European Agricultural Machinery

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Unleashing the potential of modern farm equipment for the Circular Economy

Benefits, barriers and recommendations to encourage sustainable agricultural systems in Europe

The European agricultural machinery industry represented by CEMA fully supports the concept of promoting the transition towards a Circular Economy.[1] Smart, dedicated machinery can be of great added value to this initiative and can also contribute significantly to reaching wider EU objectives such as the Energy Union, the EU's climate objectives and higher levels of resource efficiency.

By generating knowledge and offering innovative ways to transform agricultural commodities into a more suitable input for re-use initiatives, advanced farm machinery can make a difference for farmers and their contribution in the initiative. As such, the agricultural machinery industry is committed to being an active contributor to this process.

1. The specificities of agriculture need to be taken into account

Whenever – in the context of a Circular Economy approach – agriculture, farm machinery and agricultural vehicles are considered, the specificities of the agricultural sector must be duly taken into account. A number of fundamental structural differences exist between the agricultural sector and other production processes in the sense that:

- agricultural production processes are complex biological structures involving many different actors, products, and industries;
- agriculture is subject to a range of dedicated EU and national legislative provisions – including a unique subsidy scheme in the form of the Common Agricultural Policy (CAP) – all of which exert a strong impact on the way farming processes are conducted in Europe, including, for instance, the in-field use of agricultural machinery.

In light of the inherent complexity of agricultural production processes and the myriad of regulations governing them, it is of utmost importance that any future Circular Economy approach with regards to agriculture and agricultural machinery:

- fully respect the principle of subsidiarity;
- follows a sufficiently coherent and comprehensive approach which duly considers the multiple interdependencies along the agricultural production chain, rather than putting an isolated focus on specific parts of the production process without considering potential spill-over effects.

[1] See also CEMA's Position Paper *Promoting the Circular Economy in agriculture & agricultural machinery: the need for a smart, holistic approach to green products & processes* (October 2015): http://www.cema-agri.org/publication/promoting-circular-economy-agriculture-agricultural-machinery-need-smart-holistic

CEMA aisbl - European Agricultural Machinery
Bld A. Reyers 80, BE-1030 Brussels
T +32 (0)2 706 81 73 - F +32 (0)2 706 82 10
secretariat@cema-agri.org - www.cema-agri.org

2. Farm equipment: characteristics of capital goods & the need to put farmers at heart of any economic sustainable approach

In terms of Circular Economy initiatives, it must be pointed out that agricultural machinery are capital goods produced in low volumes which imply a relatively high cost of production. As a consequence, the upfront investment for customers is significantly high. It is important to note, farmers will only do the long-term investment if the added value is clear: increase environmental protection of farming areas, improve working conditions and sustain farmers' economic activities.

Farming is already a highly-regulated sector. In that sense, measures to further encourage a Circular Economy approach should provide farmers with the means that create new economically sustainable processes while considering key aspects such as protecting biodiversity, improving farming practices (e.g. water management, soil quality preservation) and creating a value in return to farmers and rural areas. To make these initiatives fully successful the farmer should be the central beneficiary of such an approach.

3. Circular Economy: the potential of modern farm machines

Modern farm machines can greatly contribute to Circular Economy gains in terms of waste reduction and agricultural residues re-use during food production process.

The use of more intelligent, efficient, and connected agricultural machines will allow a **precise and optimised use of resources** in a particular area, considering for example a specific soil composition or a water layer depth. Although technology advances fast, the renewal rate of farm machines is rather low. The average age of tractors in some EU countries is around 30-40 year and the situation is not much better for other types of equipment such as sprayers, seeders etc.

Digital Farming: enhancing the Circular Economy
The use of farm data, farm management information system and digital tools allows farmers to acquire an unprecedented level of knowledge about their crops, livestock, and operations and be more connected to the rest of the world. Access to digital tools can support farmers in:

- being more efficient in the use of resources (application of inputs, water management, protection of the soil) in agriculture and a better food production systems
- having a stronger role across the food value chain
- developing new business ideas related to waste valorisation practices such as bio-methane, pellets, bio-fuels[2].

This said, the potential of Precision Farming technologies is out there but according the latest EU information estimate that only 25% of EU farms use technologies which include a Precision Agriculture component[3].

