

The Northern China Agricultural Engineering of Farmer's Courtyard Energy Ecological System

Wei Baorong & An Xiangjun

Agricultural & Animal Husbandry Dept of Liaoning Provincial
No. 2 Taiyuan Street Shenyang P. R. of China

ABSTRACT

The so-called northern Agricultural Engineering of Farmer's courtyard Energy Ecological System is a courtyard-type energy ecological synthetic application system, that combines into one the biogas pool, pig house, toilet and plastic-membrane green house in a fully-closed condition in farmer's court yard, a combination of farming with breeding industry, with biogas as the key linkage, by taking full advantage of solar energy and through bioenergy conversion technique in accordance with ecological principle.

Key Word: Agricultural, Engineering, Energy, Farming, Breeding, Ecological

INTRODUCTION

The province is located in the south of the Northeast area between $118^{\circ}53' \sim 125^{\circ}46' E$, $38^{\circ}43' \sim 43^{\circ}46' N$, in middle latitude, in continental monsoon climate zone, that hot weather and rain concentrate in the same season, sun shine is abundant, plain wind is strong and cold weather is long. Annual mean temperature is between 5 and $10^{\circ}C$. Frostless period is 124~215 days. The lowest difference of temperature is $30^{\circ}C$ to $-30^{\circ}C$. Depth of frost earth is 0.8~1.5m. Freezing weather is 5~6 months; Annual sunshine is 2300~3000 hours; Annual sunshine percentage is 51~67%; Annual solar radiation is 120~135k calorie/cm².

Through decade of years of biogas construction, the province has constructed 100,000 and more biogas pools from 1977 to 1983, that plays an active role in solving the problem of shortage of firewood in rural area. Biogas pool could only

be used for five months in a year because the pool is exceptionally used for daily life energy. Moreover, it is hard for biogas pool to survive the winter, less effect was obtained and, thus, development of biogas was affected and rate of development reduced and even came to a stop.

According to natural climate conditions and features of rural commodity economic development, in development of synthetic biogas application in the province, problem of winter survival of biogas pool was first tackled, then problem of effect on farming and breeding by low temperature was dealt with. Finally, the synthetic effect of biogas development was done with. For years, through practical, an effective approach to the above problems has found, that is the northern Agricultural Engineering of Farmer's Courtyard energy ecological System (referred to as system).

The Theory of Operation The system takes ecological principle as its base, makes full use of solar energy, takes biogas as key linkage, combines farming and breeding industries, forms a courtyard energy ecological synthetic application by linking biogas pool, pig house, toilet and vegetable plastic - membrane - roofed green house in a fully - closed condition in plot of courtyard land through bioenergy conversion technique. see the following diagram.

The System Structure and Feature

1. its main structure and features of operation: At 4~5 m away from house front in the courtyard, a 100~200M² a "Four - in - One " System solar plastic membrane - roofed green house is built, with a 15~20 m² break poultry house (pig house) and a 1~1.5m² toilet built at one end. Beneath the pig house, a 6~10m³ biogas pool is constructed. See figure 2

By making full use of solar energy and taking advantage of solar plastic - membrane - roofed green house, the pattern not only provides excellent condition for pig to grow fast but also ensures safe winter survival of biogas pool to continue production. Manure emitted from toilet and pig house enters directly into biogas pool as fermentation raw material to produce biogas. Biogas thus produced is not only used for cooking and lighting, but also used for production. Through burning of infrared stove, biogas can raise temperature of the green house. Through test, burning for 25 minutes can raise the temperature of 12m² green house by 6°C, concentration of carbon dioxide by 800~1,000 ppm; Burning for 35 minutes can raise the temperature by 8°C and concentration of carbon dioxide by 1,280 ppm. Poultry house (or pig house) can also raise temperature and

concentration of carbon dioxide of green house. Through test, ten pigs over 50 kg can raise the temperature of 100m² green house by 1°C; ten pigs over 100 kg can raise the temperature by 1.5°C and, at the same time, exhale carbon dioxide, together with the carbon dioxide released from biogas pool water pressure room, may raise the concentration of carbon dioxide in green house by 1000 ppm without the need to increase additional CO₂. By test, When CO₂ concentration in green house is over 1000 ppm, photosynthetic product (CH₂O) may be raised by one time. Biogas pool may also provide nutritious material (fertilizer and forage) needed by plant growing and breeding. Vegetable fertilizer by biogas residue is free of pollution, with tender and fresh leaves, dark lustre and good quality, biogas residue improves anti-pest ability of vegetable. With high fertilizing efficiency, proper green house temperature, adequate CO₂ strong photosynthetic action, the green house yields more and better vegetable with less pest. Tests show that leafy vegetable increase by 30%; melon and fruit increase by 20%. In addition, paddy seeds soaked with biogas fluid produce 7.7% more yield, maize increase by 6.7%; Biogas residue used as fertilizer may increase yield of ginseng by 17%.

