

ECR International

Climate Energy

Green Power from America's Home Heating Industry



OUTLINE

- Overview/Background
- Micro-CHP
- Technology
- Product
- Key Issues



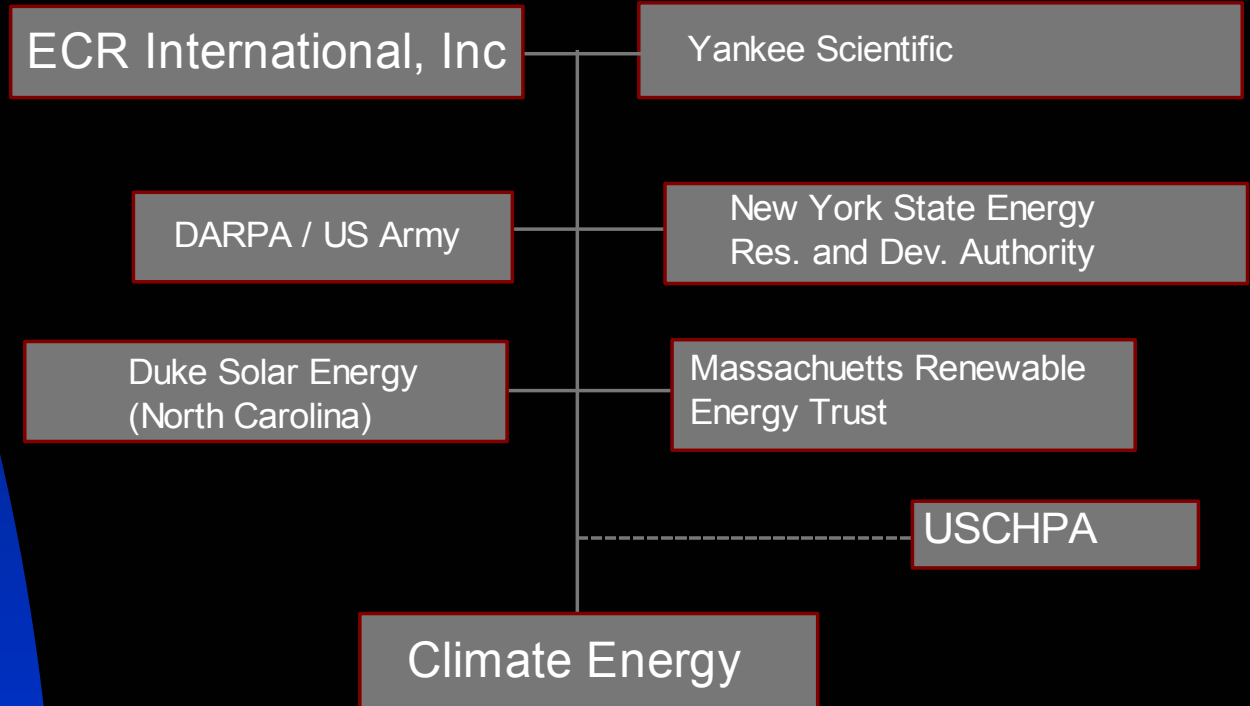
Who we are...

Climate Energy Micro-Cogen Consortium Today

Heating Appliance
Industry Leaders

Government

Renewable
Energy Partners



Overview

- **“Case” for co-generation has been amply made for years**
- **Residential level cogen (Micro-CHP) has lacked adequate technology solutions...until now.**
- **New Technology**
 - ◆ residential level applicability
 - ◆ consumer friendly
 - ◆ 90%+ efficiencies
 - ◆ Environmentally sound
- **Wishful R&D? ... No!!!**

What we're doing...

- Developing patented space and water heating appliances that...

- ◆ Cogenerate electric power

- ◆ Are “customer-friendly” (...look and work like today’s appliances...),

- ◆ Can be commercialized through existing industry infrastructure

- ◆ Achieve near term product introduction through evolutionary technology



=Micro-CHP

**Over the last 10 years the US space heating
appliance industry produced about 1,000,000
Megawatts of Thermal Capacity**



