

The Right Technology Matters

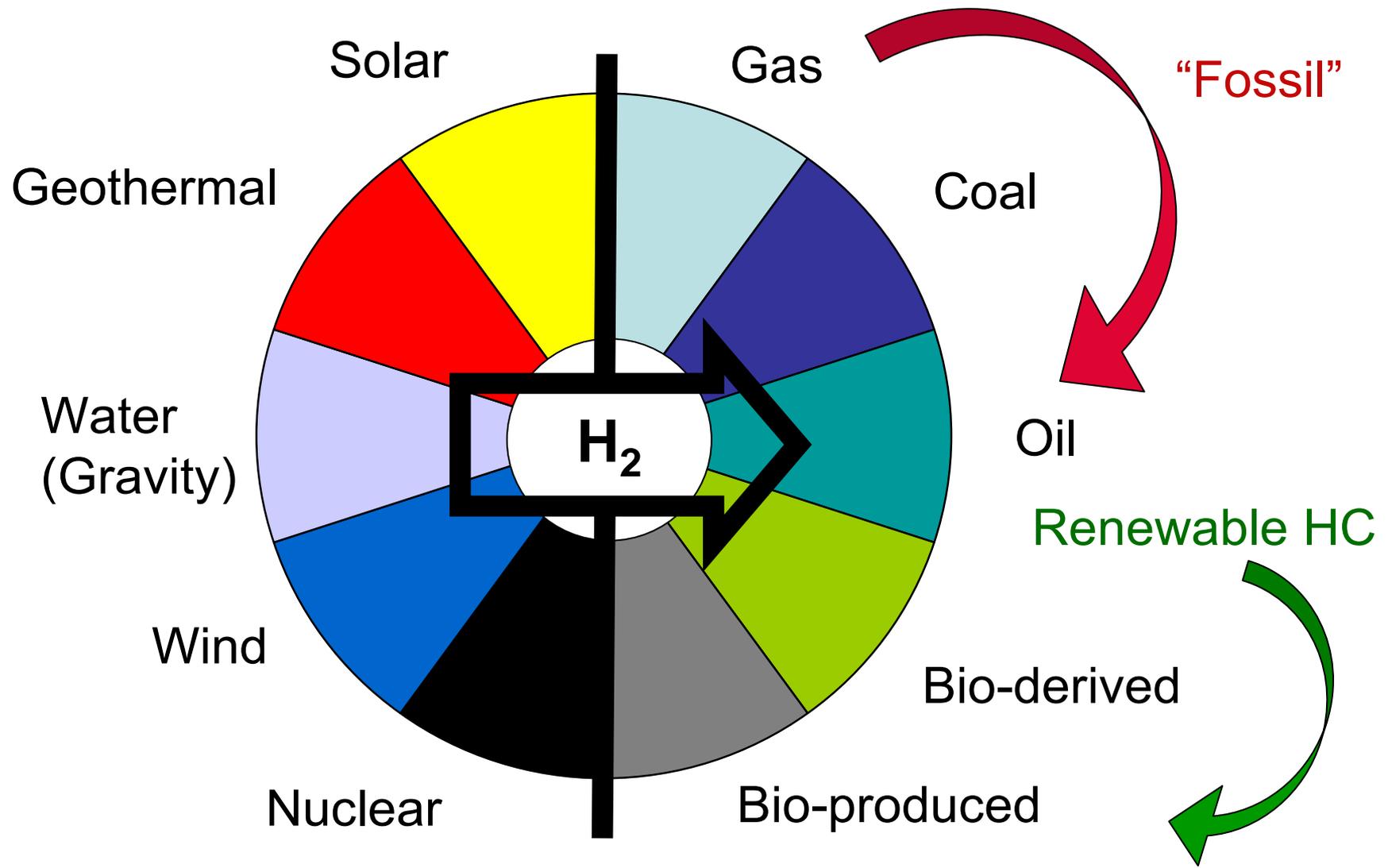
The Importance of Public-Private Partnerships for Engine Technology Development

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- Diesels in broader energy context
- Technology and Application
- Alternative fuels
- Personal example of benefits from DOE partnership

Energy Source*



Power Conversion



$\Delta P \rightarrow$ "motive force"

