Canadian Net Zero Existing Homes--Understanding of Research Problem

Don Fugler, June 2007

New housing accounts for less than 2% of the existing stock annually. Over 85% of the houses that will be in use in 2050 are currently built. Across the country, the median age of the existing housing stock varies, but in general, the existing housing stock was built without much consideration for energy efficiency. As residential uses account for over 17% of Canada's national energy requirements and 16 % of overall Canadian GHG emissions, determining cost-effective ways to retrofit houses to approach or meet net zero energy requirements is a key element to both energy security and climate change mitigation.

Houses of various ages and styles pose different challenges to retrofits for energy efficiency. Some older homes have uninsulated, damp basements and other structural issues that need to be addressed. These factors will affect the approach taken and the cost of making these buildings meet a Net Zero Energy Target. Alternative strategies depending on foundation conditions will be analyzed. Variations in regional and historical construction practices and materials choices need to be taken into consideration. The historic value of buildings, particularly their street façade and appearance of character defining elements such as windows and doors will have to be accommodated. Climatic differences make getting to net zero more of a challenge in colder regions, yet these are the regions where homeowners can benefit most.

There is a basis in practical experience for the concept of high performance energy retrofitting in Canada. Work done in the late 70's and early 80's on insulation retrofitting and air sealing can be updated with new products such as spray foam insulations, liquid applied air barriers, super windows etc.. The NRC IRC small buildings research facility in Saskatoon did a retrofit on a post war bungalow during that period: this project raised wall insulation levels up to R40 and the roof to R60 as well as running a continuous air and vapour barrier around the whole building. All of these techniques could be applied to a net zero retrofit today. Indeed, one of the EQuilibrium initiative projects, the Now HouseTM a 60-year-old wartime house in an established neighbourhood in Toronto, Ontario is exploring the net zero retrofit concept. This house, which represents hundreds of thousands of homes in Canada, is being insulated to levels similar to the Saskatoon house.

2. Review data available on Canadian housing stock and its retrofit potential.

Based on past work on energy retrofits for existing houses for CMHC's About Your House series, Abri has background information on eleven typical house types from across the country. This project will build on that existing work, taking the house type retrofits from energy efficient to net zero energy. Other house types with good retrofit potential will be put forward by the project team and advisory committee. The final list of house types will be determined by the project team and advisory committee, but will not exceed eleven.

A matrix of house types, cities and retrofit options will be developed by the team. This matrix will then be evaluated according to a "decision tree" that will take into consideration affordability and restrictions on retrofit options due to house type/age/location. Following is the preliminary base of the matrix, showing proposed house types based on the "About Your House" series and six major cities across the country with a wide range of housing stocks. Each square in the matrix will end up with a coded series of potential retrofit options (see list of potential retrofit options below). Each house type will then be modelled for a Net Zero Energy Retrofit in up to six cities across Canada (not all house types will exist in all cities, based on age of housing stock and regional differences).

Because of the variation in house types, ages and locations, not all net zero energy measures can be applied across the board. The evaluation of the matrix will take into consideration such elements as the historical value of the building façade, sideyard/setbacks, zoning issues and fire separations. An example of this would be where maintaining the façade of a solid brick house precludes the installation of exterior truss walls and super insulation, making a ground source heat pump (GSHP) a better potential option. However, soil and water conditions would need to be considered. This type of house is probably of an age where the foundation is a cellar, and is therefore damp, leading to another range of decisions on basement insulation and air sealing to bring this house to net zero.

There are generally three types of net zero energy strategies: building envelope solutions, mechanical system solutions and renewable energy solutions. Each house type will likely lend itself to a particular combination of these solutions, with some regional variations. An initial list of specific measures that can be applied an existing house to reach net zero energy is identified below. The design team will review and expand this list to provide the basis for the net zero energy packages that will be applied to the typical housing types.

SUPER INSULATION
Stand off walls with fibrous insulation RSI 7 to 8.8 (R40 to R50)
Alternative stand off systems using spray urethane for both insulation and air tightness
Increased attic insulation in the range of RSI 10.56 (R60)
Interior basement insulation typically in the range of RSI 3.5(R 20)

WINDOWS
New triple or quad glazed windows
DG low e, argon filled inserts behind fixed windows
Add acrylic glazing from the interior for opening windows

AIR SEALING
Rim joists air sealed by injecting spray urethane foam
Attic penetration air sealing
Air sealing electrical and service penetrations
Continuous membrane air barriers applied over existing walls in combination with additional insulation

HEATING SYSTEMS
Passive solar space heating
High efficiency gas boiler and fan coil systems so the DHW and space heating are optimized
Air source heat pumps in coastal regions of BC
Ground source heat pumps across the country
Ocean, lake or pond-source heat pumps
(dependent on local conditions)

