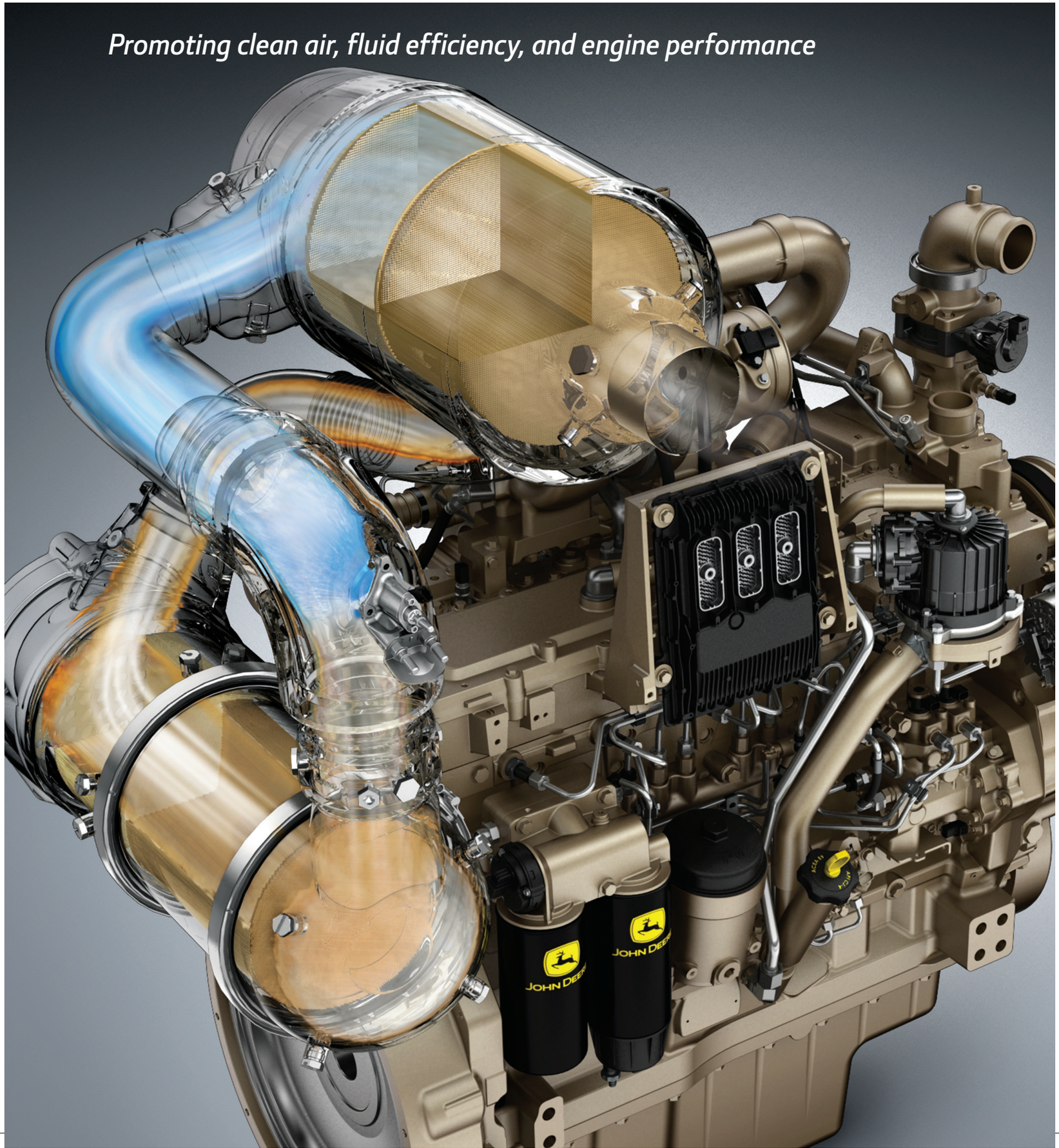
Focus On Emissions

Off-Highway Diesel Engines

JOHN DEERE



John Deere takes a focused approach to fluid efficiency and engine performance. In this guide, you'll learn about engine emissions and how John Deere is meeting emissions requirements while maximizing performance, uptime, and efficiency.

John Deere engines operate efficiently using ultra-low sulfur diesel as well as biodiesel blends. Biodiesel is an oxygenated fuel made from a variety of agricultural resources such as soybeans or rapeseeds. For more information about biodiesel, consult your engine operator's manual, contact your local John Deere engine distributor or equipment dealer, or visit JohnDeere.com/Biodiesel.

John Deere takes its responsibility to emissions compliance very seriously. We have been working on reducing engine emissions since 1967, when John Deere first installed emissions testing equipment — years before governments recognized the need for regulations.

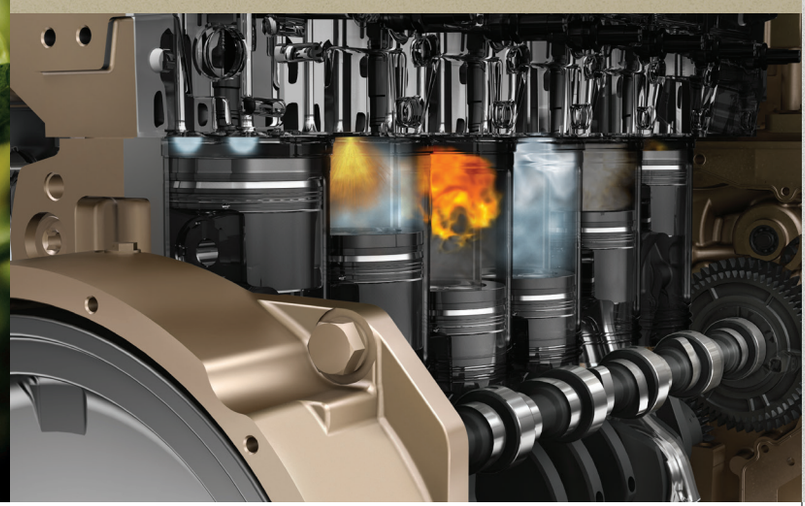
A history of meeting emissions regulations

In 1996, John Deere launched a new breed of engines called PowerTech™ to meet U.S. Environmental Protection Agency (EPA) and European Union (EU) Tier 1/Stage I emissions regulations. We built on this off-highway engine platform to meet emissions regulations for Tier 2/Stage II in 2001, Tier 3/Stage III A in 2006, Interim Tier 4/Stage III B in 2008, and Final Tier 4/Stage IV in 2013.