Heat a gas Solar

Combustion

Nuclear

Geothermal

Solar

Gravity - Water

Dams

Waves

Wind

Shaft Work Machine

Reciprocating engine

Spark Ignited (Otto)

Compression Ignited (Diesel)

Stirling

Turbine

Direct Electric

Fuel cells

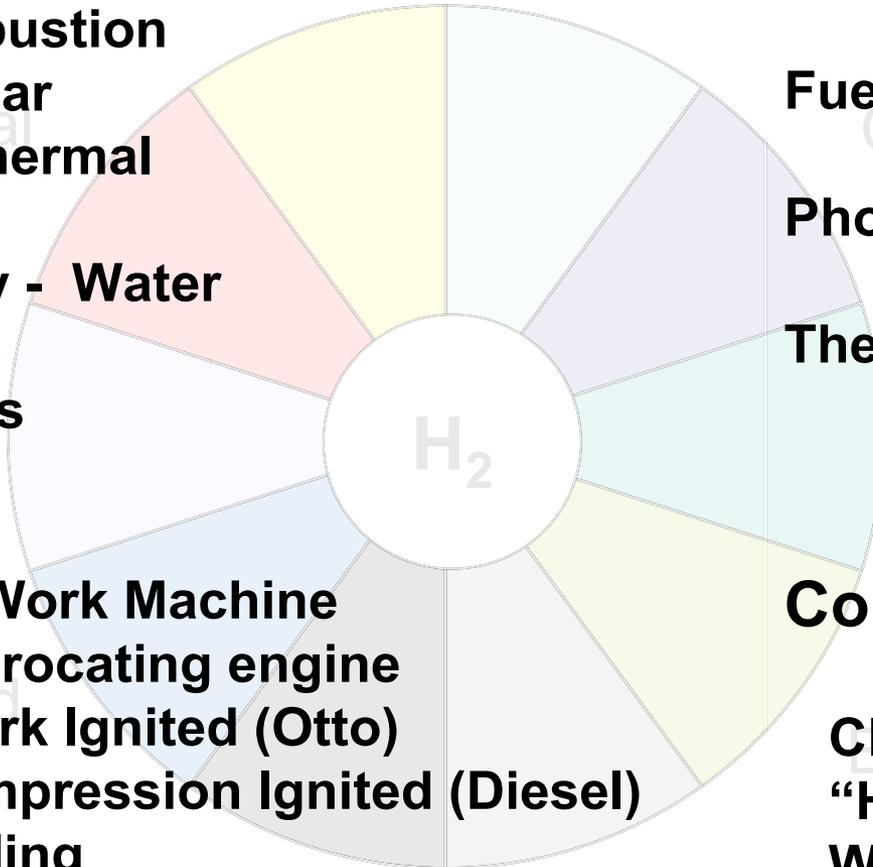
Photoelectric

Thermoelectric

Combined cycle

CHP
"Hybrids"

Waste Heat Recovery



"Fossil"

Oil

Renewable HC

Bio-derived

Bio-produced

Power Conversion



$\Delta P \rightarrow$ "motive force"

Heat a gas Solar

Combustion

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Reciprocating

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Photovoltaic

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Combined cycle

CHP-derived
"Hybrids"

