RESEARCH HIGHLIGHT

June 2005 Technical Series 05-102

Development of Micro-CHP Technology Assessment Capability at CCHT

INTRODUCTION

Recent events such as rolling brownouts in California and the blackout in eastern North America in August 2003 have raised homeowner interest in small, alternative power generation. Evolving combined heat and power (CHP) systems, such as Stirling engines and fuel cells, range from 1 kW to 10 kW. They offer opportunities for heat recovery from waste heat to provide hot water and space heating. These systems may be one way of providing backup power to grid-connected houses or primary power to remote communities where connecting to the grid is not cost efficient.

Several Canadian companies are leaders in developing fuel cells for residential CHP systems. As these promising new CHP systems advance through laboratory tests, it is important to test them in controlled, real-world situations.

Anticipating this, the Canadian Centre for Housing Technology (CCHT)[1] decided to make its twin-house research facility "CHP ready." By doing so, CCHT hopes to provide a test facility unmatched in the world for Canadian manufacturers of residential fuel cells and other residential CHP systems and give them significant competitive advantage in the global marketplace.

CCHT also hopes to provide gas and electric utilities with a facility where they can evaluate residential CHP performance to assess possible impact on energy budgets and utility distribution systems.

The project's objectives included:

- to develop and demonstrate a test facility at CCHT that can assess residential CHP systems and their integration into houses in real-world conditions.
- to quantify the performance of one early residential CHP system and examine building integration issues.
- to collect information and develop experience in installing, commissioning, monitoring and analysing the performance of residential co-generation systems.

RESEARCH PROGRAM

In early 2003, Natural Resources Canada (NRCan), the National Research Council Canada (NRC) and Canada Mortgage and Housing Corporation (CMHC) started the project.

The CHP unit chosen to adapt and test the CCHT facility was a natural gas fuelled Stirling engine. This prototype unit had a thermal output of 6.5 kW and was controlled according to the heat demand of the test house while producing a gross electrical output of up to 700 W as a by-product.

[1] The Canadian Centre for Housing Technology is jointly operated by the National Research Council, Natural Resources Canada and Canada Mortgage and Housing Corporation. This research and demonstration facility features two highly instrumented, identical R-2000 homes with simulated occupancy to evaluate the whole-house performance of new technologies in side-by-side testing. For more information about the CCHT facilities, please visit http://www.ccht-cctr.gc.ca.

Canada

CMHC SCHL
HOME TO CANADIANS

In order to integrate the CHP unit, the following modifications were designed and implemented in the test house:

- Electrical modifications so the CHP generator could provide electricity to both the house and the power grid when house loads were less than the CHP electrical output. Added components included: additional wiring, bi-directional meters, safety switches and power quality meters (see Figure 1 for a schematic).
- Design and installation of the heat management and storage system to collect, store and use heat from the CHP to meet the house space- and water-heating loads. Components included a hot-water storage tank, a hot-water heater, an air handler, pumps, piping and controls (see Figure 2 for a schematic).

The Stirling engine was installed in the test house basement and ran for 39 individual runs, each lasting one to two days, between March 13 and June 10, 2003. For each run, the CHP unit and house were closely monitored, and energy balances and system efficiencies were calculated.

FINDINGS

- The overall performance of the CHP system compared favourably with the efficiency of domestic combination space and water heaters fired by natural gas.
- Total efficiency of the CHP unit was 82 per cent, with an average 6 per cent of inputs going to electricity generation and 76 per cent going to heating.
- The heat storage and distribution system designed for this demonstration averaged 57 per cent efficiency—better optimization of the heat management and storage system may be needed to reduce standby heat losses.

Some of the issues addressed but not necessarily resolved included:

- Variability in acceptance of the concept of feeding electricity back to the grid on a micro level by local utilities across Canada.
- The cost of electrical modifications to a house (estimated to be $2,000 to $3,000).

