Residential Combined Heat and Power (CHP) Technologies – An Overview: Summary of a Panel Session Presentation

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Abstract**—Residential combined heat and power (CHP) systems are being developed using a variety of energy conversion technologies. These include conventional piston-engines with heat-recovery systems, Stirling engines, proton-exchange-membrane (PEM) fuel cells and solid-oxide fuel cell (SOFC) systems. Examples of selected systems are described.**

Governmental support for such CHP systems varies widely, from installation cost subsidies to payments per kWh exported out of a home. A basic economic analysis framework has been established, and sensitivity runs have been carried out for various capital, fuel and electricity costs.

Index Terms**—residential, cogeneration, combined heat and power, CHP, economic analysis**

I. INTRODUCTION

This panel session presentation summary provides an overview of the technologies being developed and employed in residential (single-family and multi-family) dwellings in North America, Europe and Japan.

The major barrier to widespread adoption of residential combined heat and power (RCHP) systems is capital cost. This is because residential heating systems have been highly developed, to the point of efficiencies over 90%, with reliability measured in decades, and mass-produced by a wide range of manufacturers. A representative total installed cost for a forced-air, gas-fueled heating system in the Northeast United States is on the order of $5,000. Oil-fueled systems may be slightly higher, due to the costs of an oil storage tank and associated plumbing, but this is a reasonable target cost that RCHP must compete against.

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II RESIDENTIAL CHP TECHNOLOGIES

1. Conventional Piston-engine Systems

Three well-known manufacturers of 4-cycle gasoline engines have experimented with adapting their products to manufacture RCHP systems; two of these companies now offer commercial products in the U.S. Figure 1 is an example of such a product, employed in a residential forced-air heating system.

FIGURE 1
PISTON-ENGINE OTTO-CYCLE CHP SYSTEM

2. Fuel Cell Systems

Solid-Oxide Fuel Cell (SOFC) Several companies have spent years developing SOFC systems designed for residential combined heat & power. Both tubular and planar fuel cell configurations are being explored by companies in Europe, Japan, Canada and the U.S. Prototypes have been manufactured and tested on a trial basis by a number of manufacturers, but it appears that a true commercial product is not available yet.

Proton Exchange Membrane (PEM) Fuel Cell The PEM technology has also been chosen for RCHP applications by many companies, using a variety of fuels. Perhaps the most successful venture, in terms of prototype systems installed, is the combination of Ballard (Canada - fuel cell stack) and Ebara (Japan - balance of system). The hundreds of units being tested in Japan produce 1 kW of electric power and can run on natural gas, kerosene or LPG (with appropriate reformers).

3. Stirling Engine Systems

In contrast to fuel-cell systems, the concept of a CHP system using the Stirling engine has been developed to a state of near-commercialization (some would say commercial), with hundreds of trial units installed in homes by companies in Europe and New Zealand. For greater customer acceptability, some units have been designed to look like appliances and can be installed in kitchens or other living rooms – as opposed to basements, where most furnaces are installed. Figure 2 is an example of a Stirling system designed for more-visible locations.

FIGURE 2
DEXAMPLE OF AN "APPLIANCE" RCHP SYSTEM+

+ Image from Whispergen.com web site

These three types of RCHP technologies will be discussed in more detail during the presentation,

III ANALYSIS OF RCHP SYSTEMS

A basic financial analysis has been performed to calculate the benefits and costs of a typical RCHP system versus a typical gas-fired forced-air heating system. The fundamental assumptions and parameters are shown below. With this methodology, and given reasonable data, any RCHP system can be compared with conventional fossil-fueled space heating system and domestic water heaters.

Conventional forced-air furnace cost, alone
Conventional forced-air system, installation cost
RCHP cost, alone
RCHP installation cost
RCHP rebate from a state agency (if applicable)
Other financial incentives (if applicable)
Mortgage financing term: (default value = 20 years)
Mortgage interest rate: (default value = 6% per annum)
Natural gas or oil cost at the home ($/MBtu)
Electricity cost at the home ($/kWh)
Assumed heating season: October 1 – April 30
Assumed duty cycle for heating season: 50%

IV CONCLUDING COMMENTS

Potential developments in RCHP technologies will be discussed, along with comments on the comparison of RCHP systems with high-efficiency space-heating systems and water heaters. General observations on field experience to date with RCHP systems in the National Grid and neighboring utility service areas will be provided.

V BIOGRAPHY

JOHN J. BZURA (M-1980, SM – 1989) was born in Albany, Georgia on September 14, 1944. He received the B.S., M.E.E. and Ph.D. degrees from Cornell University, Ithaca, NT, in 1966, 1967 and 1971 respectively, all in electrical engineering. In 1974, an M.B.A. degree was granted by Syracuse University, Syracuse, NY.

Dr. Bzura was employed by Arthur D. Little, Inc. from 1974 to 1983, where he performed technical and economic analyses of energy systems. He joined the New England Power Service Company (now National Grid USA Service Company) in 1983, and spent 10 years as Principal Engineer in the Demand Planning R&D Group. The last 14 years have been with the R&D / Technology Transfer group within Engineering. Projects and topics of interest include solar and wind energy systems, distributed generation (DG) technologies, DG interconnection issues, distributed energy storage, electric vehicles and broadband over powerlines (BPL).

He is a member of the IEEE Power Engineering Society, the Energy Development Subcommittee (EDS) and serves as Chairman of the Distributed Generation and Energy Storage Working Group within the EDS.