The residue of biogas fermentation not only contains Nitrogen, phosphorus and potassium but also contains trace elements and nine amino acids required by poultry and animals. It is a nutritious additive. The biogas fluid, used as forage additive, gives pig appetite, makes pig act less and sleep more and put on weight in a rapid way. Test shows that it can increase weight of a pig by 0.08 kg a day. Biogas residue, when used as forage, can heighten survival rate of fish and promote fish growth. Test shows that it can increase fish weight by 0.2 kg and raise fat content by 20%. For earthworm, the residue can put out 22 kg per m². Then the worm is fed to chicken, the chicken manure, when fermented, is fed to pig, the pig manure is fed to the pool to make biogas and then is turned into fertilizer that is used to produce pig forage and feed pig, thus, forming a food-chain production line for scientific breeding work.

2. The structure and features of biogas pool: Design requirement, The "Four-in-One" System must be realized. The pattern is featured with (1) economized use of land, biogas pool underneath, poultry and pig house above; (2) favourable for the biogas pool to survive winter; (3) easy to manage, save labour force, easy to put in and put out material and easy to use fertilizer; (4) easy to use the energy for daily life and production; (5) synthetic application, forming a benign circulation, favourable for pest control and environmental hygiene.

In addition to reservation of the good points of the original hydraulic pool, structure of biogas pool is modified in accordance with the principle of practicability, several structures were tested. See figure 3

Experiments show that in severe winter, the biogas pool at 12~18°C, still keeps on turning out gas. Annual productivity of average volume is 0.2~0.3 m³/m³/day, with annual average at 300~400 m³.

3. Structure and features of poultry and pig house: A back wall can be set up at 1~1.5 m north of the biogas pool (according to depth of frozen earth) . To keep warmth. For every 8 layers of brick, a layer of brick is laid on the space to reinforce of the wall. The inner gable should be laid on the inner edge of the outlet of the biogas pool; thickness of the gable is 24 cm and in the gable, two ventilation holes are opened, the higher hole being 1.6 m from the ground and the lower hole 70 cm from the ground, opening of the holes being 24 cm * 24 cm. CO₂ exhaled by animals and poultry flow into the green house through the lower hole in the wall, as gaseous fertilizer for growth of the vegetable. The oxygen generated through photosynthesis by vegetable flows into the poultry (or pig) house through the higher hole, to enable the poultry and animals to get more fresh air. According to requirement of pig for environmental condition, through ventilation hole where changes in temperature and humidity effect growth of pig, temperature in pig house should be kept at 10~20°C and relative humidity at 75% . Outside the fence, grape may be grown that sheds shade in summer for pigs. Floor of pig house is paved with cement with gravel underneath. The floor above the biogas pool is the "hot bed" (which is as hot as 18°C), for pigs to pass the winter. The device turns the inhibiting winter months for pig to grow into the best period for pig to grow. Tests show that each pig may put on weight by 0.5~0.75 kg per day. Forage is economized by 30% and pigs may ripen for sale two to three months ahead of schedule and sale may be made twice a year.

4. Structure and features of solar green house: A proper place should be spotted to build solar green house. According to feature of the northern residential houses, that face south with a courtyard, the green house should be built in front of the residential house in lee ward to accept sunshine. According to sunshine in winter, east - west - ward green house should face south to receive sunshine. There are two types of solar green house; one is bamboo and wood structured, the other is steel skeleton structured. Angle between arch - type verticle window and ground is 62° ~ 65°, while angle between green house surface

and ground is $22^{\circ} \sim 25^{\circ}$. with south - north span being 5. 5~6 m. area of the plastic - membrane - roofed green house is generally between 100~200 m². Such green house is spatial, small in temperature difference between day time and night and good in heat preservation. Temperature of the green house should be 8~28°C. when lower than 8°C, the house should be heated with infrared stove. When higher than 28°C, the house should be ventilated in time.

Frostbite preventive measures must be taken in winter for no matter what type of solar green house is adopted: 1. A east - west frostbite preventive ditch is dug at 0.5 m from the south end of the vertical window, its depth depending on local depth of frozen earth, with width being about 0.5 m, within it thermo - fermentating material being filled (such as rice husk, soft grass, tree leaves and crop - stem fertilizer, etc), which is rammed and covered and sealed with earth. 2. the plastic roof is covered with frostbite preventive curtain (such as cotton quilt, paper quilt and grass mat), which is removed in day time to receive sunshine and replaced in the evening or cloudy day to preserve heat in the house.

