COMMITTEE FOR EUROPEAN CONSTRUCTION EQUIPMENT

CEMA
European Agricultural Machinery

CECE and **CEMA** **O**ptimising our industry **2** reduce emissions.

REDUCING CO_2 EMISSIONS: THE POTENTIAL OF MODERN AGRICULTURAL & CONSTRUCTION MACHINERY

Reducing greenhouse gas emissions (GHG) and adapting to the consequences of climate change has become a global task and major challenges for the years to come.

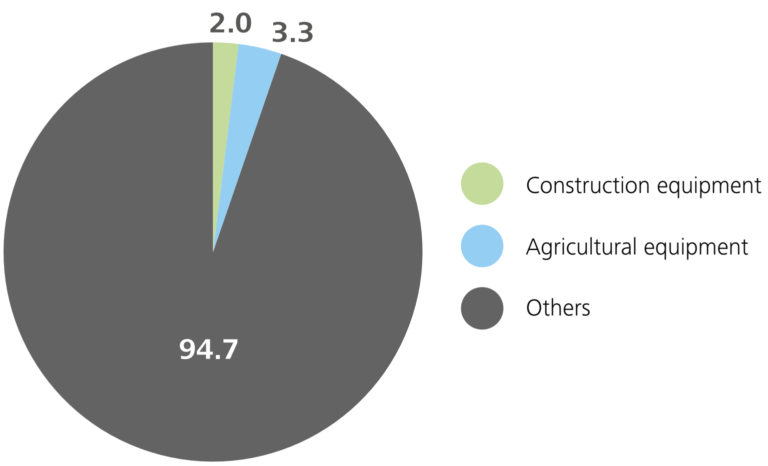
Boosting an impressive track record in achieving energy efficiency gains in the past 50 years, the agricultural and construction machinery industries continue to be committed to reducing GHG emissions, in particular CO_2, even further in the coming years.

Agricultural and construction machines are crucial investment goods and working tools for their users. With regards to Fuel, being one of the highest input costs in agricultural and construction processes, manufacturers have come up with innovative solutions that reduce fuel consumption while ensuring a high performance of the machines as well as compliance with ever stricter exhaust emission limits at the same time. Modern user interfaces assure full exploitation of these innovations for skilled and trained operators

The industry has heavily invested to develop state-of-the-art machines and the substantial energy-efficiency gains are increasingly the result of the deployment of ICT-related, 'smart' technologies such as interconnectivity or satellite navigation. This is due to the complex processes that agricultural and construction machines are involved in. Compared, for instance, to passenger cars, which simply transports people from A to B, agriculture and construction involve a wide range of different types of operations, all of which can have a direct impact on fuel consumption and machine performance.

Therefore, to understand the potential of CO_2 emissions reductions offered by modern machinery, it is important to move from a traditional machine-specific approach to a more holistic view, considering the overall energy efficiency and emissions reductions that modern machinery can help achieve in the entire production processes.

EU CO2 emissions transport (2007)



Sources: JRC EU Commission. 2007 Technical Review of the NRMM. September 2008.

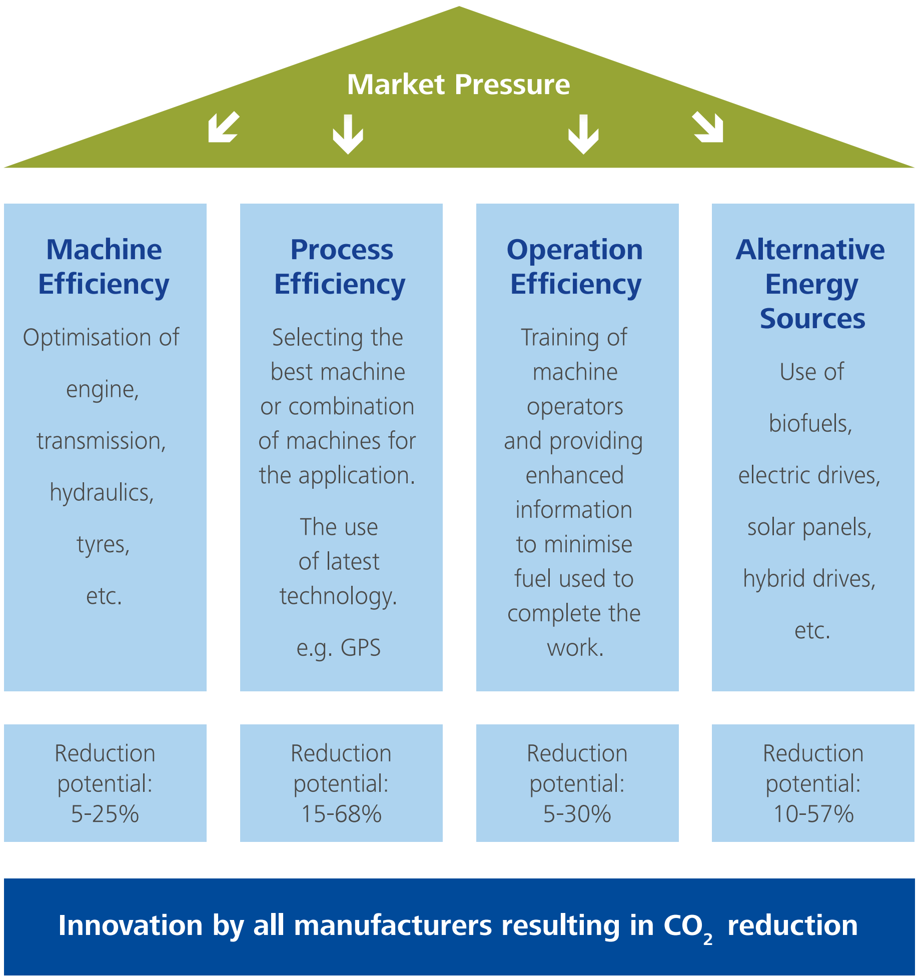
KEY ELEMENTS IN CO2 REDUCTION

There are four main pillars or pathways to take into account for optimising the energy efficiency with their own related costs and energy-saving potential: machine efficiency, process efficiency, operator efficiency and alternative energy sources

- Machine efficiency looks at the optimisation of all elements related to the machine itself (engine, transmission, hydraulics, tyres, etc.)
- Process Efficiency considers the setup of the process to fulfil the desired job (e.g selecting the combination of machines for the application, the best machine for each task etc.) and the use of latest technologies (e.g coordination of multiple machines' operations via GPS).
- Operation efficiency includes the training of machine operators or technologies to simplify machine use (e.g. providing enhanced process information to the operator, fully/partly automate machine operation)
- The use of alternative energy sources that deliver the same amount of energy but emitting less CO_2 such as biofuels, electric drives, solar panels, hybrid drivers, etc.

