MAHLE
Powertrain

Advanced Lean Burn Micro-CHP Genset

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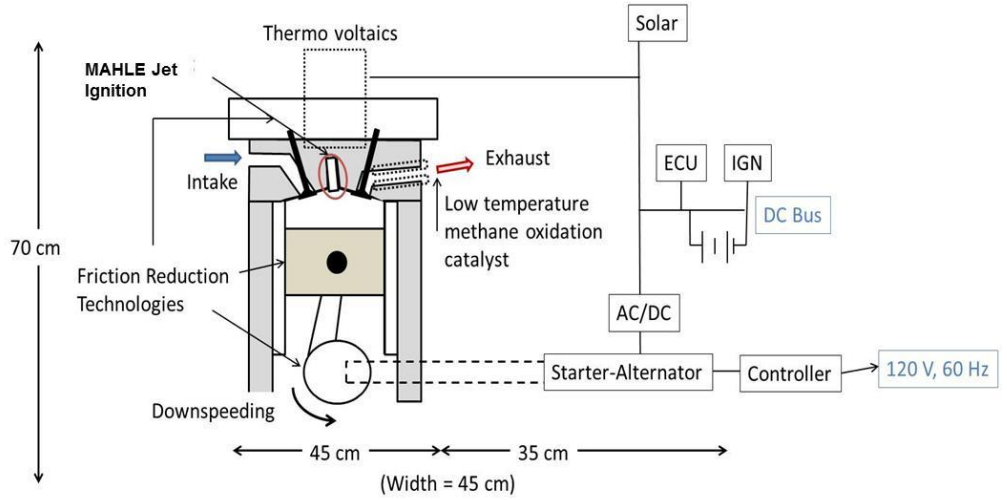
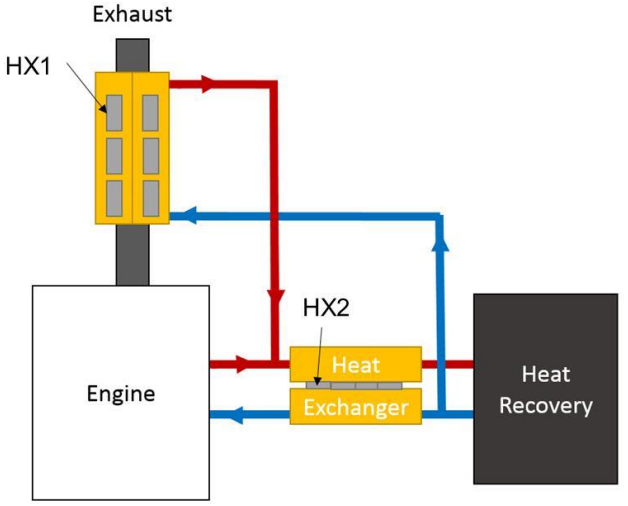
Project Proposal

- Proposal: NG-fueled single-cylinder internal combustion engine utilizing MAHLE Jet Ignition® combustion system to operate ultra-lean (homogeneous λ > typical SI lean limit)
  - Clean sheet engine design based around the MJI concept
  - Incorporate MAHLE lightweight engine components to provide system-level friction reduction
  - Apply low temperature aftertreatment to meet emissions requirements
  - Extract heat from exhaust and coolant to provide heat to process water
  - Use efficient power conversion technologies