Effect For years, there has been a good tendency in development of the northern Agricultural Engineering of Farmer's courtyard energy ecological system. Having enlisted the systematic project as a model of developing high - efficient agriculture, the provincial government has taken it into orbit of developing the rural commodity economy. This has become an important component part of household income. Its economic, social and productive effects are relatively remarkable.

Economic effect: Construction of a "four - in - one" biogas pool, covering 140 m² of land, pig house above the ground is 20 m² and solar green house is 100 m² and more. Underground biogas pool is 10 m². Their construction costs are 2,500~3,000 Yuan.

Fund comes mainly from low - interest loan from Agricultural Bank, that is loaned, put into production and sold by private operator, who usually raises intensively 10~30 pigs. They save 1000~3,000 kg of forage as compared by regular pig breeding. pigs come out of shed for sale in 5~6 months. Counted on the lowest number of pigs raised, annual net income is 1,500~2,000 Yuan. For vegetable planting in solar green house in winter, spring and mid - fall, net income is 1,500 Yuan, plus 80 Yuan from chemical fertilizer economized and 320 Yuan from cost of coal and power saved. Then annual net income for each household may be as much as 2,900~3,000 Yuan.

In 1991, the synthetic effects of 16 energy ecological model households in Qingshui Farm, Dawa County, Panjin City, are: Everage household saved 3,000 kg of firewood (or one ton of coal), 180kw of electric power (lighting and blower) every year. The two items are equivalent to 174 Yuan. The fire-wood saved by everage household could be returned to five mu of farm land, economizing 100 kg of chemical fertilizer, equivalent to 80 Yuan; Additional 6.5 pigs can be raised, thus, In addition to six months saved in early output of pigs (time effect is negligible), 250 kg of forage can be saved. Thus pig breeding increase 650 Yuan of income. Courtyard planting increase 1342 Yuan of income. the synthetic economic benefit is 2,246 Yuan. MR. LI, front Yingkou City, He built an 8 m³ biogas pool upon which he built a pig shed in which 12 pigs were raised. For every 5~7 months, pigs are put out of shed, with total output of pig being 970 kg and 2,000 Yuan of profit. His plastic-membrane-roofed green house covers 600 m², which produced, cucumber, vegetable, tomato, garlic, cabbage, grape. The pool produce 15 ton of biogas fertilizer every year, saving 90 kg of chemical fertilizer, and he saved 50 Yuan for pesticide. All together he got 11,000 Yuan.

Social effect: The pattern prospers social economy, turning slack season in farming into a busy one off season into a peak period, thus, increasing supply of vegetable, melon, fruit, meat and egg to the market and prospering social economy. This not only plays an important role in supporting and enriching urban "vegetable basket project" and increasing effective supply, but also has a special effect on supporting and promoting development in poor regions. According to statistics made to 90 households of workers in DaWa County, 45.6 mu of courtyard economy area supplies every year 250,000 kg of vegetable and 300,000 kg of meat and egg to market, total output being 429,010 Yuan and 7,800 Yuan of income for every mu. Thus, surplus labour time and labour force find a full use, changing the situation in which one family member works and the rest look on and summer is busy season, but winter is slack season. This stimulates the initiative of broad farmers to get rid of poverty, to become rich and to strive for well-off standard of life.

Ecological effect: The pattern has changed environmental hygienic aspect in rural area. manure is put into biogas pool at any time, reducing the breeding place of flies and mosquitoes, eliminating pollution and purifying environment. At the same time, the parasite eggs and pathogen in manure are killed in fermentation of biogas, that reduces disease and promotes health of human being. biogas

fertilizer, when returned to farmland, increases organic matters in soil, changes the physical and chemical characteristics of soil and improves farming ecological environment.

For the time being, more than 22, 000 households in the province have set up this Farmer's Engineering System and develop courtyard economy by means of biogas synthetic function, to change the face of rural area and to improve people's quality, thus making certain contribution to the construction of the two civilizations. Practice shows that biogas construction in rural area not only improves the standard of people's life, but also plays an important role in building up resources for further development of agriculture, promoting development of rural commodity economy and in protecting ecological environment. But there are still problems existing in imbalanced development and technical resources and managerial level failing to meet the practical need in popularizing this pattern. These problems are to be talked in future work.

