

Indian Diesel Engine Manufacturers' Association



Conference on Infrastructure Projects in India

Mumbai

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**Technologies to Meet Future Off-Highway
Emission Requirements**



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Chairman, Technical Committee

IDEMA

⁵[(ca) "construction equipment vehicle" means rubber tyred (including pneumatic tyred), rubber padded or steel drum wheel mounted, self-propelled, excavator, loader, backhoe, compactor roller, dumper, motor grader, mobile crane, dozer, fork lift truck, self-loading concrete mixer or any other construction equipment vehicle or combination thereof designed for off-highway operations in mining, industrial undertaking, irrigation and general construction but modified and manufactured with "on or off" or "on and off" highway capabilities.

Explanation.—A construction equipment vehicle shall be a non-transport vehicle the driving on the road of which is incidental to the main off-highway function and for a short duration at a speed not exceeding 50 kms per hour, but such vehicle does not include other purely off-highway construction equipment vehicle designed and adopted for use in any enclosed premises, factory or mine other than road network, not equipped to travel on public roads on their own power;]

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TABLE

Limit Values for Type Approval (TA) as well as for Conformity of Production (COP)

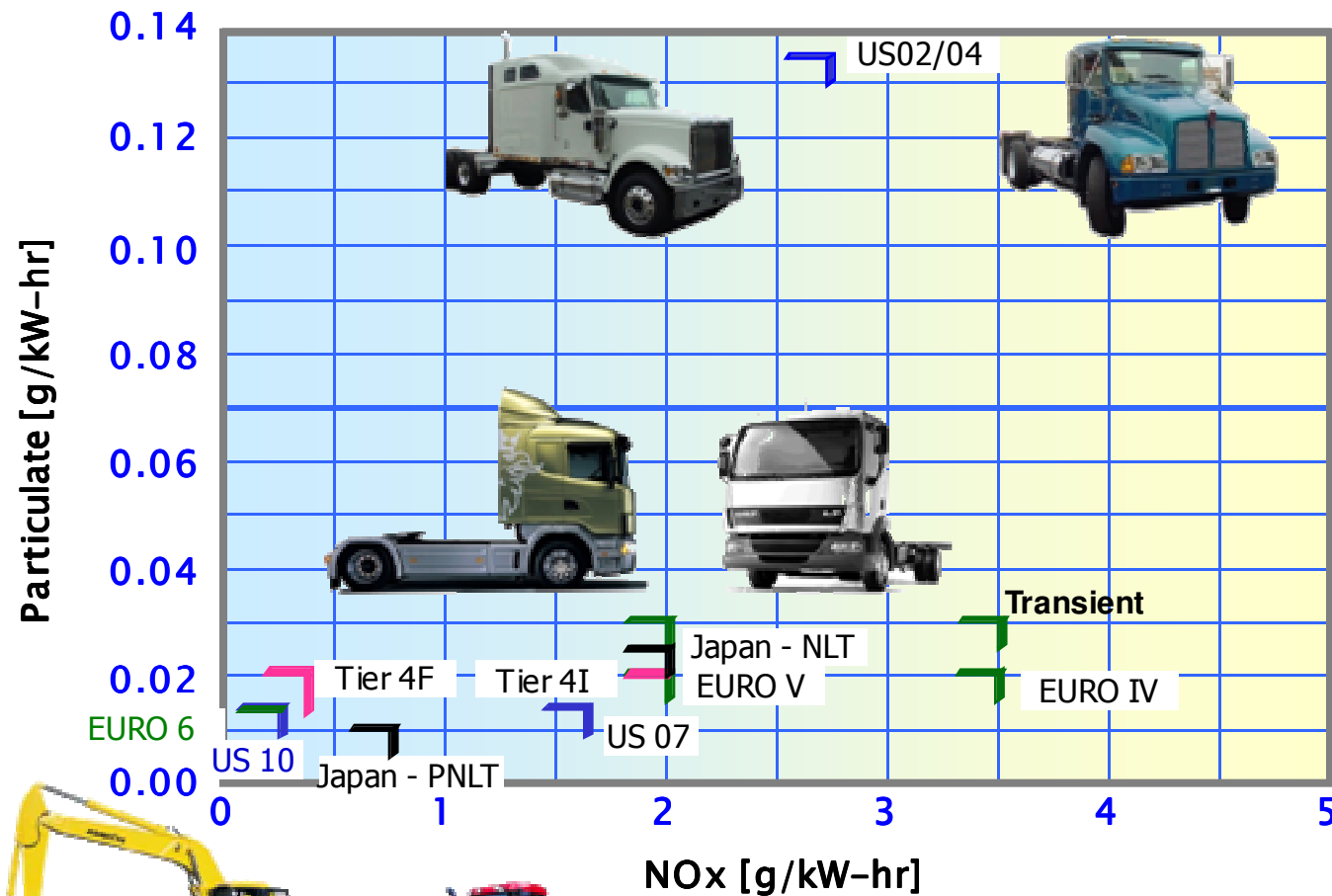
Bharat Stage II (CEV)	Applicable with effect from the	CO	HC	NO_x	PM
Category		g/kWh			
kW < 8	1 st October, 2008	8.00	1.30	9.20	1.0
8 < kW < 19	1 st October, 2008	6.60	1.30	9.20	0.85
19 ≤ kW < 37	1 st October, 2007	6.50	1.30	9.20	0.85
37 ≤ kW < 75	1 st October, 2007	6.50	1.30	9.20	0.85
75 ≤ kW <130	1 st October, 2007	5.0	1.30	9.20	0.70
130 ≤ kW < 560	1 st October, 2007	5.0	1.30	9.20	0.54