VENTILATION SYSTEMS
ERVs.
HRVs

DOMESTIC HOTWATER
High efficiency units combined with space heating
Ground source heat pump desuperheater
Drainwater heat recovery
Solar thermal

LIGHTING
Daylighting- window distribution, reflectivity of exterior and interior surfaces
Tubular skylights
Energy efficient lighting, typically compact fluorescent or fluorescent tune (T 8’s) (Taking into consideration latest NRCan research on baseline energy use of CFLs)

APPLIANCES
All appliances to be in the top 10% Energy Star

ELECTRICAL POWER GENERATION
Grid connected PV arrays
Micro Wind Energy Systems

COOLING
Radiant barriers, shading devices
Wind driven cross flow ventilation and night flushing
Passive solar cooling options
High efficiency ceiling fans (potentially directly PV

CMHC worked closely with NRCan to create a modified EnerGuide for Houses rating system for the EQuilibrium Housing Initiative. It would be best if all modeling was done using this modified rating system to be able to make comparisons across the board and to leverage work already done by CMHC and NRCan towards quantifying net zero energy housing. With this in mind, the net zero energy retrofits will be designed with the goal of reaching a modified EGH rating (EGH*) of at least 90. Where possible, the envelope design target will be a standard EGH rating of 82 with standard HVAC equipment and no renewable energy. All EnerGuide for Houses modelling will be done by the project team with input from NRCan's support group from the EQuilibrium Housing Initiative.

The EnerGuide for Houses database is the most comprehensive source for energy related housing information in Canada although it does not provide information on such parameters as roof slope and orientation. To compensate for this, a sensitivity analysis will be run using RETScreen, based on typical roof slopes (Flat, 3 in 12, 4 in 12, etc up to 12 in 12) and orientations (South, SE, SW, W and E) for roofs in the different cities to get an understanding of what the solar contribution could be for domestic hot water. PV arrays and passive solar heating potential can be treated in the same way with a sensitivity analysis. Base window areas and mass levels for passive solar options will be run through CMHC's Comfort Design Checker to ensure that comfort levels will not be adversely affected. Based on it's professional experience, the team will select construction materials and methods with consideration for their environmental impacts. Preference will be given to materials that have low embodied energy and pollution content and that can be locally sourced.

3. Calculate operating cost savings derived from retrofits vs. capital expenditures
As has been observed in the years between the early work in Saskatoon and the present, the amount of money that homeowners are willing to spend on energy efficiency measures is minimal in comparison to 'sexier' renovations and retrofits such as kitchen or bath makeovers. Even the carrot of lower operating costs does not necessarily change
the direction of a planned renovation. Any net zero energy measures offered up to homeowners require clearly defined benefits coupled with financial mechanisms that make net zero an affordable option.

The cost-comparison portion of the study will look at the potential for affordable solutions such as simpler, lower cost solar water heating systems that do not require purchased energy to operate. In addition, long-term energy savings devices such as drainwater heat recovery (DWHR) units will be analyzed. NRCan has recently developed an on-line energy savings calculator for these devices, which should be available to the public by July 2007. Where other energy saving calculators for specialty items or specific measures are available from reputable 3rd parties (ie, US DoE, NREL, IEA), they will be utilized by the project team.

The analysis of expenditures will include a comparison between replacing 'standard' equipment and appliances with high efficiency units (Energy Star certified or other 3rd party verification required). This cost-benefit analysis will model the difference between operating costs for a non-Energy Star appliance and those of an equivalent Energy Star unit in relation to the premium on the capital costs of the Energy Star appliance.

One issue that needs to be addressed is how households budget for retrofits and HVAC/appliance replacements. Typically, this is done on the fly or in emergency situation, homeowners lack of time for research and a good portion of households do not have a the ready cash to fund such expense. To help home owners address these challenges we believe the following issues need to be addressed if Net Zero retrofits are to become a reality
• Based on past research carried out by CMHC the Energy Service Company (ESCo) model can be applied to this industry segment but it needs to be determined whether this can be made to apply to Net Zero retrofits.
• For outlays that would impact municipal infrastructure or utility-based demand side management programs such as net metering, could utility backed funding or municipal taxes be used as household loans for purchase of super insulation retrofits or such high-ticket items as PV and/or solar thermal?
• Could CMHC provide insurance for private lenders to finance Net Zero upgrading?

• How would Net Zero retrofit relate to financing supplied by the EcoEnergy program?

A range of possible financing/funding options will be explored. Precedents for a variety of funding options and incentives will be drawn in part from the 218 US federal, state and municipal incentives that are listed on the DSIRE (Directory of State Incentives for Renewable Energy) on-line database.