The Factor 9 Home: Reducing Energy Consumption by 90%

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Green Building Festival, Toronto

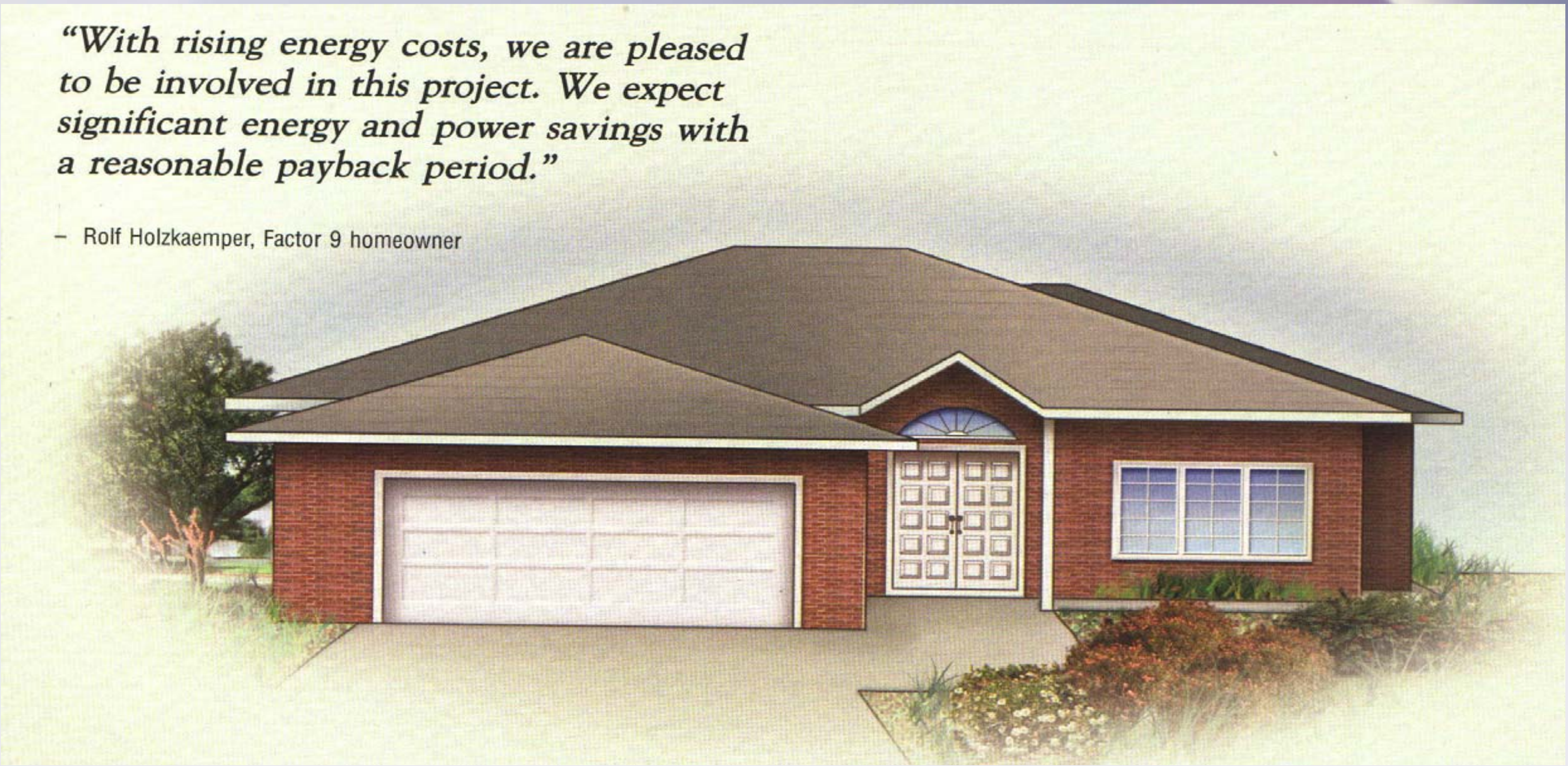
September, 2008

Toronto Healthy House 1994

- Unconventional appearance, high performance

Factor 9 Home 2007:

- Conventional appearance, high performance




An energy efficient house...
and it still looks nice!
7335
Saskatchewan's
GREEN STRATEGY
Saskatchewan
saskatchewan.ca
CBS

Factor 9 Home: What Is It?

- A new Demonstration home built in Regina
- A home that is projected to use ***<u>90%</u>*** less energy than a conventional 1970 home of the same size
- A home that is projected to use ***<u>50%</u>*** less water than a conventional home of the same size
- A home that will feature other environmental approaches

A Few Words About the Regina, Saskatchewan Climate

- Annual average outdoor temperature in January: -17 C
- Annual hours of bright sunshine: 2300 53% of possible
- Annual Solar Radiation on horizontal: 5.1 Gigajoules/m2
- Annual Solar Radiation on S. Vertical: 4.9 Gigajoules/m2
- Outdoor Design Drybulb Temperature for Cooling Systems in Summer: +31 C Wetbulb: +21 C
- Annual total precipitation: 365 mm

In other words…

- Continental North American Climate
- Very cold in winter
- Long winters (snow on ground for about 5 months each year)
- Sunny
- Short but relatively warm summers
- Modest annual precipitation

North Side: Factor 9 Home

Why Factor 9?

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- This is the number that one arrives at when looking into the future of what the energy use of homes and other energy using devices should be for the world to be sustainable.
- Future world population growth: Factor 1.5
- Future world consumption growth per person: Factor 3
- Future reduction needed in world GHG production: 2
- 1.5 x 3 x 2 = **9**

Factor 9 Home Under Construction in Regina, Saskatchewan

- August 3, 2006

Design for the Factor 9 Home

Key points:

- ➥ 1. Integrated design
- ➥ 2. Value engineering
- ➥ 3. Energy Conservation
- ➥ 4. Renewable Energy Use

