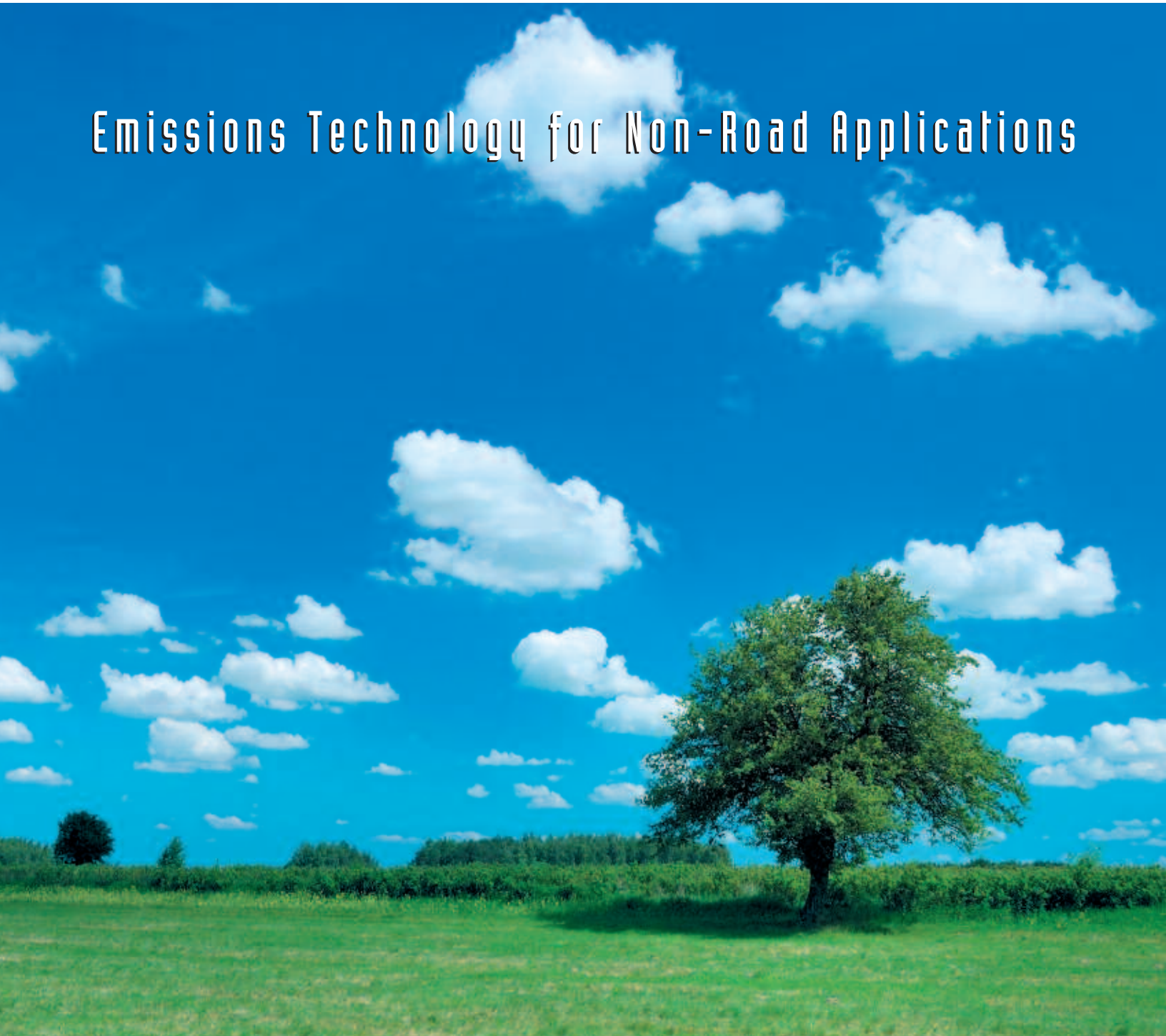
JOHN DEERE

Engine Performance, Fuel Efficiency, and Clean Air

Emissions Technology for Non-Road Applications



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John Deere takes an integrated approach to engine performance, fuel efficiency, and clean air. In this brochure, you'll learn about past, present, and future emissions regulations for non-road engines, the technology options to meet them, and how we're applying this technology to answer emission requirements, improve fuel efficiency, and meet customer needs. You'll see how John Deere is meeting current Tier 3/Stage III A regulations and how we are positioned to solve the stringent demands of Interim Tier 4/Stage III B and Final Tier 4/Stage IV regulations in the years to come.

More than emissions.

Reducing emissions requires a combination of proven technologies, some new ideas, and a keen understanding of the unique demands of non-road applications. John Deere engineers look at meeting engine emissions as an opportunity to advance new technologies that increase fuel efficiency and improve engine performance parameters such as power bulge, peak torque, low-speed torque, and transient response time.

Non-road integration.

John Deere works closely with OEMs to apply emissions solutions in a multitude of non-road applications. We use cutting-edge engineering tools and principles to design and validate our engine and drivetrain products. You have to experience results in many non-road applications to truly evaluate engine performance and provide an optimized solution. Through John Deere Coffeyville Works (formerly known as Funk Manufacturing) and Phoenix International® subsidiaries, we also bring a wealth of non-road experience in drivetrain products and electronic systems. Being able to integrate all of these drivetrain components and electronic control units will become even more important as the industry moves closer to Tier 4/Stage IV.

A long history of environmental responsibility.

John Deere takes its responsibility to the environment very seriously. We have been working on lowering engine emissions since 1967, when John Deere first installed emissions testing equipment – years before government standards were set in the United States and Europe. John Deere also worked actively with industry partners such as the Engine Manufacturers Association (EMA), the European Association of Internal Combustion Engine Manufacturers (EUROMOT) and regulatory agencies worldwide to advance environmental initiatives.

In our efforts to reduce engine emissions and fuel consumption, John Deere engineers employ a global network of technical resources. Today, we utilize the latest technology for lowering oxides of nitrogen (NOx), particulate matter (PM), carbon monoxide (CO), hydrocarbons (HC), and carbon dioxide (CO_2) emissions – all while improving fuel efficiency. And we continue to devote considerable resources to making the product perform better.

These efforts result in engines that comply with non-road emission regulations for the U.S. Environmental Protection Agency (EPA), California Air Resource Board (CARB), the European Union (EU), and Japan. Like Tier 1/Stage I and Tier 2/Stage II engine offerings, we launched our Tier 3/Stage III A engines ahead of EPA and EU deadlines. And we accomplished it while maximizing fuel efficiency and engine performance.

John Deere meets emissions regulations.
In 1996, John Deere launched a new breed of engines, called PowerTech™, to meet Tier 1/Stage I emissions regulations. We built on this non-road engine platform to meet Tier 2/Stage II in 2001, and now Tier 3/Stage III A emissions regulations. In the years to come, John Deere will continue to use this platform for Interim Tier 4/Stage III B and Final Tier 4/Stage IV solutions.

Lowering emissions.

The non-road industry has made significant gains in its efforts to reduce emissions while improving performance. Currently, less than 0.3 percent of non-road engine exhaust contains emission pollutants like NOx, CO, HC, and PM. The rest (99.7 percent) of engine exhaust is made up of natural elements in the air like nitrogen (N_2), oxygen (O_2), and water vapor (H_2O). At the same time, engine power output has steadily increased over the years.

