MARATHON ENGINE SYSTEMS

ARPA-E

Workshop on Small Engines

Case Study: Marathon Engine Systems

Chicago, Il.
May 28, 2014

MicroCogen Partners LLC

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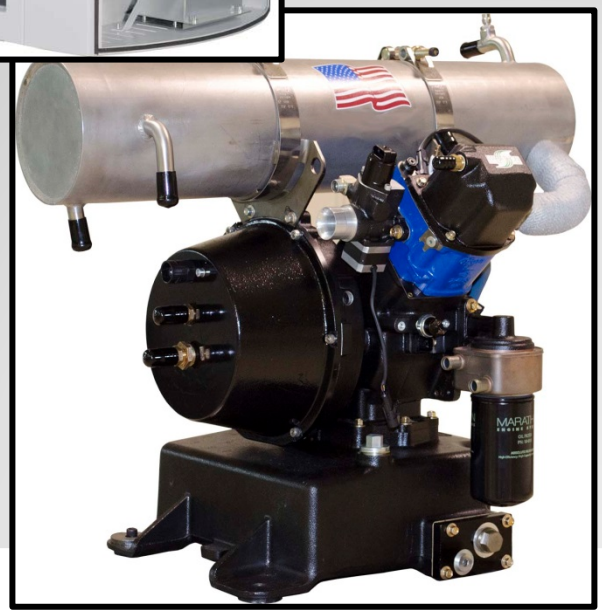
Background and History

- 1984– **GRI** approached **Battelle** Columbus to design an engine driven NG heat pump.
- 1988—**Triathlon** prototypes were started w/ potential suppliers: **York Intl, Briggs & Stratton, Honeywell, Copeland.**
- **Key *Marathon* engine specifications** :
  - 4,000 hr oil change interval (11 liter sump. Equivalent to 160,000 miles)
  - Ten year life or 40,000 hr. (Equivalent to 1.6 million miles).
  - 7.5 hp, 272cc, 12.8/1 compression.
  - 1200-3600 rpm. Single cyl. No belts.
  - **York Intl.** marketed and sold units from 1992 to 1997. About 3,000 systems in place. Warranty issues caused demise.
- **1998--HyPro, Inc**. bought the engine and started MES for remote power application.
- **2001--Teledyne Brown** sold Minotaur for cathodic protection. MES bought that also.

Evolution of ecopower



- **1998-** Call to Briggs from ecopower Energy Solutions AG, Swiss venture backed company with a microCHP--new product **- in need of a long life engine**.
- mCHP starting in Europe.
- Two engines were sold for **testing. Worked well.**
- 150 sold in Europe– but...
- **2002**– ecopower AG--bankrupt,
- **MES** bought **world** rights and **Vaillant (German boiler Co.)** bought European rights-using the Marathon engine--until 2011– now use German engine.
- **MES** tried to market the ecopower in US but had no idea of the barriers.

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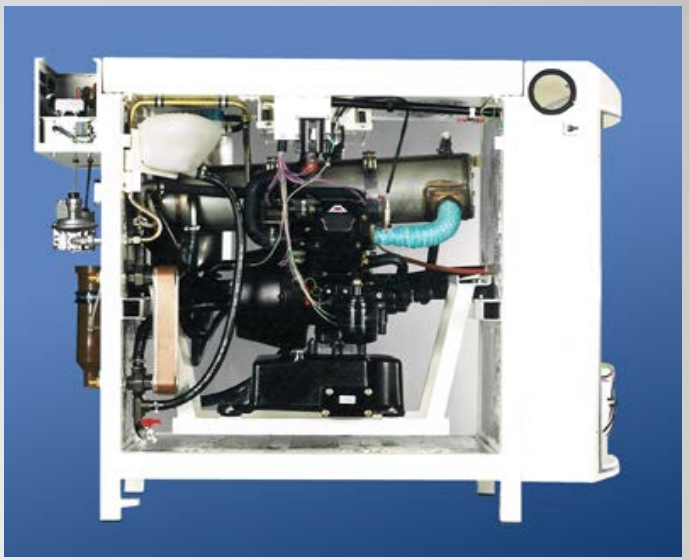
ecopower™ Microcogen Appliance

- Electrical output 2.2 - 4.4kWe/hr modulating
- Heat output is 20,000 -- 47,000 BTU/hr
- Maintenance interval: 4,000 hours –Oil, filters, spark plug
- Engine life – 40,000 hours.



