

## WAYS TO IMPROVE ENERGY EFFICIENCY BY REDUCING FUEL CONSUMPTION

### Summary

*This article presents in a synthetic way the energy efficiency in agriculture. A special role has been given to fuel use in agriculture. Basing on a Swiss analysis about one third of the total energy consumption needed in agriculture has to be spent only for fuel. There are some ways that can be used to reduce the amount of fuel used during work operations. These methods typically are used during traveling and working in the field. Article presents the most common solutions used in agriculture: keeping the engine in good condition, reducing engine speed, reducing the wheels slip, optimizing machine and implement settings, efficient work in transport, working depth adjustment, proper engine speed, the correct driving technique, ballast loading adjustment, tyre pressure and engine speed adjustment, eco-driving.*

**Key words:** agriculture, energy efficiency, fuel consumption, energy saving methods

## SPOSOBY PODNOSZENIA EFEKTYWNOŚCI ENERGETYCZNEJ POPRAZ OGRANICZENIE ZUŻYCIA PALIW

### Streszczenie

*Artykuł w syntetyczny sposób przedstawia problem efektywności energetycznej na przykładzie sektora rolnictwa. Szczególną rolę poświęcono problemowi zużycia paliw w rolnictwie. Przedstawiono kilka sposobów, które mogą zostać zastosowane w celu zredukowania ilości wykorzystywanego paliwa podczas wykonywania operacji rolniczych. Wspomniane czynności najczęściej dotyczą transportu drogowego oraz pracy w polu. Do najczęściej stosowanych można zaliczyć: utrzymanie silnika w dobrym stanie technicznym, zmniejszenie oporów ruchu, ograniczenie poślizgu kół napędowych, właściwie dobrane narzędzie robocze, poprawne ustawienie narzędzia roboczego, zarządzanie pracą w polu, efektywna praca w transporcie, dobranie właściwej głębokości roboczej, właściwa prędkość obrotowa silnika, poprawna techniki jazdy, eko-jazda.*

**Słowa kluczowe:** rolnictwo, efektywność energetyczna, zużycie paliw, metody oszczędzania energii

### 1. Introduction

EUROPA 2020 strategy is a strategy of continent development which underlines the fact that Europe should develop in a sustainable manner with strong public involvement. As a part of the strategy the following areas of improvement were defined:

- society (level of living),
- energy,
- ecology,
- environmental protection technologies - possibility of sustainable development environment,
- natural resources and new materials,
- economic growth,
- infrastructure.

Experts estimate that thanks to the Strategy Europe 2020 towards Poland occurs possibility of upgrading research and development infrastructure and energy. From the Polish point of view extremely important seems to be the European Union assistance, both in the form of legal and financial adjustments. Expenses associated with implementation of energy-climate package are very high. The new strategy is to provide Europe with a new dynamic. It needs to combine the principles of the social market economy and a strong eco-friendly attitude. It is a goal that requires the mobilization of the entire Community [8].

The European Union acts towards the economic growth, with a strong priority on environmental protection and sustainable development. In connection with economic development, energy needs are still increasing.

In the current situation, crucial part of the activities is to support all kinds of initiatives that may directly or indirectly contribute to the development of innovative solutions related to the energy issues. The studies carried out in the framework of the Operational Programme Innovative Economy show that environmental and energy related issues still play a marginal role for the Polish society. Polish people remain essentially indifferent to the efficient and ecological use of energy. According these research results, it becomes extremely important to popularize this issue. Nowadays, it could be hard to reduce energy consumption. One thing that should be done is changing its model. Each resource saving, multiple usage or reprocessing have a positive impact on the environment and contribute to the economic growth [5].

### 2. The energy situation in the agricultural sector

The activities at the local level should provide information on the available techniques to improve energy efficiency, transport and the energy consumed by technical equipment. Changes in the agricultural sector in the 90's, initially did not contribute to the decline in energy consumption.