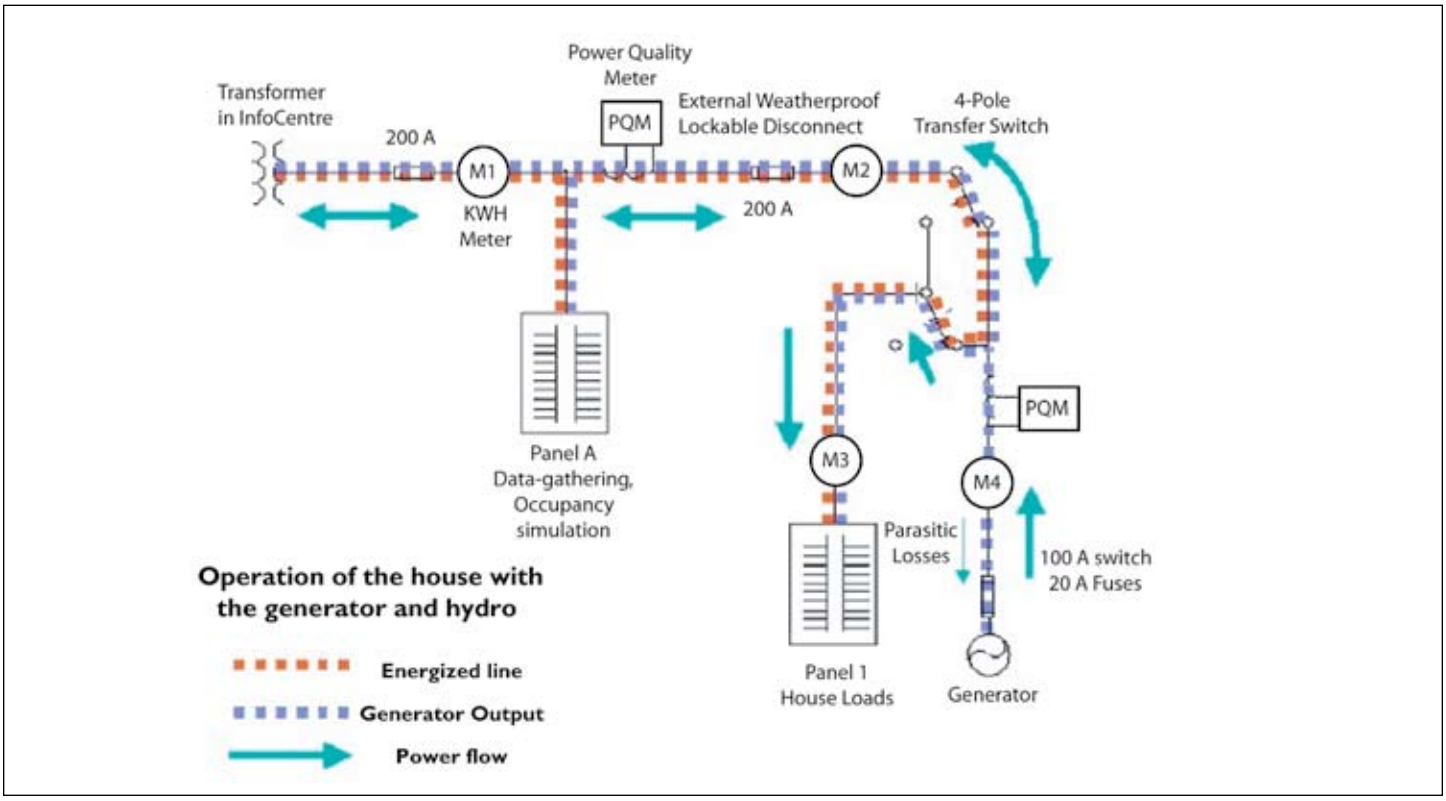

Figure 1 Schematic of the upgraded wiring and metering in the CCHT houses

- The need in the Canadian Electrical Code for an "external, weatherproof, lockable disconnect."
- The cost of the CHP unit itself—current models (late 2004) cost approximately $7,500 US.
- Issues relating to reliability, durability, and value of the electricity generated.
- Following shutdown, the long warm-up period required before the CHP unit can resume generating electricity—about 30 minutes.
- The design and control of heat storage and distribution to minimize shutdown of the CHP and maximize the overall efficiency.
- The role of a heat-driven CHP unit in the summer, when the thermal load is small and heat losses to a house are relatively high.
- Whether or not a backup burner (in the form of a water heater in this project) was needed to address all space- and water-heating loads of the house.

CONCLUSIONS AND IMPLICATIONS FOR THE HOUSING INDUSTRY

Although the Stirling engine CHP unit was installed with the primary purpose of demonstrating the test facility, its performance throughout the demonstration showed promise and merits follow-up work.

Through this project, a wealth of information and experience was developed in installation, commissioning, monitoring and analysing the performance of residential co-generation systems. With the modifications to its electrical and thermal installations, combined with the monitoring and data analysis techniques demonstrated in this project, the CCHT facility now has a proven track record that clearly demonstrates that it is ready to test a range of combined heat and power systems in residential applications and can deliver very useful performance information on the CHP unit.