Integrated Design

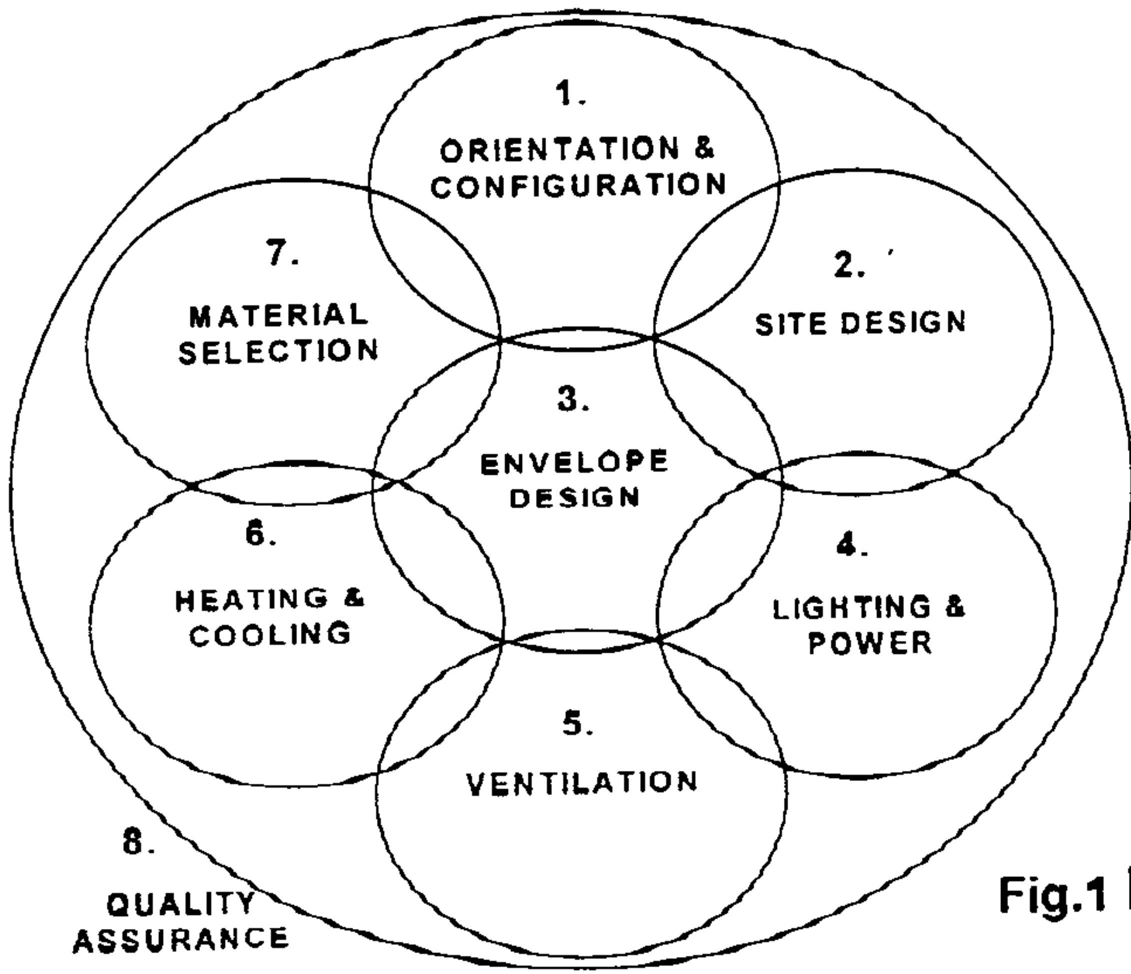
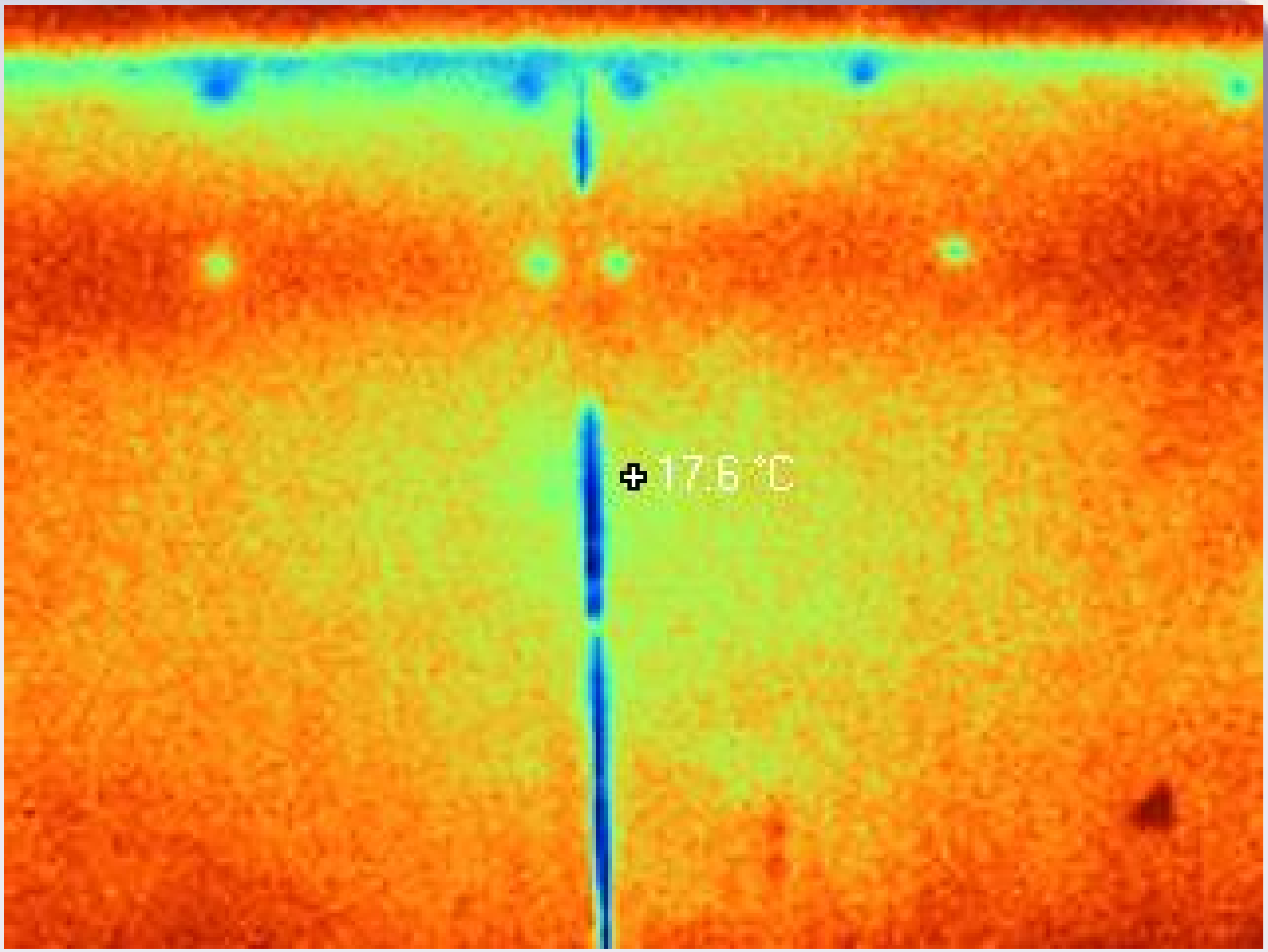


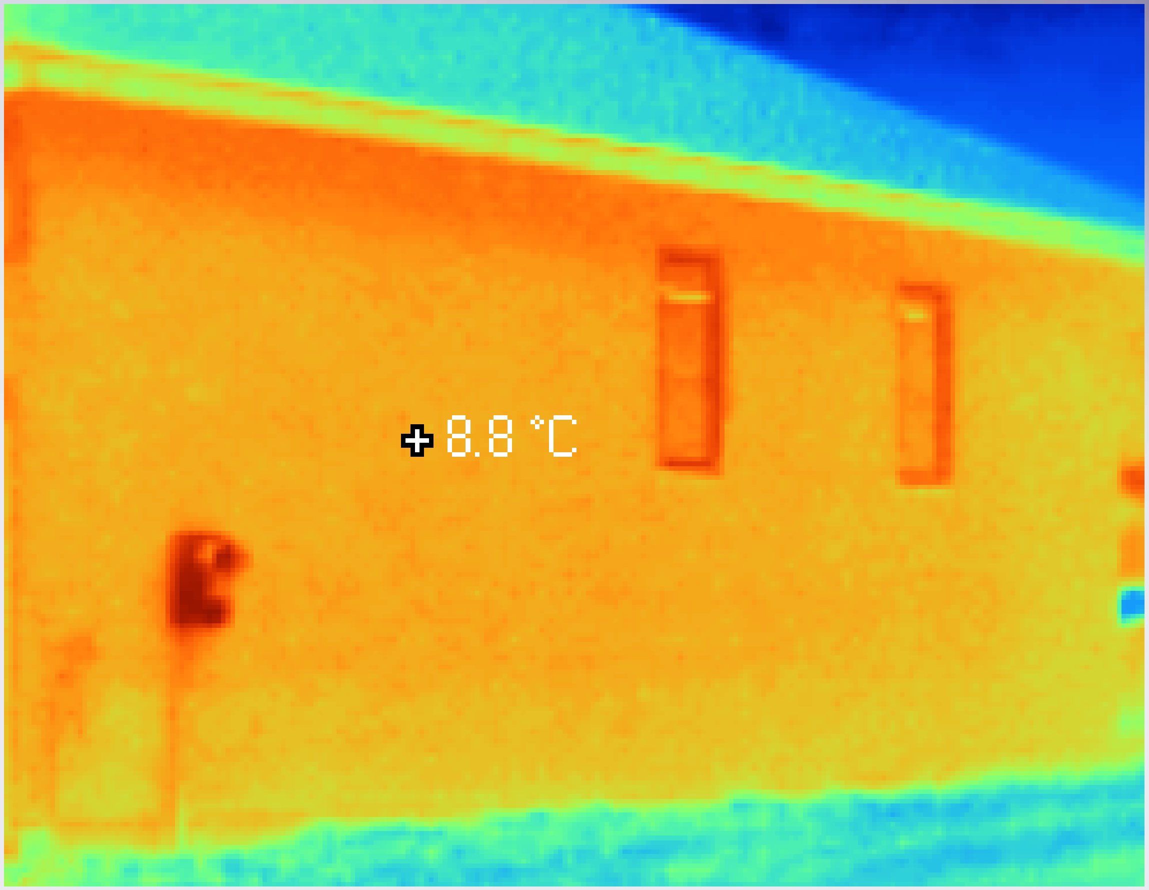
Fig.1 Pro


ELECT
ROC
RIALS CO. LTD.
SOLUTION.

