Agricultural Machinery

VDMA

More output, less CO_2 –

Saving Fuel with Innovative Agricultural Machinery

Greetings from the Presidents of CEMA and the VDMA Agricultural Machinery Association

Agricultural machinery sets the pace for climate protection!

Dear readers,

Until recently a concern only of the ecology movement, today climate change is a crucial, if not the most important, policy area of our time: Climate and environmental protection refers to the issue of carbon dioxide, nitrogen oxides and particulate matter. These concepts are part of almost every debate, in a manner that is seldom purely factual and often highly emotional.

The agricultural machinery industry addresses this concern with facts and expert knowledge. This has long been the case, dating back to the beginning of the 1990s, an era when such commitment did not yet attract great publicity.

With consistently promising results from the joint industry research project 'EKoTech' (Effiziente Kraftstoffnutzung der Agrartechnik – Efficient fuel utilisation of agricultural machinery), which considers the fuel efficiency of agricultural machinery from a process perspective, we now have the deliberate intention of engaging in the current climate discussion. With generous financial support from the German Federal Ministry of Food and Agriculture, for the first time a highly qualified consortium with wide-ranging industry, scientific and association expertise has provided cross-manufacturer evidence that innovative agricultural machinery, intelligent process control, and modern operating concepts can ensure considerably reduced yield-related fuel consumption.

In other words: It is now time to reap the benefits of our efficiency strategy. On balance, along the agricultural production chain we can speak of a steeply falling CO_2 curve relative to the yield. 35 to 40 percent less fuel – the agricultural machinery industry upholds this strong reduction potential for the period from 1990 to 2030. According to simulations and model calculations, these are realistic values. In addition, if the diverse potentials already promised by alternative fuels and drive systems are taken into account, the path to 'climate-neutral agricultural machinery' may already be indicated.

However, in order for the large portfolio of intelligent technologies and application options to reach the necessary market penetration rapidly, accompanying policy measures are indispensable – incentive policies in the sense of investment support and tax relief, as well as education and communication policies to ensure know-how and acceptance for the energy transition in agribusiness.

The entire panorama of possibilities is presented in the following pages in an easily readable, accessible way. We wish you an inspiring, insightful read!

Christian Dreyer
VDMA Chairman

Anthony van der Ley
CEMA Chairman

Why EKoTech?

What we have achieved so far

EKoTech stands for efficient agricultural machinery fuel utilisation. The proper handling of scarce resources is currently a major social challenge, which thus requires all stakeholders to ensure a systematic reduction of emissions that are harmful to health and to the climate.

Fuel consumption and the associated CO_2 emissions are a significant determining factor which can be influenced by the agricultural machinery industry. Properly adjusting this factor is beneficial in two respects: Reduced fuel use improves the ecological balance and also has a positive effect on production costs.

However, this question is not new to the agricultural machinery industry. In recent years, an enormous development of engines and machinery has taken place. From a purely physical point of view, in many areas the industry has already achieved the maximum possible results in terms of individual machines and engines. To realise further gains in efficiency, the sector has expanded its perspective to focus on process components: It is well known that agriculture is characterised by a high degree of complexity. Many factors that affect efficiency are difficult to predict and can scarcely be quantified with standard values. Examples are the effect of annually variable precipitation on the yield, and the diversity of procedures and tools used in soil tillage.

These framework conditions pose a serious challenge to arriving at generalisable statements concerning optimisation potentials. On the other hand, the diversity of processes has the indisputable advantage of providing many optimisation opportunities. A systematic integrated focus thus makes possible considerable savings potentials along the entire production chain. These have been successfully determined, defined and evaluated across manufacturers by the project consortium. The results are summarised in condensed form in this brochure.

What we are doing industry-wide to enhance the efficiency level further

Due to its innovative strength, the agricultural machinery industry is one of the most important branches of machinery and plant engineering. Its international competitive position is excellent. Ongoing high expenditures in research, development and product innovations underline the leading position of the sector. Recently the industry has invested the largest share of its

Agricultural machinery: assists climate protection, emits little CO_2

Only 0.75 percent of Germany-wide CO2 emissions originate from agricultural machinery combustion engines

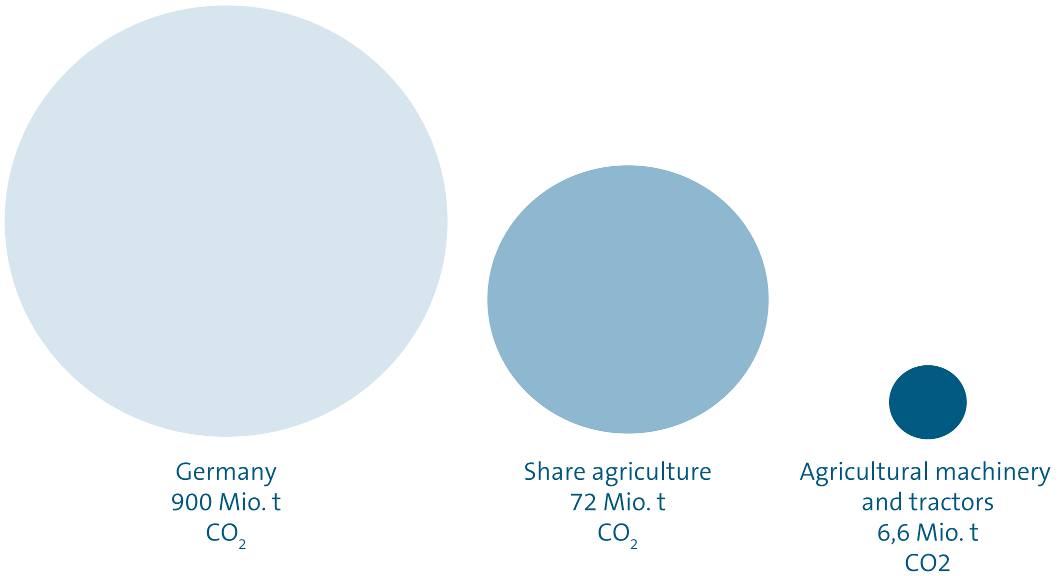


Image source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

development budget in the optimisation of engine and emissions technology, to provide clean machinery for roads, fields and farms.

In future, the market expects even more: Mapping technologies and high-precision steering and automation systems incorporated into intelligent data management systems point the way to technological development that is consistently responsive to the demands of the three aspects economy, ecology and social responsibility.

EKoTech – the project results at a glance

Research design

- The EKoTech researchers made a detailed investigation of 17 selected and typical farms in Germany and other areas of Europe.
- The research focused on machinery and processes for the production of wheat, maize and forage.
- Data were collected via more than 100 expert interviews, which were validated with the aid of statistical analyses.
- Over 2,500 test reports were evaluated and 120 hours of field trials were carried out, to ensure a sufficient database for the simulation model.
- A complex mathematical simulation model supported the definition and evaluation of technological efficiency drivers in more than 530 simulation runs.

