kW standby electrical power for the operation of the port.

Keywords: renewable energy, Livestock Port, anaerobic digester, biogas, electric power production.

Introduction:

The renewable sources such as hydro, wind, solar and bio- energy are gaining more importance in terms of research and development as well as for implemented systems. A common feature of renewable energies is that they are intermittent

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literature and information on the biogas production side and the existing technical and scientific know-how on the side of internal combustion engines. An engine fuelled by biogas shall become understandable as a core module in a system of energy supply, energy transformation and a demand of energy for a useful purpose. This research attempts to provide a source of essential information for decision-making, planning, modification and operation of biogas engines within this system [1].

We hope that this study will contribute in the development of electricity in Sudan and will become as a reference for any individual who wants to get background or information concerning biogas production and application in electrical power generation or any issue related to it.

Materials and Methods:

Definition:

Biogas is a combustible mixture of gases. It consists mainly of methane (CH_4) and carbon dioxide (CO_2) and is formed from the anaerobic bacteria decomposition of organic compounds, i.e. without oxygen. The gases formed are the waste products of the respiration of these in nature and require close management and recognize stand by portion.

The energy crisis of the next few years is the shortage of fuel for the daily needs of millions of people. The renewable energies such as biogas plants are intended to help solving this problem. It is time to set about the task in professional manners in the best sense of this word.

Focusing on renewable energies particularly biogas will eradicate the disadvantages of the none renewable energies for instance their bad impacts upon environment from the health side(the combination of the oxides of nitrogen (NOx) and volatile organic compounds in the atmosphere creating damage to ground level ozone) and their high cost compared to the renewable energies.

The main objective of this study is to examine and develop the production of biogas from animal dungs in Livestock Port and use it to generate electricity approximately 250 kW. The paper includes what an individual producer might do with their own generation to offset their own load. The aim of this study is to build a bridge between the elaborate

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depends on the substance that is being decomposed [2].

decomposer microorganisms and the composition of the gases

Table 1 Biogas Components

Gas	%
Methane(CH_4)	50__70
Carbon dioxide (CO_2)	25__45
Hydrogen sulphide (H_2S)	1__2
Hydrogen (H_2)	1__2
Ammonia (NH_3)	1__2
Carbon monoxide (CO)	Trace
Nitrogen (N_2)	Trace
Oxygen (O_2)	Trace

broken down into smaller units. Specific groups of micro-organism are involved in each individual step.

The Biogas process:

The process of biogas formation is a result of linked process steps, in which the initial material is continuously

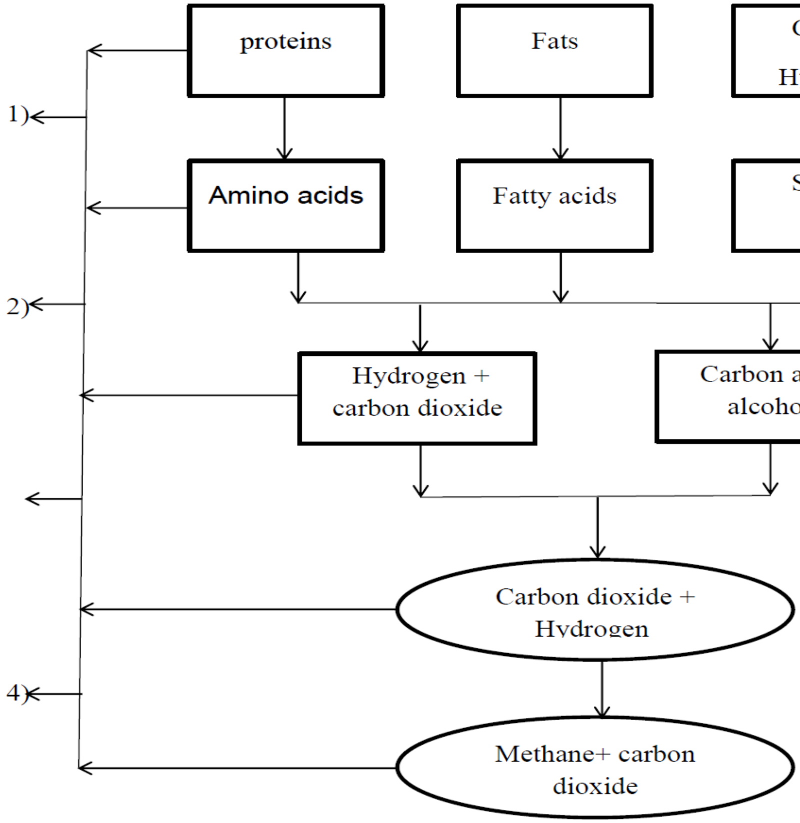

Figure 1 the main process of anaerobic digester

1) Hydrolysis,2) Acid genesis,3) Acetogenesis, 4) Methanogenesis. [2]

