Progress Report No. 15
November 8, 2007
Factor 9 Home: A New Prairie Approach

1. **Short term measurement of the Drain Water Heat Recovery Unit Effectiveness**

A photo of the Drain Water Heat Recovery unit used in the Factor 9 Home is shown in Figure 1a. The unit was supplied by Watercycles (www.watercycles.ca). The main copper pipe on the unit has a nominal diameter of 3 inches (76.2 mm). The company kindly supplied an extended length unit with a length of 7 feet (2.1 metres).

Figure 1a. Drain water heat exchanger in the Factor 9 Home Basement

The potable water entering the 0.5 inch (12.7 mm) nominal soft copper piping is split into two paths to reduce pressure drop. The two paths are then

rejoined at the top of the unit. All of the waste water from the main floor fixtures passes through the waste water heat exchanger. There is a bathroom in the basement with a toilet and sink, but none of the waste water from these fixtures passes through the drain water heat recovery unit.

On August 29, 2007, a check was made of the effectiveness of the heat transfer during steady flow conditions. Temperature sensors were attached in 3 locations on the drain water heat recovery unit; two thermocouples were used to measure the inlet and outlet water temperatures of the potable water pipes and one thermocouple was attached to the 3 inch diameter copper pipe at the top of the unit. The thermocouples were attached along the pipes to minimize stem conduction errors and insulation was placed around the thermocouples.

A hot water tap in the sink on the main floor was turned on, and the three temperatures recorded until steady state conditions were achieved.

The following table presents the measured data.

Temperature of incoming potable water (^oC)	Temperature of leaving potable water (^oC)	Temperature of waste water entering top of drain water heat recovery unit (^oC)	Heat transfer effectiveness
14.7	35.4	47.2	0.64

At the time that the test was done, the flow through the potable water side of the unit was 4.4 litres per minute and the flow through the waste water side of the unit was also 4.4 litres per minute (assuming that evaporation of the water in the sink was negligible).

The measured effectiveness value was 0.64.

The effectiveness of a heat exchanger is a measure of how much heat transfer occurred compared with an infinitely long counterflow heat exchanger or “perfect” exchanger. A “perfect” heat exchanger would have an effectiveness of 1.0 (100%)

The effectiveness value of 0.64 is quite good.

A 2007 report on testing of drain water heat exchangers (Zaloum, Lafrance, and Gusdorf, Drain Water Heat Recovery Characterization and Modelling,

Final Report, Natural Resources Canada) tested 8 drain water heat exchangers. At a flow rate of 4.4 litres/minute, the effectiveness values of the various models of heat exchangers from different manufacturers varied from a low of 0.39 to a high of 0.68.

As noted in the report by Zaloum et al, the heat transfer effectiveness of the units is dependent on the water flow rate. For all of the units that were tested, the effectiveness value falls as the flow rate increases. For best performance, it is desirable that low flow rates are used. Thus, for example, low flow shower heads are very desirable from a drain water heat transfer effectiveness point of view as well as from the water conservation aspect.

Thermal Comfort in the Summer Period

In the ASHRAE Handbook of Fundamentals, there is a chart that outlines the thermal comfort conditions for both summer and winter conditions. The chart is reproduced in Figure 2.