99.7% Products of Complete Combustion

N_2 – Nitrogen
O_2 – Oxygen
CO_2 – Carbon dioxide
H_2O – Water

0.3% Regulated Emissions

NOx – Oxides of nitrogen, which react in the atmosphere with hydrocarbons to form particulate matter
CO – Carbon monoxide, a product of incomplete combustion
SOx – Oxides of sulfur, which contribute to acid rain
HC – Hydrocarbons, another product of incomplete combustion
PM – Particulate matter, a non-gaseous product of combustion and atmospheric reactions

Leadership in biodiesel.

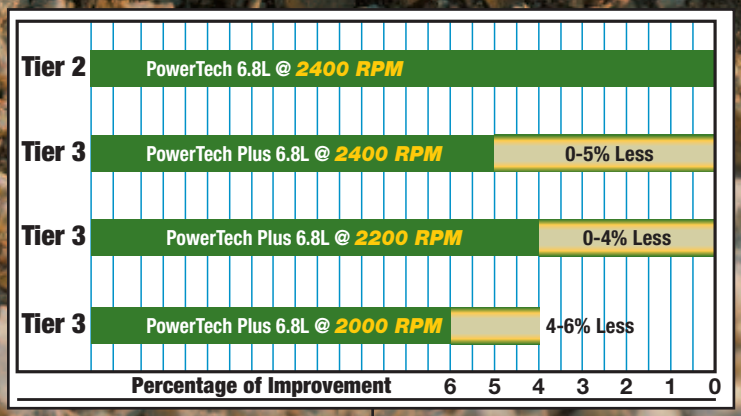
John Deere's leadership in the use of biodiesel is another example of our commitment to environmentally friendly engine solutions. Biodiesel is a clean, oxygenated fuel made from renewable agricultural resources such as soybeans and rapeseeds. It is simple to use, biodegradable, and free of sulfur. Using biodiesel fuel reduces particulate emissions, as well as decreases dependence on crude oil.

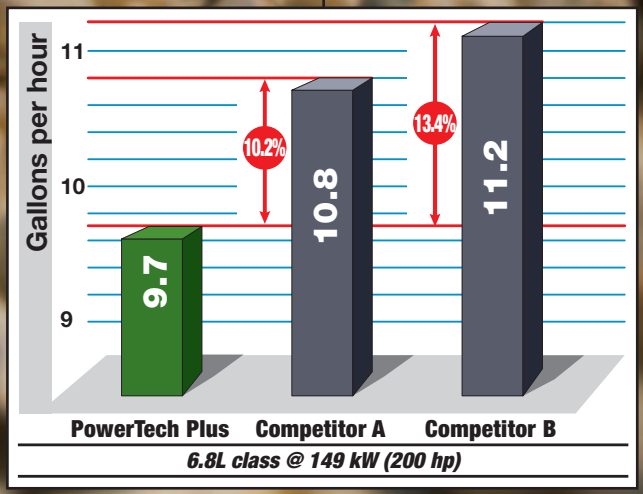
John Deere was one of the first engine manufacturers in the non-road industry to factory-fill biodiesel B2 fuel (2 percent biofuel and 98 percent diesel) in North America. We approved B5 fuel in December 2001. John Deere has proven the practicality of B5 biodiesel fuel, and many manufacturers in the industry are following our lead.

A record of improved fuel economy and performance.

John Deere not only has a responsibility to reach lower emissions levels, we have a responsibility to provide customers with improved engine performance and fuel efficiency. The record shows we've been able to achieve both.

PowerTech Plus 6.8L

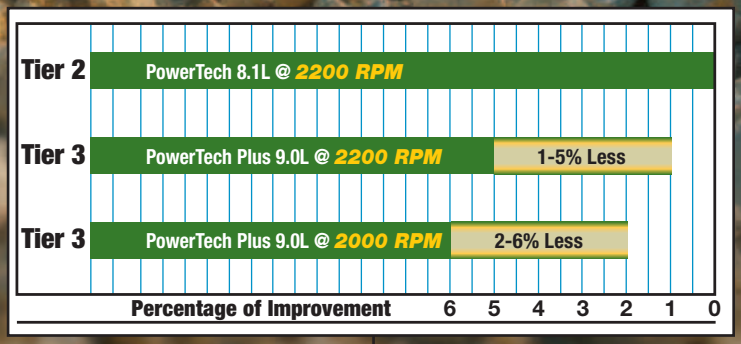


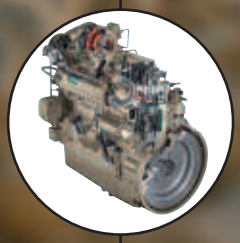


Based on $2.50 a gallon for diesel fuel, you can save between $2,750 and $3,750 for every 1000 hours of operation.

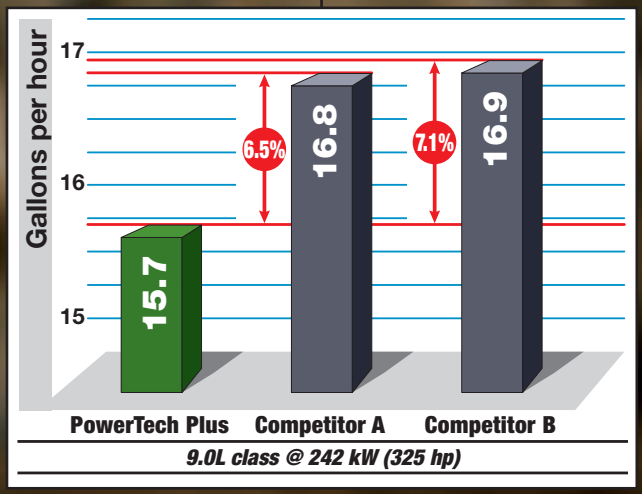
Tests of the PowerTech Plus 6.8L and 9.0L — utilizing cooled exhaust gas recirculation (EGR) and the variable geometry turbocharger (VGT) — show up to 6 percent improvement in fuel economy when compared to John Deere Tier 2/Stage II engines. When compared to competitive engines, the PowerTech Plus engines show up to 13.4 percent improvement in fuel economy.

PowerTech Plus 9.0L





1 gallon = 3.785 liters



Bare engine data obtained from competitive Tier 3/Stage III A performance curves or factory observed bare engine data at full load rated speed. Results may vary based upon application of engine.

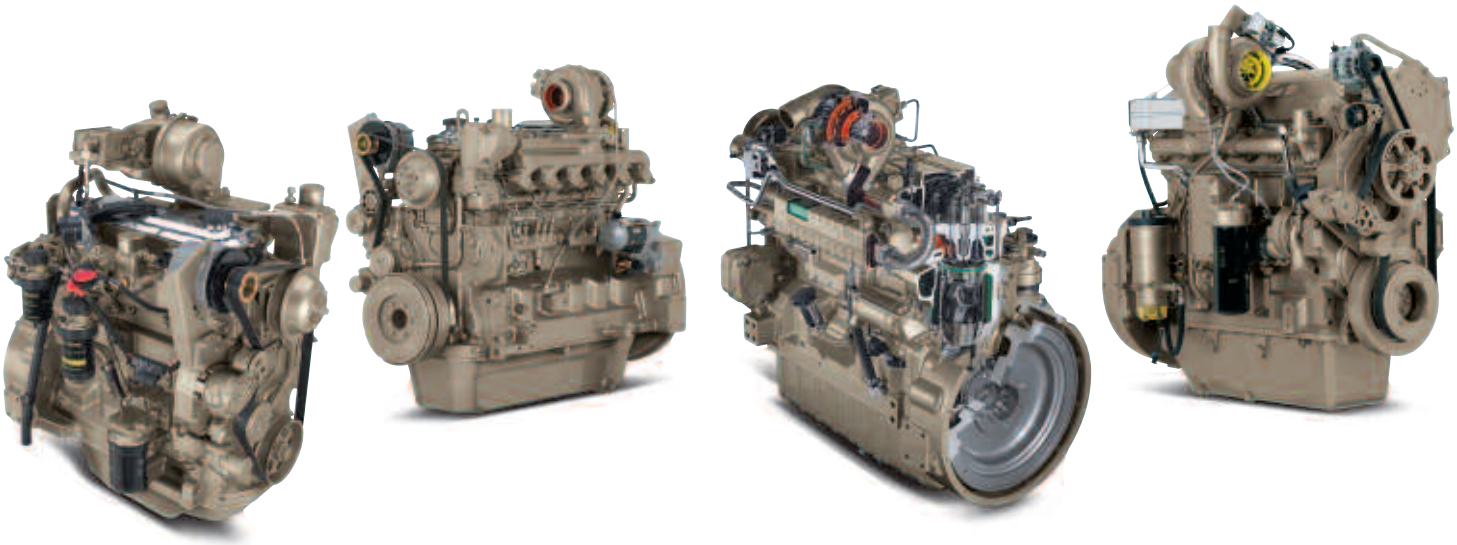
John Deere knows non-road applications.

