PRE-FEASIBILITY STUDY

BIOGAS PLANT AT THE KANT FARM

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Summary

This work presents the results of the pre- feasibility study on biogas plant installation in Kant farm near Bishkek - the capital of Kyrgyzstan. The study suggests that installation of biogas plant with methane-tank of 25 m^3 and with around 116,650 m^3 biogas output annually for heating purposes is viable. Besides biogas the plant will produce 200 tons of organic fertilizers annually, which is sufficient to fertilize 200 hectares or arable farmlands. The production of bio-fertilizers will help replace mineral fertilizers and result in 14,000 USD annual savings. Moreover, methane produced will substitute 6.4 tons of diesel fuel, which is now used for farms heating and save 3,120 USD annually. Hence, the project in question is cost-effective and could be replicated throughout Kyrgyzstan and other Central Asian countries.

The project requires investment for preparation of a feasibility study at the rate of US$20,000, implementation of the project activities at the rate of US$30,000 and implementation of constructional and technical works at the rate of US$40,000. The investment required for the project implementation is estimated to be recovered in around 5 years.

1. Annotation

In the former Soviet Union, energy resources demand and supply models were determined at the regional level in the Central Asia. Kazakhstan was in charge of coal industry, Uzbekistan – natural gas, and Turkmenistan – oil.

Although the Kyrgyz Republic possesses all the above mentioned resources, these resources were not developed as in other Central Asian republics. After the collapse of the Soviet Union, the Kyrgyz Republic had to import natural gas and oil at considerably higher prices in comparison to the former subsidized prices. The country's dependence on external suppliers (Russia and other Central Asian countries) covers 60 % of the main energy demand.

The share of the domestic sector in primary energy consumption has significantly increased. In the early 1990's population consumed 16% of the total electricity supplied to the domestic market; state public sector - 19%; industry, agriculture and commercial users - 65%. Coal production was more than 5 million tons per year, of which 4.5 million tons were consumed within the country, natural gas was supplied in the volume of 2.5 billion cubic meters, fuel oil - 600,000 tons. Today, the structure of the electricity consumption has changed and the population now consumes 63% of the total electricity supplied to the domestic market; state public sector - 12%; industry, agriculture, commercial users - 25%. The consumption of coal today is only 1,609 million tons, gas - 664 million cubic meters and fuel oil - 37,000 tons. The decrease in consumption of coal and gas has increased the pressure on electric power industry. Hydroelectric power plants are located in the south of the Republic, and deliver energy to the north of the country. At the same time, there is a low use of small hydro and alternative energy sources.

The decline in energy consumption has been due not only to the decline in economic activity but also to industry restructuring. Improvement in the national economy in the past few years has been the result of the increase of economic activity and transition from energy consuming industry (e.g. machinery, chemical industry etc) to production of consumer goods in accordance with the demands of local and external markets. There is considerable energy consumption by individual heating in the Kyrgyz Republic that leads to a considerable seasonal difference in energy consumption.

The energy consumption peak in the winter period causes problems due to limited capacity of local electrical distribution lines. Municipal and industrial wastes are not used as a source of energy.

Local sources of biomass are agricultural cattle waste and straw. Biomass is rarely used for heating and in industry. The existing coal power plants cannot process biomass for incineration.
Local rural population use dry manure for heating, however inefficient stoves used for these purposes lead to high levels of internal and external pollution.

The total consumption of biomass is approximately 730 thousand m^3 but in many cases some of the consumption is not registered by official statistics.

The most promising biomass applications are improved stoves for biomass incineration in individual houses, and improvement of local small-scale boilers that use biomass and biogas. Biomass application in heating is very important and can improve energy supply in the remote rural regions, employment and improvement of rural living standards, and improvement of energy efficiency and abatement of environment pollution. It is worth noting that wide use of biomass can help poverty reduction and economic development of rural regions of the Kyrgyz Republic.

To date, there has been no national strategy to increase the biomass application for energy production in the Kyrgyz Republic (support programs, etc.) However, the Kyrgyz Association for Renewable Energy Sources (KARES) and the Ministry of Agriculture have elaborated the state program that aims at wide application of biogas plants for obtaining methane and highly efficient organic fertilizers.

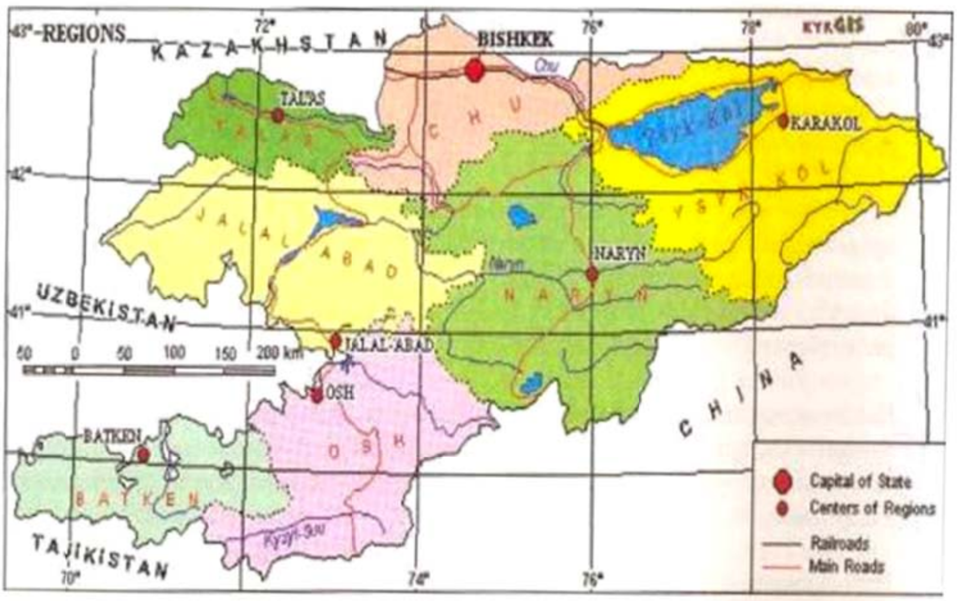
In connection with the above, it can be noted that wide biogas use is attractive not only from financial and economic perspectives but also for the solution of strategic tasks of poverty reduction, sustainable development and environment protection.

2. Map of the project location in the country and (or) in the region, city

This study examines the feasibility of a biogas plant operation in the MIS-Kant farm, located 25 km from Bishkek. The biogas plant would produce 20-40 m3 of biogas per day and would produce 20-24 tons per month of highly efficient and ecologically clean organic fertilizer by processing cattle waste of the farm of MIS-Kant.

3. Introduction

The Kyrgyz Republic has a territory of 198,500 sq.km, with a population of 5.99 million people (2015). The capital Bishkek is located in the north of the country with a population of 1,000,000. There are 7 oblasts in the Kyrgyz Republic. The largest parts of the territory are mountains. Fig. 1 is a map of administrative regions of the Kyrgyz Republic.