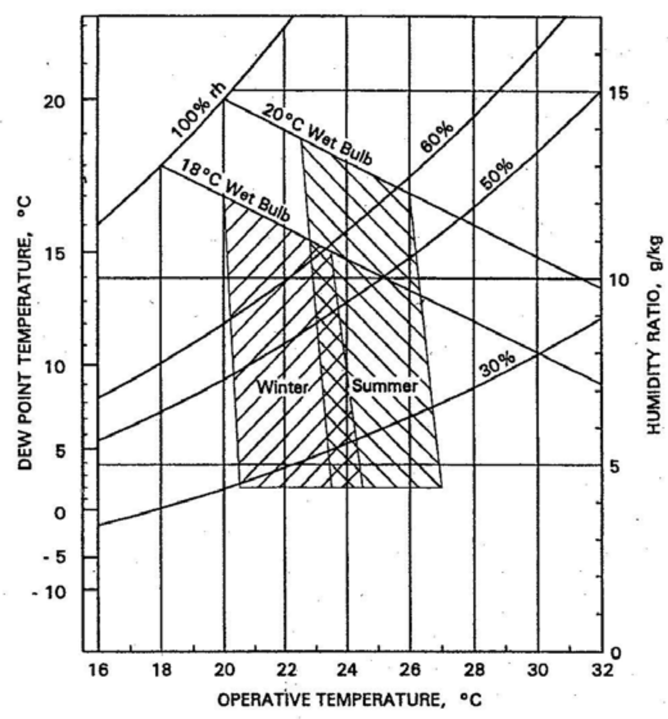


Fig. 4 ASHRAE Summer and Winter Comfort Zones
(Acceptable ranges of operative temperature and humidity for people i
typical summer and winter clothing during primarily sedentary activity

Figure 2. ASHRAE Thermal Comfort Chart

As can be seen from the chart, the acceptable temperatures indoors in the summer season range from 22.5 to 27 degrees C for typical summer clothing and primarily sedentary activity. Relative humidity is also a factor.

The acceptable interior summer relative humidity ranges between about 20% and 80% with some dependence on the temperature. Health Canada has developed “Exposure Guidelines for Residential Indoor Air Quality” and for summer conditions the relative humidity should be between 30% and 80% relative humidity. (Acceptable Short Term Exposure Range). The Health Canada Guidelines, however, do not specify acceptable temperatures to accompany the relative humidity values.

At the upper limit of 80% relative humidity in summer, Health Canada and ASHRAE are in agreement.

At the lower limit for relative humidity in summer, Health Canada recommends 30% and ASHRAE 20%. In the summer period, it is very unlikely that relative humidity values would drop below 30%.

In July 2007 Regina experienced both high outside temperatures and high exterior humidity. June had been quite a rainy month in Saskatchewan, and it is believed that the high exterior humidity was in large part due to the June rain.

A plot of the outdoor temperature measured at the Factor 9 Home is presented in Figure 3. This temperature was measured in the shade on the north side of the home under the soffit.

