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Automotive Catalysts

ECT 2018

Technologies & Solutions for upcoming Off Highway

Dr Alain Ristori

ECT 2018, Pune, October 25th, 2018

Agenda

- Umicore short introduction
- Global NRMM technical trend Worldwide
- Main challenges for India
- Legislation update and system layouts for India

Who we are

A global materials technology and recycling group

One of three global leaders in emission control catalysts for light-duty and heavy-duty vehicles and for all fuel types

A leading supplier of key materials for rechargeable batteries used in electrified transportation and portable electronics

The world's leading recycler of complex waste streams containing precious and other valuable metals

Unique position

in clean mobility materials

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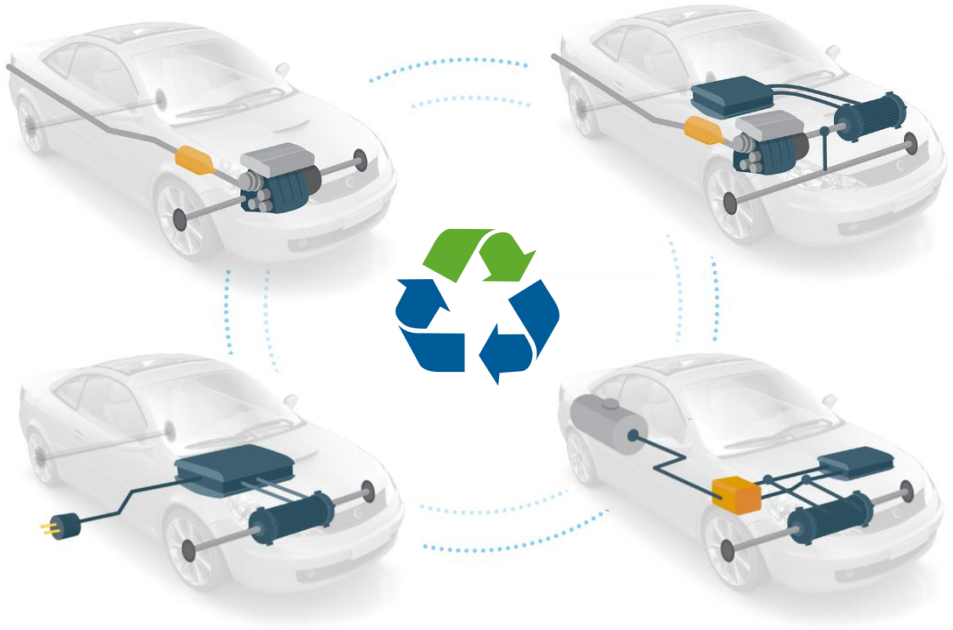
ICE
Emission control catalysts