The national economy of the country is mainly agricultural. Cotton, tobacco and wool are the main agricultural products. Industrial exports are gold, uranium, mercury, electricity, textiles, cement and consumer goods. The Kyrgyz Republic is the first Central Asian country to be a member of the World Trade Organization. According to the information of National Statistic Committee the dynamics of prices change during the last 5 years varied a lot. In 2007-2008 inflation rate was 20%, in 2009 consumer prices and tariffs remained almost unchanged compared to December 2008. In 2010 there has been a great increase in the inflation rate (19,2%), and in 2011 the inflation was reduced to 5.7%. The inflation rate in 2014 in Kyrgyzstan was 10.5% and in 2013 it was 4%. In 2015 the inflation in Kyrgyzstan was 10.7% with GDP growth of 1.7%.

A major decline in the national economy took place after the collapse of the Soviet Union in December 1991, however by the middle of 1995 it began to recover because of an increase in exports. Additionally, Kyrgyzstan experienced economic decline at the end of 1990's and in the last years.

Energy is a socially and politically sensitive problem in the Kyrgyz Republic and it has a considerable impact on the national economy, especially in the rural areas, which are poorer and have high energy demand. Therefore this project proposal involving biogas use will also help solve economic, social, ecological and other problems in the Kyrgyz Republic.

4. General Information

4.1. Description and prospects of the sector

The project will be implemented in the MIS-Kant farm as a pilot project. MIS-Kant is a seed selective breeding farm that has its own animal breeding farm with 1900 cattle. It is a typical farm in the Kyrgyz Republic and therefore, it would be suitable for replication by many other farms.

This project is aimed at processing a small share (15-20%) of the total accumulated dung, and, at this stage, is not aimed at processing 100% of all available cattle's dung. The farm has 4900 hectares of land. Today 3 dairy farms and cattle farms operate there. The total number of cattle is given as 1900, however, their number is probably considerably higher and in fact the annual volume of accumulated dung is probably greater than f approximately 36 thousand tons of manure accumulated on the territory of the farm and officially declared.

At the end of the 1980's, the fields were annually fertilized with mineral fertilizers comprising nitrogen, phosphorus and potassium: nitrogen - 900 tons, phosphorus - 320 tons, and potassium - 240 tons. The average crop capacity of cereals was 6.2 to 6.4 t/ha, corn – 3.58 t/ha, hay of alfalfa – 1.25 t/ha. At present the fields are fertilized with an annual 120-130 tons (t) of nitrogen fertilizer. As a result the crop capacity of cereals has reduced to

4 t/ha, corn – to 1.8 t/ha, hay of alfalfa – to 0.75 t/ha. One of the reasons of crop capacity reduction is the drastic reduction in mineral and organic fertilizers being applied. One of the solutions to the problem is construction of a pilot biogas plant for obtaining up to 240 t of liquid organic fertilizers per year as well as biogas as a fuel. Annual demand in fertilizers for Kant Farm is 30 thousand tons of fertilizers.

The proposed pilot project will cover only 1/128 share of the total farm-wide demand in fertilizers. The produced gas will be used for the boiler of a diary shop and then with increased gas production for heating. If applied to the whole farm's accumulated dung, the replicated project could provide sufficient fertilizer for the whole 4900 ha. At present, cattle dung is not used as a fuel or composted. The dung is packed into a concrete storage area and later it is spread on the fields of the farm. This is not an ideal situation as the value of the untreated dung as a fertilizer is very low, and transportation costs are very high.

4.2. Prospects, limitations and problems

The project has a national level wide application potential in the Kyrgyz Republic. The wide application of biogas plants would:
(i) resolve the problem of heating and cooking of more than 40% of rural habitants,
(ii) enable the improvement of the quality of soil and increase the crop capacity of arable lands by 15-20%,
(iii) promote the solution to poverty reduction by using agricultural waste to increase yields and decrease price of a fertilizer,
(iv) create additional profits by reducing the expenses related to consumption of coal, gas, firewood, and
(v) generate higher crop yields.

Moreover, it will reduce migration of rural population to cities: operating biogas plants requires additional human resources. There could also be great ecological advantages: annually in the country 2.5-3.5 million tons of waste is accumulated, the decomposition of which leads to the atmospheric emission of millions of m^3 of harmful gas, methane CH_4 and CO_2.

Strengthening the technical potential of the projects is restrained by the following main factors:
• lack of state investment and of internal and external investment;
• absence of efficient coordination on implementation of planned steps;
• incompleteness of legislative acts for tasks realization; and
• lack of information for potential consumers concerning the prospects of new technologies.

4.3. Goals of sustainable development

This project has evident advantages from the point of view of sustainable development. The project makes possible the use of additional ecologically clean resources (biomass) to solve the problems of energy supply. The project meets the Sustainable Development Goals by contributing to poverty eradication, ecological sustainability and promotion of global partnership with the purpose of development.

4.4. Government strategy and policy in the sector

At present, the energy conservation policy of the Kyrgyz Republic is determined by the Laws "On Energy", "On Electric Power Industry " and " On Energy Conservation". The Law of the Kyrgyz Republic "On Energy" was adopted in October 30, 1996. It defines the basic principles of the organization and regulation of economic activity in the energy sector. The provisions of this Law shall apply to all enterprises of the fuel and energy complex, irrespective of their form of ownership. The objectives of this Act are to increase efficiency and reliability of the fuel and energy complex, protecting the interests of consumers and producers.

The Law of the Kyrgyz Republic "On Electric Power Industry" was adopted on 28 January 1997. It is based on the Law of the Kyrgyz Republic "On Energy", and applies to all entities regardless of ownership, as well as individuals that produce, transmit, distribute, sell and consume electricity and heat. The purpose of this Act is to provide reliable, secure and uninterrupted supply of electricity, heat energy and to improve the quality of services to all consumers, creating a competitive environment and the formation of the energy market, the promotion of private sector development and investment. It identified the need to also include the cost of electricity and thermal energy cost saving.

"Law on Energy Conservation" is aimed to improve energy efficiency in its production, transmission and consumption and was adopted in 1998. However, due to the fact that this legal instrument has an indirect rather than direct application, it did not have a material impact on the improvement of energy efficiency policy in the country. By-laws and regulations for its practical implementation have not been developed and there is no clear allocation of responsibilities and incentives for its implementation

In 2003 Jogorku Kenesh (Senate) has adopted the law “State policy in the field of renewable energy”. All these documents and laws are aimed at attraction and application of new advanced technologies in energy sector, improvement of living standards of population and poverty reduction, abatement of harmful emissions. The same policy is conducted in agricultural sector.

However, it should be noted that political and institutional prospects for implementation of renewable energy technologies are still not developed well enough; there are still major barriers and constraints. Among which,

the most important are:
• There is no national strategy and action plan in the field of renewable energy use;
• There is no national agency on renewable energy and energy conservation;
• The wide use of new renewable energy technologies cannot be applied in practice.

5. Description of the proposed project

5.1. Feasibility of the project from the point of view of the main stakeholders

The main stakeholders of the project are the Government and MIS-Kant. MIS-Kant is one of the largest leading agricultural enterprises specializing in the selection of seeds and having 3 diary farms and the cattle farm. For successful implementation of its activity, it needs organic and mineral fertilizers for 4900 hectares of arable lands. The demand in fertilizers is now 30 thousand t per year.