In addition, the right training and skills to use equipment efficiently, maintain it properly, or interpret machine data correctly, are crucial factors to increase energy efficiency in any process. The use of alternative fuels or other energy sources helps achieve multiple benefits - from less CO_2 emissions to reducing exhaust emissions.

Within machine efficiency the focus is on the drive-train and auxiliary powers. Much higher efficiency gains can, however, be achieved during the production process, where the choice of the right machine(s) with the best technologies play a key role.

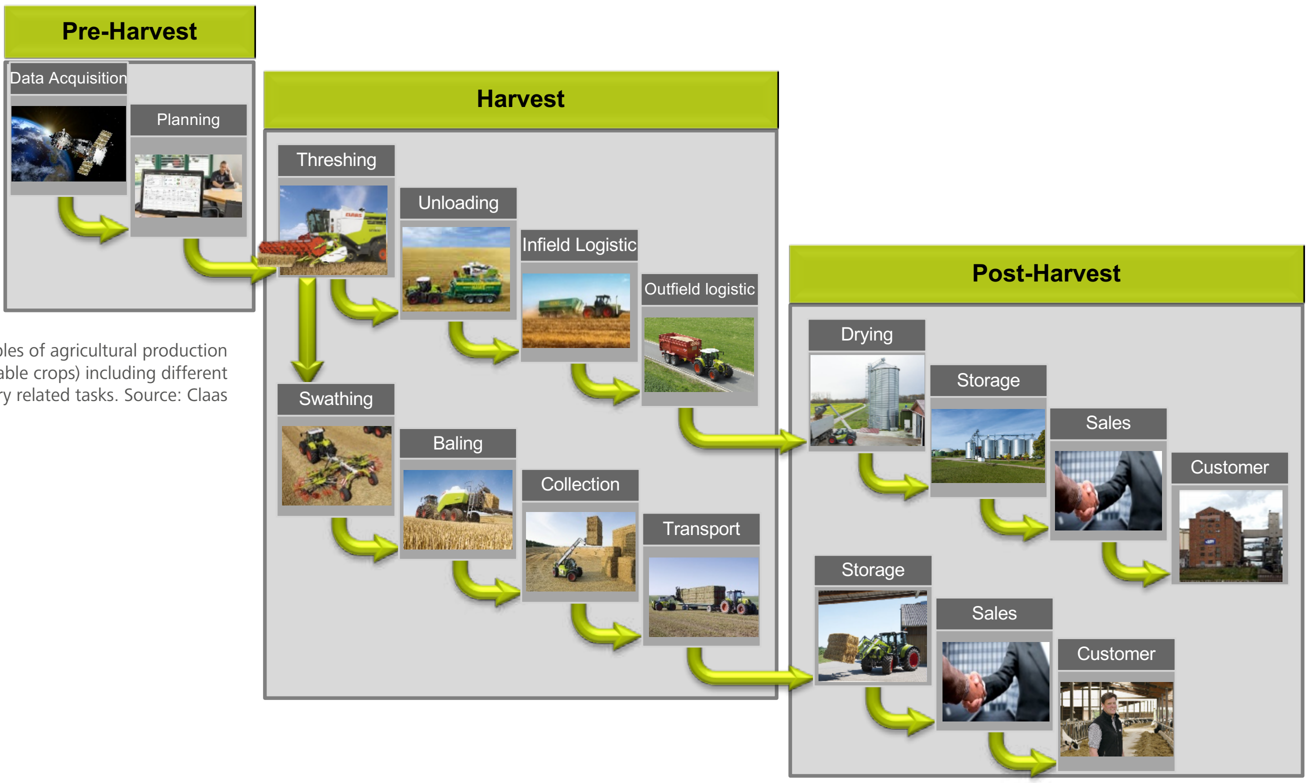


AGRICULTURE & CONSTRUCTION MACHINES: ACHIEVING CO2 REDUCTION THROUGHOUT THE ENTIRE WORKING PROCESS

"Increasing the process efficiency has the highest potential to achieve major energy efficiency" gains."

Agricultural and construction equipment are used to carry out a range of different operations such as drilling, cutting, collecting, pulling, ploughing, seeding, spraying, harvesting or transport. The work performed by these machines depends, furthermore, on a large variety of parameters (e.g. from weather and soil conditions to size and shape of the construction site) that impact fuel consumption.

Users of agricultural and construction machines are interested in the overall efficiency of the process that leads them to achieving their final result: whether producing a ton of wheat or a kilometre of paved road. Machine efficiency is just one element in making the overall process cost- and energy efficient. It is essential to consider the savings potential across all the phases of the production process from planning to operations, to logistics coordination and site/farm management, including the cross-linking between operations and phases.



Examples of agricultural production process (arable crops) including different machinery related tasks. Source: Claas

To reap the full potential of greenhouse gas mitigation in agriculture and construction further, it is key to consider that the more the machines' operations and the entire process chain are assessed as a whole, the higher the energy efficiency gains and CO_2 emissions reduction are that can be achieved during crop production or construction works.

SMART MACHINES & PROCESS EFFICIENCY: NEW TECHNOLOGIES TO REDUCE CO_2 EMISSIONS FURTHER

State-of-the-art agricultural and construction machines such as tractors and excavators have reached unsurpassed levels of intelligence in areas like automation, precision application and connectivity in the last years. Thanks to the use of advanced technologies like GPS, smart sensors and actuators, these machines are able to achieve ever higher levels of accuracy in the working process from precision seeding to road placement. The integration of more and more intelligent machines with precise technologies results in:

- optimised machine operations and machine use such as reduced working hours and passes, combining operations and limiting the number of tasks.
- target input application like fertiliser or pesticides that help reducing the environmental impact
- making better use of the machine park thanks to connectivity between vehicles and coordination within the farm/construction site
- Improvement of the planning of different operations to be carried out during the process

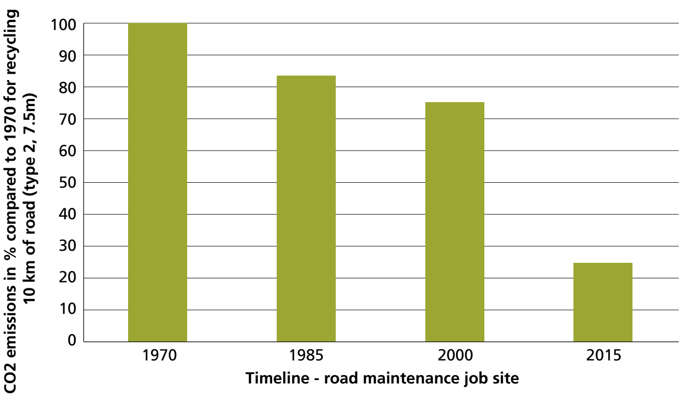
“FOCUS ON THE PROCESS AS A WHOLE AND THE DIFFERENT OPERATIONS PERFORMED BY THE MACHINES ARE KEY ELEMENTS TO REDUCE CO_2 EMISSIONS”