Infrared Photo of Basement wall from interior; Vertical line is Stud in the joint between two panels



Infrared Photo of East wall while house was pressurized by blower door
Note very uniform wall temperature due to absence of thermal bridges; “hot spot” at the electrical box due to lack of sealant around electrical wires



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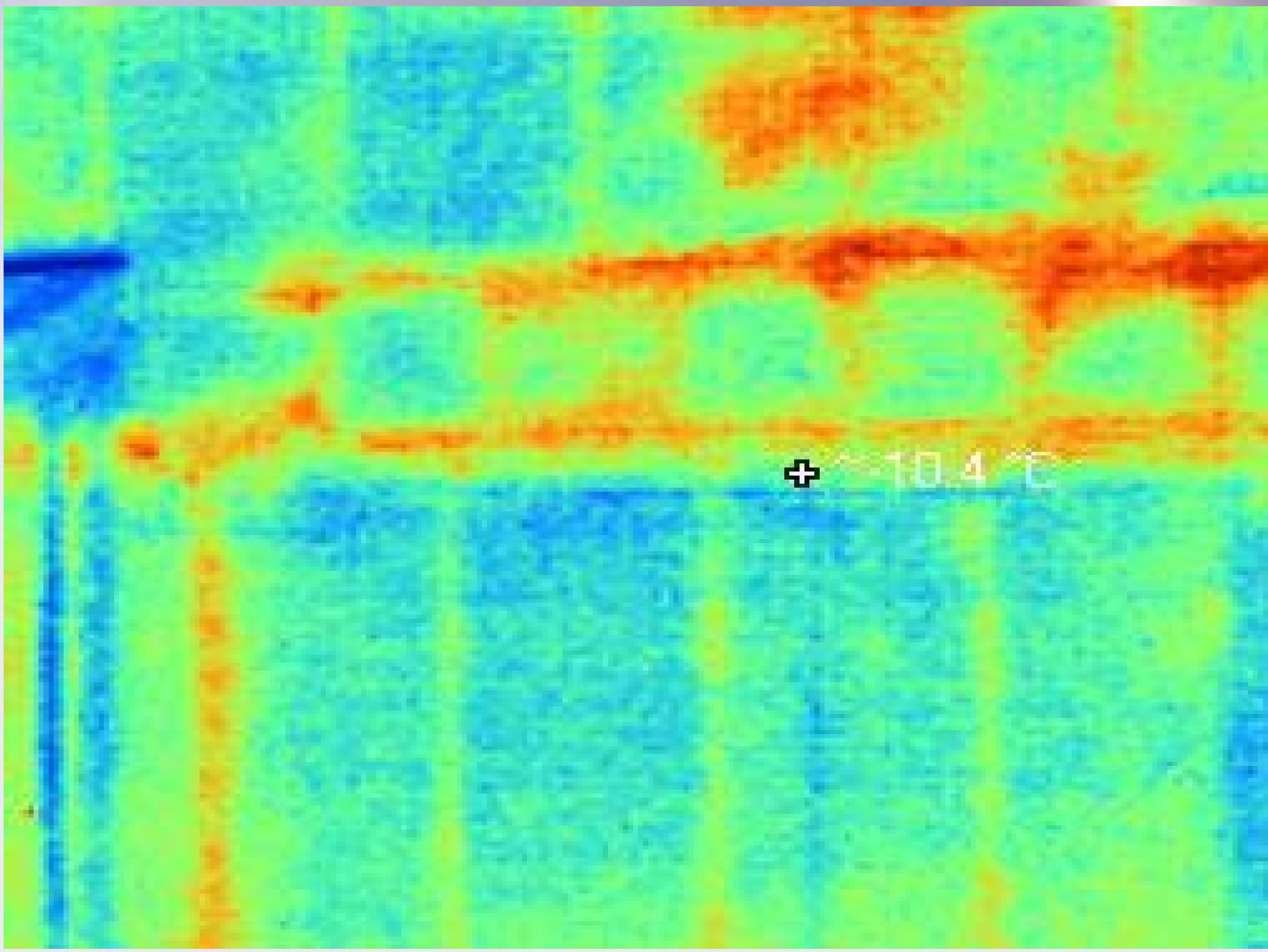


x

Air Tightness, Ventilation and Heat Recovery

- Air tightness target of 0.5 air changes/hour at 50 pascals [3x tighter than R2000 standard)
- High effectiveness air to air heat exchanger with brushless DC motors

Windows

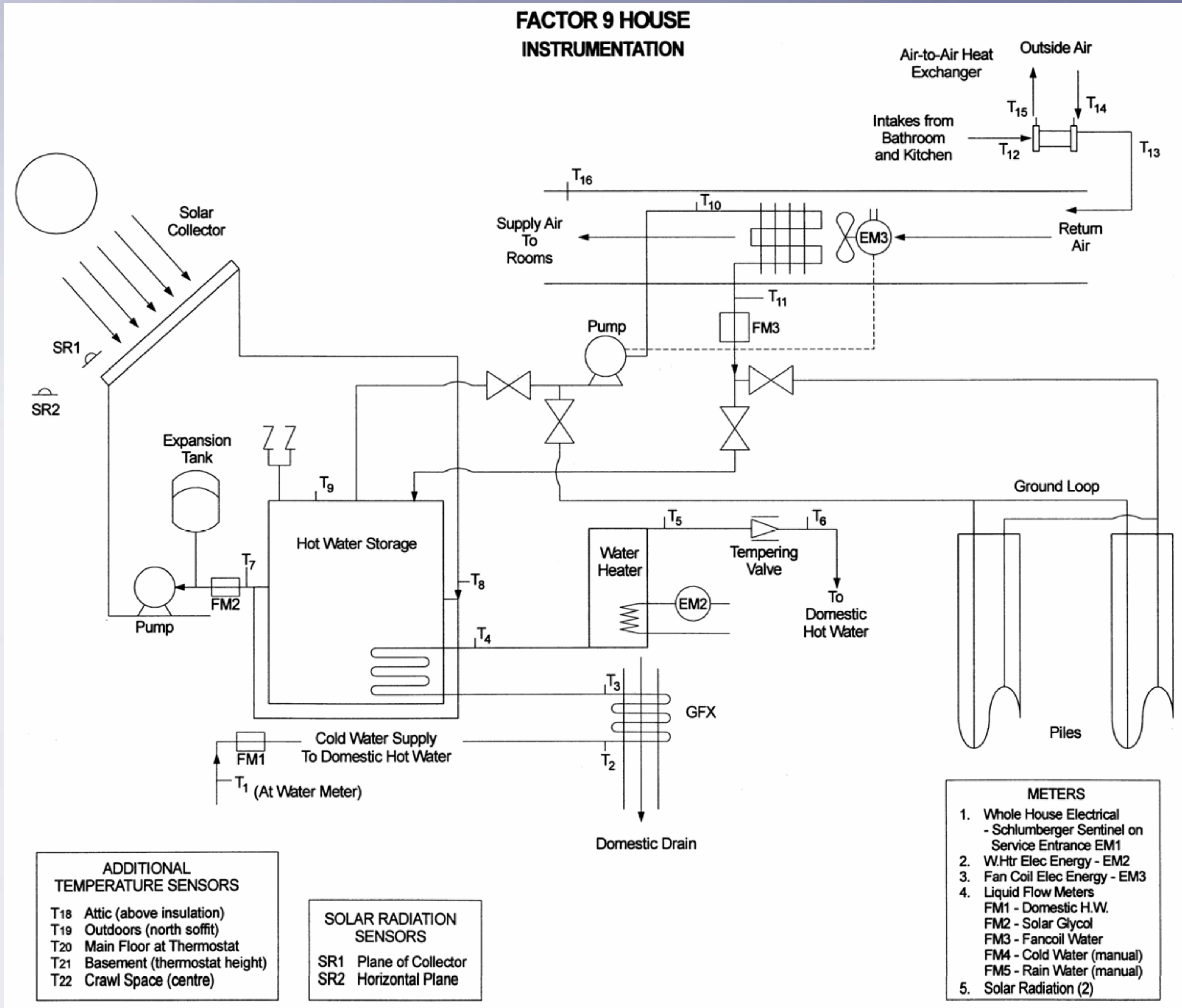
- Predominantly south facing
- High performance windows
    - Inert gas fill
    - Low e coatings
    - Low conductivity spacer bars
    - 8.3% ratio of south window area to total floor area
    - Additional thermal mass incorporated
    - Performance tuned to orientations
        - Solar gain stressed for south orientations
        - High thermal resistance stressed for non-south orientations

Sustainable Energy Features

- Very low heat loss building envelope to minimize need for space heating
- Passive solar space heating through south windows
- Active solar space and water heating through south vertical solar heating panels (21 sq.m.)
- Orientation of the south roof so that photovoltaic panels can be placed as the cost comes down (7 Generation thinking)
- Extraction of cooling from the 4.5 metre deep pilings under the house

South Wall of Factor 9 Home
Active Solar Thermal Panels are in a horizontal band at the mid-height of the south wall

Recycled Water Storage Tank for Active Solar Heat (2350 Litres) and drain water heat exchanger


