FPT
POWERTRAIN TECHNOLOGIES

POWER GENERATION
STAGE V

Our efficiency.
Your edge.

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THE STAGE V CHALLENGE

Technological excellence and product innovation for FPT Industrial represent the truly determining factor and part of its primary strategic mission. The company has focused its research and development activities in order to become the innovation leader in the agriculture and construction powertrain field and a reference provider of the most advanced solutions for emission compliance. Now this expertise is available also for Power Generation engines.

FPT Industrial engines comply with any emission legislations worldwide, always ensuring advantages on performance and efficiency, even at the most stringent regulations through the patented HI-eSCR technology.

The breakthrough HI-eSCR technology, based on more than 25 years of experience and 1.000.000 units produced, allows our engines to meet $Tier_4$ Final standards, guaranteeing the highest NO_x conversion efficiency (over 95% versus 80-85% of best competitors) with a maintenance-free system.
The evolution of HI-eSCR into HI-eSCR2 make FPT engines comply with both $Tier_4$ Final and the future Stage V regulation, still granting the outstanding results of best-in-class performance and total costs of ownership.

Scenario

During the combustion process, the chemical energy of the fuel is converted into mechanical energy. Because of the chemistry of combustion, several pollutants are produced, of which the most harmful are Nitrogen Oxides (NO_x) and Particulate Matter (PM).

Since 2011, when the European StageIIIA came into force, many efforts have been made to reduce such pollutants damaging the environment.

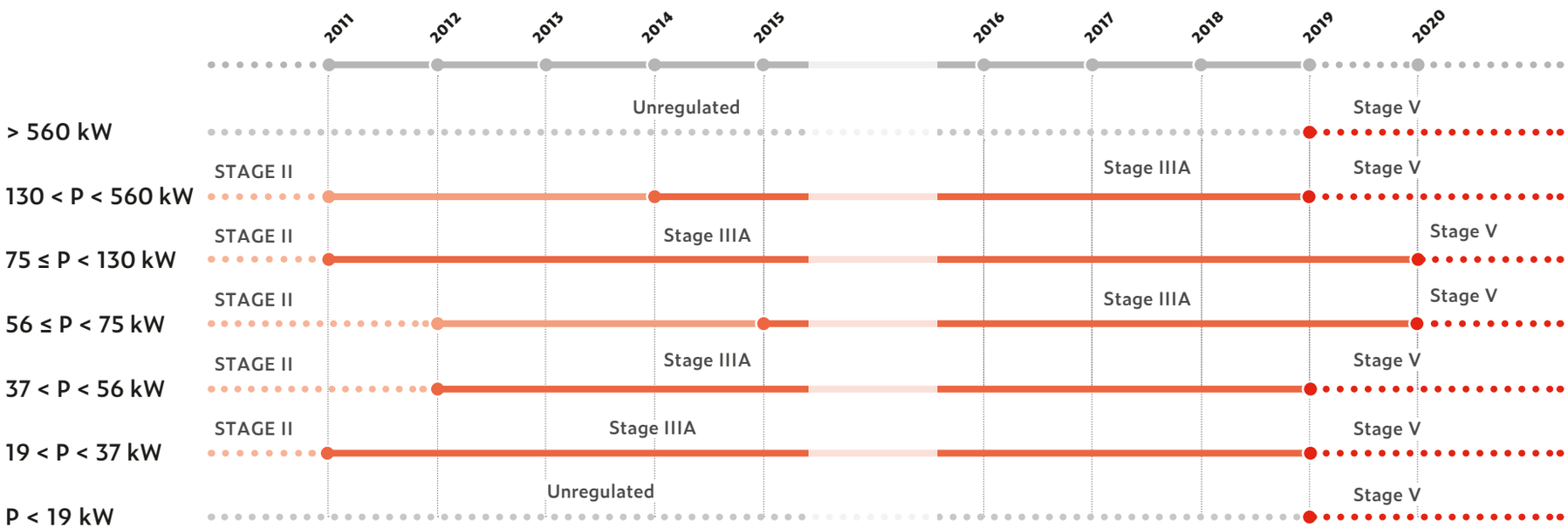
EPA $Tier_4$ Final regulation, introduced in 2014, implied a further significant reduction of NO_x (-80% Vs. previous step) while PM is not affected by further reductions.

Stage V is a new regulatory step that has been introduced in Europe from 2019 (depending on engine power level), further tightening the limits on PM emissions: admitted PM quantity will be reduced by 90% compared to Stage IIIA and a new limit will be introduced on the number of emitted particles (Particle Number Limit, PN).

In addition, Stage V regulation will involve power ranges currently with lighter or no legislation at all in Europe (power ranges below 37kW or above 560kW).