Biogas plants

Three main types of simple biogas plants can be distinguished**:-**

1. Balloon Plants
2. Fixed-Dome Plants
3. Floating-Drum Plants

The process steps quoted in Figure 1 run in parallel in time and space, in the digester tank. The simplified diagram of the anaerobic digester (AD)

Process shown in Figure 1 highlights the four main process steps:

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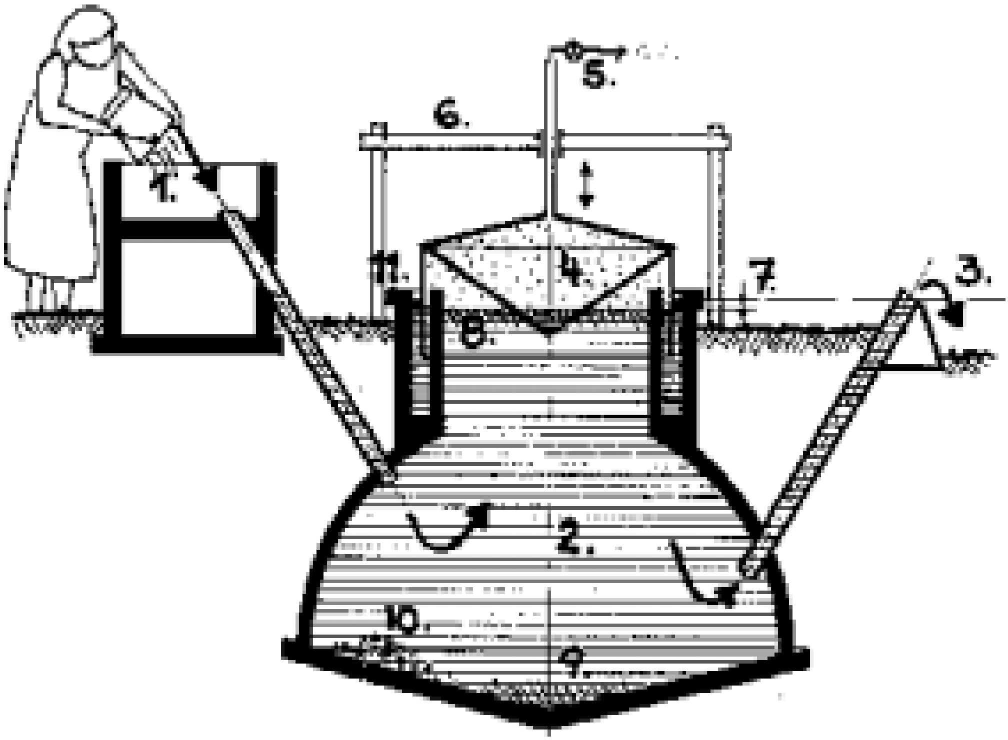

Figure 2 Floating-drum plants

1. Mixing tank with inlet pipe.
2. Digester.
3. Overflow on outlet pipe.
4. Gasholder with braces for breaking up surface scum.
5. Gas outlet with main cock.
6. Gas drum guide structure.
7. Difference in level = gas pressure in cm in water column.
8. Floating scum in the case of fibrous feed material.
9. Accumulation of thick sludge.
10. Accumulation of grit and stones.
11. Water jacket with oil film.

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weight of each dungs was obtained (Table 2). An equivalent of 50 grams dry weight of each dungs was then weighed out.