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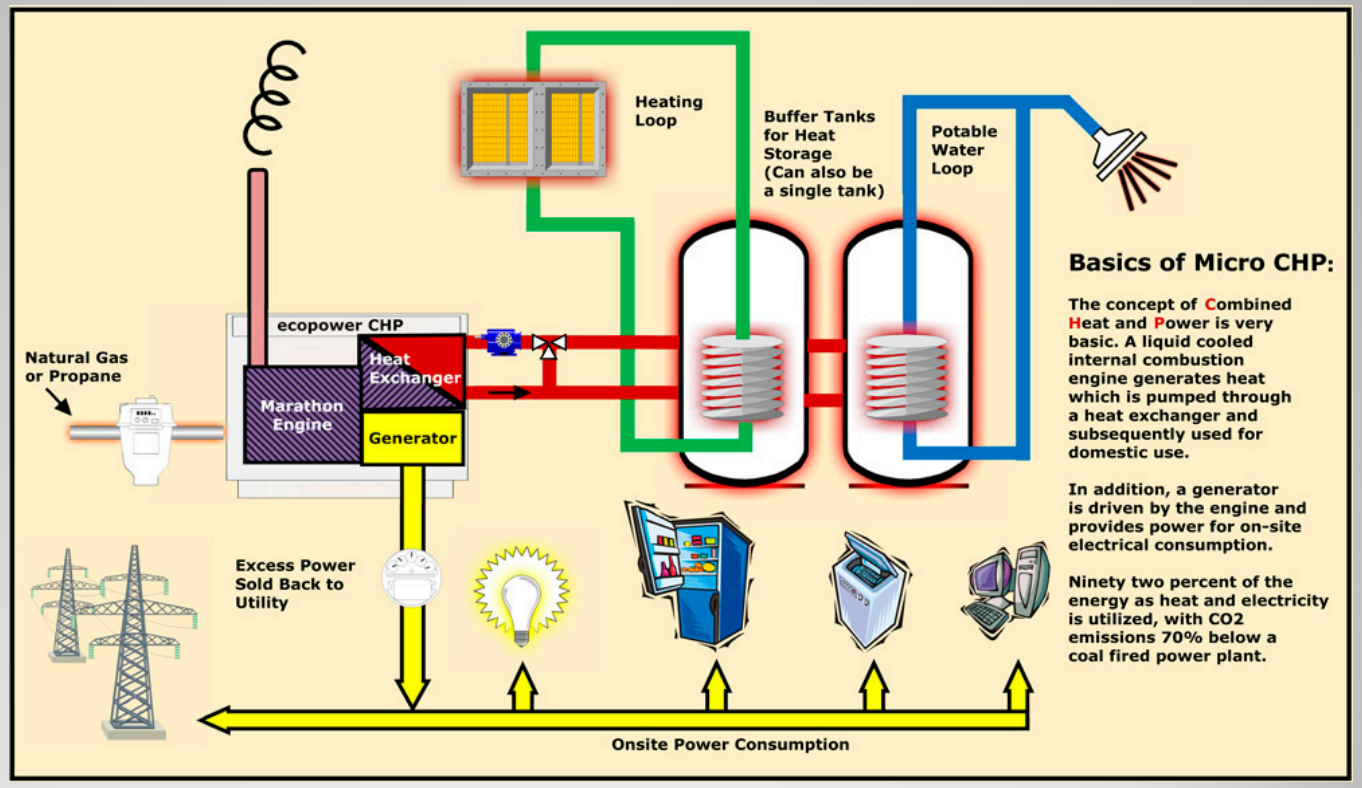
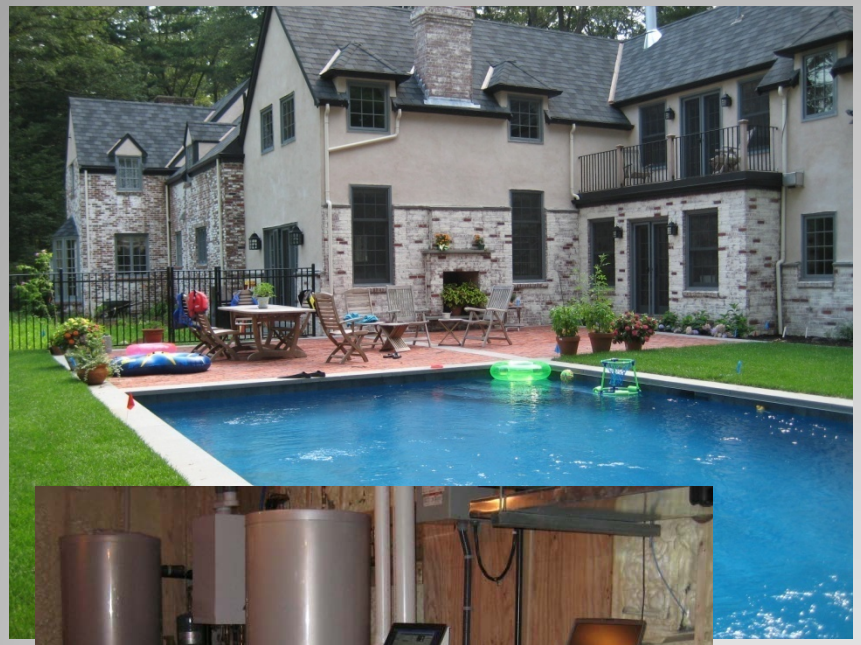
“Energy cannot be created or destroyed..

