THE CHALLENGES OF RETROFITTING AN HISTORIC SINGLE FAMILY HOME USING A NESTED THERMAL ENVELOPE DESIGN

CCBST 15 Vancouver B.C.

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The “Gemini” Project

Concept: Nested Thermal Envelopes

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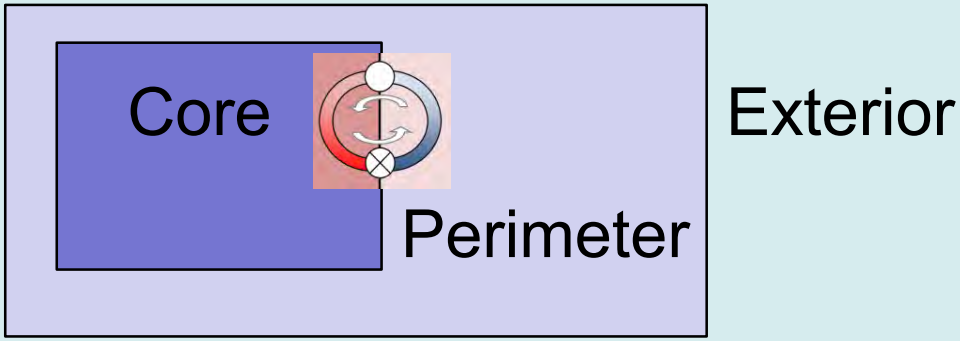
The Gemini House

- Owned by University of Toronto
- Built in 1879
- 2 Storey detached
- Solid Masonry
- > 16.4 ACH @ 50Pa
- 114 m^2 Standard
- 69 m^2 Core
- 45 m^2 Perimeter

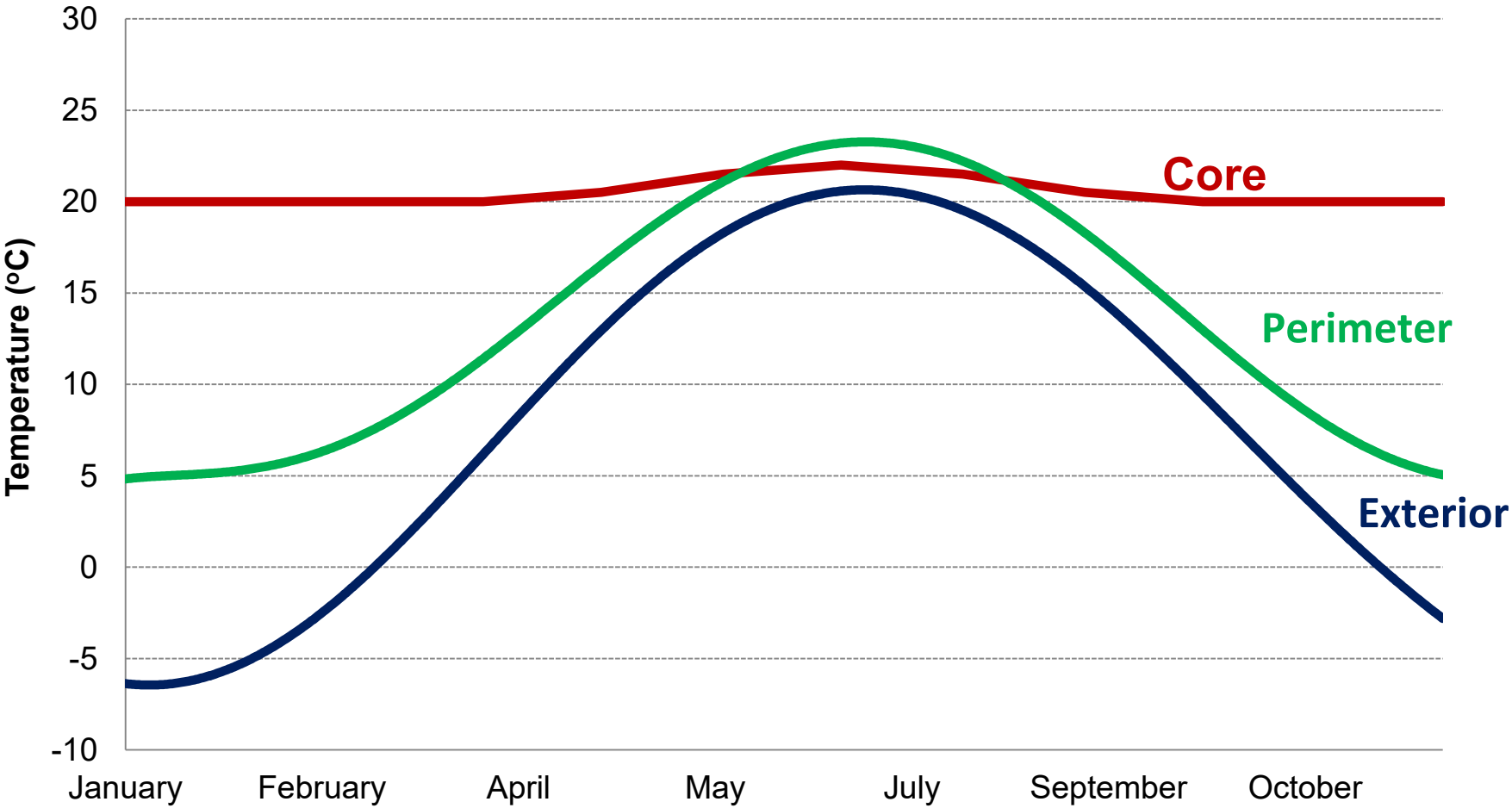
What is GEMINI NTED™?

