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# Emerging HD Technologies

AESI Presentation to  
California Air Resources Board  
Symposium on Phase II GHG Standards  
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Presented by:  
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# Overview

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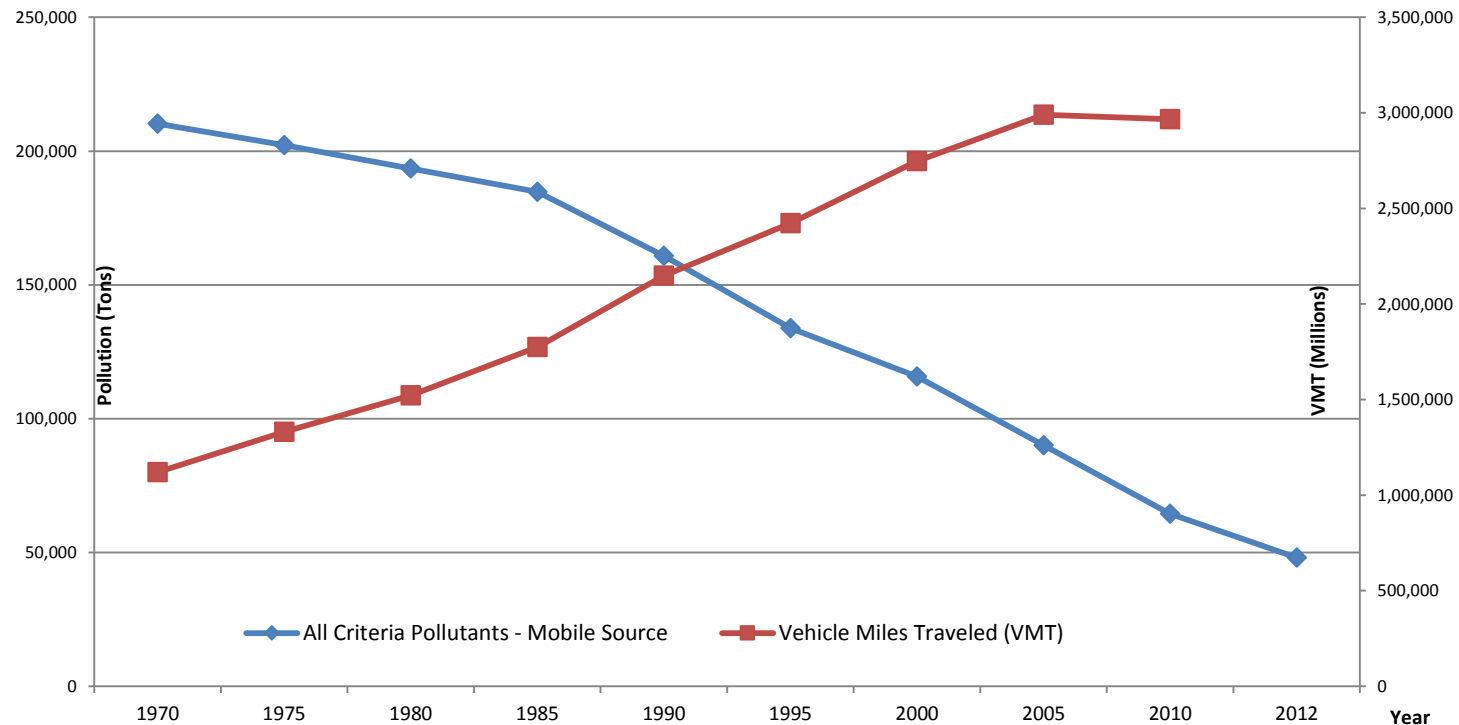
- Technology to reduce the environmental footprint of transportation has been evolving continuously since its introduction in 1975
- Reducing GHG emissions is parallel focus along with criteria pollutants for regulators and our customers
- Next generation technology will continue to produce integrated systems that optimize GHG and criteria emissions performance
- Technology neutral standards will continue to bring most cost-effective solutions to market