FACTOR 9 HOUSE
INSTRUMENTATION
Air-to-Air Heat Exchanger
Outside Air
T_{15}
T_{14}
Intakes from Bathroom and Kitchen
T_{12}
T_{13}
T_{16}
T_{10}
Supply Air To Rooms
EM3
Return Air
T_{11}
FM3
Solar Collector
SR1
SR2
Pump
Expansion Tank
T_9
Hot Water Storage
T_7
FM2
Pump
T_8
T_4
Ground Loop
T_5
T_6
Water Heater
Tempering Valve
EM2
To Domestic Hot Water
T_3
GFX
T_2
Cold Water Supply To Domestic Hot Water
FM1
T_1 (At Water Meter)
Domestic Drain
Piles
ADDITIONAL TEMPERATURE SENSORS
T_{18} Attic (above insulation)
T_{19} Outdoors (north soffit)
T_{20} Main Floor at Thermostat
T_{21} Basement (thermostat height)
T_{22} Crawl Space (centre)
SOLAR RADIATION SENSORS
SR1 Plane of Collector
SR2 Horizontal Plane
METERS
1. Whole House Electrical
- Schlumberger Sentinel on Service Entrance EM1
2. W.Htr Elec Energy - EM2
3. Fan Coil Elec Energy - EM3
4. Liquid Flow Meters
FM1 - Domestic H.W.
FM2 - Solar Glycol
FM3 - Fancoil Water
FM4 - Cold Water (manual)
FM5 - Rain Water (manual)
5. Solar Radiation (2)