Waste Heat Recovery

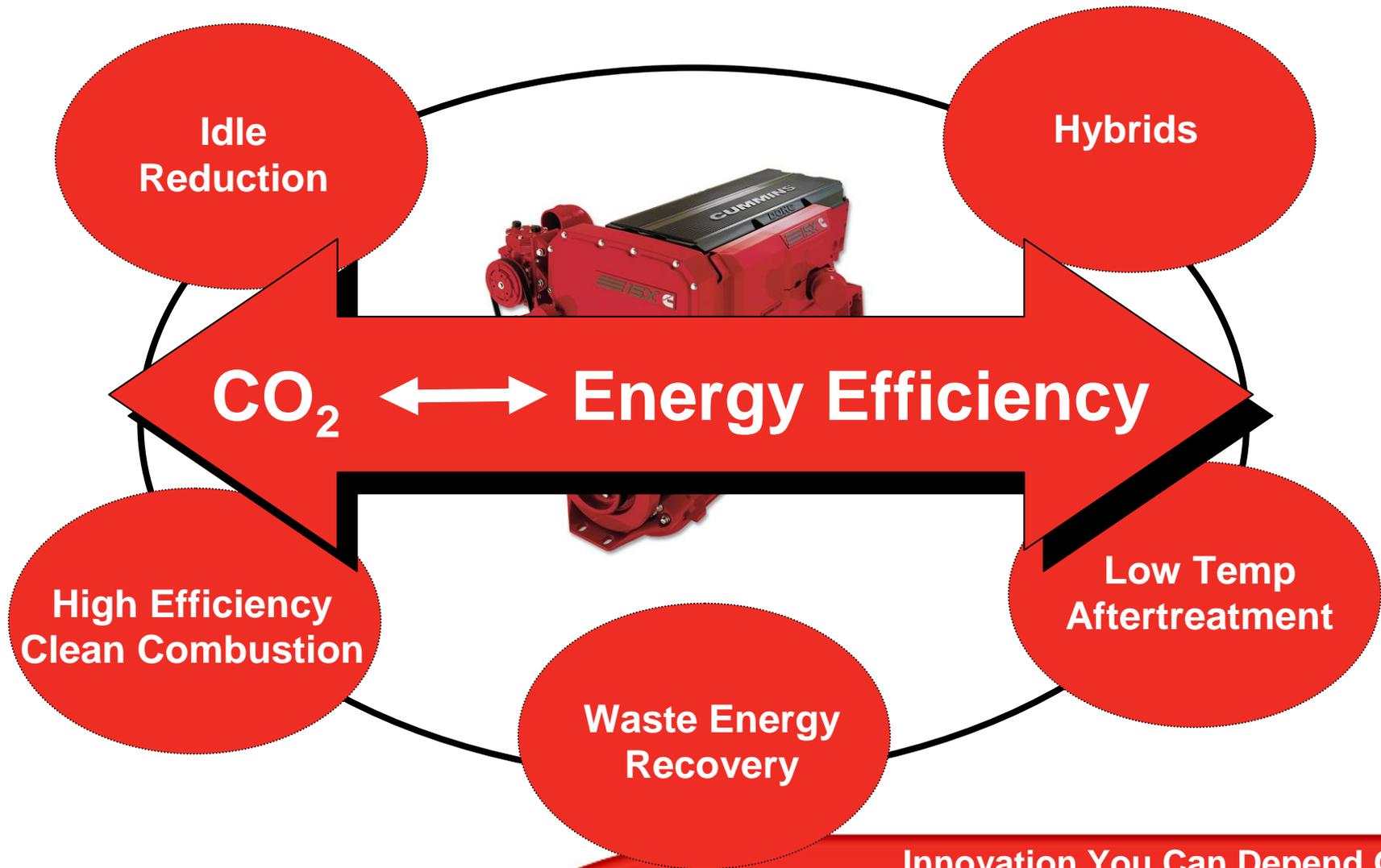
Efficiency

Conservation

Energy Efficiency



Improving Efficiency / Reducing CO₂ Footprint



Partitioning the System



▶ **Fuels**
Reduced carbon intensity
Improved combustion

▶ **Engines**
Efficiency improvements
Reduced Carbon Fuels
Hybrids / Waste Heat Recovery