Stage V ready

John Deere launched many of its engines ahead of EPA and EU deadlines, and is ready to meet Stage V emissions regulations scheduled to begin in 2019 using our proven diesel particulate filter (DPF) solutions.

Our engineers continue to employ a global network of technical resources and the latest technology to lower emissions while improving performance and fluid efficiency.



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Understanding engine emissions

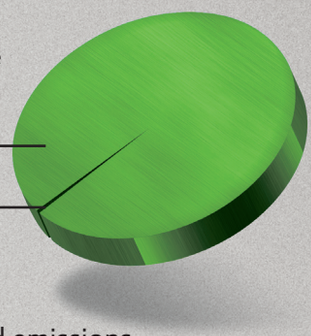
A small but real challenge

Regulations require off-highway engine manufacturers to remove almost all emissions pollutants such as nitrogen oxides (NOx), carbon monoxide (CO), hydrocarbons (HC), and particulate matter (PM). Most remaining engine exhaust is made up of elements commonly found in the air like nitrogen (N_2), oxygen (O_2), and water vapor (H_2O).

Engine exhaust is primarily made up of the following elements

99.7% Products of complete combustion

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



0.3% Regulated emissions

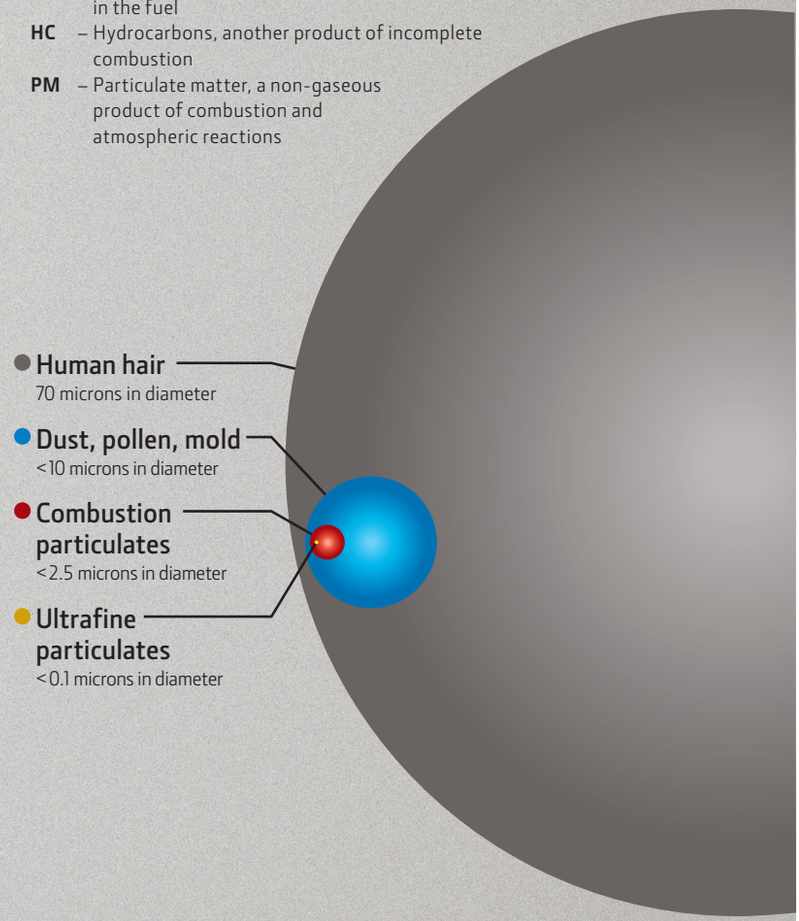
NOx – Nitrogen oxides, caused by high temperatures and pressure during combustion
CO – Carbon monoxide, a product of incomplete combustion
SOx – Oxides of sulfur, resulting from oxidation of sulfur in the fuel
HC – Hydrocarbons, another product of incomplete combustion
PM – Particulate matter, a non-gaseous product of combustion and atmospheric reactions

Meeting Stage V requirements

The European Union's Stage V emissions regulations limit particulate number (PN) in addition to particulate mass for all engines in the 19 to 560 kW power band. By doing so, engine manufacturers will need to limit ultrafine particulate emissions.

Comparison of particulate size

The average human hair is about 70 microns in diameter — making it 700 times larger than the largest ultrafine particulates.



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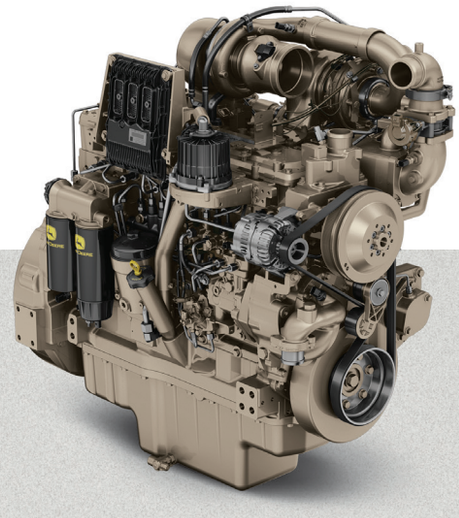
Focus On Emissions

More choices for meeting worldwide emissions regulations



John Deere PowerTech diesel oxidation catalyst/selective catalytic reduction (DOC/SCR) engines join our complete lineup to give OEMs more choices for meeting Final Tier 4/ Stage IV emissions regulations.

We continue to provide diesel oxidation catalyst/diesel particulate filter/selective catalytic reduction (DOC/DPF/SCR) engines, which deliver premium performance when the job requires it and are ready to meet Stage V regulations in the EU.

We also offer a full line of Tier 3/Stage III A, Interim Tier 4/Stage III B, and engines currently not subject to emissions regulations.

More than emissions

You get more than peace of mind with John Deere. Our engineers look at meeting emissions regulations as a continual opportunity to advance off-highway engine performance.