Bharat Stage III (CEV)	Applicable with effect from the	CO	HC + NO_x	PM
Category		g/kWh		
kW < 8	1 st April, 2011	8.00	7.50	0.80
8 ≤ kW < 19	1 st April, 2011	6.60	7.50	0.80
19 ≤ kW < 37	1 st April, 2011	5.50	7.50	0.60
37 ≤ kW < 75	1 st April, 2011	5.0	4.70	0.40
75 ≤ kW <130	1 st April, 2011	5.0	4.00	0.30
130 ≤ kW < 560	1 st April, 2011	3.50	4.00	0.20

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Emission Standards Continue to Become More Stringent Around the World



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Global Off-Highway Emission Regulations

U.S. EPA

kW (HP)		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0 - 7	(0 - 10)					(10.5) / 8.0 / 1.0					(7.5) / 8.0 / 0.80			(7.5) / 6.6 / 0.40									
8 - 18	(11 - 24)					(9.5) / 6.6 / 0.80					(7.5) / 6.6 / 0.80												
19 - 36	(25 - 48)					(9.5) / 5.5 / 0.80					(7.5) / 5.5 / 0.60			(7.5) / 5.5 / 0.30					(4.7) / 5.0 / 0.03				
37 - 55	(49 - 74)					9.2 / -- / -- / --					(7.5) / 5.0 / 0.40			Opt T4i 0.30 PM: 37-55 kW (4.7) / 5.0 / 0.40: 37-74 kW			Note 6						
56 - 74	(75 - 99)																						
75 - 129	(100 - 173)		9.2 / -- / -- / --				(6.6) / 5.0 / 0.30			(4.0) / 5.0 / 0.30					3.4 / 0.19 / 5.0 / 0.02		0.40 / 0.19 / 5.0 / 0.02						
130 - 224	(174 - 301)	9.2 / 1.3 / 11.4 / 0.54					(6.6) / 3.5 / 0.20			(4.0) / 3.5 / 0.20					2.0 / 0.19 / 3.5 / 0.02		0.40 / 0.19 / 3.5 / 0.02						
225 - 449	(302 - 602)	9.2 / 1.3 / 11.4 / 0.54					(6.4) / 3.5 / 0.20			(4.0) / 3.5 / 0.20													
450 - 560	(603 - 751)	9.2 / 1.3 / 11.4 / 0.54					(6.4) / 3.5 / 0.20			(4.0) / 3.5 / 0.20													
>560*	(>751)*					9.2 / 1.3 / 11.4 / 0.54					(6.4) / 3.5 / 0.20			3.5 / 0.40 / 3.5 / 0.10 0.67 / 0.40 / 3.5 / 0.10 ^a			3.5 / 0.19 / 3.5 / 0.04 0.67 / 0.19 / 3.5 / 0.03 ^b						
		Tier 1					Tier 2			Tier 3			Tier 4 Interim			Tier 4 Final							

Tier 1

Tier 2

Tier 3

Tier 4 Interim

Tier 4 Final

a. Applies to portable power gen engines >900kW (>1207hp).
b. Applies to portable power gen engines >560kW (>751hp).