▶ **Vehicles**
Transmissions / Axles / Tires
Aerodynamics
Tractor & Trailer



▶ **Fleets / Operators**
Duty cycles
Operator behavior

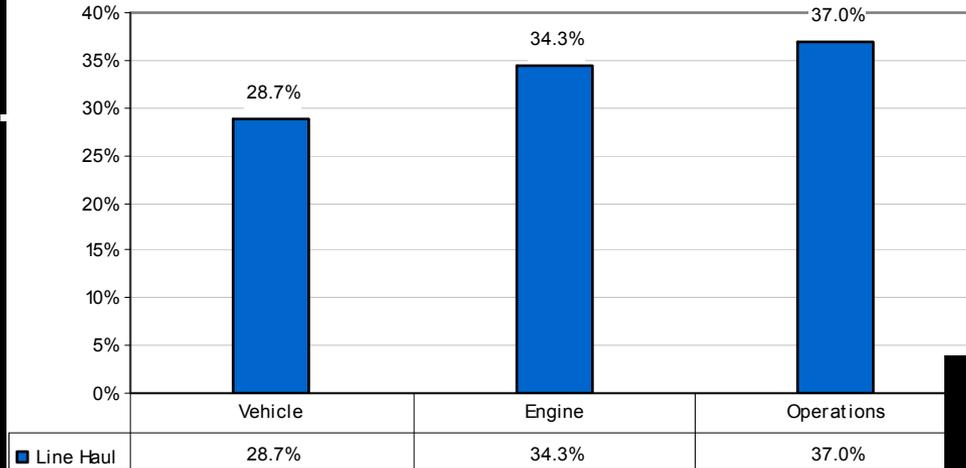
▶ **Highways / Infrastructure**
Highway Construction / Congestion
Speed limits
GVW