A HISTORY OF COLLABORATIVE SUCCESS

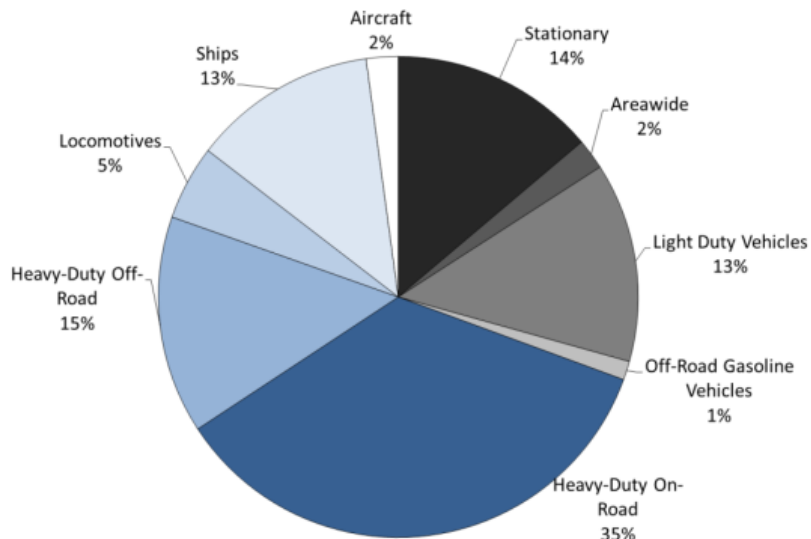
# THE SUPPLY SECTOR

# Industry's History of Success

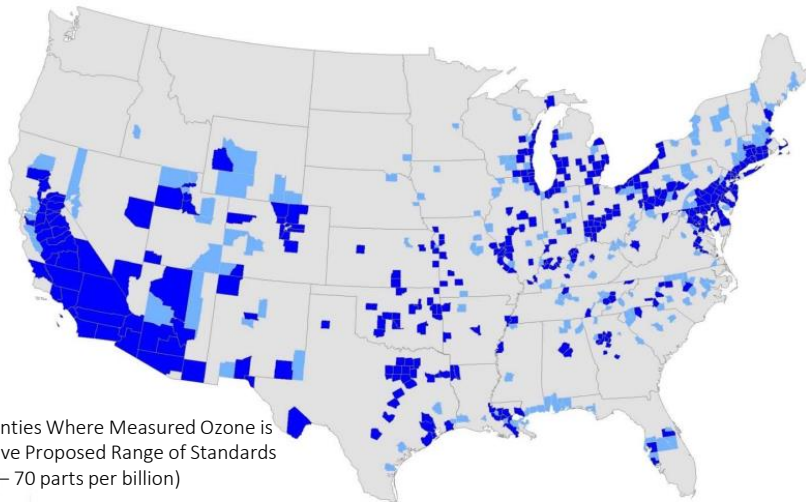
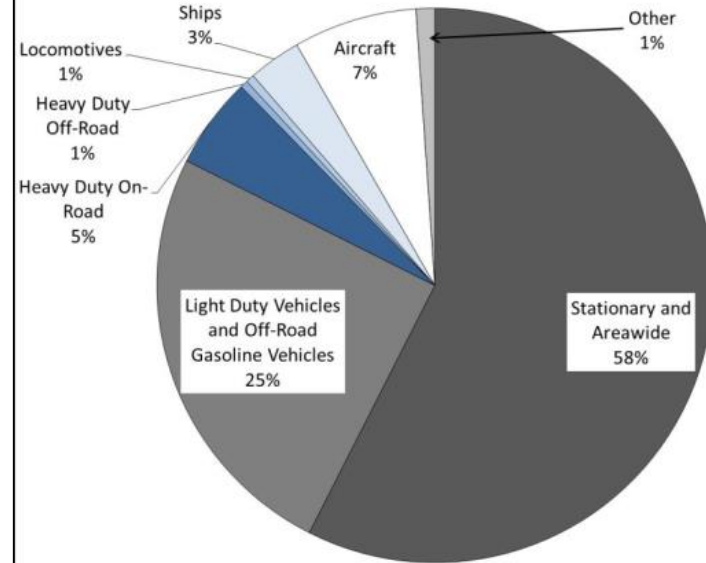


- 4 decades of emission decreases paired with unprecedented growth in transportation-related productivity
- Key partner with OEMs in dramatic emission reductions to limiting air-pollution from vehicles
- Created high-value jobs for decades
- Established U.S. as world leader in emission control technology

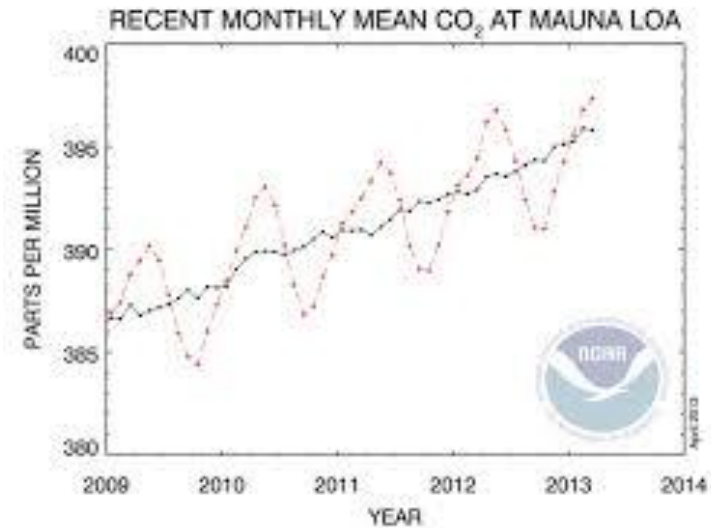
2012 Statewide NOx Emissions



2012 California Fuel Sales GHG Emissions



Counties Where Measured Ozone is Above Proposed Range of Standards (65 – 70 parts per billion)

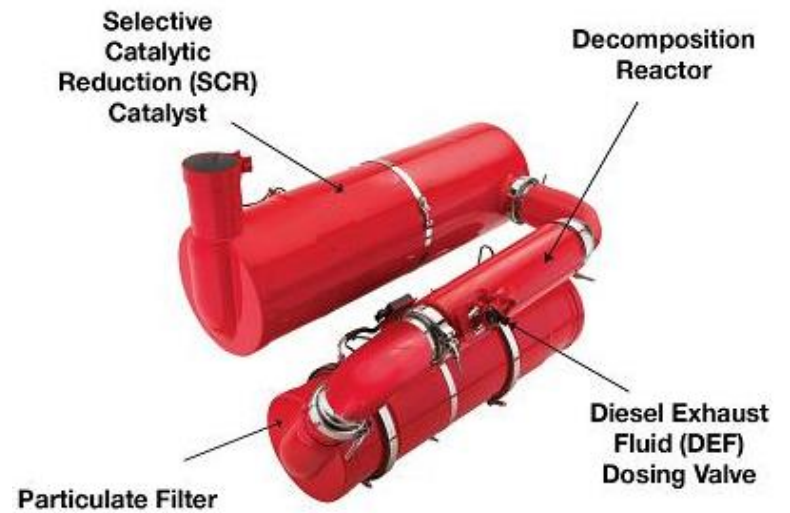


- 90% (relative to MY2010 levels) HD NOx reduction necessary for Ozone NAAQS attainment by 2031
- 80% reduction in GHG emissions below 1990 levels by 2050
- 50% petroleum use reduction target by 2030.

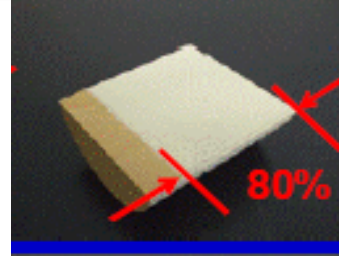
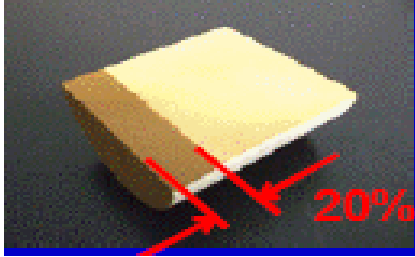
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CONTINUOUS INNOVATION