- Improve low-end torque
- Deliver high peak torque
- Increase power bulge range
- Provide fast transient response
- Offer more power density

READY TO RUN STAGE V

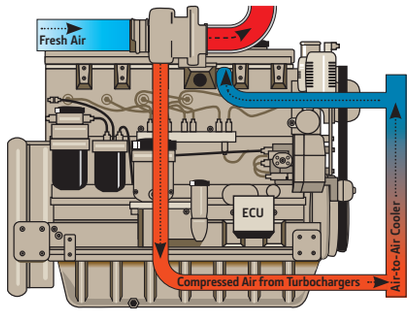
Ready to run

John Deere is ready to work, ready to generate, and ready to run with engines meeting EU Stage V emissions regulations. In most cases, OEM customers currently using a John Deere engine with a diesel particulate filter (DPF) won't have to re-engineer machine design to meet the requirements of Stage V regulations.

Emissions technologies

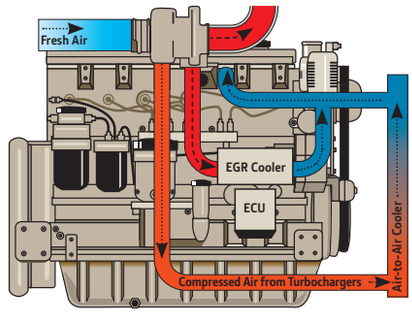
John Deere systematically adopted new technologies and integrated them with our field-proven solutions to meet each regulatory level — giving OEMs and operators more choices for applying engine power. These diagrams show how new technologies were added, but do not represent all configurations.

■ Technologies added



Tier 2/Stage II

- Electronic unit injector (EUI)
- High-pressure common-rail (HPCR) fuel system
- Air-to-air aftercooled



Tier 3/Stage III A

- Electronic unit injector (EUI)
- High-pressure common-rail (HPCR) fuel system
- Air-to-air aftercooled
- Cooled exhaust gas recirculation (EGR)
- Variable geometry turbocharger (VGT)

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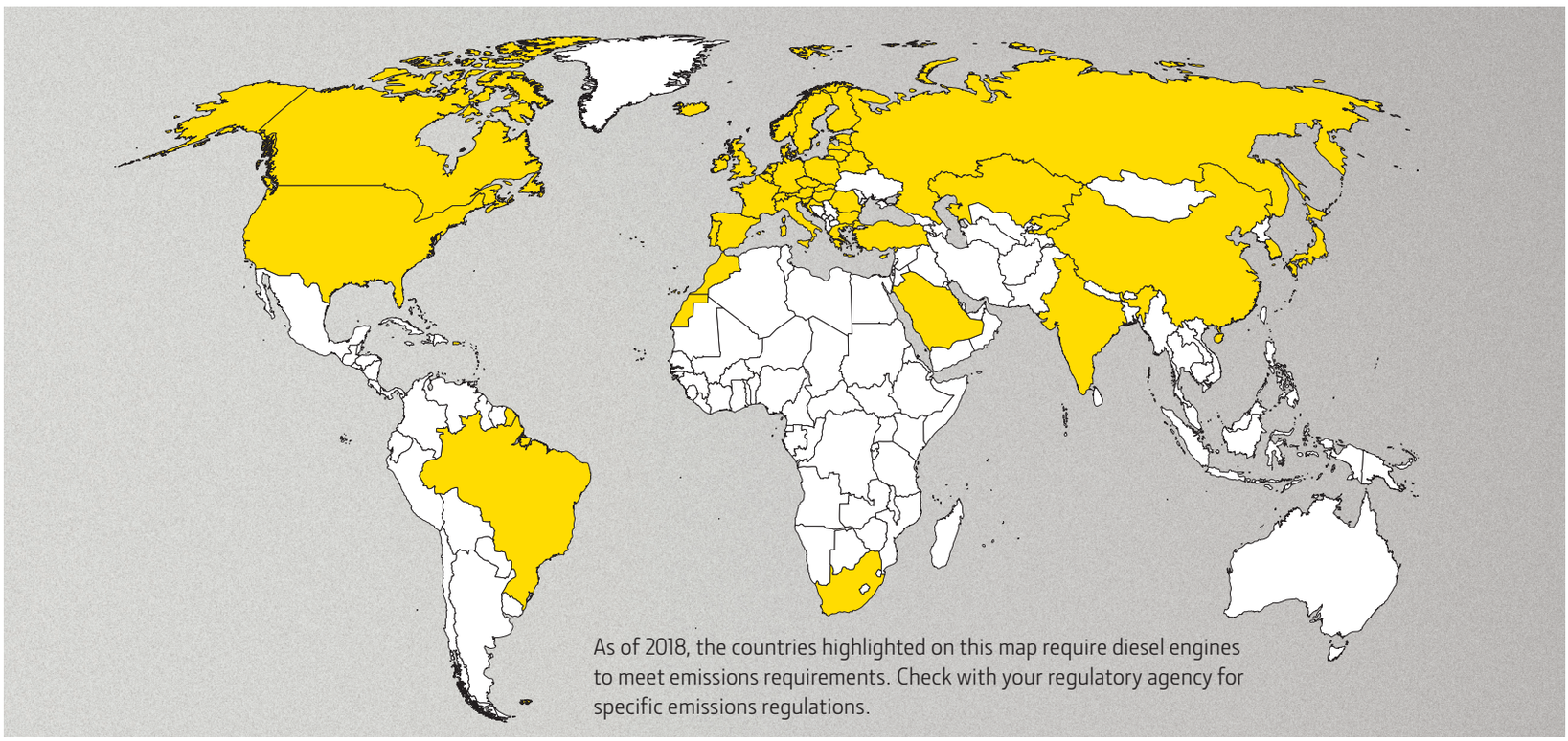
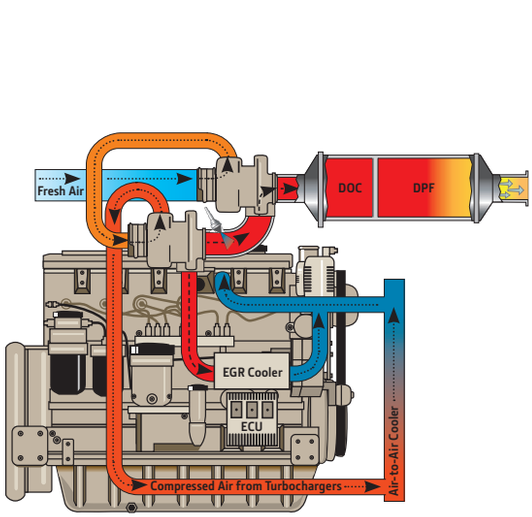
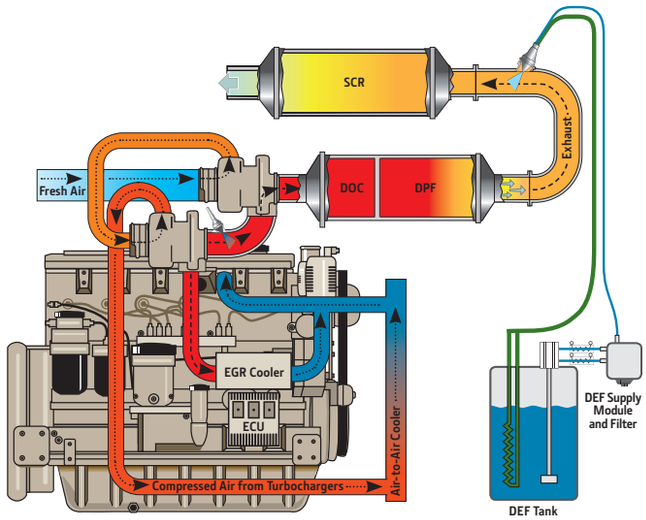