FUEL CONSUMPTION REDUCTION. A MAIN DRIVER FOR MACHINERY MANUFACTURERS

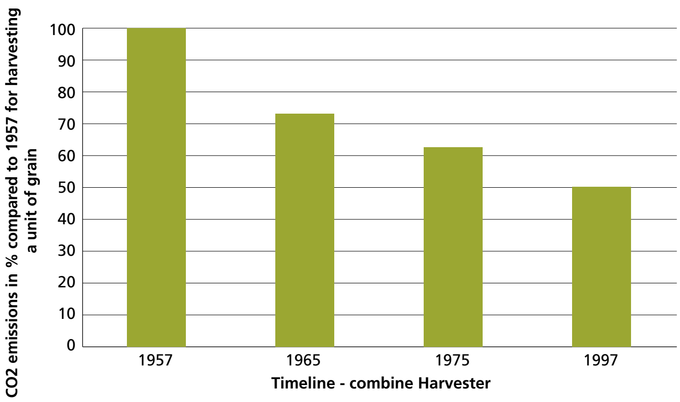
CO_2 emissions are highly correlated to fuel use. Almost all of the carbon in diesel fuel is emitted in the form of CO_2. Efficiency in converting fuel (diesel) into usable energy is one of the main demands of machinery customers. Therefore, improving fuel economy has been, and will be, **one of the main drivers** for innovation.

As a result, CO_2 emissions in both agricultural and construction machinery applications has substantially decreased in the last decades.

"FUEL EFFICIENCY IS A PRIORITY FOR CUSTOMERS"



Source: CECE (2016)



Source: CEMA (2015)

CONCLUSIONS

Over the past 50 years, the agricultural and construction machinery industries have made large efforts in reducing GHG emissions, in particular CO_2. Modern machines play a central role in agricultural and construction processes contributing to increased energy efficiency and environmental sustainability. To reduce CO_2 even further in the years to come, it is key to consider that:

- Agricultural and construction machine applications are much more diverse than on-road traffic.
- The focus of CO_2 emission reduction efforts in agricultural and construction machinery is evolving from a traditional machine ‘stand-alone’ fuel consumption approach to a more integrated approach including the process optimisation.
- To achieve major energy savings with the highest cost-efficiency it is key to take into account the farm or construction process from beginning to end.
- Modern, smart machines are the most promising tools to accomplish the highest energy efficiency potential in farming and construction processes.
- Customer demand for a fuel consumption reduction is already a main driver for innovation

MACHINE EFFICIENCY EXAMPLES

- Intelligent load adaptation for compaction rollers
- Automatic blade-sharpening
- Efficient backhoe loaders travelling on the road
- Smart power management of drilling rigs
- Full-Semi hybrid systems for machine and implement enhanced efficiency
- Torque converters and alternative braking systems
- Drive train optimisation Weight balancing boosting traction

MACHINE EFFICIENCY

INTELLIGENT LOAD ADAPTION FOR COMPACTION ROLLERS

GOAL

Cutting the fuel consumption of compaction rollers by altering the impact they produce on the ground according to analysis of the force required.

DESCRIPTION

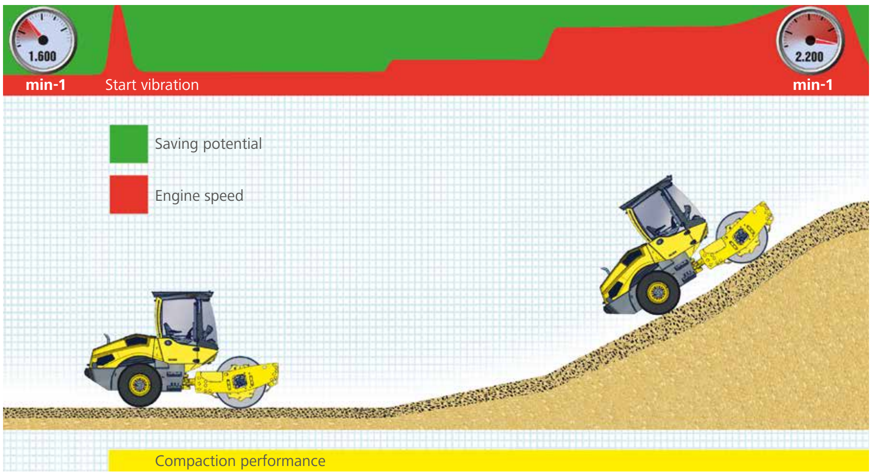
Compaction roller designers have identified significant potential to save fuel by adjusting the load imposed by the roller on the ground below it according to the force which is required.

This system of load adaption technology links the hydraulic function of a compaction roller with the engine that powers the machine to form an intelligently-controlled operation system which determines the load needed, and hence adapts the load delivered. A form of active energy management, this provides the roller with power only when required, and reduces the power input when conditions permit – on ground that is already firm.

An intelligent sensor system instantly and continuously calculates the power required by the roller's hydraulic system in respect of the surface on which it is working, and automatically adjusts the engine speed to account for this. It is this that directly results in the machine's lower fuel consumption.

RESULTS

Tests show that compaction rollers fitted with intelligent load adaptation use **20% less fuel** to achieve the same amount of work.



MACHINE EFFICIENCY

AUTOMATIC BLADE-SHARPENING

GOAL

Development of a blade-sharpening system that operates automatically, so that the forage wagon (grass harvester) to which the blades are attached always cuts as cleanly as possible. Sharp knives minimise energy consumption.

DESCRIPTION

Cattle require preserved grass to consume through the winter, when grass growth in the fields ceases. The most common way to collect and store this is to make silage. Grass is chopped into short lengths so that, when stored in a pit or silo, it can be easily compacted.

The energy required to chop grass is directly related to the sharpness of the blades used. Traditionally it has been necessary to regularly remove the blades from a forage in order to sharpen them, and so keep the machine run- ning at peak performance and lowest fuel consumption.

Recent advances mean that sharpening of the blades can now be carried out with them in situ, with machine design incorporating a sharpener that works on an au- tomatic cycle. This ensures that the blades are always as sharp as possible, and so fuel consumption in this respect is as low as it can possibly be.

RESULTS

Forage wagons fitted with automatic blade sharpening systems have been shown to have a **15% lower power requirement** and consume 5.0 l/hr less fuel than comparable machines without the system.