# TECHNOLOGIES

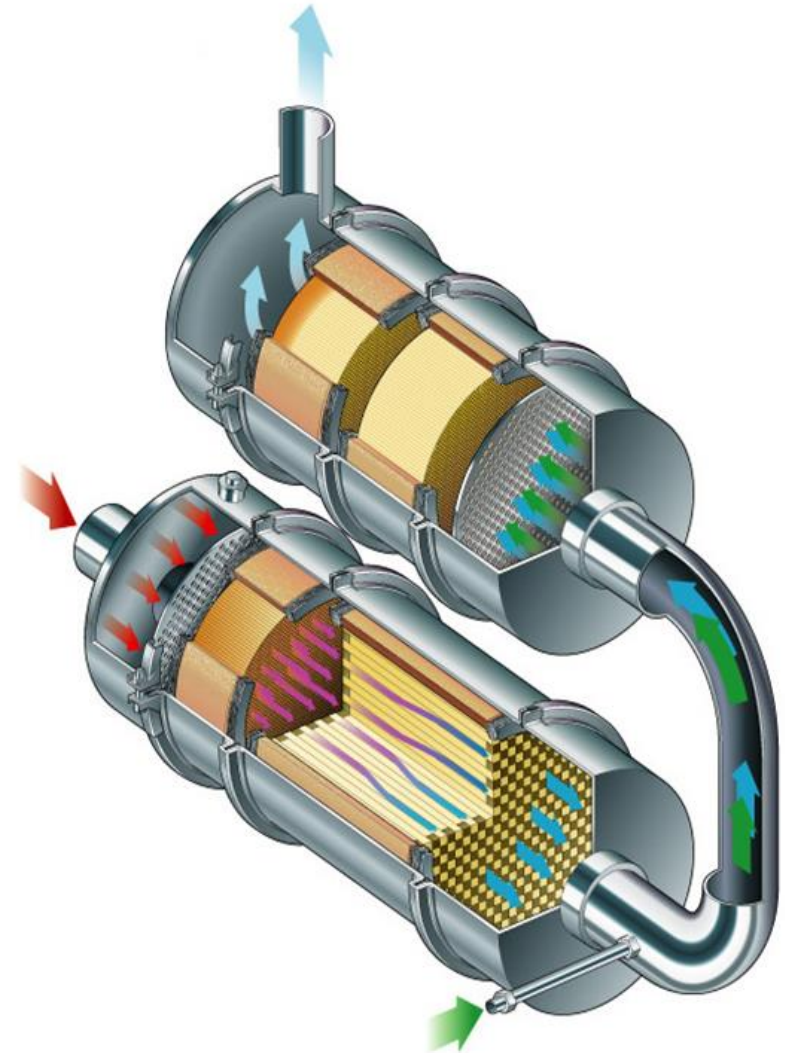
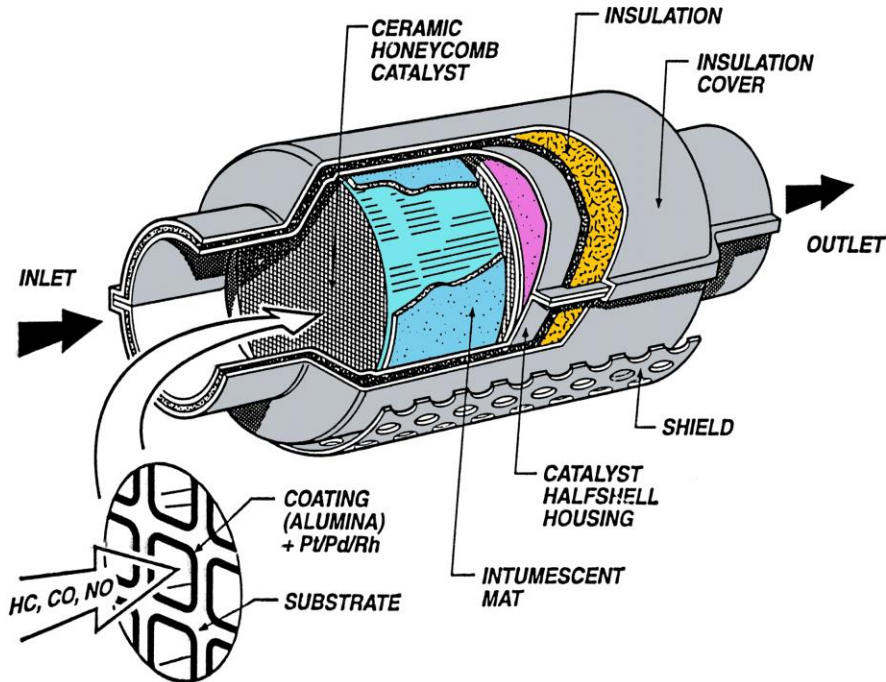


# Current Technologies Utilize Advanced Design Strategies to Maximize Cost Effectiveness



Pd is zoned in the front to give fast HC light-off

Rh in the back to protect against catalyst poisons





# Technical Challenges

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- Multiple emission challenges must be addressed simultaneously – GHG, NO<sub>x</sub>, PM, N<sub>2</sub>O, CH<sub>4</sub>
- Several strategies to reduce HD engine GHG emissions impact NO<sub>x</sub> reduction strategies
  - Longer periods of cold-temp operation can impact in-use NO<sub>x</sub> emissions
  - Lean burn operations increase engine efficiency – but result in more engine out NO<sub>x</sub> emissions
- Filters increase weight and backpressure – reducing engine efficiency



# Optimized Systems to Tackle GHG & Criteria Emission Challenges

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## Technology Development

R&D currently moving far beyond current standards

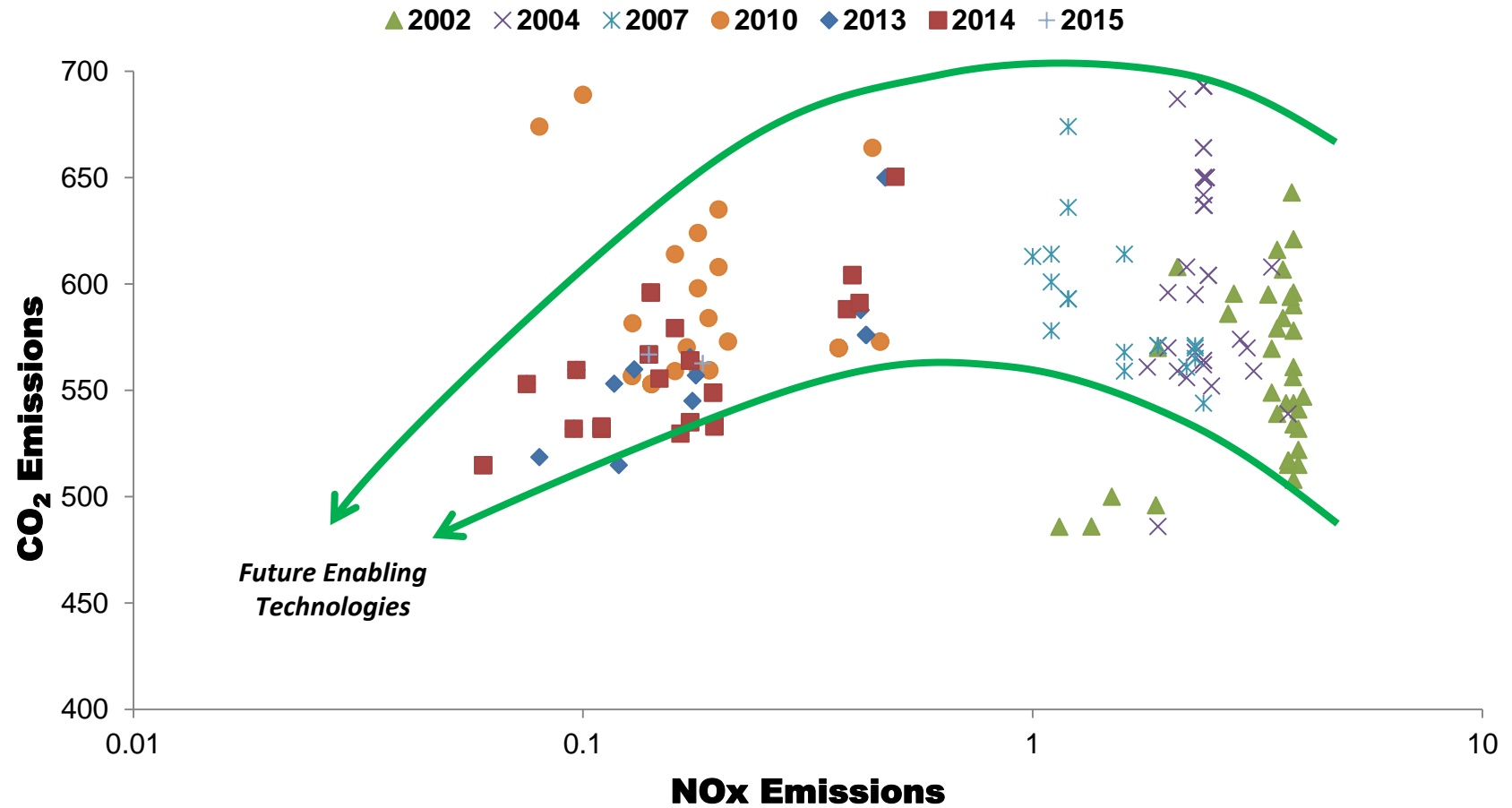
Requirements for development process:

- Phase II GHG standard is treated as a constant
- Cost conscious – our customers must be able to sell new trucks
- Sizing constraints are integral to concept and design development

## Optimized Technology Strategies

- NOx storage technologies
  - Could enable greater efficiency optimization of cold-temp operations
  - Could further reduce NOx emissions
- Thermal Management strategies could
  - Utilize waste heat (energy) to reduce fuel demands
  - Utilize exhaust slip-streams to maintain optimal catalyst temps
- New filter substrates could reduce backpressure and reduce weight
- New drivetrain technologies emerging rapidly (braking re-gen, battery reprocessing, fuel cell systems, etc.)

# Positive Trends In Certified Engines

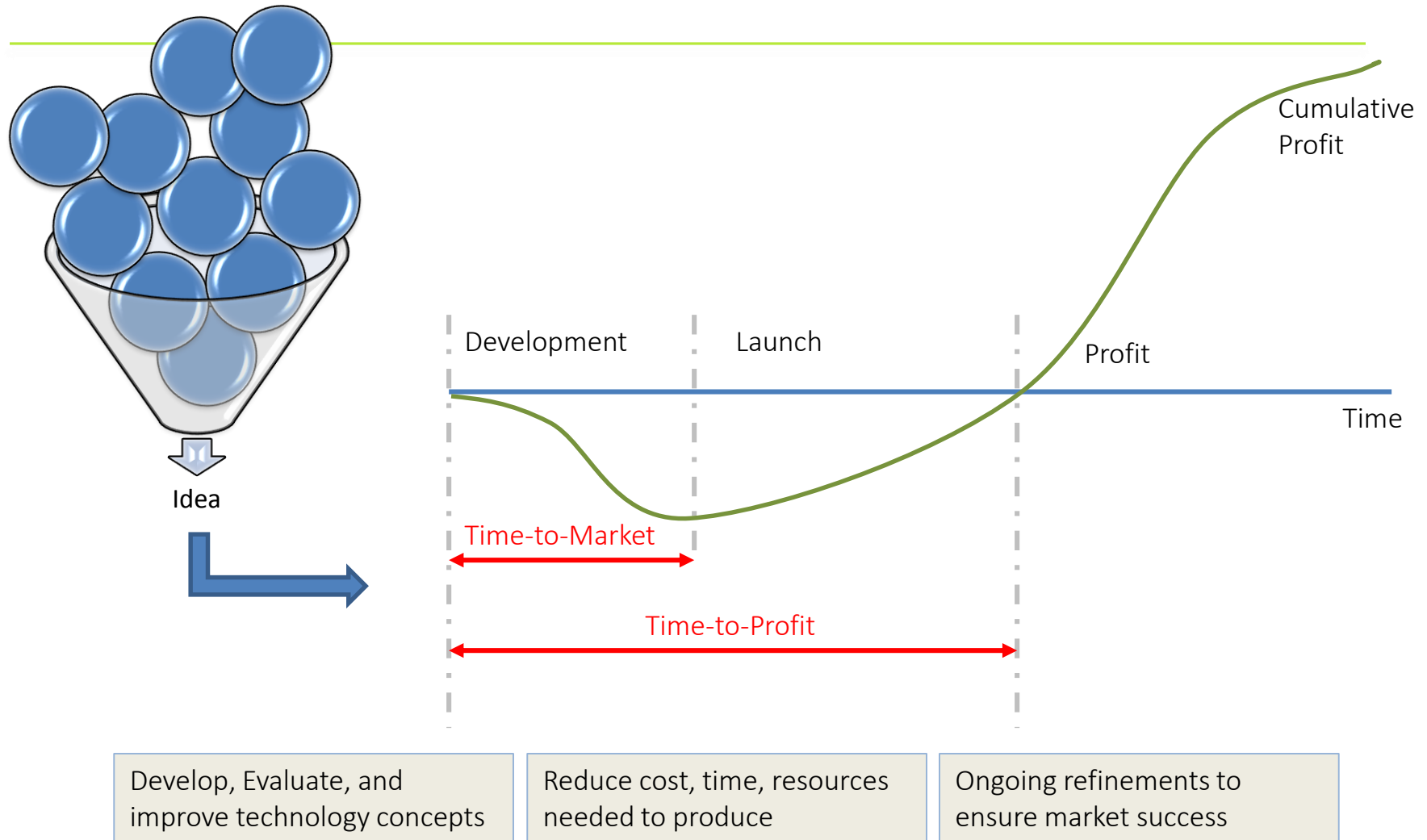


# Emerging Engine and Exhaust System Technologies

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- Designing with a “both” not an “either/or” approach
- In some cases combining multiple systems allows for optimizations and results not available with a single technology
- Sizing, cost, integration, and other real-world constraints must be addressed at every stage of development