Results

- For the period from 1990 to 2030, the EKoTech team forecasts a fuel consumption savings potential between 35 and 40 percent.
- A highly qualified group of industrial, scientific and association experts selected and qualitatively and quantitatively evaluated 27 specific cross-manufacturer innovations. The savings potentials of the individual innovations range from 2 to 42 percent.
- The greatest fuel consumption takes place during soil tillage and the harvesting of agricultural produce.
- 19 of the 27 savings potentials relate to process steps with the greatest fuel consumption in the farm production chain.
- The greatest savings can be achieved by combining the process steps for soil tillage and sowing.

Future perspectives

- Alternative fuels and drive systems, driver assistance systems and intelligent forms of machine and data management are current areas of development with the potential to allow additional optimisation of the agricultural carbon footprint, always keeping in mind the long-term goal of complete climate neutrality.
- The three stages of technology extend from assistance, to automation, to autonomy. The industry is presently working on this at full speed.

Accompanying policies

- However, this ambitious efficiency path is practicable only with accompanying policy measures. These include:

... investment incentives for climate-friendly agricultural machinery and tractors

... systematic CO_2 pricing, to increase the attractiveness of technological innovation solutions

... a sustainable research support policy

... technological openness, so that the best solutions can become established in the competition for innovation

... education policy measures for an accelerated transfer of know-how

... communication policy campaigns, to ensure acceptance of the energy transition in agribusiness

Top 10 savings potentials*

* in relation to the yield

	Technology	Saving Potential
1	Combined soil tillage and sowing	42 percent
2	Stubble cultivation with short disc harrow	30 percent
3	ECO PTO shaft	20 percent
4	Controllable working hydraulics - "Tailor-made volume flow"	14 percent
5	Traction booster	10 percent
6	Type selection suitable for application - lightweight construction, ballasting, tyre pressure	9 percent
7	Automatic machine optimization with measuring and control technology (combine harvester)	5 percent
8	Increase in performance	5 percent
9	Low rpm concept	5 percent
10	Efficiently controlled auxiliary units	5 percent

„Allowing automated steering means achieving considerable savings“

Two thirds
of a tractor driver’s attention is taken up with steering.

That can be halved
if automatic assistance systems are used.

Diesel savings of 10 percent
can be achieved this way in field operation.

Science and agricultural practice – Teamwork to reach the goal

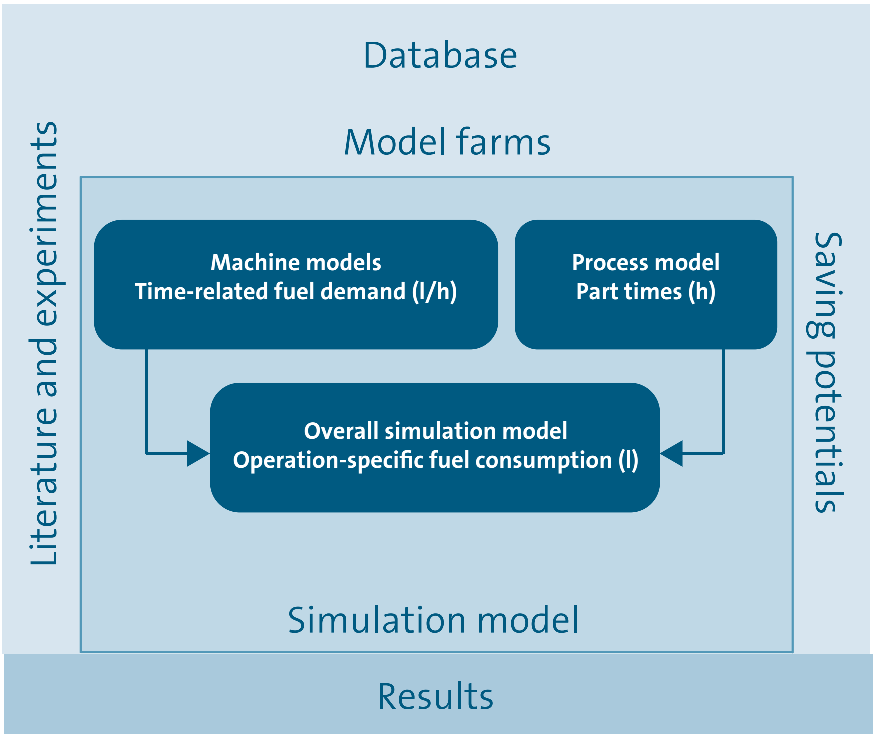
At the beginning there were many unanswered questions, since the field of research was completely new:

- What are the characteristics of the regionally different process chains, and what machinery is in use?
- How have agricultural fuel requirements for these process chains evolved since 1990?
- What savings potentials have been available for the period since 1990, and how can they be evaluated?
- How can the available data and information be combined in a simulation model?
- What technologies can be used in which process chains to save fuel?

To make effective use of the leverage of efficiency to reduce fuel consumption, well-founded answers to these questions are needed. Only in this way is it possible to derive usable results and recommendations for action for agriculture, industry and policy.

For this purpose, the project team pursued the approach illustrated in the following diagram: First a shared database was developed. It contains key performance indicators for the model farms concerning the cultivation processes and machinery used, the evolution of energy requirements and fuel consumption since 1990, data from field trials, and the definition of cross-manufacturer savings potentials available since 1990.

Methodical structure of the project



This information was transferred to the machine and process models. These were used to form the complete model, which models the interdependencies between the process and the individual machine models. With the expertise of farmers and the database of the KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft – Association for technology and construction in agriculture), the plausibility of the results was validated. In this way, farm-related fuel requirements per tonne of yield can be calculated for the various process chains, individual innovations and machinery settings.

The database

Model farms configured in a targeted manner provided the foundation for the simulation of a wide range of process chains. Agricultural practitioners and experienced agricultural advisors from Germany and other European countries supported the project team in the modelling. An initial retrospective analysis of process chains in different regions was carried out for the year 1990. In a second step, this was complemented by a prospective scenario up to the year 2030. More than 100 individual personal interviews with farmers provided a reliable database for modelling the farms with their process steps and machinery used.

It was found that since 1990, soil tillage has been extensified, especially by East European farmers. In contrast, the number of passes over the field for the purpose of plant protection has increased. For the application of pesticides, considerably less fuel per hectare is required. Whereas farms interviewed in southeast Poland now manage with around two soil tillage passes on average, in 1990 they made an average of four passes for soil tillage. Conversely, the number of passes for plant protection has increased from fewer than two in 1990 to more than five.

These and other findings for the model farms provided information concerning what individual machines had to be incorporated into the simulation model for the period from 1990 to the present. The processes and machines defined via the model farms were evaluated in relation to energy requirement and fuel consumption trends since 1990. In order to generate a sufficient database, the Institute of Agricultural Engineering of the University of Hohenheim, the KTBL, the Johann Heinrich von Thünen Institute and participating industry partners jointly collected the required machinery and process data. Technical literature, measurements made by the project team and approved databases functioned as data sources. Data relevant to the project were entered into a specially developed database.

