



21st Century Truck Partnership IWG Meeting

DOE's Advanced Heavy Hybrid Propulsion Systems Program

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AH²PS

Program Objectives



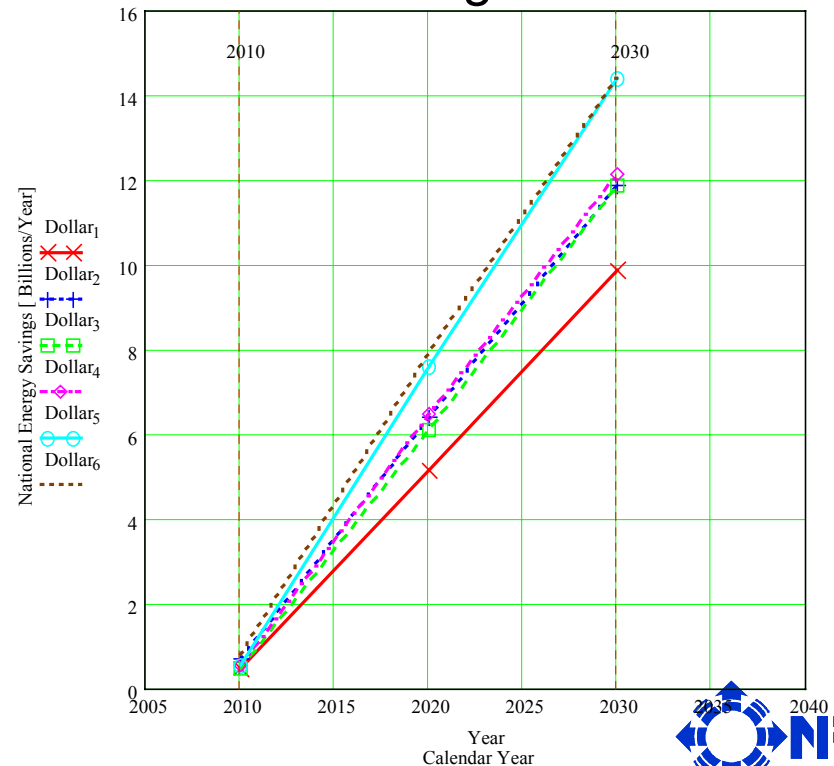
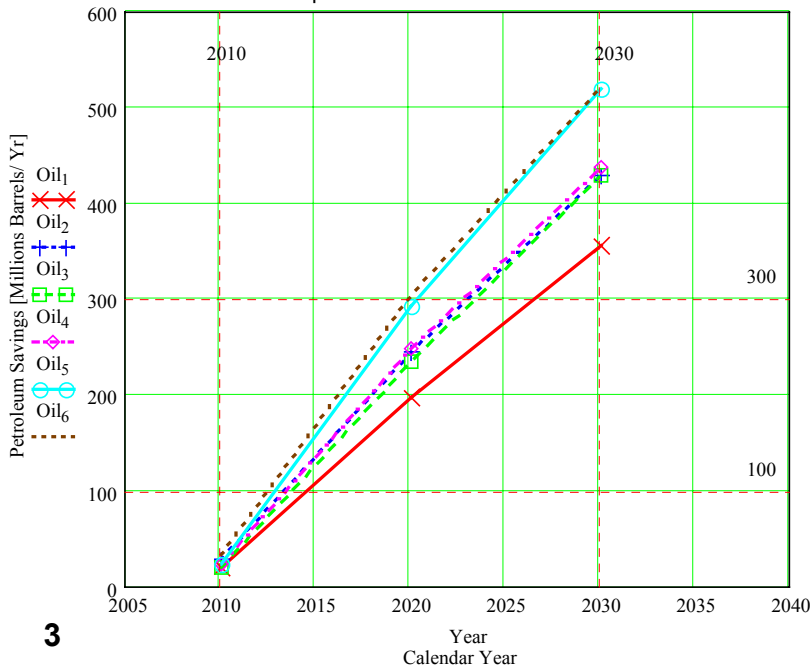
- **Develop and Demonstrate Cost-Effective, Advanced, **Next-Generation** Heavy Hybrid Components & Systems**
 - **At vehicle-level: Provide, Contribute to, or Enable up to 100 percent Increase in Powertrain Fuel Efficiency Relative to Today's Conventional Powertrain Technology**
- **Develop Heavy Hybrid Systems that Maintain 2007 Environmental Protection Agency (EPA) Emissions Standards**
 - **No_x - 0.2 g/bhp-h (2007-2010)**
 - **Particulate Matter - 0.01 g/bhp-h (2007)**
 - **Non-Methane HydroCarbon - 0.14 g/bhp-h (2007-2010)**
 - **Diesel Fuel Sulfur - 15 ppm (June 2006)**
- **Supports 21st Century Truck Partnership Goal of Improving Fuel Economy by 60% While Meeting 2007 EPA Emissions Standards**





AHHPS National Oil Savings (DOE Vision Projection)