# The Technology Innovation Process

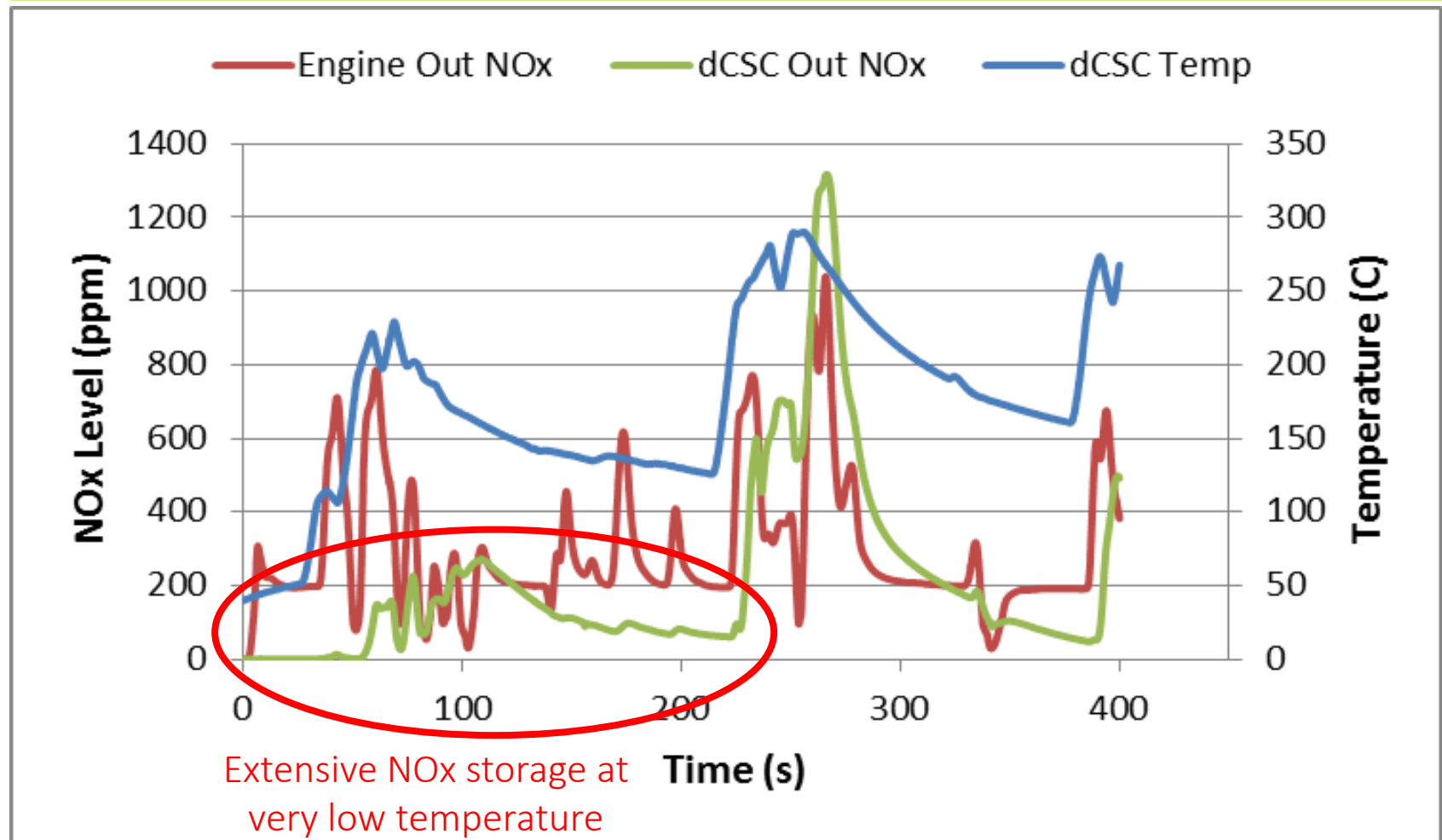


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TECHNOLOGIES UNDER DEVELOPMENT