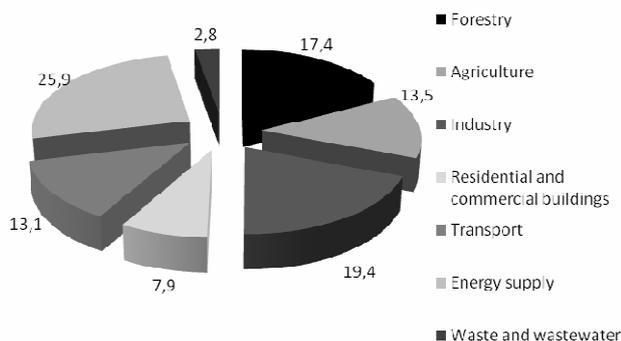
In the European Union, there is an urgent need to improve the energy efficiency, especially by end-users. Improving energy efficiency leads to a reduction in the energy intensity of the economy, which is a precious phenomenon from many points of view. Reducing energy process will not reduce the competitiveness of industry, agriculture,

transport, etc. (such as emissions charges that are problematic). In order to provoke rational decisions about energy use, end-user should be provided with valuable knowledge and taught taking appropriate actions. The awareness of energy consumption and the possibility of obtaining information on available energy efficiency improvement measures, technical parameters of machines, vehicles and equipment that consumes energy, is one of the priorities to which we should strive [1].

The current situation shows that among selected European countries, Poland has relatively high energy consumption in the agricultural sector. The high share of Polish agriculture in the total energy consumption by the national economy compared with other EU countries may be caused by two basic facts:

- 1) higher than in other countries, the share of agriculture in GDP - Poland 4%, Italy 2%, France 2%, 1% Germany, Austria 2%, 1% Belgium, United Kingdom 1%) [3],
- 2) The lower efficiency of obsolete tractors and machines that Polish farms are equipped with.

Agriculture is a sector of the economy, which consumes large amounts of energy and that has a very strong impact on the environment, water quality, soil, air and biodiversity. The key role of agriculture is providing food for the human population. This sector is a major energy consumer and causes significant greenhouse gas emissions. (see Figure 1).



Source: author's own study based on [7]

Fig. 1. The share of the economy sectors contributing to global greenhouse gas emissions

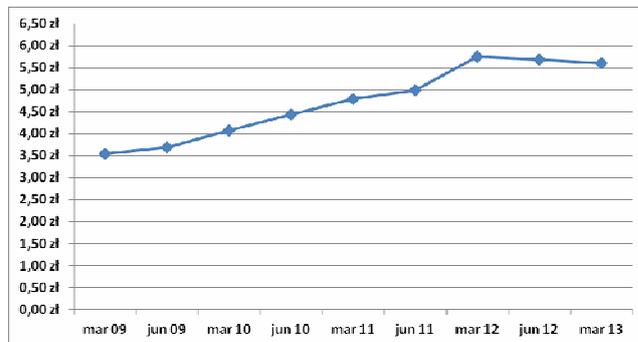
Rys. 1. Udział poszczególnych sektorów gospodarki w globalnej emisji gazów cieplarnianych

### 3. Small changes, big benefits in reducing energy consumption

The situation in the fuel sector clearly indicates that reduction of fuel consumption, can lead to significant cost savings. Fuel prices in the past few years have increased significantly throughout Europe. This upward trend persists (see Figure 2).

At a price of around 4 PLN per liter (excluding VAT), fuel costs represent over one-third of the total cost of ownership of an agricultural machine. In the case of continuous increase in fuel process, the ratio may rise and account for up to 40-55% of all operating costs (see Figure 3). This is why the reduction of the fuel consumption has a strong economical significance on the overall costs.

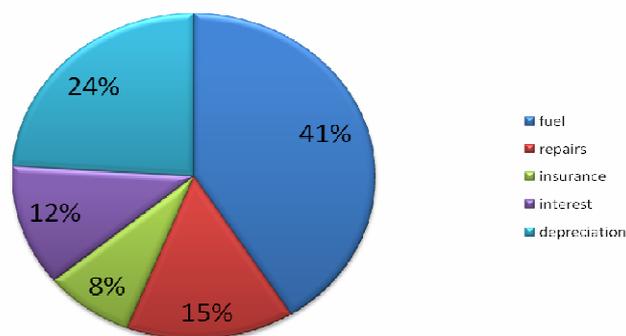
Sometimes, in order to obtain this goal there is a need to make some small changes in the form of simple, common sense actions.



