SUSTAINABLE ENERGY SUPPLY FOR AGRICULTURAL MACHINERY THE SESAM VISION

Peter Pickel

John Deere

1. Introduction

Sustainable energy supply from renewable resources will be one of the top issues of society and of environmental policies in the long term. Agriculture should be a key driving force for renewable energy, because it is the sector which not only consumes, but also has the potential to produce large amounts of renewable energy which will be the most important non-food product of agriculture.

The energy balance of agricultural production systems is generally positive, while costs for energy from fossil sources (e.g. fuel) and energy equivalent inputs (e.g. fertilizer) are continuously increasing. Therefore, farmers increasingly establish own energy production lines to substitute fossil energy sources. Energy production is becoming more and more an integral part of agricultural production systems.

Due to the characteristics of energy consuming applications, two basic types of energy supply can be distinguished. The first type is energy supply to stationary applications. The second type is energy supply to mobile machinery which is technologically challenging with respect to the (electric, chemical, or electro-chemical) energy carrier needed to bring the energy onto the vehicles.

2. Biofuels

Regenerative energy for stationary applications is mostly gas, electrical power or heat at low temperature levels. These forms of energy are generated and supplied on farms on the basis of decentralized power stations. These power stations use either organic materials (for biogas production) or wind or solar radiation as energy source.

Today, mobile applications mostly need chemically bound energy such as fossil or biofuels. The use of regenerative energy in mobile applications is still restricted due to technological reasons and due to limitations of production of bio-fuels caused by the high amount of farmland needed. Nevertheless, the use of bio-fuels in agricultural equipment still is a highly promising option for meeting climate protection requirements. Especially pure vegetable oil is an interesting candidate among biofuels because the production can be done on the farm itself from the field into the tank. Under certain conditions when produced decentralized rapeseed oil, which is predominantly used in Central Europe, allows for green house gas emissions (GHGE) savings of 60% compared to diesel fuel and thus can meet minimum GHGE saving that will be compulsory from 2018 on according to the Renewable Energy Directive 2009/28/EC [see Stöhr, Pickel 2012]. Besides the obviously broad ecological benefits due to the carbon footprint, pure vegetable oil offers an enormous economic potential for agricultural. This is especially true in decentralized supply chains [CEMA, CECE 2011, Dieringer, Pickel,2012].

To enable the use of such cold pressed vegetable oil fuels, modern engines have to be adapted and the fuel itself has to fulfill some strict quality requirements in order to ensure a reliable long term operation of the engines [Dieringer, Pickel,2012]. John Deere received the Gold Award at the SIMA 2013 fair in Paris for a prototype Multifuel tractor concept. This tractor adapts automatically to various types of mineral and biofuels and is a one-tank-solution for diesel and diesel substitutes such as biodiesel, biofuels or any blends of these fuels. Thus, the multifuel tractor provides a convenient, flexible and highly cost efficient solution when using bio-fuels such as pure plant oils (PPO) in agricultural equipment and for meeting climate change protection and greenhouse gas emission reduction requirements.

Figure 1. John Deere Multifuel tractor

The self supply with vegetable oil fuel will require only about 10% (or even less) of a farmer's acreage. This is a similar ratio as was used in pre-industrial times for the production of feed for draft animals. Knowing that Europe is importing 80% of its required plant proteins, the vegetable oil production can be seen the other way round. When pressing the oil seeds, only one third of it will be retrieved as oil. Two thirds of the seeds will be the press cake, which is a protein feed that can replace protein imports, for example soya from the American continent. Thus the oil can be seen as a by-product of the more and more relevant protein production, see Figure 2. Here, one could even consider the social aspect of sustainability, which due its abstract nature is not yet to be evaluated by a particular method, and make the assumption, that it will not be compromised trough excessive use of land territories for production of fuel instead of food.

Figure 2. Usage of the whole seed for food and fuel

Thus, the usage of Vegetable Oil Fuel improves the environmental performance within the use phase. A holistic approach for an environmental optimization has to start in the early lifecycle phases, when the physical product does not yet exist. The availability of options for improvement, which promise much greater effect, is much higher within the product development phase compared to the others life cycle phases. An extensive LCA could also deliver reliable information on economical and social impact of solutions such as vegetable oil fuels and many others developed by the agricultural and construction machinery industry [CEMA, CECE 2011].