If the only place engines had to perform was in a testing lab, everyone's job would be a lot easier. In the working world, John Deere non-road engines power thousands of applications – many of them in not-so-nice conditions such as dusty fields, rugged construction sites, and extreme hot and cold. Think of any harsh location and a John Deere engine is probably working there. As a leader in non-road engines, John Deere is uniquely positioned to provide technologies that meet the distinct demands of these applications.

How does John Deere do it? We take technologies that have proven to be effective and add innovations specifically suited to non-road applications. Because much of the technology is well established, John Deere can focus on adding benefits such as better fuel economy and greater engine performance.

John Deere non-road firsts.

- John Deere was the first to use a turbocharger in ag tractors (1969).
- John Deere was the first to use air-to-water charge air cooling in non-road applications (1971).
- John Deere was the first to use air-to-air charge air cooling in non-road applications (1988).
- John Deere was the first to utilize electronic engine controls in non-road applications (1988).

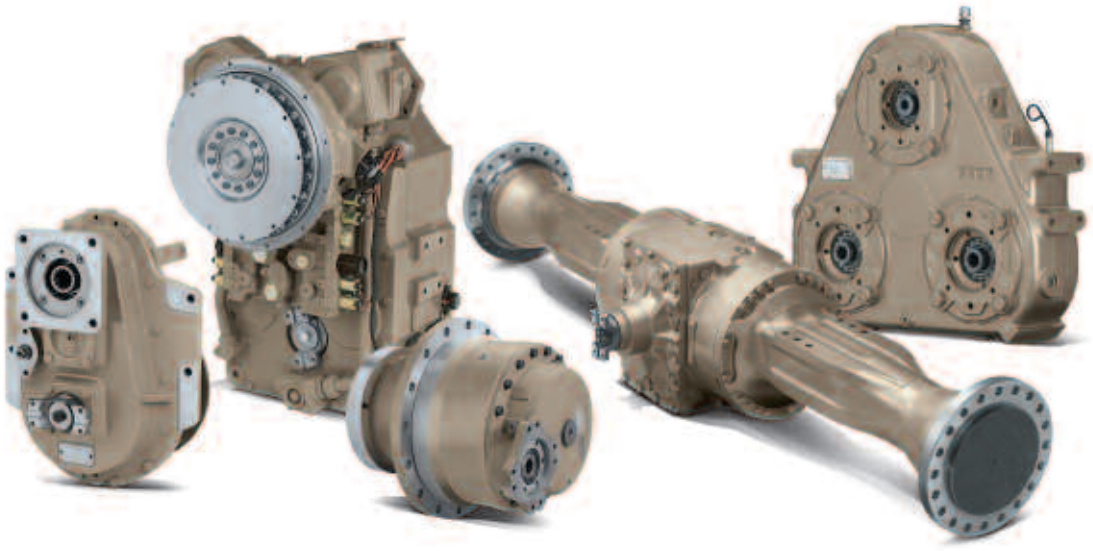


Many machines for many jobs – the unique challenges of non-road applications.

The EPA recognizes that non-road applications pose unique challenges for meeting emissions regulations.

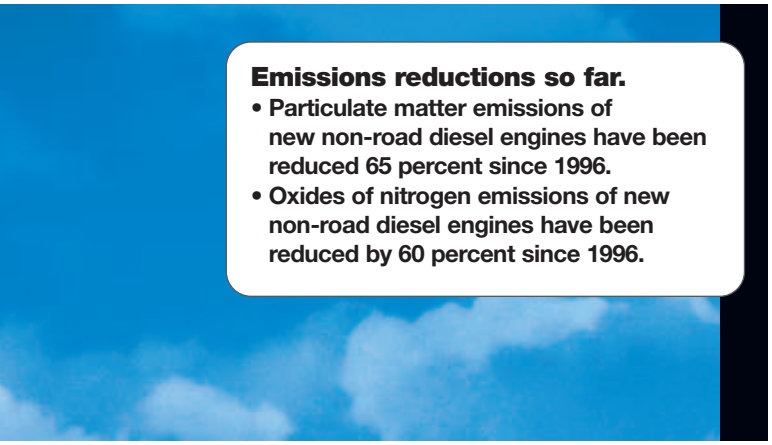
- Non-road diesel-powered equipment is used in a wide variety of applications including construction, agricultural, industrial, power generation, and airport services.
- Unlike other categories of mobile engines, the non-road diesel category applies to a broad range of engine sizes, types of equipment, and power ratings.
- Varying equipment sizes and configurations create packaging and engine envelope constraints.
- More difficult to apply air-to-air aftercooling.
- Most companies involved in the non-road diesel industry are not "vertically integrated" – they do not produce both engines and equipment.
- Over 650,000 pieces of non-road diesel equipment are sold in the United States each year. There are about 6 million pieces of non-road diesel equipment currently in use. According to the EPA, the entire fleet of diesel engines is expected to be transitioned to near-zero emission levels by 2030.

John Deere Power Systems (JDPS) manufactures 30 to 448 kW (40 to 600 hp) diesel engines for a variety of non-road applications. In addition to engines, John Deere also provides heavy-duty drivetrain components such as powershift transmissions, hydrostatic motor-driven transmissions, axles, planetary drives, and pump drives used in non-road applications.



Understanding emissions regulations.

All engines – diesel, gasoline, propane, and natural gas – produce exhaust containing carbon monoxide, hydrocarbons, and oxides of nitrogen. These emissions result when complete combustion does not take place in the cylinder. Diesel engines also produce particulate matter. As more focus is placed on health and environmental issues, governmental agencies throughout the world are enacting tougher emissions laws.



Emissions reductions so far.

