Onsite Power:
Small scale, highly reliable engine opportunities

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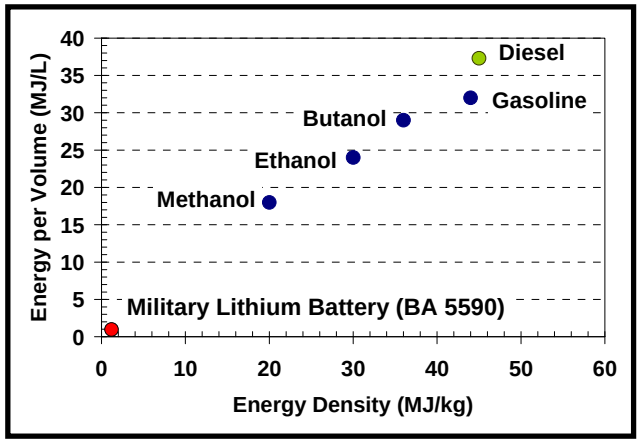
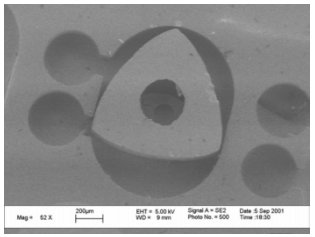
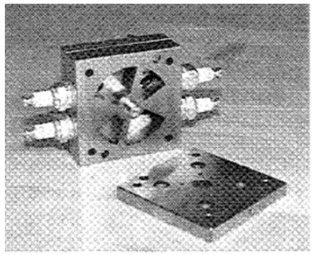
Micro and Mini Engines, Background

- **Prior work was mostly focused on:**
  - Portable power
  - UAV or Ground Robot propulsion
- **Interest in Microengines stimulated innovation in the field of Power MEMS**
  - However, onsite power implies an order of magnitude larger units and a more conventional design
- **Unique challenges for NG power generation**
  - **Fuel properties**
  - **Ultra-high reliability, maintenance free**

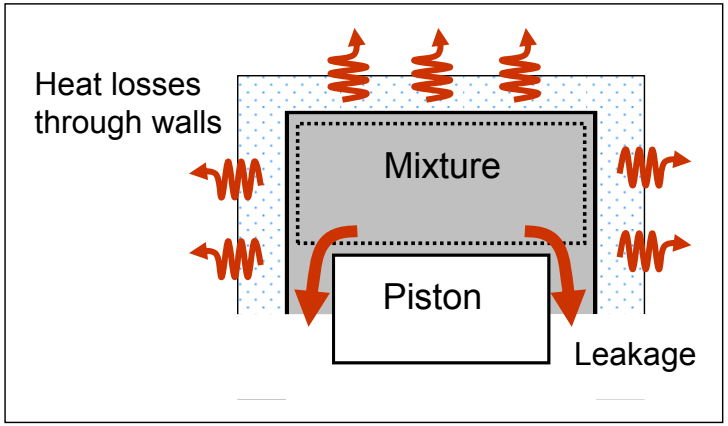






Onsite Power Generation Requires a New Approach

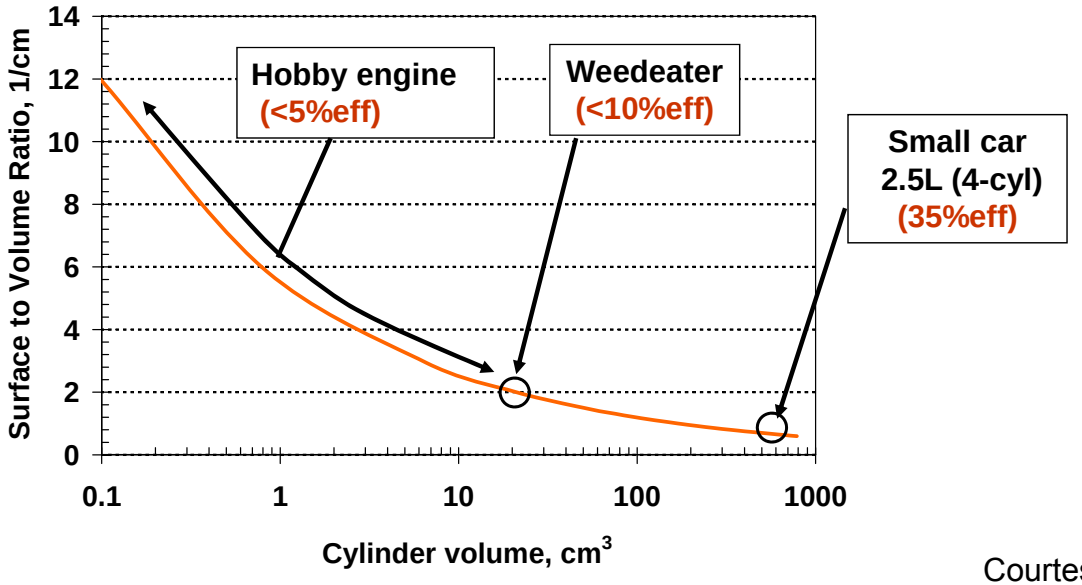
- **Fundamental Challenges**
  - Small scale has a profound impact on heat transfer, boundary layers are very large on a relative basis
  - The same applies to blow-by, loss of charge through crevices
  - Most designs require a “specialty fuel” for stable combustion