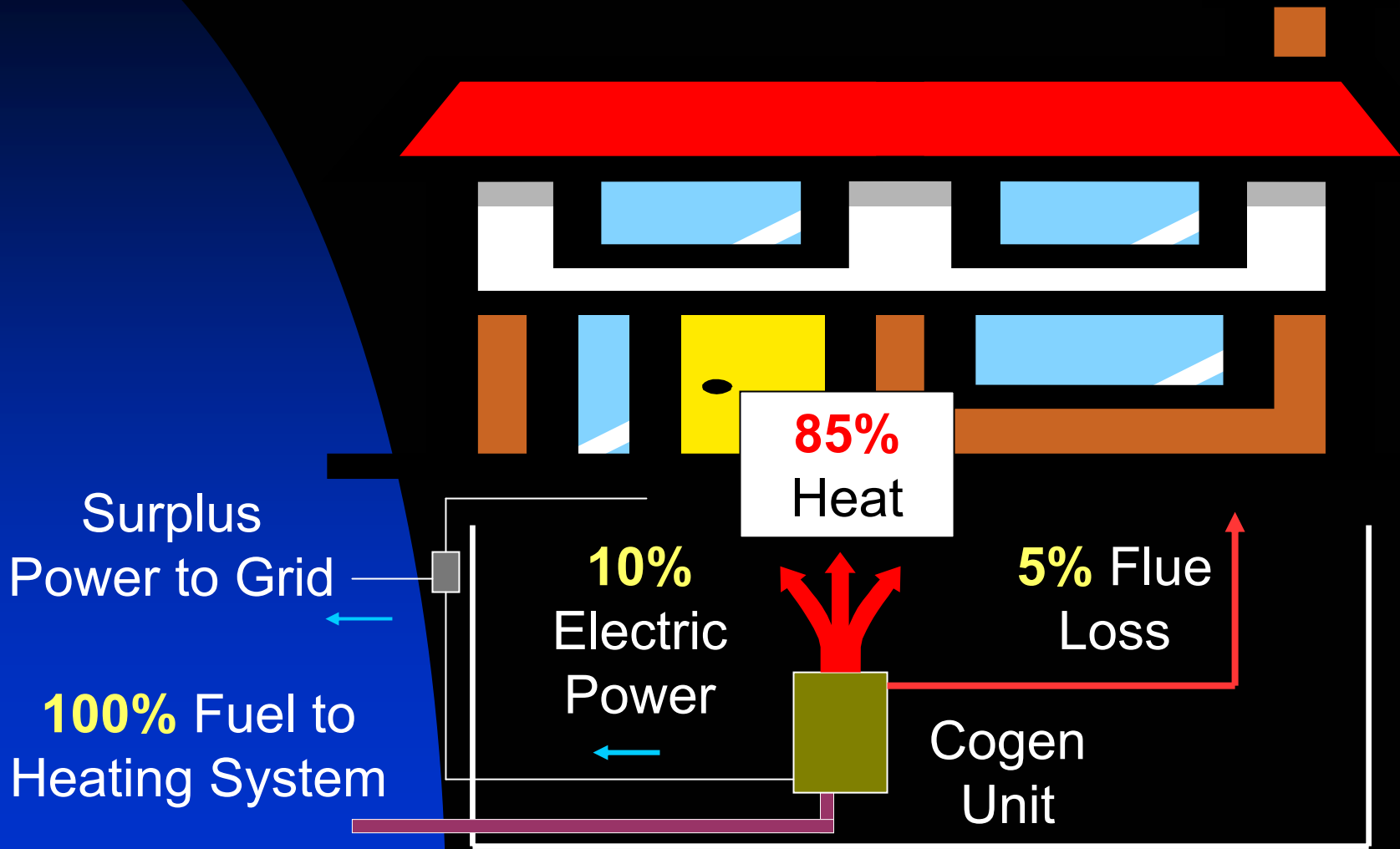
**Total USA Installed Electric
Capacity ~ 600,000 Megawatts**



Why Micro-CHP Now ...

- **CHP has fundamental energy and environmental value, if done right**
- **Improved understanding of the opportunity and emergence of good business model**
- **Evolutionary technology solutions exist**
- **Electric industry developments and national agenda have made Micro-CHP relevant**

Micro-CHP uses up to 95% of the Available Fuel Energy



What's really required for Micro-CHP

- Economical
- Practical
- The right capacity
- Low emissions
- Grid connection
- Backup-power