- Two thermal envelopes: “core” and “perimeter” spaces that control heat, moisture, and air movement
- Perimeter to gather solar gains during winter months

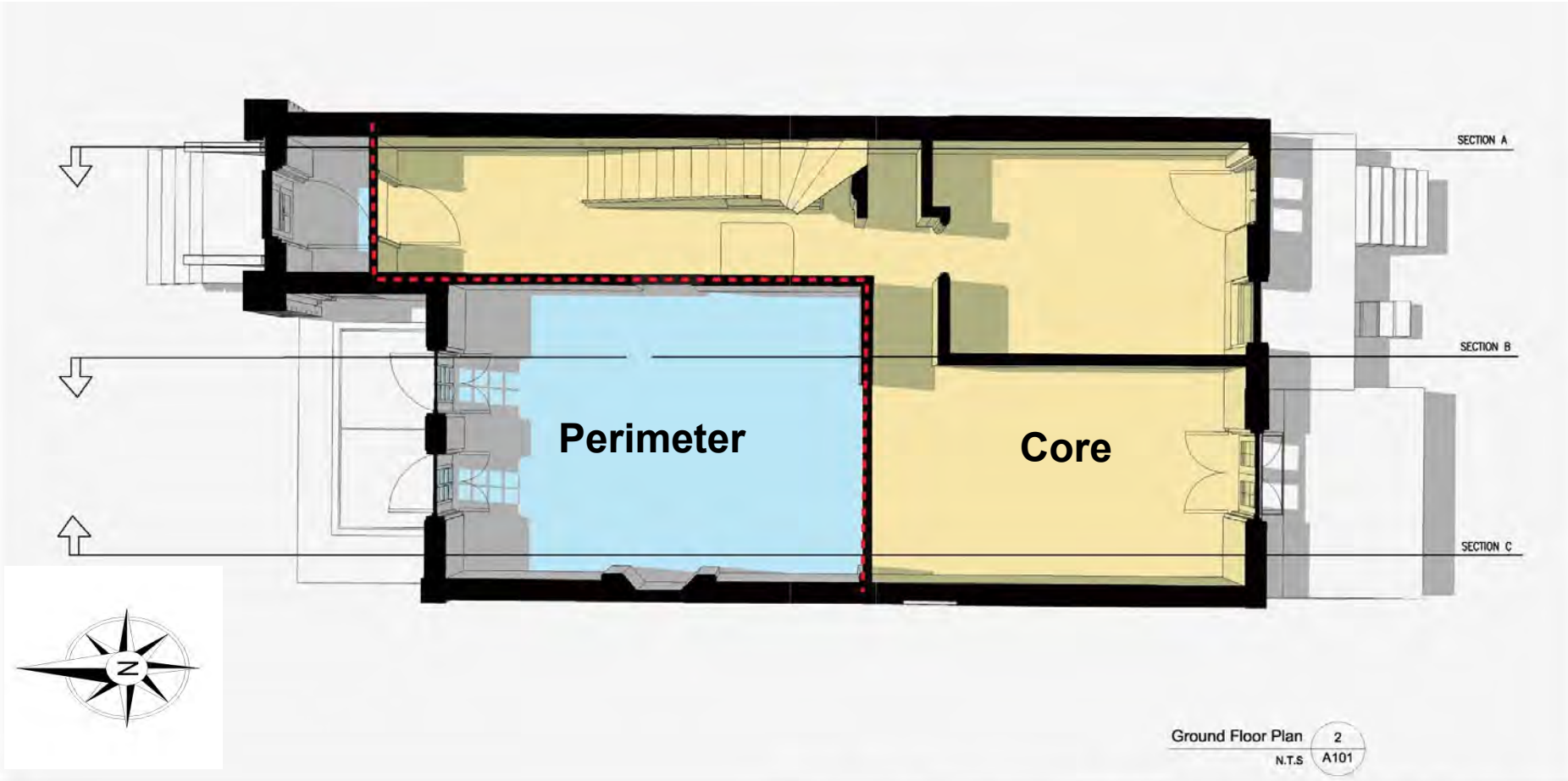
Nested
Thermal
