Ministry of Agriculture & Fisheries

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FUEL FROM ANIMAL WASTE AND GRASS -- A REVIEW OF THE POSSIBILITIES

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9/8/77
Lent to Chris Gamber
"SNG from Refuse, Sewage sludge
by the Biogas process
Ghosh
Klass
Orlando
Florida

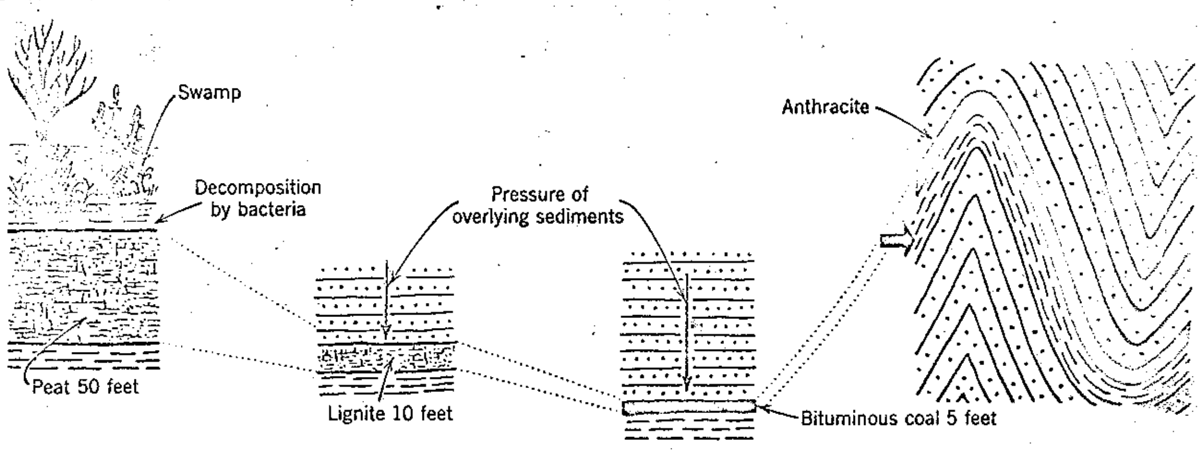
INTRODUCTION

Today the world depends for most of its energy on coal and petroleum. The energy is obtained by burning these materials in air according to the basic reactions:

$$C + O_2 \longrightarrow CO + CO_2$$

$$C_xH_y + O_2 \longrightarrow CO + CO_2 + H_2O$$

When coal and petroleum are burnt with the formation of carbon dioxide and water a cycle is completed that was begun many years ago when plants photosynthesised carbon dioxide from the air. When the plants died bacterial action over the years transformed them to coal, oil, and natural gas.



Accumulating plant matter is converted into coal by decomposition and pressure.

In the present time where we see the worlds reserves of coal and petroleum dwindling it is therefore logical to consider the possibility of replenishing them using the same cycle that has occurred in nature. In fact all that is required is for man to speed up the cycle in order to provide coal or petroleum at a rate that can keep pace with world energy demands - a goal for science that should not be too difficult if it is considered that in nature the process occurs by accident with many unfavourable factors to contend with. If science is successful in harnessing this cycle the world will be assured of a truly renewable energy supply.

TO DATE

A comparatively small amount of research has so far been directed towards the production of petroleum (the word petroleum includes natural gas and oil) from plant material yet it has been remarkably successful. The starting material in most studies has been animal wastes, partly because the preliminary bacterial decomposition of the plant material has then been accomplished within the animal, but also because the disposal of animal wastes in such a way as to avoid pollution of soil and water has been a problem that has attracted considerable research over recent years, and recycling the wastes with production of useful byproducts would be an ideal solution. It has been claimed (1) that the use of such a process would reduce by half the problem of sewage and animal waste disposal in the U.S.A. and that enough fuel could be produced from this source to meet all present fuel needs in the U.S.A.