Because of the lack of finance, the land is fertilized with only 120-130 t of fertilizers. MIS Kant has its boiler for heating farms and offices and partially for workers' houses and annually burns 300 t of diesel. Implementation of a demonstration project for 1 diary farm will allow applying the technology of getting methane for the boiler and highly efficient fertilizers for their fields. This project is proposed to be a pilot project and in the case of its successful implementation, it can be disseminated more widely at MIS-Kant as well as in the wider rural area for small-scale farms and can considerably solve the state tasks in eradicating poverty and sustainable rural development.

This dissemination strategy needs further development in this project's feasibility study phase. It should be noted that such biogas projects reflect the UNECE interest in supporting such technologies. Moreover the UNECE has an opportunity to make a crucial contribution to developing biogas technologies market in the Kyrgyz Republic.

5.2. Tasks of the project, aim, expected results, specific characteristics and conditions

Goals of the project. Implementation of pre-feasibility study of the pilot small scale biogas plant (BP) for processing some of the cattle waste from cattle farm number 2 for producing methane and highly efficient organic fertilizers in MIS-Kant.

For meeting this objective, the following tasks were implemented:
• The calculation of potential of organic raw material was made;
• The demand for organic fertilizers and biogas was studied;
• The real possibility of dissemination of such project in the country was

studied;
• Calculation and selection of parameters of the project was made;
• Preliminary elaboration of the project was made;
• The level of impact on environment and reduction of harmful emissions was estimated;
• Advantages and ways of wide-scale dissemination in the Kyrgyz Republic were considered.

Expected results of the biogas project implementation are:
• Processing of wastes of the farm and obtaining methane and organic fertilizer;
• Reduction of harmful emissions;
• Increase crop capacity of arable lands.

The technical data of the pilot biogas plant is demonstrated in Table 1.

Table 1. Technical Data

Technical data of BP	indexes
Methane-tank, m3	25
Gasholder, m3	25
Surplus pressure in methane-tank, atm.	0,4
Pressure in a gasholder, atm.	20
Compressor,	
Compressor pressure, atm	15
Pump	
Automatic block	
Electric motor	
Engine power, kW	1,7
Electric boiler	
Electric boiler power, kW	20

5.3. Impact on poverty reduction

The quality of life of the main part of the population is not high as more than 60% of the population is poor, and income differences are growing. The quality of life of the considerable part of population, especially of rural population, is unsatisfactory. Among the most vulnerable layers of population are young people. It leads to economic problems, great demographic load on employed population. Unemployment has risen to a considerable level.

Hence, the project contributes to achieving the Sustainable Development Goals.

5.4. Technology transfer

Technology of processing biomass will be transferred by the proposed project. Technical support on installation and launching will be provided. Knowledge of biogas plant operation and technical requirements of its construction is new for biogas plant users, thus a suitable training program will be necessary.

5.5. Products or services of the project

Implementation of the project allows offering the following services.

Table 2. Technical data in the extraction of methane

Methane in biogas, %	55-65
CO2 in biogas, %	25-35
Hydrogen sulfide, %	Less than 1
Nitrogen, %	Up to 3
Heat of combustion, Mjoule	21-26
Temperature regimes, °C 1. Psycrophylous 1. Mesophylous 2. Thermophylous	 Less than 20 20-45 45-60

Daily efficiency will be:

$$V_{daily} = 2/3\ V_{meth.} \bullet K \qquad (1)$$

where: V daily. – daily efficiency of a BP, mP3P.
V meth. – volume of a methane-tank, mP3 P
К – factor of efficiency.

Taking into account that V meth. = 25 m^3, К = 2,5:

$$V_{daily} = 2/3 \bullet 25 \bullet 2,5 = 41,6\ m^3/day$$

Weekly, monthly and annual volumes will be as follows

$$V_{week} = V_{daily} \bullet 7_{days} = 41,6 \bullet 7 = 291,2\ mP^{3P}$$
$$V_{month} = V_{week} \bullet 4 = 291,2 \bullet 4 = 1164,8\ mP^{3P}$$
$$V_{annual} = V_{month} \bullet 10 = 1164,8 \bullet 10 = 11648,0\ m^3$$

In Fig 2. the diagram of biogas production is shown.

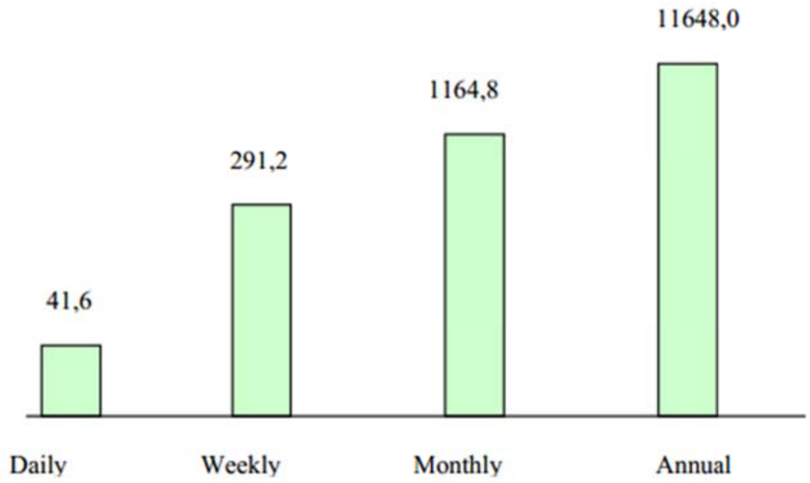


Fig. 2. Diagram of biogas production

Annual load is calculated for a 10-month operation of a BP. Two months are needed for maintenance works. The efficiency of producing organic fertilizers 20 t a month during 10 months of a BP operation:

$$V = 20 \times 10 = 200 \text{ t/year}$$

Therefore, the pilot biogas plant can adequately fertilize approximately 200 hectares of lands annually.

The norms of mineral fertilizers for crops in the Kyrgyz Republic are in Table 3.

Table 3. Norms of Mineral Fertilizers

№	Crop	Nitrogen				Phosphorus				Potassium				Total fertilizers per 1 ha annually	
		kg	Carbamide 46%	Price per som		P_2O_5 kg	Supephasphate 20% kg	Price per som		K_2O kg	$CaCL_2$	Price per som		kg	som
				1 kg	per 1 ha			1 kg	per 1 ha			1 kg	per 1 ha		
1	Wheat	120	260	42,5	11050	120	600	20	12000	40	72	20,6	1483	932	24533
2	Corn	160	348	42,5	14790	120	600	20	12000	60	109	20,6	2245	1060	27850
3	Sugar-beet	100	217	42,5	9222	100	500	20	10000	80	145	20,6	2987	860	20082

The project proposes to produce annually 200 t of organic fertilizers for adequately fertilizing 200 hectares of arable lands and to extract 11648,0 c.m. of biogas for heating purposes.

6. System design and project implementation plan

6.1. System design

The scheme of a BP location is shown in Figure 3.

From a manure reservoir, raw material is pumped into a methane-tank installed on a concrete foundation. It is located near a gasholder. Also a foundation for pumps is constructed.

The civil works of the proposed BP are as following:
• Preparation of the site
• Construction of foundations for a methane-tank, gasholder and other equipment
• Installation of equipment
• Commissioning and testing of a BP.