Bobcat
T190
TURBO
Bobcat
KENROC


EMERCOR PANELS
EMERCOR PANELS
ELECT
FF 13
FF 14

FF
12
ELECT
ELECT
EMERCOR PANELS
FF
13
FF
14
EMERCOR PANELS
BOSCH


TYPAR
TYPAR
TYPAR
ELECT
ELECT

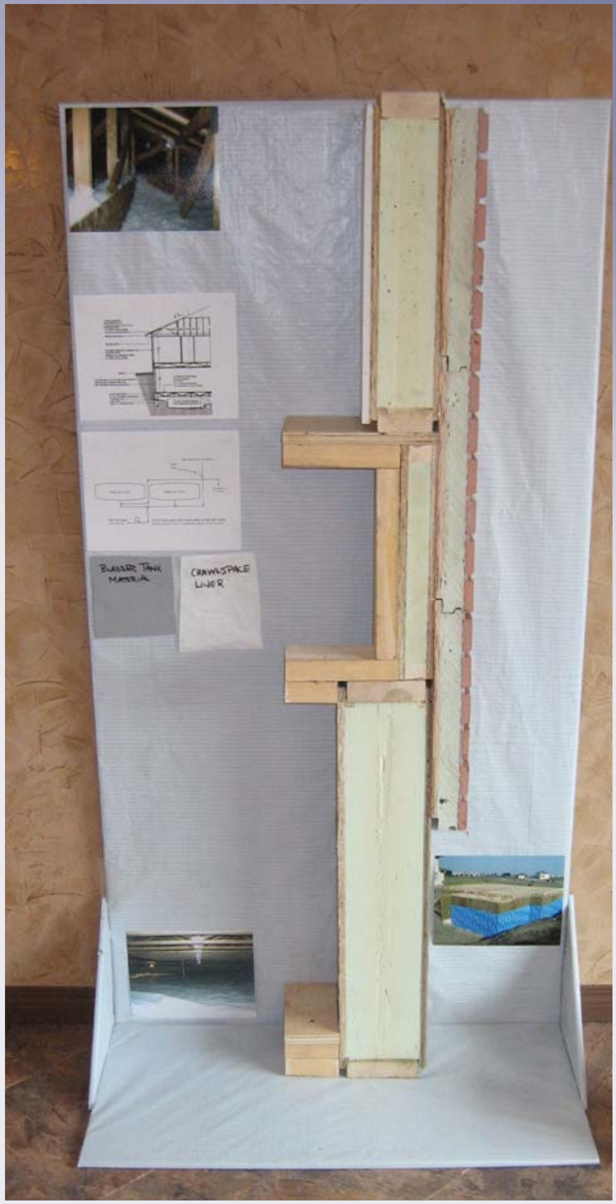

EVERCOR PANELS

South Side: Note effectiveness of overhang in shading the upper windows

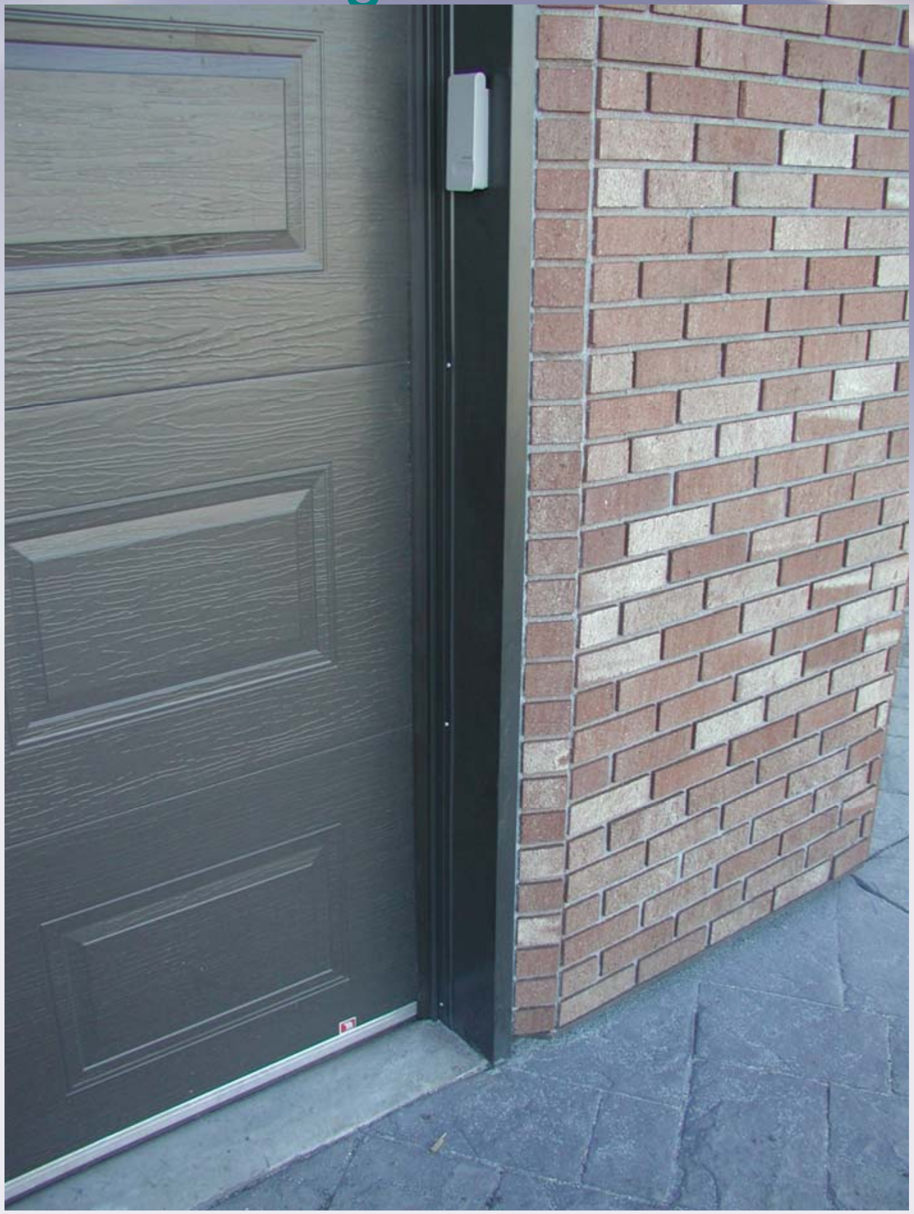
View from Southwest

North Side of Factor 9 Home

Wall Construction



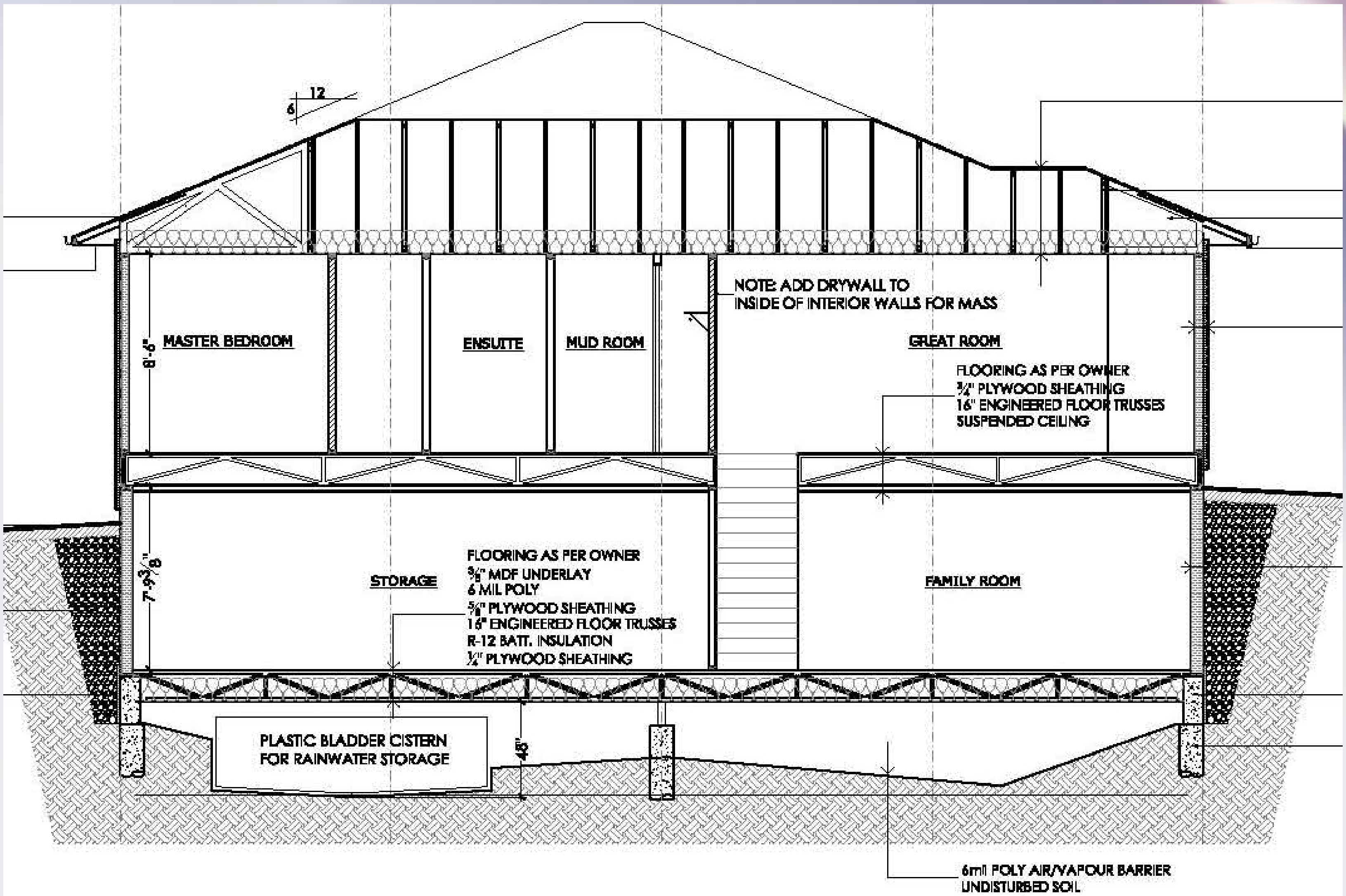
Insulating Brick Siding



Water Efficiency Measures

- Use of low flow toilets, shower heads, dishwasher, and clothes washer
- Use of low water use landscaping
- Water collection from roof water using bladder storage tanks (22,000 litres storage) Water collected will be used for toilets and exterior water use (about 38,000 litres/year of rain will fall on the roof each year.)

Cross Section Showing Water Storage Tanks in the Crawl Space



Water pump for the toilets and exterior water usage

Thermal Resistance Values for the Factor 9 Home

- Attic – R80 (RSI 14)
- Walls – R34.5 (RSI 6.1)
- Basement Walls – R50 (RSI 8.8)

Sustainable Energy Features

- Passive solar space heating through south windows
- Active solar space and water heating through south vertical solar heating panels (21 sq.m.) with 2400 litre heat storage tank
- Orientation of the roof to the south so that photovoltaic panels can be placed as the cost comes down
- Extraction of cooling from the 15 ft (4.5 metre) deep pilings under the house

Solar Thermal Panels

- Vertical Mount on the South Wall
  - **Disadvantage**: Reduced solar gains relative to optimum angle (4.9 GJ/m2 per year vs 6.1 GJ/m2 per year)
  - **Advantages:**
    - 1. Untempered glass can be used
    - 2. Heat loss from rear of panels helps heat the house
    - 3. No hoar frost or snow accumulation on panels
    - 4. Reduced siding cost
    - 5. Allows for a more conventional appearance

Recycled Water Storage Tank for Active Solar Heat (2350 Litres) and drain water heat exchanger

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Other energy efficiency measures

- Energy Star White Appliances
- Compact Fluorescent Lamps
- Drain Water Heat Exchanger
- Air to air heat exchanger with brushless DC motors
- The Energy Detective™ whole house electricity monitoring device
- Fan coil with oversized heating/cooling coil and brushless DC fan motor

Instantaneous Readout Device for Electricity Consumption

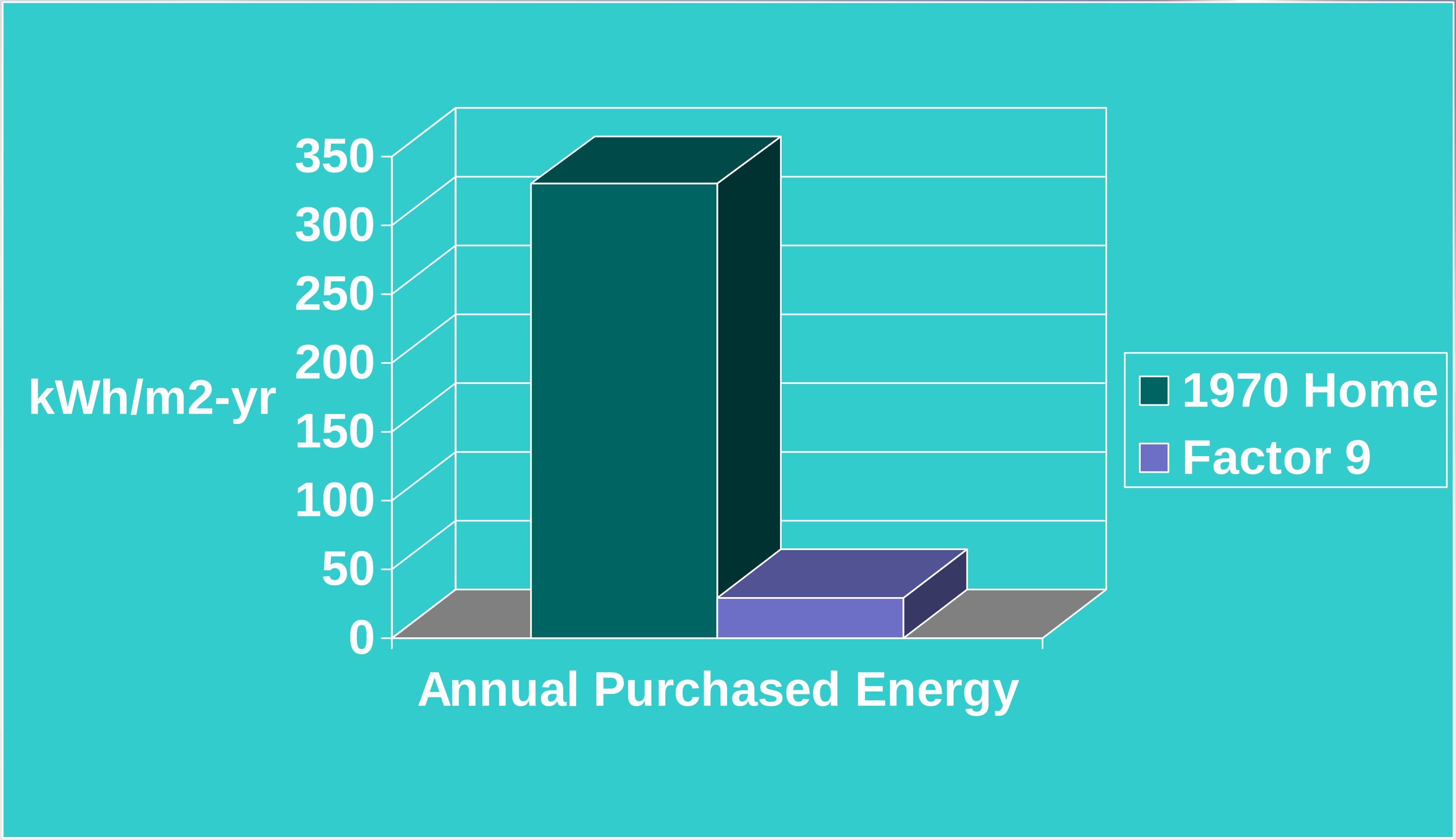
Grand Opening, April 2007
Premier Lorne Calvert, the owners, and
President Laurier Schramm of SRC

Factor 9 Home Measured Performance Monitoring Period June 1, 2007 to May 31,2008

- 1. Energy Target of 30 kWh/square metre of floor area total purchased energy was met.
- Actual consumption was 28.9 kWh/square metre of floor area (corrected for the long term annual heating degree days for Regina) This represents a reduction of 88% compared with a conventional 1970 home