EUROPE

kW (HP)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
18 - 36 (24 - 48)					8.0 / 1.5 / 5.5 / 0.8				(7.5) / 5.5 / 0.6													
37 - 55 (49 - 74)				9.2 / 1.3 / 6.5 / 0.85				7.0 / 1.3 / 5.0 / 0.4				(4.7) / 5.0 / 0.4						(4.7) / 5.0 / 0.025				
56 - 74 (75 - 99)																		3.3 / 0.19 / 5.0 / 0.025		0.4 / 0.19 / 5.0 / 0.025		
75 - 129 (100 - 173)				9.2 / 1.3 / 5.0 / 0.70			6.0 / 1.0 / 5.0 / 0.3		(4.0) / 5.0 / 0.3									3.3 / 0.19 / 5.0 / 0.025				
130 - 560 (174 - 751)				9.2 / 1.3 / 5.0 / 0.54			6.0 / 1.0 / 3.5 / 0.2		(4.0) / 3.5 / 0.2									2.0 / 0.19 / 3.5 / 0.025		0.4 / 0.19 / 3.5 / 0.025		

Stage I

Stage II

Stage IIIA

Stage IIIB

Stage IV

JAPAN (Tier 1 standards applicable by application. Tier 2 and Tier 3 applicable by power category. Introduction dates October of year listed.)

kW (HP)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
19 - 36 (25 - 48)				Tier 1 application-specific standards				8.0 / 1.5 / 5.0 / 0.8				6.0 / 1.0 / 5.0 / 0.40						4.0 / 0.7 / 5.0 / 0.03				
37 - 55 (49 - 74)				9.2 / 1.3 / 5.0 / --; Tier 1 standards are application specific and apply to engines 30-260 kW				7.0 / 1.3 / 5.0 / 0.4					4.0 / 0.7 / 5.0 / 0.30					4.0 / 0.7 / 5.0 / 0.025				
56 - 74 (75 - 99)													4.0 / 0.7 / 5.0 / 0.25					3.3 / 0.19 / 5.0 / 0.02		0.4 / 0.19 / 5.0 / 0.02		
75 - 129 (100 - 173)				Tier 1 application-specific standards				6.0 / 1.0 / 5.0 / 0.3				3.6 / 0.4 / 5.0 / 0.20						3.3 / 0.19 / 5.0 / 0.02		0.4 / 0.19 / 5.0 / 0.02		
130 - 560 (174 - 751)				Tier 1 application-specific standards				6.0 / 1.0 / 3.5 / 0.2				3.6 / 0.4 / 3.5 / 0.17						2.0 / 0.19 / 5.0 / 0.02		0.4 / 0.19 / 3.5 / 0.02		

Step 1

Step 2

Step 3

Step 4

Step 4

NOx/NMHC/CO/PM or (NOx+NMHC)/CO/PM

Indian Diesel Engine Manufacturers' Association Diversity – Vehicles and Applications



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Products Must Meet the Customer Requirements