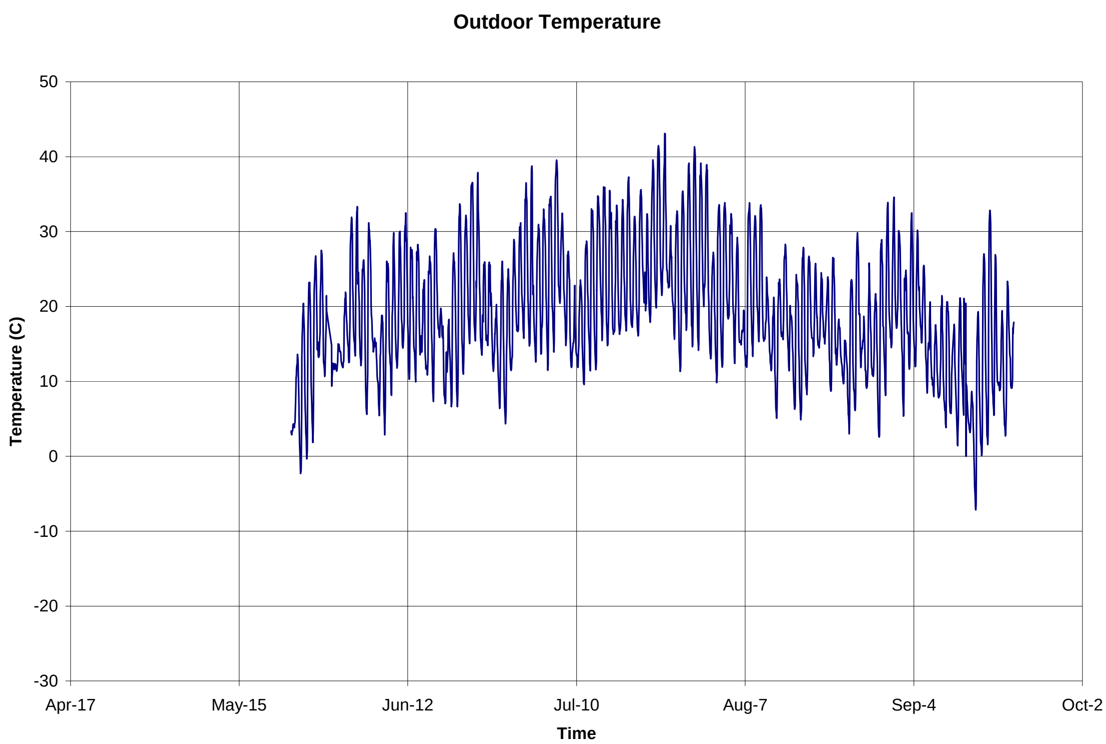


Figure 3. Outdoor dry bulb temperature

The outside temperature reached a peak of 43.0 C on July 24, 2007 at 17:00 hours.

The Factor 9 Home does not have a conventional air conditioner. In summer, the homeowners normally close the windows and doors during the day and use outdoor air cooling to reduce the interior temperature at night. As can be seen from Figure 3, the outdoor temperature will fall considerably almost every night. The warmest overnight temperature was about 22 C. (Regina, located at an altitude of 575 metres, has a continental climate with relatively large day/night temperature swings.)

To supplement the cooling provided by night flushing of the house, the house has a mechanical cooling system that extracts cooling from the ground using an array of plastic pipes embedded in the concrete pilings supporting the house. The water circulating through the pipes is cooled; this cooled water is then circulated through a fan coil. The cooled air is then circulated with a brushless DC fan motor.

A plot of the air temperature measured at the thermostat on the main floor of the house is presented in Fig. 4. For comparison purposes, the vertical scale is the same as that used in Fig. 3.