Plan of a site and the scheme of the BP location

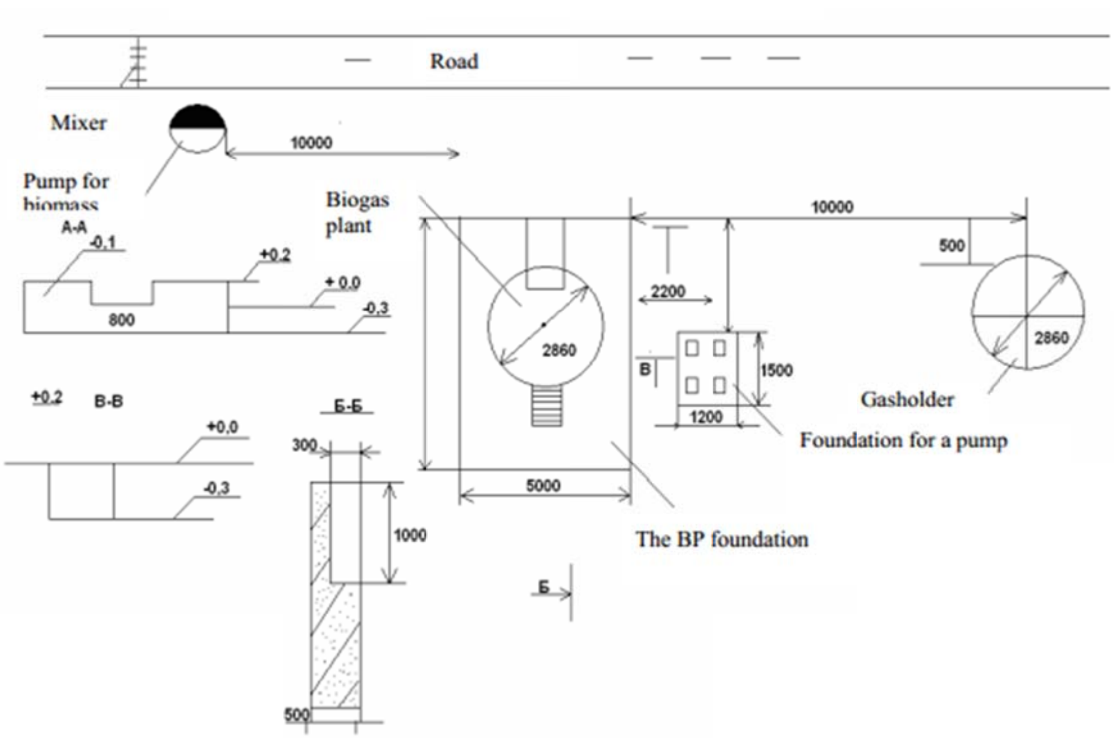


Fig. 3. The scheme of the BP foundation

The general scheme of a BP and a scheme of connections are shown in Fig.4 and specification of the main elements is shown in Table 4.

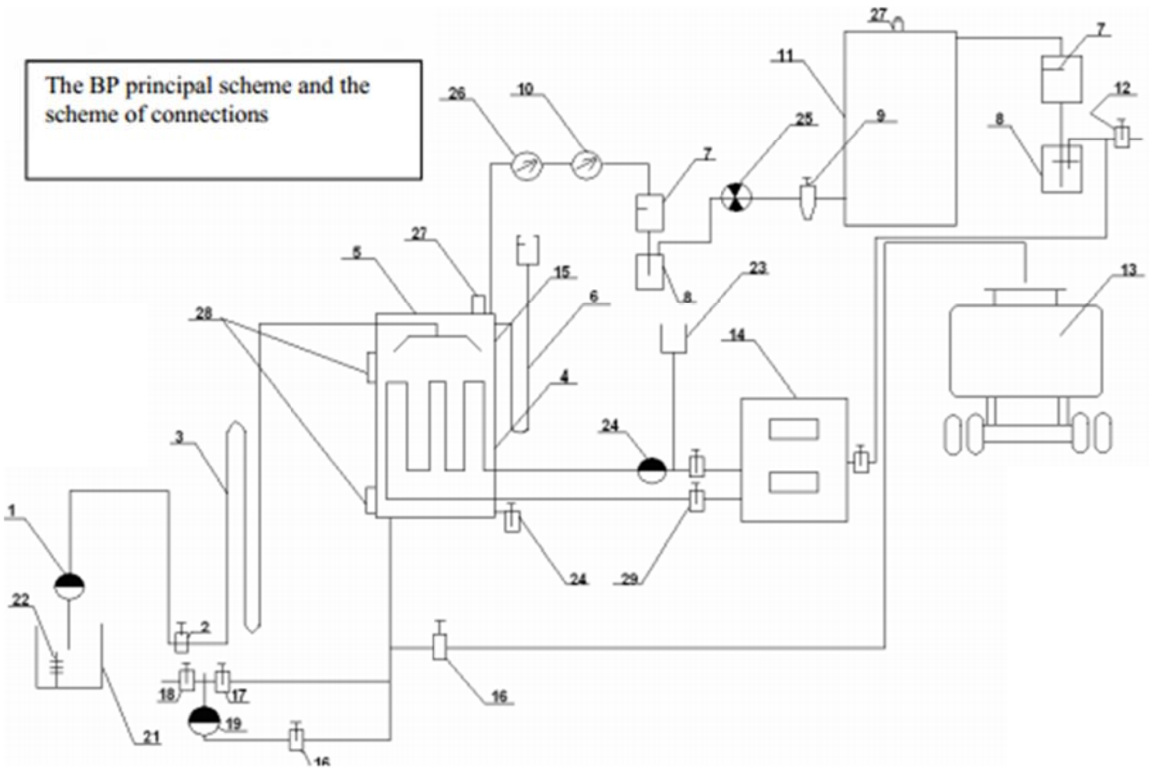


Fig. 4. The BP principal scheme

Manure is delivered from a farm to a manure reservoir (21). With the help of an electric agitator (22) fresh manure of around 17-20% solid content is mixed with an approximately equal mass of water to give slurry of 90-95% water content, and then it is pumped into a methane-tank (5) up to the level (28) visually and with an electronic relay ESP-50. Slide valves – 200 mm: (2) is open and (18) is closed. The arrester and pump are switched on by hand, the pump is switched off automatically.

After filling the methane-tank with liquid manure the electric boiler (14) is switched on and with the help of a pump (24), registers (14) and automatic controller and thermal sensors, the temperature of the liquid manure reaches 55P°C, after that a boiler is switched off and further the temperature is maintained in the limits 50-55°C during 1 day. The slide valves (29) are open. For the normal operation of the heating system it is necessary to release air from registers.

Agitating a substrate in a methane-tank is made two times 30 minutes with an electric agitator (22) and two times 30 minutes with the help of a pump (19). The slide valves (2 and 17) are closed and (18) are open. In a process of operation of a BP it is necessary to control concentration of acidity in substrate. A sample in a substrate is taken through a valve. The acidity should be pH=6,9 to 7,6, The BP principal scheme and the scheme of connections.

After loading the bioreactor with liquid manure, hydrogen sulfide will be discharged.