Therefore, the inevitable **replacement of the old fleet of agricultural vehicles** pose a significant opportunity to incorporate simultaneously the necessary digital tools that can make the difference to improve farming practices and the Circular Economy.

[2] Ref. Annex I on Case Studies: farm machines contributing to a Circular Economy
[3] Precision Agriculture and the Future of Farming in Europe, 2016, STOA - European Parliament Think Tank

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Bld A. Reyers 80, BE-1030 Brussels
T +32 (0)2 706 81 73 - F +32 (0)2 706 82 10
secretariat@cema-agri.org - www.cema-agri.org

4. Investment intentions & barriers

4.1 Farm machinery tops farmers' investment list

On 12 September 2014, the Joint Research Center (JRC)[4], the European Commission's in-house science service, published a study on the investment intentions of European farmers in the period 2014-2020. For the survey, 780 farm-households in six EU countries (Poland, Italy, France, Germany, Spain and Czech Republic) were contacted.

Some of the main findings the study included were:

- 56% of farmers are intending to invest in the period 2014-2020.
- With 40.3 % machinery and equipment are ranked at the top of investments in the coming years followed by investment in land (21.0%), buildings (20.3%), and training (16.2%).
- Nonetheless 28% of the farmers are only intending to invest in one type of assets. Among those, 36% only intend to invest in machinery and equipment.

Why do farmers want to invest? According to the surveyed farmers the main benefits expected from investments are:

- improved working conditions on the farm and
- an increase in the production quality

To achieve these goals, investments in machinery and equipment would contribute to 52% and 24% respectively.

On the other hand, 43.5% of the farmers **do not foresee to invest** over the period 2014-2020. The main reasons given in the study are:

- uncertain expected returns on investment,
- no need for new assets and
- a lack of financial resources to invest.

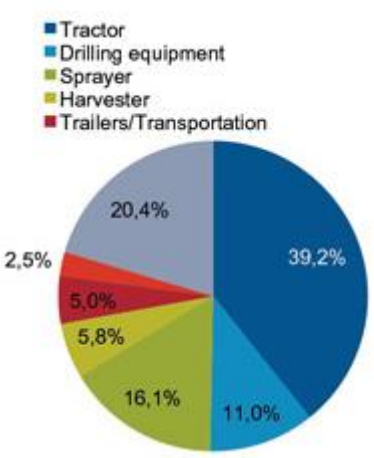
Regarding the question of financial resources, only 4 % expect to receive subsidies to upfront their investment.

Finally, the study showed there are big discrepancies between countries **in terms of interest to invest** due to the characteristics of the farm (size-income, input-output pricing) but also the differences between Member States on the functioning of their market. It was said that most interest exists with those farmers that are dependent on the CAP certainly for investment in machinery/equipment.

[4] European farmers' intentions to invest in 2014-2020, 2014, European Commission's Joint Research Center

CEMA aisbl - European Agricultural Machinery
Bld A. Reyers 80, BE-1030 Brussels
T +32 (0)2 706 81 73 - F +32 (0)2 706 82 10
secretariat@cema-agri.org - www.cema-agri.org

Figure 1: Intentions to invest in machinery and equipment type

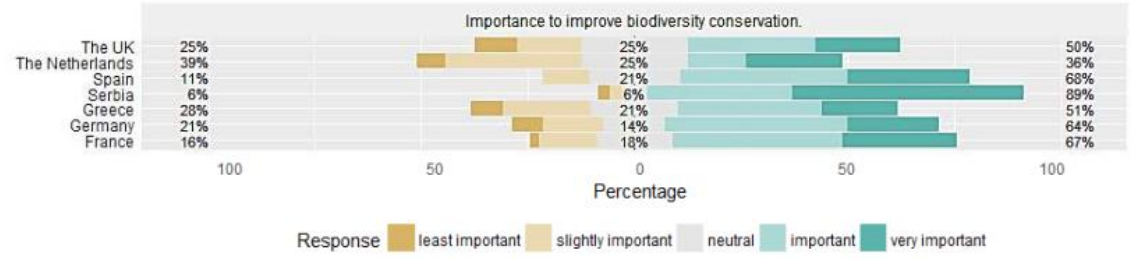


Source: EC's Joint Research Center

4.2 Farmers' willingness to improve biodiversity in the farmed environment

A study performed[5] by the H2020 Smart AKIS EU funded project (www.smart-akis.com) confirmed the positive attitude of farmers towards biodiversity conservation.