Potential Efficiency Improvement / CO₂ Reduction



Line-Haul Applications



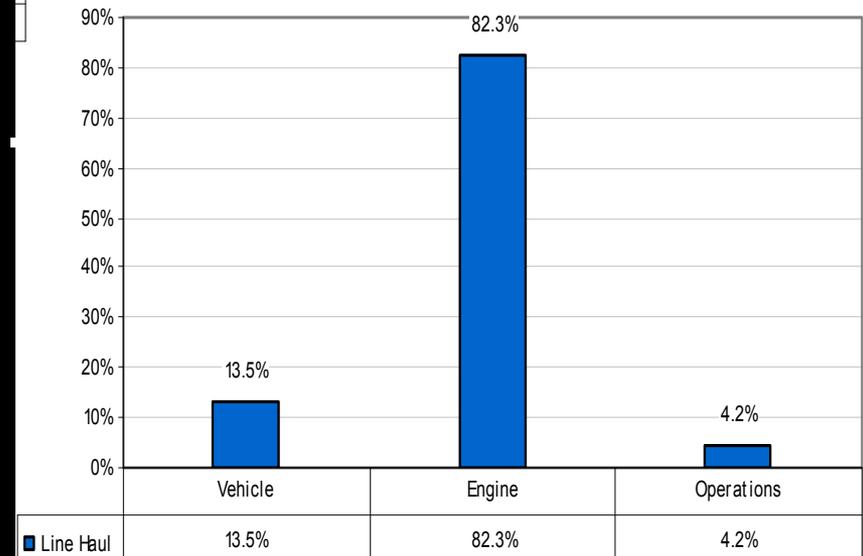
Vehicle

Engine

Operations

Vocational Applications

Refuse Truck

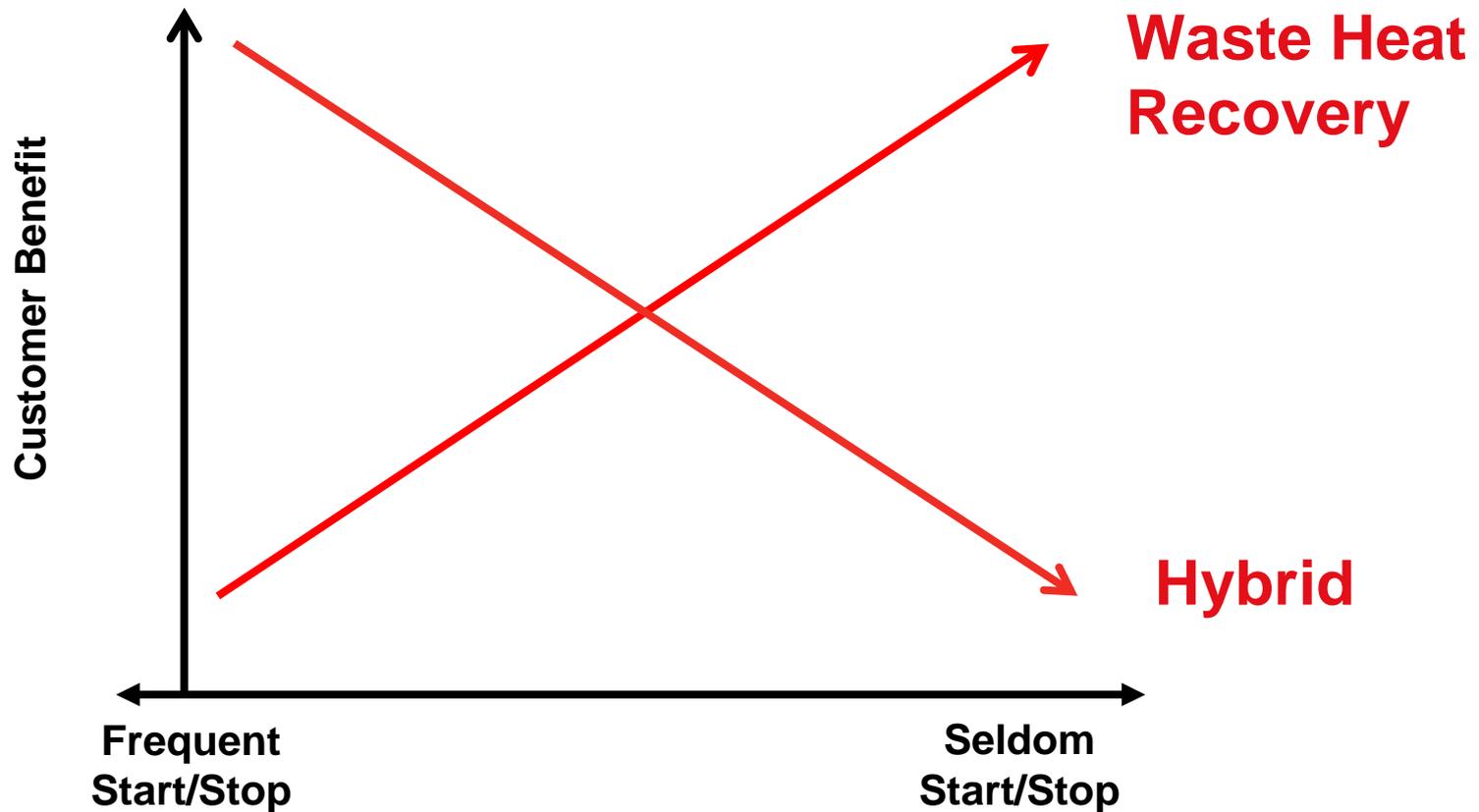


Waste Energy Recovery

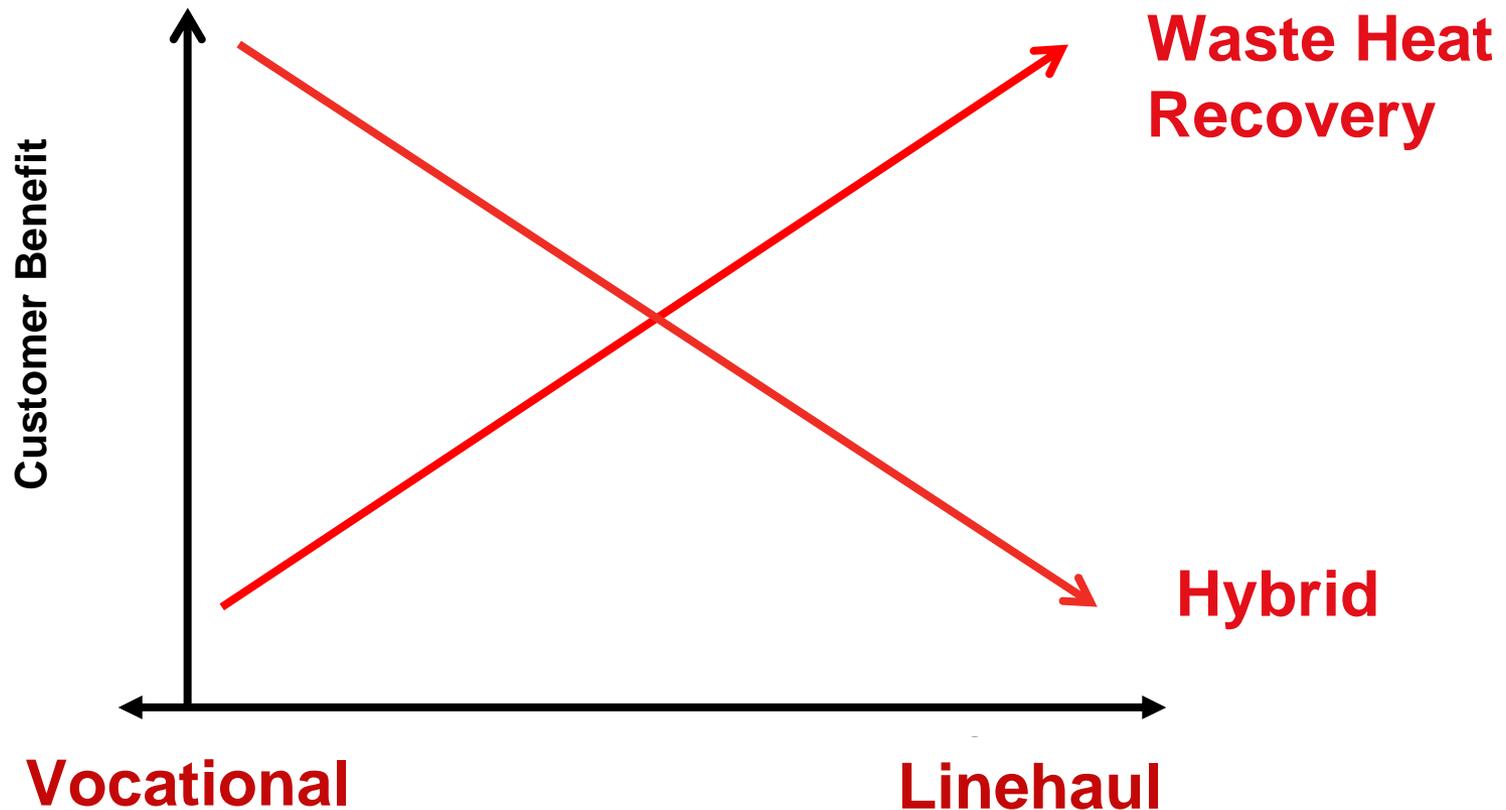