3. The electrical pathway

If electricity from wind or PV installations would be used to supply the energy for mobile applications, even less (farm)land would be needed per driven unit distance compared to mobility where biofuels are used in combustion engines. This is because electric engines are 3 times more efficient than combustion engines and wind and PV installations need 10 times less land area to produce the same amount of energy as biofuels. Therefore, the transfer of energy from stationary regenerative power stations into mobile applications would have a very high ecological and energetic potential.

Furthermore, wind energy and PV installations are dramatically increasing and already lead to electric grid bottlenecks in some areas. This is typically the case in rural areas with weak electric grids where agriculture is predominant. Hence, more local use of renewable electricity in such areas and applications with inherent storage systems, e.g. with electric vehicles, can reduce the need for quick and strong grid extensions and improve the overall economy of enhanced renewable energy use.

While on the short and mid term combustion engines will stay the the fundamental drive train technology, in the long run electric energy is expected to be the key energy form, and since electrification will be an enabler for automation and by this for higher precision and more sustainable farm operation, electric drives, storage devices and electric power supplies have highest potential for significant technological and market benefits. In 2007 John Deere for the first time presented a new tractor with a high voltage electric system supporting auxiliary drives with electric power. This E-Premium tractor was awarded with a gold medal at the Agritechnica fair 2007. The succeeding tractor (6RE series) is equipped with a high voltage electric connector to run electric implements.

John Deere has entered and several projects (LIB-Off-Road, eE-Tour, econnect, and SESAM) funded by the German Ministry for Economics (BMWi) described as follows. In the projects LIB-Off-Road, eE-Tour, and econnect Germany prototype hybrid tractors have been developed and demonstrated. All hybrid tractors use the E-Premium base machine as a design platform. SESAM aims at building a new full electric prototype machine.

3.1. The LIB-Off-Road project

Within the cooperative project LIB-Off-Road ("Einsatz von Lithium-Ionen-Batterien in Off-Road Nutzfahrzeugen zur Effektivitäts- und Autarkiesteigerung") a hybrid prototype tractor (Lithium-Ion-battery based) were developed, tested, and demonstrated.

3.2. Projects eE-Tour and econnect Germany

The project eE-Tour Allgäu ("Effiziente Elektromobilität und Tourismus") and the follow-up project econnect Germany are large scale projects to demonstrate e-mobilty in a touristic area and in collaboration utilising municipal, touristic, industrial, and agricultural infrastructure. The John Deere sub-project demonstrates the integration of battery driven tractors into medium-sized decentralised rural power grids. The electric energy storage on the agricultural production and transport vehicles would support smaller rural electric power grids for renewable energies. Thus, a strong positive impact on the development of rural areas and on the improved usage of electric energy from renewable resources shall be given.

The basic idea (here) is to attach an originally stationary used battery to a partially electric tractor (John Deere E-Premium or 6RE series) for mobile use. When being attached to the tractor this battery modifies the vehicle dramatically in different ways:

1. The battery replaces the ballast weight which the tractor needs anyways for many, many applications. So, the battery is not an obstacle as it could be in a car.
2. The battery is a completely new energy source on the tractor besides the diesel engine.
3. The battery changes the conventional tractor into a hybrid vehicle.

From this, some pretty valuable features can be derived:

1. The battery can be used as an energy carrier to bring renewable energy from stationary grid onto the mobile application replacing use of fossil diesel.
2. The tractor can be "boosted" (power can be added for a limited period).
3. Several applications could run with the diesel engine turned off avoiding parasitic losses (similarly as Nicolai explained before).
4. Energy can be regained (or as many say recuperated) e.g. when braking in transport operation or when running a loader application.

Figure 3. Integrated energy concepts for sustainable agricultural production – the SESAM vision

3.3. The SESAM project

Within the recently started project SESAM (Sustainable Energy Supply for Agricultural Machinery) for the first time at all a full (battery) electric tractor shall be build (as a prototype) and several extended power supply concepts will be investigated. Electric mobile agricultural machinery together with plant oil fired machine could contribute to an integrated sustainable solution for autonomous energy supply in rural areas in the future as illustrated in Figure 3.

5. Summary

The SESAM vision comprises an integrated or holistic sustainable solution for autonomous energy supply for future farms including there mobile machinery. SESAM prototypically will provide a new generation of drive train technology based on pure plant oils as diesel substitute on the one hand and electric drives on the other. Both integrated pathways for future energy use include the idea of decentralised production on local consumption of energy. Thus the energy paths are short and provide the best efficiency achievable.

6. References

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