- **Particulate matter emissions of new non-road diesel engines have been reduced 65 percent since 1996.**
- **Oxides of nitrogen emissions of new non-road diesel engines have been reduced by 60 percent since 1996.**

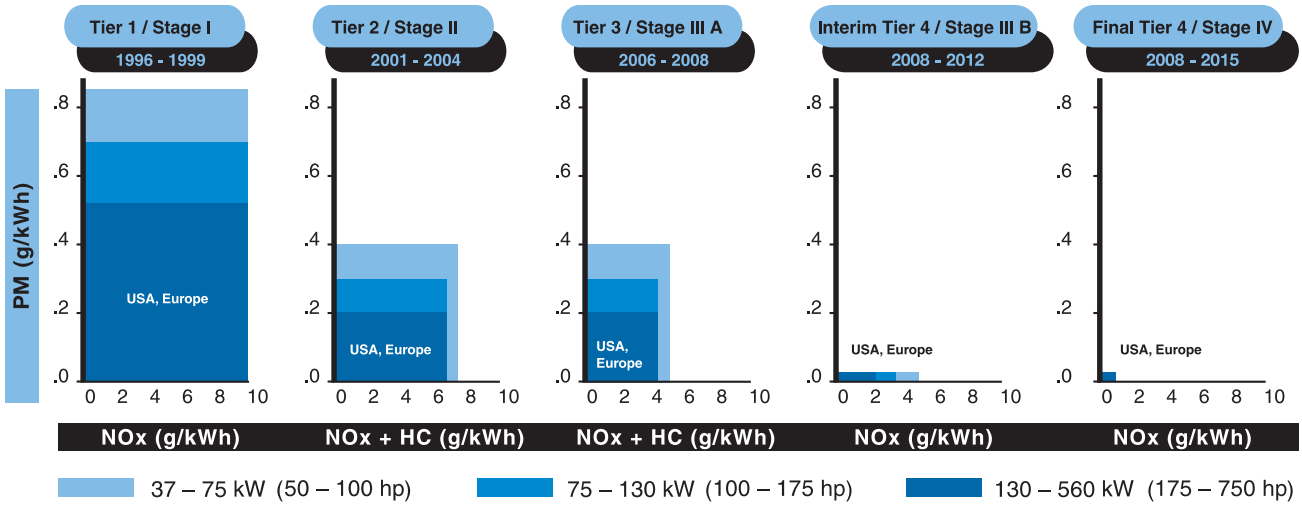
Because so many diesel engines are used in trucks, the U.S. Environmental Protection Agency and their counterparts in Europe and Japan first focused on setting emissions regulations for the on-road market. While the worldwide regulation of non-road diesel equipment came later, the pace of cleanup and rate of improvement has been more aggressive for non-road equipment than for on-highway engines.

The first standards for new non-road diesel engines over 37 kW (50 hp) were phased-in from 1996 to 1999 (EPA Tier 1). European standards for non-road engines (Stage I) began in 1999. All authorities have set increasingly more stringent Tier 2/Stage II and Tier 3/Stage III A standards for all equipment with phase-in schedules from 2001 to 2008. Tier 4/Stage IV regulations are scheduled to take effect as early as 2008 for engines 37 kW (50 hp) and below, and to be completed by 2015. See the chart at the right for detailed dates and emissions levels for the EPA and European Union regulations. Engines designed for EPA and EU emission regulations may not meet lower particulate matter requirements in Japan and may impact a manufacturer's ability to sell common products into the Japanese market.

Reducing worldwide emissions.

Tier 3/Stage III A standards required an approximate 65 percent reduction in PM and a 60 percent reduction in NOx from 1996 levels. Interim Tier 4/Stage III B standards, which will take effect for many horsepower ranges in 2011, require a tenfold reduction in PM along with a twofold drop in NOx. Final Tier 4/Stage IV standards, which will be fully implemented by 2015, will decrease NOx an additional fivefold. When all the dust settles, emissions levels for non-road engines will be reduced 90 percent from current levels. The chart below is a good illustration of the reductions in the United States and Europe. For any other country-specific request, feel free to contact John Deere.

NON-ROAD EMISSIONS REGULATIONS: 37 – 560 kW (50 – 750 hp)



EPA and EU Non-Road Emissions Regulations

hp (kW)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
<11 (8)					7.5 0.80			7.5 0.40		7.5 0.60					
(<8)	Not regulated in EU														
≥11 (8) <25 (19)					7.5 0.80			7.5 0.40							
(8 - 19)	Not regulated in EU														
≥25 (19) <50 (37)				7.5 0.60				7.5 0.30					4.7 0.03		
(19 - 37)	8.0 1.5 0.80						7.5 0.60								
>50 (37) <75 (56)				7.5 0.40				4.7 0.30					4.7 0.03		
								4.7 0.40				4.7 0.03			
(37 - 56)				7.0 1.3 0.40				4.7 0.40					4.7 0.025		
>75 (56) <100 (75)				7.5 0.40				4.7 0.40				3.4, 0.19 0.02			0.40, 0.19 0.02
(56 - 75)				7.0 1.3 0.40				4.7 0.40				3.3 0.19 0.025			0.40 0.19 0.025
≥100 (75) <175 (130)			6.6 0.30				4.0 0.30					3.4, 0.19 0.02			0.40, 0.19 0.02
(75 - 130)			6.0 1.0 0.30				4.0 0.30					3.3 0.19 0.025			0.40 0.19 0.025
≥175 (130) <300 (225)			6.6 0.20			4.0 0.20					2.0, 0.19 0.02			0.40, 0.19 0.02	
≥300 (225) <600 (450)	6.4 0.20														
≥600 (450) <750 (560)		6.4 0.20													
(130 - 560)		6.0 1.0 0.20				4.0 0.20					2.0 0.19 0.025			0.40 0.19 0.025	
≥750 (560)						6.4 0.20					3.5, 0.19 0.10				3.5, 0.19 0.04
(>560)	Not regulated in EU														
Fuel Sulfur	5000 ppm							500 ppm			15 ppm				
Fuel Sulfur	2000 ppm							1000 ppm		10 ppm (not finalized)					

EPA	Tier 1	Tier 2	Tier 3	Interim Tier 4	Final Tier 4
EU	Stage I	Stage II	Stage III A	Stage III B	Stage IV

NOx, NMHC or NOx+NMHC g/kW hr, PM g/kW hr

Emissions technology options.

Reduced emissions don't have to come at the expense of engine performance. John Deere engineers utilize a combination of innovative engine design and new technology to improve fuel economy and performance while meeting emissions regulations.

Available technologies for reducing emissions include:

- Charge air cooling
- In-cylinder solutions
- Exhaust gas recirculation
- Turbocharging
- Fuel injection systems
- Full authority electronic controls
- Aftertreatment

Charge air cooling.

Keeping air intake temperatures as low as possible controls NOx. John Deere leads the industry in applying air-to-air charge air cooling to non-road applications. This technology has been used on John Deere engines for nearly 20 years. Air-to-air charge air cooling not only reduces NOx, it improves engine durability and increases low-speed torque and power density. It is the most efficient method of cooling intake air to help reduce engine emissions while maintaining low-speed torque, transient response time, and peak torque. Charge air cooling enables an engine to meet emissions with better fuel economy and lower installed costs.

In-cylinder solutions.

Combustion bowl and piston ring design.

Particulate emissions have been reduced on John Deere engines by increasing injection pressure and improving the shape of the combustion bowl at the top of the piston. A reduced lip radius on the re-entrant bowl piston increases turbulence and air fuel mixing, helping burn all available fuel during combustion.

The addition of valve guide seals limits particulates by reducing oil consumption. Directed top-liner cooling reduces oil consumption and enhances combustion efficiency by reducing wear in the top ring turnaround area and improving piston ring performance.

Premixed compression ignition (PCI).

In traditional diesel combustion, the burning occurs in the rich regions of the spray resulting in high temperatures and high NOx. With premixed compression ignition (PCI), multiple fuel injection strategies are used to lower temperatures. This technique reduces NOx without using exhaust gas recirculation.

Exhaust gas recirculation (EGR).