This extensive body of data served to represent the evolution of fuel and energy consumption since 1990. From a methodological point of view, these data formed the basis for validation of the simulation model, which helped to determine prognostic savings potentials exemplified by the model farms. The researchers primarily investigated available data concerning the use of soil tillage equipment. The initial focus was on the plough, cultivator, disc harrow and rotary harrow.

Parallel to data collection, to take into account the diverse framework conditions of agriculture, the research team tested suitable model approaches for calculating the energy requirements of cultivation equipment. This work entailed comparing the calculations with measured values. To fill gaps in the data, additional measurements were made, for instance in the use of the rotary harrow for wheat cultivation. For this purpose, an energy measurement frame available at the University of Hohenheim was equipped to capture measurement data and relevant tractor data via the CAN bus.

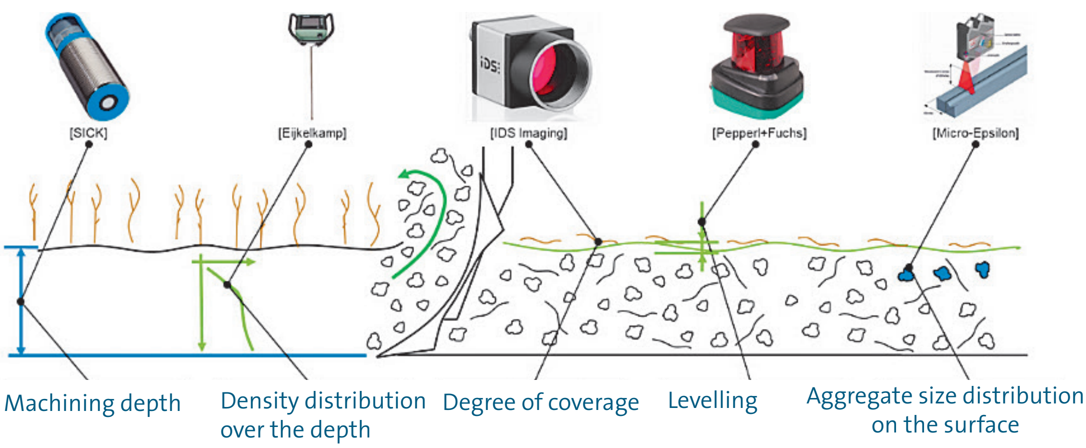
Industry partners in particular were consulted concerning the qualitative and quantitative evaluation of savings potentials since 1990.
A four-stage model was developed to categorise the savings potentials. Stages 1 to 3 focus on technologies that are already available on the market, while stage 4 summarises the potential of future technologies which may be available on the market in the period from 2020 to 2030.

To enable technologies to be described in a uniform manner, innovation cards were developed, ensuring a consistent, clearly understandable structure. The cards include a qualitative description and, if possible, a quantitative evaluation of the innovation. On this basis, the contents of the innovation cards were combined and prioritised. Technologies with a clear influence on fuel consumption were subsequently integrated into the overall model developed by the Technical University of Braunschweig.

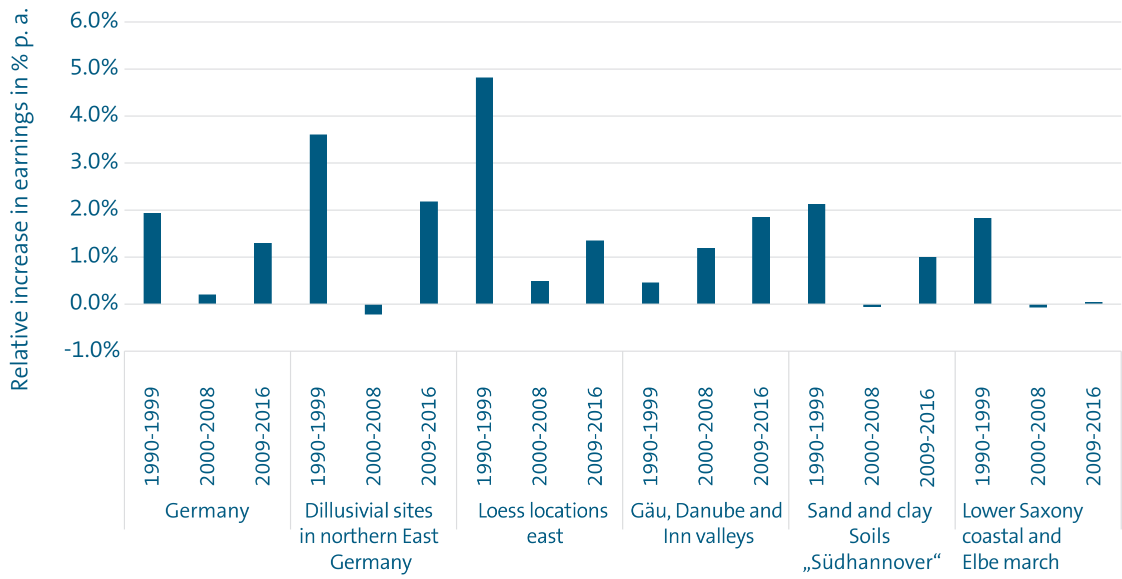
To define the specific effects of the respective savings potentials, it was necessary to derive either a corresponding increase in efficiency or a direct saving of fuel. These values – such as throughput performance in tonnes per hour [t/h], or fuel consumption in litres per hour [l/h], litres per hectare [l/ha] or litres per tonne [l/t] – were determined by the technical departments of the respective industry partners and the universities, with the aid of available measured values as well as modelling in terms of the characteristic maps used.

One of the most ambitious tasks in the course of data collection was the evaluation of the work quality of process steps. As an example, a valid evaluation system was developed for stubble tillage. The procedure involved several steps, from selecting the measurement equipment and putting it into operation, to carrying out the testing and follow-up work. The measurement equipment was selected in close consultation with sensor manufacturers. In the illustration, corresponding sensors are shown with the

Selected sensors for determining the quality of stubble falls



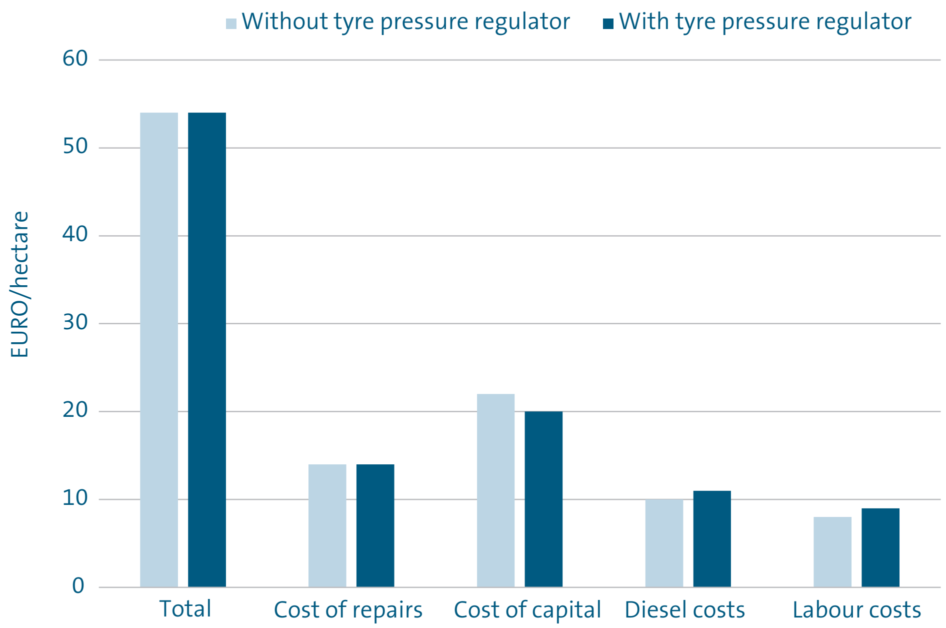
Average annual growth rates of wheat yields for selected soil climatic chambers



quality characteristics to be measured. The penetrologger, RGB camera, stereo camera and 2D rotary laser delivered promising results.

