Advanced Fuel-Flexible, Quad-Generation System

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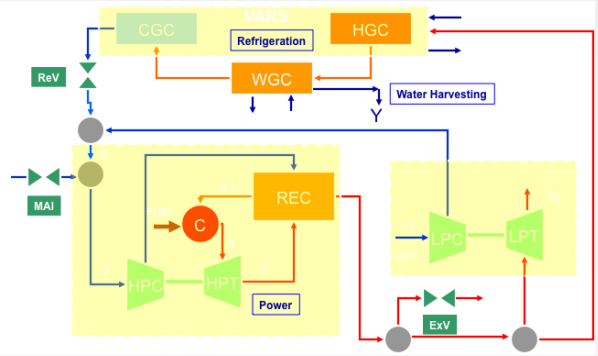


Innovation

- **Improvement to distributed generation/microgrids**
  - **Highly compact, transportable integrated system**
  - **Rapid installation of power, cooling, heat, water**
  - **Water and heat coupling to biomass gasification**
  - **Multi-fuel**
  - **Life cycle cost advantages**
  - **Dispatchable – counters stochastic effects**
- **Energy security, cost, sustainability improved: efficient, fuel-flexible, ultra low emissions, zero net water use gasification, distributed energy**

Current Status

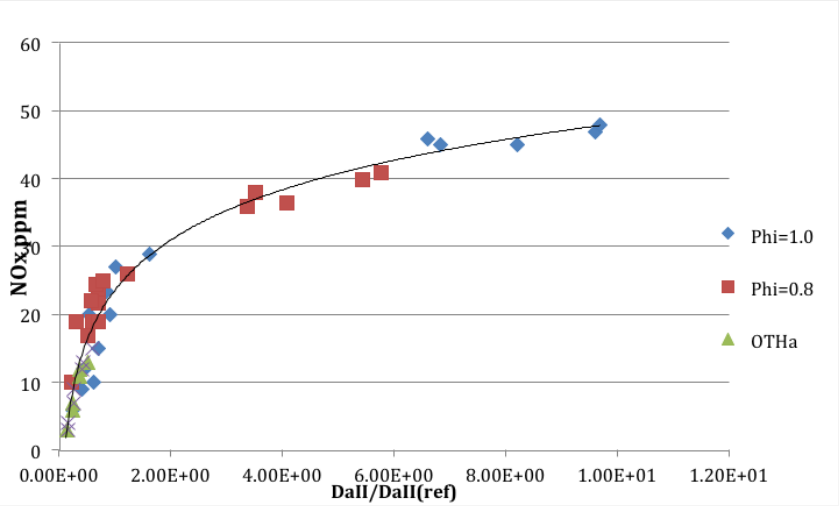
- Full system demonstration/brassboard nearly complete (~200 kW)
- Lab engine fully operable (~90 kW): demonstrates power, water, heat, and cooling production
- Design codes developed/validated vs lab engine results
- Current engines limited in boost pressure due to existing core engine designs
- Current recirculation limited by existing combustor designs

Development Plan

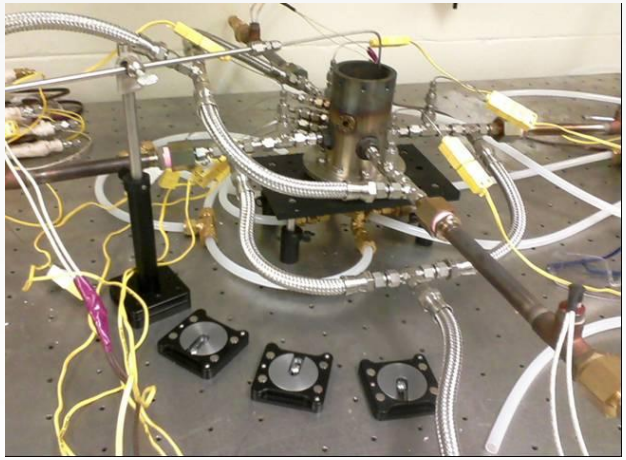
- **24 month advanced prototype program**
  - **Design next generation system, including high pressure LPC/LPT and advanced combustor**
  - **Build/modify demo system**
  - **Test to demonstrate high efficiency, water production, high power density, fuel flexibility**
- **Metrics: efficiency improvement equivalent to Diesel of same power output; water collection of 75% of theoretical maximum; efficient operability over 20-100% power; operation of multiple heavy fuels with acceptable emissions**
- **Full scale productization and field testing in following 30 months**
- **Accelerated schedule depends on level of resources**