MACHINE EFFICIENCY

EFFICIENT BACKHOE LOADERS TRAVELLING ON THE ROAD

GOAL

Reducing the fuel consumption of backhoe loaders by disconnecting hydraulic functions

DESCRIPTION

Backhoe loaders, machines that incorporate rear-mounted booms for digging and front-mounted loaders for moving materials, provide the main source of power for a multitude of construction applications. They can be moved on the public highway between sites under their own power.

Backhoe loader designers have introduced a number of features to reduce fuel consumption during road travel. One of the major developments has been a feature which allows the engine to directly drive the gearbox, eliminating power wastage. Another has been a hydraulic speed control system which automatically disconnects the first hydraulic pump when in the top road gear, meaning that fuel is not powering hydraulic functions when on the road, when they are not needed.

RESULTS

The system **reduces fuel consumption by up to 25%**, whilst at the same time increasing both road speed and working range by up to 10%.

MACHINE EFFICIENCY

SMART POWER MANAGEMENT OF DRILLING RIGS

GOAL

Reducing fuel use by adapting the power provided to hole-boring drilling rigs according to the operating conditions in which they are working.

DESCRIPTION

Drilling rigs, the machines used to bore holes in the ground for a multitude of different construction tasks, use at least two main hydraulic circuits, usually powered by variable-displacement pumps, with the pump power regulators set to a fixed ratio, usually providing 50% of the engine power to each of the pumps.

Depending on the drilling task, the hydraulic loads vary over a wide pressure and flow range, and each pump has to serve multiple hydraulic demands simultaneously. To minimise the power these demand and the fuel consumed, a new control device enables the pump with the higher load to receive the engine power the pump with the lower load doesn't need. If an additional load – like a water flushing pump – is switched on occasionally during drilling, the appropriate required power will be au- tomatically deducted from one of the pumps. On electrically-controlled drill rigs, the system is optimised by monitoring the various hydraulic load consumers.

RESULTS

The system offers the potential to make **fuel savings of between 5% and 15%**, depending on the work in hand.

MACHINE EFFICIENCY

FULL-SEMI HYBRID SYSTEMS FOR MACHINE AND IMPLEMENT ENHANCED EFFICIENCY

GOAL

Fuel consumption and carbon emissions are reduced on both tractors and on large-scale construction equipment through the use of electric drive systems.

DESCRIPTION

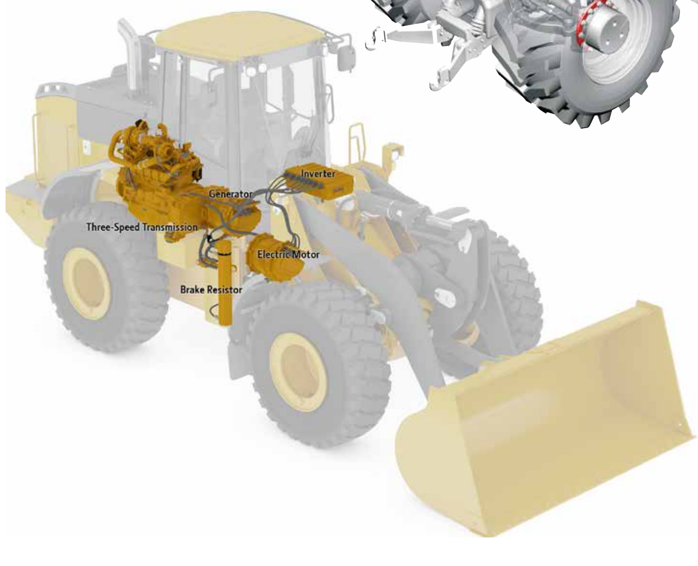
The efficiency of diesel engines as power sources on large machines is improved when they are integrated with elec- tric generation capability on many machines. One method used allows for operation at a steady state without wide variations in engine speed, creating electricity that is then used to power motors for machine propulsion or for auxiliary systems. Operating at or near peak efficiency range allows for large reductions in fuel consumption

and exhaust emissions without compromising operator or machine productivity. This benefit varies with machine form and with work load profile. Machines with variable and repeatable working cycles will see the most benefits from this approach.

In agricultural machines, new energy management and drive systems are being used to power electrically-driven implements, improving fuel efficiency by optimising adjustment and operation independently of the diesel engine powering the machine, which therefore operates more economically.

RESULTS

Fuel savings of up to 20% have been identified by large construction machines incorporating diesel- electrical generators running at a steady state. Further use of electrification could boost this figure to 30% by eliminating the mechanical driveline and integrating an energy storage system. In agricultural machines, fuel savings of up to 10% have been identified from various integrated use of electrical power.



MACHINE EFFICIENCY

TORQUE CONVERTERS AND ALTERNATIVE BRAKING SYSTEMS

GOAL

Boosting fuel efficiency by avoiding braking with the torque converter.

DESCRIPTION

Torque converters are particularly suited to high-capacity machines

such as wheeled loaders, which are often used for digging into piles of loose material and then moving heavy loads. They work by transferring power hydraulically, with the engine powering an oil pump which, by way of a turbine, then transfers drive to the transmission. A drive clutch mechanically locks the pump rotator and the turbine rotator to eliminate power losses.

In short cycle loading – moving material from a heap to a nearby lorry, for example – a forward/reverse shuttle lever can be used to change direction without applying the brakes, the torque converter handling the deceleration. However, this method results in energy loss and places a lot of strain on the converter due to heat transfer. It is possible to

use a braking feature that automatically assists machine deceleration by using the standard service brake instead of the torque converter. This provides a smoother deceleration and direction change, and since the converter is no longer used for braking, not only is converter wear reduced, but fuel use is too.

RESULTS

Fuel savings on machines fitted with this system working in loading and carrying applications can be **as high as 15%.**

MACHINE EFFICIENCY

DRIVE TRAIN OPTIMISATION

GOAL

Optimising the drive train efficiency of a tracked machine.

DESCRIPTION

During the most frequent operations of tracked dozers, from travelling to dozing, an automatic locking function routes the engine power directly to the transmission, bypassing the torque converter, to prevent power loss.

In large dozers, and also in wheel loaders, all functions can be powered by a hydrostatic travel drive which is continuously adjustable, allowing high efficiency over the whole speed range, based on optimal drive adjustment, and allowing the use of fewer moving parts.

Over time, transmissions for these vehicles have changed to much more efficient systems, from the single sliding gear type to the electrohydraulic and power shift and finally to the Continuous Variable Transmission. The efficiency management strategies possible with CVT are constant gear ratio, constant engine RPM, constant speed, economy mode and automatic full power control.