The apparatus for digestion and gas collection consisted of a 1-litre aspirator bottle connected to a 2-litre aspirator bottle by means of glass tubes and rubber bungs. The 2-litre aspirator bottle was then connected to a measuring cylinder with the aid of a rubber tube. From the top of the 2 litre aspirator bottle runs a tube through which gas can be collected and tested. Another 5-litre aspirator bottle filled with water was kept nearby. The tube leading to the measuring cylinder was connected to this 5-litre bottle whenever gas was to be burnt while a Bunsen Burner was connected at the end of the tube which runs from the top of the Aspirator bottle. The 50g equivalent of the 6 different fresh animal dungs was placed in separate 1-litre aspirator bottles. Tap water was added to make the volume a little above 1-litre. The mixture was then stirred manually with the aid of a glass rod to form

Case study:

Comparative Studies on Biogas Production using Six Different Animal Dungs:

This study was carried out in Ahmadu Bello University to compare the rate of and amount of gas produced from six different animals' dung under anaerobic conditions. 50 grams dry weight of each animals dung was weighed out in duplicates digested under anaerobic conditions in the laboratory, sheep dung was found to produce the greatest amount of gas (1.15 litres) followed by chicken, pig, goats, cow and horse dung respectively which had total gas production records as 0.65 litre, 0.45 litre, 0.17 litre & 0.03 litre respectively [3].

Materials and Methods:

Fresh dung of six different animals were collected in cellophane bags from in and around the University (Ahmadu Bello University) and brought to the laboratory. A little of the six different dungs were placed in 6 different crucibles & dried to a temperature of 104.40c. The dry

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There was a gradual rise in gas production up to the 3rd week where the peak was reached in the Horse, Sheep, Goat dungs, 4th week in the Pig and 5th week in the cow dung after which there was a gradual decline in gas production in the cow. The other dungs however, showed alternate rises and fall in gas production except in horse dung that gas production was nil at 5 weeks and beyond.

The chicken dung, however, produced a high amount of gas in the first week, this was then followed by a sharp decline by the 3rd week, and subsequent weeks showed alternate rises and falls in rate of gas production, as shown in Table 3.

The total amount of gas produced by the various dungs differed greatly. Table 3 shows that sheep produced the greatest amount of Gas totalling an average of 1.15 for the 8 weeks with a capacity to produce as much as 2.8litres in a single week (3rd week, Table 3) Next to it, was the chicken which produced as much as 1.03litres during the 8 weeks with a capacity to produce as much as 3.02 litres in slurry. A rubber bung was then placed tightly over the bottle preventing the entrance of atmospheric oxygen and possible leakage of gas produced. During digestion, gas released from the digester flask (1-litre bottle) enters the 2-liter bottle containing water and displaces water equal to the volume of gas produce. The displaced water collects into the measuring cylinder. This volume of water was read daily and at times reading was taken twice a day. Daily temperature reading was also taken. The gas produced was tested regularly with a lighted match stick the experiment was carried out in duplicates.

Results:

The result of this experiment which held in Ahmadu Bella University by its students showed that a change in colour of the various dungs was observed during the second week of digestion. Also a reduction in volume of water in the collection bottle was recorded as more and more gas was produced.

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0.17litre & 0.03litre respectively [3].

The gas produced by all the dungs was combustible and odourless.

the 6th week (Table 3). The pig, goat, cow and horse dungs followed respectively with gas production over the 8 weeks recorded as 0.65litre, 0.45litre,

TABLE2 DRY WEIGHT OF ANIMAL DUNGS

ANIMAL	WET WEIGHT OF DUNG TAKEN (g)	DRY WEIGHT AFTER DRYING IN OVEN (g)	WET WEIGHT EQUIVALENT TO 50 grams DRY WEIGHT
Cow	32.2	6.7	241.04
Horse	22.5	4.5	250
Sheep	19.75	5.13	192.5
Goat	26.35	8.29	158.9
Pig	25.29	8.39	150.7
Chicken	13.95	4.05	172.2

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TABLE 3 WEEKLY GAS PRODUCTION

Week	Average temperature (0c)	Cow	Horse	Sheep	Goat	Pig	Chicken
1st	29.9	0	0	3.5	0	20.8	899.8
2nd	32.3	53.3	69	533.5	332.5	84.3	150.5
3rd	32	210	165,5	2815.5	1125.5	379.9	38
4th	31	235.4	19	860.5	519.5	1758.8	93
5th	31.2	301.8	0	1910	669	988.5	585.8
6th	29.4	216.3	0	1474.5	387.8	447.8	3024.5
7th	27.5	208	0	828	319.5	818.5	948.6
8th	27.7	162.5	0	761.5	261.8	679.5	2464
Total average production (ml)		1388	253.5	9188	3615.6	5178.1	8240.2
Average weekly production (l)		0.174	0.032	1.149	0.452	0.647	1.03

kWh of useable electricity and the rest turns into heat which can also be used for heating applications.
2 kWh is enough energy to power a 100 W light bulb for 20 hours or a 2000W hair dryer for 1 hour [4].
From Above:

$$1m^3 \text{ from biogas} \longrightarrow 2\ kWh \qquad (1)$$

Discussion:

How much energy is in biogas?