Biomass Utilization and Flameless Combustion – W. Lear

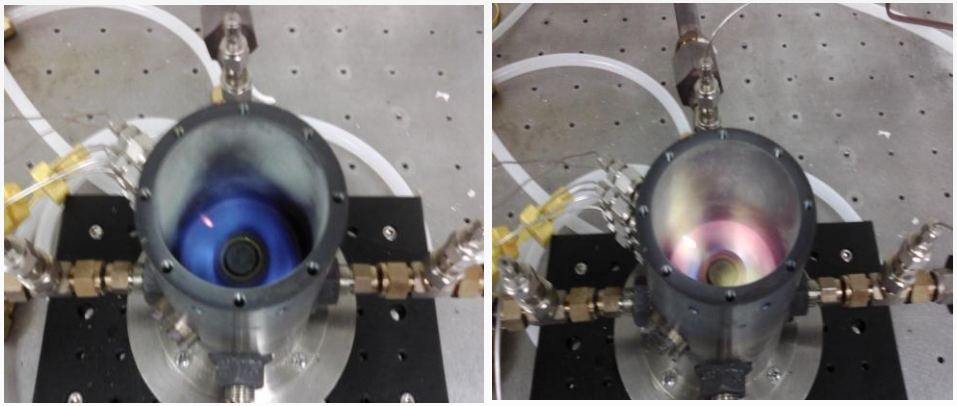
- Specialized facility to study flameless combustion
- Flameless combustion allows great fuel flexibility, esp. biomass
- Project developed gasification systems, novel coupled distributed generation system w/ flameless, low emissions, zero net water use.



Flameless Model Validation



FESC Flameless Combustion Facility

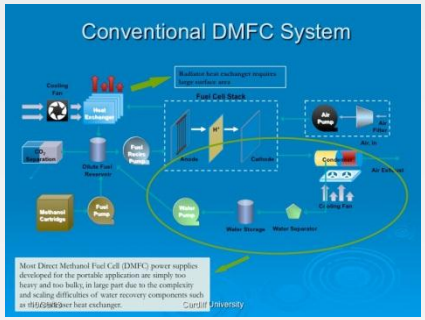


Both with same fuel: effect of Da_{II} parameter

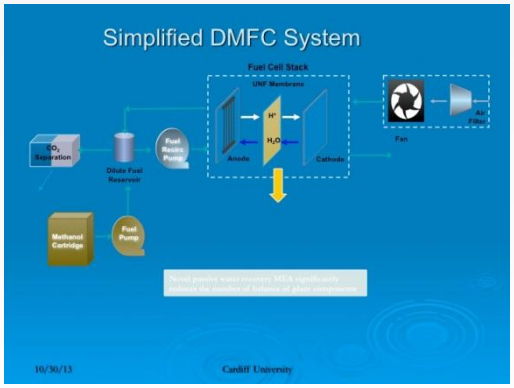
Ultra Light Mobile Power System – W. Lear

Direct Methanol Fuel Cell

- Novel architecture provides extreme compactness
- About ¼ the weight of Li+ batteries for 72 hour operation
- Advantages in 10-150W range, 10-200 hours
- Mobile/autonomous robots, portable electronics, small drones, portable battery charging, etc.
- Tested 10,000 hours



Conventional DMFC



Improved DMFC system