Figure 2: Farmers' ranking of the importance of improving biodiversity conservation of farms

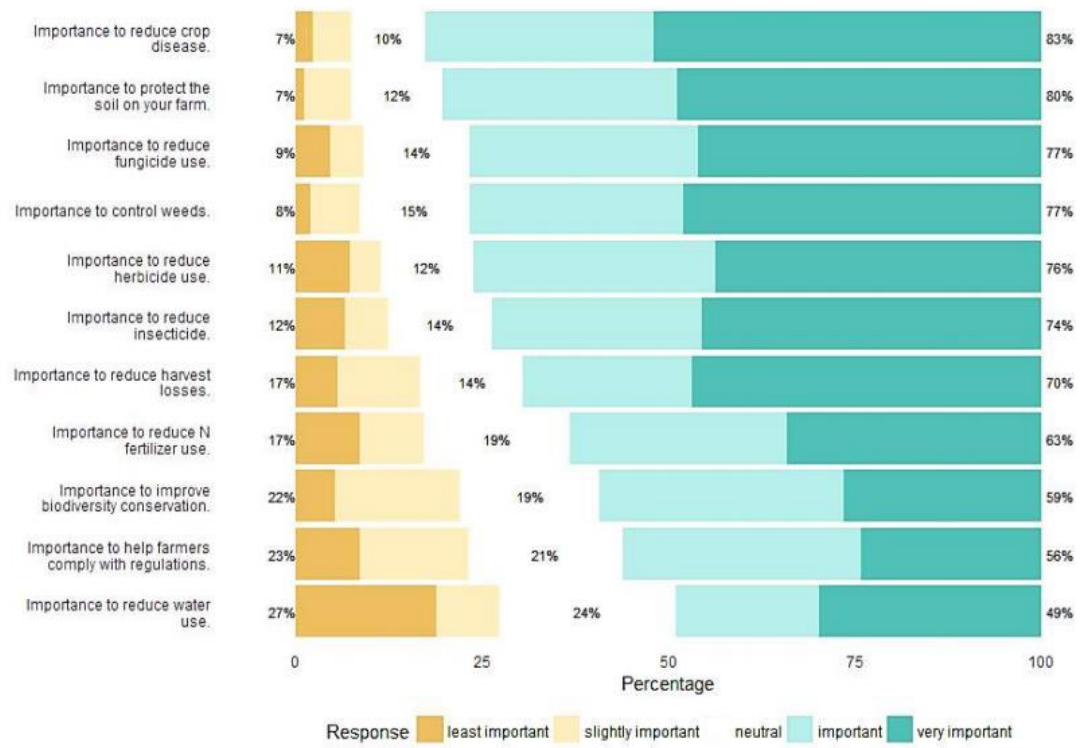


Source: Smart AKIS. CC BY 4.0

The study also surveyed about those challenges farmers face in agriculture and their importance according to them. Protection against crop diseases and harvest losses are very important for farmers as it can put their income at risk. At the same time the reduction of inputs like pesticides and fertiliser is gaining importance.

[5] Report on farmers' needs, innovative ideas and interests, 2017, Smart AKIS H2020 EU funded project

Figure 3: Farmers' perception of challenges in general across Europe



Source: Smart AKIS. CC BY 4.0

In a nutshell, investment intentions and actual market demand are different stories: on the one hand, farmers are very much willing to invest in new technologies and modern farm machinery as they see related benefits to reinforce sustainability in the farming areas while ensuring quality production and sustaining their economic activities. On the other hand, the lack of financial resources arises as one of the main barriers to renew the old legacy fleet and encourage the adoption of new technologies in European agriculture.

5. Other factors hampering the adoption of Smart Farming Technologies (SFTs) – the Smart AKIS report[6]

Farming is a complex activity and agricultural realities differ from one country/region to another and even between and within fields. The overall challenges seem to be similar across Europe even if farm size and crops may differ: reduce agricultural inputs, improve natural resource efficiency management and maintain the competitiveness of the sector.