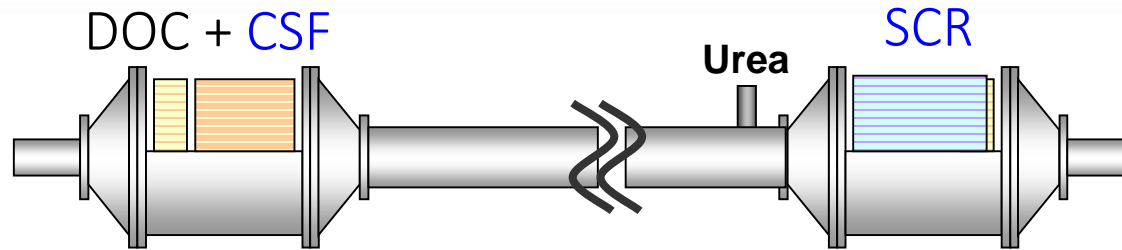
# EMERGING CONCEPTS

# Technology Opportunity: NOx Storage



# Technology Opportunity: SCR on a Filter

Today  
Filter + SCR  
Separated



Future  
SCR on DPF  
Integrated



## Benefits

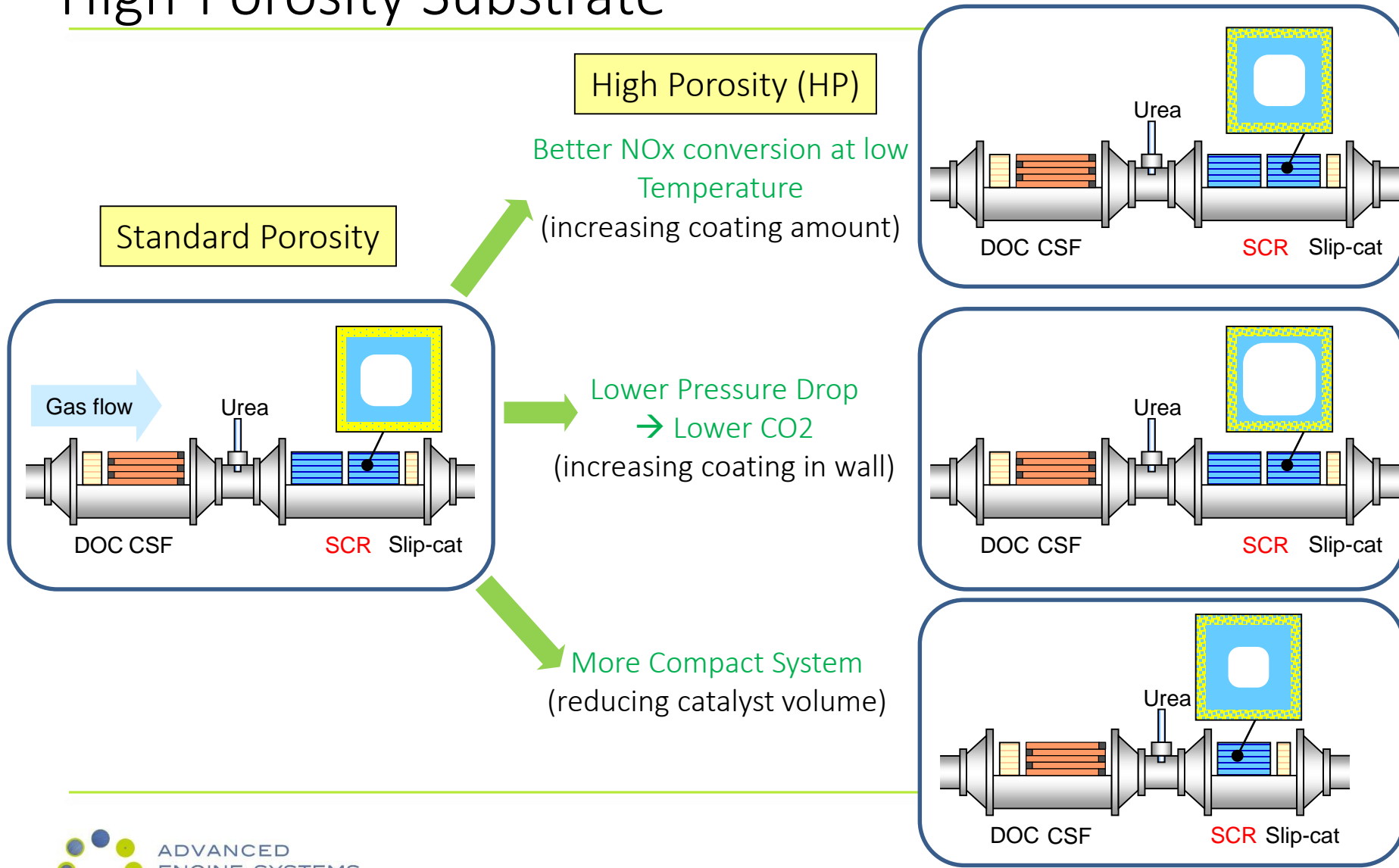
- Light Off ; Better Thermal Management
- Downsizing
- Low Cost
- High NO<sub>x</sub> Conversion ( ~ 98%)

## Challenges

- Trade-off between Pressure Drop and SCR Loading
- Particle Number for bare filters (EU6, Stage V)
- Passive Regeneration (HDV)

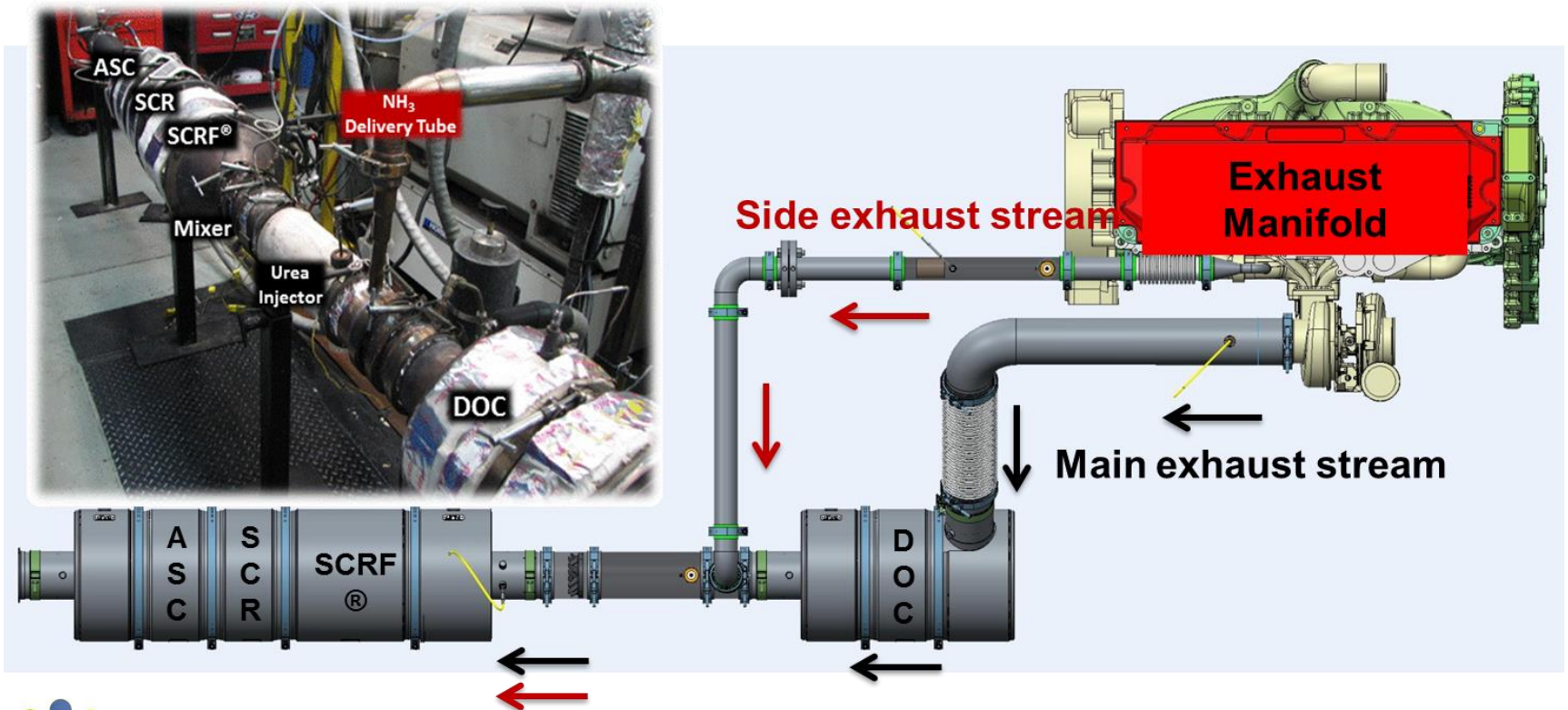


# Technology Opportunity: High-Porosity Substrate



# Technology Opportunity: Exhaust Stream Thermal Management

- Side system pulls hot exhaust from pre-turbo
- Urea is injected into side system, hydrolysis catalyst converts urea to  $\text{NH}_3$
- Gaseous  $\text{NH}_3$  is delivered to SCRF component inlet at low temperature
- Side  $\text{NH}_3$  doser and main urea injection used in tandem during transient cycle