As of 2018, the countries highlighted on this map require diesel engines to meet emissions requirements. Check with your regulatory agency for specific emissions regulations.



Interim Tier 4/Stage III B

- Electronic unit injector (EUI)
- High-pressure common-rail (HPCR) fuel system
- Air-to-air aftercooled
- Cooled exhaust gas recirculation (EGR)
- Variable geometry turbocharger (VGT)
- Series turbochargers
- Diesel particulate filter (DPF)
- Exhaust temperature management (ETM)



Final Tier 4/Stage V

- Electronic unit injector (EUI)
- High-pressure common-rail (HPCR) fuel system
- Air-to-air aftercooled
- Cooled exhaust gas recirculation (EGR)
- Variable geometry turbocharger (VGT)
- Series turbochargers
- Diesel particulate filter (DPF)
- Exhaust temperature management (ETM)
- Selective catalytic reduction (SCR)

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Our solutions to different regulations

John Deere engines comply with the two major nonroad emissions regulations — the U.S. Environmental Protection Agency (EPA) and the European Union (EU).

We also provide engine configurations that are appropriate for other regions of the world such as Asia, the Middle East, and South America. We're here to help you with John Deere engine products, wherever they may work.

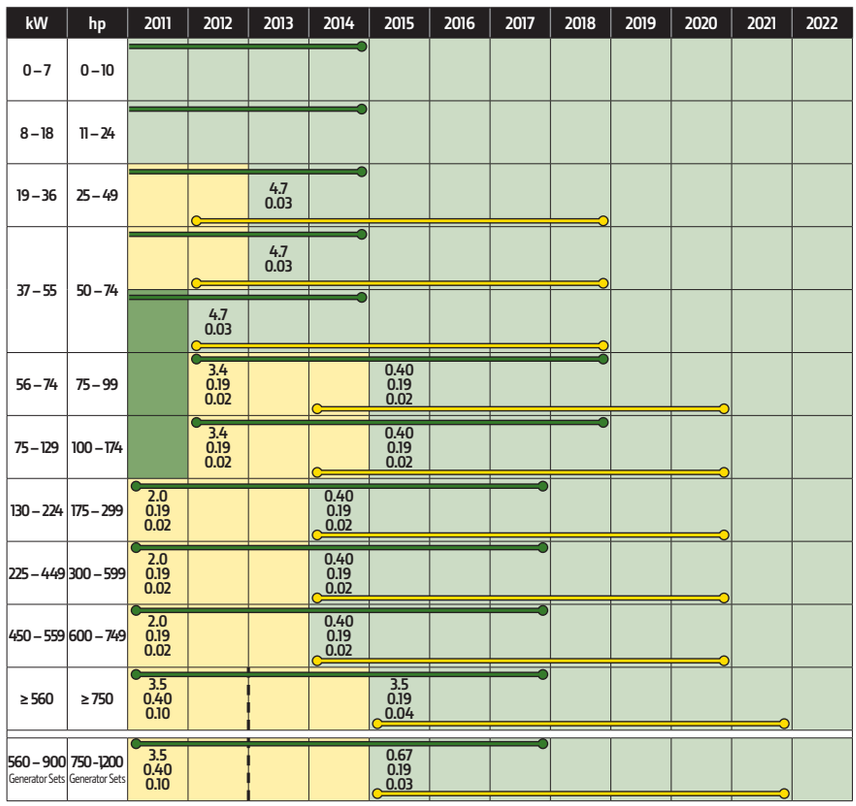
Fuel sulfur regulations

The type of diesel fuel used can have a significant impact on emissions control devices. Sulfur content levels of typical off-highway diesel fuels vary by country — ranging from more than 10,000 parts per million (ppm) to 10 ppm.

The use of exhaust filters and SCR catalysts on Interim Tier 4/Stage III B and Final Tier 4/ Stage V engines require using diesel fuel with a sulfur content of less than 15 ppm (ultra-low sulfur diesel or ULSD) for the EPA and less than 10 ppm in the EU.

Contact your John Deere engine distributor for information about fuel sulfur regulations in your area.

EPA nonroad emissions regulations



*In the 50 to 74 horsepower category there are two options. Option 1 requires a reduced PM level (0.30 vs. 0.40) but allows Final Tier 4 to be delayed one year (2013).

NOTE: The vertical dashed lines separating the years show when the seven-year life of the Tier 2/3 Equipment Flexibility Provision ends and engines can no longer be placed in vehicle production.

NOTE: In emergency standby applications, the EPA does not require engines to use aftertreatment.

