

the Energy to Lead

Small Scale Gas-Fired Power Generation

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Methane Mitigation ARPA-E Workshop
April 24, 2013

Value of Power- GasStar and Beyond

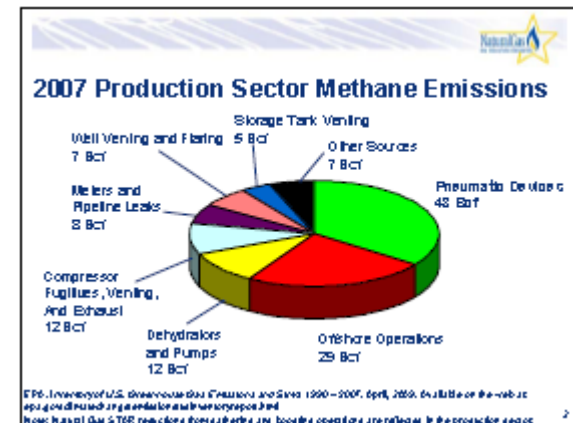
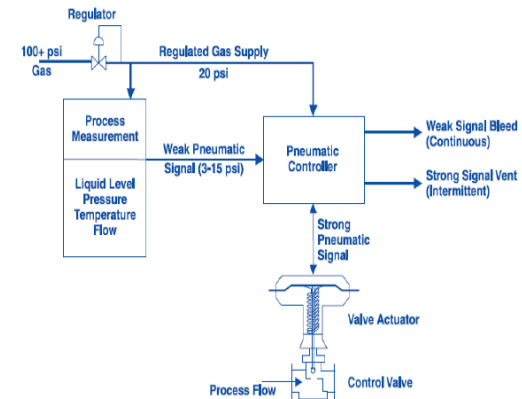
Displace gas-driven devices

- > **Pneumatic valves - EPA rules 4/12**
 - 2.5X Capex, payback ~2-4 years
 - Some actuator limitations
- > **Gas-driven pumps**
 - MeOH, corrosion inhibitors, etc
- > **Gas-driven compressor starters**

Enable more sophisticated instrumentation and control

- > **SCADA, Smart Valves, Historian, etc**
- > **Sensors**

Enable two-way communications



Stirling Engines

Kinematic Sterling

Efficient Home Energy (jv between Whisper Tech and Mondragon)

- > UK: trials 1999 with National Grid; commercial launch 2005
- > Netherlands: Commercial trial with MK IV [running] & MK V [starting]
- > Ireland: Commercial trial with MK IV
- > Germany: Beta trials with MK IV & MK V
- > Spain: Factory 30,000 units/yr

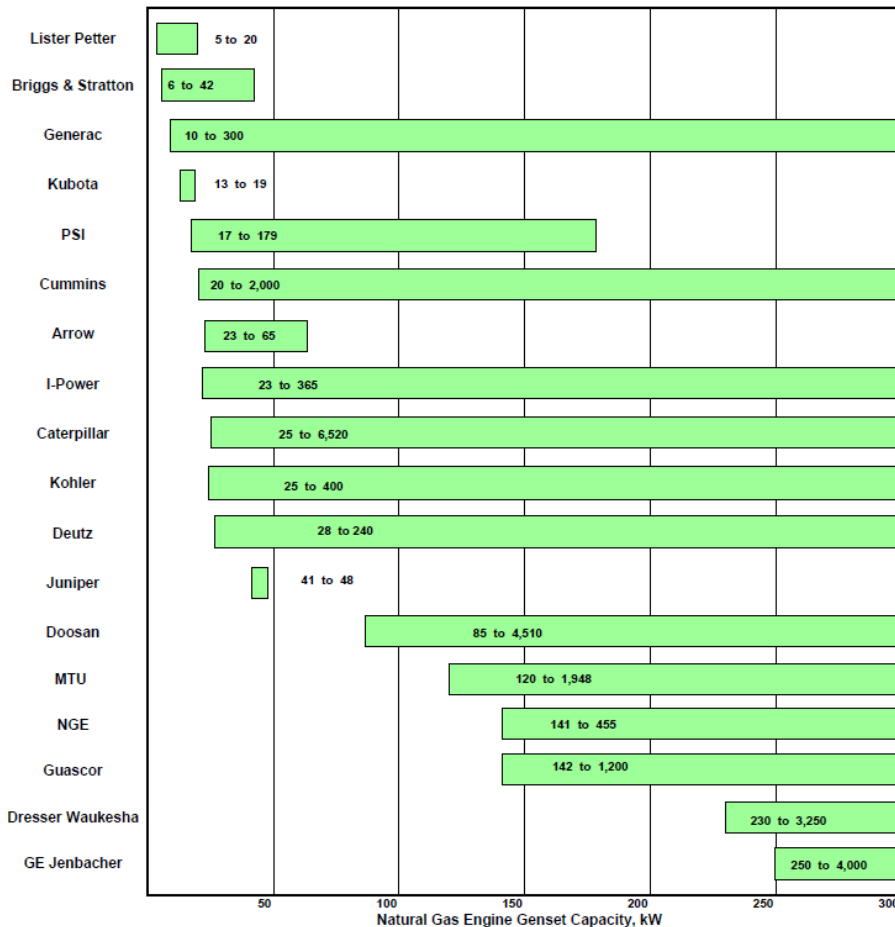
Free Piston

BDR Thermea (merger of Remeha and Baxi)