Emission regulations-roadmap

European emission standards for non-road mobile machine with constant speed engine



After the introduction of StageIIIA emission limits in 2011-2012, a further regulation re-enforcement will be introduced for European Non-Road mobile applications in 2019 or 2020 depending on power levels.

No new type approval in Europe for existing emission stage permitted in the year before new emission stage introduction

FPT Power Generation - Stage V Emission regulations-roadmap 13

Emission regulations-roadmap

ENGINE POWER	STAGE II				STAGE IIIA			Stage V					
	CO	HC	NO_x	PM	CO	NO_x+HC	PM	CO	HC	NO_x+HC	NO_x	PM	PN
kW	g/kWh				g/kWh			g/kWh					1/kWh
P ≥ 560	–		–	–	–	–	–	3.5	0.19	–	0.67	0.035	–
130 ≤ P < 560	3.5	1.0	6.0	0.2	3.5	4.0	0.2	3.5	0.19	–	0.40	0.015	1×10^{12}
75 ≤ P < 130	3.5	1.0	6.0	0.2	5.0	4.0	0.3	5.0	0.19	–	0.40	0.015	1×10^{12}
37 ≤ P < 75	5.0	1.3	7.0	0.4	5.0	4.7	0.4	5.0	–	4.7	–	0.015	1×10^{12}
19 ≤ P < 37	5.5	1.5	8.0	0.8	5.5	7.7	0.6						
8 ≤ P < 19	–		–	–	–	–	–	6.6	–	7.5	–	0.40	–

LEGEND

CO Carbon Monoxide
HC Hydrocarbons
NO_x Nitrogen Oxides
PM Particulate Matter
PN Particle Number

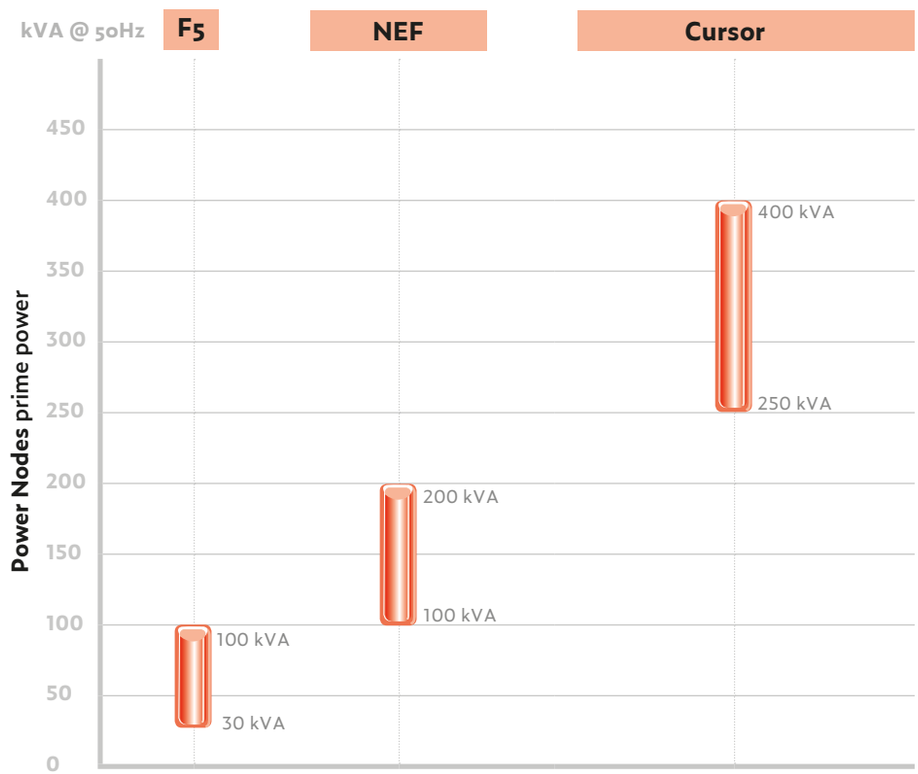
FPT Industrial's Answer

Wherever energy has to be delivered quickly and reliably, FPT Industrial provides the optimal answer with its state-of-the-art range of engines for Power Generation applications.

To fulfill market requirements, FPT Industrial has developed different engine ranges respectively compliant with most demanding Emissionss Standards. FPT Industrial products offer functional layouts, hi-tech contents and carefully selected top quality components as well.

Power Generation Engine Portfolio

Stage V



kVA = kiloVolt Ampere
Calculations based on typical generator efficiency and 0.8 power factor

HI-eSCR2 Technology

Stage V:
To maintain the advantages of the unique and unbeaten HI-eSCR technology, FPT Industrial will integrate a maintenance-free filtering device on its SCR catalyst, thus allowing to comply with tightened limits on PM emissions within a compact package.