Legend

EPA	Tier 3	Interim Tier 4	Final Tier 4

General Availability of Tier 4 Equipment Flexibility Provision | **Delayed** Availability of Tier 4 Equipment Flexibility Provision

Examples

NOx NMHC PM	0.40 0.19 0.02	Nitrogen oxides allowed in g/kWh Nonmethane hydrocarbons allowed in g/kWh Particulates (mass based) allowed in g/kWh
NMHC + NOx PM	4.7 0.03	Nonmethane hydrocarbons + nitrogen oxides allowed in g/kWh Particulates (mass based) allowed in g/kWh

EPA: Environmental Protection Agency

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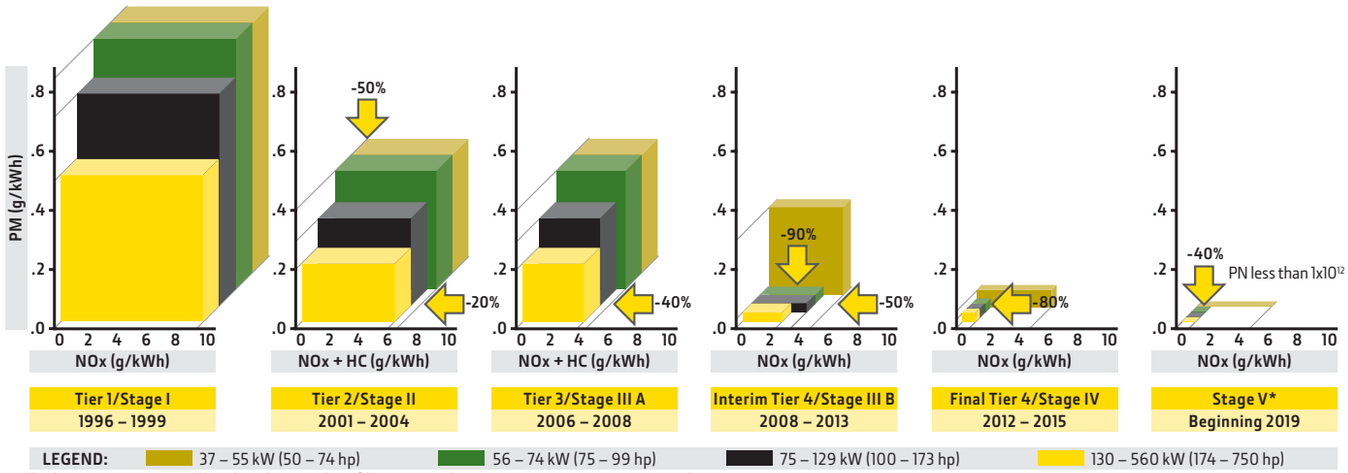
EPA and EU nonroad emissions regulations: 37 – 560 kW (50 – 750 hp)



**John Deere engines with a diesel particulate filter are ready to meet Stage V emissions regulations.*

EU nonroad mobile emissions regulations — variable-speed engines

kW	hp	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
0 – 7	0 – 10	Not regulated in EU								7.50 0.40 –			
8 – 18	11 – 24	Not regulated in EU								7.50 0.40 –			
19 – 36	25 – 49									4.7 0.015 1x10¹²			
37 – 56	50 – 74			4.7 0.025						4.7 0.015 1x10¹²			
57 – 74	75 – 99		3.3 0.19 0.025			0.40* 0.19 0.025					0.40 0.015 1x10¹²		
75 – 129	100 – 174		3.3 0.19 0.025			0.40* 0.19 0.025					0.40 0.015 1x10¹²		
130 – 559	175 – 749	2.0 0.19 0.025			0.40 0.19 0.025					0.40 0.015 1x10¹²			
≥ 560	≥ 750	Not regulated in EU								3.50 0.045 –			

*October 1, 2014

EU nonroad mobile emissions regulations — constant-speed engines

kW	hp	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
0 – 7	0 – 10	Not regulated in EU								7.50 0.40 –			
8 – 18	11 – 24	Not regulated in EU								7.50 0.40 –			
19 – 36	25 – 49	7.5 0.60								4.7 0.015 1x10¹²			
37 – 56	50 – 74		4.7 0.40							4.7 0.015 1x10¹²			
57 – 74	75 – 99		4.7 0.40								0.40 0.015 1x10¹²		
75 – 129	100 – 174	4.0 0.30									0.40 0.015 1x10¹²		
130 – 559	175 – 749	4.0 0.20								0.40 0.015 1x10¹²			
≥ 560	≥ 750	Not regulated in EU								3.50 [1] 0.045 –			
≥ 560	≥ 750	Not regulated in EU								0.67 [2] 0.035 –			

Examples

NOx NMHC PM	6.0 1.0 0.20

6.0, Nitrogen oxides allowed in g/kWh

1.0, Nonmethane hydrocarbons allowed in g/kWh

0.20, Particulates (mass based) allowed in g/kWh

NMHC + NOx PM	4.0 0.30

4.0, Nonmethane hydrocarbons + nitrogen oxides allowed in g/kWh

0.30, Particulates (mass based) allowed in g/kWh

NMHC + NOx PM PN	4.7 0.015 1x10¹²

4.7, Nonmethane hydrocarbons + nitrogen oxides allowed in g/kWh

0.015, Particulates (mass based) allowed in g/kWh

1x10¹², Particulates (number based) allowed in #/kWh

NOx PM PN	3.50 0.045 –

3.50, Nitrogen oxides allowed in g/kWh

0.045, Particulates (mass based) allowed in g/kWh

–, Particulates (number based) standard does not apply in this power segment

Legend

EU	Stage II	Stage III A	Stage III B	Stage IV	Stage V

Availability of EU Flexibility Scheme

NOTE: Stage V emissions regulations have implementation dates of 2019–2020. The EU does not regulate engines to an emissions stage for stationary applications.

EU: European Union

[1] Nonroad mobile — Industrial
[2] Nonroad mobile — Generator Set

18028_DSWT41_Emissions_Brochure-v7fnl.indd 7 4/4/18 8:46 AM

Emissions technologies

John Deere uses a combination of innovative engine designs and new technology to meet varying application and emissions requirements around the world.

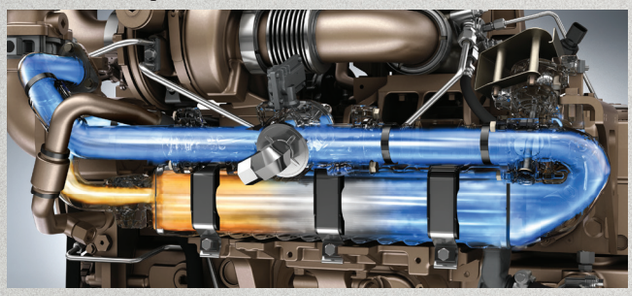
Air-to-air aftercooled

Air-to-air aftercooling not only reduces NOx, it allows increased low-speed torque and improved engine durability. 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.