- > 1 kW commercial launch for Baxi's Ecogen and Remeha's Evita in 2010



Internal Combustion Engines (ICE)



> Honda ECOWILL

- Exlink engine
 $\varepsilon=26.3\%$
- Japanese launch
2003
- US 2006
- Germany 2011

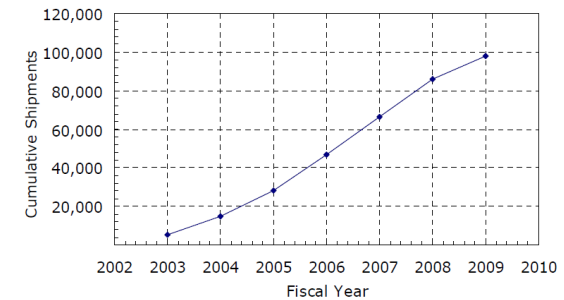
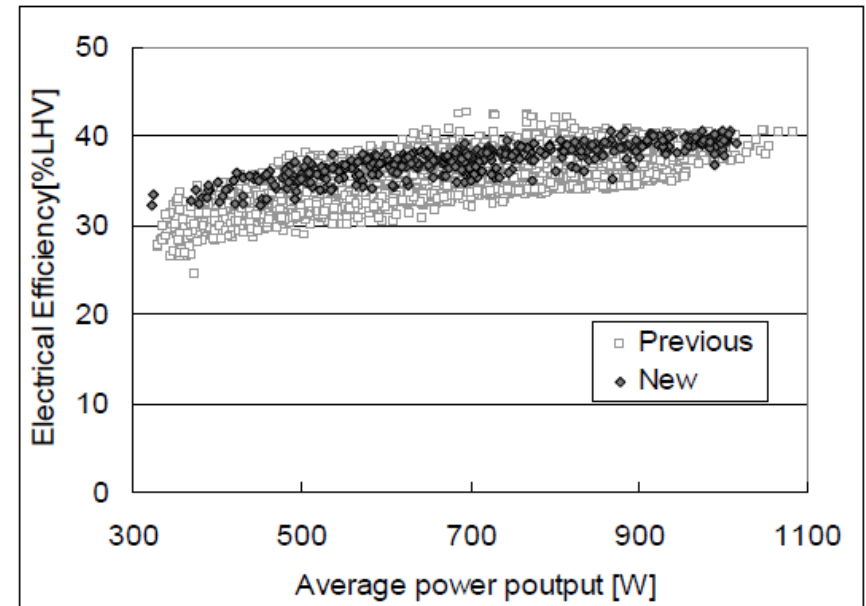


Figure 1 : Cumulative Sales of ECOWILL in Japan

Tokyo Gas/Panasonic ENE FARM PEM Fuel Cell

- > Launch 2005 with 520 units (lease only)
- > Commercial 2008, \$30K before subsidy
- > 1kW, $\epsilon = 38-45\%$
- > 3300 in 2005; 34,000 units at the end of 2012.
- > Goal is to have 5.3 million units installed by 2030
- > Cost targets \$8000 by 2016, \$5500 Government subsidies for Ene-Farm end in 2015



Japan SOFC Demonstrations

- > Demo start 2007; target commercial date 2015
 - 65 systems installed
 - Kyocera 0.7 kW; 45%
 - Nippon Oil 0.7 kW units for LPG and kerosine
 - Toto 0.7, 2, and 8kW systems
 - Experimental 3 kW micro-tubular SOFC achieved 59% efficiency for DC power

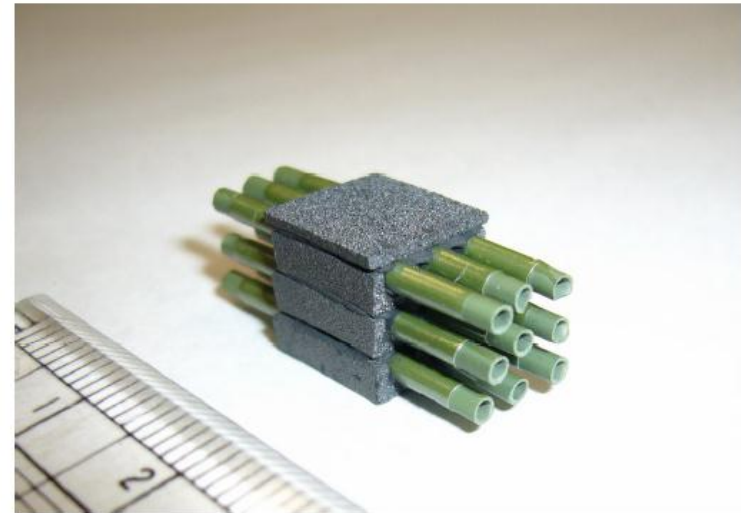


Fig.6 Cube Bundle

EU Fuel Cell Demonstrations

- > Baxi: 1kW PEM in beta testing
- > Valliant/Plug Power: CHP for multi-family dwellings in UK; also developing SOFC
- > Ceres Power: 1kW SS fuel cell operating at 500-600C; Centrica placed forward order for 37,500 units
- > CFCL: NetGen testing in Australia, New Zealand, UK, Germany; agreements with E.ON and GdF-Suez
- > Hexis: Galileo 1000N 1kW, 30% efficiency, primarily testing with E.ON



US Fuel Cell Technologies

