Mr. Rob Dumont, building scientist with the Saskatchewan Research Council (SRC)

Abstract: Mr. Dumont shared the story of the Saskatchewan Research Council (SRC's) journey to build a "net zero" energy home – super insulated, efficient, and producing the amount of energy it consumes. Four examples of cold climate homes were presented along with their energy saving features with an emphasis on insulation and building envelopes. The presentation included construction and energy costs and their overall energy performance. He concluded with the challenges for building net zero homes and the issues that need future research.

Mr. Dumont's presentation "On the Road to Net Zero Energy Homes in Cold Climates: Canadian Prairie Contributions" began with a comparison of the climates in Saskatoon, Canada to Fairbanks, Alaska. Fairbanks is colder (41 below compared to 31 in Saskatoon) and has more heating degree days (13,980 compared to 11,000 in Saskatoon.) Saskatoon also has about 50% more annual solar radiation on a horizontal surface (5.0 Gj/m^2 compared to 3.3 Gj/m^2 in Fairbanks.) That said, it is still a harsh northern climate and thus comparable.

He showed examples of cold-climate low energy houses: First, the Saskatchewan Conservation House, a "super insulated" home built in 1977 in Regina, Saskatchewan. This home experimented with many "firsts," installing R60 attic, R-44 walls, R-60 basement walls and R-30 basement floor insulation. It has vacuum tube solar collectors on the south side with a 2,900 gallon storage tank in the basement to store for heat, insulating shutters on south windows that come down at night, a grey water heat exchanger, and Canada's first air-to-air exchanger. It was built on pilings due to terrible clay soil conditions. Clay will move around and push on standard foundation systems. This home was very influential in helping people to understand the benefits of having a well sealed building envelope and good ventilation.

They learned the passive features worked very well as the space heating loads were provided on most days by solar gains as well as heat from lights, appliances and pumps. The house needed heat from the solar collectors for only two hours in a three day period where the temperature ranged from 15 - 32̊ F. They learned that features such as high insulation levels, good air tightness, and passive solar design all work well together and are low maintenance. They learned that ventilation is very important. Homes need about 60 cfm (or 30 L/s) of outdoor air exchange to control moisture, carbon dioxide, volatile organic compounds (VOC) and odors. They learned that heat recovery is very important in a low energy house to keep heat costs low but maintenance must be done. Providing 60 cfm of ventilation when the air outside is -31 F (-35C) requires 2 kW of heat to compensate for heat loss in ventilation systems without heat recovery. It's also important to use low energy lights and appliances as electricity for appliances is more expensive that energy for space heating. A mantra that evolved was insulate first, then insolate (use the sun) second. They found the exterior movable insulating shutters would rattle and shake the house in high wind situations and that moving parts fail. They also found that the vacuum tube solar panels had a number of serious problems:

- Snow would collect on the outside of the individual tubes and not melt or slide off
- In a power outage on a sunny day, the glycol mix would boil and cause a vapor lock, effectively shutting down the collectors

- The pressure drop through the collectors was high, requiring a high wattage pump to circulate the anti-freeze solution
- The manufacturer stopped supporting the collectors, and then stopped making them.

Overall, Mr. Dumont advised to keep it simple, passive is better than active and to remember that moving parts will fail.

The second example was Mr. Dumont's own residence built in Saskatoon 1992. When built, it was called "the best insulated house in the world" with an R80 attic, %-60 walls and basement, and R-35 basement floor insulation. He used about 8 tons of cellulose insulation throughout the house. He used high performance, triple glazed, low-e, argon gas filled windows with wood framing and non-metallic spacer bars. The home is well sealed and utilizes passive solar south windows, and active solar thermal collectors with a 3,000 L water heat storage tank. They incorporated the solar into the design of the house, putting them on angled overhangs that provided shade for the windows in the summer. He used small windows on the north side with shutters to give them a bigger appearance. He has an 85% efficient air to air heat exchanger using brushless DC motors, energy efficient appliances using a "green plug" device on the refrigerator and freezer that lowers the voltage by about 10 - 15%, compact florescent lights (CFL), low water use in appliances and landscaping and a detached garage (to keep garage fumes from entering the house) that is sloped and ready for photovoltaic panels. They did a feasibility study to see if they could make a better "net-zero" home by reducing annual energy consumption of the Dumont residence from 13,500 kWh/year to 5,000 kWh/year by improved appliances (more energy efficient), windows (bigger south facing and smaller north facing), improved solar thermal collectors and a 5kW photovoltaic system.