The Technology

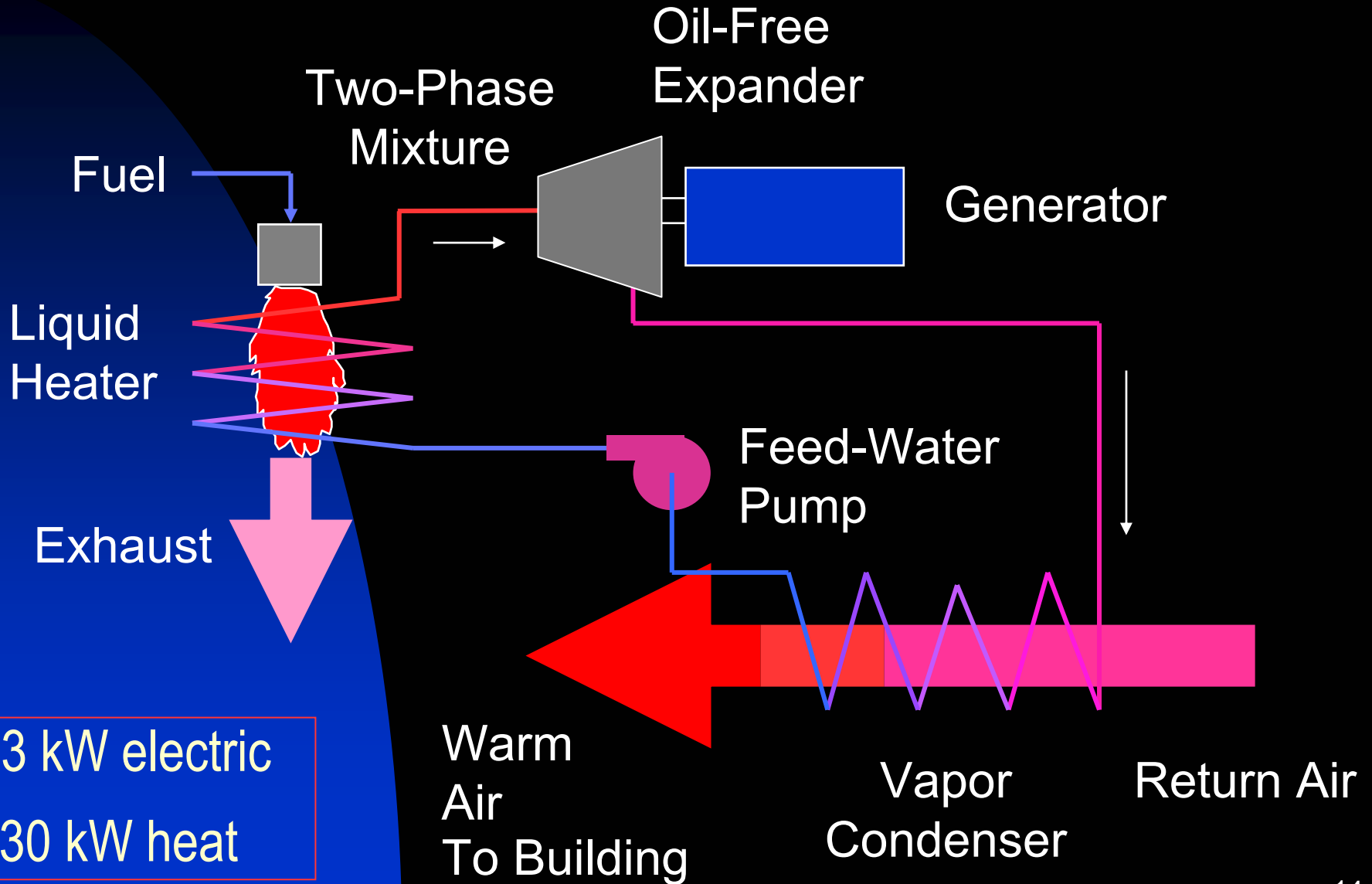
Liquid-Injected Cogen

- Evolutionary hydronic heating technology
- Synthesizes new technology with old
- Compare to “hybrid” automobile

Liquid-Injected Cogeneration

- **Simplified “Steam” power cycle made possible by modern materials, manufacturing and electro-mechanical technology**
- **Cycle configured to specific needs of Micro-CHP**
 - ◆ **Instantaneous water heating with only partial vaporization**
 - ◆ **Power from two-phase, oil-free expander**

Liquid-Injected Cogen Furnace



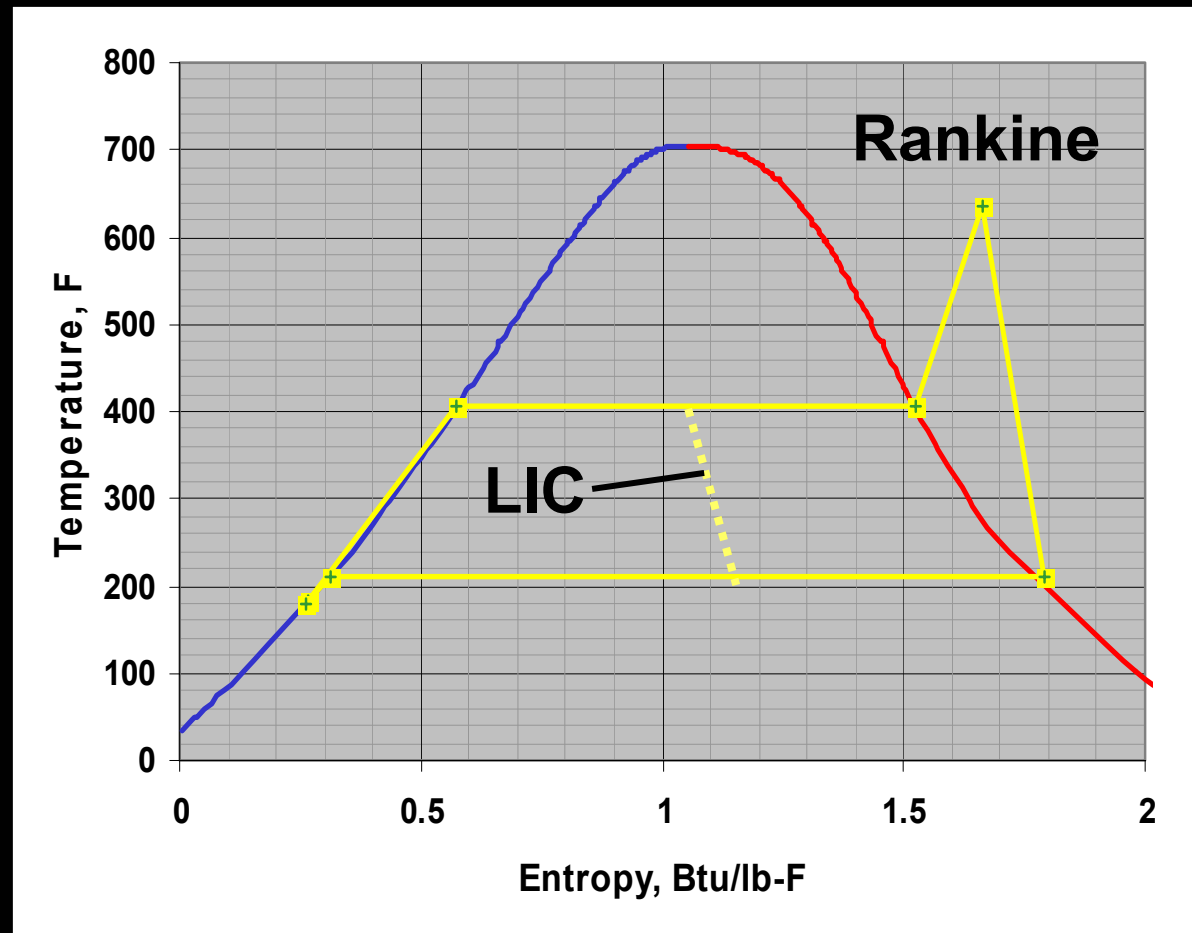
Why Use Water ?