The project likewise identified and obtained suitable measurement equipment to determine the aggregate size distribution. The concept of "Qualified Efficiency" defined by the Technical

Costs with and without the use of a central tyre inflation system



University of Braunschweig is based on productively combining theoretical and practical approaches. Ultimately, savings potentials relative to work quality were successfully evaluated.

To relate the effects of savings potentials to yield, the basis of consideration was fuel consumption in litres relative to yield in tonnes. Official statistics served as an important data basis for considering the evolution of yields at different European locations.

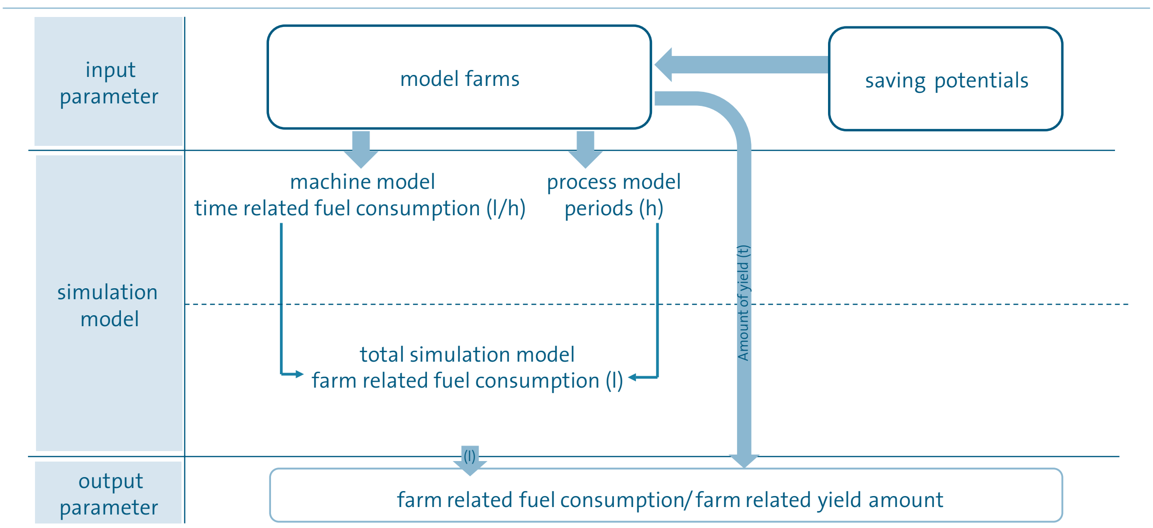
As can be seen from the graph, annual yield increases in Germany as a whole reached their maximum with 2 percent per year between 1990 and 2000. This is primarily due to the enormous yield improvements in East Germany following reunification.

Between 2000 and 2008, with Germany-wide annual yield growth considerably lower than 1 percent, average yields scarcely increased. Since 2008, an annual yield growth of 1 to 2 percent can again be observed in most regions.

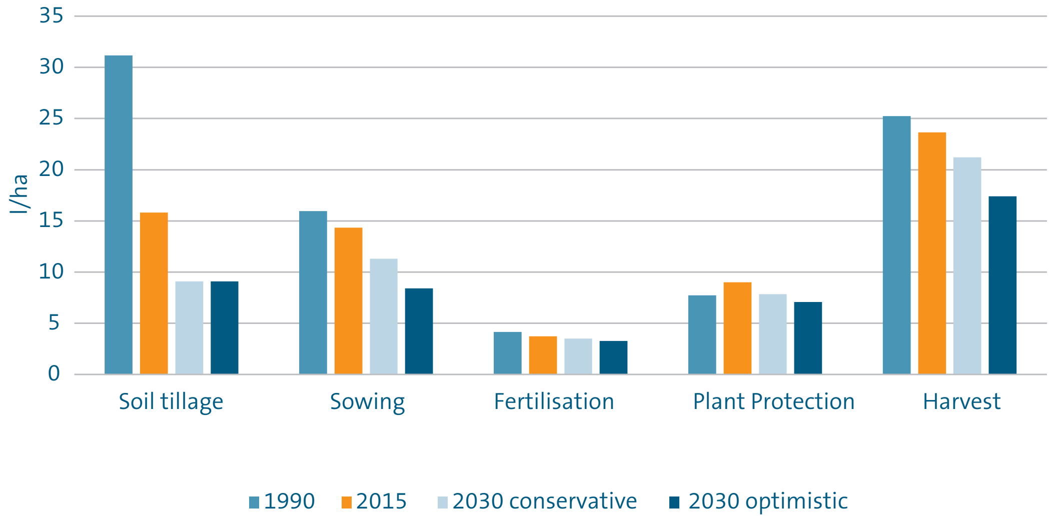
A further, extremely relevant practical basis of assessment is the economic benefit of savings potentials. In this context, a central tyre inflation system is an important example. The following illustration compares the cost situation for sowing and cultivating, with and without the use of a central tyre inflation system.

If a central tyre inflation system is used to adapt the tyre pressure to different operating conditions, on average it is realistic to expect a 4 percent reduction in fuel consumption. With the aid of a matrix that represents the agricultural process steps of the model farms, individual savings potentials can be transferred consistently to the simulation model and their plausibility can then be validated.