(p)HEV
Battery cathode materials and emission control catalysts



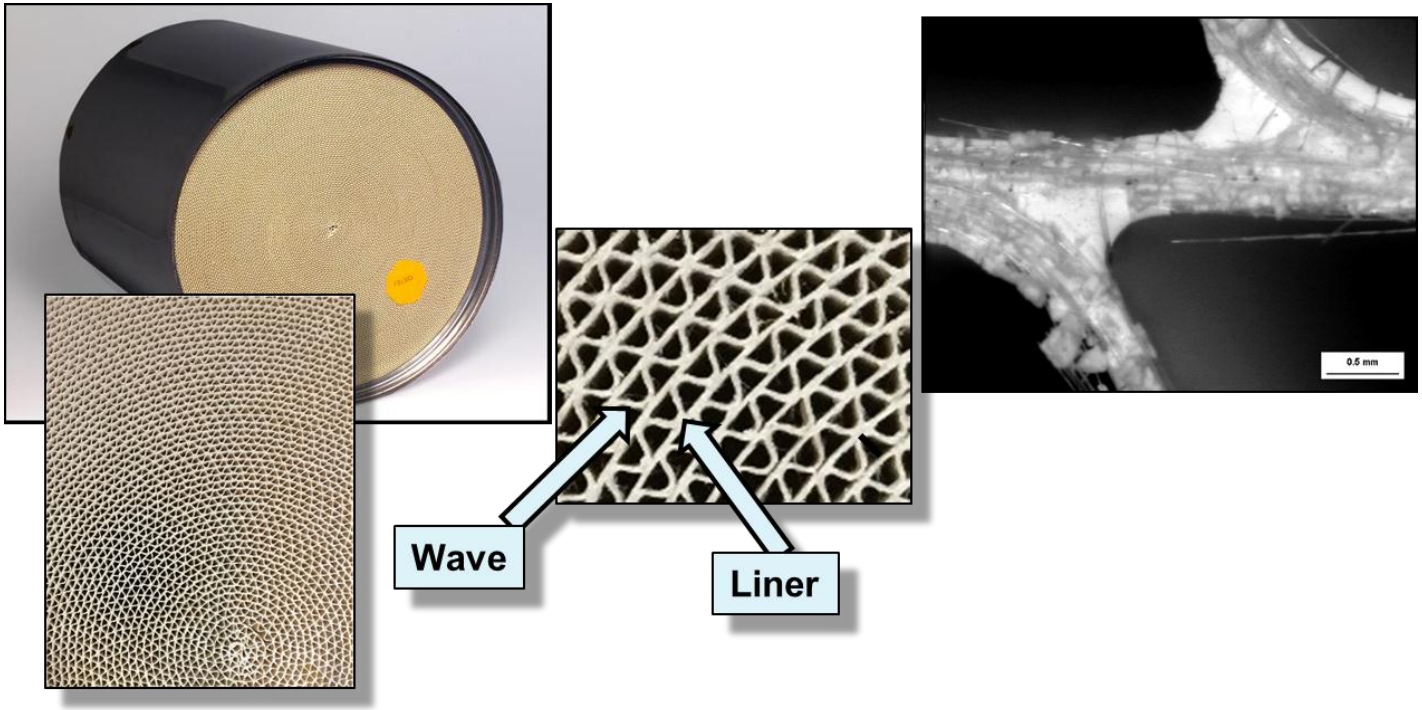
BEV
Battery cathode materials

Fuel cells
Electro-catalyst and battery cathode materials

Investing in Umicore AC's future

In 2017: Acquisition of catalyst business of Haldor Topsoe for €120M

- Corrugated SCR technology, strong HDD presence @ Scania and China market



Vanadium SCR on corrugated substrate

A unique Umicore solution also for advanced ATS

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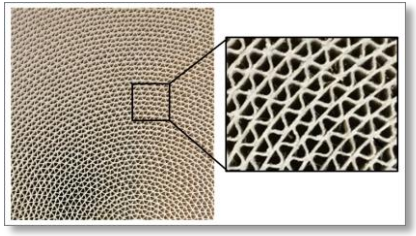
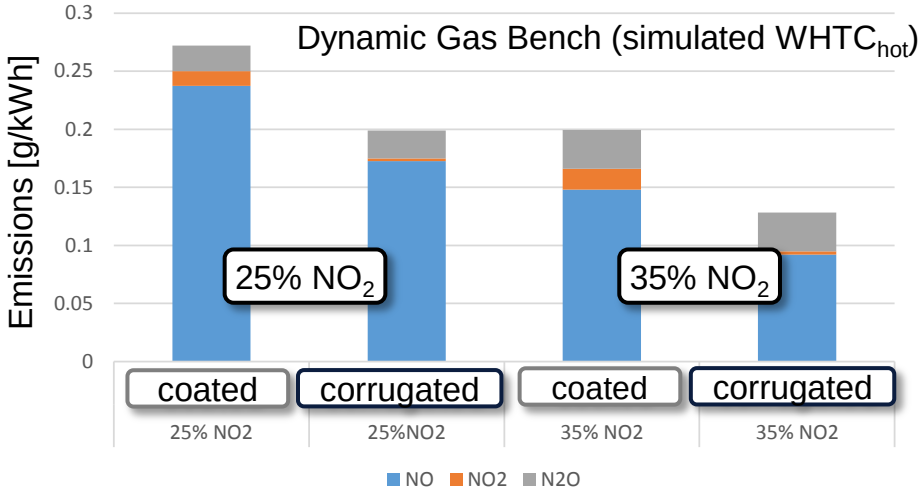
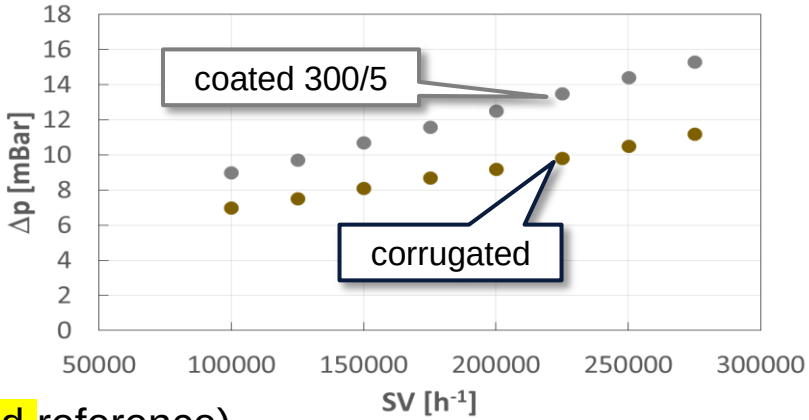