(and not “refrigerants”)

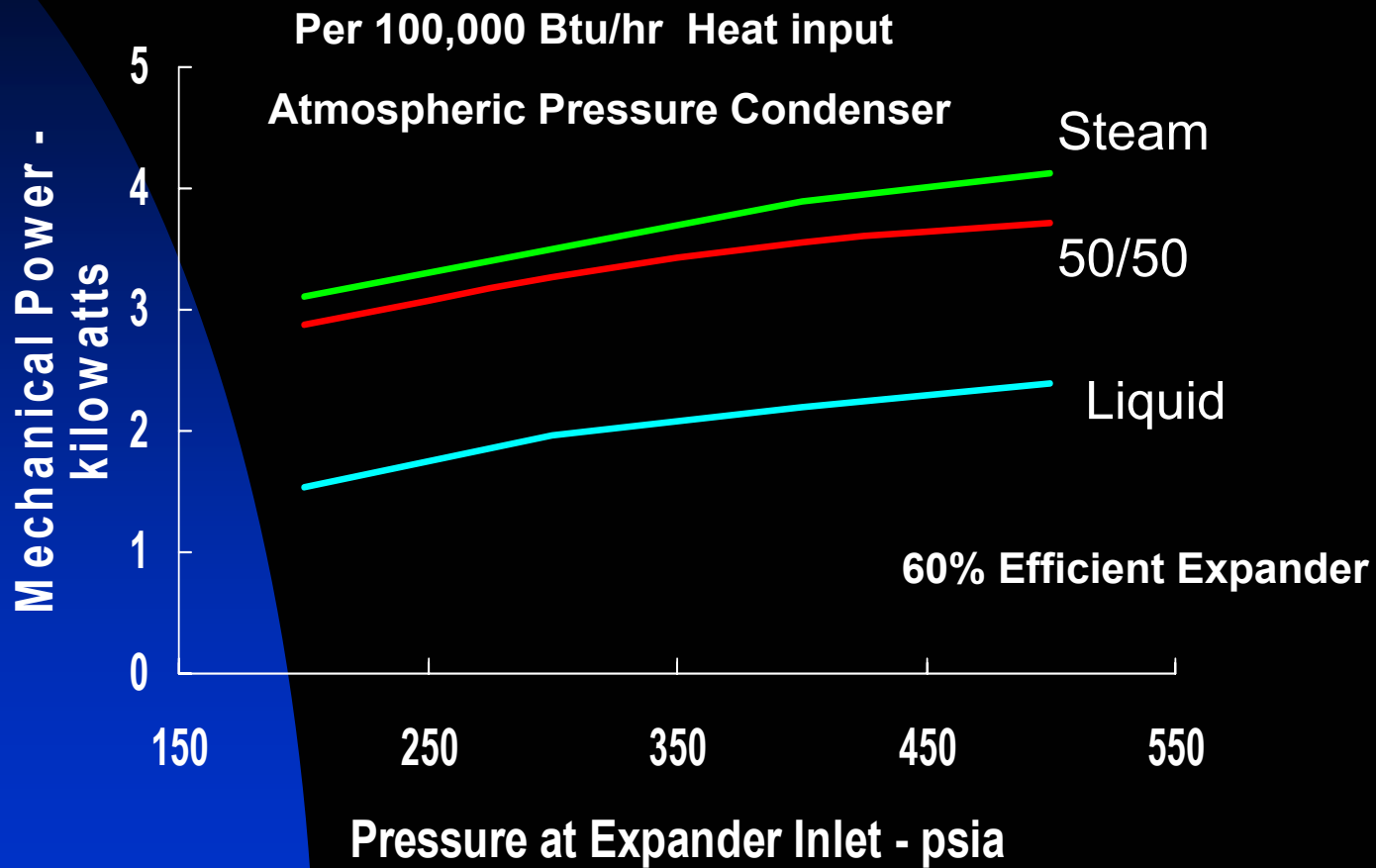
- Best thermodynamic properties for Cogeneration (Most of our electric power is from “steam” plants)
- Thermal stability (can’t burn, can use direct fired heat exchangers)
- Non-Toxic, No cost
- Can tolerate significant leakage
- Very high heat transfer rates means compact heat exchangers (compared to refrigerants and organics)