Only converted from one form to another”

First Law of Thermodynamics





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Private Residence –
Dover, Massachusetts

- **9,000 sq.ft.**
- **28,000 gallon pool @ 85°F (Grandkids)**
- **Full in-floor radiant heating system in the house**
- **Geothermal system as backup.**
- **In 20 months of ecopower use -- generated 40 Mwh of electricity @ $0.23/kWh savings of $9,000**

Multifamily Apartment

Domestic hot water for a 56 Unit, LEED Platinum apartment building . Bronx, NY

- Two units: 9.4kWe and 78,000Btu/hr total.
- Installed August 2009
- Can generate: 6.5 Mwh/mo
- Current electric rate is $0.25/kwh
- In the first 12 months – 69Mwh.
- **Savings of $17,000** + per year in electrical costs.

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Commercial Hot Water Applications

- LEED Platinum, 125 unit apt. in NYC.
- 3,000 gal buffer tank
- Units generate 9-12,000kWh per month
- Savings of up to $2400/mo. in electric costs.
- Discounted gas

- YMCA swimming pool complex in Wisconsin
- New install – awaiting data.

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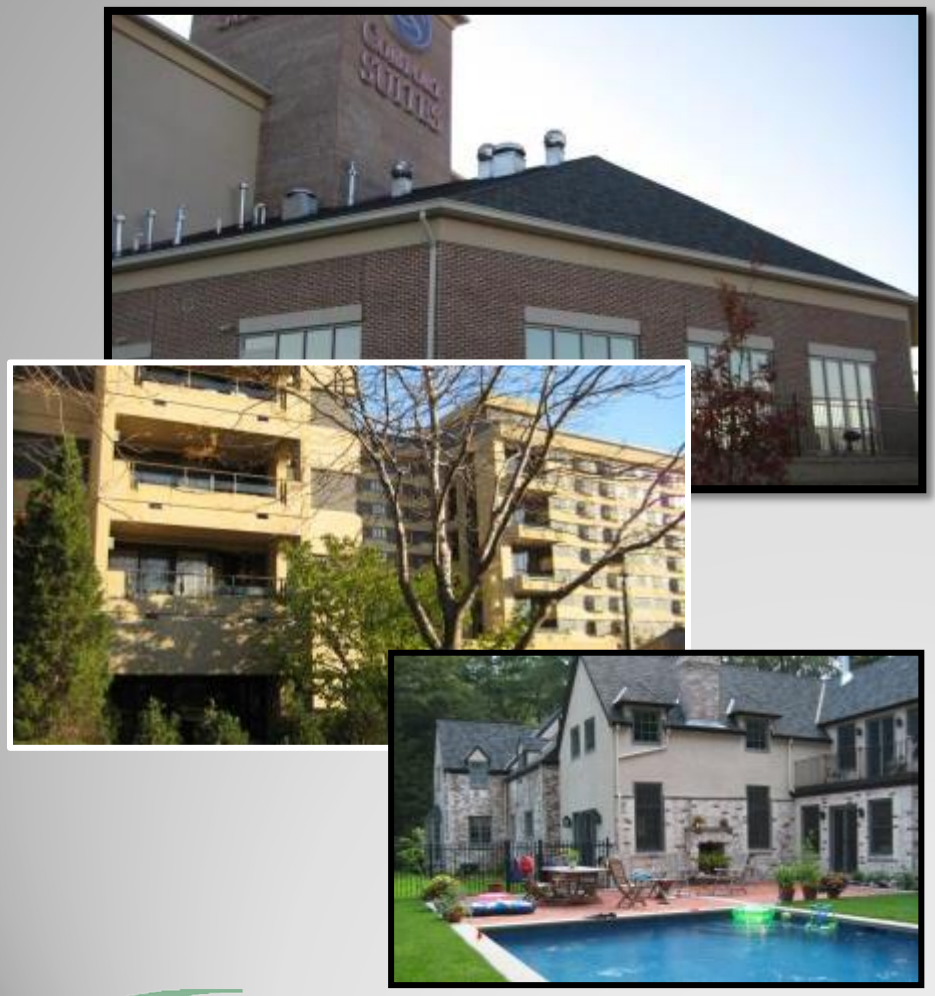
Markets for mCHP



Commercial Market is stronger and shows promise

- Multifamily apartments
- Nursing Homes/ Assist. Living
- Health Clubs
- School District Swim Pools
- Restaurants/ Truck Stops
- Medium Size motel
- Hydroponic farms
- Greenhouses
- Laundries
- Car Washes
- Large Building Reheat
- Larger Homes w/ pools.