Basic structure of the simulation model



Area-specific fuel demand for individual process steps of wheat cultivation in the region "Südhannover"

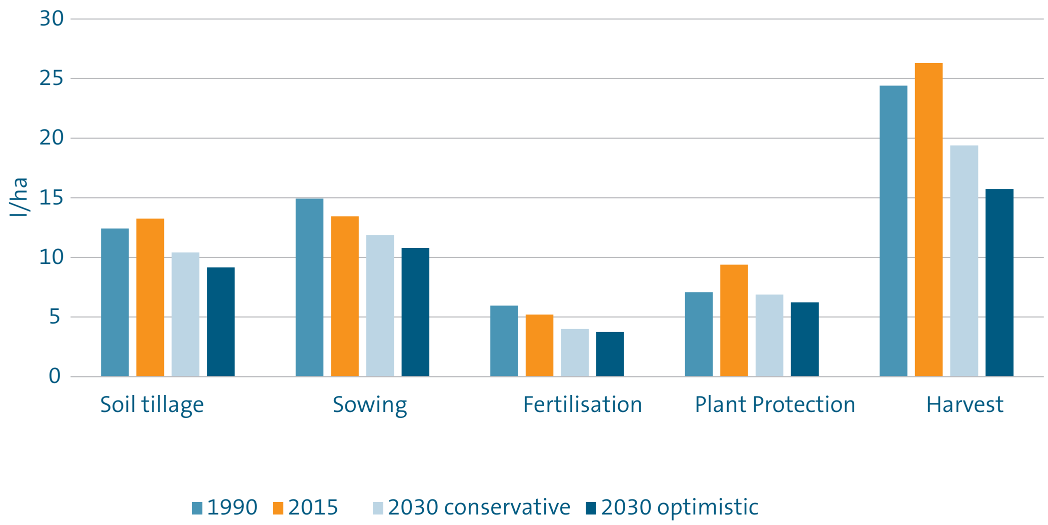


The simulation model

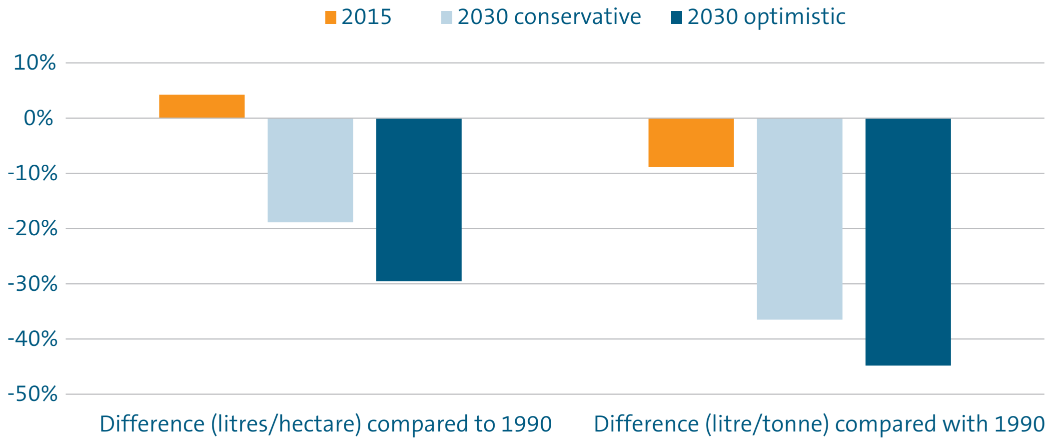
The aim of the simulation model is to calculate fuel requirements and possible savings potentials based on model farms, and to relate the results to the respective yields. The simulation model allows calculations concerning technological and process-specific measures that affect fuel consumption to be carried out quickly and precisely.

With the aid of the model, machine-specific fuel use in different agricultural (wheat, maize and forage) production processes can be simulated.

Area-specific fuel requirements for individual process steps of wheat cultivation in the region "Bayrisches Gäu"



Development of the fuel consumption for a process chain of wheat cultivation in the region "Bayrisches Gäu"



The illustration shows the basic structure of the simulation model, which is subdivided into three areas. On one hand, a machinery model has been defined, consisting of individual machine models with which time-related fuel requirements (l/h) are determined for defined situations, for example, in the framework of a turning process or work operation. On the other hand, a process model has been developed, with which detailed partial times for these individual tasks are simulated, based on farm conditions and the agricultural process chain.

Each machine model consists of defined components. The behaviour of each component in relation to the energy demand is based on characteristic values derived from the literature, own measurements and from manufacturer specifications. As a target value, the time-related fuel requirement is obtained, taking into account operating conditions such as the driving speed, soil type, etc.

The function of the process simulation is to determine the times required for individual subtasks in different process steps. For this purpose, an object-oriented simulation model has been developed which models the farms and simulates the procedures. Within the simulation environment, the machines or machine combinations perform practical actions depending upon the process step. During the process sequences, the time is determined by recording the time required for individual subtasks such as turning, work operations or road travel.

The results

Results from the two model approaches are combined in a higher-level simulation model and related to a forecast harvest yield.

This makes it possible to determine the fuel requirements for the process chain as well as for individual process steps. The results vary widely for different types of farm. The following graphs present the results for the 'Südhannover' and 'Bayrisches Gäu' model farms (both situated in Germany). Four different scenarios were simulated: The situation in 1990, the situation in 2015, a conservative estimate for 2030, and an optimistic estimate for the year 2030.

The results show that for both model farms, a reduction in fuel requirements could be realised over the period from 1990 to 2030. The differences observable in the 1990 soil tillage and harvest results are due to differing cultivation strategies.

The results shown take into account modifications in the farm structure and machinery configuration as well as process changes such as the reduction of tilling depths and the increase in plant protection requirements. For both scenarios focussing on the year 2030, relevant estimates were made in consultation with the participating agricultural machinery manufacturers and farmers in the respective regions. By using the underlying anticipated yields for the individual model farms and dates under consideration, fuel requirements can be related to the mass of grain equivalents. Based on the results for all the model farms, for the period from 1990 to 2030, the EKoTech team forecasts a fuel consumption savings potential of 35 to 40 percent.

How to save diesel – Potential for savings at a glance

Fields of action for industry, agriculture and politics

From a practical perspective, the results of the complex model calculations and analyses can be condensed at four levels, which produce an ambitious efficiency pledge on the part of the agricultural machinery industry:

(I) Machinery efficiency
Be it needs-based lightweight construction, intelligent engine management or automatic central tyre inflation – dormant efficiency potential is already being leveraged at the machinery level. To the benefit of users and the environment. For example, reducing the weight of a tractor by 20 percent – which would be quite sufficient for transport, fertilising or plant protection purposes – can cut the amount of diesel required by up to 5 percent.

Improvements in traction that bring choice of tyres, tyre pressure, ballasting and the adjustment of axle load distribution into balance to meet the respective situation are proving to be even more economical. This can be achieved conveniently and reliably with the aid of assistance systems that provide support in the choice of the right add-on weights and the required tyre inflation pressure. The touch of a button is all it takes if a central tyre inflation system is installed – a sensible fitting that is particularly worth having in the case of frequent combined road and field operation. Savings of up to 10 percent during primary soil tillage are possible if tractor configuration is optimised.

If the focus is placed on the tractor, there are already a large number of possible ways available to improve efficiency: Hydraulic systems with variable capacity pumps for fuel delivery are a further element for reducing fuel consumption. Here pressure and pressure flow are not constantly kept at a maximum rate, but are always need-based. Their application reduces fuel consumption during various tasks by up to 14 percent. Innovative auxiliary components that are not dependent on the rotational speed of the tractor engine also help to reduce energy loss. The result: fuel savings of more than 1 percent just for the fan; altogether, savings of up to 5 percent are possible for the auxiliary components.