Rankine vs. LIC Cycles

- Rankine shown with ~200 F superheat
- LIC shown with 50% steam quality



Potential Output of L-I Cogen Unit

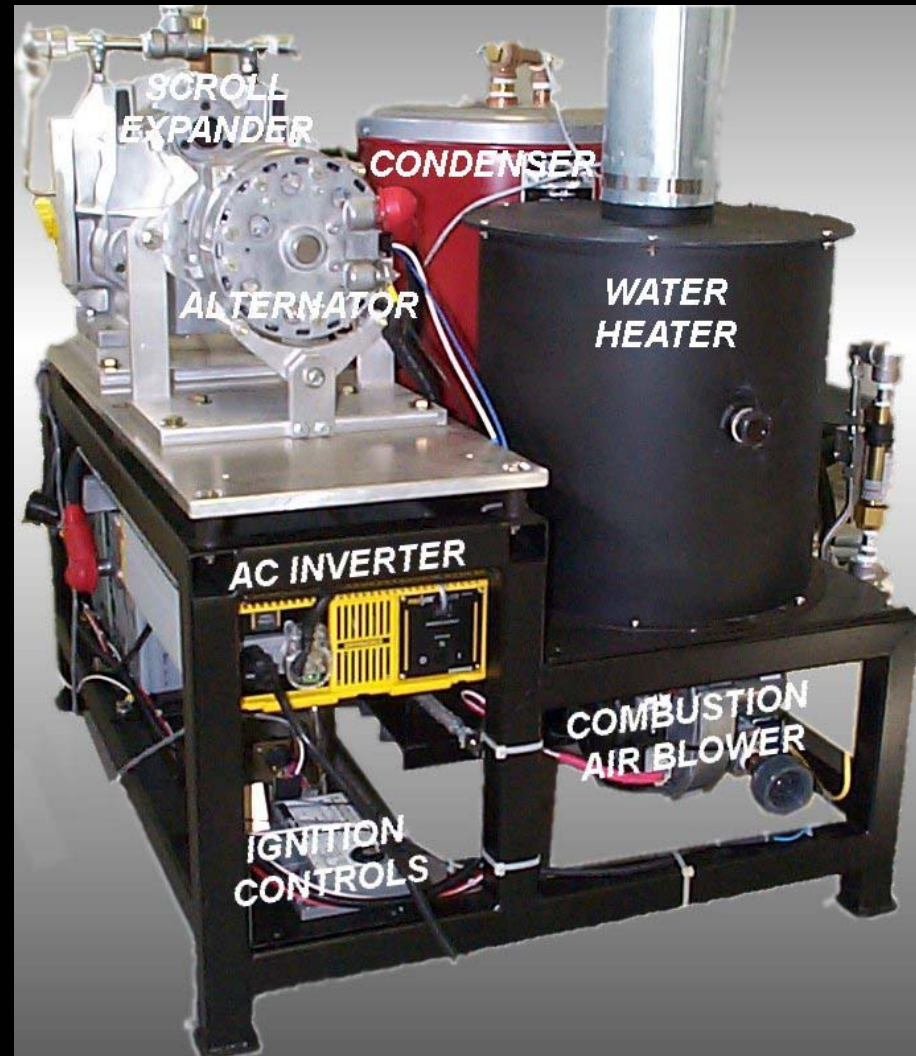


Advantages of Liquid-Injected Cogen

- Appropriate heat/power ratio for homes
- Low hot water inventory – intrinsically safe
- Uses compact, lightweight, high performance components
- Expander rotation matches generator speed
- External combustion - low emissions
- Quality heat provided at up to 200 F
- Builds on existing heating industry technology and business base