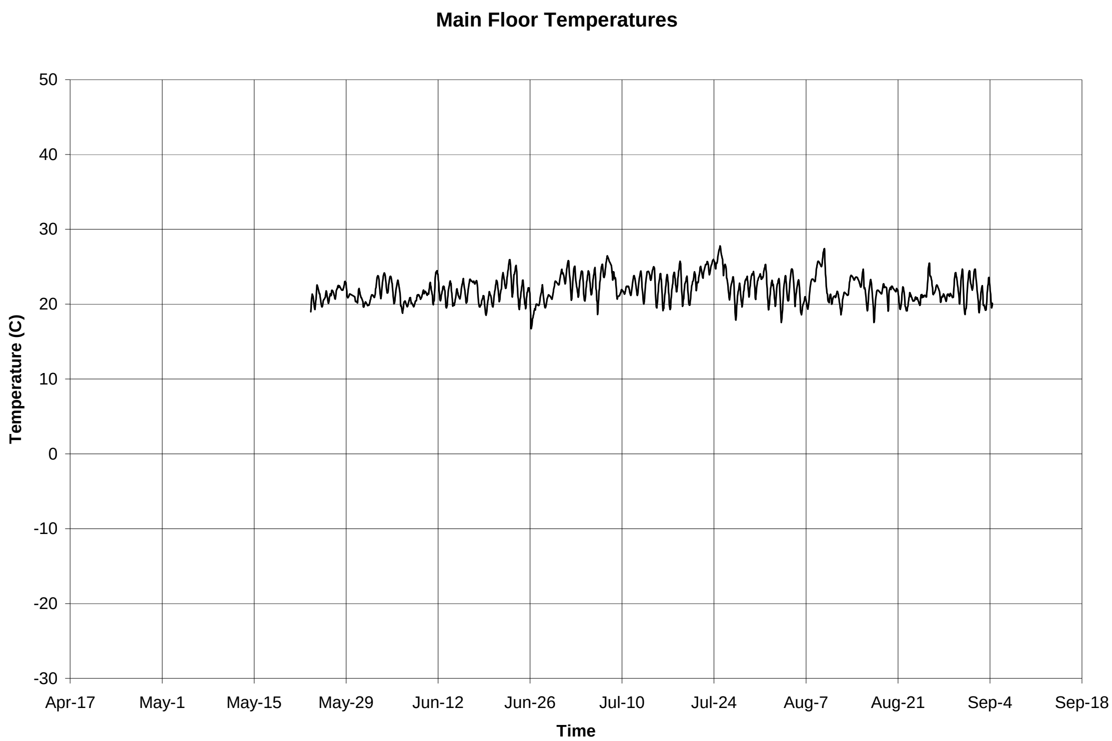


Figure 4. Main floor temperature as measured at the thermostat

During the month of July, the peak air temperature inside the house was 27.4 C at Midnight on July 24. (Note that the peak outdoor temperature was 43.0 C at 17:00 hours or 7 hours earlier on July 24.)

A plot of the relative humidity in the house is shown in Figure 5.

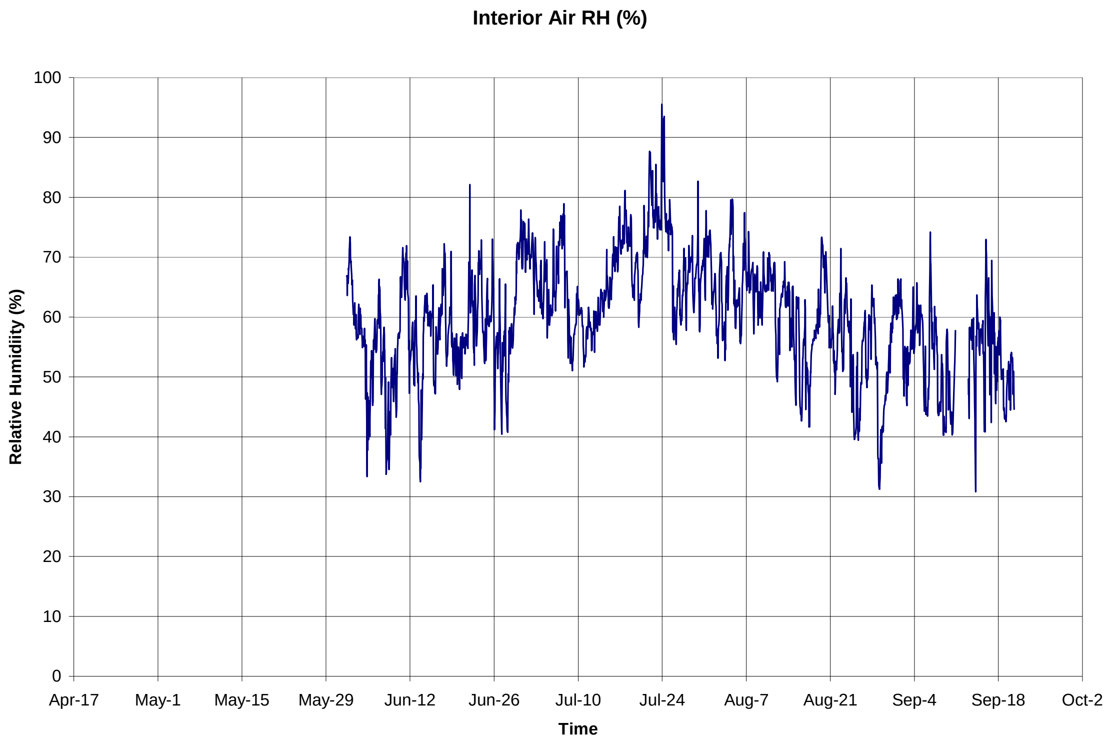


Figure 5. Interior relative humidity in the Factor 9 Home

The relative humidity reached a peak of 95.5% on July 23 at 22:00 h. As can be seen from the graph, aside for one hour in June and 14 hours in July, the interior relative humidity value was lower than the guideline of 80%. During the entire period represented on the graph, the interior relative humidity was higher than the 30% guideline. The occupants will occasionally air dry clothes on racks in the house to conserve energy, and the air drying contributes to higher indoor relative humidity levels.

