



# An Analysis of Farm Methane

## Methane Project Cancelled Due To Poor Feasibility

A typical farm of the Energy Project farms 350 acres, 250 of which is cultivated. The operations include livestock, primarily dairy, hogs and beef.

### NUMEROUS DIFFICULTIES UNCOVERED

The potential of methane generation was studied for one of the farms, having a 30-cow dairy and 100-hog finishing operation. The project was cancelled by the farmer due to escalation of cost and low return on investment. The study included provisions for electrical generation, although power companies are reluctant to pay for farm electricity provided to the power grid.

Several other problems were encountered, including manure handling difficulties with the solid manure system, availability of enough quality manure, and high labor requirements. Gaseous

fuel use on the farm was non-existent, requiring conversions of equipment to utilize methane gas.

The study seems to conclude that methane generation may only be feasible for quite large systems or for very small demonstration devices, and not for current conditions of the average farm of the Energy Project. Certain unique situations, including summer gas use, other than electrical generation, could improve the potential.

### OTHER ALTERNATIVES

Other alternatives to methane generation are considered in this "Special Report" including aerobic composting of the manure. For composted manure, as much as 50% less weight is hauled to the field when compared to the original raw manure. Effluent from methane generators would have increased weight when

diluted for the process. Less capital is required for composting than for methane generation.

### AN "APPROPRIATE" TECHNOLOGY QUESTION

Despite the negative aspects of methane generation for small farms, anaerobic digestion should be considered for the future as energy prices continue to rise, perhaps making the process more feasible. However, the results of this study indicate that not all forms of alternative energy are "appropriate" for the small farm, and should be closely analyzed before being adapted. Most energy innovations adapted by Energy Project cooperators are simple, home-built, and low-cost systems. Methane production is considerably more complicated and expensive for the farmer to implement.

## The Study of Farm Methane

### ENERGY USE BY PROJECT FARMS

Average energy use by farms cooperating in the Energy Project has been studied. Major energy costs are for electricity and motor fuels in addition to fertilizer purchases. Total direct energy costs are over \$3000 per year, excluding fertilizer costs. Average gross income in 1977 was \$33,800 for 16 general livestock cooperating farms.

### FARM USED IN THE METHANE STUDY

One farm cooperator showed particular interest in development of a methane system. The livestock on the farm includes 30 cows of the dairy operation, 100 head of 150 lb. hogs on the average at any given time, and 200 laying hens.

Energy use by the farm is given in Table 2. Energy consumption is similar to that of the average farm of the Energy Project. Car and truck gas, however, is considerably higher. Electrical peak demand during winter months has been near 4800 kwh/month for this particular farm, about double the summer demand.

### BACKGROUND OF THE STUDY PROCESS

It should be noted that the digester under consideration was of interest to the farmer for energy production purposes. Most methane systems in use in this country today, however, seem to have started with a primary objective of pollution control for environmental control purposes. Workshops on the topic of methane generation were held. A proto-type scaled down version was planned, but construction was never fully completed.

The design work for potential systems involved several processes. Energy Project staff reviewed much of the literature

TABLE 2. Farm Energy Purchases, 1976-1978, of Farm in Methane Study

	Unit Purchases		
	1976	1977	1978
ELECTRICITY (kwh)	32,950	33,980	33,130
FUEL OIL (gal.)	820	860	1180
PROPANE (gal.)	—	—	—
DIESEL (gal.)	885	1306	1100
TRACTOR GAS (gal.)	1040	1115	1100
CAR GAS (gal.)	1500	2057	2700
	(est.)		

and worked closely with the farmer to design a system to meet the farm's needs. The eventual design was reviewed by 8 different consultants. Ted Landers of Missouri, who has cooperated with the U. of Missouri, Rolla, on methane generation, was selected to develop a final design for final feasibility study. Throughout the process, the farmer was consulted for adapting the design to his farm and various modifications were made by him. Salvage equipment, including 4000 gal. fuel tanks and a 30 h.p. engine, were considered in the analysis.