Discharge of methane will start in 3-5 days. Gas pressure in the bioreactor (5) should not exceed 0,4 atm and is controlled visually with the help of a manometer (26) and a hydraulic (6) and mechanical (27) safety valve. Gas from the methane-tank through a gas meter (10), a flame-arrester (7), a compressor (25) enters the gasholder. The gasholder has a maximum pressure 20 atm. The compressor gives a gas pressure up to 15 atm. The safety valve (27) of the gasholder must be regulated up to 20 atm. Biogas through a flame-arrester (7) and a stopcock reaches a consumer. During testing a BP it is necessary to use an individual gas stove with a reducer as a consumer. Unused gas is released into atmosphere through a safety valve P=0,4 atm., although it would be beneficial to flare this surplus methane rather than simply release it.

Discharge of biogas continues for 12-15 days with intensity of 20-40 m3 a day. After this period and reduction of gas discharge, operation of a BP stops. Getting of fertilizers – methane effluent (19) is pumped into a transport tank (13). A slide valve is closed and (17, 20) opened. Some residues of the effluent are left in the bioreactor for formation of new colonies of bacteria.

An almost empty bioreactor is again filled with liquid manure from a manure reservoir and a cycle is repeated as ultimately multiple biogas digesters are planned to be used in a complete technological cycle and the cycle would then become continuous. The approximate duration of a cycle is 20 days. For 1 cycle 300-600 m3 of gas and 16 t of fertilizers are produced.

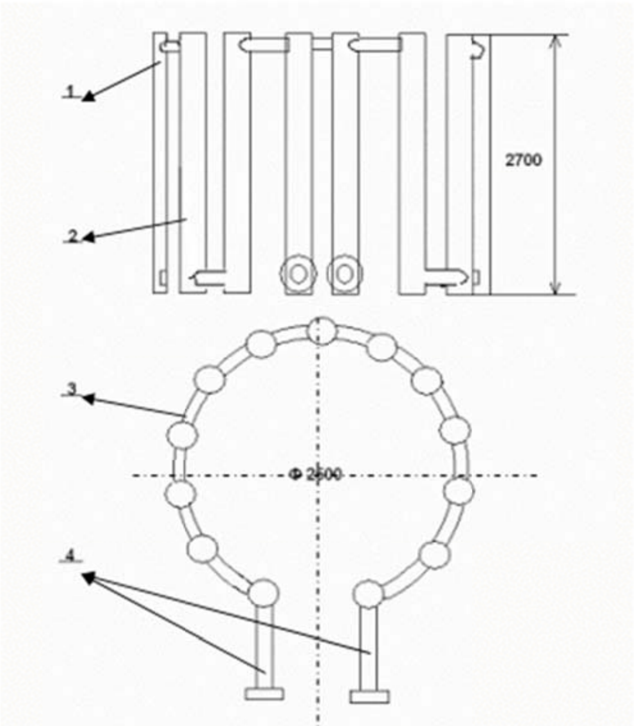
The maximum efficiency of technological process is achieved if:
1. 2/3 of a methane tank is filled with liquid manure with humidity 90-95%.
2. During the whole cycle to maintain the methane tank temperature without sharp fluctuation 50-55°C.
3. Systematically mix a substrate in a bioreactor.
4. Absence of an access of oxygen in methane tank.
5. Pressure of a gas in a bioreactor not more 0,4 atm.
6. Timely picking of a gas and fertilizers – methane effluent from a methane tank.

The project proposes to use existing operating electric agitator and a pump installed in an existing manure reservoir for filling a raw material into a methane tank. Note that the animals are currently housed in a hard feedlot. Feed is presently transported to the animals with the help of a wheel tractor from which feed is given to the animals from feedlots. Dung is transported away from the feedlot and spread on the fields. Equipment specifications are shown in Table 4.

Table 4. Equipment specifications

№	Material	Unit	Quantity	Price	Total price
Materials					
1	Pipes				
	d = 219 mm	m	40	1665	66600
	d = 159 mm	m	60	935	56100
	d = 76 mm	m	6	275	1650
	d = 50 mm	m	10	196	1960
	d = 25 mm	m	30	110	3300
	d = 15 mm	m	10	63	
2	Slide valves Ru-10				
	d = 200 mm	-	5	6000	30000
	d = 50 mm	-	2	1500	3000
3	Coupling valve d = 15mm	-	1	1000	1000
4	Stop cork d = 25mm	-	3	700	2100
5	Glass water level gauges	-	4	1000	4000
6	Rolled iron L-bar 50 x 50 x 4	-	0,2	39000	7800
7	Rolled iron sheet d = 3-50 mm	t	0,7	48000	33600
8	Rolled round iron d = 16-140 mm	t	0,1	39000	3900
9	Isover 6=30 mm	sq.m	85	300	25500
10	Technical rubber d=4 mm	kg	20	40	800
11	Cement mortar	m3	3	2000	6000
12	Concrete M-200	m3	25	3000	75000
13	Bearing №210	-	1	400	400
14	Varnish BT-577	kg	30	200	6000
15	Cable KRPT 3 x 4 + 1 x 1,5	m	30	200	6000
16	Electrode Э-42	kg	20	90	1800
17	Oxygen	cylinder	7	450	3150
18	Carbide	kg	35	90	3150
			Total:		342810
Equipment					
1	Tank V=25 cubic m P=0,4 atm	-	1	60000	60000
2	Gas holder V=25 cubic m P=20 atm	-	1	90000	90000
3	Compressor P=15 atm 7-10 cubm/h	-	1	20000	20000
4	Sanitary pump	-	2	15000	30000
5	Pump 1,5 K-6	-	1	13000	13000
6	Electric agitator	-	1	20000	20000
7	Reducer	-	1	3000	3000
8	Gas meter 10 cub.m/h	-	1	3500	3500
9	Safety valve 1 atm (0,4)	-	1	700	700

	d=20 mm 20 atm d = 20 mm	-	1	700	700
10	Automatic temperature controller	-	1	3000	3000
11	Level control relay ESP-50	-	1	3000	3000
12	Compressor controller	-	1	3000	3000
13	Electric motor 1,7 kW 1500 rot./min	-	1	4500	4500
14	Thermometer 0 - 100 °C	-	3	500	1500
15	Manometer 0 - 1 atm 0 - 20 atm	- -	1 1	700 1300	700 1300
16	Electric boiler 20 kW	-	1	10000	10000