Envelope
Design



Average Core, Perimeter, and Outdoor Air Temperatures in Toronto



Creating Zones – Ground Floor



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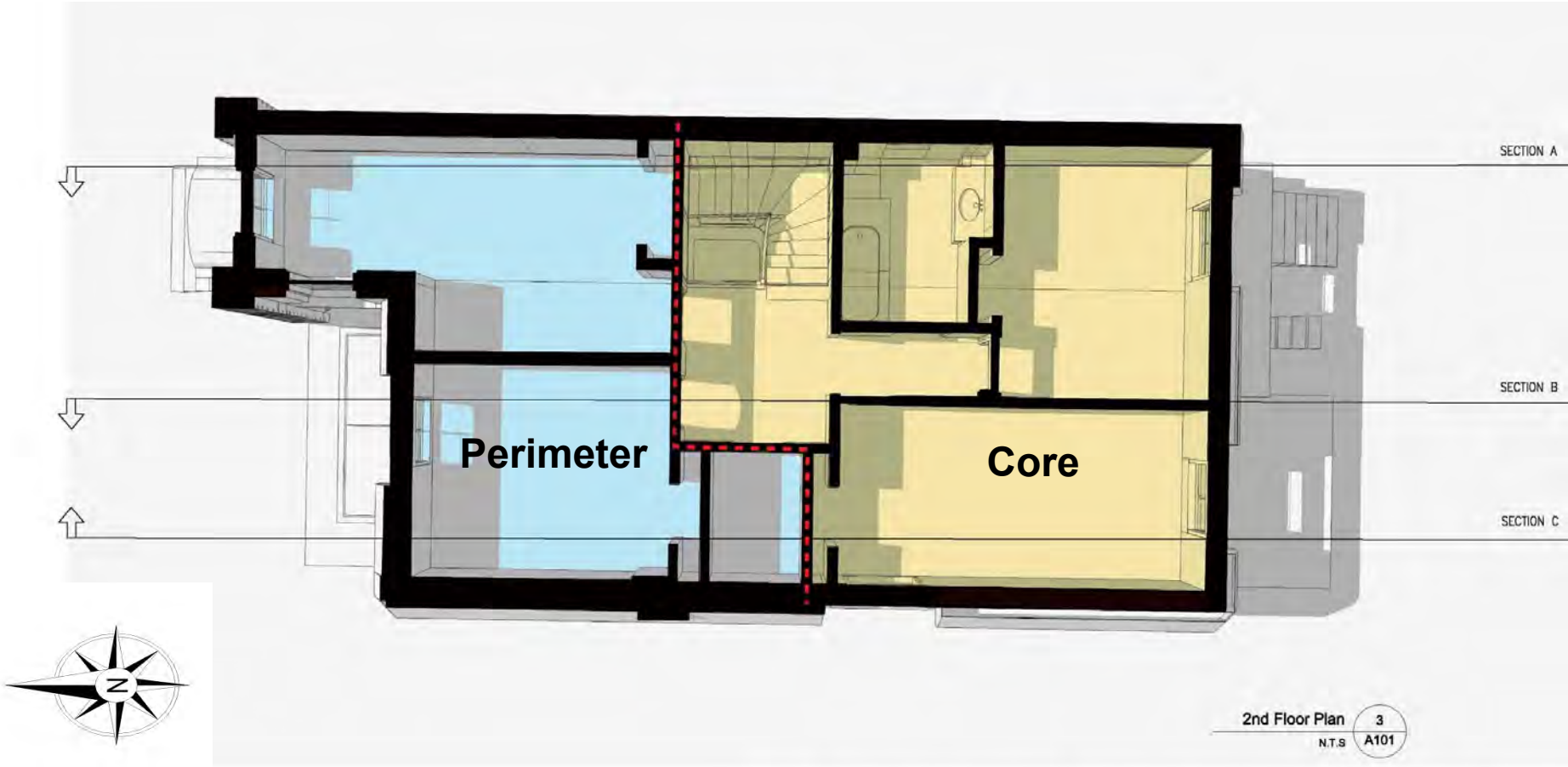
E.R.A.