# Ongoing Demonstration and Validation: Southwest Research Project



- Demonstrate 90% NO<sub>x</sub> reduction (0.02 g/bhp-hr) on HD and stoichiometric CNG engines
- Reduction Targets (from 3-4g engine out NO<sub>x</sub>)
  - 95% efficiency for cold start
  - 99% efficiency for hot start
  - 99% SET
- Engine calibration in parallel with exhaust control development
- System integration and demonstration
  - Full useful life (435K miles, 22,000 hrs.)
  - HD-FTP transient cycle, sustained low-load and low temperature operation

Project  
Advisors

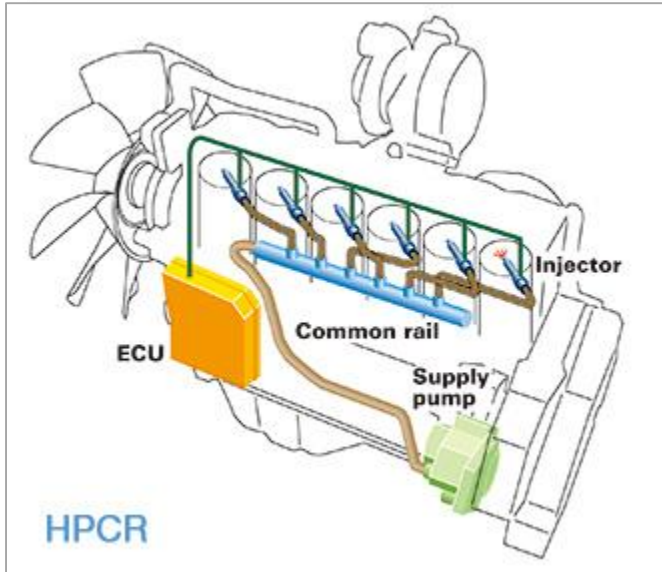


# Technology Opportunity: Waste Heat Recovery

- Waste heat recovery systems reduce fuel consumption and CO<sub>2</sub> emissions for trucks.
- They convert waste heat from the exhaust gas and the exhaust-gas recirculation system into mechanical or electrical energy.
- Recaptured energy can be used to:
  - Power the vehicle drivetrain
  - Optimize emission control functions
  - Improve vehicle warm-up time



# Technology Opportunity: Advanced Engine Systems



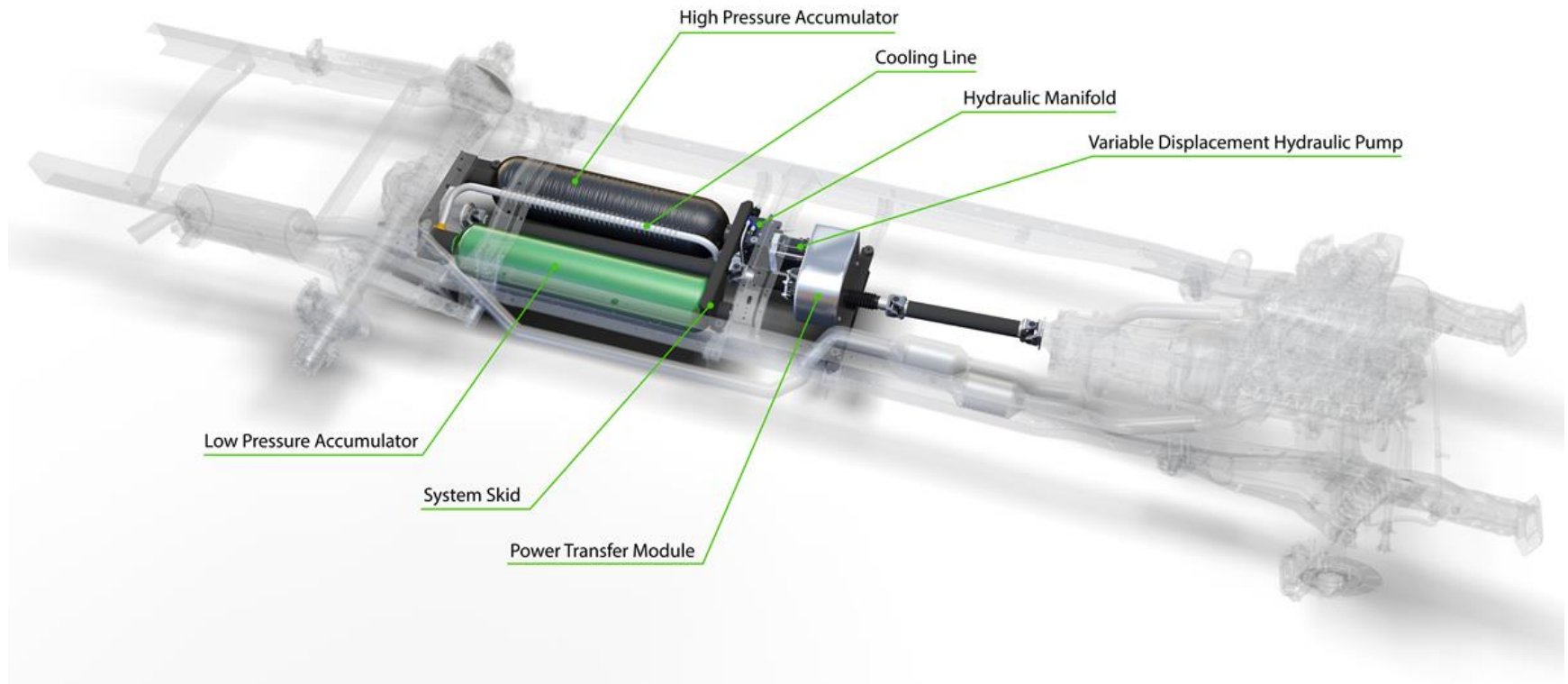
- High Pressure Common Rail – Computer controlled high pressure fuel injection ensures a more efficient in-cylinder fuel burn.
- Cutting Edge Electronic Control System – The advanced electronic control system controls air flow, EGR gas flow rate, fuel injection parameters, and after treatment function through intelligent software.