Total:	267900

Fig. 5. Construction scheme of the heater register

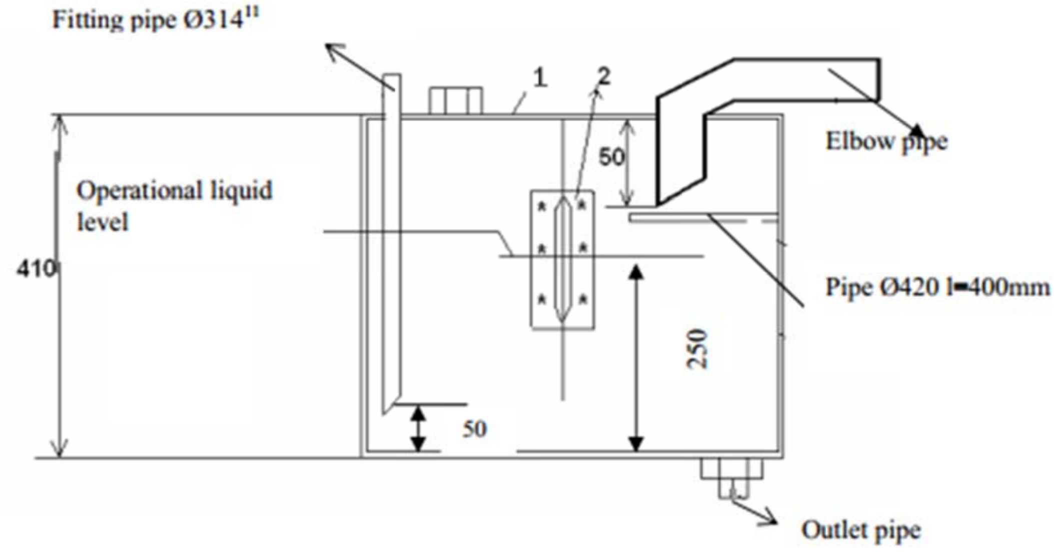


Fig. 6. Check valve
1 – top, 2- level, 3 – screen, 4 – bottom.

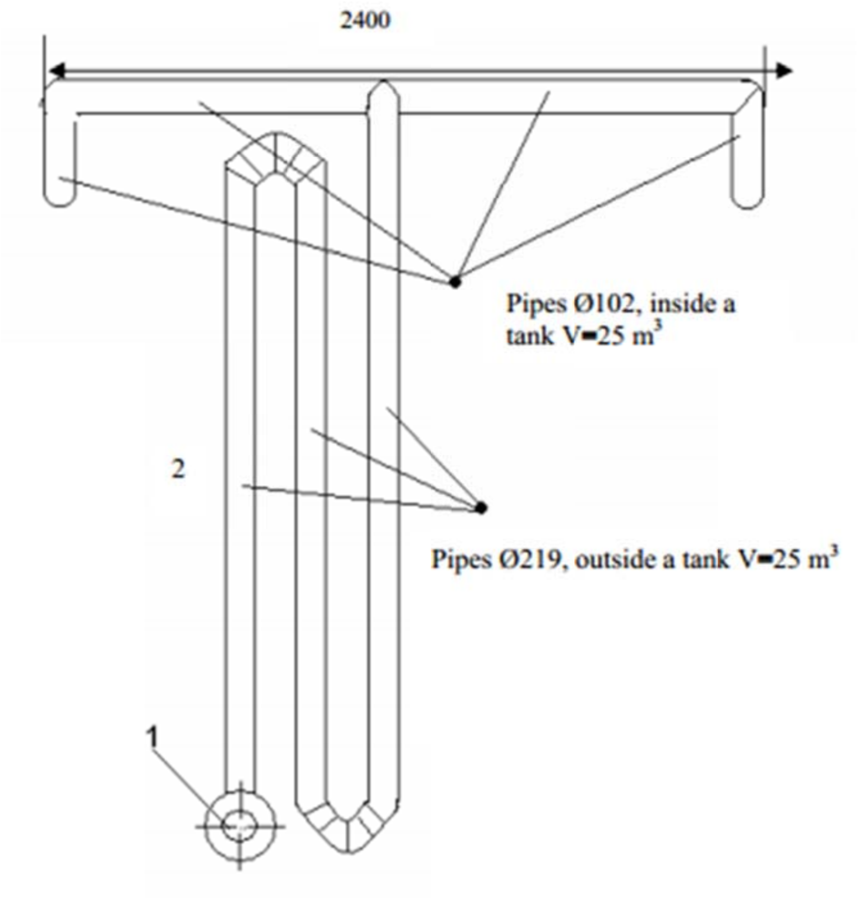


Fig. 7. Loading valve
1 - flange 2 – pipes

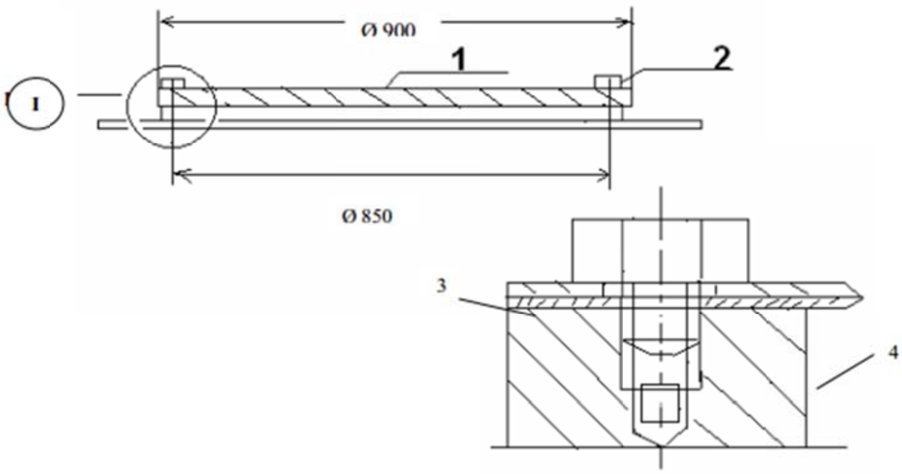


Fig. 8. Construction of a hatch of a methane tank

6.2. Project implementation plan

There are several stages:

- Pre-Feasibility Study and full Feasibility Study preparation;
- Site preparation;
- Acquisition of materials and equipment;
- A BP installation;
- Launching;
- Commissioning and testing

Fig. 9. Plan of FS preparation and implementation

№	Activity	Months						
		1	2	3	4	5	6	7
1	Collection and analysis of information							
2	Calculation and selection of parameters and a scheme							
3	FS and project proposal preparation							

In fig. 10 a sequence of construction works and commissioning of a biogas plant is shown. The period between starting project implementation and finalizing with commissioning will take approximately 10 months.

№	**Activity**	**Months**									
		1	2	3	4	5	6	7	8	9	10
1	**Construction works**										
	Site preparation										
	Preparation of foundation										
	Preparation of non-standard equipment (resistor of a heater, a lid, a valve etc.)										
	Acquisition and installation of methane tank, gas holder										
	Acquisition of standard equipment (pump, engine, compressor, boiler etc.)										
2	**Installation works**										
	Installation of a methane tank										
	Installation of a gas holder										
	Installation of pumps and valves										
	Installation and assembling of a reducer										

	Assembling of a system of heating										
	Installation of a BP										
	Commissioning and testing										

Fig.10. Construction Works

After installation and commissioning of a BP it is necessary to conduct maintenance works (Table 5)

Table 5. Temporary maintenance schedule of a BP

1	Pump Cleaning of a screen of a suction pump Checking of gas tightness Greasing of bearings	Constantly Constantly Constantly
2	Methane tank Cleaning of pipelines Gas leakage control Manometer operation control Heat isolation control Examine a safety valve	Monthly Monthly Weekly Monthly Constantly
3	Gas holder Examination of a safety valve Visual examination of a casing	Constantly Monthly
4	A reducer и compressor examination	Monthly

Electric engine, gas reducer, control sensors, and dates of their maintenance are determined by user’s instructions. It may be possible to reduce the scheduled two- months annual shut down for maintenance after plant operation technology is optimized and suitable experience is accumulated by the operating staff who increase their qualifications and skills.