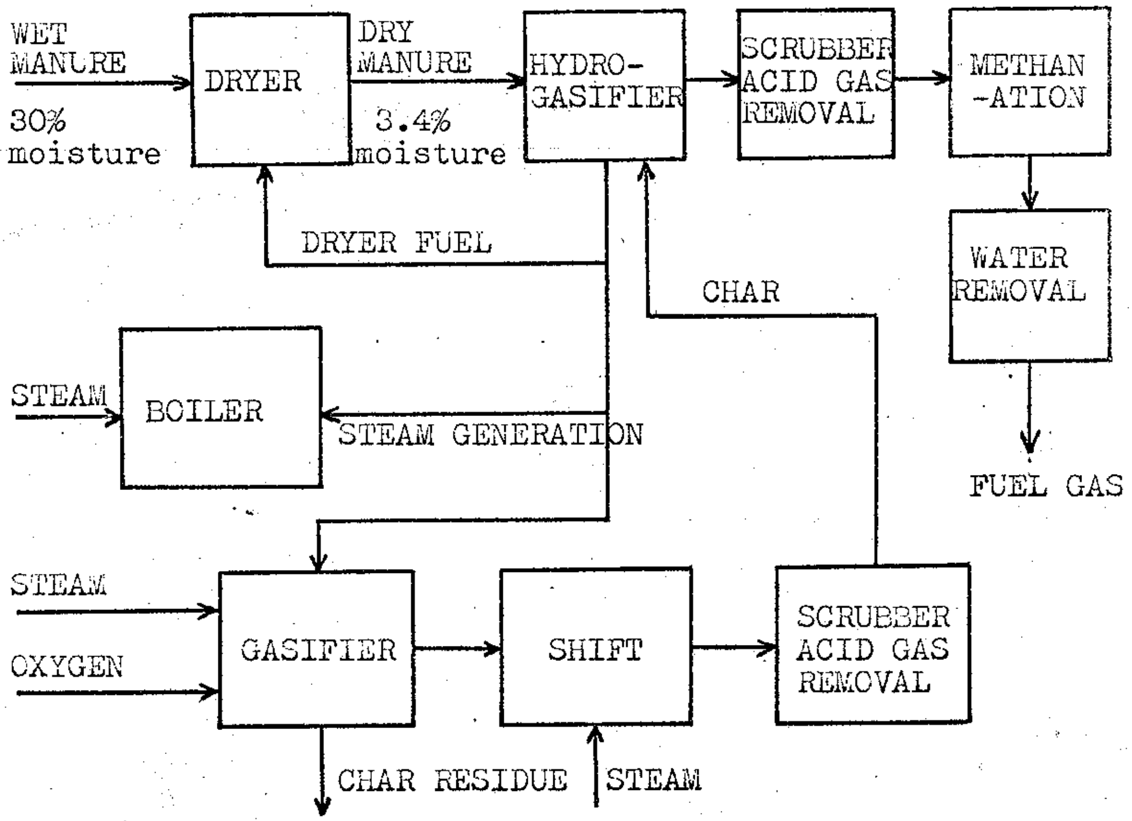
In India animal and vegetable wastes have long been used as a source of energy, and in 1962-3, for example, almost as much energy was produced from this source as from oil (44.5 Mt.c.e. compared to 55.3 Mt.c.e.*)(2). A plant for production of fuel gas from animal wastes was developed by the Indian Agricultural Research Institute as early as 1959 (called 'gobar-gas'plants from the word gobar meaning dung) and between 1961 and 1973 7,500 of these plants were installed throughout the country.

A farm-size digester that produces methane gas from pig manure has been developed at the North of Scotland College of Agriculture in Aberdeen (3). At the present stage of development the waste from 100 pigs produces only 300,000 Btu s of energy each day (the equivalent of about 25lb. of coal) but the process eliminates odour problems and greatly reduces pollution risks.

*Million tons coal equivalent

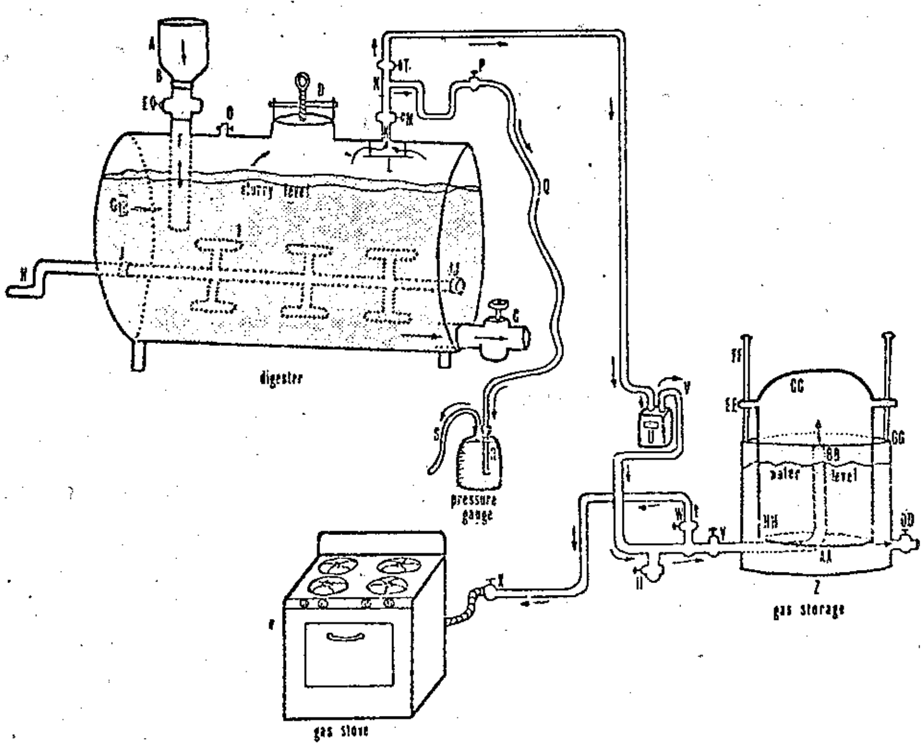
A more successful conversion of animal and vegetable wastes to fuel has been achieved by an English inventor named Harold Bates (4). He obtains methane gas from a mixture of 75% chicken and pig manure with 25% straw, the equivalent of 50 gallons of petrol for each 300 pounds of manure, and has developed a converter that enables him to power a standard automobile with the gas. The cost of a 'gallon of petrol' works out at 3c.!