Eco power take-offs reach their rated speed at a significantly lower engine speed. This reduces fuel costs and the impact on the environment. The consistent use of appropriate power take-offs can lead to remarkable diesel savings. Modern tractors operate continuously within the range of their highest torque at a low rotational speed and with the lowest possible specific diesel consumption. Depending on the model, fuel savings of up to 5 percent can be achieved with this sustainability concept.

However, it must be clear to everyone that a tractor is only used in the field in combination with appropriate mounted equipment. Therefore, savings can also be achieved through the right choice of mounted equipment. For instance, easy-to-pull short disc harrows enable quick and effective work with just a fraction of energy. Depending on the conditions on site, diesel savings of up to 30 percent are realistic.

(II) Process efficiency
Process solutions integrate intelligence into the production chain – beyond the individual tractor. After all, complex functions of different tractors, implements, makes and processes are synchronised with each other with the aid of mechanics, hydraulics and algorithms. Precision arable farming is one example, where the objective is to assess the heterogeneity in a plot of land or a crop in order to adapt tasks ranging from tillage to sowing, fertilising and plant protection to the requirements in the respective partial area. The optimisation of every task stage in the different

field areas is increasingly achieved with geo-based sensors, highly automated technology and artificial intelligence (AI).

Intuitively operable machine terminals serve not only the digital transmission of assignments or work results, but also the exchange of information and the optimisation of different units within a process chain. Thanks to these technologies plus increasingly effective means of remote monitoring, human beings still have the decision-making authority in this optimisation circuit. The result: Not only diesel input, but also other scarce resources such as fertilisers and pesticides are adapted to the level actually needed for the respective crop, with the yield increasing at the same time.

Combined primary soil tillage and sowing is an efficiency turbo that is being utilised more and more frequently. Because intelligently linking two energy-intensive process steps with each other means achieving savings not only in time, but also in fuel and hard cash. And unnecessary additional drives across the fields become a thing of the past.

Tractors with sufficient performance reserves and both mechanically and electronically linkable implement combinations are a prerequisite. The bottom line is up to 42 percent more diesel left in the tank.

(III) Operator efficiency
What is right for car drivers must be right for tractor drivers, too. After all, the big headings are similar: the right choice of gear, correct tyre pressure plus acceleration and braking adapted to the given situation play an important role for both cars and tractors.

However, the actual implementation is quite different. Tractors, combine harvesters and forage harvesters are primarily not means of transport but mobile machinery for specific purposes and have to accomplish complex tasks on changing terrain, either alone or in machinery configurations. The industry demonstrates in a number of ways how machinery settings can be optimised, process sequences controlled and the accelerator foot trained. That includes training on site or on the internet, but also intuitive user interfaces, adaptive menu guidance or practical assistance systems that lead to optimised utilisation of machinery capacity. According to experts, fuel savings of up to 20 percent are realistic if one takes the entire user potential into consideration.

(IV) Alternative fuels and drives
Practicable efficiency proposals always deal with several dimensions of a question.

The topic of CO_2 reduction naturally also raises the question of alternative fuels. This is only consequent as that is an area with considerable savings potential that can easily be tapped. This applies particularly to innovative power-to-X solutions, which ensure that excess green electricity can be converted into liquid fuels in an environment-friendly way with the aid of chemical synthesis processes.

In addition to electrical energy, primarily water and CO_2 are required as source materials – the latter can either be gained from biomass or separated directly from the air. One method is called 'direct air capture' and is currently in the testing phase. Ideally, it could make entirely CO_2-neutral diesel fuels possible; Fuel researchers and start-ups are already working flat out on it. Biofuels, particularly those of the second generation, are similarly promising. They are often gained from waste materials and thus mean a much lower threat to food production than conventional bio-fuel from rapeseed or maize. Used systematically, they can reduce emissions by up to 90 percent.

Biogenic and synthetic fuels should soon make a considerable contribution to the decarbonisation of vehicle fleets within and outside the field of agriculture. They combine the advantages of powerful diesel units in an ideal way with the necessary climate policy goal to reduce emissions as far as at all possible. The perfect technical solution for highly stressed traction drives in agricultural machinery and tractors. Mounted equipment such as fertiliser spreaders or seed drills, which require precise steering rather than pure power, are increasingly being equipped with infinitely variable electric motors.

„1 litre of diesel for 160,000 bread rolls – that's efficiency“

4,000 tonnes of grain
are harvested on average each season with a modern combine harvester.

1,200 football fields
are equivalent to the area harvested.

160,000.000 bread rolls
are then produced by bakeries.

1 litre of diesel
is needed to produce 160,000 bread rolls.

On the way to climate neutrality – Tomorrow's efficiency solutions

The agricultural machinery industry is well on the way to climate neutrality. Every day and with great commitment. On the one side is the continuously falling CO_2 curve and on the other a rapidly rising learning and yield curve. In other words: Agribusiness is thinking about the future today and is a climate pioneer. Because emission reduction is an innovation topic of the highest priority.

Alternative fuels and drive concepts that define the path to the decarbonisation of agribusiness are becoming more and more important. The technical prerequisites of numerous approaches are extremely favourable; however, there are often not enough units in the market to enable a benefit from economies of scale. But that is the only way to ensure the economical use of technologies of the future.

Electric traction drives can be used in special cases. Today there are already hardly any technical obstacles to implementation, particularly in the lower and middle tractor segments. Corresponding transport and supply infrastructures require political commitment and implementation and are indispensable for providing appropriate impetus in this direction to the market.

Experts see the optimisation of entire processes in which machinery is used as one, perhaps even the decisive parameter. Here the driver plays an important role. So far, the installed capacity of the machinery and implement fleets in use is not optimally exploited. Systems for qualifying drivers, but particularly for reducing operating complexity, are right at the top of the specifications for the engineers. Digital management or assistance systems are already in use today and will increasingly find their way into more machinery in the future.

The automation of sub-processes or complete process stages can make a contribution as a next step. Possible areas of application range from use in a single unit to machine communication and plant cultivation aspects and on to the adaptation of processes to special local conditions.

In the long term, autonomous processes will prevail throughout the industry; however, numerous experts expect entirely new machinery concepts. Research on the use of robots has, for example, been driven forward for many years now through university competitions supported by industry.

Technological innovation capacity, economic strength and an international horizon act in the best sense as catalysts of a pro-active climate approach for agribusiness regarding agricultural machinery, which can, however, only be really effective if it meets with political support and societal acceptance.

Innovative technologies for reducing fuel consumption – "This is where to invest!"