CONCLUSION

1. It has solved the problem of biogas energy application, that has troubled development for years in the province. So that the pool may be used all year round.
2. The System promotes pig growth, shortens breeding cycle, save forage and heightens effect of breeding industry, so as to increase income of household.
3. It is possible on the same plot of land, to realize synchrony of biogas production with fertilizer collection to conduct at the same time farming and breeding industries and to build a courtyard energy ecological system tie project that enables a quicker circulation of energy flow and goods flow with more biotic population and a complete food chain structure.
4. It becomes a pattern for high - yield, high - quality and high - efficient farming activities, makes full use of land, energy, time forage and labour force and has evident the synthetic economic effect of production development, and increase in benefit.
5. The system has changed environmental hygienic aspect in rural areas, that reduces and promotes health of human being.

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SOLAR ENERGY

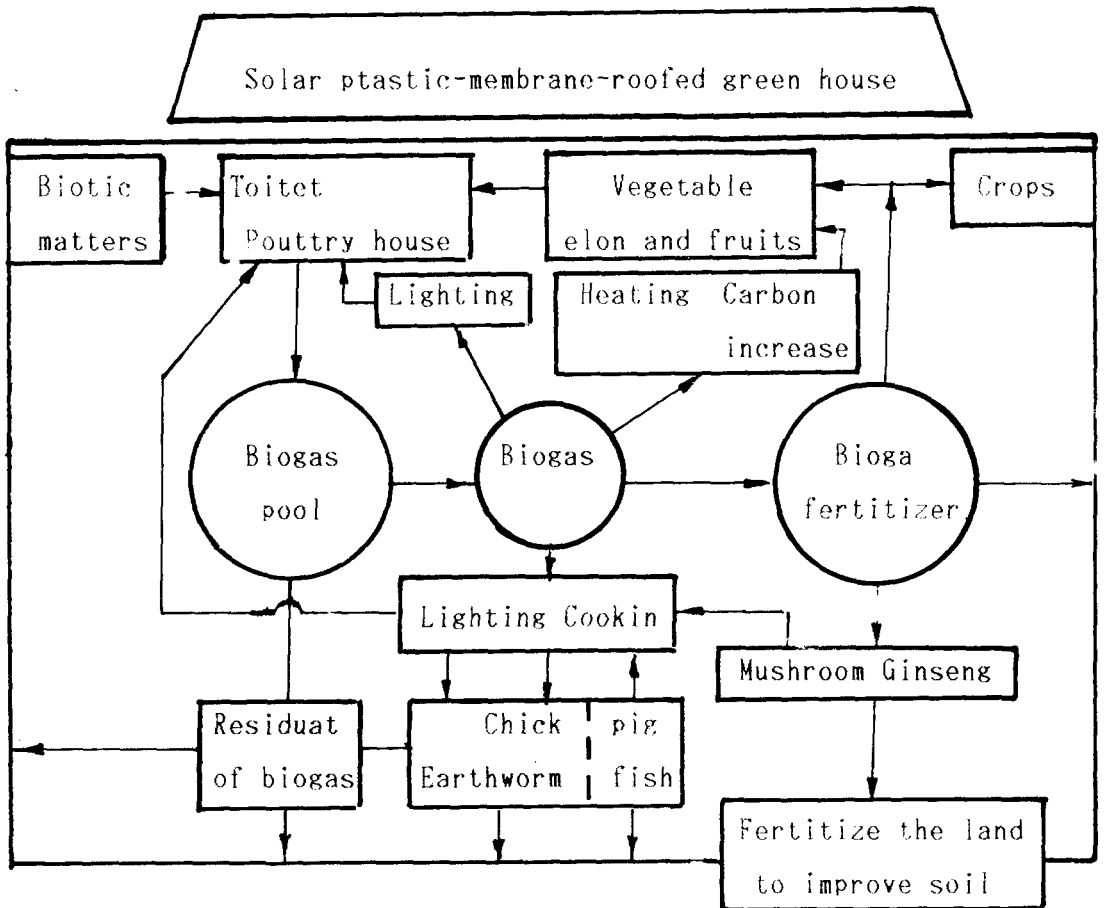


Diagram of the northern energy ecological system

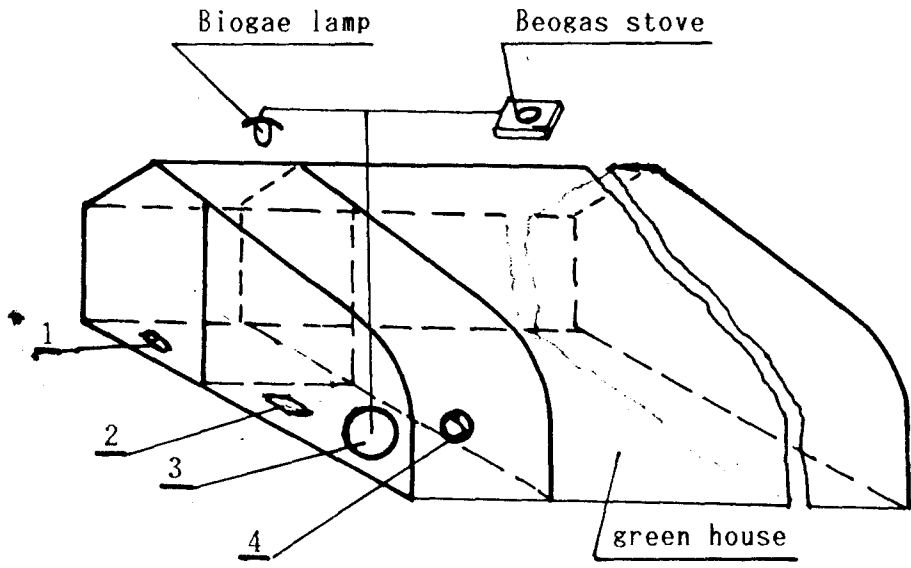


Figure 1. Cubic plan of the four-in-one biogas pool
 1.Toilet 2.Inlet 3.Biogas pool 4.Outlet

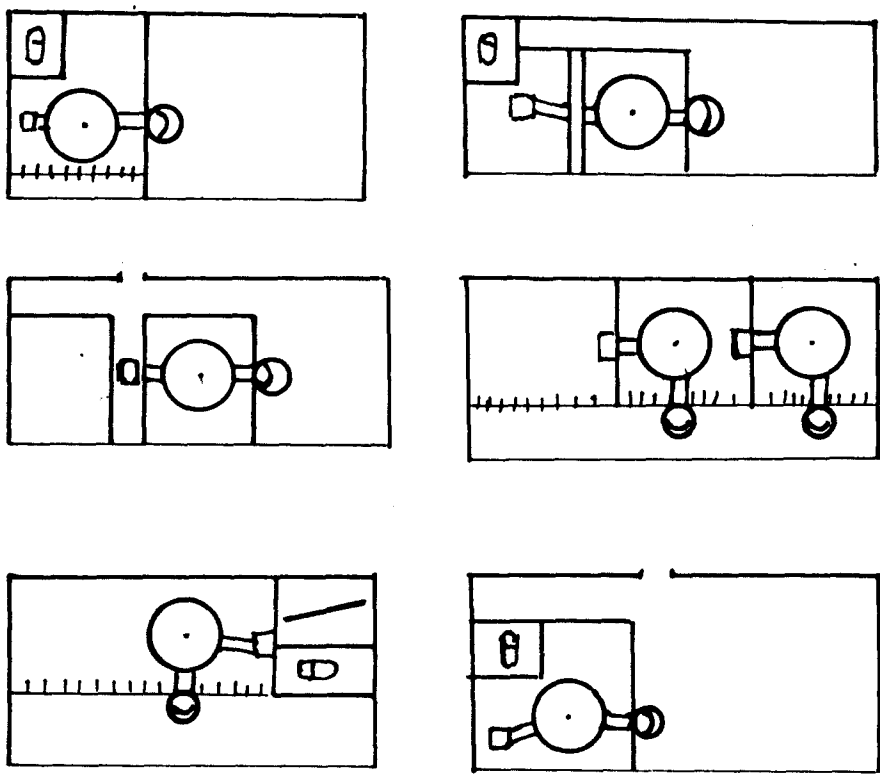


Figure 2. Plan of the four-in-one

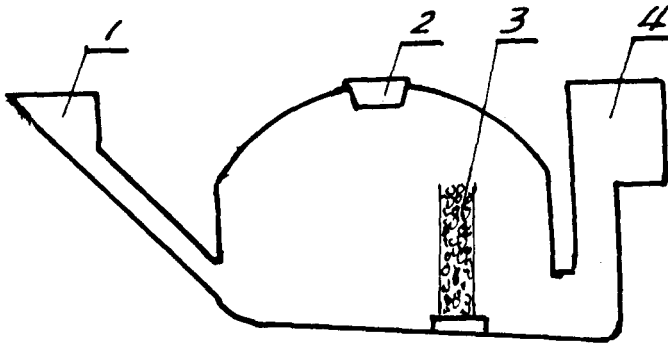


figure 3
biogas pool

- 1. inlet
- 2. "stated moving cover"
- 3. "biotic column"
- 4. outlet