RESULTS

For tracked dozers, bypassing the torque converter results in a **10% increase in efficiency.**

Using a hydrostatic travel drive in large dozers up to 50 tonnes could **cut fuel consumption by 15%.**

Research has shown that for wheel loaders the fuel savings range **from 20 to 40%.**

In tractors with CVT transmissions, **fuel reductions up to 10**% can be observed depending on the working application.

MACHINE EFFICIENCY

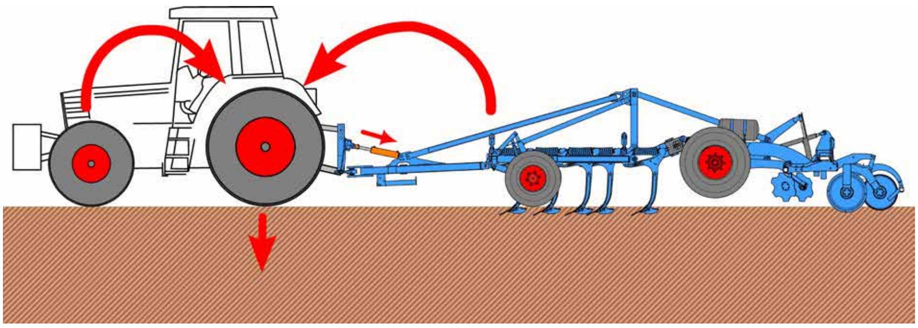
WEIGHT BALANCING BOOSTING TRACTION

GOAL

To improve traction and fuel efficiency by transferring the weight of semi-mounted machines from the implement to the rear axle of the tractor.

DESCRIPTION

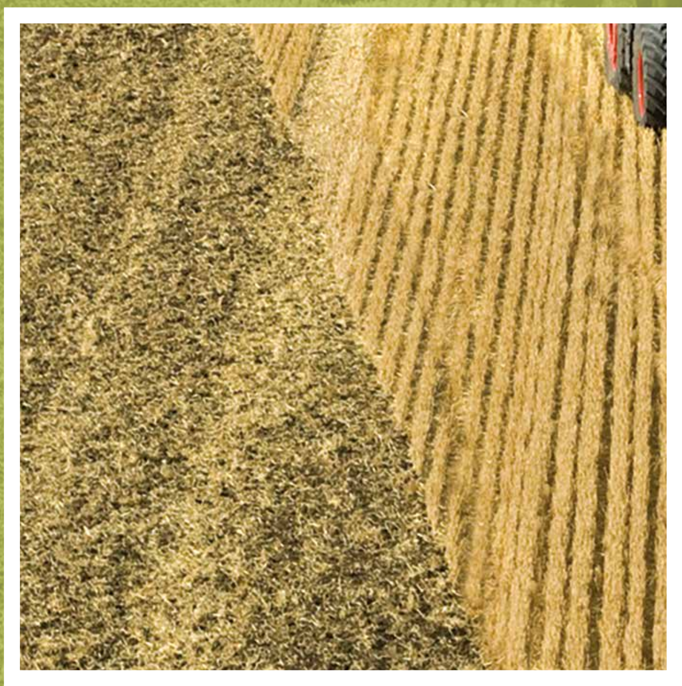
The weight of machines that can be mounted on a tractor and lifted fully by it can be used to improve traction, and therefore fuel efficiency, when working the soil. The weight carried by the tractor acts on the wheels and improves their traction. But wider machines must be trailed, and so lose this benefit. To account for this, a traction-boosting system has been developed to shift part of trailed implements' weight to the tractor, and from the tractor's front axle onto the rear axle, creating an 'intelligent' weight transfer system only provided when required in the field. This cuts wheel slip, boosting traction and therefore fuel efficiency, and allowing lighter, more economical tractors to be used for deep soil cultivation.



RESULTS

This system significantly reduces wheel slip. Working speed can be increased, tractor performance remains more constant, and **up to 20% energy can be saved.**

PROCESS EFFICIENCY EXAMPLES



Intelligent reduction of field passes

Cold recycling process for road repairs

New tillage methods

Automatic machine controls and guidance Precision farming

Optimizing fleet utilisation

PROCESS

INTELLIGENT REDUCTION OF FIELD PASSES

GOAL

Reducing the number of passes tractors make in the field.

DESCRIPTION

New implement designs and combinations of implements can be used to cut the number of passes necessary to complete a task, such as planting potatoes, sowing cereals or cutting and drying grass. This may be done with one machine, or a combination of machines mounted front and rear on one tractor. Certain types of seed drill, for example, can sow fertiliser at the same time. Other machines work in tandem, carrying out operations front and rear. These require sophisticated controls to coordinate them. Communication through a data communica- tion system with the tractor can allow such control.

Combined with the use of minimum tillage to reduce or eliminate fuel- hungry deep cultivations, the use of the right equipment and combined implement systems can, depending on conditions, cut fuel consump- tion in half. In some cases – potato land preparation, for example, there is also the benefit of reduced soil erosion because the land does not remain uncultivated during winter.

RESULTS

Combining field processes can result in a potential **fuel consumption savings up to 50%.** Replacing four tractors pulling 3m implements with two larger ones pulling 6m machines cut overall tractor travel by 25% to complete the same job, **reducing fuel consumption also by 25%.**

PROCESS

COLD RECYCLING PROCESS FOR ROAD REPAIRS

GOAL

Recycling of asphalt when repairing roads and pavements to reduce the need to transport new materials.

DESCRIPTION

For the rehabilitation of asphalt roads a cold recycler granulates the existing pavement material "in-situ" while homogeneously mixing in binding agents and water at the same time. This method produces a recycled construction material mix in just one single machine pass. Cold recyclers are equipped with powerful milling and mixing rotors and with highly efficient injection systems for bituminous binder.

Some machine models are additionally fitted with paving screeds for placing and pre-compacting the recycled material mix or it is delivered straight to an asphalt paver. The outcome is a base layer of high load-bearing capacity. This cold recycling process is reusing the existing material and requires only small quantities of bituminous binder e.g. hot bitumen injected as foamed bitumen. It saves precious natural resources and considerably reduces the number of material loads, which otherwise needs to be transported to the job site. In addition, cold recycling does not require heating for the material processing and consumes less energy.

RESULTS

Cold recycling has been shown to produce **up to 68% less CO_2** when compared to conventional road repair procedures.

PROCESS

NEW TILLAGE METHODS

GOAL

Reducing the amount of fuel per hectare needed to establish a crop by disturbing only the portion of the soil in which the crop will grow.

DESCRIPTION

Traditional cultivation using ploughs requires considerable power, and hence considerable quantities of fuel. New crop establishment techniques plant seed directly into the ground or use shallow-working cultivators instead to disturb the soil far less, using less power and less fuel as a consequence. They also reduce the number of field passes necessary to make a seedbed.