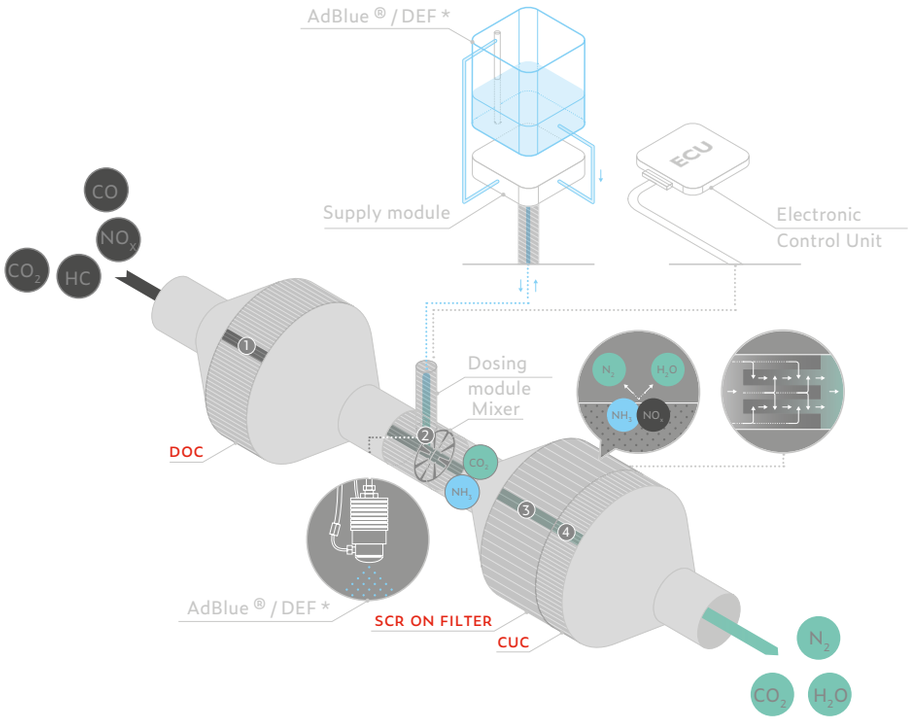
Applicable for engines above 56kW and below 560kW, the second generation HI-eSCR2, traps and oxidizes the Particulate Matter, converts NO_X into Nitrogen (N_2) and water (H_2O) thanks to the chemical reaction of Ammonia (NH_3).

The result is a reduction of NO_X superior to 95% and the PM levels within Stage V emission limits. Thanks to optimized combustion, leadership on performance and fuel efficiency are confirmed.

HI-eSCR2 Patents

- "Closed" loop control through dedicated sensors to provide accurate monitoring of exhaust gas composition; adaptive dosing system to optimize AdBlue consumption
- ClosedThermally insulated high turbulence mixer to allow homogeneous AdBlue evaporation and urea hydrolysis ensuring correct distribution in exhaust gas flow
- Optimized exhaust gas temperature control to speed up SCR light-off in cold part of the mission

HI-eSCR 2



1.
Diesel Oxidation Catalyst
NO → NO_2
HC, CO and PM oxidation

2.
AdBlue* / DEF Injection
Hydrolysis → NH_3+CO_2

3.
Selective Catalytic Reduction on filter
NO and NO_2 reduction by NH_3 to N_2 and H_2O
PM oxidation with NO_2

4.
Clean Up Catalyst
Residual NH_3 oxidation

*AdBlue®/DEF = $CO(NH_2)_2 + H_2O$

Legend

PM Particulate Matter
HC Unburnt Hydrocarbons
NO_x Nitrogen Oxides
CO Carbon Monoxide
N_2 Nitrogen
CO_2 Carbon Dioxide
H_2O Water

HI-eSCR2 Main Components

HI-eSCR2 main components are:

- ✓ *The DEF/AdBlue Supply Module*
- ✓ *The DEF/AdBlue Dosing Module*
- ✓ *The Disel Oxydation Catalyst (DOC)*
- ✓ *The DEF/AdBlue Mixer*
- ✓ *The Selective Catalytic Reduction (SCR) on filter*
- ✓ *The Clean Up Catalyst*

The whole system is fitted with a network of integrated sensors to control, among others, the NO_x and any excess of NH_3 (ammonia) produced.

Exhaust gas flow coming from the engine enters the DOC, where NO is oxidised to NO_2, in order to maximize SCR catalyst's efficiency conversion.

The ECU (Engine Control Unit), the brain behind the HI-eSCR2 system, checks, through integrated sensors network, the amount of Water-Urea (DEF/AdBlue) solution to be injected in the exhaust pipe. To increase the durability of the injector, Dosing Module is cooled by the engine coolant.