- AHHPS Is Projected to Savings Millions of Barrels of Oil
 - ~20 Million Barrels/Year in 2010
 - ~250 Million Barrels/Year in 2020
 - ~425 Million Barrels/Year in 2030
- Billions of \$\$/Year Projected National Cost Savings
 - ~0.5 Billion/Year in 2010
 - ~\$6 Billion/Year in 2020
 - ~\$12 Billion/Year in 2030





- **Phase I**

- 3-year, \$22M Research & Development Effort (FY 03-05)
- 50%/50% Government / Industry Cost-Share
- Design, Develop, Characterize, and Show Feasibility of Energy & Fuel Saving Heavy Vehicle Hybrid Propulsion Technologies
- Targeting Wide Range of Class 3 – Class 8 Heavy Vehicles



- **Phase II**

- 3-Year Technology Validation Effort (FY 06-08)
- 50%/50% Government / Industry Cost-Share
- Validate Phase I Next-Generation Technologies in Class 3 - Class 8 Heavy Vehicle Prototypes
- Next-Generation Technology Insertion into Wide Spectrum of Heavy Vehicles





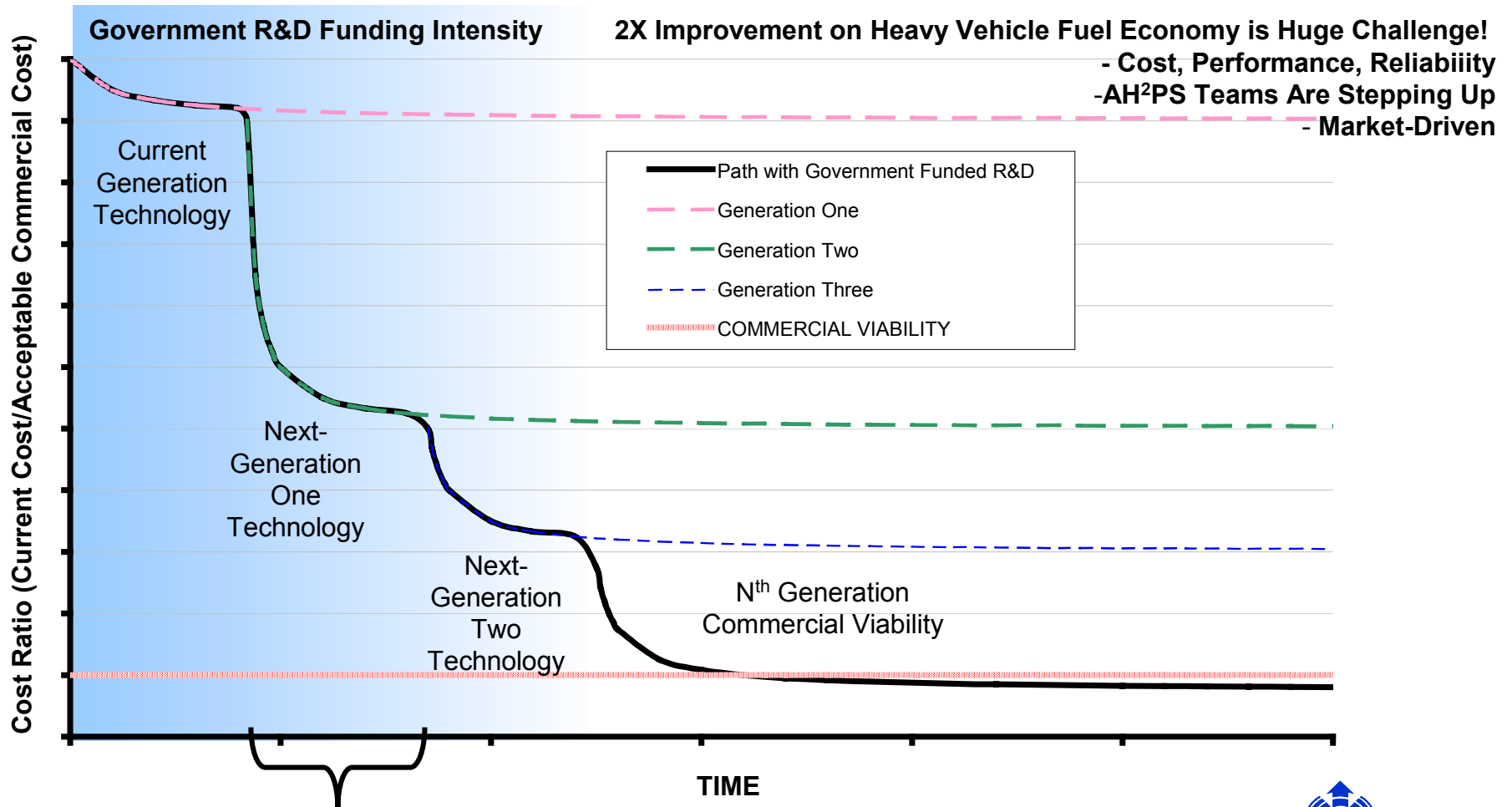
AH²PS

AH²PS Project Roles



- **DOE – Overall Program Direction & Funding**
- **NREL**
 - **Project Direction, Guidance & Execution**
 - » Technical Direction & Funding Management
 - » Coordination With Other DOE Programs
 - **Subcontract Administration (Execution)**
 - » Subcontract Management (Contract Admin & Costs)
 - » Intellectual Property
 - **Technical Tasks (Execution)**
 - » Hybrid Vehicle System-Level Analysis & Optimization
 - » Hybrid Component / System Benefits Analysis
 - » Heavy Hybrid Technical Target Analysis
 - » Heavy Hybrid Vehicle Testing