They learned that the insulation and passive features worked well but a greater passive solar gain could be achieved with bigger south facing windows with better low e coatings and gas fills. They learned that when designing a house you should always design the roof to be "solar ready" to install a photovoltaic system when affordable. Also more energy efficient appliances would be helpful. Most windows manufactured in the U.S. are made for the "sun-belt" and have a low transmission of solar radiation into them (as southern homes would want to block passive heat from entering the home). He found the best northern windows in the world to be the made by a company in Ottawa called Thermotech. They have a high solar heat gain factor, small window frame, better low e coatings, etc. Mr. Dumont discussed embodied energy (the energy required for resource extraction, transportation, manufacturing, etc. to make a material.) Wood buildings use about one half to one third as much embodied energy as steel or concrete buildings. Wood is about 50% carbon, almost all of which is extracted from the atmosphere. The Dumont residence used natural materials over synthetic or conventional (cedar shakes vs. asphalt, wood frame windows vs. vinyl, wood walls vs. concrete, cellulose insulation vs. fiberglass, wood floors vs. carpet or vinyl, etc.)

The third example was the "Factor 9" home built in 2007 designed to use 90% less energy and 50% less water than a conventional home. Water in Regina comes from about 400 miles away from the Rocky Mountains. This home uses solar thermal panels set at the mid-height of the south wall (and look like windows) and spandrel glass panels as well as a 2,400 L heat storage tank. They used insulated brick exterior walls. The home has a rainwater catchment system for toilets and irrigation with the rainwater stored in a plastic cistern in the basement, and extraction of cooling from 15' deep buried pilings with a liquid pump. The home has R-80 attic, R-34.5 walls, R-50 basement walls, and R-11.4 basement floor insulation. They used passive solar space heating through south facing windows, and orientation of roof for south facing photovoltaic panels. The home uses the Energy Detective, a monitoring device that lets the owner know how much energy is being used by the various appliances and equipment. The home has energy star appliances, CFL lights; drain water heat exchanger, air to air heat exchanger, and a fan coil with brushless fan motor.

The fourth example is the Riverdale Net Zero Duplex currently being built in Edmonton, Alberta. This home uses double 2x4 construction with blown cellulose R-100 attic, R-56 walls, and R-24 basement floor insulation. They are using "value engineering" techniques using less lumber than a standard 2'x 6' wall 16" on center. The windows are triple (south) and quadruple glazed windows with low e and argon gas for passive solar space heating. The home has active solar thermal for water heating and photovoltaic for electricity generation using high efficiency Sanyo panels that can capture solar radiation on the back side of the panels as well.

The R100 attic wound up being that level of insulation because they kept increasing the insulation level until they achieved the level needed to save one annual kW of energy was equal to the cost of producing one annual kW/h of energy with PV panels. The home also has energy star appliances, CFL lighting, drain water heat exchanger, air to air heat exchanger and a whole house electricity monitoring device. The home is projected to have a net annual energy consumption of zero due to the grid connected PV system generating enough energy in a year to compensate for all the purchased energy used by the house.

The following table summarizes the energy savings and costs of the four homes:

House	Purchased Annual Energy (kWh/m^2)	Insulation R-Value*				Incremental Construction Costs** (excluding land)	Energy Performance (energy consumed Btu/ft^2)
		Attic	Walls	Basement Walls	Floor		
Saskatchewan Conservation House (1977)	76	60	44	44	30	unknown	24,100
Dumont Residence (1992)	47	80	60	60	35	7%	14,900
Factor 9 Home (2007)	30 (projected)	80	34.5	50	11.4	12%	9,500
Riverdale Net Zero Home (2008)	0 (projected)	100	56	56	24	35%	0 (projected)
*Canadian Code for attic insulation is R-40 **Estimated incremental cost of about $100K, mostly due to cost of PV and active solar systems							

Some may say that so much insulation will drive up the cost of the house. Currently homes in his area cost $150 per square foot to build, whereas the cost of the R-100 insulation was only $2.50 per square foot, a nominal extra cost for such potential savings. Mr. Dumont concluded with a discussion of the challenges and lessons learned building net-zero energy homes. He mentioned two challenges: 1) the costs of energy efficient products and systems make the homes more expensive to build, and 2) society needs to pay the real value of carbon emissions. The biggest lesson learned was the importance of developing an integrated design – one in which the entire building is designed as a system and not as a group of unrelated components and which considers the building envelope as the central part of the design. When energy conservation measures are used in the building envelope, in addition to lowering fuel and energy bills, they can also reduce the capital cost of a heating system by reducing the size and complexity of the system. In milder areas, you can build these cold climate houses and eliminate the need for a heating system even. He emphasized the idea that it is more cost effective to put money into improving the building envelope that into heating systems – Insulate! Insulate! Keep it simple!

