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PROSPECT OF GASEOUS FUEL APPLICATION IN PLANT-GROWING IN UKRAINE

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Summary. An increase of energy carriers' prices has a substantial influence on the production cost. The application of cheaper gaseous fuel is one of the ways of cutting the cost of the energy resources. The analysis of the possibility of using the fuel in agribusiness is given in the paper. It is shown that natural gas is an economically effective type of fuel and manure gas is a prospective one.

Key words: liquefied petroleum gas, natural gas, manure gas

INTRODUCTION

The agrarian sector of the Ukrainian economy consumes 37% of diesel fuel and 14 % of gasoline. Plant-growing is the most power-intensive sector of agriculture. In 2003, the fuel part in the production cost of plant-growing was about 27%, and in the livestock-rearing – 7% [Zacarinskiy (red.) 2004]. Fuel consumption for some crops is shown in Fig. 1.

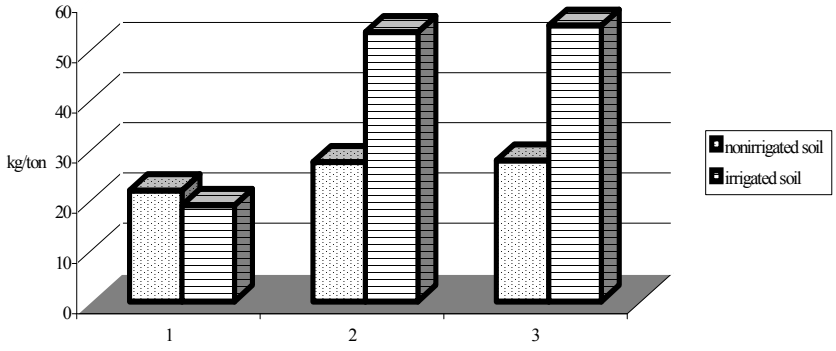

Fig. 1. Specific fuel consumption for producing: 1 – wheat; 2 – corn; 3 – sunflower

The above calculations are done on the basis of standard technology for the south of Ukraine [Tipoviye tekhnologicheskiye…1984]. As it can be seen in Fig. 1, using of irrigation can decrease the consumption of fuel only for wheat. It is explained by the following: Irrigation makes the soil dense. Therefore, it is necessary to use more power-intensive technological operations for cultivating such soil.

To estimate the efficiency of different fuels such an index as the expense of fuel (kg) on the unit of products (ton) was used. But it is not quite correct because it does not take into account their cost. That is why the criterion of fuel efficiency is suggested

$$\gamma = \frac{U \cdot P}{\sum_{i=1}^{n} \left(B_i \cdot Pf_i \right)}, \tag{1}$$

where:

U – the crop capacity, ton/ha;
P – cost of crop, USD/ton;
B_i – consumption of fuel type i (i = 1,2,…), kg/ha (m^3/ha);
Pf_i – cost of fuel type i, USD/l (USD/m^3);
n – amount of types of fuel.

Values of criterion of fuel efficiency for the crops (shown in Fig. 1) are presented in Table 1.

Table 1. Values of the criterion of fuel efficiency γ

Crop	Values of criterion of fuel efficiency γ	
	nonirrigated soil	irrigated soil
Wheat	6.64	7.66
Corn	3.75	1.94
Sunflower	11.82	6.03

From the view of fuel efficiency, those crops which have a higher value of the criterion of fuel efficiency are more advantageous.

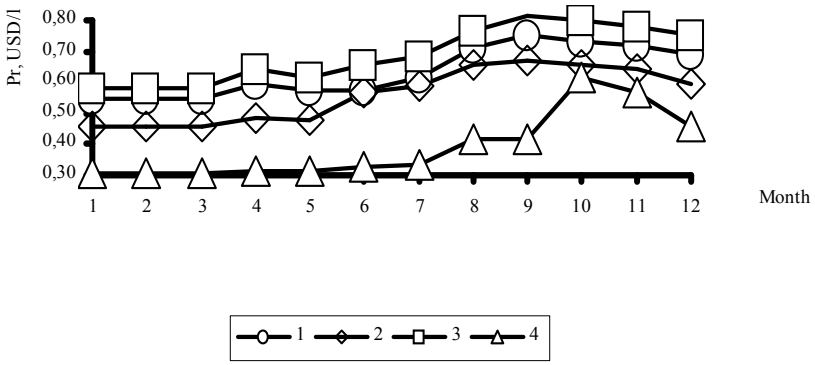

Fig. 2. Fuel price history in Ukraine in 2005: 1 – diesel fuel; 2 – gasoline A-80; 3 – gasoline AI-95; 4 – liquefied petroleum gas.