7. Contribution to sustainable development

Implementation of the project provides long-term greenhouse gas (GHG) emission abatement and reduction of local pollution utilizing organic waste, protecting soil and water as well. Another advantage of the project implementation is poverty reduction: additional profit from a biogas plant operation, improvement of living standards, economic stability, crop capacity increase, employment. However, it cannot be automatically assumed that advantages of biogas will improve living conditions of poor people. Much depends on ownership models and on the size of installations that are suitable for participation in the scheme. This requires more detail in order to fully explore the link between biogas and poverty reduction. The level of poverty reduction depends on many parameters: not only on the installations size and ownership models but also on the living standards of a user, activity, education etc. These issues must therefore be considered in more detail at the project feasibility study phase.

An important factor in the project sustainability is an opportunity of the project dissemination in the country and the Central Asian countries. The potential demand of rural population is 10.000 biogas plants. Such quantity of 20 c.m. biogas plants can process 2,5 million t. of manure and to get 100 million c.m. of biogas and 1,2 million t. of organic fertilizers. The 10,000 biogas plant ultimate market is a very rough approximation, based on each biogas unit being of the same size and waste being processed from the same size herd. The reality will be a range of different sizes, from very small to very large, depending on herd numbers and distribution. After the process of privatization in the agricultural sector there were a great number of farms formed with different average herd sizes. Unfortunately, there are no any reliable official state statistics concerning average herd sizes. The estimation of 10.000 biogas plants demand was conducted by the experts from the KARES as a first order-of-magnitude estimate.

8. Financial Analysis of the Project

8.1 Main Assumptions

Specific features of this project include:

(i) Utilization of the biomass does not produce direct revenues for the farm, as the biogas plant products will be used to meet the needs of the farm. Therefore, in the analysis below, the incomes generated by the project have been calculated on the basis of the cost of inputs (commercial fertilizers and diesel fuel) substituted by the biogas plant products and no tax charges have been applied. Implementation of the biogas plant provides also certain savings on transportation of fuel and fertilizers to the farm while the biomass is available within the range of 50m from the plant from the hard feedlot manure storage area. The organic fertilizer from the biogas digester would then need to be transported up to 10km to the fields.

(ii) The farm has a staff of skilled fitters and ironworkers that allow carrying out the installation of the pilot plant on a part-time basis with low internal labor costs. This refers also to the subsequent maintenance and repair of the biogas plant. The wage expenditures of the farm for the implementation and maintenance of the biogas plant have been determined by the farm management.

(iii) The farm has an excessive stock of raw materials (manure), which are freely available for the operation of the plant (in fact, the plant will not be capable to process all the waste produced by the farm, however, it will provide some additional savings on waste disposal). This is because there is little net productive value for the dung at the moment, as the cost of transporting it to, and spreading it on the fields in a wet and undigested phase is currently less than its value as fertilizer or conditioner. Therefore, it was assumed that the cost of raw materials is 0 for the project.

(iv) All references made here to currencies mean: KGS - Kyrgyz soms; and $ - US dollars. References to "tons" (t) mean metric tons.

Main technical and financial assumptions used in the financial analysis are summarized in Table 6.

Table 6. Assumptions used in financial analysis

Technical assumptions		
Biogas plant design capacity	25 m3	
Annual production output:		
combustible methane	11,648 m3	
liquid organic fertilizer	200 t	
Combustible methane heating value	23 MJ	
Project life (years)	25	
Financial assumptions		
Average fertilizer application rate	4.5 t/ha	
Average annual cost of commercial fertilizers per 1 ha	KGS 24,155	$318.0
Diesel fuel price per 1 kg	KGS 37	$0.49
Discount rate (nominal)	20.0%	
Inflation	8.1%	
Exchange rate (KGS/US$)	75.87	
CO_2 equivalent reduction per 1t of methane produced	22.5 t	
Depreciation rates:		
on buildings	no buildings used	
on equipment	10.0%	
Income tax	not applied	

Notes:

1. *Fertilizer*: The farm management aim is to reduce significantly the consumption of commercially available nitrogenous, phosphoric and potassium fertilizers by applying 1 t of biohumus produced by the biogas plant per 1 hectare. However, the research-based recommendations from the agronomists and similar fertilizers producers widely available in agricultural press and the Internet vary from 2.5t to 10t per hectare depending on the soil and crops. For the crops cultivated by Kant MTS the recommended application rates are 3-6 t/ha with the average of 4.5 t/ha.

Assuming that the plant produces 200t annually, bio-humus produced will be sufficient to fertilize 44.4 hectares of crops. The average annual cost of commercial fertilizers per 1 ha as applied by the farm at normal application rate (see table 3 in Section 5.5 above) amounts to KGS (24,533+27,850 +20,082)/3 = KGS 24,155. Therefore, the revenue generated through the substitution of commercial products in Farm No2 will amount to KGS 24,155x44.4 = KGS 1072,482 or US$14,136 annually. However, for the full feasibility study analysis there is a need to conduct direct comparison of the fertiliser benefit of biogas residue and based fertiliser and mineral fertilisers. For example, Pakistani authorities have found that in some cases a blend of mineral and organic fertiliser was best at a 75% mineral and 25% organic ratio. So, it is not yet possible to definitively state that mineral fertiliser can be replaced by the same quantity of organic fertiliser or at what ratio of substitution without chemical (N,P, and K) comparison and suitable field trials having been undertaken for specific Kyrgyz Republic conditions.

2. *Combustible methane*: Currently, Farm No.2 of Kant MTS consumes approximately 150 t of diesel fuel (1/2 of the total Kant MTS consumption) annually, which is used for heating of the dairy farm, administrative building and staff residential houses. The intention is to substitute a part of the commercial fuel by biogas, which will generate considerable cost savings for the farm. Assuming that the reference net calorific value of diesel fuel is 41.868 MJ/kg and that of the biogas is 23 MJ/m3, it can be calculated that with 11,648 m3 annual production of methane the biogas pilot plant will be able to substitute 23 x 11,648 / 41.868 = 6,399 kg or 6.4t of diesel fuel. With the current price of diesel fuel 37 KGS /kg this will provide annual savings KGS236,763 (US$3,120.6) on fuel costs (this is only a rough estimate as part of the methane generated will be consumed by the biogas plant itself).

3. *Exchange rate*: 75.78 KGS to US$1 for December 2015, with the subsequent 5.2% annual reduction to account for the exchange rate temporal trend over the last 3 years.

4. *Depreciation*: Standard rate is used for depreciation as provided by the Tax Code of the KR.

5. *Inflation rate*: 8.1% is the average rate for the last 3 years.

6. *Financing*: Currently, Kant MTS is not able to raise funds for the initial investment; and long term loan financing is also available from the Kyrgyz banking sector. A potential solution is to seek funding from an international financial institution or development program for the pilot project. Therefore, at this stage a feasible financing plan cannot be prepared. In a full scale feasibility study, the similar funding barriers for other farms will need to be addressed, including whether there is likely to be any willingness to provide state funding mechanisms on the basis of a successful pilot project demonstration.