In order to make these 'reduced cultivations' possible, manufacturers of other machinery also play a part. Most combine harvesters, for exam- ple, now incorporate a straw chopper which processes unneeded straw into small fragments, improving its distribution across the field and eliminating the need for it to be removed.

Seed drill manufacturers have developed a new technique known as strip-till, where only the rows of soil where the plants will grow are cultivated, with the strips in between, which represent 80% of the total field area, left undisturbed. This means less power/fuel is required to es- tablish the crop, and can allow wider machinery to be used, thus com- pleting field tasks in fewer passes. A further advantage is a reduction in soil erosion, with previous crop roots remaining relatively undisturbed, and hence binding the soil together.

RESULTS

Reducing the number of field passes necessary to plant a crop can **reduce fuel use by 50%**, depending upon the systems used. Strip-tillage disturbs only the soil needed for the seed rows, leaving 80% untouched, with consequent fuel use benefits.

PROCESS

AUTOMATIC MACHINE CONTROLS AND GUIDANCE

GOAL

The use of automatic machine control and guidance systems to improve accuracy when grading land for new roads.

DESCRIPTION

Machine control and guidance products are tools that combine digital design data, in-cab operator guidance, and automatic blade controls. Bulldozer manufacturers now produce machines which have five different systems offering varying levels and combinations of automatic cross-slope and elevation control. From machine-mounted sensors and ultrasonic technology to GPS and laser guidance, machine controls and guidance products use high precision to deliver high productivity.

In a study, two identical roads were built, one created the conventional way, with stakes on the ground for guidance, and the other the new way, using the machine controls and guidance systems.

RESULTS

The road built with the machine controls and guidance systems was constructed in exactly half the time, with finished design accuracy within tolerance 98% of the time, compared with 45%. Accuracy was also more consistent, resulting in better quality, resulting logically in material savings. Achieving the final design in less time and with considerably fewer passes resulted in **43% fuel savings**.

PROCESS

PRECISION FARMING

GOAL

The adoption of advanced GPS technology and sensor technology to reduce overlaps and misses in fieldwork and hence maximise efficient use of fuel, seeds, fertiliser and other crop inputs.

DESCRIPTION

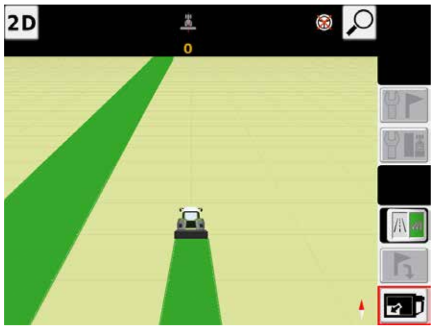
Data gained by sensor technology that measures crops' nutrient needs based on their colour combined with GPS data make it possible to create maps based on results of soil analyses and yields.

The use of these overlaying maps leads to more efficient and therefore reduced application of fertilizers and plant protection products. Even greater efficiencies can be achieved by using GPS to steer tractors with accuracies down to 2.5cm, minimising overlaps and misses when applying fertilisers and crop protection products, as well as cutting fuel use when performing tasks such as cultivation. An average reduction in overlapping means up to 15% savings in fuel and inputs such as seeds and fertiliser.

The accuracy of GPS technology also allows new field practices to be adopted, such as strip-till (only cultivating the portion of the soil that is to contain the seed row) or controlled traffic farming (reducing soil compaction by using the same tractor paths year-on-year).

RESULTS

Every tractor pass with a cultivator is completed at the fullest possible width with no misses or overlaps, using the pass-to-pass accuracy of GPS guided auto-steering, has been shown to **cut fuel consumption by 15%** and the time taken to cover a hectare of land by 16%.



PROCESS

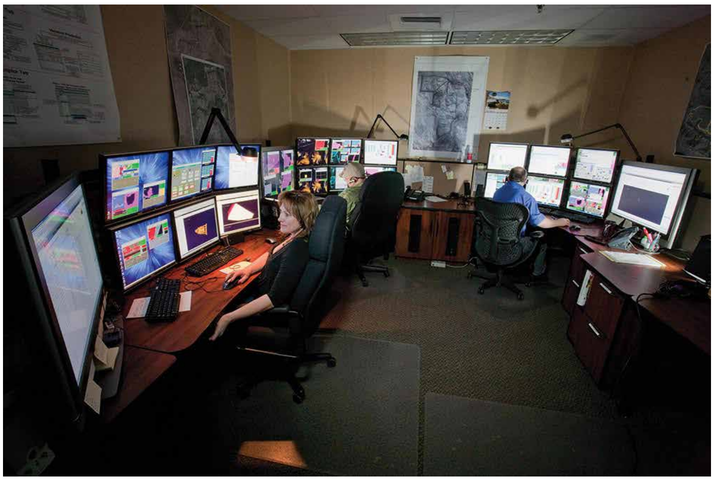
OPTIMISING FLEET UTILISATION

GOAL

Better management of overall machine flow and utilisation leads to improved productivity and lower fuel consumption.

DESCRIPTION

Monitoring systems can be installed on both construction site vehiclesand on working sites. By utilising GPS input, machine position can be tracked and a wireless radio network can allow the machines to communicate with the base office. This technology allows machines to be co-ordinated and routed in the most efficient manner. By generating assignments for each machine that take into account all the other machine tasks, this management control system can manage overall traffic flow, thus optimising the movement of the machines, while meeting the site production goals. Operational considerations such as fuel con- sumption can be incorporated into these systems. The result is a more streamlined, efficient operation, translating directly into fewer machines needed for the same amount of work performed, less idling time and lower CO_2 emissions.



RESULTS

Using this technology to monitor machines across a job site can reasonably achieve **increases of 10-15% in productivity**, with the same, or lower, fuel consumption.

OPERATION EFFICIENCY EXAMPLES

Fuel saving operating mode selector/automatic deceleration control

Correct tyre pressure

Inform, train and teach correct machine use

Inform, train and teach in process management

OPERATION EFFICIENCY

FUEL SAVING OPERATING MODE SELECTOR/ AUTOMATIC DECELERATION CONTROL

GOAL

To improve the fuel efficiency of bulldozers.

DESCRIPTION

To enable him to operate in the most fuel efficient mode, the bulldozeroperator can choose between two operating modes, one for work where capacity counts and the emphasis is on working speed and power, and another designed for fuel saving, for the operation being performed. An 'eco gauge' can be displayed on the monitor screen to help the driver operate the machine in an environmentally-aware and energy-saving way.