- ***Engine Waste Heat Recovery***
- ***Vehicle Kinetic Energy Recovery
(Hybrids)***



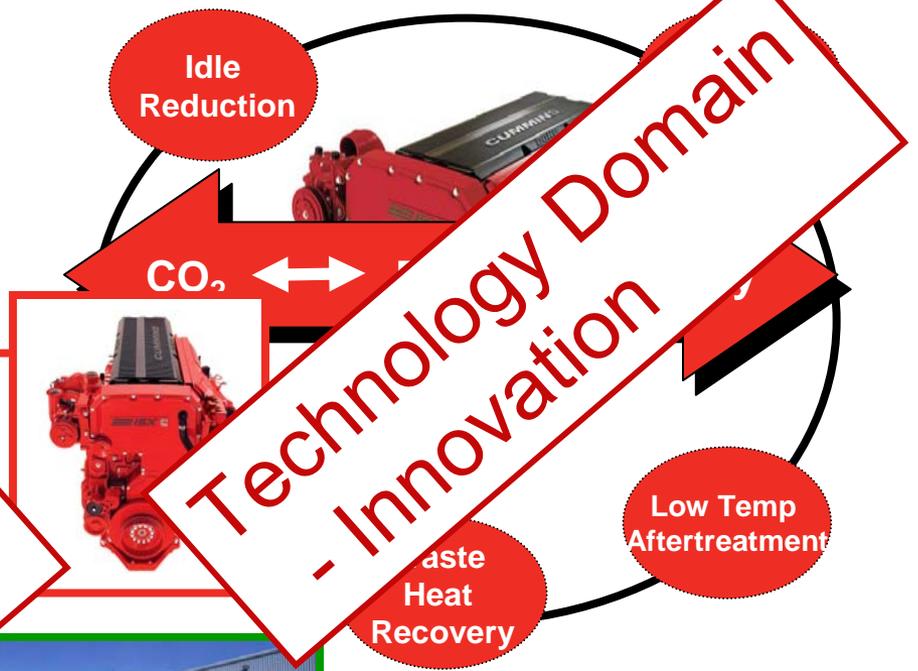
Waste Heat Recovery vs. Hybrid



Waste Heat Recovery vs. Hybrid



Public - Private Partnerships



The Right
Technology
DOES Matter!