NO_x performance



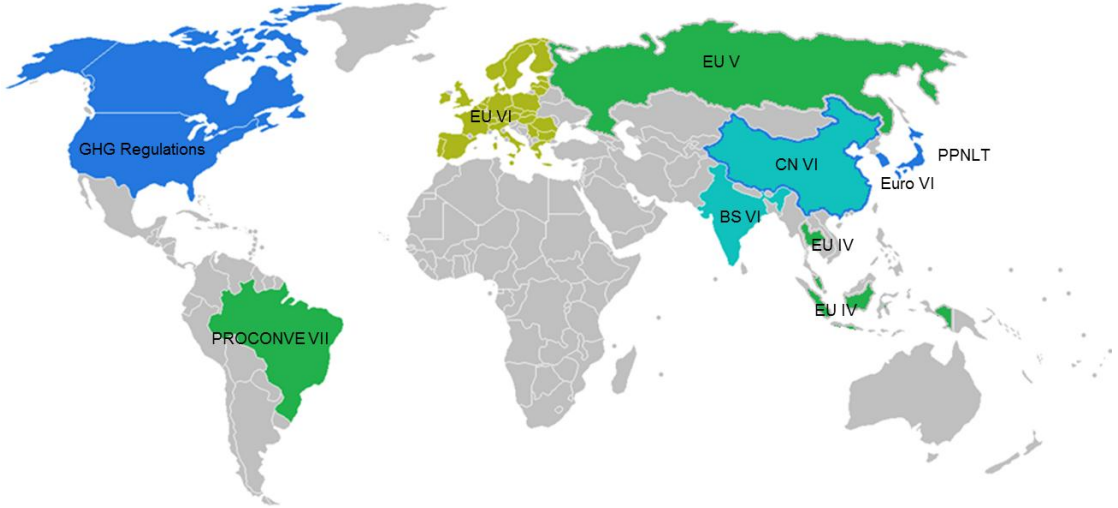
Pressure drop



- Lower Pressure Drop
- Lower catalyst mass (> -30% vs. coated & extruded reference)
- @ competitive performance & cost

System layout -Technologies – Global Overview for NRMM

Upcoming Systems with announced legislations (up to 2024)

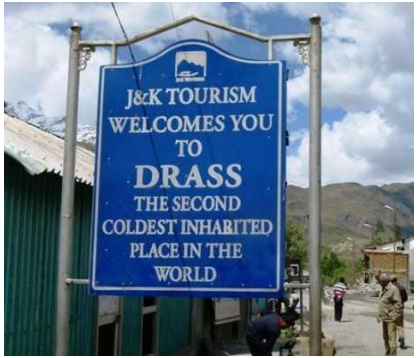


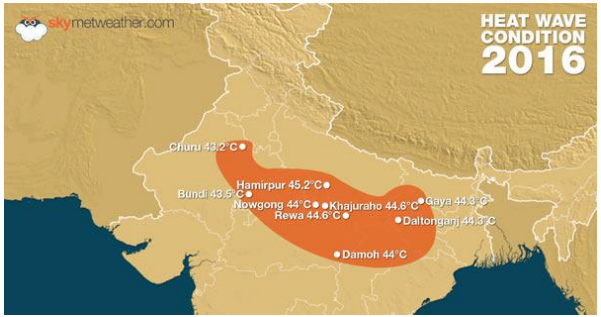
- US Tier IVf — V / Cu / Fe SCR, no particulate number limit => DPF not mandatory
- Europe Stage V — V / Cu / Fe SCR, Soot filter is mandatory, SCR on filter is an option
- China Stage IV — Cu / Fe SCR, Soot filter is mandatory. Use of V SCR will be regulated
- India CEV/TREM IV/V — V / Cu / Fe? SCR, is SCR on filter an option?