The Smart AKIS EU-funded project tried to bring also clarity on other than the purely capital investment argumentation/factors that might hinder the overall adoption of Precision Farming Technologies in the agricultural ecosystem:

[6] Report on factors affecting adoption of innovation and dissemination processes in Smart Farming, 2017, Smart AKIS H2020 EU funded project

Socio-demographic & economic factors

- Different levels of education among farmers
- Farm size together with crop type
- Limited financial resources coming from farm incomes
- Recession period

Political factors

- CAP subsidies mainly used to support farmers' low income
- Reduction of advisory national services
- Rural development strategies not rightly oriented to facilitate access to SFTs e.g. due to bureaucracy

Societal factors

- Lack of reliable broadband access in rural areas
- Gap between research and real applications in farming
- Obsolete image of agriculture in Europe delivered by media and education
- Smart Farming Technologies available on the market more adequate for bigger farms

6. Recommendations to encourage the uptake of modern agricultural machines contributing to Circular Economy and sustainable farming processes

With regards to the Circular Economy, farming processes should therefore be assessed in greater detail by:

- gathering reliable information and data regarding the impact of the users of agricultural machinery: their expectations, behaviour and willingness to change;
- carry out an analysis to identify areas of true potential and possible ways to improve use patterns and to enhance innovative behaviour in the agricultural production process (to reduce or reuse agricultural residues).
- Such assessment should always integrate the economic aspects.

To promote the Circular Economy in agriculture and agricultural machinery, CEMA:

1. supports the idea of devising dedicated EU measures to promote research and innovation and encourage cooperation between relevant actors for instance trough the Horizon 2020 Programme.

2. Encourages public policies e.g. CAP to devise the adequate mechanisms for farmers to invest in farm technologies with proven environmental benefits that can greatly contribute to the optimization of agricultural residues while creating value for farmers.

3. Promotes the need to develop innovative systemic approaches and cross-sectoral cooperation. For the agricultural machinery sector, this would imply a twofold focus:
   - To deliver a healthier crop of higher quality with a minimised input (including all resources that have an impact on the environment as well as any energy resource necessary);
   - To be part of a smart open network of providers/interested parties that can work across sectors and processes to add value from waste, energy recuperation.

4. Encourages a further assessment of public policies to consider smart machines & intelligence gathered on the field can make a huge contribution to overall resource efficiency of the agricultural production process in the future.

5. Promotes the development of innovative business models for the Circular Economy, particularly to overcome the high costs to make the change-over to an agriculture 4.0. e.g. through machinery cooperatives or suitable incorporation of agricultural contractors.

6. Promotes the development of specific measures to encourage the uptake of Circular Economy ideas among SME's, more specifically to ensure SME's are included in new developments such as Internet of Things (IoT).

7. Encourages the take-up/consideration of the added value for end-users (or lack of it) as an important element in any cost-benefit analysis.

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CEMA aisbl - European Agricultural Machinery
Bld A. Reyers 80, BE-1030 Brussels
T +32 (0)2 706 81 73 - F +32 (0)2 706 82 10
secretariat@cema-agri.org - www.cema-agri.org

Annex I – Case Studies: modern farm machinery enhancing the Circular Economy

Sustainability & benefits of advanced farm machine technologies in Europe

This document provides three case studies regarding the sustainability and benefits of advanced farm machine technologies in Europe. The case studies focus on:

1. Advanced manure application equipment
2. In-field straw pelleting machine
3. Use of bioenergy in agricultural machinery (pure plant oil & methane)

Each of the case studies describes the sustainability and benefits of the technology, existing limitations/barriers to their use (e.g. scalability, cost etc.), and ways to address these barriers.

1. Advanced manure application equipment

1. Description of the technology

Manure is a nutrient-rich organic fertiliser. However, natural variance meant that there were difficult variations in manure fertilisation that could not fully be managed. With advanced manure application equipment farmers can now precisely apply the slurry, thereby reducing ammonia emissions and do so based on a nutrient target and limit rate in kg/ha and even utilise site-specific prescription maps.

The sensor in the manure application equipment automatically controls the desired nutrient application rates during application. Such a measuring instrument is based on NIR (Near-InfraRed Spectrometry) technology and can analyze the manure and valorize the Phospate, Nitrogen and Potassium contents in manure.

2. Contribution of this type of machine to Circular Economy with focus in agricultural processes

- Increase environmental protection: injection greatly reduces N loss during application (only 10% compared to upt to 70% in spreading) and thus helps to reduce ammonia emissions.