Cluster	Technology / instrument	Segment	Relevance	Savings of up to XX % possible	Viability	Time horizon
Electric traction drives	Pillar I: for particular use cases	Lower to middle tractor segments, feed mixing wagons	Medium, potential of up to 100 %	100%	Technically viable with medium efforts; infrastructure still insufficient	Immediately
Logistics	Road transport	Road travel	High, 50 %	50%		Immediately
Assistance process	Pillar III: Skills-based operating complexity	Digital management systems focus on the operator	Medium 10 % on average	10%	Technically viable with little programming effort, ZB unclear	Immediately
Autonomy process	Machinery	All motorised agricultural machinery	Up to 15 % (complete process chain)	15%		Immediately
Autonomy process	Machine to machine (M2M)	All motorised agricultural machinery	Up to 15 % (complete process chain)	15%		Immediately
Autonomy process	Plant cultivation	All motorised agricultural machinery	Up to 15 % (complete process chain)	15%		Immediately
Autonomy process	Processes adapted to special local conditions	All motorised agricultural machinery	Up to 15 % (complete process chain)	15%		Immediately
Alternative fuels	Power-to-X	All motorised agricultural machinery and tractors	High, due to positive CO_2 effects with little effort required; potentials of up to 100 %	100%	Easy technical feasibility, but political commitment is indispensable in order to generate economies of scale	2020
Alternative fuels	Biofuels	All motorised agricultural machinery and tractors	High, due to positive CO_2 effects with little effort required; potentials of up to 100 %	100%	Easy technical feasibility, but political commitment is indispensable in order to generate economies of scale	2020
Automation process	(Partial) autonomy	All motorised agricultural machinery	5 % (on top)	20%		2030 +
New forms of machinery (robotics)	Machinery		Up to 50 %	50%		2030 +
New forms of machinery (robotics)	Plant cultivation		Up to 50 %	50%		2030 +

Bringing hp onto the road – the reason why the agricultural machinery climate protection offensive needs political support

Political support for technological momentum

No matter how efficient and creative the industry's developers may be, they are just as dependent on reliable political framework conditions that contribute to actively shaping the remarkable technological momentum in agribusiness in the interest of farmers and contractors.

For sustainable innovations with welfare economic benefits can only be created where a clear sense of direction, the right incentives for motivation, and optimisation coupled with a competitive outlook exist. This is, on the one hand, because it encourages the industry itself to think and act in an unconventional way; on the other hand, because it makes it far easier for users to change traditional processes and ways of working. In other words: Innovative solutions for users, products and processes intended to optimise fuel efficiency must be promoted and established on a broad scale if they are to fully unfold their potential in practice.

Recommendations for political decision-makers

Incentive policy

Incentive effects are among the tried and tested instruments for driving the diffusion of innovative, environmentally friendly technologies forward in the market. VDMA sees prospects for positive leverage in the following areas:

- Investment support

A large number of farmers in Germany and Europe are professionals and therefore not averse to investing, especially when investments are in technologies and systems to improve efficiency. According to a current VDMA statistic, a good 15 percent of farmers and contractors plan to invest in agricultural machinery in the coming six months. However, anyone who decides on state-of-the-art interlinked process solutions will often face financing obstacles. Here politics could unfold a steering effect based on fast-start funding and state aid:

- for innovative technological and system solutions
- for upgrading existing machinery

Tax incentives

From the users' point of view, tax incentives are the ideal, precisely regulatable policy instrument for achieving a quick switch towards ideas for CO_2 efficient technology and processes. They include:

- a reasonable approach to CO_2 pricing that serves the internalisation of external costs and regulates damage to the environment according to the polluter-pays principle,
- pricing policy advantages for biofuel and synthetic fuels based on tax relief,
- a broadly defined tax relief offensive for all CO_2 reducing measures,
- well-targeted bonus systems for users, for instance a 'diesel bonus book' based on the reimbursement scheme for diesel used in agriculture.

Deregulation

An entrepreneurial way of thinking has always united industry and agriculture. After all, many things can be dealt with much better independently at the enterprise level than on the basis of extensive sets of rules. It is therefore sensible to promote deregulation wherever possible, because:

- this ensures that competition in innovation can develop freely,
- it will force the consistent implementation of existing laws instead of constantly having new legal norms (legal certainty),
- and it will make expensive and inefficient labelling measures redundant right from the start.

"Allowing automated steering means achieving considerable savings"

Two thirds
of a tractor driver's attention is taken up with steering.

That can be halved
if automatic assistance systems are used.

Diesel savings of 10 percent
can be achieved this way in field operation.

Research policy

The agricultural machinery industry is a research-intensive industry. On average, a good 5 percent of annual turnover flows into the development and construction of new machinery and software systems. Digital cross-brand and cross-process methods promise users considerable efficiency and savings potential – also and particularly with regard to fuel consumption. However, research-based solutions require major investments. Promoting such investment more strongly than has been the case so far – also in the small and medium-sized industrial segment – is a fundamental element for increasing sustainability. In this context, the research achievements of the automotive and fuel industries must also be taken into consideration.

Research promotion with regard to the agricultural machinery industry

- Programmes to strengthen joint research across enterprises on an interdisciplinary basis to optimise the efficiency of machinery and processes
- Consequent promotion of the small and medium-sized segment
- Cooperation with universities

Research promotion with regard to the vehicle and fuel industries

- Exploration of alternative propulsion systems and fuels
  - technologically neutral
  - complementary
  - in the interest of achieving an intelligent energy mix
- Fields of research at the propulsion system level
  - engine research
  - fuel cell research
  - research on rechargeable batteries
- Fields of research at the fuel level
  - synthetic fuels (power-to-X)
  - biofuels

Infrastructure policy

Powerful analogue and digital infrastructures form the backbone of energy-efficient processes of the future.

As far as digital infrastructure is concerned, the cards have long been on the table because fast mobile internet is not only the basic prerequisite for Industry 4.0; agriculture, no matter whether small-scale or large-scale, can also no longer do without high-speed networks. Anyone wanting to adapt sowing and fertilising to the individual plant in real time, to schedule harvesting logistics to the second and to synchronise documentation tasks with the work process, needs high speeds and short latency periods on the field, in the barn and in the farmyard. In the event of success, full process control along the entire value chain and significant reduction potential for CO_2 are on the assets side.

Similarly, analogue transport and utility infrastructures will have to be reliably expanded before even the most promising technologies of the future would be sustainable in the long term.

Digital network infrastructures

- The provision of extensive high-speed networks in 4G and 5G standard, but also fibre, throughout the country is a necessary prerequisite for the successful management of the transition to greater efficiency.
- Machinery and process control in real time and with maximum (fuel) efficiency is only possible if these prerequisites are met.

Transport and supply infrastructures

- Ensuring the availability of alternative or synthetic fuels
- Creating filling stations for biogas and hydrogen plus EV charging stations

Data policy

Considerations on data transparency and standardisation must include agribusiness. After all, only in very few other areas is day-to-day business so strongly characterised by measurable data, which for the most part are derived from nature. This includes e.g. topographic and pedological data, but also meteorological data and location-based application rules for farm inputs. All of these factors contribute to improving the management of the production process and generating less CO_2 while increasing yields. Frictions arising from laborious manual work can be stopped straight away if the following requirements are met:

Comprehensive provision of publicly available data

- e.g. all public data corpora of the land registry offices and environmental authorities
- retrievable in a machine-readable form

Cross-border data standards

- standardisation of data formats for fields, requirements etc.
- compatibility across territorial borders
  - national
  - pan-European

Education policy

Good professional practice is a matter of education. That applied in the past and still applies today. However, the requirements are changing more dynamically than ever before. Farmers wanting to digitalise their farms in the best possible way or seeking to implement targeted economic and ecological processes are dependent on knowledge and skills that are imparted and deepened at schools and universities, but also in extra-occupational teaching and educational measures. Only those who know how to utilise this leverage can fully exploit the potential of efficient operating processes.