Each cubic meter (m^3) of biogas contains the equivalent of 6 kWh of calorific energy. However, when we convert biogas to electricity, in a biogas powered electric generator, we get about 2

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X m^3 from biogas → 250 kWh (2)

Then X= (250/2)

X= 125 m^3

So for generating 250 kWh we need 125 m^3 from biogas

- From tables (2) and (3) we found that:

192.5 g from sheep → 1.115 l g (3)

241 g from cow → 0.174 l g (4)

1 tonne from cow dungs → 25 m^3 biogas [5]. (5)

From the equations (3), (4) and (5) there is a different in the gas production as follows:

1 tonne from sheep dungs will produce {25*(1.115/0.174)}

So that 1 tonne from sheep dungs= 165.229 m^3 biogas (6)

(7) X tonnes from sheep dungs = 125 m^3 biogas

From (6) and (7):

X= (125/165.229)

= 0.756 tonnes

X= (0.756*6)

= 4.5 tonnes *

*This is the required amount of sheep dungs to generate the 250 kW for six hours. This could be seen as shown in figure 3 below.

And this is enough to generate 25 kW. The required standby power for the operation of the Livestock Port is 250kW for six hours.

From above to operate the generator for six hours, the required tonnage of sheep dung is:

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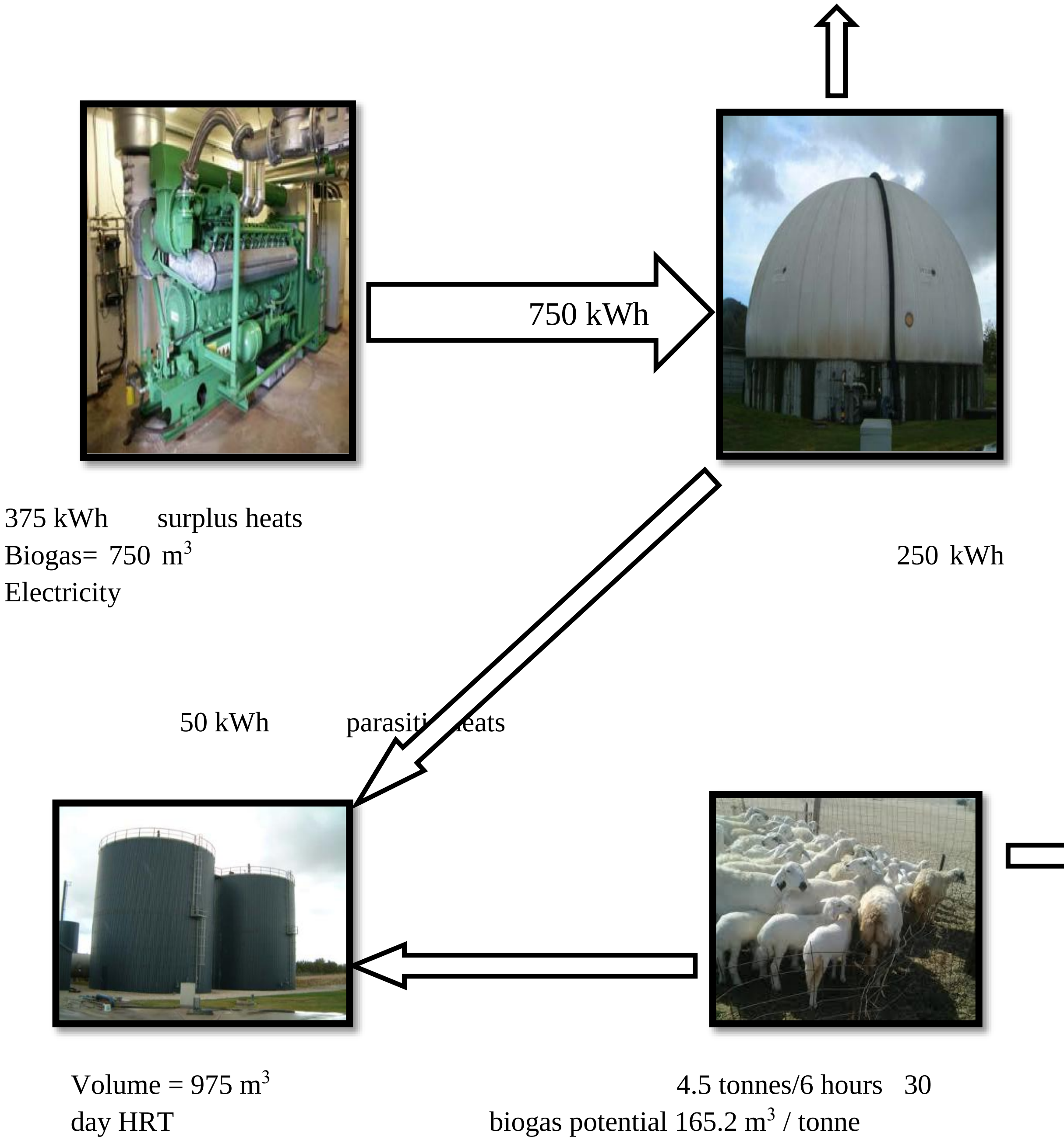