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- Improve sustainability of agricultural production systems: enables continuously controlled dosaging, based on nutrient levels (N, P, K); no varation between separate loads; no under- or overdosage.
- Increase farmers' incomes based on return of investments in such machines:
- Maximises yield and product quality while cutting substantial costs on mineral fertiliser later in the spring (and avoiding manure disposal costs).
- Ease of process: real-time analysis, replacing existing methods (laboratory samples no longer needed to control manure content)
- Automatic documentation and link to integrated farm process management (Precision Farming)

3. Availability of machines on the market

Yes, these machines are readily available on the market and are produced by different manufacturers.

3.1 If yes, how the idea emerged to build up such a machine?

- Specific request to cope with a challenge in a particular agricultural area: the machines were developed specifically to reduce ammonia emissions from organic fertilizer (through injection) and to analyse and control the exact nutrient content of the manure being applied in the field.
- What would be the expected demand by 2030? Demand is expected to rise in the coming years, as EU Member States are starting to tighten legislation on manure application (requiring immediate application through injection) and farmers now having the tools to control and manage the nutrient content in manure application.

4. Type of end-users (actual and/or future)

The machines can be used by all types of end-users, primarily by larger farms and contractors.

5. Use of the described technologies in European farming

- Northern Europe
- Crop types: arable crops (in combination with livestock)

Pictures of the machine: please click on below weblinks for images of the machines
Weblinks:

- https://www.deere.co.uk/en_GB/products/equipment/agricultural_management_solutions/precision_farming_solutions/manure_sensing/manure_sensing.page
- http://www.fliegl-agrartechnik.de/ultraschall-steuerung-bringt-perfekte-bodenanpassung-fliegl-slurryjib/150/4836/5251/
- http://www.veenhuis.com/products.asp?pagename=bemesters&pageType=products&categoryID=115

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2. In-field straw pelleting machine

1. Description of the technology

The machine produces pellets from agricultural feed crops directly from swath in the field. The pellets can then be transferred to a waiting truck by conveyor belt and delivered straight to the end customers who use them as fodder, bedding and of course, fuel for heating systems. It can also be used outside the harvesting season thanks to an optional bale shredder which converts it into a stationary pelletizer for year-round operation. The machine has a throughput of 5000 kg per hour, making it far more efficient than most conventional stationary pelletizers.

The pickup with a 2.35 m working width picks up the crop which is then transported from the feed rotor to a conveyor belt. The crop is forced through the matrix of perforations into the interior of the roller. After pressing the pellets are transported via an internal screw conveyor to a conveyor belt and from there, to an integrated hopper.

2. Contribution of this type of machine to Circular Economy with focus in agricultural processes

This innovation enables renewable agricultural raw materials and secondary raw materials to be used for energy generation, thereby reducing CO2 emissions. 2.5 kg of pellets can replace approx. 1 kg of heating oil, resulting in significant cost savings compared with heating oil and other fossil fuels. By integrating refinement processes (i.e. pellet production) on the farm, it can also contribute to diversify and solidify farm income.

3. Availability of machines on the market

3.1 If yes, how the idea emerged to build up such a machine?

- Specific request to cope with a challenge in a particular agricultural area: all-in-one automation of straw harvest to pellet transformation
- What would be the expected demand by 2030? Will depend on future emergence of pellet heating systems as part of a sustainable heating mix in Europe.

4. Type of end-users (actual and/or future)

The machine can be used by all types of end-users, primarily by larger farms and contractors.

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Bld A. Reyers 80, BE-1030 Brussels
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5. Use of the described technologies in European farming

- Northern Europe
- Crop types: arable crops

Pictures of the machine: please click on below weblinks for images of the machines

Weblinks
http://landmaschinen.krone.de/english/news/news-archive/news-archive-2015/gold-for-krone-premos/

3. Use of bioenergy in agricultural machinery (pure plant oil & methane)

1. Description of the technology

Several new innovative models exist to power agricultural machines with bio-based energy produced directly in a decentralized manner on the farm. Two of the most interesting and promising approaches are:

- **Plant-oil powered tractor:** certain tractor models today can already drive with either diesel, biodiesel, or pure plant oil. The machine automatically recognizes the fuel and the electronic control unit of the engine reacts accordingly so as to comply with the strict EU engine emission standards for off-road vehicles. Certain plant oil such as rapeseed oil is widely available across Central Europe and can often be sourced on the farm itself.
- **Biogas-powered tractor:** prototypes for methane-powered tractors have been developed. The methane can be generated through renewable biomass produced in a biogas plant available on the farm.