Creating Zones – 2nd Floor



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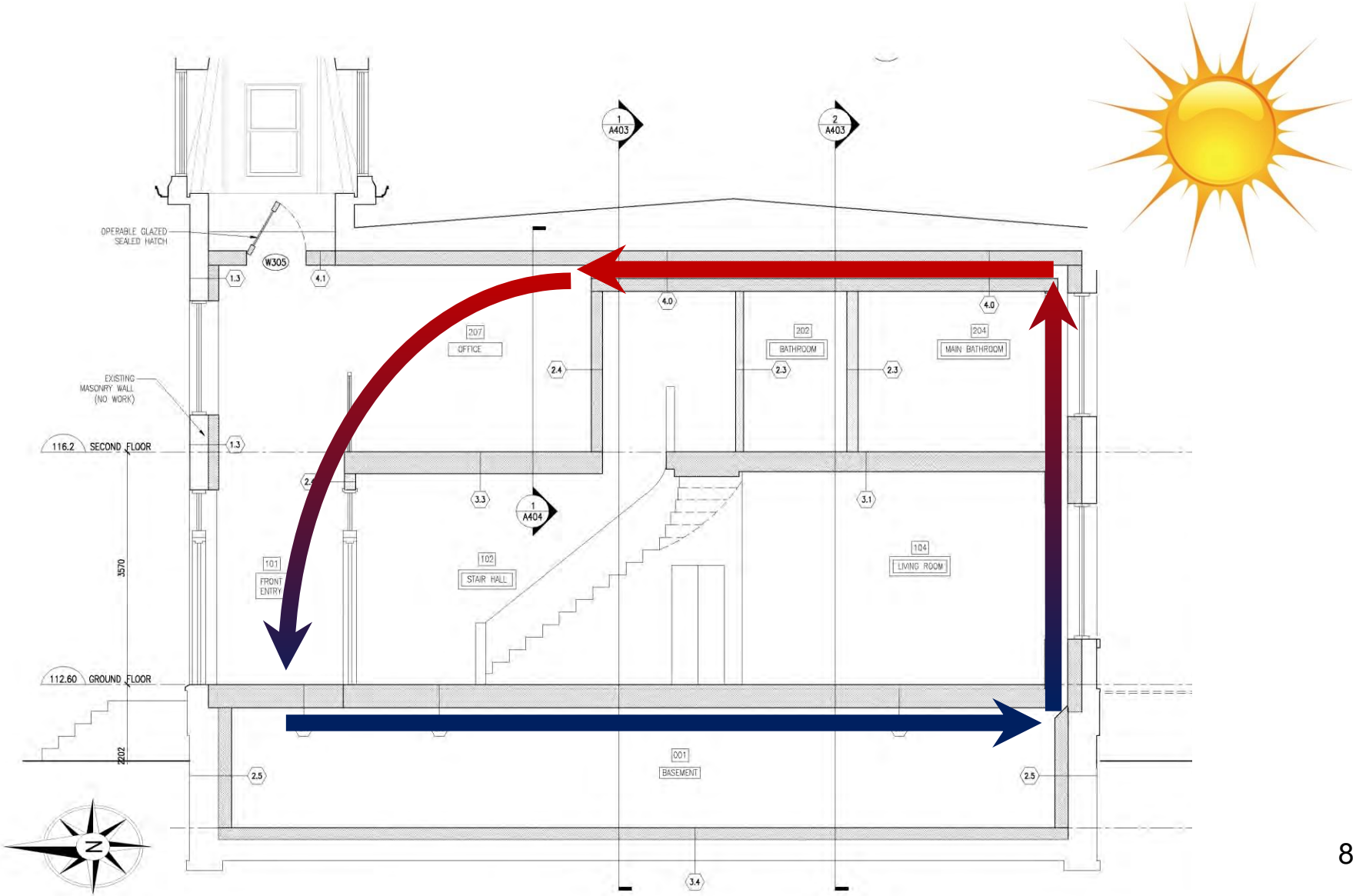
Air Movement



HVAC Equipment

- Radiant floor heating system
- **Two** Energy recovery ventilators condition incoming air (Core ERV / Perimeter ERV)
- Supplementary form of heating or cooling: Inter-zonal heat pump