8.2 Overall Cost Estimates

Capital and operating costs estimates are presented in Tables 7 and 8 below.

Table 7. Capital costs

Capital costs	KGS	$
Civil works (installation and fitting)	110,000	1,451.6
Digester, piping and accessories	620,000	8,181.6
Electromechanical equipment	160,000	2,111.3
Contingency	20,000	263.9
Total	910,000	12,008.4

Note: A more detailed basis for obtaining these estimated amounts would be useful in the full feasibility study.

Table 8. Operation and maintenance costs

Operation and maintenance	**monthly**		**Annual**	
	KGS	$	KGS	$
Technician/workers wages	20,000	263.9	240,000	3,167
Repairs and maintenance				
Electromechanical equipment (1.00%)			1,600	21.1
Digester, piping and fixtures (1.00%)			6,200	81.8
Administrative expenses	2,500	32.99	30,000	395.88
Total			**277,800**	**3,665.8**

Note: 'Administrative expenses' include the part-time wages of the engineer and the accountant. The electro-mechanical equipment could be expected to depreciate much faster than this 1% p.a. 5 to 10 years before a complete rebuild would be more realistic. This needs to be revisited in a full-scale feasibility study.

8.3 Project Financial Analysis

As discussed earlier, the project will produce gaseous methane and organic fertilizer in the proportion of approximately 58 m3 of methane per each ton of organic biogas residue (dried weight) fertilizer. However, in terms of cash flow generation there is no difference between the two products; therefore, for the convenience of calculations in the analysis below both cash flows have been 'tied' to the main product (fertilizer) unit (1t) as a sum of the following components:

1) savings on commercial fertilizers KGS1072,482 / 200t = 5,362 KGS/t; and

2) savings on diesel fuel KGS236,763 / 200 t = 1,183.8 KGS/t.

For example, savings generated by 1 ton of the conventional product will amount to 5,362+1,183.8 = KGS 6,545.8. Note that these calculations need to be refined after recalculating the value of the organic fertiliser in chemical fertiliser equivalent terms in the feasibility study.

Although this project is only a pilot facility for large-scale feedlot operations in the Kyrgyz Republic, the above figures emphasise its feasibility and financial viability for scaled up operations in large farms.

The core factor determining the value of project contribution to the financial viability of Kant MTS dairy farm is the size of cost savings on commercial fertilizers purchased by MTS, while the savings on fuel is less important due to insignificant proportion of diesel fuel substituted by biogas in the total consumption. Sensitivity of project financial indicators to variations in commercial fertilizers price and the area of crops fertilized with organic fertilizer produced by biogas plant is demonstrated in Tables 9 and 10.

Table 9. Financial contribution of biogas plant at 15 percent variation in commercial fertilizes price

	Fertilizers market price 15% lower	Base case	Fertilizers market price 15% higher
Fertilizers price, KGS	12015.6	14136	16256.4
Savings per 1t of product, KGS/t	4557.7	5362.0	6166.3
Savings per 1t of product, KGS/t including diesel fuel replaced (+KGS 1183.8)	5563.93	6545.8	7527.67

Table 11. Financial contribution of biogas plant depending on fertilizer application rate

Fertilizer application rate	50% higher	Base case	50% lower
Fertilizer application rate, t/ha	6.75	4.50	2.25
Crops area fertilized, ha	29.6	44.4	88.9
Total savings on commercial fertilizers, KGS '000	714,988	1072,482	2144964
Savings per 1t of product, KGS/t including diesel fuel replaced (+KGS 1183.8)	3,272.5	6,545.0	9,817.5

The above analysis demonstrates that the project reviewed is clearly 'bankable', and the cash flow generated through savings on commercial fertilizers and fuel makes it possible to recover the initial investment in a very short time. Financial indicators vary significantly with the change in the actual area of crops where the commercial fertilizers are substituted by the own product. It should be noted, however, that the payback period figures obtained by standard mathematical calculations should be adjusted to the seasonality of fertilizers application and, therefore, to the times when the farm can make actual savings on purchased fertilizers. In this regard the project reviewed also does not provide for any storage facility (which can require certain investment) for keeping liquid fertilizer during the periods when it may not be immediately used, unless the structure of crops can accommodate the continuous production process. So these fertiliser values, and the equivalence of the organic fertiliser produced with commercial NPK fertilisers, needs testing in field applications and then refinement in a more comprehensive feasibility study project proposal.

9. Conclusions and Recommendations

These studies prove financial and technical viability of MIS-Kant biogas project. The concept of biomethanation of cattle waste is well proven, and should be supported in principle. However the argument presented in this proposal contains many simplifying initial assumptions that need further clarification and elaboration in order to reach the stage where it could be considered complete in a subsequent feasibility study.

In short, the main outstanding questions surround the comparisons made between the value (both cash and mineral) of organic fertiliser versus mineral fertiliser. It influences very significantly the financial calculations and requires clarification in a subsequent feasibility study.

Specifically, more data in a subsequent feasibility study is required on:

- The number of cattle to be included in the test and how they are presently farmed; i.e. are they on hard feedlots all year round or free ranging for some periods of the year? What is done with the dung at present, and especially what proportion is returned to the fields and by what method and frequency? How much dung is produced by a single animal now? What seasonal variation is there in diet and feed quantity and location? How will seasonal temperature variations impact biogas production?

- The wet dung from the cow has typically around 16 to 20% solid content and the remainder is water. It needs to be clarified whether the calculations in this initial prefeasibility study refer to wet or dry waste materials.

- What is the socio-economic profile of the local population? What are average herd sizes, and do they fit this proposed model and scale? What technical support is required, and can it be accessed in remote locations? Information on the replication model is required, taking into account the poverty status and difficulty in accessing finance.

- Has there been any testing or laboratory analysis of the animal dung to ascertain its suitability as a feedstock for the biogas digester? This has an impact on the expected gas outputs, which has an impact on project finances. It also influences the ability of the organic material to substitute mineral fertiliser. Previous experience in Pakistan suggests that organic fertiliser from cattle dung is not a direct substitute for inorganic NPK fertilisers, but instead works best in a 75% mineral and 25% organic fertiliser blend. It is not necessarily a 100% 1:1 direct replacement as suggested in the proposal.

• The construction costs have to correspond to market prices, and could supporting documentation be provided for the generator/compressor/digester and construction costs for this system?

The proposal clearly has merit in terms of the concept of taking (an assumed) waste material and turning it into a fertilizer resource and an energy resource. But much greater detail and analysis is required to show and support how energy, fertilizer and greenhouse gas conclusions are arrived at.

So, before taking further steps in conducting a more detailed analysis on technical feasibility, it is necessary to revise the general provision of the structure of the project. The working plan of the project will lead to the more exact budget of financial and economic studies. As a further step of development, the versions should be discussed with all the stakeholders. Results and data, including more detailed studies and analysis of location will jointly lead to the technical feasibility. The further steps may be summed up as follows:

• search of financial institutions;
• the proposed project should be submitted to local administration, their comments and proposals should be taken into account; and
• to discuss expected results, mechanisms and the project implementation scheme with community and private business

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