NREL Working With & Challenging Industry to Develop Next-Generation Technologies to Satisfy AH²PS Program Objectives



We are still operating back in here for the projects under the AH²PS Program





- **AH²PS Program is Designed to Research, Develop, & Validate Next-Generation Heavy Hybrid Technologies**
 - 4 AH²PS Industry Teams Partnering with NREL/DOE
 - Wide Spectrum of Heavy Hybrid Vehicle Applications
- **Technical Barriers**
 - Initial & Life Cycle Component & System Costs
 - Component & System Performance
 - Heavy Hybrid Testing (Procedures & Certification)
- **Next-Generation Heavy Hybrid Technologies Include:**
 - Advanced Propulsion Systems
 - Advanced Engine Technologies
 - Advanced Motor/Generator Technologies (PM & Induction) & Motor Control
 - Advanced Energy Storage Architectures & Systems
 - Advanced Power Electronics & Control Architectures/Systems
 - Auxiliary Load Electrification
 - Advanced Vehicle Systems Modeling & Optimization
 - Waste Heat Recovery Systems
 - Heavy Hybrid Testing Development





AH²PS Subcontracts



- **GM – Allison Transmission**

- Heavy Hybrid Transit Bus Application & Prototype Validation
- Advanced Parallel Hybrid Powertrain
- Advanced Traction Motor Development (~80-100 kW), Power Electronics (~150 kW, 600V), Control Architecture & Systems



- **Eaton / International / Ricardo**

- Class 4-6 Vehicle Applications & Prototype Validations
- Advanced Parallel Hybrid Powertrain
- Advanced Engine / Generator / Traction Motor (~40 kW), Li-ion/NiMH Battery Subsystem, Auxiliary Load Electrification, Power Electronics (~50 kW), Control Architecture & Systems



- **Oshkosh / Rockwell / OSU / JME**

- Class 7-8 Vehicle Application & Prototype Validation
- Advanced Series Hybrid Powertrain
- Engine / Generator / Traction Motor (~110 kW) Integration, Ultra-capacitor/NiH Subsystems, Regenerative Braking, Power Electronics (~100-150 kW), Control Architecture & Systems



- **Caterpillar, Inc.**

- Hybrid Waste Energy Recovery
- Several Vehicle Applications





21st Century Truck Partnership

Current AH²PS Program Next-Generation Pathways



AH²PS – Phase II

~2.0X F.E. Improvement
Parallel Diesel/Hybrid
Hybrid Transit Bus

~2.0X F.E. Improvement
Parallel Diesel/Hybrid
Class 4-6 HH Vehicle

~2.0X F.E. Improvement
Series Diesel/Hybrid
Class 7-8 HH Vehicle

AH²PS – Phase I

1.67X F.E. Improvement
Parallel Diesel/Hybrid
Hybrid Transit Bus

1.67X F.E. Improvement
Parallel Diesel/Hybrid
Class 4-6 HH Vehicle

1.23X F.E. Improvement
Series Diesel/Hybrid
Class 7-8 HH Vehicle

1.5X F.E.
Improvement Parallel
Diesel/Hybrid

1.4X F.E.
Improvement Parallel
Diesel/Hybrid

1.0X F.E. Improvement
Series Diesel/Hybrid

Allison

Eaton

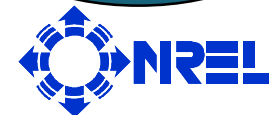
OTC

Caterpillar

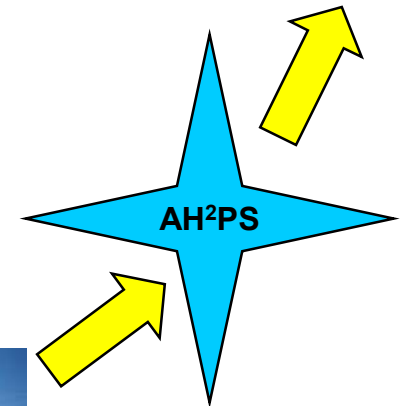
Hybrid Waste
Energy
Recovery

R&D \$\$\$

Time



- AH²PS Program is On Track for \$\$ Available
 - Current Funding Limits the # of Partners/Projects
 - Additional Partners/Activities Could Enhance Program With More \$\$
- NREL is Industry's Partner & Program Champion to Ensure Program Success
 - Programmatically
 - Technically
 - Commercially
- Subcontractors Generally Performing Very Well
 - Programmatically
 - Technically
 - Working Well with NREL
- AH²PS Program Intended to Change Heavy Vehicle Landscape



Are There Other Next-Generation Hybrid Technologies That Industry Sees?



- NREL Has Some Ideas to Expand Program With More \$\$, But
- Challenge: What Does Industry Think Some Fertile Ground Might Be?