The lower an engine's peak combustion temperature, the less the amount of NOx created. EGR is an effective method of reducing peak combustion temperature and reducing NOx. The concept is simple. During certain conditions of engine operation, the EGR valve opens and measured amounts of exhaust gas are routed back into the intake manifold and mixed with the incoming fresh air. Since this process removes some oxygen from the air, the exhaust temperatures in the combustion process are lowered and the levels of NOx are reduced.

Cooled EGR, as used in John Deere PowerTech Plus™ engines, increases the effectiveness of NOx reduction, while enhancing engine efficiency and power density (similar to charge air cooling).

Turbocharging.

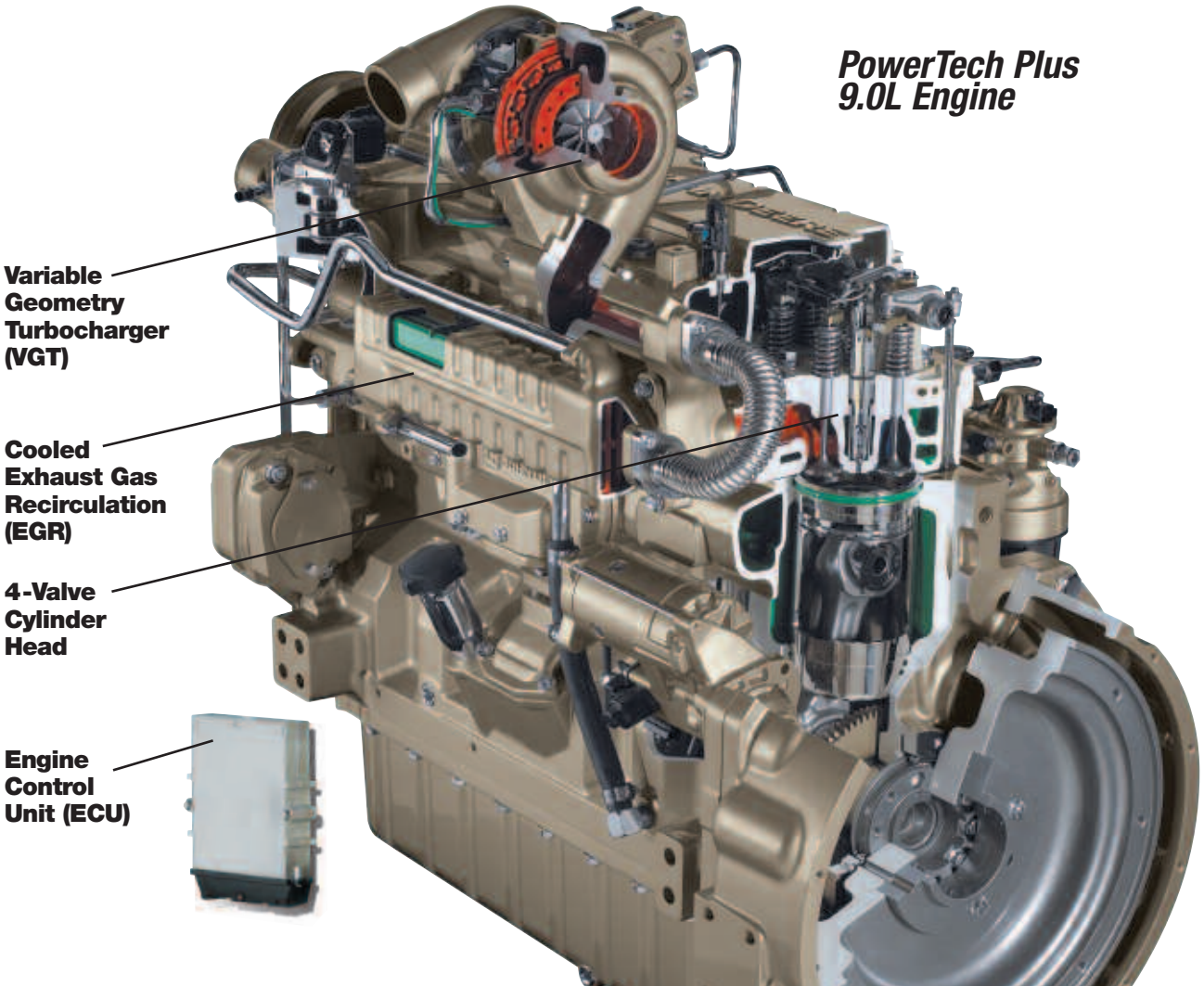
Standard or wastegated turbocharger.

Depending on the power rating, standard or wastegated turbochargers are precisely matched to the power level and application. Transient smoke is controlled by using higher-boost turbochargers, including using wastegated turbos that increase low-speed torque and prevent over-boosting at high speed.

Variable geometry turbocharger (VGT).

Another key feature of John Deere Tier 3/Stage III A PowerTech Plus engines is the variable geometry turbocharger, which helps drive exhaust gas recirculation. The VGT tailors the amount of recirculated exhaust gas that mixes with the fresh air. This is accomplished through the engine control unit, which changes the pitch of the VGT vanes in order to maximize power and efficiency. The amount of cooled EGR required is determined by load and engine speed. When the exhaust flow is low, the vanes are partially closed. This increases the pressure against the turbine blades, making the turbine spin faster and generating more boost.

The VGT minimizes the impact on engine envelope size and provides excellent performance across the entire operating range of the engine, including transient response and fuel economy. It is also a highly effective approach to meeting Tier 3/Stage III A regulations and allows a wider power range using common engine performance hardware – reducing the number of engine configurations for OEM customers and distributors.



Fuel injection systems.

High-pressure common rail fuel injection system.

For middle range engines, the high-pressure common rail fuel injection system provides constant control over fuel injection variables such as pressure, timing, duration, and multiple injections. It delivers higher injection pressures, up to 1600 bar (23,500 PSI), for more efficient combustion.

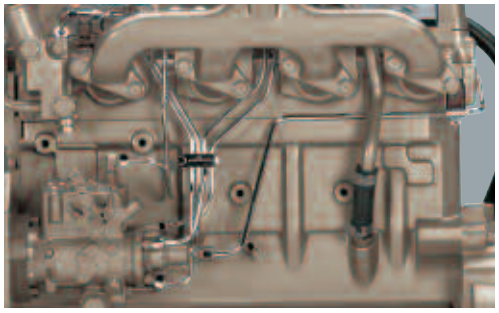

Electronic unit injector (EUI)

Electronic unit injector (EUI).

For the larger size engines, the EUI fuel injection system is used to increase fuel pressure for more efficient combustion. This helps reduce NOx and PM.

Mechanical fuel system.

For smaller engines, John Deere has been able to meet many emissions regulations by making improvements to the mechanical fuel system. Newer mechanical fuel systems are able to generate higher injection pressures for more efficient combustion.


Mechanical fuel system

Full authority electronic controls.

Another key component in emissions reduction is the engine control unit (ECU). It uses sensors and models to control fuel quantity, injection timing, air-to-fuel ratio, multiple fuel injections, amount of cooled EGR, and a host of other control parameters to deliver peak engine performance and fuel economy.

Integrating electronic controls between the engine and the entire vehicle also reduces emissions and improves performance. John Deere's subsidiary, Phoenix International, focuses on integrated electronics that can withstand the harsh physical and electrical environments of non-road applications. With more than 200 engineers, Phoenix has the expertise to design, manufacture, and integrate many types of electronic systems – everything from embedded controls for engines, transmissions, and electro-hydraulics to CAN communications, fiber optics, and multiplexing.