In the U.S.A. the commercial production of "synthetic natural gas (SNG)" (a strange terminology when it is considered that 'synthetic' and 'natural' are opposites) is well om the way to being a reality. Research carried out by scientists of the U.S. Bureau of Mines Energy Research Centre (5-10) has shown that the production of both oil and SNG by physico-chemical processes, such as treating the dried manure with hydrogen under pressure, is both feasible and economic. In fact SNG produced by the scheme shown below is likely to cost about half as much as natural gas.



A plant that will produce 640 million cubic feet of methane per year from bacterial decomposition of manure provided by large feedlots is at present being built in Oklahoma and is scheduled for completion by mid 1976(11). The gas produced by this plant will be fed into the natural gas supply system of Chicago and will be used for domestic and industrial heating.

Small plants have also been developed. One that produces 2½ cubic feet of methane each day from 30 gallons of animal manure and crop wastes has been designed and built by staff of the Pennsylvania State University Cooperative Extension Service. According to the designers, a plant that would "be able to service an average-sized dairy farm, costing between $4,000 and $8,000, could pay for itself in 5 years."(12) Another small methane generator is currently being used to provide all the cooking fuel on a California farm. The generator, shown below, produces more than 2,000 cubic feet of methane from each ton of fresh manure.(13)



Plans of the unit are available from the designers - L. Auerbach, Route 1, Box 28A, Winters, California, U. S. A.

Research to date indicates that municipal sewage wastes may also be treated by similar procedures to those used to treat animal wastes to yield fuel gases. A patent has bee. taken out by Texaco Development Corp. (Texaco is one of th world's largest petroleum companies) for the production of fuel gas from garbage(14). An economic feasibility study mad by the U.S. Bureau of Mines Energy Research Centre led to the conclusion that "for most urban areas conversion of solid wastes to pipeline gas may be the cheapest method of disposal.(15)

In other countries, too, research is being carried out on methods of conversion of wastes to fuel. In Japan the Government Biochemical Engineering Research Institute has been studying the optimum conditions for production of methane from organic wastes (16), whilst in Poland a system of classification of sewage sludges according to fuel value has been devised (17). A German patent has been taken out for a process in which household refuse is burnt to produce gases which are used in the city gas supply or for generating electricity.(18)

IN N.Z.

New Zealand's future energy demands cannot be wholly met by hydroelectric power, and supplementation by generatio from coal and oil and natural gas will be necessary. It has been claimed that it will also be necessary to introd nuclear power stations. Whilst New Zealand has coal reserves to last several hundred years, oil and nuclear fuels must be imported, and both these fuels will be in great demand by other countries. If New Zealand becomes reliant on these energy sources it will continue to suffe under the whims of suppliers just as happened in the rece "oil crisis". Only by supplementing hydroelectric power with another renewable energy source such as SNG or methan from animal wastes and plant materials can New Zealand bec independent in its energy supply.