Based on the measured interior temperature and relative humidity in the house, the ASHRAE thermal comfort conditions were met for almost all of the month of July.

Performance of the Ground Based Cooling System

A short term measurement was made of the cooling water temperature entering and leaving the fan coil on August 3, 2007 at 15:00 h. The entering water temperature to the coil was 12.0 C, the leaving water temperature was 18.3C. Based on the estimated air flow through the fan coil, and the temperature rise of the air through the coil, the amount of air cooling amounted to about 6000 BTU/h or 1.76 kilowatts.

A thermocouple located at the base of one of the concrete piles indicated a temperature of 5 C at that time.

The electricity used by the fan coil that distributes cooled air throughout the house is shown in Figure 6.

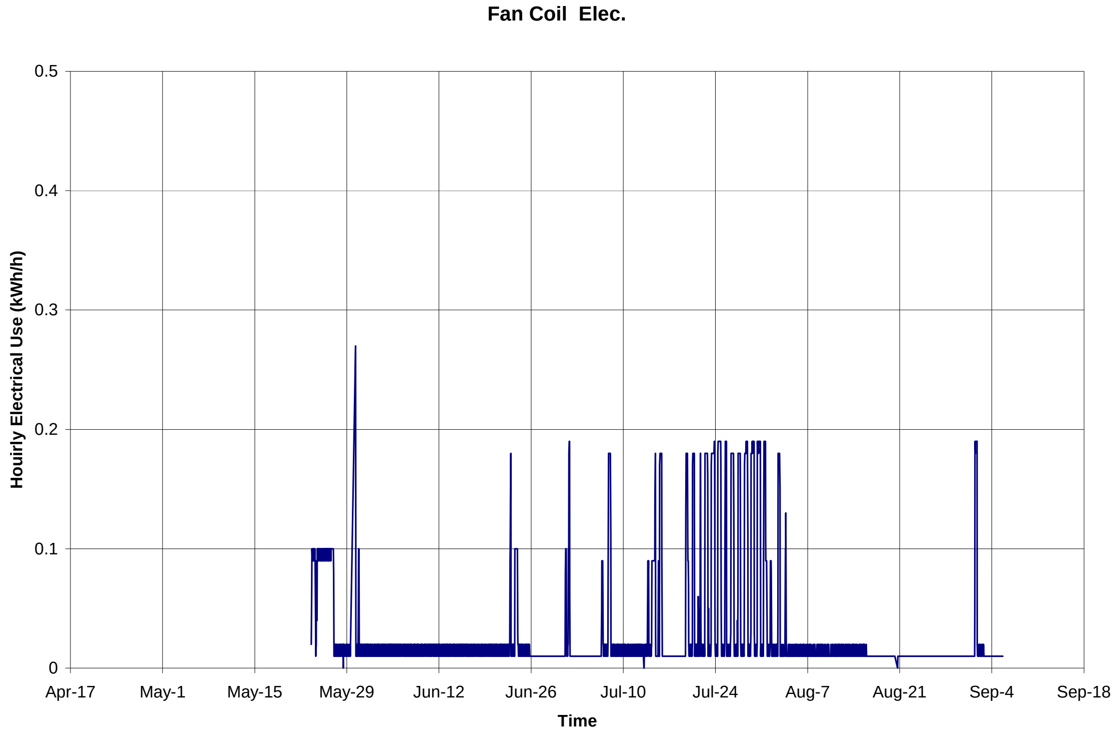


Figure 6. Fan Coil Electricity Use.