Reliable and Durable

High Performance



Highly Sociable



Fuel Efficient

Connected and Integrated Systems



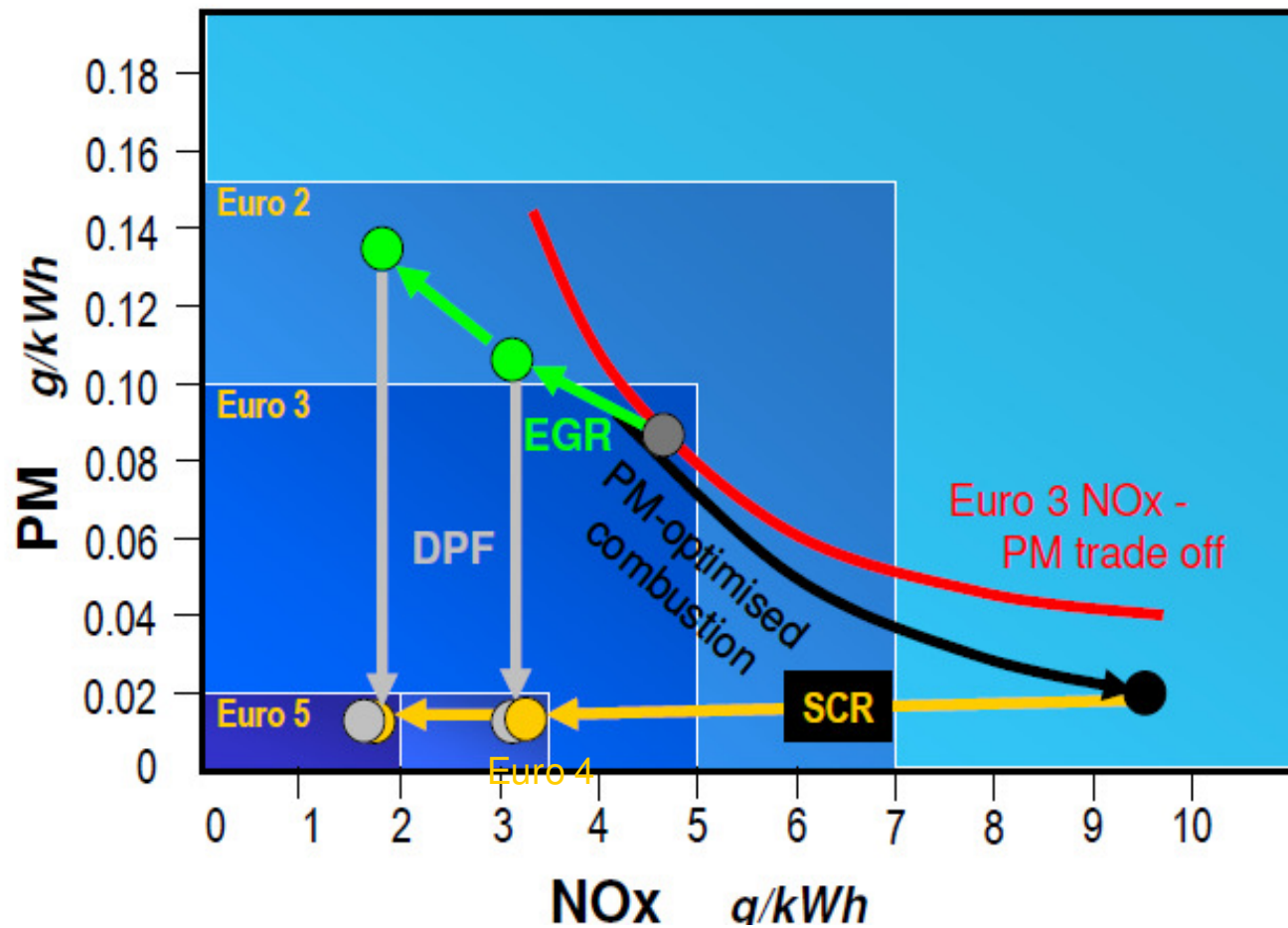
Low Initial Cost



Low Maintenance



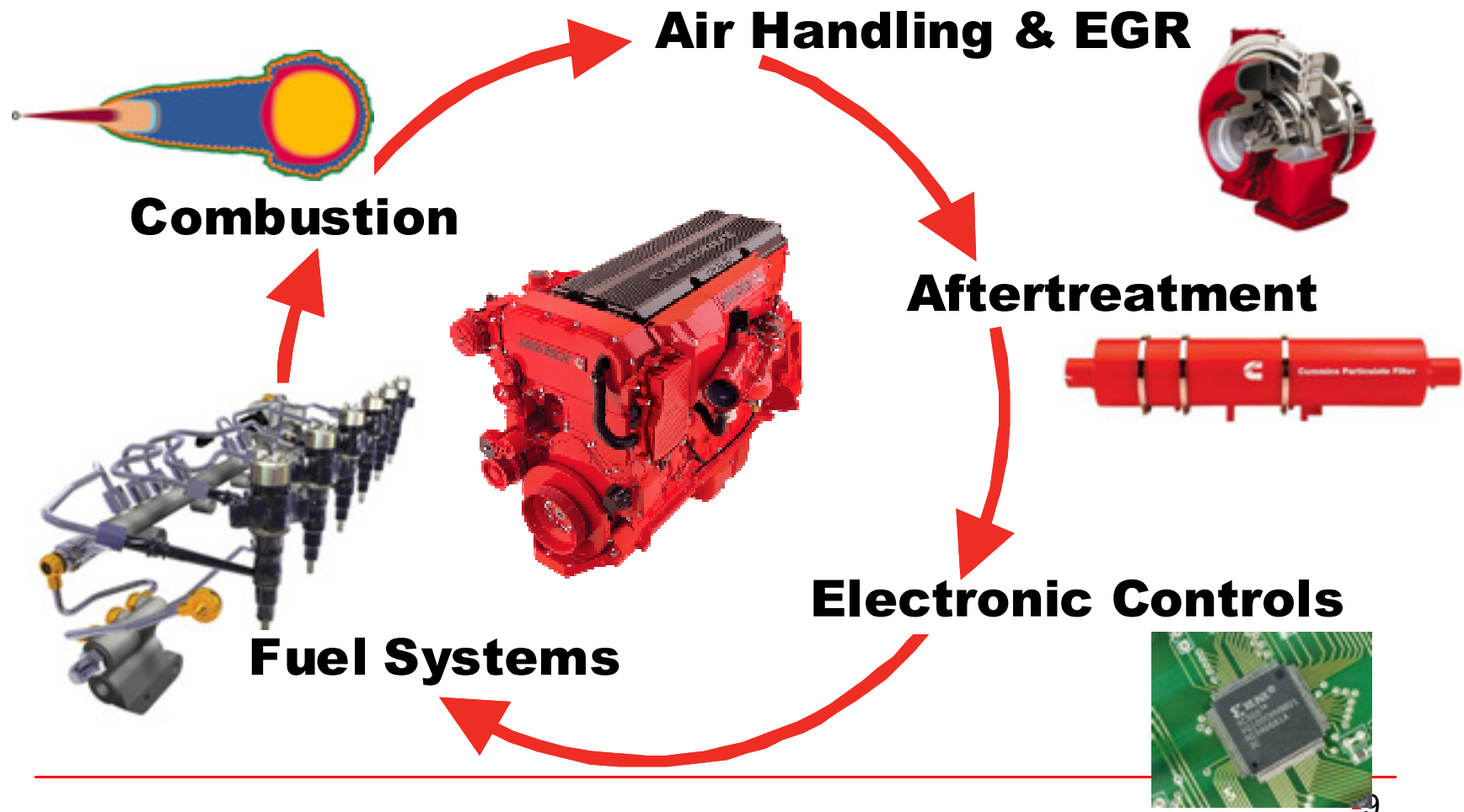
High Quality and Aesthetics