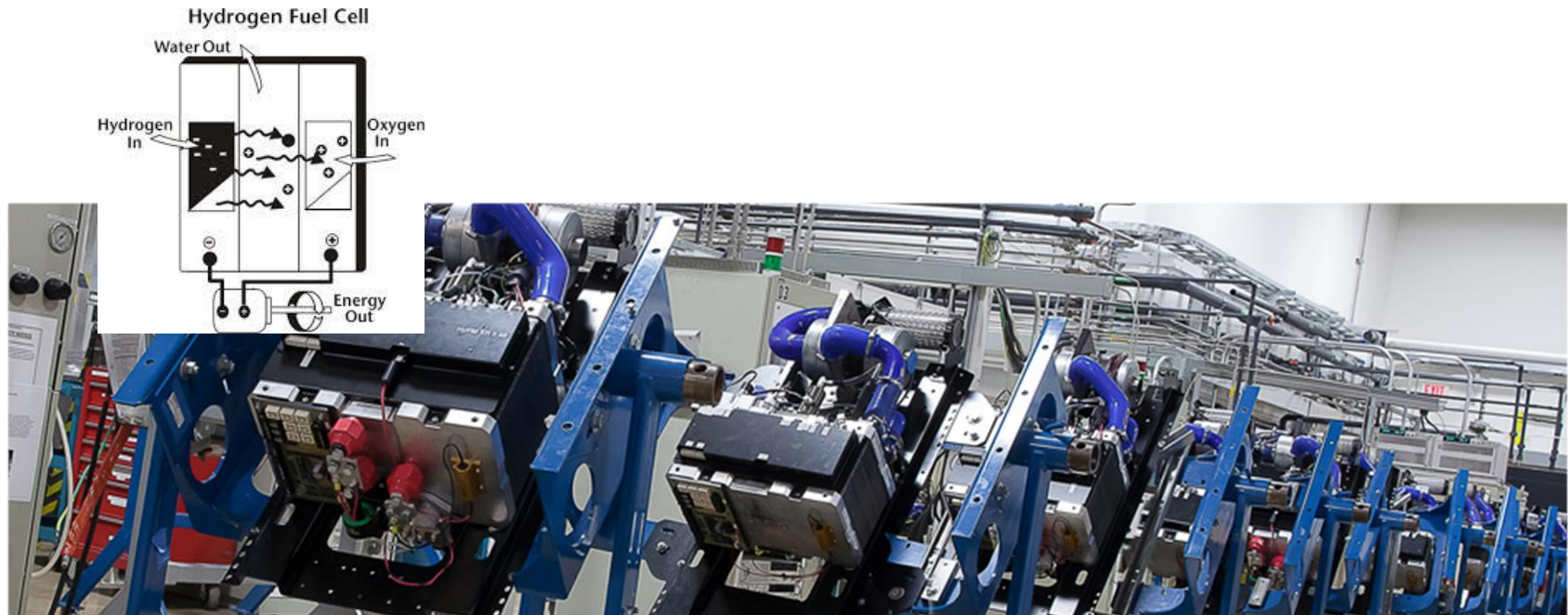
# Technology Opportunity: HD Regenerative Braking Systems

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# Technology Opportunity: Fuel Cells

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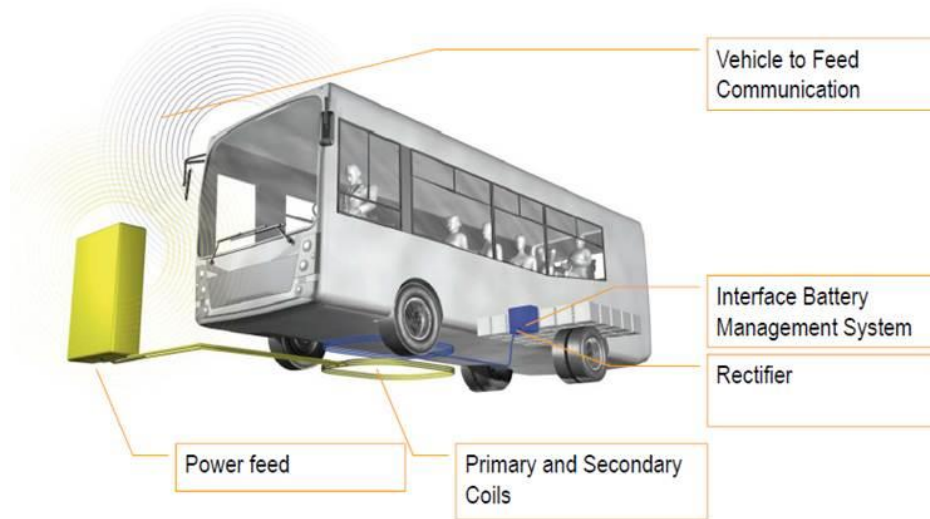


- Commercial systems available for 30kW to 180 kW vehicles
  - Solution for fleet vehicles such as buses, trucks and forklifts
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# Technology Opportunity: HD Battery Applications

- Hybrid bus range-extender
  - GPS controlled EV driving mode
  - Vehicle operates only in EV mode until it leaves the EV zone.
  - Target markets would be busy city centre to suburb & immediate surrounding areas
- Lifecycle Battery Management
  - Battery recycling
  - Battery reprocessing



Mining Truck 64kWh dual battery  
-- lithium iron phosphate

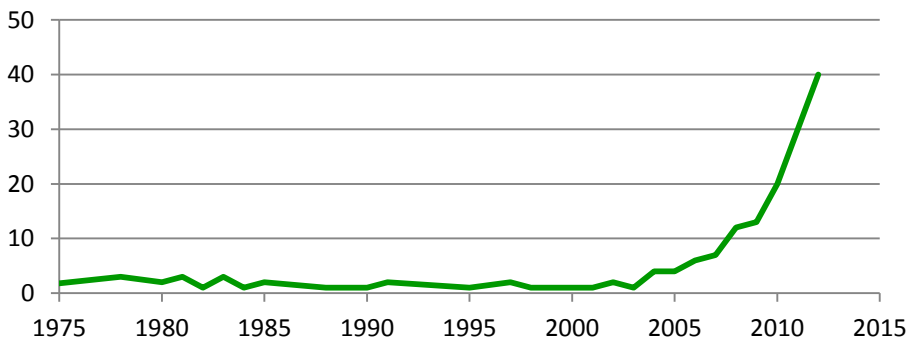


Wheel-loader hybrid 500 V Lithium force air cooled

# Innovation – A Work in Progress

- Increased attention across the industry to technology development opportunities
- Accelerating experiences through strategic collaborative supplier partnerships
- Rapid advances in new technologies taking place

Number of patent publications by year



Development is incomplete

All technical challenges must be addressed before a technology can be considered “proven”

- Cost
- Complexity
- Integration
- Optimization
- Dependability
- Size/space limitations
- New/additional fluids may be required
- New materials must be developed/refined
- Incomplete engineering

# View of the Future

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- Conventional powertrains will continue to be an important part of the HD fleet for some time to come
- Technology neutral standards will elicit most cost effective solutions to achieve CA's criteria and GHG reduction goals
- Alternative powertrain technology evolving rapidly and adoption will grow steadily
- The proliferation of technologies will provide customers with increasing options to fit their applications

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## Thank You

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