To further reduce fuel use and reduce operating noise, an idling caution is displayed on the monitor screen whenever the machine is left idling for more than five minutes. A few seconds after placing the operation lever in neutral, the automatic deceleration control decreases the engine rpm to prevent unnecessary fuel consumption.

RESULTS

Idling system and choice of operating modes results in a **fuel efficiency improvement of up to 10%.**

OPERATION EFFICIENCY

CORRECT TYRE PRESSURE

GOAL

Providing information on tyre selection and inflation to help machine buyers maximise tyre life and limit fuel consumption.

DESCRIPTION

Tyre pressure control systems mean tractor tyre pressures can be increased on the road, where a firm tyre is required for good fuel efficiency and handling, and reduced in the field. With lower pressures more tyre is placed in contact with the ground, meaning less energy loss through slip, therefore ensuring more effective tractor traction power and less soil compaction. Ultra-low pressure tyres provide not only a low slip rate but also a low rolling resistance, meaning productivity and fuel savings.

In construction machinery, studies have proven the impact tyre selection has on efficient backhoe loader operation. On soft ground a traction tyre is best; for hard ground, an industrial tyre is preferable.

Using the wrong tyre, pressure setting or ply can significantly increase fuel consumption and replacement frequency. Informing and educating operators about tyre selection has also significantly reduced overall machine running cost. Lower fuel consumption from fitting the correct tyres and operating them as recommended also leads to significantly lower CO_2 emissions.

RESULTS

The use of the correct tyres on a backhoe loader can **reduce fuel consumption by up to 10**% and widen replacement intervals by up to 30%. Varying the tyre pressures between field and road on an agricultural tractor both protects the soil and **improves fuel efficiency by up to 30%.**

OPERATION EFFICIENCY

INFORM, TRAIN AND TEACH CORRECT MACHINE USE

GOAL

To help all who work in construction, from managers to machine operators, select the right machine for the task and operate it as efficiently as possible, saving fuel and cutting CO_2 emissions as a result.

DESCRIPTION

Training classes offered at manufacturers' factories or the customer's workplace help to educate machine owners and operators in choosing the correct machine for the job in hand.

Additionally, each customer receives training in machine operation and application specifics when a new machine is delivered. Aspects include the most efficient way to complete a task, as well as the economic operation of the machine.

One large construction company which uses 10 million litres of diesel to power its machine every year has lowered consumption by around five per cent. Not only does that save the business about €250.000, but it also cuts CO_2 output by around 500 tonnes. Eco driving – operating machines at the forward speed and engine speed required by the task – not only reduces CO_2 emissions, but benefits operators by way of reduced stress, improved safety and a more secure working area.

Another large firm has cut fuel use by 5% as a whole, and 12% at one site, or about 50-70.000 litres for ten machines. At the same time, the companies concerned benefit from faster job completion.

RESULTS

Fuel savings ranging from 5 to 30%, with associated benefits of improved operator awareness of what the training is trying to achieve, from better business efficiency to reduced fuel use and CO_2 output.

OPERATION EFFICIENCY

INFORM, TRAIN AND TEACH IN PROCESS MANAGEMENT

GOAL

Machinery efficiency in the whole process of farming is the primary path to reduced fuel consumption and, consequently, reduced CO_2 emissions. Professional driver courses and training can help achieve this.

DESCRIPTION

Choosing the right machinery for a process does not automatically minimise CO_2 emissions. The wide variety of different machines used on a farm and their increasing complexity make training crucial. But much of agriculture's business is transportation, mostly carried out with tractor-trailer combinations. Education and training can help drivers to learn the best way to use brakes, throttle and gears to minimise fuel use, as well as ensuring machines are set-up, ballasted and serviced to operate at peak performance. New systems allow operators to adjust tyre pressures so they can be lowered in the field, increasing ground contact, traction and fuel efficiency.

Operator training and education also helps drivers to choose the optimum machine combination for specific conditions, taking into account crop requirements, soil type, erosion sensitivity and weather conditions.

RESULTS

Professional driver courses have been shown to **reduce fuel consumption by up to 20%**.

ALTERNATIVE ENERGY SOURCES EXAMPLES

- Hybrid drivetrain technology of a compaction roller
- Pure plant oils
- Dedicated hybrid excavator
- Battery and fuel-cell, a dream coming through
- Energy storage cylinder for excavators
- Electric excavators and material handlers

ALTERNATIVE EFFICIENCY

HYBRID DRIVETRAIN TECHNOLOGY OF A COMPACTION ROLLER

GOAL

Lower fuel consumption and less CO_2 emitted, in addition to lower noise levels.

DESCRIPTION

In addition to the usual conventional drive components, the 'hybrid' roller has an electric motor generator, a high-capacity battery and associated electronics. Operation is simple and efficient: the battery is charged in generator mode – e.g. when braking (reversing) or during vibration shutdown – using the difference between the power generated by the engine and the power take-up. Any unused power is stored. Power peaks are levelled out when the electric motor takes power from the battery – when switching on vibration or during acceleration, for example. Using this system reduces the size of engine required, lower- ing CO_2 output in itself. At the same time, the engine always operates at optimum performance and efficiency, which lowers fuel consump- tion and associated CO_2 emissions significantly.

RESULTS

When used on compaction rollers, hybrid drivetrain technology results in significant **savings of up to 30% in fuel consumption** and a comparable reduction of CO_2 emissions.

ALTERNATIVE EFFICIENCY

PURE PLANT OILS

GOAL

To create a clean fuel supply system for mobile working machinery by complete replacement of fossil fuels.

DESCRIPTION

Pure plant oil is one of the most promising of all renewable fuel sources, particularly for agricultural applications, where pure vegetable oil could play a key role in future farming strategies. And production of such oils offers spin-off benefits – rapeseed crushed for plant oil can then be used as a livestock protein feed. The crop therefore provides an integrated solution for feed, food and fuel production.

Besides the obviously broad ecological benefits due to its low carbon footprint, pure vegetable oil offers an enormous economic potential for agricultural farms in the field of energy production. This is especially true in decentralised supply chains or for fuel self-supply in farms.

RESULTS

The fossil fuel-derived CO_2 reduction potential for fully refined plant oil, at a **minimum 57%**, is one of the highest of all cold-pressed plant oil biofuels.

ALTERNATIVE EFFICIENCY

DEDICATED HYBRID EXCAVATOR

GOAL

To improve the fuel efficiency of 360-degree excavators.