Aftertreatment.

Selective catalytic reduction (SCR).

SCR is an aftertreatment option that requires a urea-based additive to reduce NOx emissions. When ammonia in urea is mixed with engine exhaust in a catalytic converter, a chemical reaction takes place and the NOx in the exhaust is converted to oxygen, nitrogen, and water. This method adds costs because of the extra tank, pump, associated components, and the SCR additive – but it provides better fuel efficiency than other NOx-reducing methods.

Lean-NOx catalyst.

There are two types of Lean-NOx catalysts with different methods of regenerating. The DeNOx catalyst is a precious metal-based system that reduces hydrocarbons in an oxygen-rich exhaust stream. Without using electronic controls, the catalyst's efficiency for reducing NOx is less than 10 percent. When electronic controls are used, the efficiency is still less than 30 percent – with a substantial fuel economy penalty.

A more effective Lean-NOx catalyst is the NOx adsorber (NAC), or sometimes called the Lean-NOx trap (LNT). It must be regenerated in an oxygen-deficient environment, requiring more sophisticated controls. When the unit is clean, it can reduce NOx by 90 percent. However, it is very sensitive to fuel sulfur levels and can lose efficiency quickly (to near zero) when exposed to high-sulfur fuels. When that happens, sulfur has to be removed from the catalyst. This process of sulfur removal is called desulfation. It requires very sophisticated controls and exposes the engine to high thermal stress while running at a significant fuel economy penalty. By using electronic engine controls with this type of catalyst, John Deere has been able to maintain efficiency of greater than 60 percent over the life of the engine.

Diesel oxidation catalyst (DOC).

The diesel oxidation catalyst (DOC) doesn't reduce NOx, but it is effective at reducing carbon monoxide, hydrocarbon, and some particulate matter. The flow-through oxidation catalyst oxidizes both gaseous (volatile) hydrocarbons and the semi-volatile portion of PM known as the volatile organic fraction (VOF). At higher exhaust temperatures, DOCs can also oxidize sulfur in the exhaust to form sulfate PM. Catalyst manufacturers have been able to achieve the needed VOF reduction while minimizing sulfate formation. DOCs operate at peak efficiency when the sulfur concentrations in the fuel are 0.05 percent or lower.

DOCs typically reduce emissions of particulate matter by 20 percent. DOCs also reduce emissions of hydrocarbons by 50 percent and carbon monoxide by 40 percent.

Active diesel particulate filter (DPF).

Everyone knows that DPFs (or particulate traps) will likely be one of the options used to meet particulate matter reductions in Interim Tier 4/Stage III B and Final Tier 4/Stage IV. The questions that OEMs want answered are: "How much will they cost?" "What size will they be?" "How long will they last before servicing is needed?" Manufacturers are working hard to reduce the cost and optimize the size of these aftertreatment devices.

The DPF traps and holds particulates in the exhaust. Exhaust gas flows through channels with porous walls that allow exhaust to escape, but traps soot and particulates. Then, with the help of a catalyst, the DPF regenerates by burning the collected soot. Because high exhaust temperatures are required for this regeneration to take place, the challenge is to design DPFs that provide consistent regeneration at all levels of engine operation. "Active" diesel particulate filters solve this problem, by raising the exhaust temperature based on particulate filter backpressure. John Deere is working to develop active DPF systems that will regenerate in low-load and normal operating conditions.

Metals and ash found in lubricating oil can become trapped in the DPF as well. Since ash and metals cannot be burned off during soot regeneration, they are left in the filter. The buildup can eventually clog the filter and may require maintenance and cleaning. The use of lubricating oil with low ash can help alleviate this issue.

Meeting current regulations – Tier 3/Stage III A.

The major directive of Tier 3/Stage III A regulations is a 40 percent reduction in oxides of nitrogen. Engines 130 kW (175 hp) and above were the first to be affected by EPA Tier 3 and EU Stage III A regulations. Building on our success with meeting Tier 1/Stage I and Tier 2/Stage II regulations, John Deere is now applying proven engine technologies to the Tier 3/Stage III A engines in our PowerTech™ engine family.

Multiple solutions.

To meet Tier 3/Stage III A regulations, John Deere worked closely with OEMs to determine which technologies would best fit their applications. We quickly established that one technology couldn't meet the varied needs of non-road OEM customers. Some customers required higher performance and improved fuel economy, some just wanted to meet emissions without sacrificing performance, while others wanted the lowest possible cost and ease of maintenance. The result is three distinct engine solutions: PowerTech Plus™, PowerTech E™, and PowerTech M™.

PowerTech Plus

PowerTech Plus™ features proven technology, larger displacement, better performance, and best-in-class fuel economy. PowerTech Plus models are available in the 4.5L, 6.8L, 9.0L, and 13.5L displacements.

The major difference in the PowerTech Plus is the level of emissions-control technologies employed. While PowerTech Plus and PowerTech E categories use a high-pressure common rail fuel system and electronic controls, PowerTech Plus engines are equipped with cooled EGR and a VGT to provide the best engine performance and fuel economy in a reliable package.

High Performance – PowerTech Plus engines meet Tier 3/Stage III A emissions without sacrificing performance. John Deere has maintained or increased power output from all PowerTech Plus models, and in many cases, power bulge, peak torque levels, transient response time, low-speed torque, and cold weather starting have actually been improved compared to Tier 2/Stage II.

Durability – PowerTech Plus Tier 3/Stage III A engines are designed for rugged non-road operation, with features such as heavy-duty heat exchangers and new power cylinder materials for unparalleled durability. John Deere Tier 3/Stage III A engines are as durable or more durable than John Deere Tier 2/Stage II engines.

Ease of installation – Because we maintained our Tier 2/Stage II engine package size without derating power, changing over to Tier 3/Stage III A models is easier. John Deere PowerTech Plus models take up less engine envelope space than many competitive engines with similar horsepower.

PowerTech E

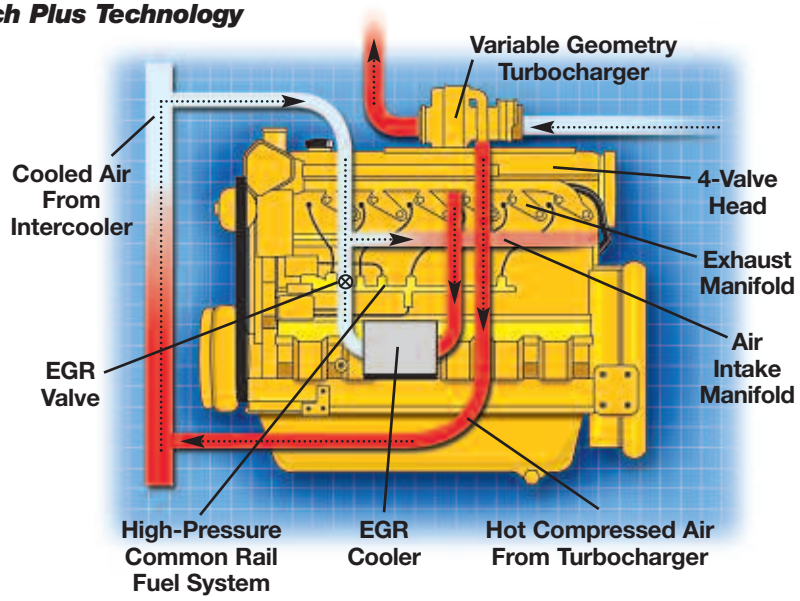
PowerTech E™ engines incorporate a high-pressure common rail fuel system (4.5L and 6.8L), electronic unit pumps (2.4L and 3.0L), a two-valve cylinder head, full authority electronic controls, and all the performance of Tier 2/Stage II engines and more.