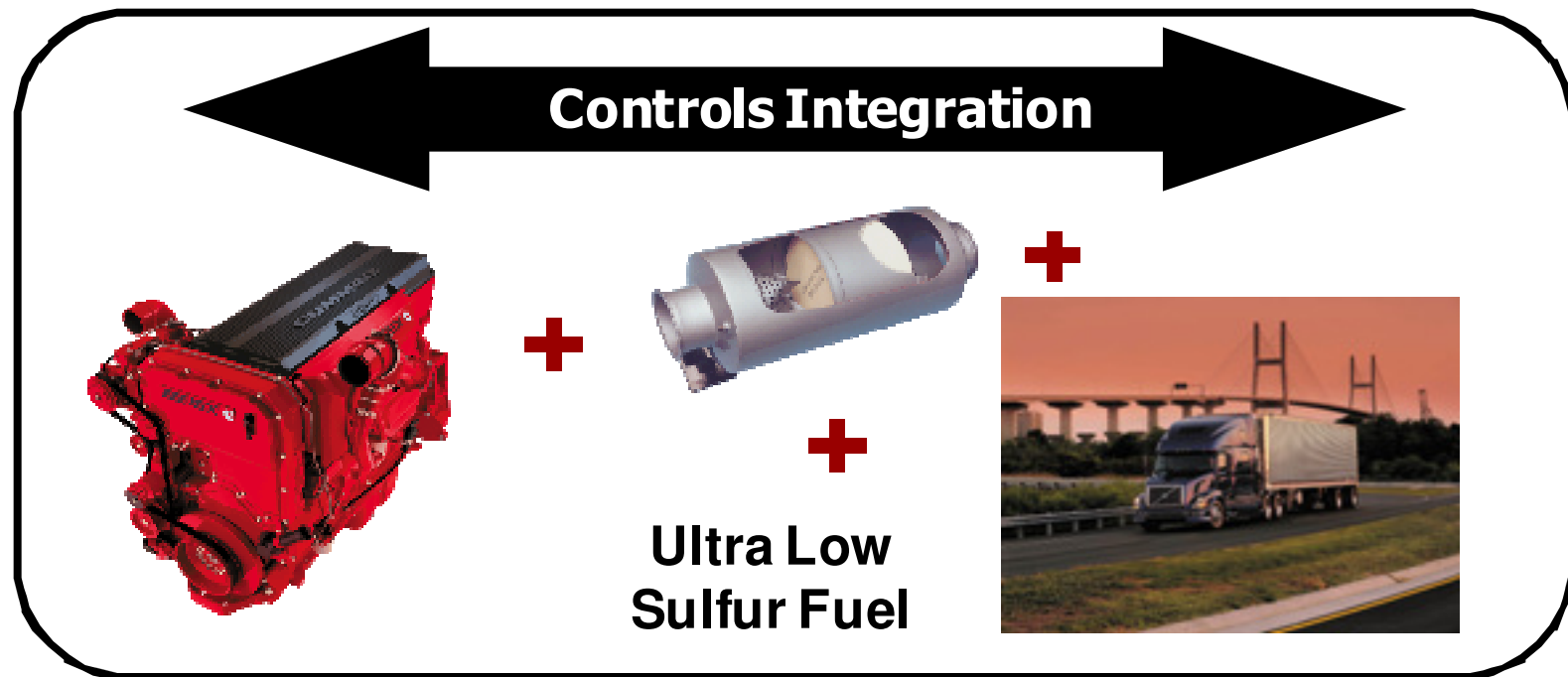
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Ultra-Low Emission Engine
It's ALL about Technology Integration



Indian Diesel Engine Manufacturers' Association System Integration is Critical



- Vehicle, engine, aftertreatment and fuel . . .
 - a single system designed to optimize
 - performance, reliability, cost and emissions
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- The broadest technology portfolio of any engine company
- Ability to leverage on-highway preceding technology