(M1) Hydronic LIC Concept Demo

- Input:
120,000 Btu/hr
- Oil free scroll expander
- Produces 2 kW shaft power

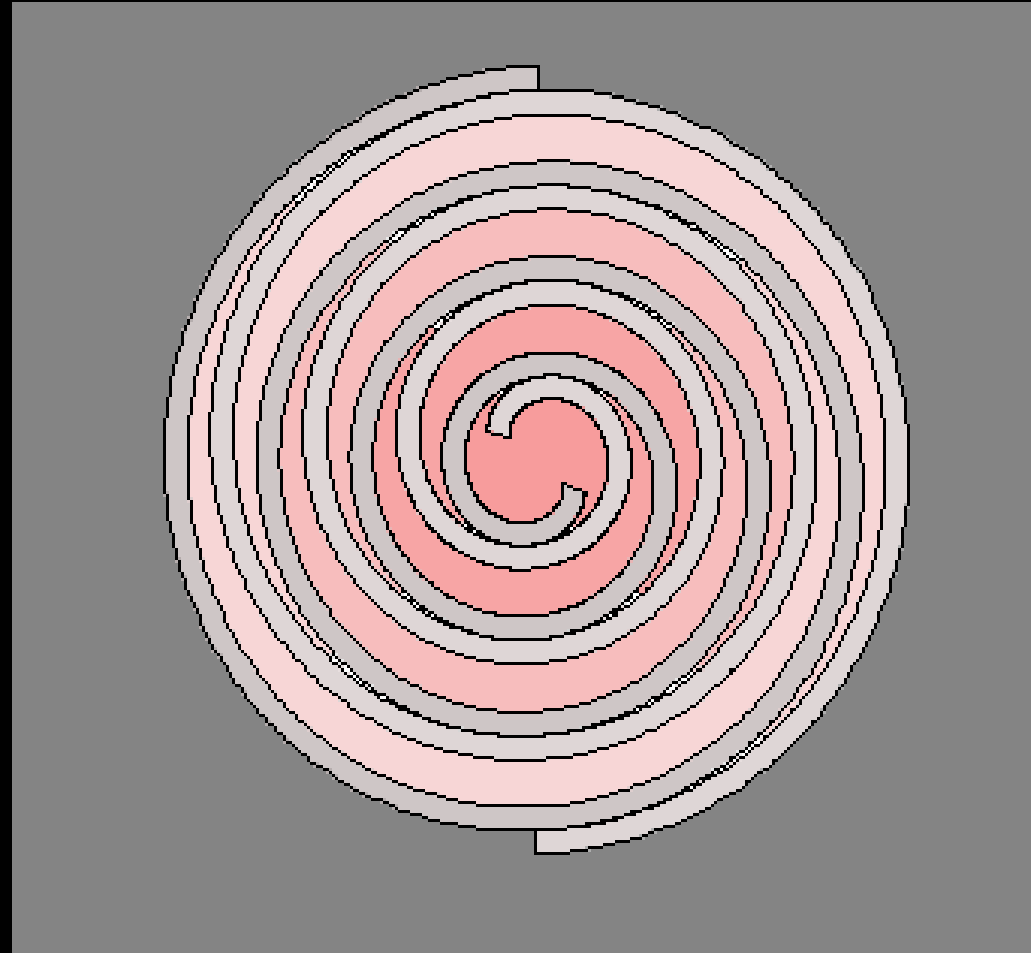


The Oil-free, Steam/water Scroll Expander –Why?

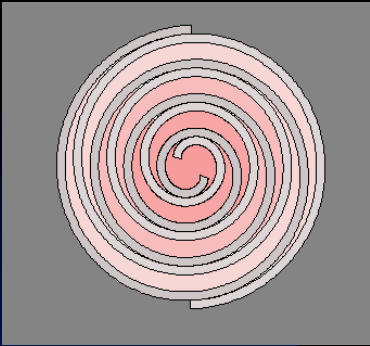
- Need to keep oil out of high-performance heat transfer components
- Oil-free technology is emerging
- Handles two-phase over wide mixture range
- No valves
- Self-starting, smooth-running, quiet

Scroll Expander – Creating the Power

- Mixture enters at center, expands spirally-outward
- Scroll technology now preferred design for refrigerant compressors
- No valves, oil-free, quiet



Scroll Devices for Fluid-Pressure Work Conversion



- A century old principle for positive displacement machine
- Recent commercialization enabled by advanced manufacturing capability
- 2000 US patents in last two decades
- Millions of compressors manufactured annually (Copeland, Carrier, Hitachi)
- Many desirable features relative to reciprocating pistons



Scroll-Expander Requirements

- Oil-free
- Corrosion/erosion resistant to water/steam/air environment
- Volume Expansion ratio of about 5
- Up to 200 psig inlet, 0 psig outlet
- Isentropic expansion efficiency about 50% or more
- Limited leakage (< 0.2 lbs/hr)
- 10,000 –20,000 hour life, 5,000 hour service interval