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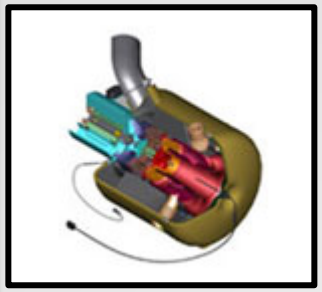
Yanmar

ClearEdge


FreeWatt


EC Power


Capstone

Current MicroCHP Manufacturers Marketing in the US

- **Marathon Engine Systems**. manufactures and marketed the ecopower 4.7 kW(e) ICE
- **Yanmar**– Two products in the market – a 10kWe ICE unit and now a 5kWe .
- **ClearEdge**– Fuel Cell (5kWe) and is on hold. Recently filed for bankruptcy.
- **Climate Energy/ Freewatt**– Marketed by ECR but *now in a reorganization*. Most applications in the Northeast with 300 + installs. 1.2 kWe ICE (Honda)
- **Capstone Turbine-** a family of six units 30kWe to 1000kW. Sales worldwide.
- **EC Power**– Danish ICE based system. Four sizes: 6, 9, 15, 20kWe. In Canada now, starting a US office 1Q2014.

Total Sales: Worldwide* -- 212,000

- Japan ---155,000 units
- Europe--- 45,000 units
- Rest of the World --- 12,000
- US ~ 600 units

(* Source: Delta-ee)

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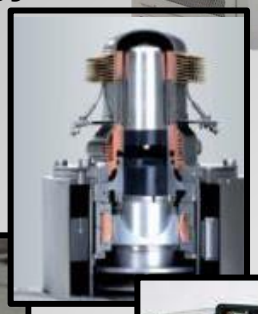
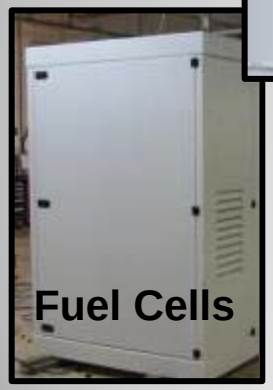
New Entrants in the Market

Qnergy

M-Cogen

Microgen





Fuel Cells

NRG /Deka

- **Qnergy** – an Israeli company has developed a **7.5kWe Stirling engine** (FPSE) for use in the mCHP market as well as remote power. Will enter in 2015.
- **Microgen**- a consortia of companies have taken the **1kWe Stirling** engine developed by Microgen and a number *of them are considering* the NA market. In addition **NRG Energy and DEKA** are set to market a **10-15kWe (6kWe)**? Stirling.
- **Fuel Cells**– a number of small fuel cell product mfgs (1-3kWe) are *looking seriously* at the NA residential market.
- **Thermal Acoustic/Electric Generators** are in development and could enter in the next two years**.<3kWe**
- **M-Cogen---** Houston based company that has developed a Trigen system using an ICE and an ***adsorption cooling system***. Heat, power and cooling**. 6kW(e) and 5 tons of cooling**.

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Advantages and Disadvantages of microCHP Technologies

	Usage in the World	Major Advantage	Major Dis-advantage	Electrical Efficiency	Overall Efficiency
ICE	78% Now 66%*	Proven technology	Needs long life engine	20-30%	85-92%
Stirling	18% Now 6%*	High heat Fuel Agnostic	Difficult to Manufact.	10-20%	Low 80's
Organic Rankine	<2%	Low Cost Hi Heat	Poor Elect Efficiency	~10%	90+%
Fuel Cell PEM	2% Now 25%*	Low Emissions	Hi Price Reformer?	30-35%	77-80%
Micro-Turbine	<1%	Hi heat out Long life Multi- fuel	Hi press gas. Hi price	Mid 20's	80-92%

Delta ee * **Change because of 23,000 FC sales in 2012 in Japan**

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Future for MicroCHP*

Drivers:

- Energy Costs
- System Costs
- Aging Grid
- Energy Awareness
- New Entrants and Competition

Opportunities

- Large Market
- Proven/positive track record
- Spark Spread is very favorable.
- Clean Emissions – significantly less CO_2 NOx and SO_2. Carbon Credits (?)
- Good Niches– Hot water apps.
- High Efficiency
- Leasing is becoming viable
- Backup power can be an option.
- Smart Grid / Demand Response
- Multiplexed for larger needs.