Mr. Dumont concluded with a discussion of issues needing more research:

1. Improved reliability of heat recovery ventilation systems (air-to-air heat exchangers) that have reduced maintenance requirements and reliable defrosting in cold climates. The energy costs to run some heat exchangers (50 – 200 watts of electricity) are higher than the heat energy saved, so they need energy efficiency improvements.
2. Improved efficiency refrigerators and freezers, better insulated and low cost.
3. Reduced phantom loads from electricity leakage.
4. Integrated windows and photovoltaic systems
5. Passive solar access through street orientation for housing developments

The panel session concluded with a question and answer period:

Question: Is research being done on window shutters? Did (Chris Ives') window shutters work? Why did (Rob Dumont's) shutters fail?

Answer: (Rob) There are books out there such as "Thermal Shutters and Shades" by William Shurcliff and another by an architect in South Carolina. To his knowledge though, no one is researching this – exterior shutters are expensive, need to be well sealing to be of any value, and moving parts do tend to fail in time. He thinks shutters are better used for sound control and excluding solar reflection during the day. Chris Ives said that he knows of a renovated old 1778 building in Nova Scotia that used windows with shutters on the inside. Also the home he grew up in had interior shutters. Rich S. disagreed saying that interior shutters would create problems in cold climates as they would create a vapor barrier of sorts leading to moisture and ice buildup on the windows. It would be okay in milder climates. A great thing would be a functional, retro-fittable, durable, affordable shutter that would work here in cold climates would make solar heating feasible as it would make the window a wall when it doesn't need to be a window. 71% of solar radiation here at this latitude comes between March 21st and December 21st. We have a tremendously unequal distribution of solar radiation.

Question: (directed to Dan White) as a student – when will the technology presented at this conference be available on campus and what student opportunities are there at UAF to learn about them?

Answer: (Dan) UAF campus is doing research on energy issues, like Ron and Rich and others. There is much infrastructure there and opportunities for students.

Question: Are wood basements banned? How long do wood houses last compared to brick buildings?

Answer: (Rob) knows of a wood house built in Oslo in 1200 that is still standing. Wood can last hundreds of years if maintained properly. As for wood foundations – they must be kept dry below 20% moisture content. Wood uses less embodied energy than producing bricks. The concrete industry, due to the endothermic reaction in making concrete, is the single largest carbon dioxide producer in the world and requires a lot of energy to make. An Alberta study showed wood foundations, if built properly, didn't need to use pressure treated wood (although he was skeptical of that conclusion!) Ron added wood increases fire potential depending on where you live (such as forest fire areas).

Question: Wouldn't using all-wood mean cutting down the forests? What about composite materials?

Answer: (Rob) to be sustainable, we can't continue extracting finite resources. Wood is renewable and fixes carbon. Also there is a problem with vinyl siding; it damages easily, especially in the cold. Stucco being mostly concrete and sand also have very high greenhouse gas emissions.

Question: European technology is ahead of the U.S. They have shutters that operate on solar that roll up and down like a garage door. They go down in summer and up in winter. He asked builders in Europe if they had a problem with icing and they said no.

Answer: (Rich Siefert) they aren't good. People have tried them here and discovered they failed. The trouble is the word doesn't' get out. Failures aren't publicized, only successes! I don't see the insulating value – they're just plastic. I don't see the foam injected shutters. Moving parts fail. Aluminum shutters would be bad due to high thermal conductivity. If it was an easy problem we would have solved it by now. (Oliver Drerup) I believe there is a shutter study going on right now in Canada by the National Research Council (NRC). They studied interior shutters last year and will study exterior shutters next year so we will have data soon.

Question: (directed to Dan White) you referenced the development of the "hot belt" of geothermal in the Aleutian Islands. The Natural Step philosophy is that we shouldn't use materials that come out of the ground as much. The Inuit's are very concerned about mining operations and the opening of the NW passage. So why is it a good idea to encourage the development of an industry that causes environmental damage in an environmentally sensitive region of the world?

Answer: (Dan) it's our responsibility to look at ways that it can be done sustainably. Geothermal causes no carbon dioxide emissions and is entirely responsible. Why not do it? The issue of land rights and development are valid issues and need dealt with, but from an engineering standpoint it can be done sustainably.

Question: I just want to encourage everyone here to look up two promising products called Grancrete and Ceramcrete – geopolymers and magnesium phosphates that will have a huge impact on the concrete industry. He thinks the “giant” Portland cement industry is keeping them from coming to the market. All are based on materials readily available such as ash instead of gravel.

Answer: (Chris Ives) – has heard of compressed air blocks such as used in Shanghais, China and the Botanic Gardens in Montreal. Some blocks have water damage but some look very good.

Question: (directed to Dan White) Explain carbon sequestration of CO2 in rocks?

Answer: (Dan) CO2 is pumped into the subsurface where it forms a carbon substance film on the rock surfaces. Rich S. suggested reading the book called “The Solar Hydrogen Civilization” by Roy McAlister on harvesting methane hydrates from the ocean using CO2 as a base raw material for development of carbon fiber materials. (Ron) Another thought is to store hydrogen energy with carbon nano-tubes.