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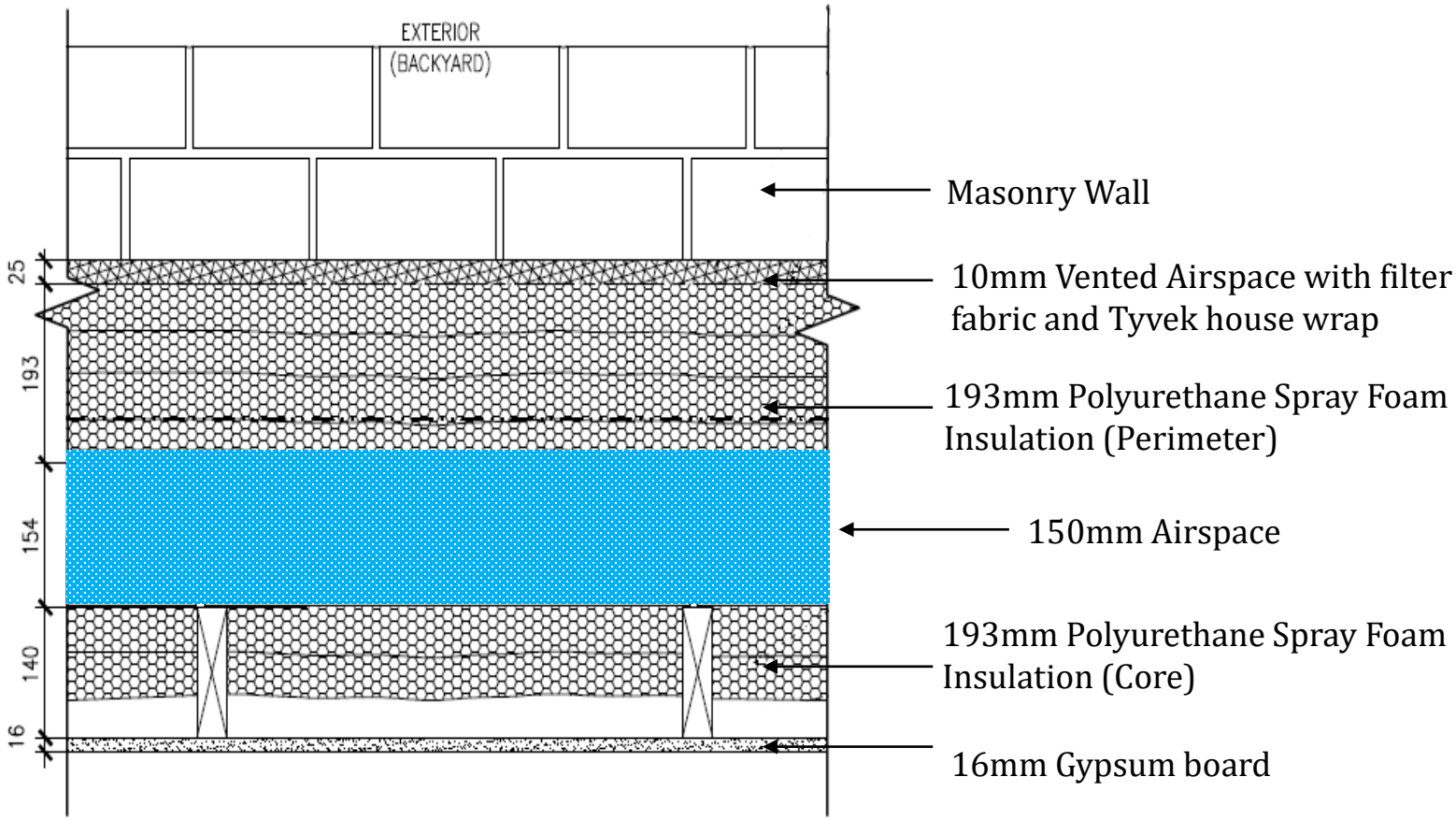