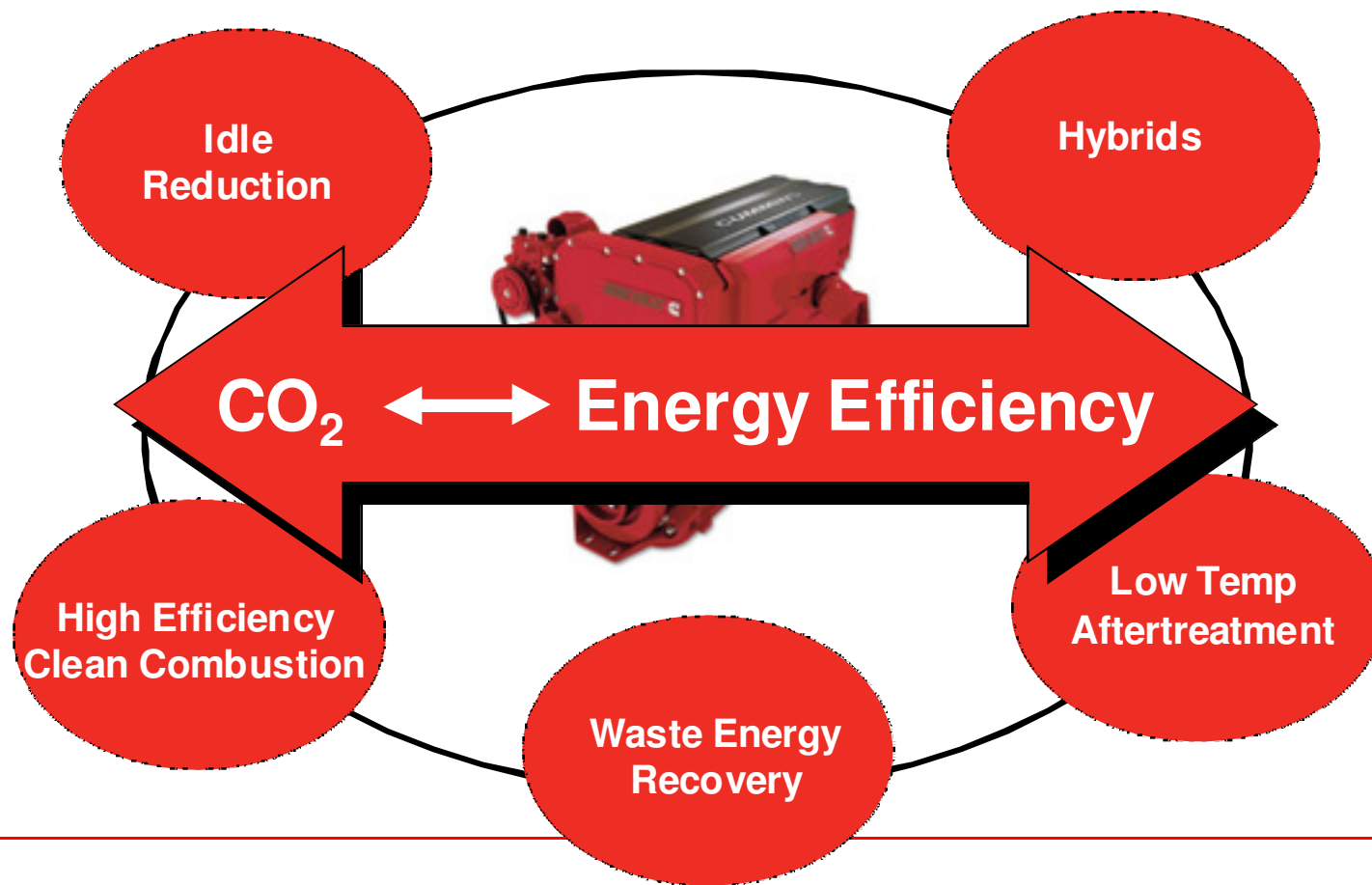
Application	In-Cylinder Only	Cooled EGR	PM Filter	NOx Adsorber	SCR
EPA Tier 3/EU Stage IIIA 2005/6	●				
EPA Tier 2 > 751 hp 2006	●				
Euro IV Truck & Bus 2006					●
EPA 2007 Truck & Bus		●	●		
EPA 2007/10 Ram Truck		●	●	●	
Euro V Truck & Bus 2008					●
EPA 2010 Heavy-duty auto		●	●		
EPA 2010 MidRange auto		●	●		●
Euro VI Truck & Bus 2011/12	under development				

How BISIII-CEV emission norms were achieved

Case 1 – Internal EGR, Rotary pump, CAC, Waste Gate Turbo with high efficiency, Higher A/F ratio

Case 2- Internal EGR, Rotary pump, CAC, Turbo with higher air flow (Higher A/F), 4 valve head

Reducing our CO₂ Footprint



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IDEMA Manufactures BS-III-CEV readiness

01-Feb-11

		In pipeline		
Engine Families	Already Certified	Before 28-Feb-2011	Before 31-Mar-2011	Will be certified after 31-Mar-2011
Percentage	42	26	11	21

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■ Number of Engine Families Certified – 07-Feb-2011

No. of Engines Certified Till Date		28
In progress		5

These include engines by IDEMA members, non IDEMA members and imported engines

Important points for future emissions

- Diesel engine with after treatment and low sulfur fuel is clean, efficient power
 - After treatment systems are complex and require system integration
 - Future technology for India is on the road today in the US and Europe
 - Needs further work to meet cost and durability needs
 - Ultra Low Sulfur Fuel is an integral part of any long-term emission reduction strategy
 - *50 ppm may not be low enough*
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Thanks