Incredible India

Why is India a unique market?

One of the coldest place in the world with temperature down to -45°C…





… but also one of the hottest in the world with temperature up to +50°C in Rajasthan …

Superior Kerosene Oil / Kero
IndianOil Kerosine meets the requirements of
IS 1459 : 1974 (2nd Revision) with Amendment (No 1 thru 3)

Sr No	Characteristics	Requirement	Method of Test IS : 1448
(i)	Acidity, inorganic	Nil	P:2
(ii)	Burning quality a) Char value, mg/kg of oil consumed, Max b) Bloom on glass chimney	 20 Not darker than grey	P:5
(iii)	Colour (Saybolt)*, Min	*10	P:14
(iv)	Copper strip corrosion for 3hr at 50°c	Not worse than No. 1	P:15
(v)	Distillation		P:18
	a) Percent recovered below 200°C, Min	20	
	b) Final boiling point °C Max	300	
(vi)	Flash point (Abel)°C, Min	35	P:20
(vii)	Smoke point, mm, Min	18**	P:31
(viii)	Total Sulphur, percent by mass, Max	0.25#	P:34

… with very unique challenges like kerosene which can contain up to 2500ppm Sulfur!

Lubricant quality?

Incredible India

Why is India a unique market?

With very unique in use conditions…

Bharat Stage CEV/TREM IV & V

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Expected Systems

Bharat Stage CEV/TREM IV

Power (kW)	Start	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	PM (g/kWh)	PN (#/kWh)	Test Cycle
37 ≤ P < 56	Oct. 2020	5.0	4.7			-----	NRSC & NRTC
56 ≤ P < 130		5.0	0.19	0.4		-----	
130 ≤ P < 560		3.5	0.19	0.4	0.025	-----	

DOC (+DPF)

SCR / SCRT

Bharat Stage CEV/TREM V

Power (kW)	Start	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	PM (g/kWh)	PN (#/kWh)	Test Cycle
P < 8	April 2024	8.0	7.5			-----	NRSC
8 ≤P < 19		6.6	7.5			-----	
19 ≤P < 37		5.0	4.7			1×10^{12}	NRSC/NRTC
37 ≤ P < 56		5.0	4.7			1×10^{12}	
56 ≤ P < 130		5.0	0.19	0.4		1×10^{12}	
130 ≤ P < 560		3.5	0.19	0.4		1×10^{12}	
P > 560		3.5	0.19	3.5		-----	NRSC

No EATS

DOC + DPF

SCRT

SCR only

Bharat Stage CEV/TREM IV (October 2020)

Overall very much comparable to Tier IVf/Stage IV

Engine power(kW)	Technical Routes	DPF Reg.	Comment
37<P<56	Non CR, EGR, DOC+cDPF	CRT+Standstill	with HC doser
		Active Reg.	with HC doser
	CR, EGR, DOC (+partial filter?)	CRT	**Mainstream ?**
56<P<560	Non CR, w/ or w/o EGR+SCRT	CRT+Standstill	with HC doser
		Active Reg.	with HC doser
	CR, w/o EGR, (DOC)+SCR	No filter needed	

The ATS will be depending on the engine development stage

- The OEM can chose to develop a new engine with common rail system
- The OEM may also chose to stay with a mechanical pump

Bharat Stage CEV/TREM V (April 2024)