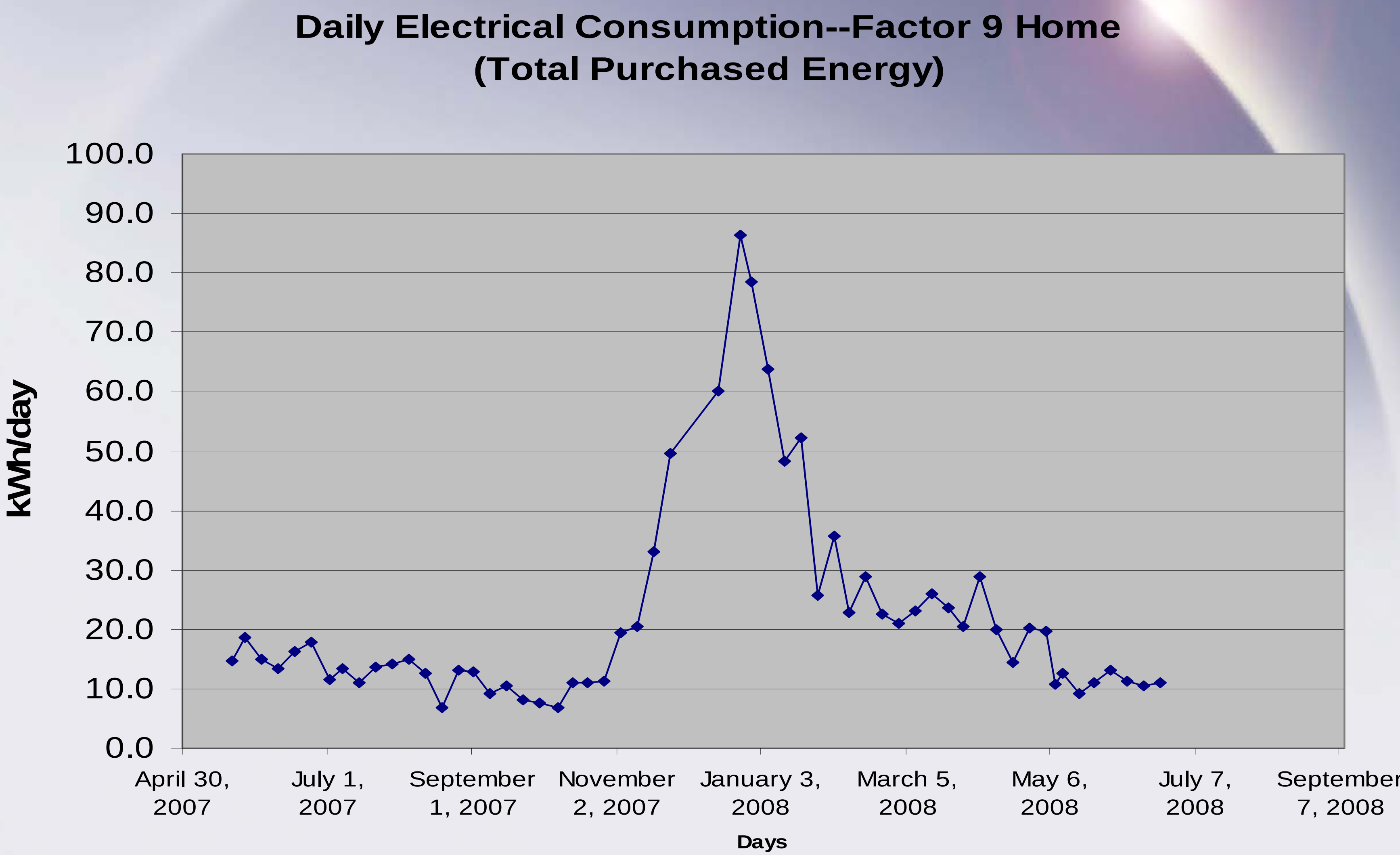
Data Logging Equipment to measure temperatures, energy flows, carbon dioxide levels, solar radiation

Comparison of Factor 9 Home with Conventional 1970 Home in Regina



- Typical Canadian Home with an Electric Water heater
- Lights and appliances 22 kilowatt-hr/day
- Domestic water heating 12 kilowatt-hr/day
- Sum 34 kilowatt-hr/day

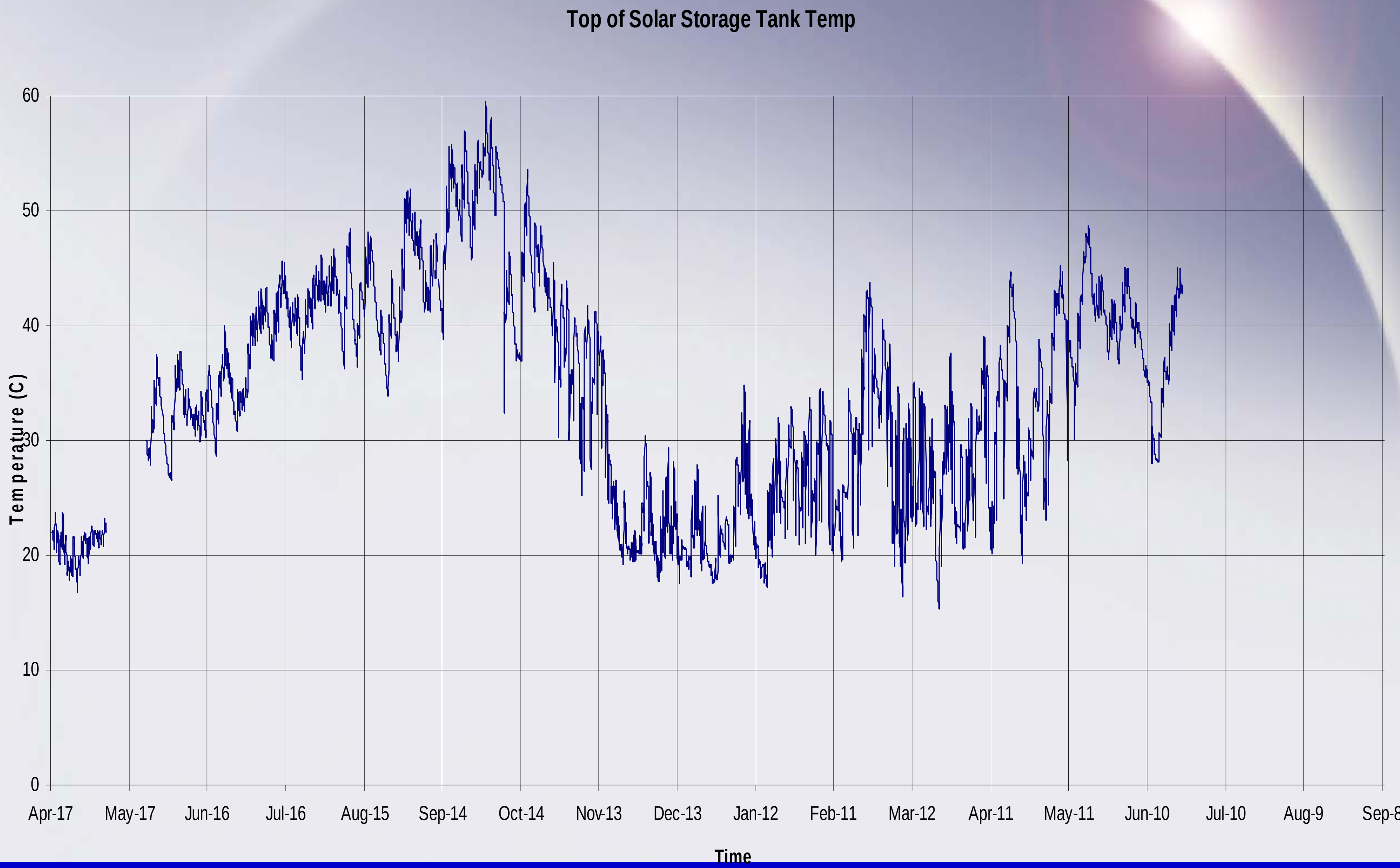
Daily Purchased Energy Over the One Year Monitoring Period