- **State of the art:**
  - Even with recent advances, the small engine market is dominated by very crude designs compared to modern automotive engines
  - NG gensets such as Kohler are modernized, but too large

Cylinder Size vs. Efficiency for Reciprocating Engines

- Wall heat losses more pronounced as the cylinder size is reduced:
  - Surface area relative to cylinder volume increases dramatically as the cylinder size decreases; more heat lost through the combustion chamber walls
- Heat loss reduces the efficiency of the cycle; in addition, quenching in the boundary layer reduces combustion efficiency
  - Novel architectures, advanced designs and materials could offset the losses
- Mechanical losses



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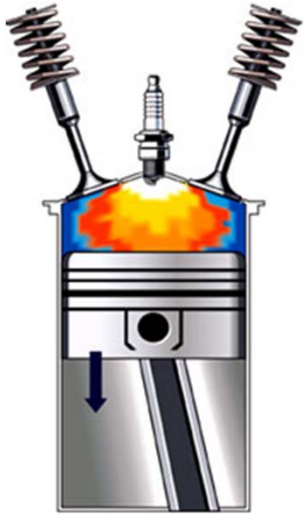
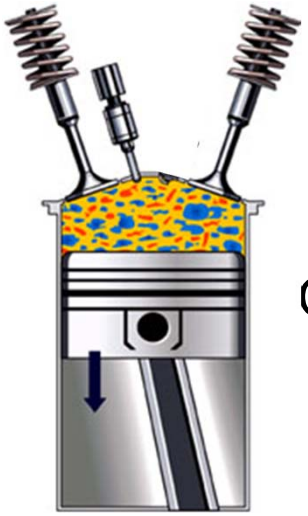
Pathways to Achieving Ultra-Reliable NG Engine for Onsite Power Generation

Spark Ignition



vs.



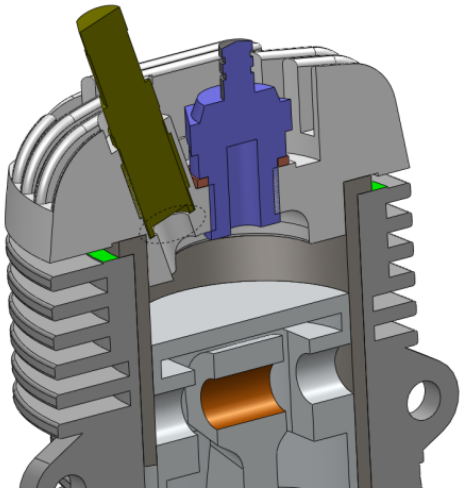
Compression Ignition

Pros	Cons
Ignition control	
Stable combustion	
Easy mixture preparation	
	Ignition energy, high pressure
	Durability of the ignition device
	Lower efficiency; low CR, throttle

Pros	Cons
No spark – higher reliability, no fire hazard	
High CR, lean	
	Poor autoignition properties of NG
	Harder load control
	Combustion stability
	Mechanical stresses
	Blow-by

Research and Development Issues

- SI option will hinge upon development of a:
  - Novel and highly durable **ignition device**
  - Innovative **mixture preparation system**, simple and robust (DI?)
- CI option will require:
  - Reduced heat loss is a must! **Ceramic coatings, ceramic liner**
  - High CR and possibly **internal residual**
  - **Assisted ignition**, e.g. glow plug
  - Optimized tradeoff between blow-by and durability
- Lubrication
- 2-Stroke or 4-Stroke ?
- Novel architectures, Linear engine ?
- Integration with the electric generator, control
- Cold start



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Thank you !

Questions?