The HI-eSCR2 after-treatment system adopts a filtering device on its SCR catalyst. At the same time as trapping and oxidizing the Particulate Matter, the catalyst converts NOX into Nitrogen (N_2) and water (H_2O) thanks to the chemical reaction of Ammonia (NH_3) generated from DEF/Adblue. In the end, the integrated CUC eliminates the remaining Ammonia (NH_3). The result is a reduction of NO_x superior to 95% and the PM levels within Stage V emission limits.

Key Features

The statement “five steps ahead” holds true for FPT Industrial, and five pillars explain how FPT Industrial's HI-eSCR2 technology has been developed to meet customer needs:

1

Leadership in engine performance, technology, power density and reliability.

2

Exclusive HI-eSCR2 technology based on 25 years experience in SCR

3

Maximum uptime: no additional maintenance stops thanks to “For life” after-treatment system

4

No additional cooling system requirements thanks to EGR free solution

5

Environmental sustainability and reduced Total Cost of Ownership guaranteed, while still maintaining best-in-class engine efficiency

POWER GENERATION

FPT Industrial Smart Installation Solution: ATS Pack

Smart Installation Package

In highly regulated markets, legislation introduced a further reduction on emission limits for mobile and prime power applications.

To comply with these new emission limits and make machine upgrade easier, FPT presents a new, smart installation package: After Treatment System installation solution (ATS Pack).

The ATS Pack includes all key after-treatment components in a single package: main catalysts and their relative sensors are included in a compact and pre-assembled set that requires no dedicated design or installation of ATS components.

The pre-packed ATS solution has a pre-validated design in terms of fluid-dynamics, manifold layout and the position of sensors in order to make the final validation process both leaner and easier.

The ATS Pack provides outstanding installation flexibility as it is available as a ready-to-use ATS solution (horizontal or vertical position).

With the ATS Pack, all electrical signals and connections are managed by a single cable for fast, reliable and quick connection to any engine.

All productivity benefits of FPT Industrial technology come in a simple package, with high performance and efficiency. The innovative FPT After Treatment Technology ensures high emission standards compliance with a maintenance-free solution.

ATS Packs:
Designed with the Needs of Genset Customers in Mind.

DESIGN

Effective Pre-assembled, pre-cabled and pre-validated solution (from 10 components to 1) for lean application sign-off and easy installation.

- FPT technological know-how guarantees the best product reliability
- No need to design a solution means time and cost savings for customers
- No need to scout new component suppliers for purchasing departments
- Optimized product inventory thanks to improved warehouse space management and complexity reduction
- ATS pack equivalent to current silencer

FLEXIBILITY

- Space effective: possibility to choose horizontal or vertical position to meet the needs of any customer

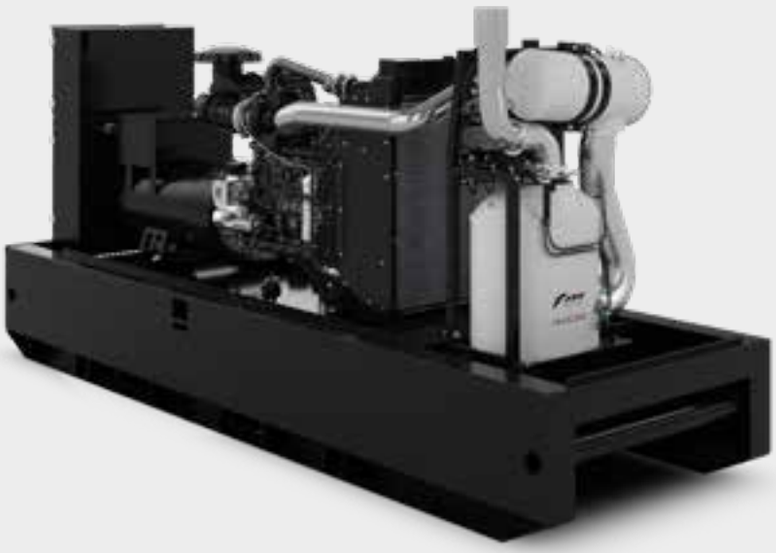
PLUG-AND-PLAY (Preassembled Solution)

Production process will run faster and with less downtime thanks to:

- Fewer components to manage
- Fewer production steps and assembly time
- Fewer assembly machines and equipment
- Fewer defaults in production process
- Less stock due to lower non conform products

INSTALLABILITY

- Easy to install thanks to rectangular shape, which fits simply into the Genset layout
- ATS pack is equivalent to current silencer: no need to change installation process
- Reduced delivery delay risk due to reduced downtime in installation process



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