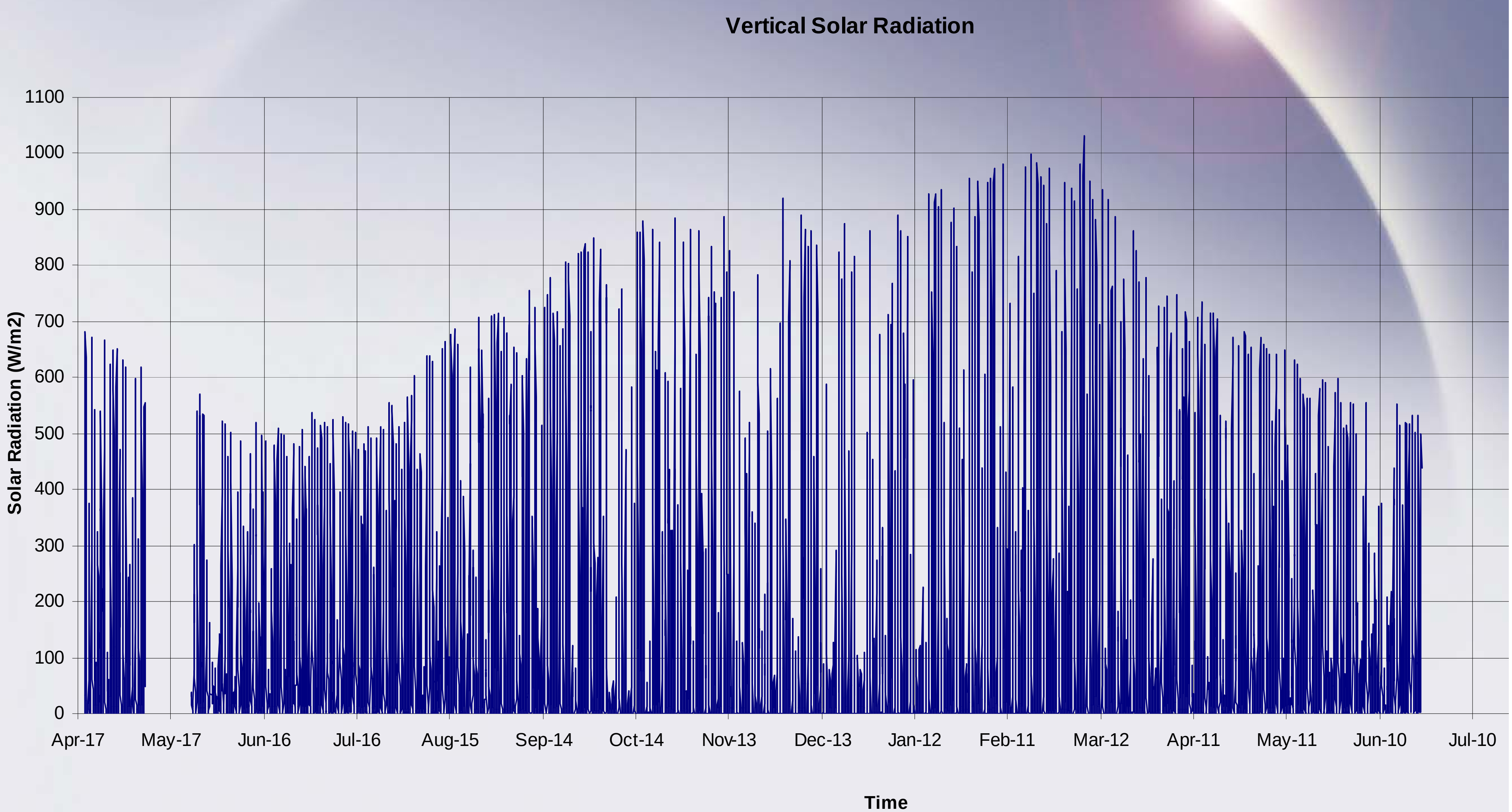
Peak Purchased Energy Consumption

- The peak daily consumption was 87 kWh/day or 3.6 kilowatts or 12,300 BTU/h

Solar Storage Tank Temperatures

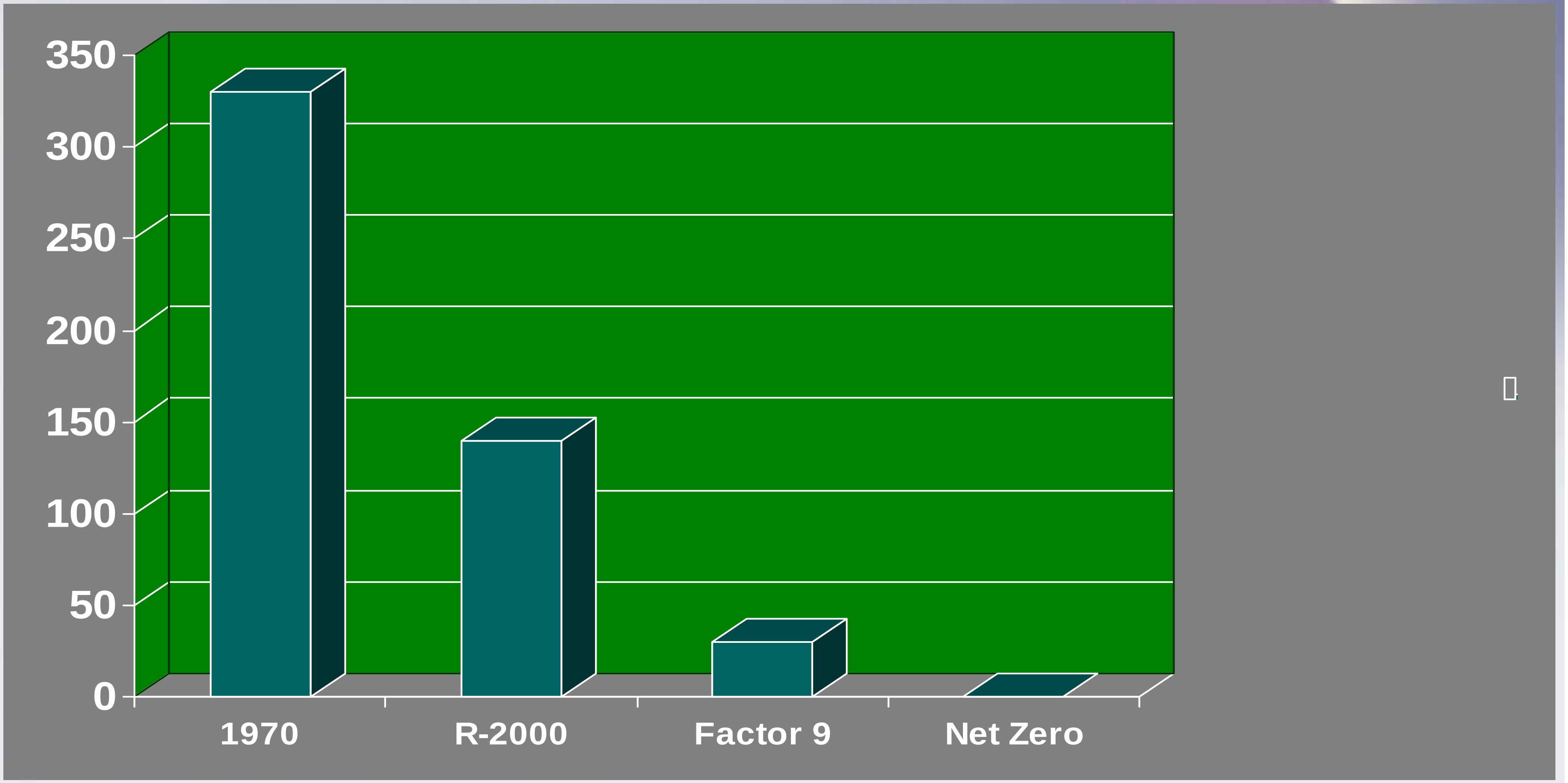


Solar Radiation on the Vertical Plane of the Solar Thermal Panels



Comparison of Annual Purchased Energy Consumption (kWh/m2)

(Based on measured data, except for Net Zero)