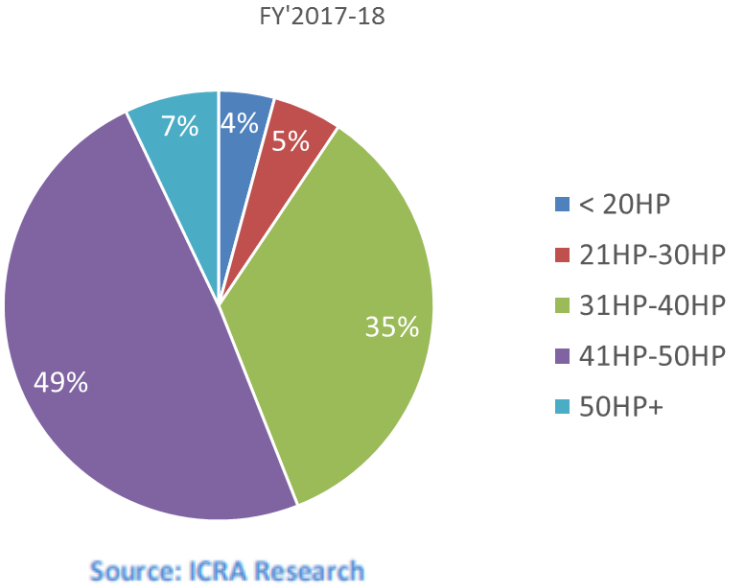
Overall very much comparable to Stage V

Engine power(kW)	Technical Routes	DPF Reg.	Comment
19<P<56	Non CR, EGR, DOC+cDPF	CRT+Standstill	with HC doser
		Active Reg.	with HC doser
	CR, EGR, DOC+cDPF	Active Reg.	**Mainstream ?**
56<P<560	CR, w/ or w/o EGR+SCRT	CRT+Standstill	
		Active Reg.	
P>560	CR, w/o EGR, (DOC)+SCR	No filter needed	

- The introduction of the particulate number limit requires the use of a Diesel Particulate Filter for all engines with a power comprised between 19kW and 560kW
- For non CR engines with a power comprised between 37 to 56kw, the same ATS layout with filter can be reused from TREM IV development

Tractor market analysis

How will the market react to TREM IV/V introduction?

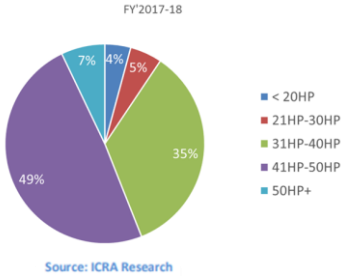


Source: ICRA Research

- Based on today market, only 7% of tractors will require an After Treatment System from October 2020
- Most probably the 50HP+ market will even drop because of TREM IV introduction
- In April 2024, with the introduction of TREM V, more than 90% of the tractor market will be equipped with an ATS system

System layout for TREM IV

How to keep the 50HP+ competitive?