Question: Does it take more energy to produce a solar PV panel than it produces?

Answer: (Rich) that has been a recurring lie and it is not true. (Ron) depending on the solar construction but typically solar PV has a 2-5 year payback period.

Question: For heat exchanger improvements, what “state-of-the-art” component did you put into the Factor 9 house and how did it compare as far as seasonal effective and energy consumption?

Answer: (Rob D.) The best units are 80 – 85% heat recovery. A 15 watt unit was invented by increasing the spacing between plates, using DC motors, and fans with a backward curve and airfoil blades. Also has heard of a 20 watt unit being produced in Germany. (Chris Ives) the “breathing window” heat exchanger in my presentation uses 17 watts.

Question: How much diesel could be saved using wind turbines such as the Kotzebue Wind Farm?

Answer: Kotzebue is a good example of a village system that saves hundreds of thousands of dollars a year in fuel oil costs and has reduced the energy load by about 20%. Brad Reed has been an Alaska pioneer in wind energy and the Alaska Energy Authority is also a big driver behind this. Wind has also become a lot more economic and efficient. The problem with wind is economy of scale – manufacturers focus on multi-mega watt turbines which are too big for villages which need only 50-100 kW.

Question: What are the comparative costs of a wind vs. a coal vs. a diesel plant?

Answer: Figure $1000 per kW for an older coal plant. Big wind turbines are $1000 a kW as well. That depends on the site (how much wind is available) and how big of a turbine and facility is needed. Also a village will need to build a facility. The cheapest is to buy a used turbine system. You can buy a diesel generator for a lot less, but then have to deal with fuel spills and fuel price increases.

Question: What about heat sinks (heat pumps)? I have heard about places in Minnesota with them that claim 50 – 90% heat savings. That seems high. Is it true? Are any Alaska studies going on?

Answer: (Rob) Most electricity in Alaska is generated by natural gas (in Anchorage) or diesel (in rural areas) at 30% efficiency generally. Ground source heat pumps give you no savings (3% or less) when the cost of the electricity to run the pump is nearly equal to the energy produced. Electricity in Alaska is high because it's produced from fossil fuels. They make more sense in places where electricity is cheap. Also they are expensive (some can run $15,000-$25,000.) Rather than spending money on a heat pump, use it to improve/insulate your building envelope.

Question: I didn't hear talk on how to retrofit septic systems in Fairbanks, Alaska. I've heard of people using buried cars for septic systems! What sustainable systems would (Dan White) recommend?

Answer: There are many good conventional designs. You can't install them in permafrost. There are innovative waste technologies that can be put inside a house. A local company called Lifewater Engineering makes them and has installed one at the Cold Climate Housing Research Center. (Chris) knows of a company called Eco-Septic that makes an 8'x8'x8' and a 4'x8'x8' system where the water is re-used for toilets and such and not discharged to the outside.

Question: Have you experimented with wetland wastewater treatment?

Answer: (Dan) Yes. The challenge with cold temperatures is keeping enough wetland thawed to treat the wastewater. More commonly done is to store wastewater in a lagoon until the wetland thaws and is able to treat the wastewater in a metered fashion through the wetlands. They are often used in summer camps here in Alaska.

Question: If the building envelope is good but needs supplemental heat, are there any good floor heating systems available to use until solar becomes economically available?

Answer: (Ron) Consider the capital expense to build a big enough tank to store solar thermal heat for winter use. It can be collected and stored in a tank under the house. (Rob) What is recommended is one gallon of storage per square foot of thermal collector. The problem is heat loss from the tank – 60% is dissipated. With bigger tanks, less percentage gets lost but bigger tanks cost more money. There is a study going on in Alberta on storing heat in the ground but again the problem is heat loss into the ground. Also they are expensive – he thinks around $125,000 per house. Think about using that money to improve the envelope. (Jack) CCHRC will be doing a study on solar thermal soon that will be well instrumented and viewable on our website. Rather than looking for one large solution, it is our contention that a number of smaller systems are the way to go. Also our waste water is monitored. We also plan to design a foundation module that incorporates wastewater treatment, water recycling, potable water, and the mechanical systems in a small modular, adjustable system that can be heated.

Question: Mr. Ives mentioned some areas with solar heat are storing the heat in silt and use heat pumps to retrieve it. Is anyone doing that around here?

Answer: (Rich) Alaska has loess so that wouldn't work here. (Chris) I can only point to the Dutch green house concept where the heated water is stored in aquifers underground. (Rich) Here the aquifers are way deep or else too close to the surface which wouldn't work because the water would just go into the ground water table. It's much easier to transfer heat from water than from soil. Insulate instead!!