# Methane Production and Economics

## Various Options Considered

The very first design for a methane system included solar air heating for the digester, with a rock heat storage unit. Later, electrical production capability was incorporated in the design, since electrical energy was a major energy need on the dairy farm under consideration. In the option of electrical generation, the system was sized to provide winter peak electrical demand. With electrical generation, considerable heat is available for providing winter heat requirements of the digester, and the solar heating concept was abandoned. However, in this first design, the efficiency of conversion of methane to electricity was over-estimated. The resulting correction increased cost of equipment to \$3000 for a 15 kw generator. The designs included a pre-mix tank for diluting and heating the incoming solid manure. "Plug flow" through the 7 ft. diameter digester tanks was included, along with a horizontal mixing device.

Later designs were developed; comparisons of those considered are given in Table 3. Sizes of the systems ranged from 8000 to 16,000 gallons in digester volumes, with gas production ranging from 850 to 1700 cu. ft. of scrubbed methane per day. "Gas use only," electrical generator, and also compressed gas for mobile motor fuel were considered for methane use. For the "gas only" option, sizing of the system was that which would provide sufficient methane for potential space and water heating, but would probably operate only during winter months. The compressed gas option had good potential with regard to the high use of gasoline on the farm for a combine, tractor, pick-up, car, and truck, costing in excess of \$2000 annually.

## Economic Factors of the Analysis

Various economic factors were utilized in the results shown in Table 3. The value of electric generation is based on 2c/kwh overall, assuming little benefit of dumping power onto the grid, currently at no return. Operating cost was included. It includes labor at \$4/hour for feeding the digester and the cost of energy and labor of running motors and grinding crop residue. A \$10/month charge by the Rural Electric Cooperative was used as the minimum or stand-by charge by the REC. The costs charged to the system included an 8% "opportunity investment cost", the above labor and energy costs of operation, and 3% maintenance costs (3% of capital investment per year). The latter two costs were escalated at 7%/year. The savings in energy benefits were given a 13 1/2% fuel price escalation. The options did not consider the cost of a honey wagon, or the benefit of investment credit, which along with other energy tax breaks could improve the pay-back. Cost of construction labor was also not considered, as is the case with most innovations of the Energy Project, where the cooperator performs most of the construction work.



—Tanks under consideration for use on the Bill Kleinschmit farm for methane production. The system, which was cancelled for various reasons, would have incorporated an electric generator powered by methane.

## Return on Investment & Project Cancellation

The best return on investment appeared to be realized in the process of compressing the gas for mobile transport. The cost was near \$17,000 with a pay-back of 11-12 years. However, the feasibility was questionable. The use of the gas by that method would have required additional labor and special handling of the gas, and conversions to most all of 5 or 6 engines. See Table 3 for "pay-back" periods.

TABLE 3. Methane Equipment Options

Digester Size in Gallons	Gas Output, Scrubbed, Cu. ft./day	Gas Use	Waste Input	Invested Capital Required	Approx. Pay-back
1. 16,000	1700	15 kw, Synchronous Electric Generator	Hog Manure & Crop Residue	\$14,500	17-18 yr.
2. 16,000	1700	15 kw, Synchronous Electric Generator	Hog Manure & Crop Residue	\$13,000	15 yr.
3. 8,000	850	Gas Only	Hog Manure & Some Dairy	\$8,000	15 yr.
4. 16,000	1700	Compressed Gas for Vehicles	Hog Manure & Crop Residue	\$17,000	11-12 yr.

In #1, 2, and 4 options above, the big cost is harvest of crop residue at \$500/year.

In #2, the savings in capital over #1 is in reduced housing cost, using an old shed and buried tank.

In #3, the system cost includes conversion of water heaters and other equipment to gas use and it includes the installation of gas lines. Plant operation probably limited to winter only.

The #4 investment cost includes compressed gas storage bottles, compressor for 2200 psi, and a generous figure for converting gasoline engines to compressed gas. Most of tractor gasoline goes to a combine just at harvest, a \$1000 value annually. A car, pick-up and truck have fuel use spread over more of the year, which allows for lower storage cost. This fuel use is also costing about \$1000 per year. But this latter option requires conversion of several vehicles.

The farmer cooperating in the venture participated in the eventual cancellation of the proposed project, just as he participated in the design. He made the final decision that the innovation was not appropriate for his farm, and probably not for the average farm similar to his. He was not interested in demonstrating an innovation that would not have the potential of being adapted by many farmers. He made the decision, despite the potential of 50 to 75 percent cost share assistance. It appears that methane systems are only feasible for very large scale livestock production and for farms larger than those considered here, or for the small scale approach as is used in India or China for limited use of cooking and lighting. The results indicate that the technology may not be appropriate for the average small farm of the Energy Project. Unique circumstances may make the potential more feasible, however.