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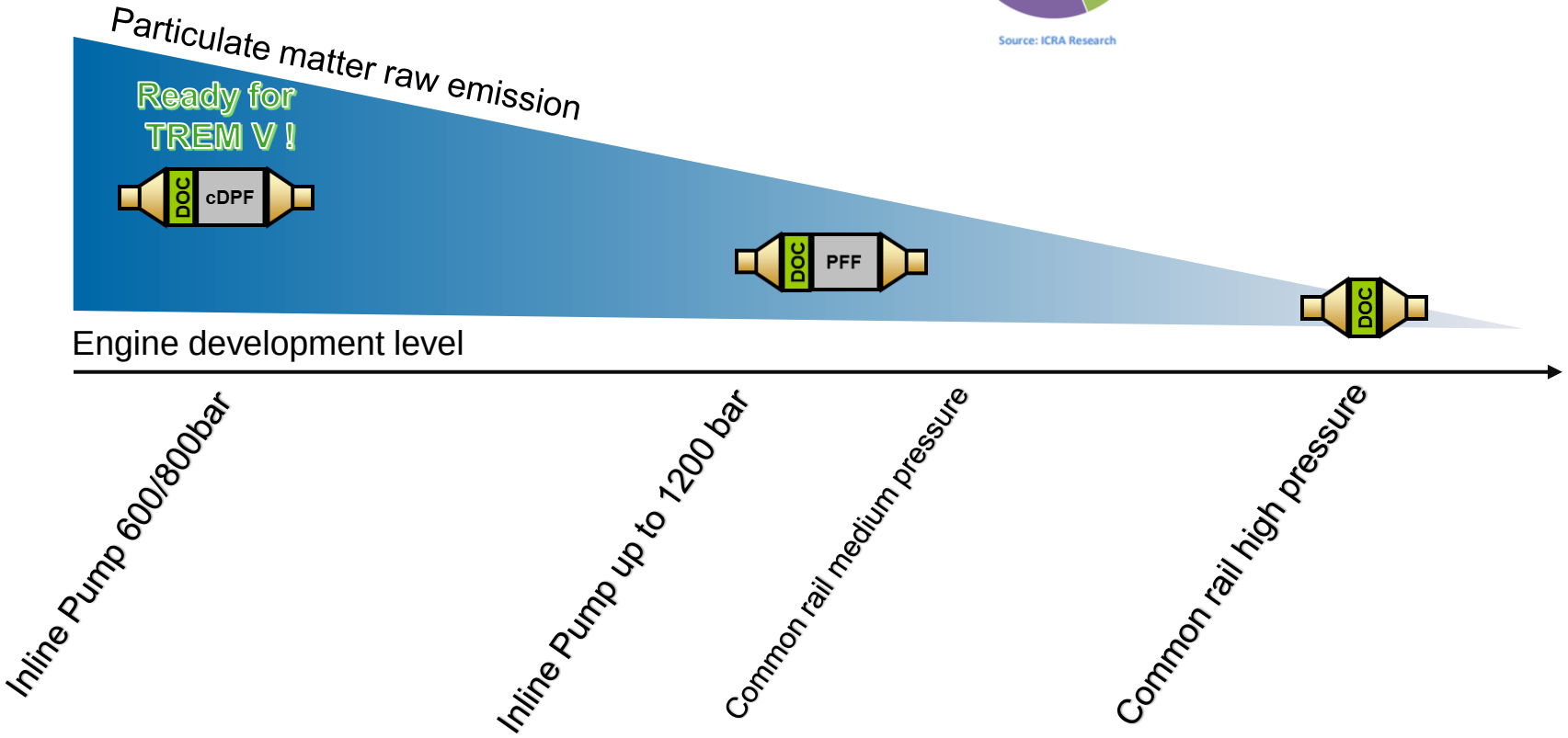
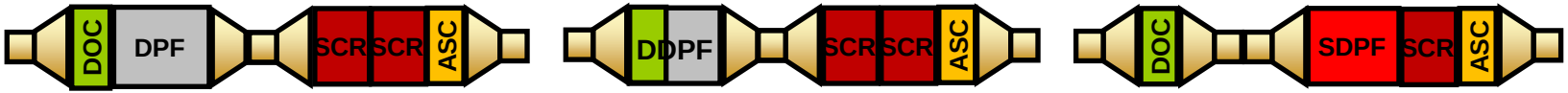


System layout for CEV/TREM V

What is the best system layout for 75HP+ applications?



SCRT

- Well proven for US2010, EuroVI & TierIVf
- High CRT efficiency
- Active Regeneration applicable w/o major restrictions
- High packaging volume

DDPF

- Volume saving potential 10-15%
- 1 brick less to can
- Very limited active regen capability
- Slightly compromised CRT efficiency

SDPF

- Volume saving potential 15-20%
- Improved cold start De-NOx activity
- Potentially 1 brick less to can
- Significantly reduced CRT efficiency
- Still not field proven

System layout review for CEV/TREM IV/V

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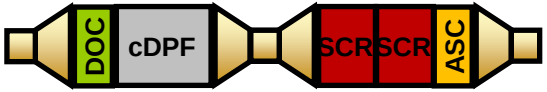
TREM IV

Up to 56kw

Mainstream ?

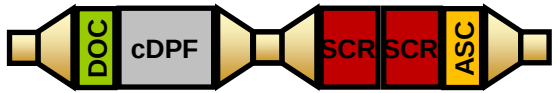
From 56kw to 560kw

Mainstream ?



TREM V

Mainstream



Mainstream

Conclusion

- The TREM/CEV IV introduction will be a good opportunity to learn about ATS for off highway applications in India…
- …even if the real challenge is coming with the TREM/CEV V introduction
- All the catalyst technologies are available and approved in US, Europe and China…
- … and can be adapted to the special environement we have in India

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Thank you!

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materials for a better life