Academic and vocational curricula with a sustainability concept

- materials appropriate to the target group and didactic approaches for
  - farmers and contractors
  - mechatronic technicians for agricultural machinery
  - agricultural scientists

Measures for further training

- industry-based and school-based further training programmes for professionals in agribusiness
- dovetailing with investment aid or bonus systems

Communication policy

Communication policy measures can unfold a steering effect and raise attention and awareness within and outside the expert community if they are well targeted. Sustainable, fuel-efficient production processes are in the interest of all parties concerned. Promoting them strongly through communication and making them the binding standard in public speech is the purpose of such a communication offensive. From the perspective of the industry, possible approaches would be:

Benchmark tables

- 'This is how efficiently future-oriented farms act' (in the sense of creating implied pressure to take action)

Information campaigns

- 'Take your foot off the accelerator' (in an instructive sense)

Image campaigns

- 'Farmers act in a CO_2 efficient way' (in the sense of motivation and appreciation of the peasantry)

Here is further information on the EKoTech idea

The sustainable reduction of emissions that impact the climate is gaining ever greater significance in view of current developments. Here you will find an overview of further publications that were created during the preparation and implementation of the project.

References

EKoTech

Decker, M.: **Effiziente Kraftstoffnutzung in der AgrarTechnik – EKoTech**. In: Frerichs, Ludger (ed.): Jahrbuch Agrartechnik 2016. Braunschweig: Institut für mobile Maschinen und Nutzfahrzeuge, 2017, pp. 1–8.

Frerichs, L.; Hanke, S.; Steinhaus, S.; Trösken, L.: **EKoTech – A holistic approach to reduce CO_2 emissions of agricultural machinery in process chains**. In: Proceedings – 9th AVL International Commercial Powertrain Conference, 10 and 11 May 2017, Messe Congress Graz, Austria.

Köber-Fleck, B.; Ahlbrand, P.; Böttinger, S.; Korte, H.: **Telematics and big data analytics – An effective way to quantify fuel saving potentials**. Conference: Agricultural Engineering, Hannover, Germany, 10 and 11 November 2017, LAND.TECHNIK AgEng 2017, pp. 227–236, VDI-MEG, ISBN 978-3-18-092300-0.

Meiners, A.; Häberle, S.; Böttinger, S.: **Advancement of the Hohenheim tractor model – Adaption on current demands**. Conference: Agricultural Engineering, Hannover, Germany, 10 and 11 November 2017, LAND.TECHNIK AgEng 2017, pp. 245–253, VDI-MEG, ISBN 978-3-18-092300-0.

Meiners, A.; Böttinger, S.: **Leistungsbedarf und Leistungsverteilung im Mähdrescher – Untersuchung zukünftiger Einsparpotentiale im realen und virtuellen Versuch**. Conference: Agricultural Engineering, LAND.TECHNIK AgEng 2018, pp. 149–158, VDI-MEG, ISBN 978-3-18-092332-1.

Nacke, E.; Köber-Fleck, B.; Hanke, S.; Böttinger, S.; Frerichs, L.: **Agricultural engineering and climatic responsibility? Initiative for a holistic approach to reduce CO_2 emissions from agricultural mechanization processes**. 1st AXEMA-EurAgEng Conference, Villepinte, France, 2017.

Schwehn, J.; Häberle, S.; Böttinger, S.: **Development of energy requirements of tractors and implements**. Conference: Agricultural Engineering, Hannover, Germany, 10 and 11 November 2017, LAND.TECHNIK AgEng 2017, pp. 237–244, VDI-MEG, ISBN 978-3-18-092300-0.

Trösken, L. Steinhaus, S.; Frerichs, L.: **Verfahrenssimulation zur Ermittlung von Maschineneinsatzzeiten auf landwirtschaftlichen Betrieben.** Conference: Agricultural Engineering, LAND.TECHNIK AgEng 2018, pp. 7–15, VDI-MEG, ISBN 978-3-18-092332-1.

Preliminary work

Fleck, B.; Nacke, E.; Böttinger, S.; Frerichs, L.; Hanke, S.: **Der Weg zur freiwilligen Selbstverpflichtung der europäischen Landtechnikindustrie zur Reduktion von CO_2-Emissionen**. 72nd LAND.TECHNIK Conference, pp. 301–308, VDI-MEG, 2014, ISBN 978-3-18-092226-3.

Fleck, B.; Hanke, S.: **CO_2 quantification for agricultural machinery in the EU**. In: Proceedings – Efficiency of Mobile Machines and their Applications – A Contribution to the Reduction of GHG. Symposium at the Institute of Mobile Machines and Commercial Vehicles, 10 and 11 March 2015, Braunschweig, Germany.

Frerichs, L.; Hanke, S.: **Efficiency of processes and machines in agriculture and construction**. In: Proceedings – 8th AVL International Commercial Powertrain Conference. 20 and 21 May 2015, Helmut-List-Halle, Graz, Austria.

Hanke, S.; Frerichs, L.; Fleck, B.; Nacke, E.: **Methode zur Ermittlung der CO_2-Emissionen von Landmaschinen in einer Verfahrenskette**. 72nd LAND.TECHNIK Conference, pp. 309–314, VDI-MEG, 2014, ISBN 978-3-18-092226-3.

Nacke, E.: **CO_2- und energieeffiziente Landtechnik – Konflikt oder Lösungsbeitrag zur Erreichung der EU-Ziele?** In: Energieeffizienz der Landtechnik – Potenziale zur CO_2 Reduktion. Symposium am Institut für mobile Maschinen und Nutzfahrzeuge, 12 and 13 March 2013, Braunschweig, Germany.

Nacke, E.: **High tech AG machinery solutions: Contradiction or contribution to sustainable agriculture?** EurAgEng. Zurich, Switzerland, 7 July 2014.

Project partners

Imprint
Imprint

Publisher
VDMA
Agricultural Machinery

Lyoner Str. 18
60528 Frankfurt am Main

Phone +49 69 6603-1891
Fax +49 69 6603-2891
E-Mail landtechnik@vdma.org
Internet lt.vdma.org

Authors of the booklet
Christoph Götz
Beate Köber-Fleck

Design
VDMA DesignStudio, Frankfurt am Main

Production
h. reuffurth gmbh, digital media & print
Mühlheim am Main
www.reuffurth.net

Image sources
Titel: IStock/oxinoxi
Source of all graphics
(unless otherwise noted): EKoTech

Climate neutral
Print product
ClimatePartner.com/11541-1911-1002

VDMA
Agricultural Machinery

Lyoner Str. 18
60528 Frankfurt am Main

Contact
Christoph Götz
Phone +49 69 6603-1891
Fax +49 69 6603-2891
E-Mail christoph.goetz@vdma.org

lt.vdma.org

DesignStudio