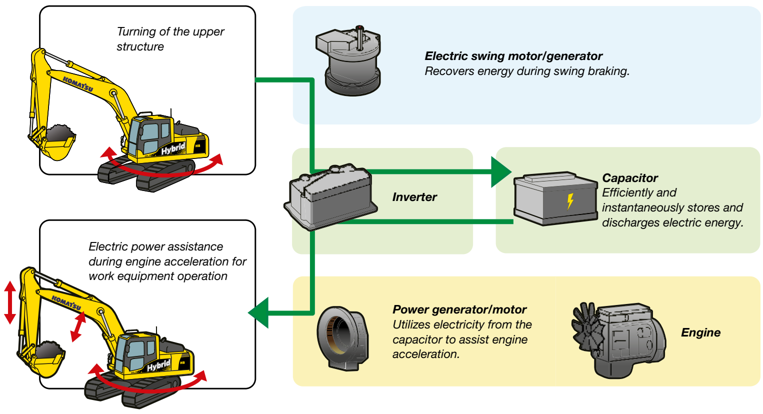
DESCRIPTION

One of the latest developments in 360-degree excavator design is power that is sourced from a hybrid system, which includes a specifically developed electric swing motor, a power generator motor, a capacitor and a conventional diesel engine. The system has been developed to work on the principle of energy regeneration from the machine's swinging action and energy storage using an ultra capacitor, which provides fast energy storage and instantaneous power transmission.

The kinetic energy generated during the swing-braking phase of the machine, when it pivots and then stops in order to dump earth or dig in a different place, is converted to electricity, which is sent through an inverter and then captured by the ultra capacitor. This captured energy is then discharged very quickly for use in rotation and to assist the engine as commanded by the hybrid controller when required for moving the digging boom.

RESULTS

Fuel savings of up to 25% have been recorded from use of the system, with associated CO_2 emission reductions.



ALTERNATIVE EFFICIENCY

BATTERY AND FUEL-CELL POWERED MACHINES

GOAL

To replace fossil fuels as a power source with renewable (mainly electric) energy.

DESCRIPTION

Farmers are increasingly substituting fossil energy sources with self-produced sustainable energy. Regenerative energy for stationary applications is mostly electric power from sources such as biogas, wind and photovoltaic systems. Electric energy is therefore expected to be the key energy form, and since electrification will be an enabler for automation, electric drives, storage devices and electric power supplies have the greatest potential for significant technological benefits.

Agricultural equipment manufacturers are researching batteries and fuel cells as carriers for electric energy and the integration of future electro-mobility concepts into medium-sized decentralised rural energy supply systems and electric power grids. The electric energy storage on agricultural production and transport vehicles would support smaller rural electric power grids for renewable energies. A strong positive impact on the development of rural areas and on the improved usage of electric energy from renewable resources will be the result.

RESULTS

The development of such a system of power generation has the potential to create energy- independent farming that **does not use fossil- derived fuels** which are positive CO_2 producers.

ALTERNATIVE EFFICIENCY

ENERGY STORAGE CYLINDER FOR EXCAVATORS

GOAL

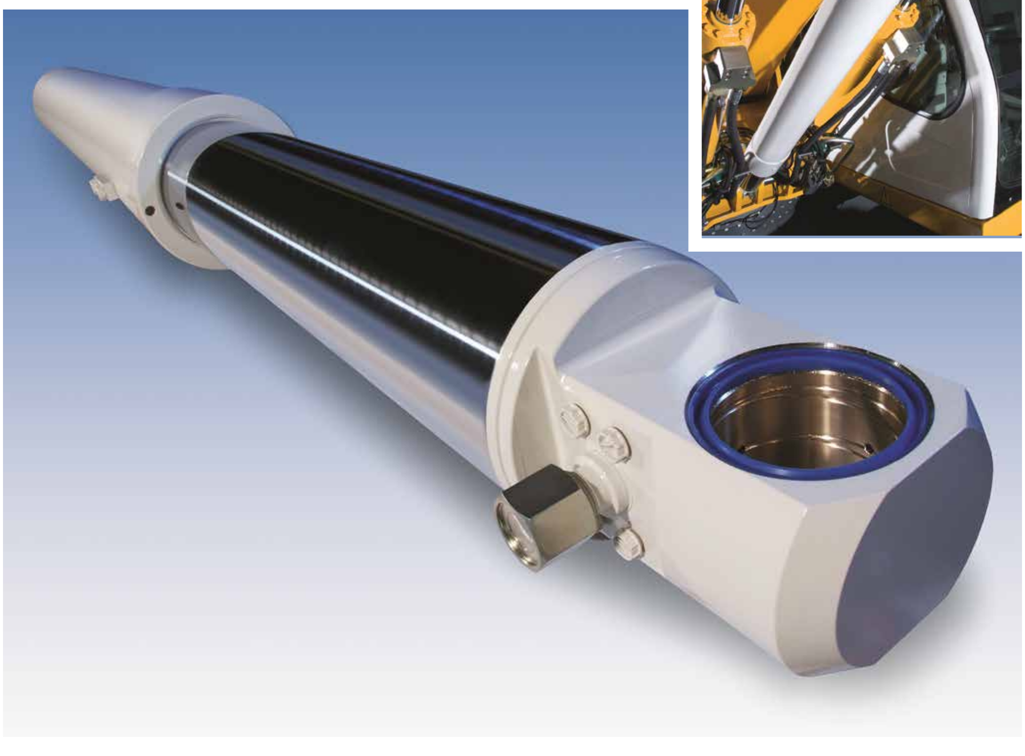
To capture wasted energy.

DESCRIPTION

This system has been developed initially for materials handling machines of between 30 tonnes and 80 tonnes in weight, with plans to extend its use to both smaller and larger materials handlers. It works by using the force created by lowering the machine's boom to compress a gas in a storage cylinder. When the boom is then raised, this stored energy then assists the action of the boom's two hydraulic lifting rams, meaning less demand is placed on the engine. The system is designed as a separate entity for use on the machine, with no need for the addition of complex additional installations such as separate storage devices.

RESULTS

Depending on the application the machine is being used for, potential **fuel savings are as high as 20**% per hour.



ALTERNATIVE EFFICIENCY

ELECTRIC EXCAVATORS AND MATERIAL HANDLERS

GOAL

Increasing the efficiency of excavators and material handlers by replacing diesel engines with highly-efficient electric motors.

DESCRIPTION

The combination of new, efficient material handlers with a pure electric drive, with no combustion engine, leads to significantly higher overall efficiency. Such electric machines are connected to the public power network and produce zero local CO_2 emissions, maximising efficiency from the energy source to the machine. The application is not limited to stationary machines, as semi-stationary machines, like crawler excavators, can use this technique as well. This solution is much more effective than, for example, electric cars, which have to carry heavy batteries.

RESULTS

This system results in 100% local $C0_2$ reduction, and **100% total CO_2 reduction when using renewable energy sources** to produce the electricity. Even where this is not the case, reduction is still in the region of **10-15%**.

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