## Difficulties of the Methane Project

A number of circumstances made it difficult to justify the methane system proposed. Farmers interested in utilizing methane production should consider the factors when planning changes or adding livestock structures to their farms.

### Solid Manure Handling

The farm in the study has a solid manure handling process, rather than automated liquid manure handling. **The solid system requires more handling labor** for use with methane production. **Freezing is a difficulty in the winter months.** The farmer had plans for installing a manure scraper system in a

proposed hog finishing unit, if and when it was constructed. The farm studied did not have enough quality manure available to feed the most feasible system adequately and, therefore, crop residue was entered into the equation. However, labor and cost of harvest increased the operating cost substantially. The labor for the basic operation of the plant also appears to be high.

### Gas Storage Difficulties

**One of the major problems** associated with methane production is its storage for later use. It requires considerable energy and capital equipment to compress the fuel into a liquid form. In the scenario of production of electricity, waste heat must be well utilized for the system to be feasible. Such consideration requires the integration of a number of facilities on the farm and involves a more complicated planning and development process. **The REC is also not willing to pay for farm produced electricity.**

### Low Gas Use

Gaseous fuel use on the farm was low. As Table 2 indicates, no propane is used. A basic difficulty is that farm energy use and equipment is oriented to purchased energy. **Conversion of energy-use equipment**, such as electric water heaters and refrigeration equipment, to gas **would have been required to make efficient use of the gas.** This, too, increased the cost of the project. In this case, stock tank heaters were also electric and the home was heated by a fuel oil furnace. These are retrofit difficulties inherent in any transition from one energy source to another. Economical transition requires judicious investment in energy end-use equipment. In addition to conversion difficulties, **gas production would be highest in the summer during optimum weather conditions, but gas use for heating would be low at that time.**



—Bill Kleinschmit inspects parts that were considered for a proposed methane digester for his farm. The project was cancelled in Sept. of 1978 due to high costs and other factors.

---

Dennis Demmel, Co-director of the Energy Project, presented a paper, entitled "Aerobic Digestion for Methane Generation on Small Farms in Northeast Nebraska", at the Mid-American Biomass Energy Workshop at Purdue U. in May. This "Special Report" includes excerpts from that presentation.

---

## Power Companies & Rural Electric Cooperatives

The installation of wind electric system equipment by one cooperating farmer of the Energy Project represented the first cooperative venture between the Energy Project and a Rural Electric Cooperative. However, the REC is not willing to pay for power placed onto the power grid by the wind system. Wind generated electricity is thought to have the potential of reducing sales, but not peak demands. **If an REC did agree to purchase the power, it could well be at the wholesale price, which is about 1/3 of the retail price of an average 3.2 cents per kwh paid by Energy Project cooperators.** The reasoning used by the REC's in their reluctance for purchasing power is that **they must maintain the lines of distribution and all of the other back-up machinery necessary** for the farmer to be able to sell any of his excess power.

With regard to the wind electric system, a ratchet or detent was placed on the electric meter to eliminate the potential of

the farm meter from turning backwards, essentially not allowing credit for "dump" power at the retail rate. A monthly demand charge of \$3 per KVA transformer capacity was also established.

**Methane used for electrical generation does have advantages over wind power.** The REC in the local area of the Energy Project has a seasonal electrical peak demand during the summer months, when methane generation is optimum. The methane can be manipulated to provide electricity during peak demand when most needed by the power company during the day. However, any "premium" for such power is not likely to exceed retail prices for the reasoning given above. During the winter months, cooperating farmers experience electrical peak demands, when the REC least needs the power. Therefore, the combination appears to have merit, to the benefit of both, if the REC were to cooperate further.

# Other Alternatives

## Options For Anaerobic Digestion

An induction generator was not considered for electrical generation in the analysis, but warrants consideration as equipment of lower capital cost. Methanol can be produced from methane, but the conversion requires expensive equipment currently. Methanol has the advantage of being stored easily as a liquid fuel. **Methane might more easily be integrated into an ethanol production system, where waste heat from alcohol distillation could provide the heat needed for anaerobic digestion.** The methane produced could then provide some of the higher temperatures required for the distillery.