Cooled exhaust gas recirculation (EGR)

EGR cools and mixes measured amounts of cooled exhaust gas with incoming fresh air to lower peak combustion temperatures, thereby reducing NOx.

▼ Cooled exhaust gas recirculation



Turbocharged

Fixed geometry turbocharger

Fixed geometry turbochargers are sized for a specific power range to maximize fuel economy between the engine's rated speed and peak torque.

Wastegate turbocharger (WGT)

Wastegate turbochargers are designed to develop more airflow than fixed geometry turbochargers at lower engine speeds to improve low-speed torque, peak torque, and transient response.

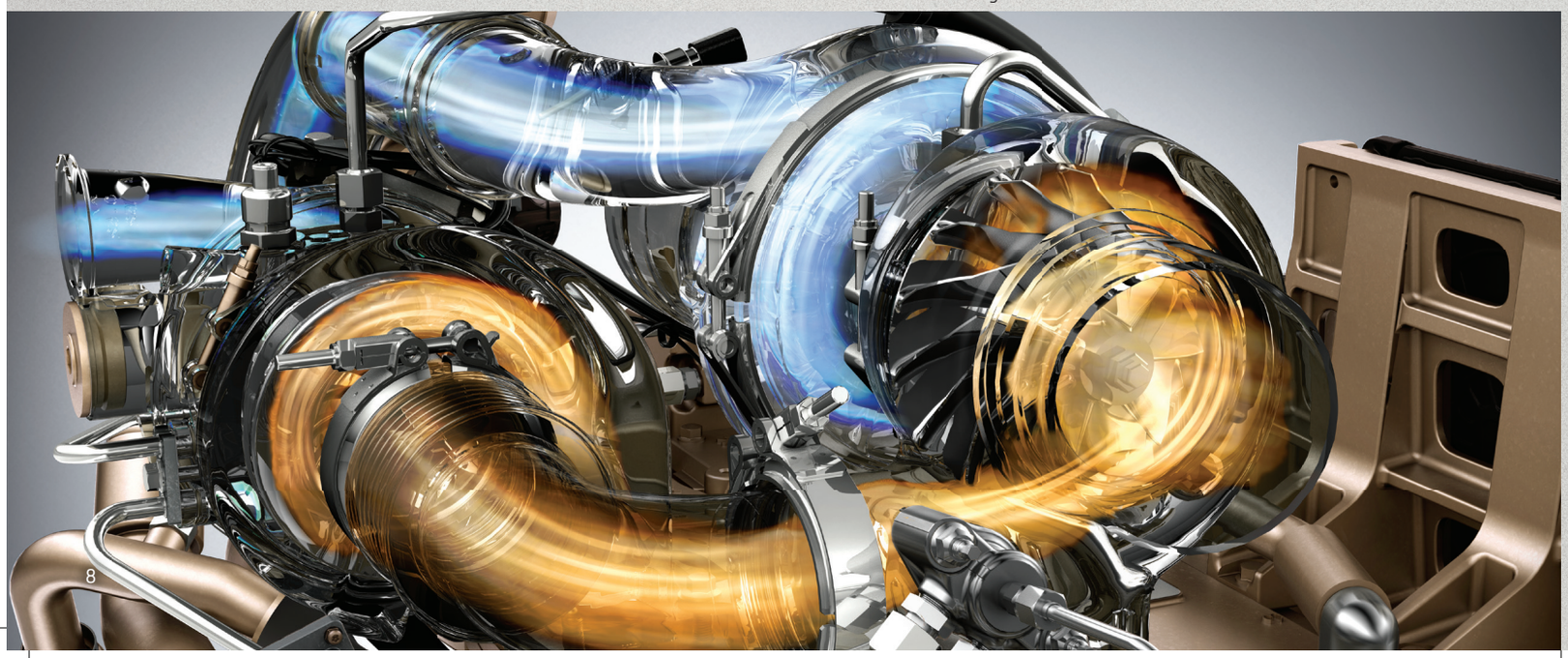
Variable geometry turbocharger (VGT)

The VGT tailors the amount of cooled recirculated exhaust gas that mixes with the fresh air. It minimizes the impact on engine envelope size and ensures excellent performance across the entire operating range of the engine, including transient response and fuel economy.

Series turbochargers

Series turbocharging is an effective means for increasing intake air pressure. By splitting the compression of the air between two turbochargers, both can operate at peak efficiency and at slower rotating speeds. This lowers stress on turbocharger components and improves reliability.

▼ Series turbochargers



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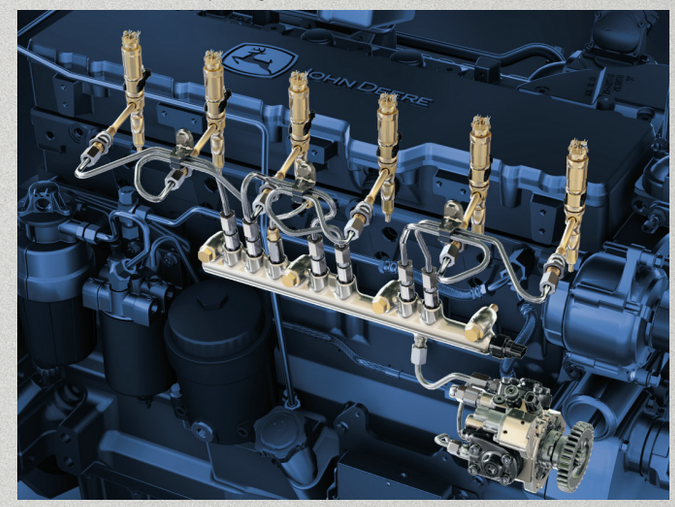
Fuel injection systems

High-pressure common-rail (HPCR) fuel injection system

The high-pressure common-rail fuel system provides constant control over fuel injection variables such as pressure, timing, duration, and multiple injections.



▲ HPCR fuel injection system

Electronic unit injector (EUI)

The EUI fuel injection system is used in larger engines to increase fuel pressure for more efficient combustion and reduced PM.