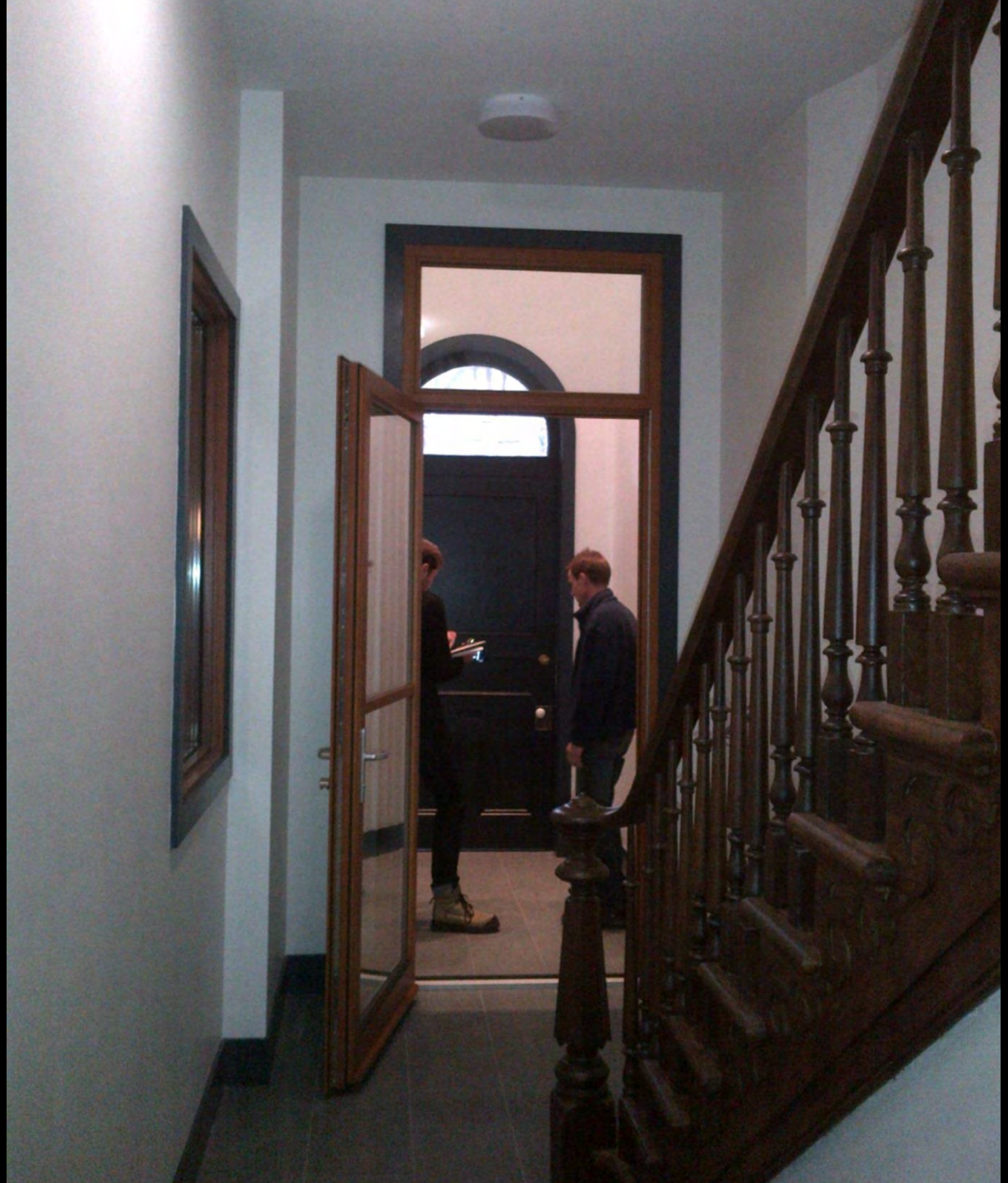
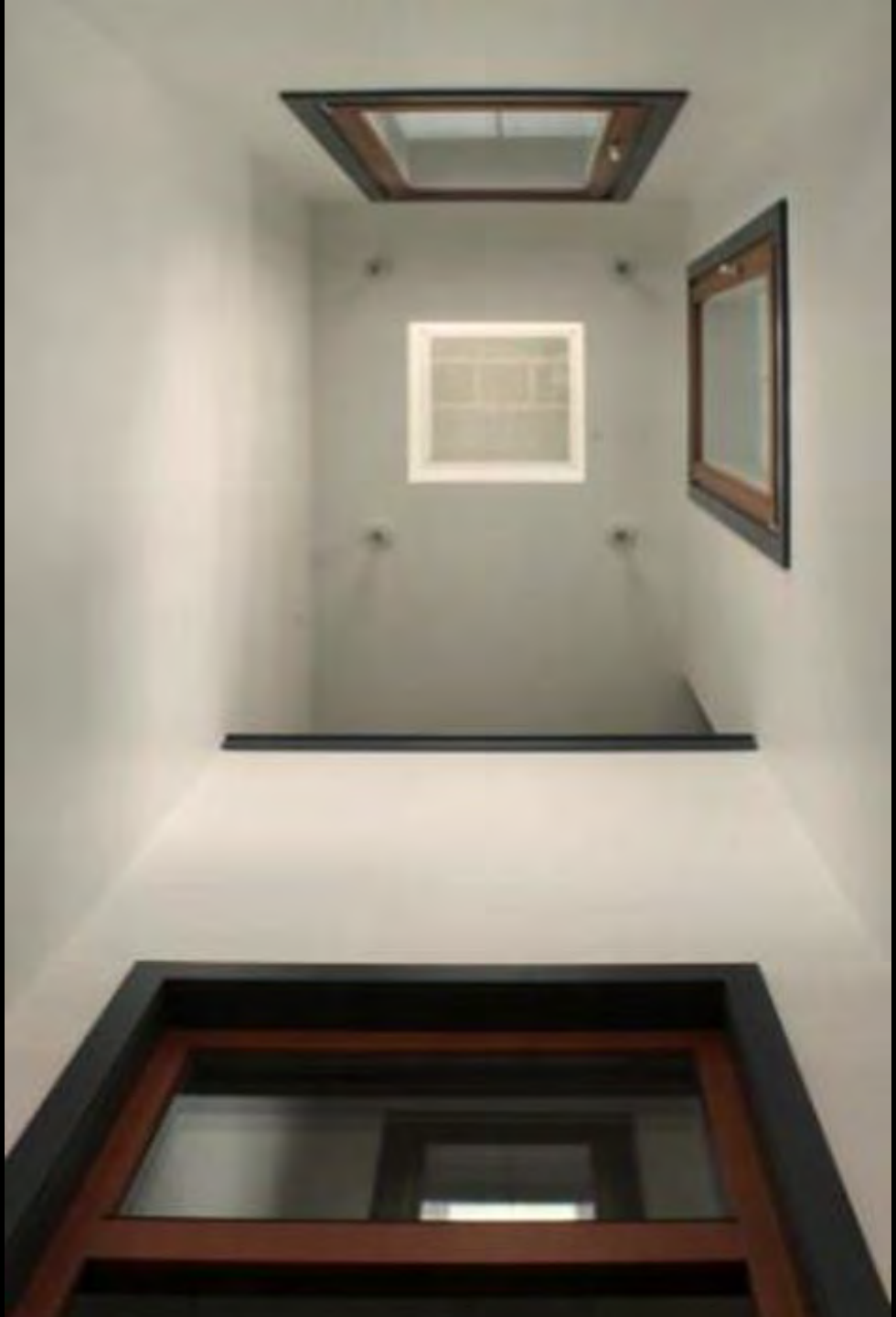
South Wall “Perimeter” Air space