An increase of crude oil price results in an increase of the cost of diesel fuel (see Fig. 2) and, therefore, the production cost goes up. So, in 2005 the increase of fuel prices resulted in a subsequent increase of the fuel part in the production cost of winter wheat which exceeded 30%. One of the ways to reduce the fuel share in production cost of plant-growing is to apply cheaper fuel, including gaseous one.

The purpose of this paper is to estimate the efficiency of different types of gaseous fuel application in agriculture in Ukraine.

THE AUTHOR'S INVESTIGATIONS

Gaseous fuels have a number of important advantages over oil fuel, most importantly: ecological cleanness, increasing of engine and lubricating oil lifetime, less cost. Meanwhile, the application of gaseous fuel requires substantial capital investments in the re-equipment of tractor and truck engines and the organization of gaseous fuel supply.

As an engine fuel both natural and derivative gases such as compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (LPG), manure gas, hydrogen etc. can be used. Compressed natural gas and liquefied petroleum gas are more widespread as an engine fuel for a heat engine.

Liquefied petroleum gas

Gaseous fuel as a fuel for the internal combustion engines was used more than 100 years ago. Unlike methane, LPG possesses an ability to turn into liquid state at low pressure and at an ordinary temperature. It makes it transportable like the traditional types of liquid fuel. In gas-fueled tractors and trucks the gas is kept in a thin-walled gas cylinder at working pressure 1,6 MPa. In the USSR the first gas-fueled tractors were created in the 1930s. After World War 2 gases modifications of tractor D-54 were developed. The power of gas engine is equal or higher than that of its fuel oil version. Specific fuel consumption in gas version engines is not bigger than in oil fuel version diesel.

A diesel engine on LPG can work both with external mixture and a direct injection. But its price is too high. That is the only thing why LPG is not used as fuel in diesel engine.

The cost of energy of fuel can be determined by a formula

$$CE = \frac{1000 \cdot Pf}{\rho \cdot Q}, \text{USD/GJ}, \tag{2}$$

where:

Pf – cost of fuel, USD/m^3;

ρ – density of fuel, kg/m^3;

Q – the lower heating value of fuel, MJ/kg.

In December 2005, the cost of energy of diesel fuel and LPG was equal to 19.56 and 20.42 USD/GJ respectively.

As to using LPG in trucks powered by petrol engines, the situation is somewhat different. In spite of a bit greater expense of gaseous fuel on a 100 km of run (approximately 15%), there is a positive economic effect due to its lower price. So, for trucks GAZ-53 and GAZ-3307 the fuel consumption goes down on 1.33 USD per 100 km. At

the cost of the re-equipment of these trucks of $340, the capital investments are covered at a run of 25564 km. For comparison, in agriculture the mean value of normative daily run of a truck is 147…170 km

For providing the reequipped trucks with a gaseous fuel it is necessary to have a mobile gas refueller (the cost is about $15.000). The calculations show that such a project will be paid off if a project life is not less than 10 years and not less than 4 trucks type of GAZ-53 or GAS-3307 type are reequipped. The economic efficiency of the project will be substantially increased if the run of trucks becomes longer or trucks with more fuel consumption are reequipped with gaseous fuel, for example, ZIL-130, ZIL – 431410 etc.

Manure gas

Manure gas is one of the possible sources of renewable fuels for agricultural vehicles. Manure gas is a product of anaerobic fermentation of the waste of organic and vegetable origin. Besides the production of combustible gas and fertilizers the manure gas power plants (MGPP) perform the role of cleaning stations, reducing bacterial pollution of soil, water and air. The process of enlargement of the manure gas stations is being observed in Europe and North America.