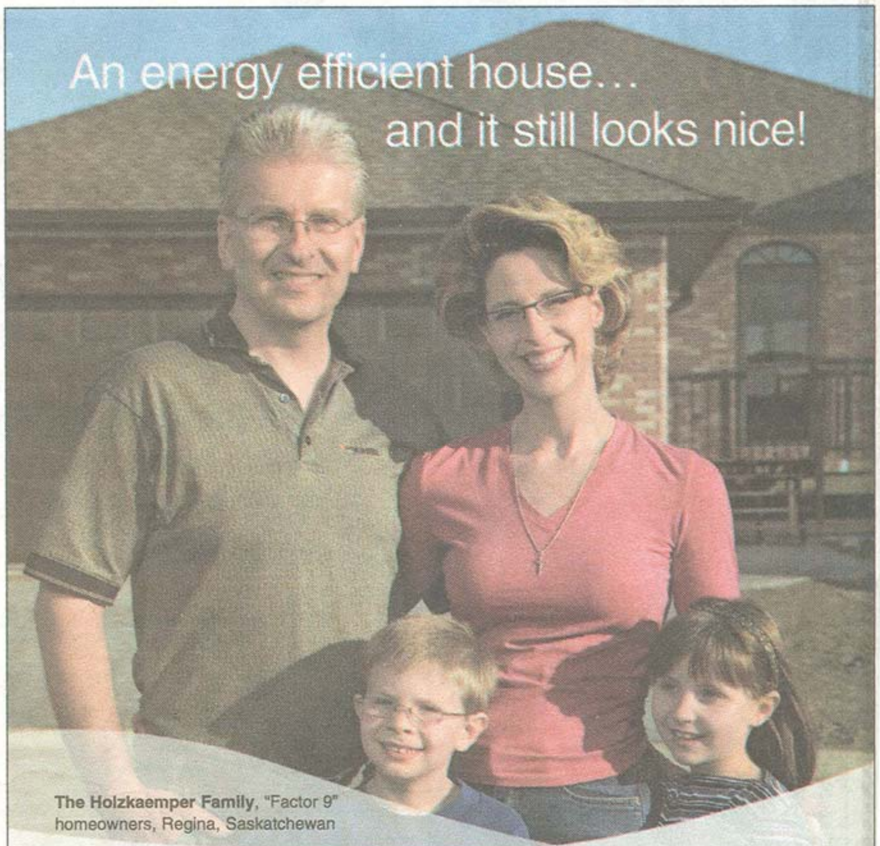
As can be seen from the graph, the fan coil was used only a relatively small amount of time through the summer of 2007, and yet the interior

temperature of the house was acceptable. During most of June and August, the fan coil was not used at all. The period between about July 20 and August 1 was the time of greatest use, which also corresponded to the highest outdoor air temperatures.
For the period from May 8 to September 30, the total electricity usage by the fan coil was 79 kilowatt hours.

There is a measurable phantom electrical load on the fan coil when the fan is not operating. As seen in Figure 6, the phantom electrical consumption varies between about 10 and 20 watts (0.01 to 0.02 kWh/h). The bulk of this electricity use is for the 24 volt alternating current transformer on the thermostat circuit for the fan coil. The phantom load at 10 watts over the period from May 8 to September 30 amounted to 37 kilowatt hours.

Publicity

On September 29, 2007, the Saskatoon Star Phoenix had a two page feature on "Going Green". The following pieces with information on the Factor 9 Home were included.



The Holzkaemper Family, "Factor 9" homeowners, Regina, Saskatchewan

The challenge was to build a highly energy-efficient house – suitable for the prairies – without creating a monstrosity. The solution is the Holzkaemper's "Factor 9" home.

Rolf Holzkaemper, who manages a building products plant, combined personal knowledge with ideas from a range of experts to create a house that uses 90% less energy than homes built in the 1970s.

"You can get to this level without a great deal of difficulty or added expense," says Holzkaemper. "It's a realistic target."

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Saskatchewan's GREEN STRATEGY

SASKATOON STAR PHOENIX
SEPT. 29, 2007

GOING GREEN

Look to the sun

❑ Solar power affordable for certain applications

By Karen Brownlee
CanWest News Service

REGINA — Will Odie knows that when his phone rings, he will likely have some explaining to do.

Odie works at Kelln Solar in Lumsden, Sask., one of the first companies in the province to offer solar energy technology more than 20 years ago.