In-cylinder solutions

Power cylinder

By optimizing power cylinder components, John Deere has been able to reduce particulate emissions.

Oil control strategies

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 PCI, multiple fuel injections lower combustion temperatures and reduce NOx without using exhaust gas recirculation.

Exhaust filters

Diesel oxidation catalyst (DOC)

The DOC reacts with exhaust gases to reduce carbon monoxide, hydrocarbons, and some particulate matter (PM).

Diesel particulate filter (DPF) – Stage V ready

Exhaust filters are used to reduce particulate matter. John Deere engines with DPF technology are Stage V ready.

The engine industry expects that Stage V limits will require use of diesel particulate filter (DPF) technology. John Deere has been using DPF technology since Interim Tier 4/Stage III B, and is well positioned to help customers transition to the EU's Stage V standard. We have extensive experience with the development and integration of DPFs in both John Deere and OEM equipment, with more than 900 million DPF hours in the field.*

**Data compiled February 2018.*

Selective catalytic reduction (SCR)

Ammonia in the diesel exhaust fluid (DEF) mixes with engine exhaust gases in the SCR catalyst to reduce NOx — converting it to nitrogen and water vapor.

Full authority electronic controls

The engine control unit (ECU) monitors critical engine functions such as fuel quantity, injection timing, air-to-fuel ratio, multiple fuel injections, amount of cooled EGR, and a host of other parameters to deliver fuel economy and engine performance. In most John Deere engines, a single ECU monitors and controls the entire Integrated Emissions Control system — simplifying application integration.

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Emissions technologies

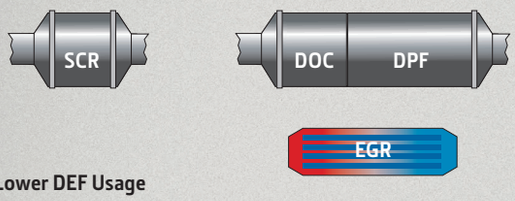
Diesel engines can be configured to produce less NOx or less PM, but not at the same time. That's why John Deere gives you a choice of two Final Tier 4 engine and aftertreatment configurations to best fit the needs of your application.

JOHN DEERE EPA FINAL TIER 4 SOLUTIONS

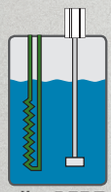
Engines that produce less NOx during combustion require the use of an exhaust filter to treat the increased PM, but also provide greater DEF efficiency that allows the use of a smaller DEF tank.

Engines that produce less PM during combustion meet Final Tier 4 regulations without a DPF, but consume more DEF and require a larger DEF tank to treat the increased NOx.

DPF option



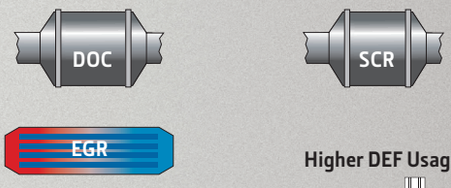
Lower DEF Usage



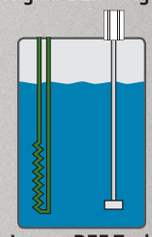
Smaller DEF Tank

+ Lower DEF consumption
+ Smaller DEF tank
+ Fewer fill-ups for operators
+ Ready for Stage V
– DPF integration for OEMs

No-DPF option

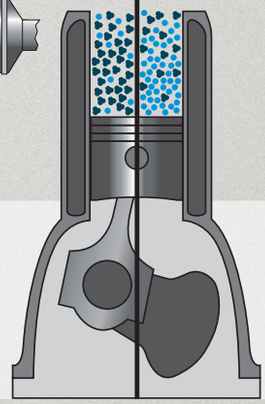


Higher DEF Usage



Larger DEF Tank

+ No DPF integration for OEMs
+ Lower installation cost
– Higher DEF consumption
– Larger DEF tank
– Not ready for Stage V



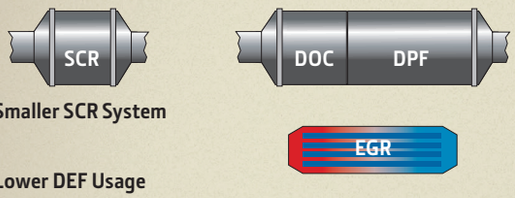
PM NOx

Particulate number limits will require the use of DPFs on Stage V engines. John Deere also integrates cooled EGR technology to reduce output of NOx, which allows for smaller SCR and DEF systems.

JOHN DEERE EU STAGE V SOLUTION

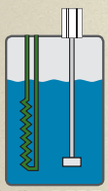
John Deere Stage V engines with cooled EGR demonstrate an exceptionally low DEF consumption compared to no-EGR engines.

EGR option



Smaller SCR System

Lower DEF Usage



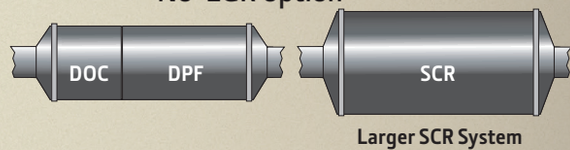
Smaller DEF Tank

+ Lower DEF consumption
+ Smaller SCR system
+ Smaller DEF tank
+ Easier integration for OEMs
+ Fewer fill-ups for operators
– Higher heat rejection

COMPETITOR EU STAGE V SOLUTION

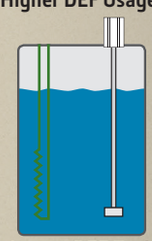
Engines without EGR require a larger SCR system and higher levels of DEF to treat the increased NOx.