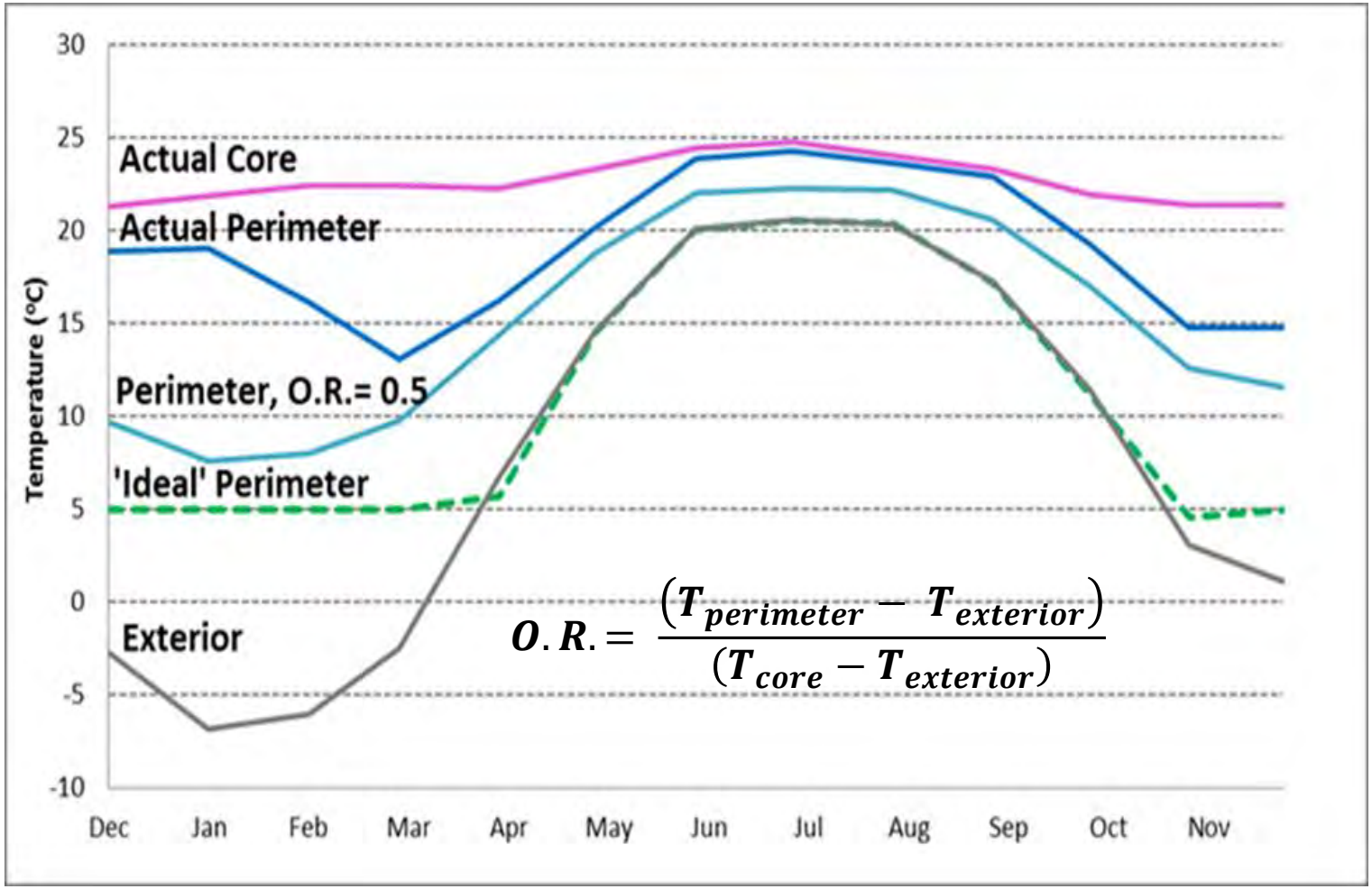




Where is the energy saved ?

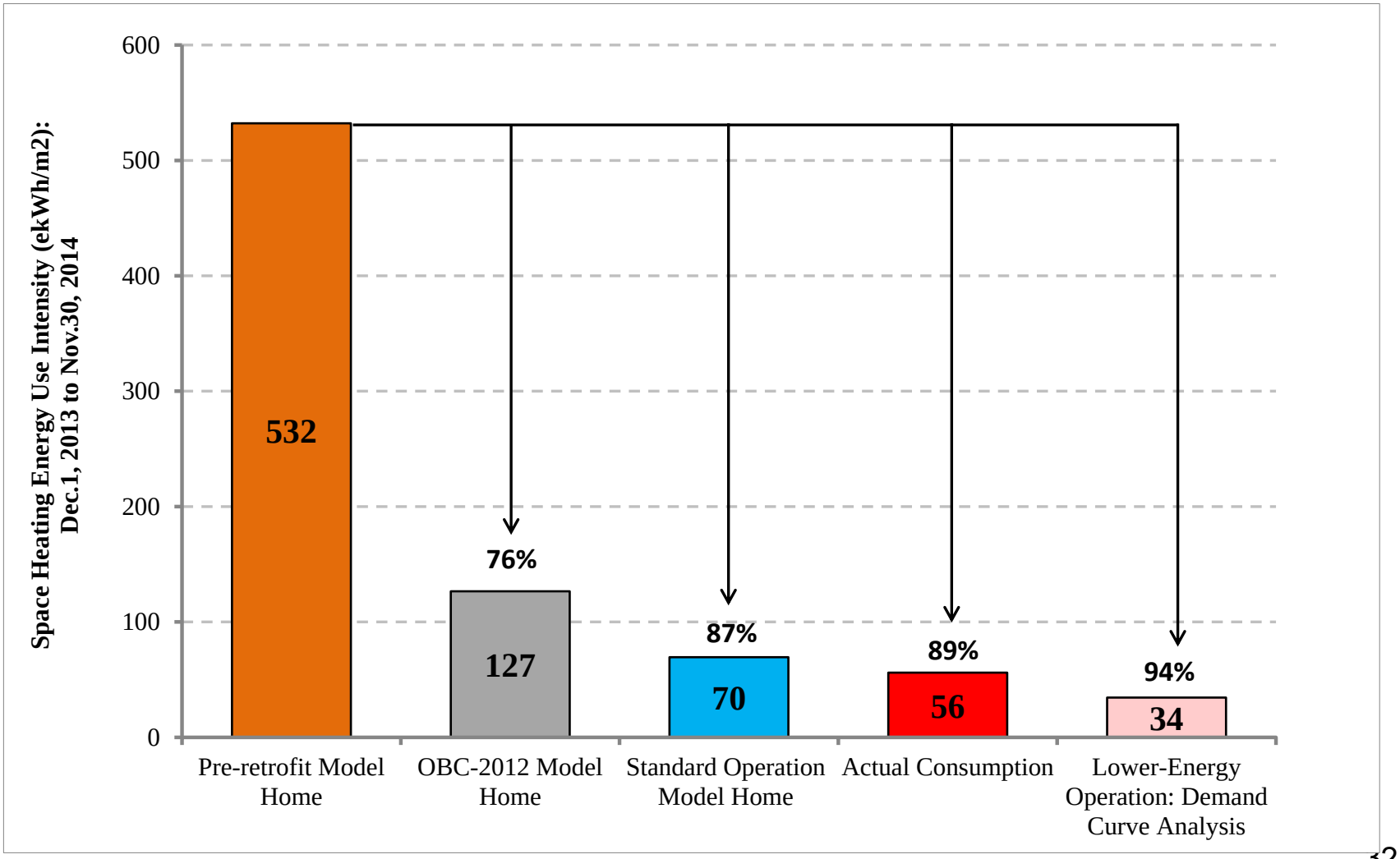
- Two well-insulated envelopes (core and perimeter)
- Potential for solar gain and storage
- Floor areas/zones heated as desired
- Some Core heat losses recovered by heat pump operating at a more efficient temperature difference
- Solar gains delivered to core as required.