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-Dual fuel operation with ignition by pilot fuel Injection:
The fuel is mixed with air towards the end of the compression stroke of the engine by being sprayed into the combustion chamber with high pressure (about 200 bars). The fuel is immediately ignited when it comes into contact with the hot compressed air [6]
In dual fuel operation the normal diesel fuel injection system still supplies a certain amount of diesel fuel. The engine however sucks and compresses a mixture of air and fuel gas which has been-prepared in an external mixing device. The mixture is then ignited by and together with the diesel fuel sprayed in.
The amount of diesel fuel needed for sufficient ignition is between 10% and 20% of the amount needed for operation on diesel fuel alone. The amount of biogas needed is this case between 80% and 90% of the amount needed for operation on diesel fuel alone.
- Operation on gas alone with spark ignition (The Gas Otto Engine):
It is a large stationary single-cylinder internal combustion four-stroke engine designed by Nikolaus Otto. It has a low-RPM

Figure 3 Suggested plant to produce biogas for generating 250 kWh [5]**.**
Due to the advantages and disadvantages of the three types of biogas plant which has been mentioned previously, we found that the suitable type of biogas plant to produce biogas from sheep dung is the floating drum plant with a volume of digester 975 m^3, because the balloon plant only used small digester as well as fixed dome plant which its volume of digester should not exceed 20 m^3.

After selecting the suitable type of biogas plant .We must choose the suitable generator to generate the required 250kW, so there are two ways to generate from biogas, firstly using biogas which is healthy to the environment compared to natural gas which has more bad impacts upon environment, as alternative for natural gas in the generators that work with natural gas. And this is the way that we focus on in this study. Secondly modification of diesel generators to operate on biogas in two different ways:-

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efficiency of the process from the mere thermodynamic point of view. Lower specific fuel consumption and a higher power output can be expected. The modification is however permanent and prevents operation on original fuel in cases of biogas shortage.

The adjustment of the point of ignition in relation to the slow burning velocity of biogas imposes no specific problem as a standard ignition system provides for adjustments in a sufficiently wide range.

The characteristics of the generator which is suitable for generating 250 kWh is illustrated in table 4 below:

machine, and only fired every other stroke due to the Otto cycle.

The Otto cycle is a set of processes used by spark ignition internal combustion engines (2-stroke or 4-stroke cycles).

The modification of an Otto engine (spark ignition, petrol or gasoline engine) is comparatively easy as the engine is designed to operate on an air/fuel mixture with spark ignition. The basic modification is the provision of a gas-air mixer instead of the carburetor. The engine control is performed by the variation of the mixture supply, i.e. the throttle valve position as has been the case with petrol fuel.

An increase in the compression ratio appears to be desirable as it provides an increase of the

Table 4 JDEC Biogas Generator [7]

Model	Rated Power		Engine Model	Rotation Speed	No. of Cylinders & Type	Displace-ment (L)	Alternator	Overall dimension	Weight (kg)
	KW	KVA	135&190&300 Series	RPM (50HZ/60HZ)			Siemens Marathon or Equal	(L*W*H) (mm)	
EJ-313NB	250	313	6190ZLT	1000/1200	6.L	35.7	1FC6 Series	4980*1760 *2230	8690

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