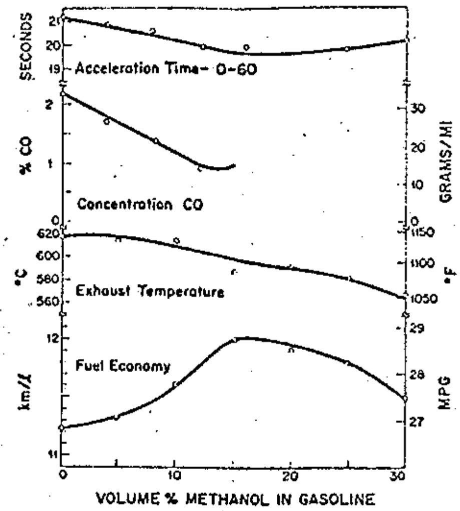
With its large population of animals relative to people, New Zealand should be well situated to produce SNG or petroleum from animal wastes. However, New Zealand at present does not have much feedlot type farming, which is the ideal form of stock management for providing large quantities of animal wastes with minimum transport costs. It may be economically desirable in the future to move towards feedlot farming if the duel advantages of tailoring beef for overseas markets and generating fuel from the animal wastes are considered. Or, it may be worthwhile for farmers to have their own small converters for on-farm generation of power.

The most promising source for generation of SNG in New Zealand is likely to be plant material. The climate of New Zealand is one of the best in the world for growing grass in large quantities, and production of fuels direct from grass would minimise transport problems and could utilise wasted grass growing along roadsides etc. as well as that produced on good pasture. Animals would play their most valuable part in harvesting hill country pasture that would not be amenable to mechanical harvesting.

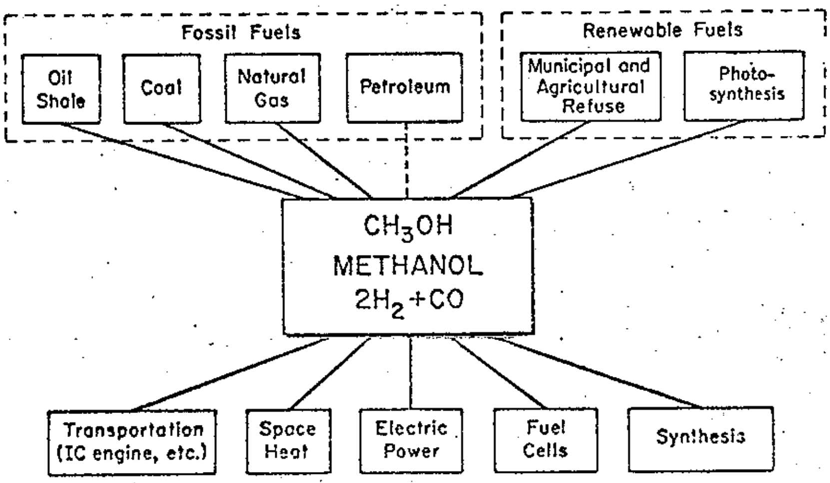
IN THE FUTURE

In the future the greatest energy demand is likely to be for an easily portable fuel to take the place of petrol in automobiles etc. Methane is an ideal starting material for the production of methanol, which has already been described as "an especially attractive alternative fuel to gasoline"(19). This article points out that methanol added to gasoline could immediately help to solve both energy and pollution problems, and presents results to show that 5-15% of methanol added to gasoline produces disproportionately large improvements in fuel economy and performance and lower-ed pollution levels.

The authors quote a number of studies that show pure methanol to be a suitable fuel for existing internal combustion engines if about $100 of conversion is done, and that noxious gas emissions would be much lower than for gasoline powered engines. A diagrammatic summary of the possible sources and applications of methanol is given below. The authors conclude their article by point-

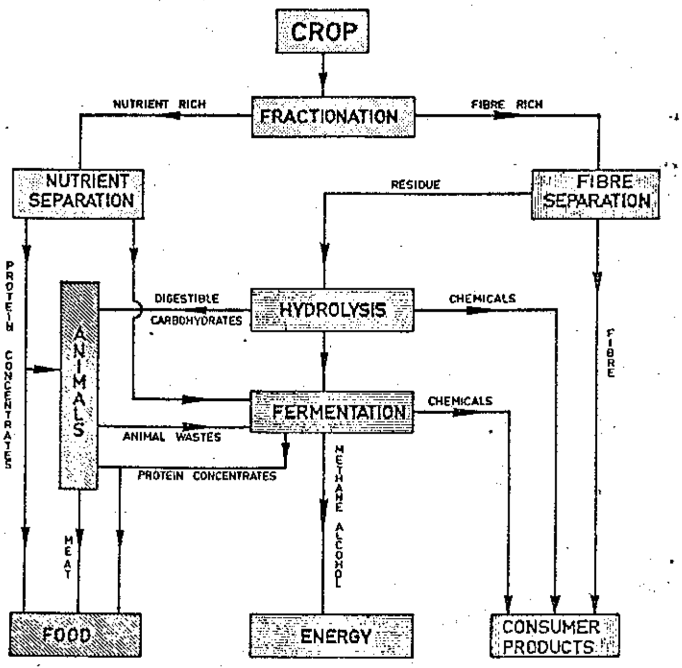


Performance of a 1969 Toyota Corona with methanol-gasoline mixtures. *MPG*, miles per gallon.



ing out that "methanol offers a particularly attractive form of solar energy conservation since agricultural and forest waste products can be used as the starting material. Indeed, at 1% conversion efficiency the forest lands could supply the entire present energy requirements of the United States".