Methane gas has been placed into pipelines for commercial distribution, but that option is open to only those farms near to a gas pipeline. In Oklahoma, such a project required an FPC permit. For the farm studied here, the nearest pipeline is 10 miles from the farm. Pressures of 500 to 1000 psi would be required. Irrigation powered by methane may be practical for farms requiring irrigation, since methane production is optimum during summer months during irrigation periods. Irrigation was not used by the farm in question.

Gasification may be an option to anaerobic digestion, particularly where crop residue is the major input rather than manure. Such "producer gas" production from the partial combustion process may require considerably less capital investment, although the quality of the gas produced would be lower than methane.

## Aerobic Composting

### As An Alternative

A better use of farm manure may be in the aerobic composting process. Although no fuel is produced, composting requires no water pumping as in the dilution of manure for methane production. **Much less weight is hauled to the field, potentially saving energy in the hauling of the compost, which is reduced to as much as 50% less weight compared to the original manure. Less capital is expended in initiating composting than with methane production hardware, since conventional farm equipment can be utilized in composting. Compost may perhaps have qualities better for the soil than the effluent of the methane digester.**

## Conclusion

Methane production does not appear to meet the feasibility requirements of the average farmer cooperating in the Energy Project. **The cooperating farmer involved in the study concluded that the technology was not appropriate for his farm.** Methane systems are probably only feasible for very large scale livestock production systems, or for small scale approaches as used in India and China, where energy consumption is lower. However, **some farmers may approve of the pay-backs presented here, especially if tax credits are useful and unique circumstances enhance the potential. Future energy prices will continue to rise and REC's may offer premiums for electrical generation. These developments would improve the feasibilities of methane systems. Further research on these aspects is needed. Farmers should consider methane production in their farm planning and changes in operations. End use of the fuel is a major consideration.**

## Future Research

**Several areas of continued research should be considered.** The potential of REC's cooperating with farmers in paying for electricity generated at peak demands would potentially benefit both parties involved. Other uses of the gas should be studied. As an example, many of the small farmers in the Energy Project locale have dairy operations that require considerable energy for refrigeration. Gas refrigeration at one time was popular, but hardware for that use is difficult to locate today.

**Comparisons of the value of effluent nutrients from the anaerobic digester should be compared to the value of compost to soils, with consideration given to a wide range of aspects including soil tilth, water retention, aerobic soil biology, and other areas, in addition to just N-P-K values.**

Presently, considerable research efforts are used to analyze large methane production systems. In the future, more small farm considerations might be made.

## Small Scale Plant Demonstrations

**Several organizations are conducting innovative demonstration work on small scale methane plants. Such systems would be tailored to farms smaller than those of the Small Farm Energy Project, and may have greater feasibility due to lower costs and simpler designs.** Two organizations are listed here.

**New Life Farm, Inc.,** is conducting a "Rural Gasification Project" to determine feasibility of low-cost digesters for rural families. The Project will provide week long training workshops in small digester construction, starting in August. Participants are eligible for cost share for their own plants. For details, contact Ted Landers, New Life Farm, Drury, MO 65638, phone 417-261-2553.

**Omega-Alpha Recycling Systems,** has taken a wholistic approach to the anaerobic process. The OARS designs include the incorporation of greenhouses, algae ponds, and aquatic plants. The research is directed by Robert A. Hamburg. Contact Hamburg at Route 1, Box 51, Orma, WV 25268, phone 304-655-8662.

## More Information

### BIBLIOGRAPHY AVAILABLE

The Energy Project has available a bibliography, "Methane Energy". The 2-page, annotated bibliography has 16 entries covering a variety of books and fliers on the subject. Several plans listed. For a copy, send 25 cents, to cover postage and handling, to the Energy Project.

### FOR MORE INFORMATION

This "Special Report" was published by the Small Farm Energy Project, a research and demonstration project sponsored by the Center for Rural Affairs and funded by the Community Services Administration. 24 farm families in Cedar County, Nebr., are cooperating in the study. Additional copies of this report are available for 50 cents. For more information, contact the Energy Project, P.O. Box 736, Hartington, NE 68739, phone 402-254-6893. □