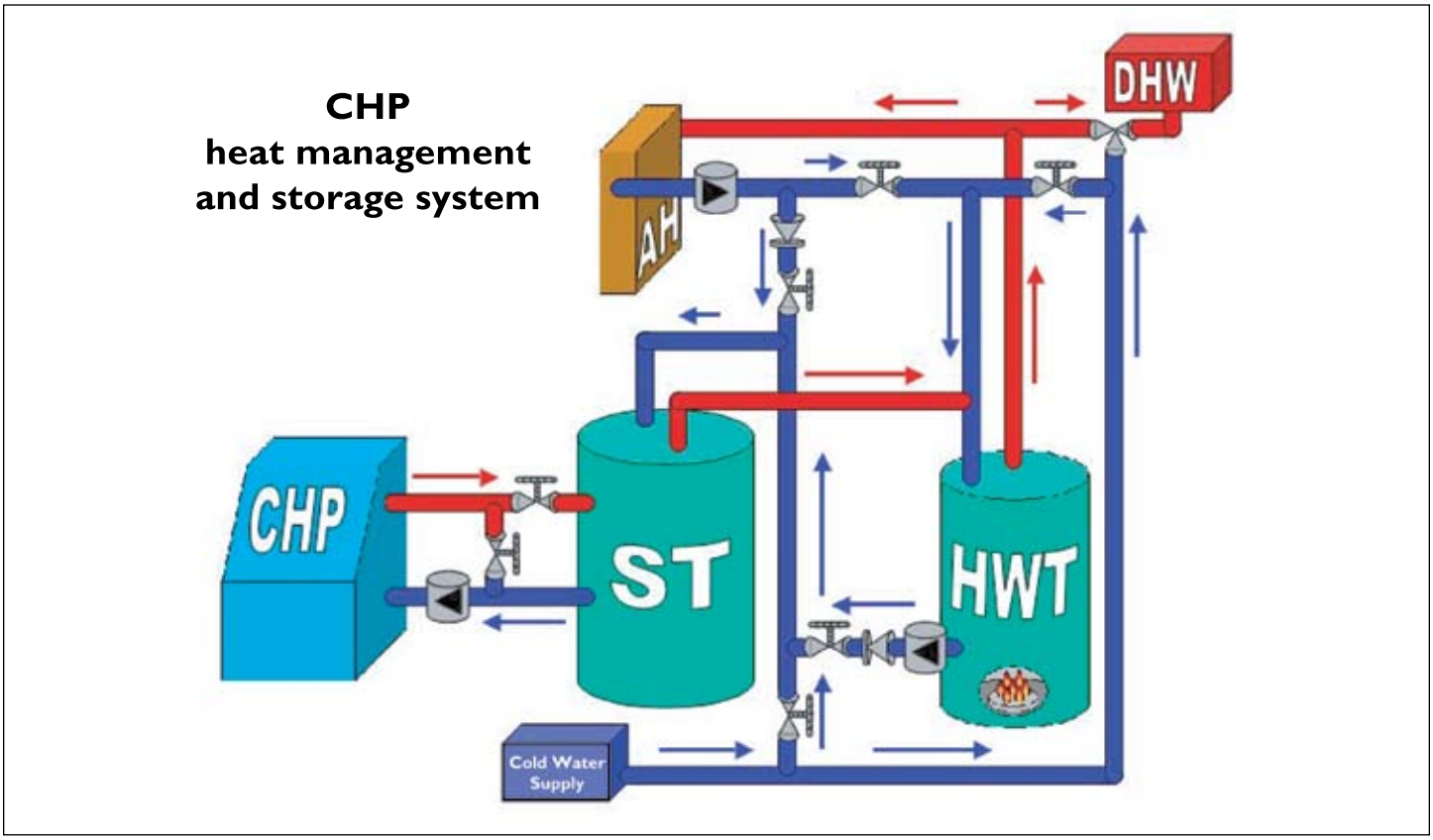

Figure 2 Schematic of the upgraded wiring and metering in the CCHT houses

The Canadian Centre for Housing Technology

Canada Mortgage and Housing Corporation (CMHC), The National Research Council (NRC) and Natural Resources Canada (NRCan) jointly operate the Canadian Centre for Housing Technology (CCHT).

CCHT is a unique research, testing and demonstration resource for innovative technology in housing. CCHT's mission is to accelerate the development of new housing technologies and their acceptance in the marketplace.

CCHT operates a Twin-House Research Facility, which offers an intensively monitored, real-world environment. Each of the two identical, two-storey houses has a full basement. The houses, 223 m^2 (2,400 sq. ft.) each, are built to R-2000 standards.

For more information about the CCHT Twin-House Research Facility and other CCHT capabilities, visit http://www.ccht-cctr.gc.ca.

Project Managers: Mike Bell, Natural Resources Canada, Mike Swinton, National Research Council Canada

CMHC representative on the CCHT Technical Research Committee: Ken Ruest

Housing Research at CMHC

Under Part IX of the ***National Housing Act***, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

To find more ***Research Highlights*** plus a wide variety of information products, visit our website at

www.cmhc.ca

or contact:

Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, Ontario
K1A 0P7

Phone: 1-800-668-2642
Fax: 1-800-245-9274

Printed in Canada
Produced by CMHC 15-12-09
Revised: 2009

63838