Barriers to Entry

- Large Capex for install– High costs because of being an emerging technology. Can be $3k-8,000/kW.
- Utility Reluctance. Slow to change
- Sales Channel-- can be difficult because of understanding new technology.
- Education – of all parties-- customer, dealer, legislators, utilities
- Stigma-- because of not being renewable.
- Legislation-- is slow to change and inconsistent. Fifty sets of rules.
- Heat Driven therefore limiting to colder climes
- Cooling technology – some exist but are expensive and not practical.

* "I hate making predictions– especially if it's about the future "
Lawrence Peter Berra

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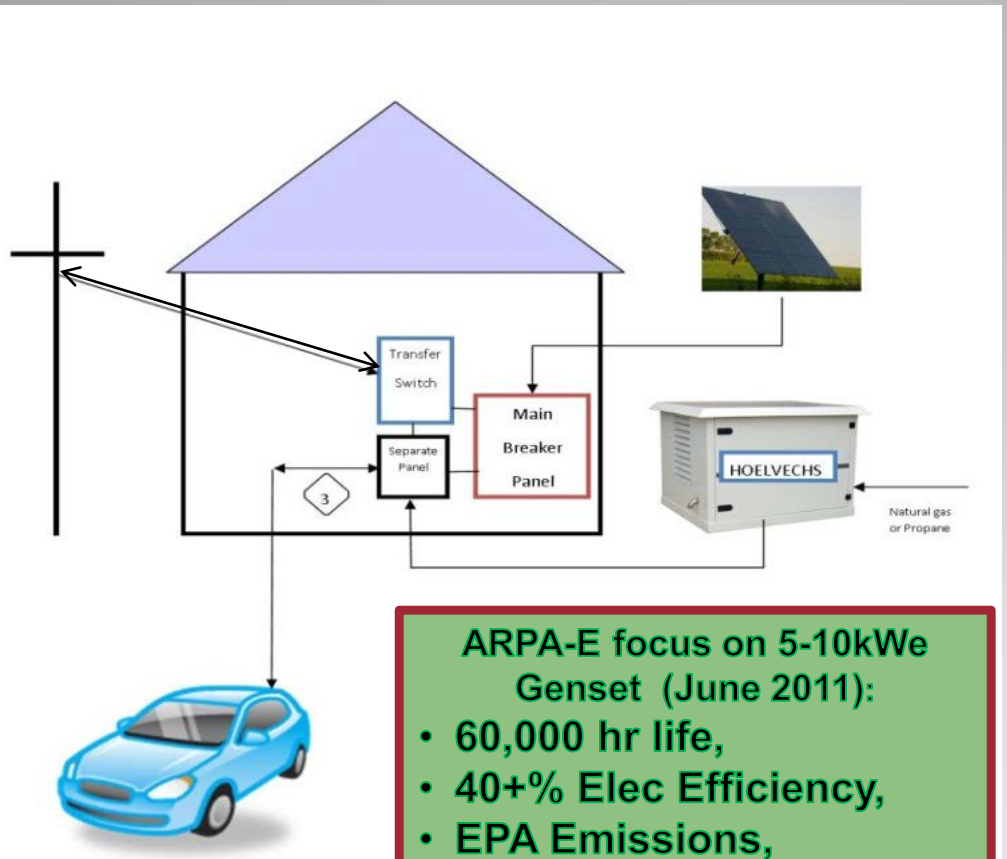
HOELVECHS* Concept Schematic



- **Long life** 5kW engine generator
- Capable of running **4,000 hours** between maintenance needs.
- Natural gas or propane fueled.
- Electric vehicle charging capable –Level 1 & 2.
- **Therefore, no grid strain**
- **Backup power capable** for grid outages. May have a battery complement. (Optional)
- Is **Smart Grid compatible**, the 5kW would be dispatchable power and controlled by the utility.
- Ultimately will be vehicle to grid (V2G) capable

ARPA-E focus on 5-10kWe Genset (June 2011):

- 60,000 hr life,
- 40+% Elec Efficiency,
- EPA Emissions,
- Install costs $10,000,
- ROI in 2-3 yrs,
- One maintenance/ year, 99.1% uptime.
- Fuel flexible, (Propane, NG)
- 120v/60Hz

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*Home Electric Vehicle Charging System

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