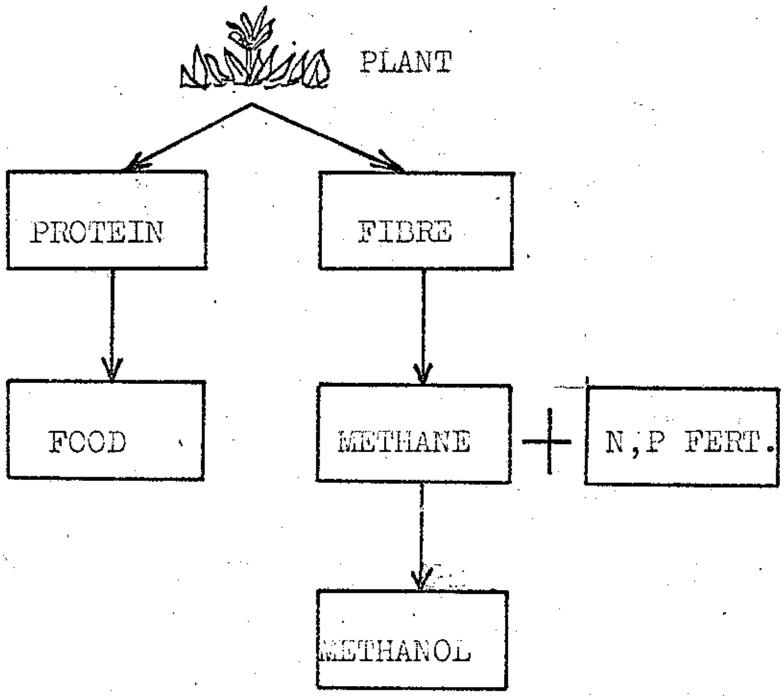
Although articles such as the one quoted above acknowledge that production of fuel from plant material is as feasible as production from manure, research on the direct conversion of plant material has so far been neglected. This is undoubtably because conversion of animal wastes solves the problem of their disposal and associated pollution risks. However, it can be argued that the bacterial decomposition begun by the animal is far from ideal if the desired end product is to be used as a source of fuel, and it could be further argued that the efficiency with which ruminants process plant material is so low that they should be bypassed if maximum efficiency is to be achieved. Better utilisation could probably be achieved by chemically separating the plant into its constituents, which may each then be used as effectively as possible. The scheme shown opposite is taken from an article by D. E. Weiss (20) in which he introduces the concept of IPPI (integrated photo-synthetic product industries) and suggests that it "has much to commend it as a national objective since it exploits efficiently Australia's biggest asset - its photosynthetic potential." He



Plants can be fractioned into two major fractions, fibres and cell components, which serve as feed for process industries. Hydrolysis provides means for switching fibres into the nutrient processing stream.

goes on to point out that "It is a realistic approach, being no more than extension and synthesis of what has already been accomplished on a large scale in integrated forest-products industries and industries extracting sugars or protein from grasses." An IPPI concept project is currently in progress in Australia involving various divisions of the CSIRO (Agro-industrial Research Unit, Divisions of Animal Physiology, Chemical Technology, Protein Chemistry and Tropical Agronomy).

A scheme for achieving maximum utilisation of plant material could be as shown below:



SUMMARY OF ADVANTAGES

The conversion of animal waste and grass to fuel has the following main advantages:

1. It provides a renewable source of energy.
2. It eliminates the pollution problems associated with disposal of animal wastes and the odour nuisance.
3. It recycles fertiliser elements (N,P,K, etc.) and the residue from the energy production is a high quality fertiliser that can take the place of rapidly diminishing world fertiliser supplies.
4. The conversion processes are non-polluting processes and the fuel produced can be used for electricity generation as a non-polluting alternative to coal and oil.
5. Since only the carbon content of the manure and grass is used to produce fuel, prior extraction of protein is compatible with the energy production, thus optimum utilisation of plant material should be possible.

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