The high-pressure common rail fuel system increases fuel pressure for more efficient combustion. PowerTech E engines offer a platform and performance similar to or better than their Tier 2/Stage II counterparts. PowerTech E models are available in the 2.4L, 3.0L, 4.5L, and 6.8L displacements.

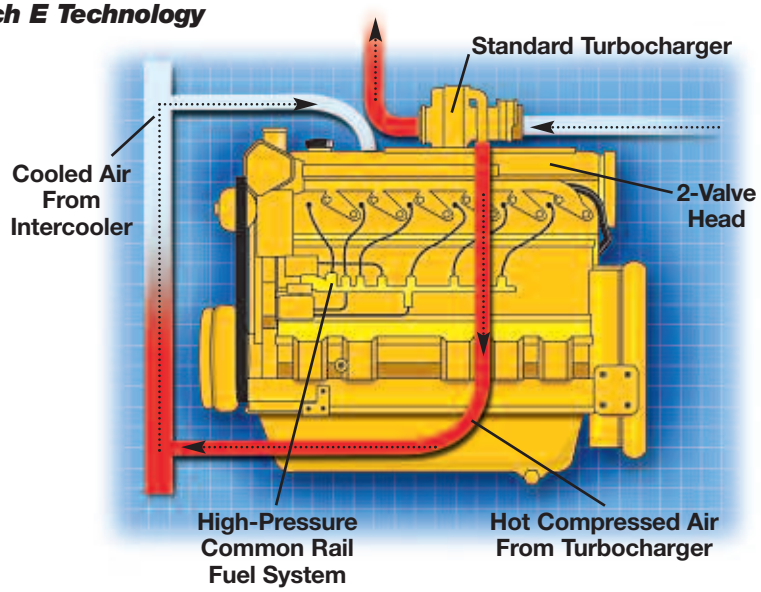
PowerTech M

PowerTech M™ engines employ economy of design and mechanical controls for efficient performance, plus all the performance of Tier 2/Stage II. These engines are ideal for lower-horsepower applications, and employ a new mechanical fuel system that generates higher injection pressures for more efficient combustion. PowerTech M engines starting at 30 kW (40 hp) will be available in advance of EPA Tier 3 and Interim Tier 4 and EU Stage III A regulations.

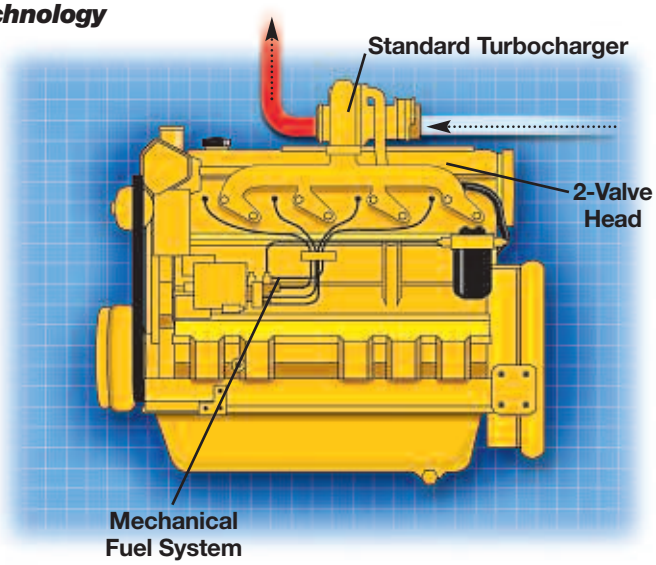
PowerTech Plus Technology



PowerTech E Technology



PowerTech M Technology



Common myths about cooled EGR.

A lot of false and misleading information about cooled EGR and the VGT on the PowerTech Plus engine has been circulated by engine manufacturers that have chosen less effective technologies for Tier 3/Stage III A. Here are some examples:

Myth: Cooled EGR adds more complexity than other technologies.
Fact: While cooled EGR engines require additional sensors and actuators, the control logic is designed into the engine control unit, which allows the complexity to be transparent, like that of a cell phone or home computer. The technology within may be complex to the average individual, but that technology is the key to the product's function, performance, and reliability. Cooled EGR is a proven technology that is used to control NOx emissions by most on-road diesel engine manufacturers, as well as millions of gasoline and diesel passenger cars.

Myth: Cooled EGR causes lower power density.
Fact: With cooled EGR and the VGT, John Deere has been able to maintain or increase the power density from each engine platform. With PowerTech Plus Tier 3/Stage III A engines, you will never be forced to go up in platform size. In fact, using John Deere PowerTech Plus engines may allow customers to go down in platform size, if they choose to do so, and lower their installed cost for a Tier 3/Stage III A engine compared to a Tier 2/Stage II engine. While John Deere has maintained or increased power density, other manufacturers have announced significant decreases in power density for some Tier 3/Stage III A platforms.

Myth: Cooling systems will have to be larger because cooled EGR has higher heat rejection.
Fact: No one would argue that cooled EGR increases heat rejection to the coolant (radiator) side of an engine's cooling system. However, John Deere has managed this with increased top-tank temperatures, increased coolant flows, and decreased fuel consumption. From a Charge Air Cooler (CAC) perspective, the VGT has allowed John Deere to better manage air flow and maintain or lower heat rejection to the CAC side compared to less efficient competitive Tier 3/Stage III A engines. The overall heat rejection rate, relative to John Deere Tier 2/Stage II engines, will increase 10 percent for the 6.8L PowerTech Plus and 5 percent for the 9.0L. There is no increase on the 13.5L. As a result, heat rejection from PowerTech Plus engines will be no higher than less efficient competitive technologies. These models could have 5 to 10 percent higher total heat rejection than some competitive engines, but the difference will be managed by the increased top-tank temperatures, increased coolant flow, and best-in-class fuel economy. In many cases, it may be possible to utilize similar-sized Tier 2/Stage II cooling components for Tier 3/Stage III A engine platforms.

Myth: Fuel consumption will be worse with cooled EGR because of high fan power requirements.
Fact: Heat rejection for Tier 3/Stage III A engines, regardless of the manufacturer, will increase. However, with a properly designed (managed) cooling package, there is no reason why fan power has to increase. In fact, John Deere is equipping many applications with new variable speed fan drives that actually reduce fan horsepower usage under most conditions. However, if OEMs choose to run 20 percent higher fan power, they would realize only a 1 percent increase in fuel consumption in a typical application. Compared to current Tier 2/Stage II and other Tier 3/Stage III A technologies, PowerTech Plus engines will achieve basic fuel consumption improvements of up to 12 percent, which far exceeds the 1 percent consumed by cooling systems with higher fan power losses.

Myth: Engines with cooled EGR require more maintenance.
Fact: John Deere PowerTech Plus engines are actually increasing maintenance intervals across all models. An optional 500-hour oil change interval will be available on all Tier 3/Stage III A OEM engines from John Deere. New fuel filtration systems with water-in-fuel (WIF) and a low-pressure fuel sensor will help extend fuel filter replacement intervals.

Myth: Cooled EGR requires low sulfur on-road diesel fuel.
Fact: Diesel fuel recommendations are unchanged for Tier 3/Stage III A engines. All John Deere Tier 3/Stage III A engines are being developed to use worldwide non-road fuels with up to 5000 ppm sulfur. For those parts of the world that require Tier 3/Stage III A engine platforms, these countries are also mandating the adoption of low-sulfur and ultra-low-sulfur fuels. Effective January 2006, the most commonly available diesel fuel in those parts of the world requiring Tier 3/Stage III A engines contain 500 ppm sulfur or less.