**Liquid-Injected Cogen
Warm Air Space Heating
Furnace Demonstration
Unit**

The Product

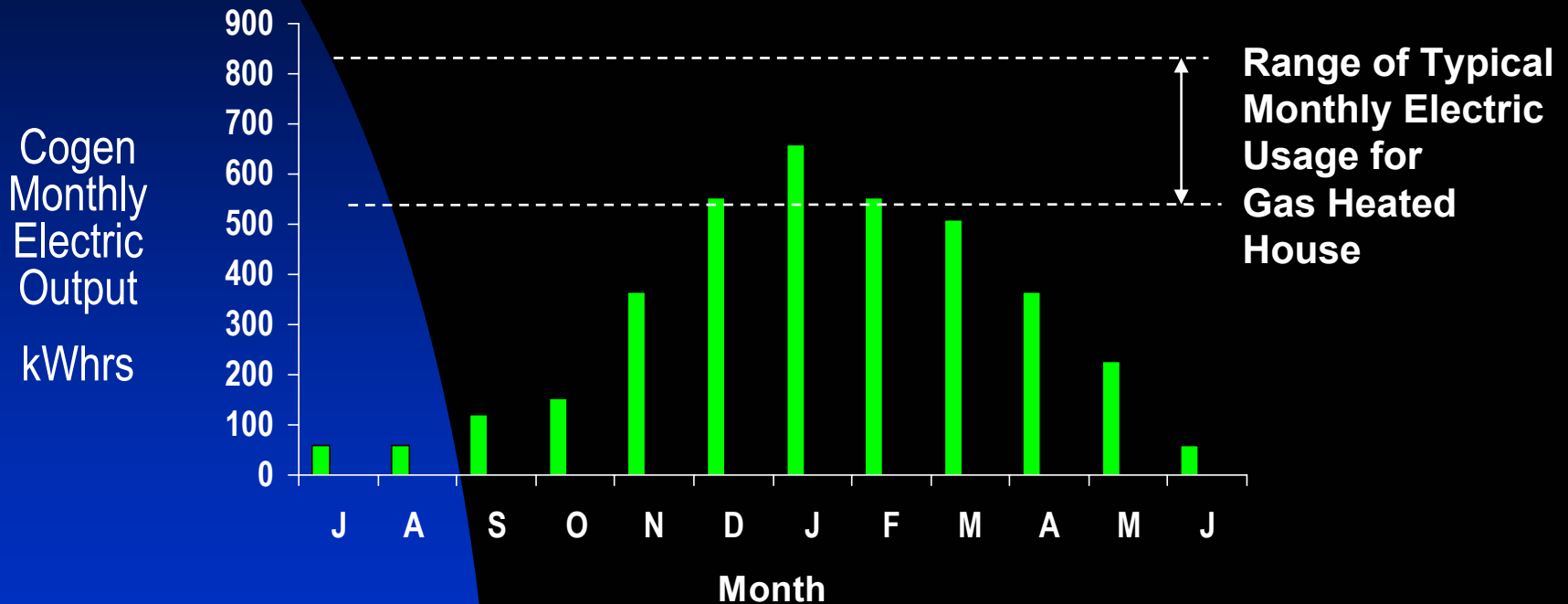
Concept View of LIC Warm-Air Furnace



Economics

- Realistic target is around twice the cost of high efficiency (heat only) furnace
- Reduced electric power costs result in good payback
- Very attractive relative to alternative on-site power generators

Cogen Heating System Monthly Electric Output*



*10% power to heat ratio,
New York example

The Market...

- 30+ Million Buildings in the US
- 50+ Million Buildings Europe & Asia
- US Market for Fuel-Fired Heating Appliances
 - Space Heating ~ 4 million/year
 - Water Heating ~ 5 million/year
- International market of similar size

ISSUES

Regulatory

Utility

Environmental

Legislative

...Making it all work

ISSUES

- **Micro-CHP fits into the reality of today's changing electric utility industry**
- **Electric utilities will view CHP both as an opportunity and a challenge**
 - **Micro-CHP – more opportunity/less challenge**
- **Key Issues**
 - ◆ **Interconnection**
 - ◆ **Permitting**
 - ◆ **Fees**
 - ◆ **Net metering**
 - ◆ **Tax credits**

Key Issues - Interconnection

*“...entry by all generators should be facilitated to the greatest extent possible... and entry by distributed generation brings unique attributes to the market. Distributed resources are an effective check on the market power of incumbent utilities...”**

* ISO/RTO Interconnection Policy for Distributed Generation
William Massey, Commissioner, FERC, April 2000

- **Safety**
- **Reliability**
- **FERC responsibility**
 - ◆ States to follow guidelines
 - ◆ Micro CHP likely less controversial (environmental performance important!!!)
- **Interconnection rules must be fair and workable**

Key Issues – “Fees”

- Utility imposed “fees” (exit/entrance, stand-by/access) ADD to the costs of CHP!!!!
- Exit fees – means to recover future stranded costs associated with loss of customer
- States “all over the place” on fees
 - ◆ Six states with no fees
 - ◆ Five states with conditional fees
 - ◆ Two states with broad fees on all self generation
 - ◆ Two states with conflicting legislative and administrative positions

Key Issues – “Fees” (cont’d)

- Other “fee” issues that are not standardized
 - ◆ Grid connected vs. independent
 - ◆ Reduction in consumption from grid vs. complete avoidance
 - ◆ “Hidden” exit fees
 - ★ e.g. stand-by rates (MIT case in MA)
- “Bottom Line”
 - ◆ Regulatory treatment of “fees” driven by local regulators/legislators/utilities/perception of CHP
 - ◆ Smaller sizes likely to receive better treatment

Key Issues – Net Metering

- Net-metering

Net total monthly electrical consumption or the difference between electricity “taken “ from the grid and the amount generated by the CHP appliance

- *Already in the “books” in many states (40+) as well as in several bills*

- ◆ *S 1766 “mandates” net metering for systems <250 kW*

- Small systems favored

- Most do not have “cash-back” provisions

- ◆ Carry-over credits

- ◆ Year-end round-up

- ◆ Net-negative flows to utility

Key Issues – Taxes

- House and Senate bills include tax credit language for CHP
 - ◆ Excludes systems < 50kW

R&D

■ House-Senate Conference Committee

SEC. 201. DISTRIBUTED ENERGY AND ELECTRIC ENERGY SYSTEMS.

(b) MICRO-COGENERATION ENERGY TECHNOLOGY.-From amounts authorized under subsection 16(a), \$2,000,000 for fiscal year 2003 and \$20,000,000 for fiscal year 2004 shall be available for activities under section 223.

SEC. 223. MICRO-COGENERATION ENERGY TECHNOLOGY.