Source: author's own study based [4]

Fig. 2. Changes in fuel prices 2009-2013

Rys. 2. Zmiany cen paliw w latach 2009-2013



Source: author's own study based on [9]

Fig. 3. The costs of the tractor use

Rys. 3. Koszty użytkowania ciągnika

### 4. Where and how can you save fuel?

This is the essential question asked by many people today. In business practice, there are many ways that enable the reduction of energy consumption and reduce significant costs. Also in agriculture number of treatments that improve the process of reducing energy use were identified. One of such examples are the initiatives aimed at reducing fuel consumption. A few simple operations are worth mentioning:

- Maintaining the engine in good condition.
- Optimizing machine settings.
- Implements adjustment.
- Ballast loading adjustment.
- Eco PTO and driving speed.
- Working depth adjustment.
- Reducing engine speed.
- Tyre pressure adjustment.
- Eco-driving.

### 5. Driving techniques in transport

Transport in agriculture seems to be very often overlooked issue. It is however crucial, especially for such agriculture model, which is characterized by a highly fragmented agricultural land. The use of fuel during transport can be a significant cost of operation for the farm. Therefore, one of the most important issues is the use of simple techniques that can reduce fuel consumption. This includes, for example, reducing engine speed and power take-off. An important issue is the technique of driving in transport

which concerns quiet, smooth ride, shifting at about 1600 rpm, correct tyre inflation (about 1.5 bar) and no unnecessary ballast. According to the conducted studies, these simple treatments provide fuel savings of 5-10%.

## 6. Work in the field

Soil tillage is an essential agricultural operation used to break down heavy soil, control weeds and mix the soil with plant debris. There are many types of agricultural operations such as shallow plowing, deep or shallow stubble, etc. The target is to put the roots (previous crop) in contact with open air and sunshine, to ensure their destruction. The fuel consumption varies considerably according to the depth of work and the nature of the soil (structure, texture, presence of stones, etc.). The research on fuel consumption while working in the field shows the importance of applying some minor techniques in order to obtain fuel savings that can be significant.

One of them is combining several working operations. For example, the combination of cultivation and sowing helps to reduce fuel consumption by nearly half compared to the situation when these processes run separately.

Further techniques that can reduce fuel consumption may include appropriate axle load distribution. This leads up to 20% fuel savings.

One of the methods used in order to reduce fuel consumption is ballast loading (see Figure 4). There is an overall principle to boost ballast to increase tyre grip when the tractor is working hard on the field and remove ballasts to reduce excessive load transport. In the case of small tractors wheel load required for traction forces should be adapted to the actual needs by adding weights in order to reduce slipping. For reasons for the soil protection, the tractor should be loaded with additional ballast only when necessary. It helps to reduce excessive wheel slippage and reduce fuel consumption by up to 10%.



Source: author's own study based on [2]

Fig. 4. Example of ballast loading  
Rys. 4. Przykład obciążenia balastowego

An important action, which is often overlooked is the proper adjustment of engine speed. Many farmers drive tractor guided by the noise of its work, which usually leads to work at around 400 rpm higher than the level for optimal power and fuel consumption. Reducing the engine speed frequently provides to the same power with less fuel consumption (See Table 1). According to the results obtained from the European project „European Farmers and Foresters Involved for Contributing to an Intelligent Energy Network towards target of 20% reduction in fuel consumption (Efficient 20)” there are fuel savings ranging from 6.5%

(for plowing hard work, work with cultivator) to 26% (light work, for example: fertilization, seeding, transport). Farmers should pay more attention to engine speed than to the engine noise. Driving with a lower engine speed is recommended in all situations where the driver can control the motor speed. This provides significant fuel savings in many areas.

Table 1. Effect of RPM on fuel consumption  
Tab. 1. Wpływ obrotów silnika na zużycie paliwa

Operation PLOUGHING		
Fuel consumption [L/ha]	Engine speed [rpm]	Solution used
22,1	2000	None
20,3	1400-1500	Eco-driving
19,2	1400-1500	Eco-driving, tyre pressure adjustment

Source: author's own study / Źródło: opracowanie własne

One of the most important issue leads to fuel savings is appropriate tyre choice, which can give fuel saving at the level of 10-15%. Another is correct tyre inflation (see Figure 5). This method has a major impact on fuel consumption, while being easy to apply thanks to the widespread use of compressors on modern tractors. Farmers, using this method, are able to save up to 10% of fuel.