Myth: Cooled EGR requires high-grade oils.
Fact: Regardless of the engine technology, oil standards are being upgraded industry-wide. Like all on-road and non-road engine manufacturers, John Deere recommends API CI-4 oils for Tier 3/Stage III A engines. These oils are currently available from all major oil companies and from John Deere. John Deere Plus 50 and Torq-Gard Supreme 10W-30 oils already meet the new standard and will continue to be recommended for Tier 3/Stage III A, just as they were for previous engines.

Myth: Cooled EGR causes dangerously low engine life outside North America and Western Europe.
Fact: John Deere PowerTech Plus Tier 3/Stage III A engines are designed with the same rigorous durability and reliability goals as previous John Deere engines. When lubricating oils and diesel fuels meet the recommendations specified in the operator's manual (and service is performed at prescribed intervals as well), there are no durability issues associated with cooled EGR technology.

Myth: Cooled EGR cannot be turned off for use outside North America and Western Europe.
Fact: Cooled EGR could be "turned off" for use in parts of the world where certified engines are not required. However, John Deere is not planning on this option because there are better, lower cost engine technologies available for use in these markets. In addition, for OEMs who export a significant number of machines to countries that don't require certification, John Deere will continue to manufacture Tier 2/Stage II and Tier 1/Stage I engines in the same platform sizes and power ratings currently provided.

Preparing for future emissions reductions.

The EPA and the EU have both issued stringent emissions standards for future non-road diesel engines. John Deere recognizes the challenge of meeting the standards as proposed, and will develop and apply appropriate technologies to achieve Tier 4/Stage IV regulations.

PowerTech takes you to Tier 4/Stage IV.

The PowerTech family of engines has been the foundation for John Deere's ongoing emissions solutions, starting with the first emissions regulations and carrying through to the current requirements. John Deere has begun exploring a number of technologies for Tier 4/Stage IV – including additional in-cylinder and aftertreatment solutions – that will be applied to the existing Tier 3/Stage III A platforms. In fact, John Deere PowerTech engines have already demonstrated Tier 4/Stage IV capabilities and will be in full compliance before those levels take effect. John Deere engines less than 37 kW (50 hp) already meet Interim Tier 4/Stage IV levels.

Transient cycle test vs. steady-state 8-mode test.

In Tier 4/Stage IV, all engines must pass additional emissions tests. They must pass the existing steady-state 8-mode tests (ISO 8178), but they must also comply with the new non-road transient emissions test cycle (NRTC).

The ISO 8178 is an international standard designed for non-road engine applications. It is actually a collection of many steady-state test cycles designed to measure emission levels of engines and equipment.

The NRTC test is a transient driving cycle for mobile non-road diesel engines developed by the EPA in cooperation with the EU. The cycle is an engine dynamometer transient driving schedule with a duration of about 1200 seconds. The test simulates engine usage in 13 different non-road applications such as agricultural tractors, backhoe loaders, crawlers, excavators, arc welders, skid steer loaders, and wheel loaders. John Deere prepared data to support two of the applications in the test cycle.

Fuel sulfur standards.

Normal levels for non-road fuel sulfur content typically range between 1000 to 3000 ppm. Because aftertreatment devices used to control emissions in Tier 4/Stage IV will be more sensitive to sulfur content, the EPA will mandate reductions in sulfur content in non-road diesel fuel to 500 ppm beginning in 2007. The sulfur levels will be further reduced to 15 ppm (ultra-low sulfur diesel) in 2010 for non-road fuel. Besides reducing emissions from the existing diesel fleet, these clean fuels will enable the use of advanced aftertreatment technologies on new engines.

Low sulfur diesel fuel is already available in many areas of the country and most on-road fuel sources already have lower sulfur levels than required for current non-road engines.

Lubricating oil and reduced ash.

There is an interaction between oil consumption and aftertreatment devices such as diesel particulate filters (DPF). Oil contains trace metals that form ash if they are burned in the combustion chamber. This ash is trapped by the DPF, but cannot be regenerated by normal oxidation methods. The ash components can collect over time and add backpressure to the filter. That is why John Deere is working hard to minimize oil consumption. This requirement of DPFs is also being addressed through the modification of lubrication oils to reduce trace metals. While “cleaner” oils may be costlier than traditional oils, they could potentially aid the reduction of metal loading in diesel exhaust catalysts, as well as boost durability and performance.

Systems integration.

Meeting future emissions standards is dependent on more than the engine. It will rely on a close integration between the entire powertrain including the engine, the engine electronics systems, and other drivetrain components. As we move into Tier 4/Stage IV regulations, John Deere is well positioned to provide seamless integration between all these components. A subsidiary, John Deere Coffeyville Works, has more than 45 years of experience designing and manufacturing Funk power-transmission products such as transmissions and pump drives. Another John Deere subsidiary, Phoenix International, is a leader in non-road electronics for the engine and the entire vehicle. Phoenix understands the demands of the non-road work environment and they build electronic systems to match.

Having all these resources under one roof means that John Deere can help integrate your entire system from the engine to the electronics, pump drives, powershift transmissions, HMD transmissions, planetary drives, and inboard planetary axles. By making these components work together more closely, John Deere is able to deliver maximum performance and fuel economy while delivering near-zero emissions.

SUMMARY

John Deere has proven that it is possible to maintain engine performance, fuel efficiency, and clean air. They bring together several essential components to successfully meet the worldwide emissions requirements for non-road applications.

- **Environmental responsibility.** John Deere has shown that there are ways to harness engine power while minimizing its impact on our environment. We have been working on lowering engine emissions since 1967 – years before government standards were established in the United States and Europe.

- **Non-road experience.** Besides our proven performance in agricultural and industrial non-road equipment, John Deere engines go to work every day in thousands of applications for the OEM market. John Deere has more experience and insight in non-road engine technologies than any other manufacturer.

- **Emissions technology.** John Deere engineers use a combination of proven and new engine technologies to improve fuel economy and performance while meeting emissions regulations.

- **Customer-focused solutions.** Not every engine customer needs high torque, or low fuel consumption, or continuous operation. John Deere caters to these diverse customer needs with three levels of Tier 3/Stage III A engines: PowerTech Plus, PowerTech E, and PowerTech M.

- **Systems integration.** As the industry moves closer to final Tier 4/Stage IV emissions regulations, integrating engine performance with the other components in the powertrain will become even more important. John Deere is positioned to integrate all these components to maximize performance and fuel economy while reducing emissions.

- **Worldwide emissions compliance.** John Deere engines comply with non-road emission regulations for the EPA, CARB, EU, Japan, and India. John Deere provides Tier 1/Stage I and Tier 2/Stage II engines for non-regulated countries.

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Nothing Runs Like A Deere™

Performance and Efficiency

John Deere engines give non-road equipment the power to build, develop, and improve our world – and they do it while minimizing the impact on the air and the environment.

When you run with Deere, you get the benefit of our ongoing commitment to making engines that run clean, use less fuel, and provide dependable performance. You also get a worldwide network of more than 4000 service and support locations to keep your engines running in any situation.

John Deere dealers and distributors are your best source for service, knowledge, and engine accessories. They're one of the many reasons to specify John Deere engines in all your equipment.

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Tier 3/Stage III A 2.4L 3.0L 4.5L 6.8L 9.0L 13.5L

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