Alternative (Diesel) Fuels



Alternative Fuels in general...

- My personal view:
 - Installed base of consumer vehicles
 - + sunk investment in delivery infrastructure
 - = alternative fuel → like conventional gasoline or diesel fuel

 - Boutique engines for boutique fuels (or vice versa) make no business sense (just lab entertainment)

- Why I might be wrong:
 - If a reformulated fuel enables a significant fuel economy improvement at low emissions, it could get more interesting to adapt special engine and fuel technology for each other.

Alternative Fuels

- “Fossil” source
 - Coal
 - Natural gas

- Renewable -- Derived from biological sources
 - Ethanol (corn, sugar cane, switchgrass / cellulose, ...) = “biogasoline”
 - Biodiesel (soy, canola, jatropha, sugar cane ...)
 - Biomass gasification (cellulose, animal waste, landfill gas)
 - Used cooking oil / animal fat ... too little volume

“Fossil Alternative Fuels”

- Synthetic liquids – Fischer-Tropsch
 - Natural gas to liquid (GTL)
 - Coal (to gas) to liquid (CTL)
- Requires lots of water for coal to liquid
- Excellent fuel properties, especially diesel
 - Zero aromatics
 - Zero sulfur
- Lower emissions – but not low enough

Other Alternative Fuels from Coal

- Methanol
 - Poor autoignition quality
 - Toxic, soluble in water

- Di-Methyl Ether (DME)
 - Gaseous at normal atmospheric pressure and temperature – requires pressure to liquefy
 - Good for cooking and for potato guns

- Neither is a good diesel fuel

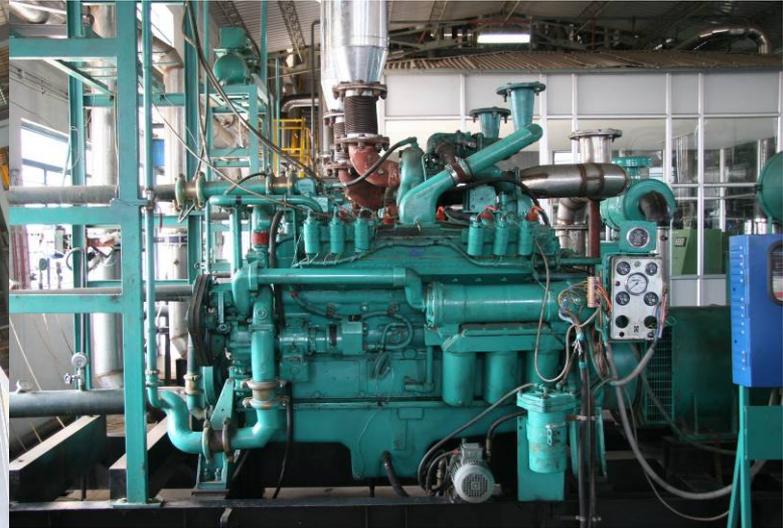
Renewable Diesel Fuels

- **Bio-derived diesel**
 - Soy, Canola / Rapeseed, Jatropha
 - Fatty Acid Methyl Ester (FAME)
 - Molecule generally heavier than average diesel
 - Quality is crucial -- Glycerin impurity is a filter killer

- **Bio-produced diesel**
 - Genetically engineered yeast produce diesel-range hydrocarbon from sugar (Amyris)
 - Algae



*Producer-Gas 1 MW
Power Generation Plant
Coimbatore, India*



Coconut Shells to Electricity and...



... Activated Charcoal

Personal Example of the Benefits of DOE Public-Private Partnerships



2007 Dodge Ram

- Cummins 6.7 l Diesel
- Met 2010 emissions 3 years ahead of schedule
- First commercial introduction of NOx adsorber for diesel emission control
- 50% reduction in noise
- Higher power and torque
- Up to 30% better efficiency than gasoline
- Evolved directly from DOE LDD technology program



Thanks!

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- 期待に答える技術革新 ■
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Confiar ■ 신뢰할 수 있는 혁신
- Inovação Que Você Pode Confiar
- नवयुक्ति जिस पर आप निर्भर कर सकें ■

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Technical Excellence.**

