Greening the Housing Stock: Comparing Retrofit and Net-Zero Homes to Reduce Carbon Emissions

By: Nick Bradley
Advisors: Jean Lavigne and Derek Larson

INTRODUCTION:
The United States housing sector accounts for 21% of total carbon dioxide equivalent (CO₂e) emissions. With CO₂ being a major contributor to global climate change, an effective way to reduce emissions needs to be developed. Two pathways that exist to combating this problem are retrofitting old, inefficient homes or building new, highly efficient net-zero homes. Both of these processes reduce home energy use and, in turn, carbon emissions. But which one not only provides the most energy and carbon savings but also represents a cost effective solution for homeowners? To determine this, I evaluated the energy savings by retrofitting or building a net-zero home in a Zone 6 (Minnesota) climate. The retrofit home is based on a 100 year old home in Saint Joseph, MN and the net-zero home is based on a home built in Esko, MN. The evaluation of these two homes will provide insight in determining what energy efficiency updates are viable and which option provides a cost effective solution for homeowners.

RANKING OF ENERGY EFFICIENT MEASURES
This chart provides the measures that should be undertaken first by homeowners in both retrofit and net-zero homes based on initial investment, payback and carbon savings.

1) Sealing Leaky Areas: From windows alone, this can save 1,501 pounds of carbon a year. With a cost of $30 and payback of 0.38 years, it is an easy do it yourself weekend project.
2) Insulation: Ranges in price from $2,050 to $13,105, has a payback of 5.5 to 14.5 years, and saves the greatest amount of carbon, 14,037 pounds to 34,468 pounds a year.
3) Exterior Storm Window: The low initial investment, at $2,371, leads this to be the third option. It will save 9,616 pounds of carbon a year and payback in 9.4 years.
4) Solar Panels: If initial investment was not as steep, this would be higher on the list. A 5 kW to 10 kW system will cost $10,700 to $16,800, pays back in 11.6 years for a 5 kW system and 9.1 years for a 10 kW system, and saves 16,640 to 33,280 pounds of carbon.
5) Water Heater: Relative to initial investment and payback, there are not significant savings to upgrading an existing water heater. It costs $1,200, pays back in 15 years and only saves 2,740 pounds of carbon a year.

Geothermal Heating and Cooling Systems:
1. Vertical Closed Loop System
2. Horizontal Closed Loop System
Both options are available for retrofit and net-zero homes depending on space.

CONCLUSION:
Through analysis, it was determined that a retrofit home provided the greatest amount of carbon savings. The biggest obstacle that existed for a new, net-zero or energy efficient home was the embodied carbon associated with its building. In order to overcome embodied carbon, the home needs intense energy efficient measures. As the home approaches closer to net-zero, the cost per square foot dramatically increases. This causes most homeowners to stop at a certain point and does not allow the home to reach net-zero; reducing the total amount of carbon savings per year. With less carbon savings, it creates a situation where it may take decades to compensate for embodied carbon. Seeing this, the old adage, “the best house is one that is already built” holds true. Homeowners should use existing infrastructure with retrofit measures to save money and reduce emissions. For this to happen, there needs to be stronger policy and incentives that facilitate the implementation of retrofit measures.

References:
http://www.energywarden.com/articles/astrategies-of-geothermal-water-heaters
http://www.greenbuildingadvisor.com/blogs/dept/musings/superinsulated
http://www.csbsju.edu/csbarchives/csbhistory/csbbuildings/offices/kinsman/pstationary2013/Geothermal_loop_options_trane.jpg
http://www.departmentofenergy.gov/environmental/energy_from_solar/solar_panel_options_for_new_homes
http://www.tuskenergysolutions.com/residential/how-to-better-energy-efficiency-of-your-home
http://www.greenbuildingadvisor.com/blogs/blogs/how-to-better-energy-efficiency-of-your-home

Table shows a summary of a retrofit and new, net-zero home. The mid level retrofit option is depicted in the chart. This chart does not take into account socioeconomic constraints of implementing retrofit or net-zero measures. But, using these two examples provides a good benchmark of the amount of embodied carbon that needs to be overcome in both a retrofit and net-zero home.

<table>
<thead>
<tr>
<th></th>
<th>Mid Retrofit</th>
<th>Net-Zero</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per Square Foot</td>
<td>$18</td>
<td>$241</td>
</tr>
<tr>
<td>Carbon Savings Per Year</td>
<td>73,614 pounds CO₂</td>
<td>68,564 pounds CO₂</td>
</tr>
<tr>
<td>Embodied Carbon</td>
<td>141,227 pounds CO₂</td>
<td>370,775 to 739,731 pounds CO₂</td>
</tr>
<tr>
<td>What is Embodied Carbon?</td>
<td>It is the amount of carbon dioxide associated with the production, transportation and implementation of a product on a home.</td>
<td></td>
</tr>
</tbody>
</table>