MAHLE Jet Ignition Overview

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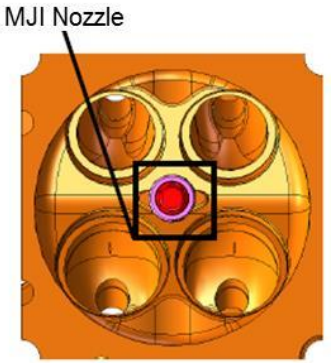
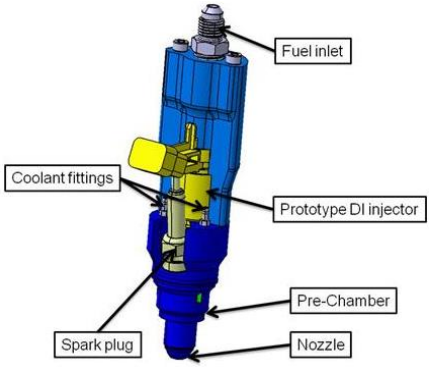
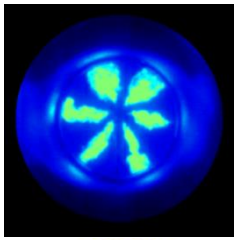
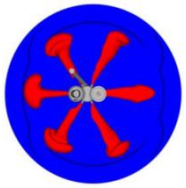
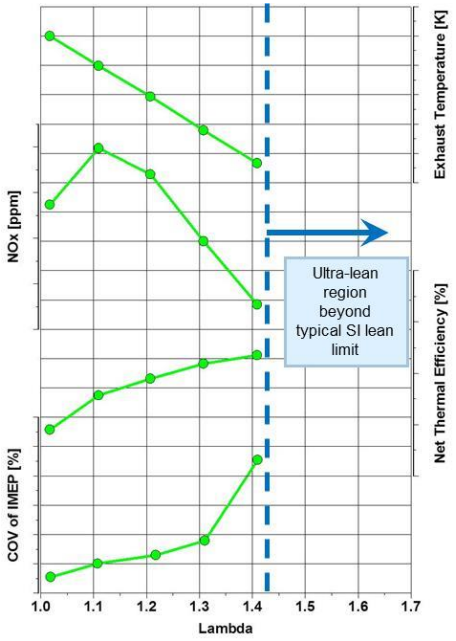
- Benefits of ultra-lean operation
  - Favorable thermal properties of charge
  - Low NO_x emissions
- MJI: pre-chamber-based combustion system
- High ignition energy from fast moving burning jets
  - Amplifies the ignition energy from the spark plug
- Benefits:
  - Enables increased CR
  - Maintains high comb efficiency @ lean conditions

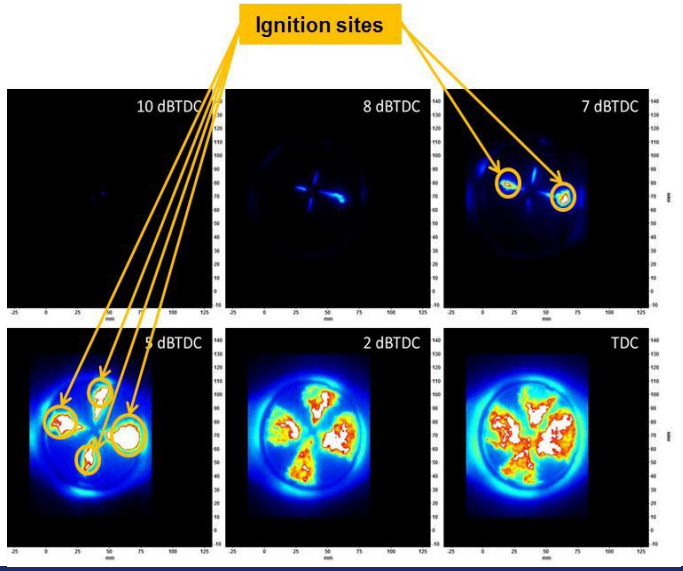












Project Team Responsibilities

- MAHLE Powertrain – Lead Organization
  - Base engine design
  - Combustion system development
  - Controls development
- Oak Ridge National Laboratory
  - Low temperature aftertreatment
- Intellichoice Energy
  - Heat extraction and utilization
- Kohler
  - Engineering support – engine design, genset operation
  - Cost and manufacturing analyses
- Louthan Engineering
  - Power electronics

Innovation and Challenges

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- Uniqueness of approach
  - Application of ultra-lean operation to small stationary power
  - System-level approach to friction reduction
  - Application of aftertreatment optimized for low temperature lean operation
  - Heat extraction from a high efficiency, low temperature system

- Expected impact if successful
  - Ultra-lean combustion as a viable high efficiency technology for small stationary power
  - Specific low temperature aftertreatment solution for lean combustion

- Major challenges:
  - **Combustion system:** engine BTE target > 42%
  - **Emissions reduction:** low exhaust temperature, maintain high combustion efficiency to minimize engine-out CH_4
  - **Capital cost:** minimize cost of lightweight components, aftertreatment, injection equipment