Source / Źródło: [9]

Fig. 5. Adjustment of the tire pressure  
Rys. 5. Regulacja ciśnienia opon

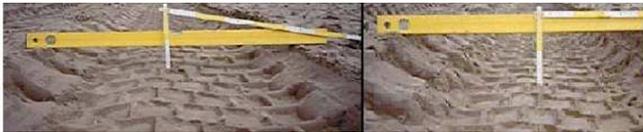
To avoid the risk of damaging tyre, it is worth getting technical advice from the tyre manufacturer about the recommended pressure for specific axle weights and types of work. Depending on the application used, fuel savings due to the adjustment of the tyre's pressure can reach up to 15%. It is important that the driver should be well informed about the properties of the selected driving mode and aware of its consequences.

One of the most important factors is adjustment of the working depth. In order to verify the impact of this factor on reducing fuel consumption two working depth settings have been tested:

- 1 > Working depth at 20 cm to realize a shallow ploughing,
- 2 > Working depth at 12 cm to destroy the previous crop of wheat and to bury poultry manure.

The operator noticed a difference in fuel consumption by 26% between the mentioned operations carried out using the same implement, but operating at different depths. The study shows that it is worth spending some time to set the correct working depth (See Figure 6), cause the fuel savings are significant.

In the case of work in the field the working width of the implement used seems to be an important factor. This method can bring fuel savings up to 40%.



Source: *Training handbook\_fuel saving methods\_Efficient20* [9]

Fig. 6. Adjustment of the working depth  
Rys. 6. Dostosowanie głębokości roboczej

## 7. Summary

Energy efficiency is a problem which should be key issue to everyone - producers, consumers, local and central governments. It is one of the most important elements of the environment which we all live in. The effective cooperation between the various sectors of the economy turns out to be very important nowadays. Creation of the relationships that allows the exchange of mutual experience on energy efficiency is very welcome. Also in agriculture, energy plays a key role. In order to optimize the costs related to agricultural activity, it is a need to reduce energy consumption, which is one of the significant cost-causing factors. Therefore, the small changes turn out to be extremely important. In the long term it allows to make considerable savings and achieve measurable economic benefits. Ways to improve energy efficiency presented in this article show meaningful impact of fuel savings activities.

The more recent and comprehensive data on energy consumption, the better the decisions and the better strategy for the efficient use of energy can be applied [6]. Everyone who wants to contribute to the improvement of energy efficiency and keep the Polish assumptions of the climate and

energy package should be led by these principles. Such attitudes have a positive impact on our environment.

## 8. References

- [1] Dyrektywa 2006/32/WE Parlamentu Europejskiego i Rady, z dnia 5 kwietnia 2006r. w sprawie efektywności końcowego wykorzystania energii i usług energetycznych oraz uchylająca dyrektywę Rady 93/76/EWG, s. L 114/64-114/65 energy end-use efficiency and energy services - Moving forward together on energy efficiency.
- [2] Farmers brochure "Put your tractor on a diet" Merle S., Lopez A., Ellis D., Handler F., Radniecki J., Gościańska J. ed al.: European Farmers and Foresters Involved for Contributing to an Intelligent Energy Network towards target of 20% reduction in fuel consumption (Efficient 20). Projekt finansowany ze środków Executive Agency for Competitiveness and Innovation, w ramach programu Intelligent Energy Europe, 2007-2013.
- [3] <http://data.worldbank.org/indicator/NV.AGR.TOTL.ZS>
- [4] [http://moto.money.pl/ceny-paliw/#polska,0,olej\\_napędowy](http://moto.money.pl/ceny-paliw/#polska,0,olej_napędowy)
- [5] Krawczyk B.: Oszczędzajmy zasoby. *Ecomanager*, 2011, 11-12.
- [6] Maciak A.: Oszczędności dzięki monitoringowi energii. *Przemysł, Środowisko, Zarządzanie*, wrzesień-październik 2011, s. 40-41.
- [7] Norse D.: Low carbon agriculture. *Environmental Development* 2012, 1, 25-39.
- [8] Szyjko C.T.: Strategia „Europa 2020” a wyzwania energetyczne Polski. *Czysta Energia*, 2011, 11, 14-16.
- [9] *Training handbook\_fuel saving methods*; Merle S., Lopez A., Ellis D., Handler F., Radniecki J., Gościańska J. ed al.: European Farmers and Foresters Involved for Contributing to an Intelligent Energy Network towards target of 20% reduction in fuel consumption (Efficient 20). Projekt finansowany ze środków Executive Agency for Competitiveness and Innovation, w ramach programu Intelligent Energy Europe, 2007-2013.