2. Contribution of this type of machine to Circular Economy with focus in agricultural processes

Apart from significant GHG emission reductions, bioenergy-powered tractors have multiple secondary benefits for farmers and the world of agriculture such as:

- turning farmers into energy providers;
- providing farmers with valuable additional income streams;
- helping to bridge the gap that Europe has in locally sourced high-protein animal feed
- reduction of Europe's dependency on fossil fuel imports
- stimulation of jobs, regional development, and rural industry in Europe

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Plant-oil powered tractor: Rapeseed plants not only provide food for the tractor but also feed for animals. Only one third of the rapeseed is made up of oil, the remaining two thirds can be turned into rapeseed press cake which is purely made up of vegetable protein and thus presents an equivalent alternative to soy feed. In other countries and continents, sun flowers, soy or cotton could be used in a similar way.

Biogas-powered tractor: Methane propulsion technology offers various environmental advantages including emissions 80% lower than a standard diesel engine. When using bio-methane, the machine's carbon impact is virtually zero, and cost savings between 25% and 40% can be achieved when compared with conventional fuels.

3. Availability of machines on the market

3.1 If yes, how the idea emerged to build up such a machine?

Plant-oil powered tractor:

- Wider user demand: demand will grow/fall depending on the price level of operating farm machinery with conventional diesel.
- Public scheme: in different German regions (Länder) such as Bavaria or Rhineland-Palatinate, the purchase of a plant-oil powered tractor is supported by a direct government subsidy.
- Specific request to cope with a challenge in a particular agricultural area: decentralized energy supply, Circular Economy, reduction of GHG emissions.
- What would be the expected demand by 2030? Demand will greatly depend on the future price level for conventional diesel and governmental subsidy policies for both conventional diesel and bioenergy use in agriculture. Demand will be weaker if prices for conventional diesel will remain low and subsidies for use of conventional diesel in agriculture will be maintained. In case cost for conventional diesel will rise and subsidies for its use in agriculture will be reduced/abandoned, bioenergy-powered tractors could become an economically more attractive alternative for farmers.

3.2 If not yet available on the market

Biogas-powered tractor:

- What are the main barriers encountered for this type of machines to reach a larger commercial base? Higher upfront investment (initially), comparative costs vs. tractors powered by conventional diesel.
- How to encourage a further uptake of these types of technologies in European farming? Targeted investment subsidies to facilitate upfront investment by farmers to purchase a bioenergy-powered tractor
- What would be the expected demand by 2030? Demand will greatly depend on the future price level for conventional diesel and governmental subsidy policies for both conventional diesel and bioenergy use in agriculture. Demand will be weaker if prices for conventional diesel will remain low and subsidies for use of conventional diesel in

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agriculture will be maintained. In case cost for conventional diesel will rise and subsidies for its use in agriculture will be reduced/abandoned, bioenergy-powered tractors could become an economically more attractive alternative for farmers.

4. Type of end-users (actual and/or future)

Both the plant-oil powered and the biogas powered tractor are constructed for all types of end-users, i.e.:

- Individual farmers
- Agricultural Cooperatives
- Machinery cooperatives
- Agricultural contractors

At the moment, plant-oil powered tractors are mostly purchased by larger individual farmers, machinery cooperatives as well as through public procurement by governmental forestry administrations in Germany.

5. Use of the described technologies in European farming

- Mostly Northern Europe
- Crop types: arable crops

Pictures of the machine: please click on below weblinks for images of the machines

Weblinks:
Plant-oil powered tractor:

- http://2ndvegoil.eu/
- https://www.biokraftstoffe-tanken.de/

Biogas-powered tractor:

- http://media.cnhindustrial.com/emea/NEW-HOLLAND-AGRICULTURE/new-holland-t6-methane-power-tractor-prototype-makes-a-statement-at-sima-2017/s/10d1c65d-4776-4cac-93ee-b2f83bbb8307
- http://www.valtra.com/dual-fuel.aspx

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Bld A. Reyers 80, BE-1030 Brussels
T +32 (0)2 706 81 73 - F +32 (0)2 706 82 10
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