No-EGR option



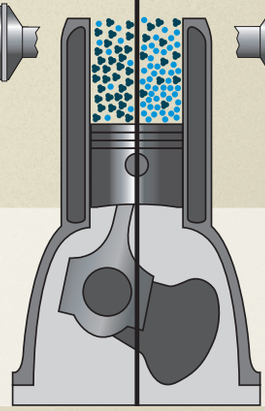
Larger SCR System

Higher DEF Usage



Larger DEF Tank

+ Lower heat rejection
– Higher DEF consumption
– Larger SCR system
– Larger DEF tank
– Complex integration for OEMs



PM NOx

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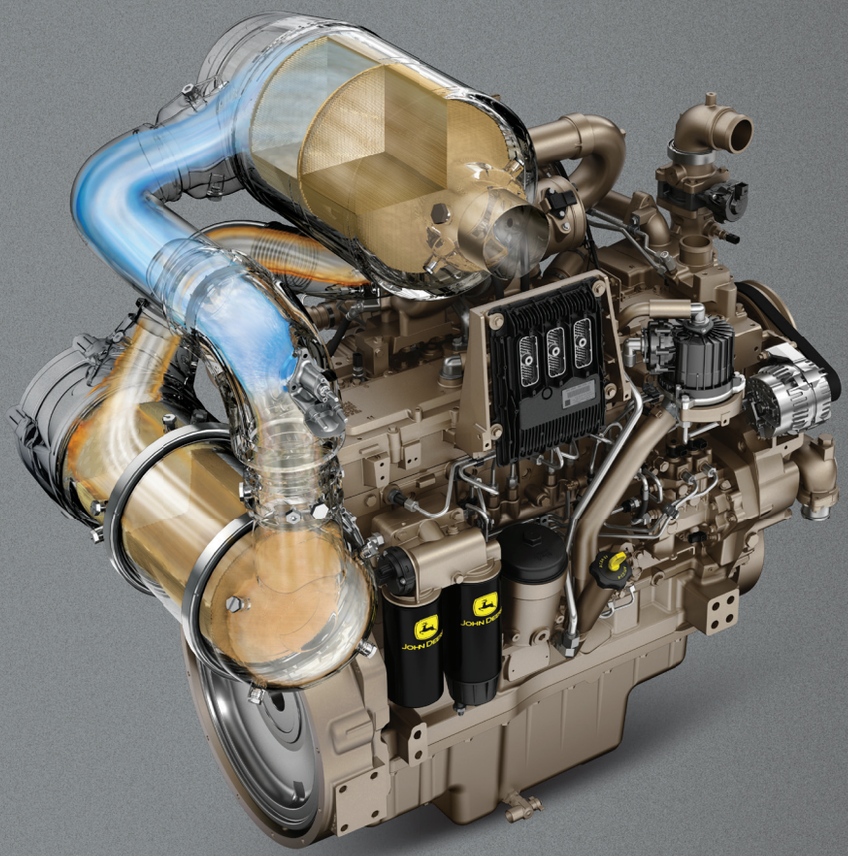
Questions about emissions technology?

Our Frequently Asked Questions page is a great place to start. For even more detailed information, contact your John Deere engine distributor or dealer.

JohnDeere.com/EngineFAQ



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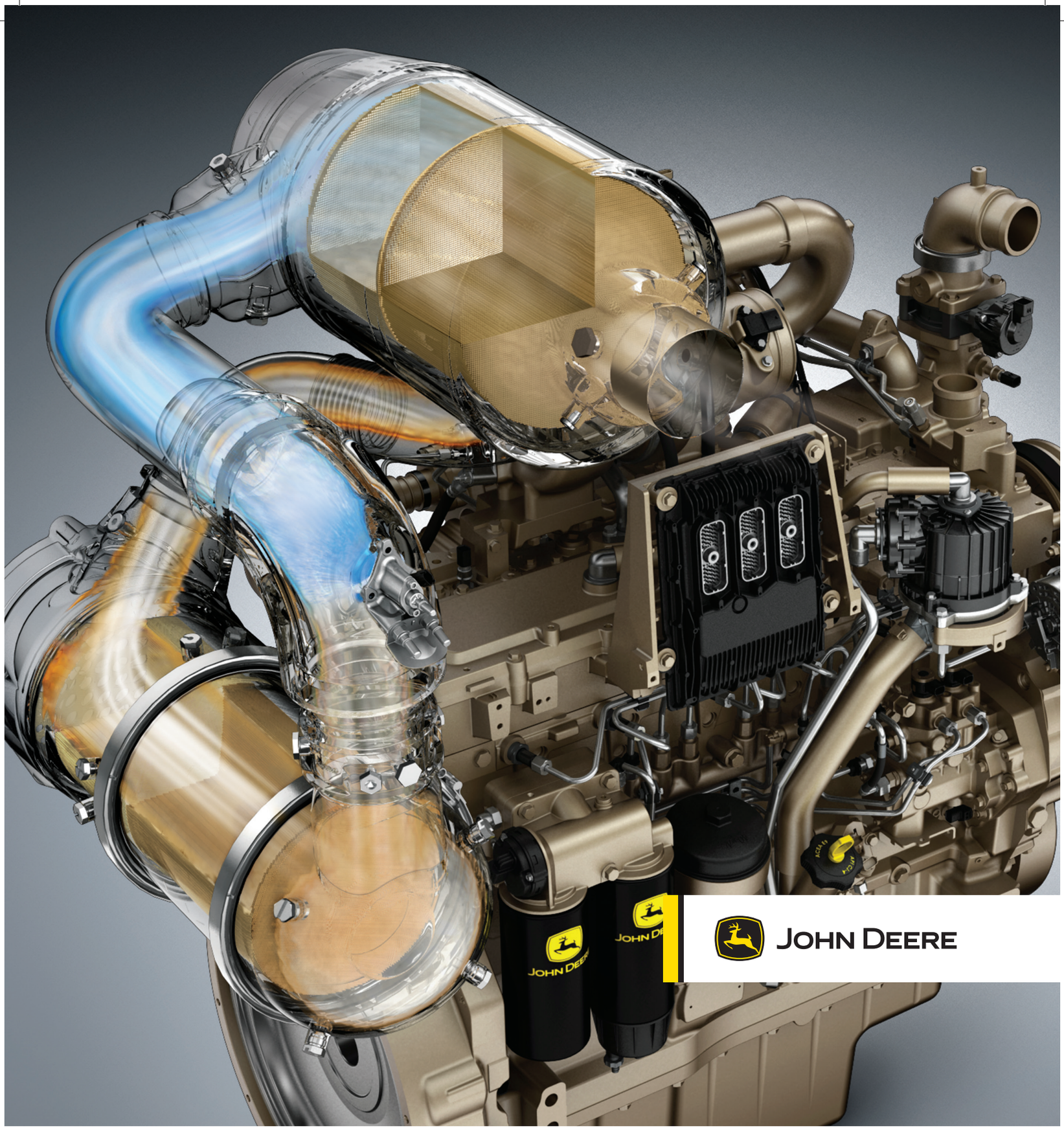

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