Efficiency Improvement Pathway

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Efficiency and Emissions Progress-Diesel Engines

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Core Caterpillar GHG Reduction Positions

• Purpose-designed legislation needed at economy-wide & national levels

• International alignment necessary

• National Climate and Energy Policies must align

• Economic action at the highest practical level drives innovation & optimal solutions
Core Caterpillar GHG Reduction Positions

• Sound science, consistency, transparency, robust stakeholder input, lead-time and stability

• Clear government agency boundaries to avoid duplication & conflicting regulations

• The “Pareto” principle (the 80/20 rule) should drive prioritization & investment
Systems Perspective
 Systems Perspective  …Why?

- Enormous diversity and complexity in the world of non-road machines
- Machines need to perform many different functions
- Efficiency and productivity usually measured on a “work performed” basis at the job-site level
Caterpillar Energy & Sustainability

Four Areas of CO2 Opportunity

**Energy Sources**
Up to 100%

**Job Site**
+10-30% Efficiency

**Machine**
+10-20% Efficiency

**Engine**
+5-10% Efficiency

**Zero Net Carbon Fuels**
Move the Dirt Once
System Optimization
New Combustion Technologies
D7E First of its Kind with Electric Drive

Machine Efficiency
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50% less operator noise
50% better steering performance

Easier to operate
No shifting
Low-effort controls

Less fluids used

35%–70% lower owning & operating costs with SystemOne™ undercarriage

Up to 20% less fuel consumed per hour

Up to 50% longer life for the electric drive train

60% fewer moving parts in the electric drive train

35% more visibility

10% more material moved per hour

25% more material moved per gallon of fuel

Less down time
No engine belts

Grade Control Ready
Factory-installed AccuGrade® ARO

10% lower lifetime operating costs

50% less operator noise

35% more visibility

60% fewer moving parts in the electric drive train

Grade Control Ready
Factory-installed AccuGrade® ARO

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Job Site Efficiency

- D10 Utilizing Computer Aided Earthmoving System (CAES)

- Caterpillar’s AccuGrade® GPS System for Road Construction

- Caterpillar’s MineStar® Fleet Commander
Focus on Fuel

- Zero Net Carbon Diesel Fuel supported by robust Life Cycle Analysis

- Price for carbon drives innovation in Fuels, Machines, & Total Integrated Systems

- Technology Neutral

- Globally Consistent Standards

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Critical Non-Road Technical Approaches

• Efficient Power Trains and Energy Conversion Systems - including "tank to tracks" approaches, heat recovery, & energy storage

• Adaptive and System Controls - including Autonomy, behavioral, operator assist, machine to machine and site level logic

• Alternative Low (or zero) Carbon Power sources - including alternative fuels, power sources and mobile sequestering
The Path Forward

• No simple solutions … only intelligent choices

• Regulation alone will not create optimized Solutions

• Technological solutions hindered by current economic reality & competing needs
The Path Forward

- Government / Academic / Business Collaborative efforts must be expanded

- Commercially viable transformational innovation must be the goal

- Caterpillar supports expansion of the DOE Vehicle Technology Program to include an explicit non-road component
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