In 2004 in Ukraine, the first large manure gas power plant was built on a pig farm of the company «Agro-Oven», Dnepropetrovsk region. UkrNIIagroproekt made the design of MGPP, the equipment was delivered by the BTG (Netherlands) company, mounting, starting-up and adjustment work were executed by the specialists of BTG and Research Center «Biomasa» (Kiev). This MGPP is intended for the treatment of 80 ton/day of the dung flows from the farm with the total number of 15.000 pigs. The project output of manure gas is 3300 m^3/day. The manure gas is used as a fuel for two cogenerator sets with electric power 80 and 160 kW. The basic economic data of MGPP are shown in table 2 [Geletyha *et al*. 2005].

Table 2. The basic economic data of MGPP

Item	Units	Value
Capital investments	thousand USD	413.3
Annual operating costs	thousand USD	21.22
Annual output:		
electricity	thousand USD	41.38
heat energy	thousand USD	5.60
mineral fertilizers	thousand USD	25.00
Total annual income	thousand USD	71.57
Pay back period	year	8.14

The operation experience reveals the problem with the sale of the electric energy to the national grid. It substantially reduces the economic efficiency of the project.

The content of methane in the manure gas is 55–60%. It allows using it as the engine fuel for the tractor diesels working on a gas-diesel cycle. This MGPP can produce up to 1 million m^3 of manure gas per year at the price of 39 USD per m^3, that corresponds to the cost of its energy of 2.11 USD/GJ. This volume is equivalent to 550,000 m^3 of natural gas. The cost of manure gas energy is considerably lower than the similar

index of diesel fuel ($19.52/GJ) and natural gas imported in 2006 (cost of DAF $2.82/GJ).

An application of the received manure gas as an engine fuel for tractor diesels allows to get an annual economic effect at the level of $322.000 and to provide annual necessity in gaseous fuel for 11 tractors of the 3rd category in accordance with ISO 730/3-82. The realization of this step will demand additional capital investments up to $120.000. As a result, the pay back period of joint project (MGPP and tractors) will be reduced to 1.6 years.

Tractors with gas cylinder equipment can be used both for maintenance of livestock-raising complex (T-16M, T-25) and for the field work in the production of forages. In accordance with the information agency of «ProAgro», at the end of 2005 the potential productivity of manure gas plants in Ukraine was equal to 900 million m^3 of natural gas. The growth of the production of meat per person to the European level will increase their productivity up to 2.7 billion of m^3.

Natural gas

The discovered supply of natural gas considerably exceeds the supply of crude oil. Shebelinka gas field is the largest (390 billion of m^3) in Ukraine. Ukraine meets the demand in natural gas due to its own resources by more than 20% (see Fig. 3).

In spite of the fact that the world prices for natural gas are rising it remains one of the cheapest types of fuel. The mean value of cost of the imported natural gas (USD per 1000 m^3) on the border of Ukraine is equal to: in 2004 – 62; in 2005 – 63,7; in 2006 – 95. One of the main reasons why farmers do not use CNG as an engine fuel is the problem of supplying this kind of fuel. There are two ways of its solution. The first is the application of vehicle gas refueling compressors units (VGRU) and the second is the application of movable vehicle gas refuellers (MVGR).

For the realization of the first method it is necessary to have a medium-pressure (0.3 MPa) pipeline on the farm. From all variety of VGRU the most acceptable plant for agriculture is SKIF-3 (Ukraine). Its productivity is 3000 m^3/day. It costs $188.000. This complex can provide for the annual necessity in the gaseous fuel for a farm having up to 30 tractors of 3rd category according to ISO 730/3-82.

The calculations done according to the prices of December 2005 (the natural gas price was $100/$m^3$ in the medium-pressure pipeline) show that the realization of this decision will be profitable if VGPU services not less than 3 tractors. The application of VGRU is the most expedient on the large farms, for example, on the State Research Farm «Sonyachne» (Mykolaiv region). The farm has more than 30 tractors. In this case the project is less sensitive to an increase of natural gas price (see Fig. 4).