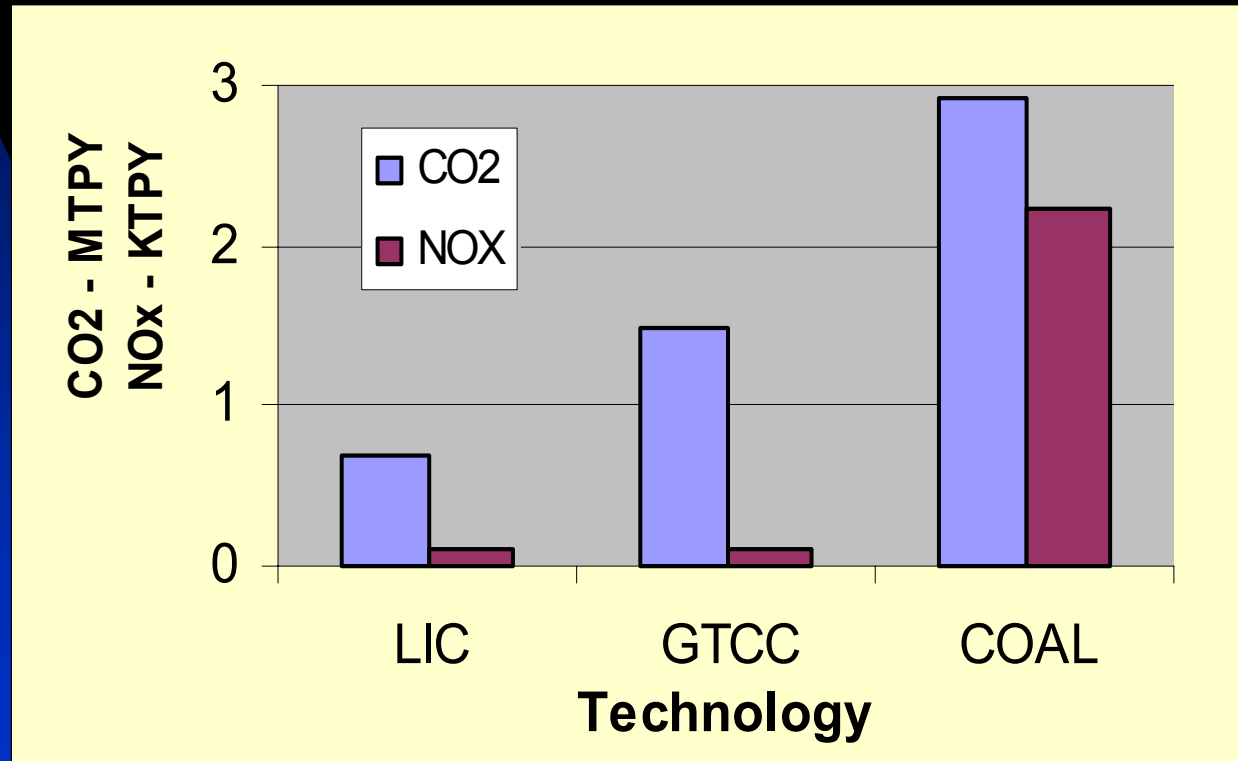
The Secretary shall make competitive, merit-based grants to consortia for the development of micro-cogeneration energy technology. The consortia shall explore the use of small-scale combined heat and power in residential heating appliances.

Bottom line...

- Legislative and regulatory issues are important to the eventual success of Micro-CHP
- Micro-CHP and intended market sector likely to yield more favorable treatment than some other technologies (size/application)

Environment

Annual Emissions Comparison (Per Million LIC Units)



GTCC and Coal are Based on
Equivalent kWhr Production

Potential Impacts at the National Level (10 Million units)

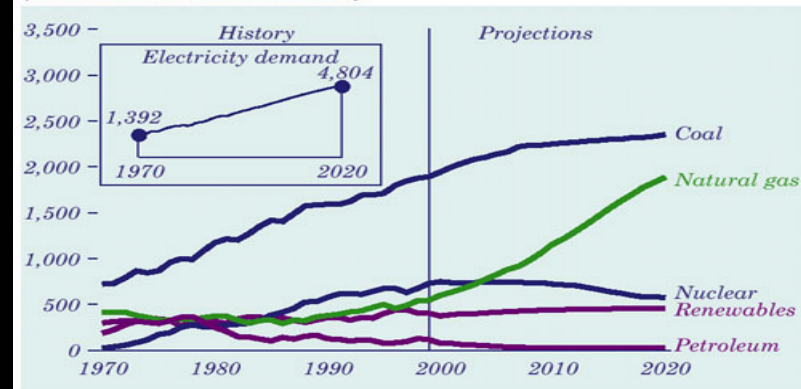
Electric generation in the US -2000

- Coal - $\sim 1900 \times 10^9$ kwhr
 - ◆ $\sim 600 \times 10^9$ kwhr for residential sector
- Gas - $\sim 500 \times 10^9$ kwhr
- Oil - $\sim 100-110 \times 10^9$ kwhr

LIC Electrical Energy Contribution

- 30×10^9 kwhr/year
 - ◆ $\sim 5\%$ of coal generation for residential sector
 - ◆ $\sim 30\%$ of total fuel oil-based electrical generation!!!
- Equivalent to:
 - ◆ $\sim 30\%$ of total Demand-Side Management (DSM) programs

Figure 4. Electricity generation by fuel, 1970-2020 (billion kilowatthours)



History: Energy Information Administration (EIA), Form EIA-860B, "Annual Electric Generator Report - Nonutility;" EIA, *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000); and Edison Electric Institute. **Projections:** Table A8.

Carbon Dioxide Emissions from Production of Electric Power



w/o MicroCHP

w/ MicroCHP



7 tons
CO₂

4-5 tons
CO₂