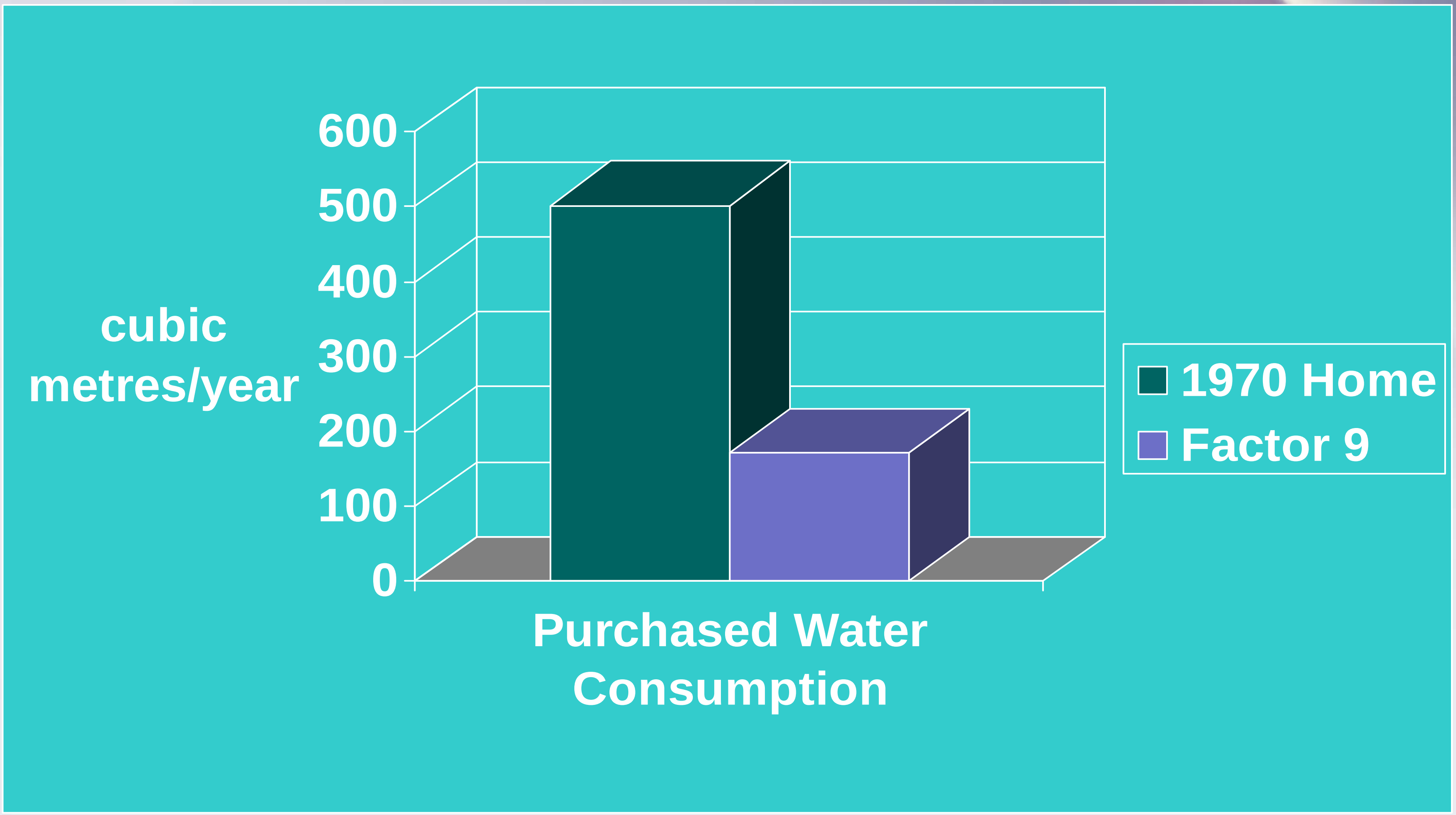


Factor 9 Home Measured Water Consumption Performance

Monitoring Period June 1, 2007 to May 31,2008

- 1. Purchased water consumption target of a 50% reduction in water consumption was met and substantially exceeded.
- Actual consumption was 171 cubic metres per year compared with a consumption of 501 cubic metres per year for a conventional house (66% reduction)

Comparison of Factor 9 Home Water Consumption with Conventional 1970 Home in Regina



View from South East

Incremental Costs for Energy and Water Efficiency Features

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- Incremental costs: $37,000 (10% of construction cost)

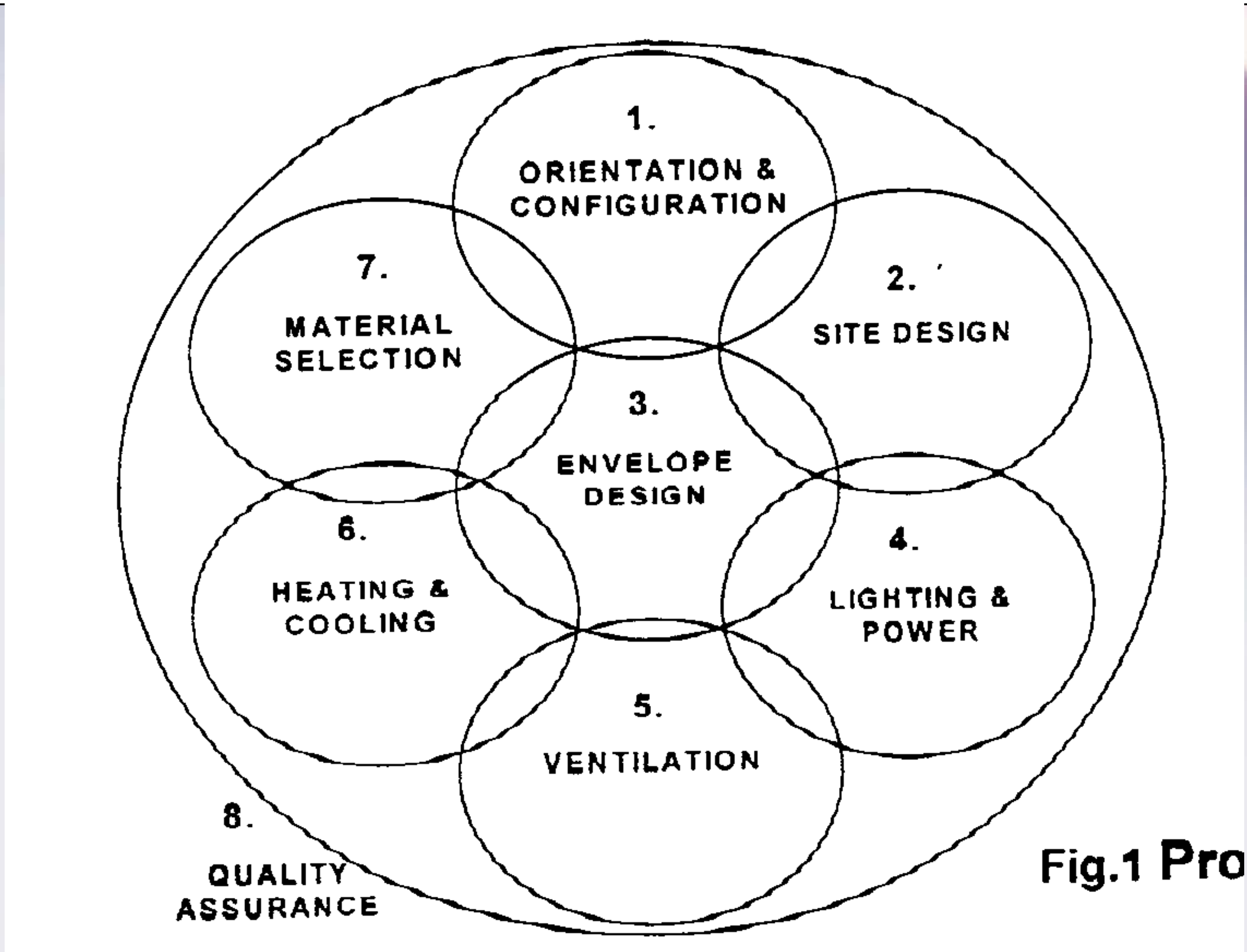
- Annual Energy Savings $952
- Annual Water Savings $488

- Simple Payback Period assuming no escalation of energy and water costs = 26 years
- Initial rate of return on incremental costs 3.9%

Overall Lessons Learned

- 1. It is very important to develop an integrated design—one in which the entire building is designed as a system and not as a group of unrelated components.

Integrated Design—
Building Envelope is Central



- 2. Energy conservation measures in the building envelope, in addition to lowering fuel and energy bills, can also reduce the capital cost of a heating system by reducing the size and possibly the complexity.
- 3. Heat recovery on the ventilation air is very important, as is building air tightness.

- 4. This cold climate house would perform extremely well in moderate climates. For instance, the Factor 9 Home in Regina needs no space heating until the outdoor temperature is below about 4^{o}C. The average temperature in the coldest month of the year in Vancouver, B.C. is 4 ^{o}C.
- 5. Occupant feedback is very important. Devices which provide the occupants with quick feedback on their energy use can be very valuable.

Research and Development Needed

- 1. Improved efficiency refrigerators, freezers and air to air heat exchangers
- 2. Reduced phantom loads from electricity leakage
- 3. Integrated solar thermal collectors and photovoltaics
- 4. Integrated windows and photovoltaics
- 5. Solar access through street orientation; solar rights. (The Greeks figured this out 2500 years ago. We are still waiting for this discovery in North America.)

Greek City of Priene (500 B.C.)

Acknowledgement of Sponsors

- Communities of Tomorrow (www.ctinfo.ca)
- Office of Energy Conservation (www.oec.ca)
- Saskatchewan Research Council (www.src.sk.ca)
- Natural Resources Canada (www.nrcan.gc.ca)
- Canada Mortgage & Housing (www.cmhc.ca)

Their participation is gratefully acknowledged

Partners

- University of Regina — Dr. Peter Gu
- City of Regina — Mr. Robert Bjerke

Product Sponsors

Factor 9 Home:

- Watercycles (www.watercycles.ca)
- Venmar (www.venmar.ca)
- Panbrick Okamoto (www.panbrick.ca)
- Emercor (www.emercor.ca)

Special Thanks to the Homeowners

Factor 9 Home

Rolf and Shannon Holzkaemper

More information

- Factor 9 Home

[www. factor9.ca]