For providing the vehicles with natural gas agricultural enterprises can apply MVGR, for example, PAGZ-2500-250. The refueller cost is $60.000, the volume of the transported gas – 2500 m^3, the coefficient of emptying – 60%. The MVGR can refuel about 10 tractors of T-150K by CNG. Thus, the annual economic effect (at the retail price of natural gas at the Vehicle Gas Compressor Filling Stations of 240 per 1000 m^3) will make up $60.690 and pay back period – 1.8 years. The project achieves a break-even point at the retail price of gas of 405 USD per 1000 m^3.

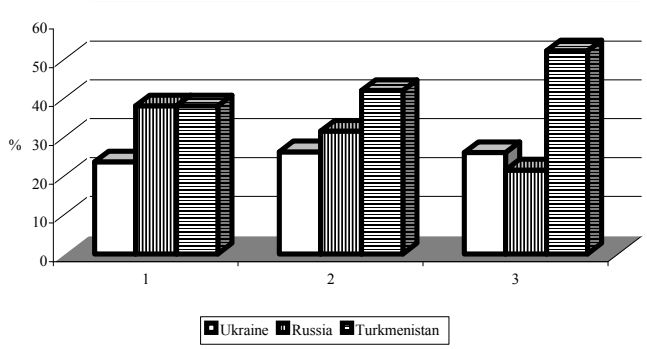

Fig. 3. Balance of natural gas in Ukraine: 1 – 2004; 2 – 2005; 3 – 2006

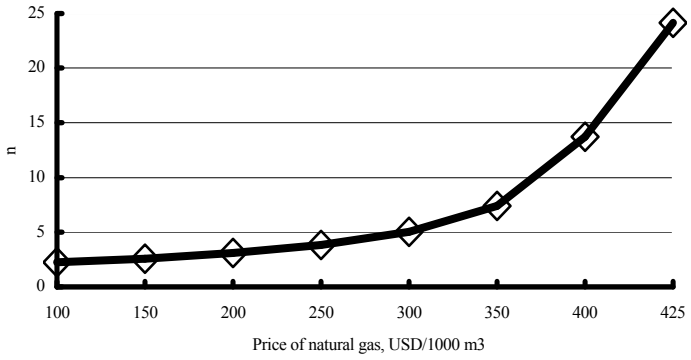

Fig. 4. Dependence of the minimum amount of tractors n serviced by VGRU on the price of natural gas

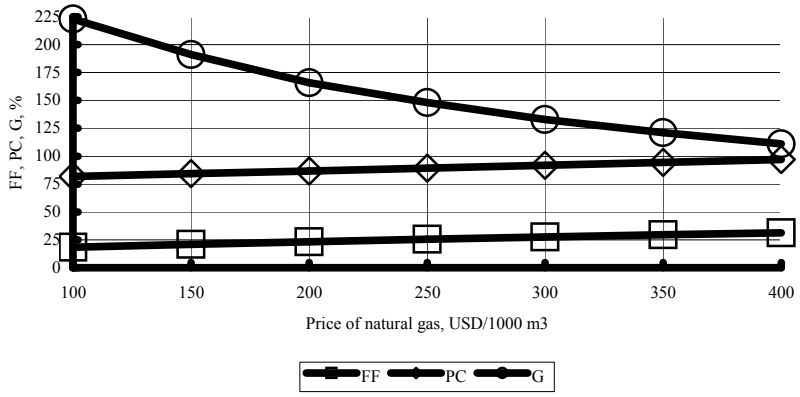

Fig. 5. Dependence of relative values of production cost of winter wheat PC, fuel part in the production cost FF and coefficient of fuel efficiency G on the price of natural gas

The application of gaseous fuel can substantially cut the production cost in agriculture. The dependence of relative values of production cost of winter wheat PC, fuel part in production cost FF and coefficient of fuel efficiency G on the price of natural gas is presented in Fig. 5.

CONCLUSIONS

1. The application of LPG as a fuel for tractors is not economically effective. This kind of fuel gives positive result in trucks powered by petrol engines.
2. The application of manure gas as an engine fuel for trucks and tractors is more efficient than its use in the cogenerator sets.
3. The application of CNG as an engine fuel will be advantageous if the price of natural gas in the medium-pressure pipeline does not exceed 425 USD per 1000 m^3 (if VGRU is used). The efficiency of the application of MVGR is limited by the retail price of the compressed natural gas (405 USD per 1000 m^3).

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