"I get calls all the time from people saying 'I want to solarize my house.' I don't know if that's a word in the English language yet, but it's pretty common usage," said Odie. "Their first thought is solar electric."

But Odie has other options he'd suggest. He wants to encourage their interest in this clean and renewable energy source for their homes, but solar electricity and the size of the photovoltaic systems needed to produce it are not what he would have homeowners invest in first.

When Odie explains that producing solar electricity costs about $7 per watt per solar panel — and when one considers a 60-watt light bulb uses 60 watts per hour — callers are surprised. When Odie tells them the average household uses about 25,000 kilowatts per day, that surprise turns to shock. Paying upwards of $40,000 to $60,000 to power their home with solar electricity (if it's not connected to a utility's power grid) is not what they had in mind.

Odie would suggest less expensive and more efficient alternatives. For instance, while solar water heaters aren't inexpensive at $5,000 to $7,000 when installed in one's home, Odie said government programs, such the federal government's ecoENERGY retrofit program for home owners, as well as provincial ones where they are offered, can help.

The systems pay for themselves in seven to 10 years, Odie explains. When such a system is used to heat pool water, he said the payback is even faster.

There are also solar space-heating systems, but Odie would start with water since it is used year-round while heat is only needed in winter.

But even before considering this technology, Odie thinks more Canadians need to think about how and where their homes are built.

"The most cost-effective way of using solar is passive solar," Odie says. This includes building better houses, and orienting them so that many of the windows face and perhaps an expanse of the roof face south for maximum sun exposure. That way, he says, "if you aren't adding active solar systems now, you can add them later."

"As individuals, there are decisions we can make that still have an impact in our lives," said Odie.

When building his new home in Regina, these are things Rolf Holzkaemper considered and implemented. His house was designed to actively and passively use solar energy. Beyond his south-facing back wall with windows and panels covering it and the entire brick exterior, his house doesn't look much different than those of his neighbours.

On the back wall, the centre row of panels have glycol running through them. It passes into his basement, where the heat is used to warm the family's water. That warm water is used, in part, for space heating. Water goes through a fan coil unit (which replaces the need for a furnace) where air is blown over the coil and then through the duct work in the bungalow.

The windows in the back of the house are double-paned with a particular glaze to allow more heat in, while windows in other parts of the house are triple-paned to hold heat. In fact, the systems in his home produce enough heat that he can use the excess to warm his garage and even his sidewalks and driveway.

"When you think of all the energy around us that we always let pass by while we find other ways to get our energy, it seems like a waste," said Holzkaemper, who spent six months designing his home and another 11 building it before moving in this May.

Jeff Knapp, Natural Resources Canada's "solar chap," explains why the federal government is focused on solar heating. There are significant environmental benefits to solar electricity, such as reducing the need to expand power generation facilities and grids, he said.

But to get Canadians to embrace solar as a source of energy, he agrees with Odie that solar heating is the place to start.

"If you put in a solar water heating system, that investment will pay you back in — depending on the project and how much work you're able to do yourself — anywhere from five to 15 years," said Knapp. "We're looking at a return on investment somewhere between seven and 18 per cent.

"On the best end of it, it's like a good mutual fund and at the worst end of it, it's like a reasonable mutual fund."

—CanWest News Photo

Rolf, Paulina, Shannon and Rolf Jr. Holzkaemper stand outside their home which has the whole south side exterior covered in solar panels

Next steps

Once the heating season starts and the house windows are closed for the winter, indoor air quality testing for volatile organic compounds, formaldehyde and radon will be conducted.

Monitoring of the house using both manual readings and the data logger will continue.

Acknowledgments

The Factor 9 Home: A New Prairie Approach could not have been developed without the strong support of its sponsors: Communities of Tomorrow, The Office of Energy Conservation of the Saskatchewan Government, Saskatchewan Research Council, Natural Resources Canada, and Canada Mortgage and Housing Corporation.

Partners include the University of Regina and the City of Regina.

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Special thanks go to the homeowners, Rolf and Shannon Holzkaemper.