Operating Temperatures in the Monitoring Period

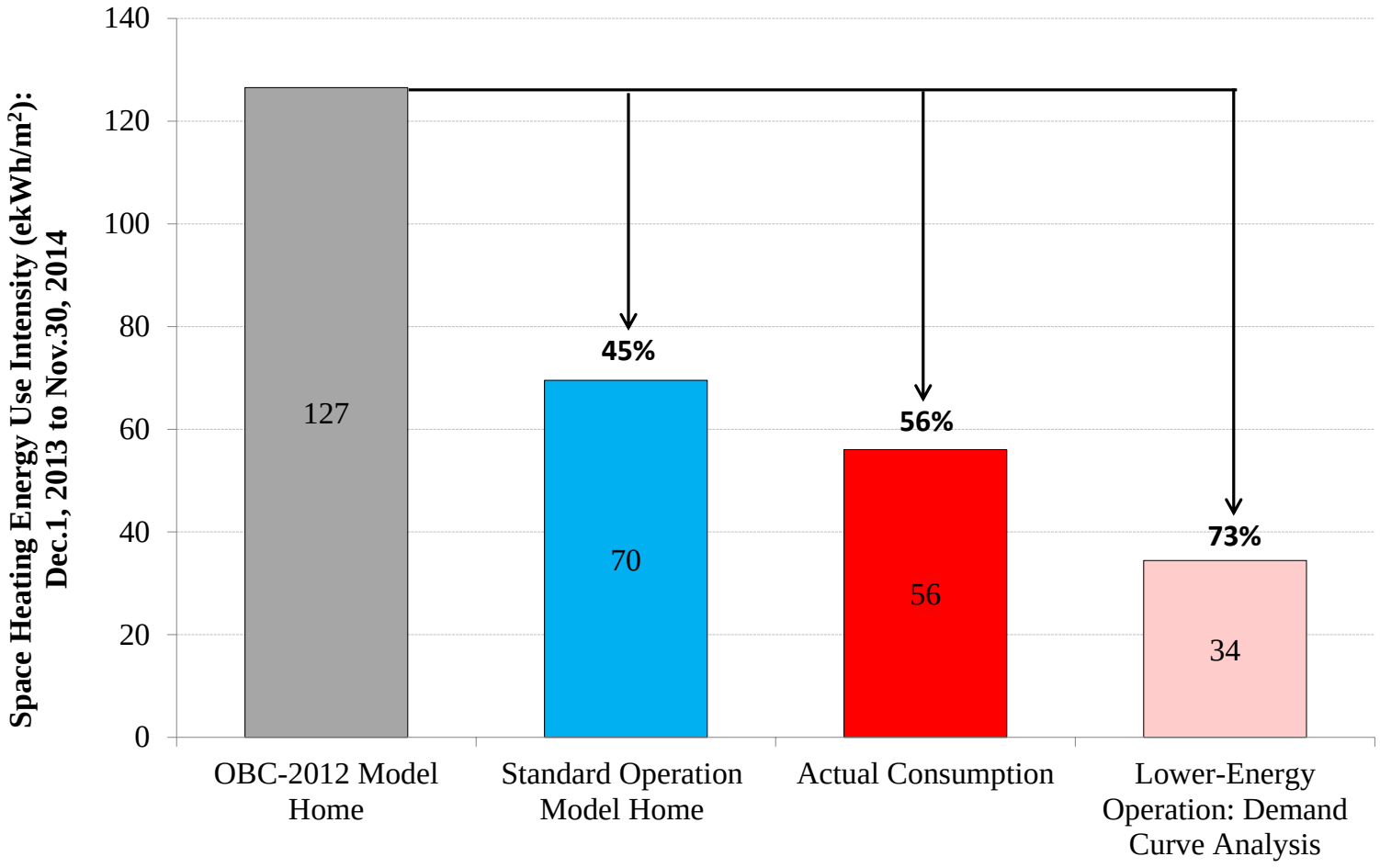


$$O.R. = \frac{(T_{perimeter} - T_{exterior})}{(T_{core} - T_{exterior})}$$

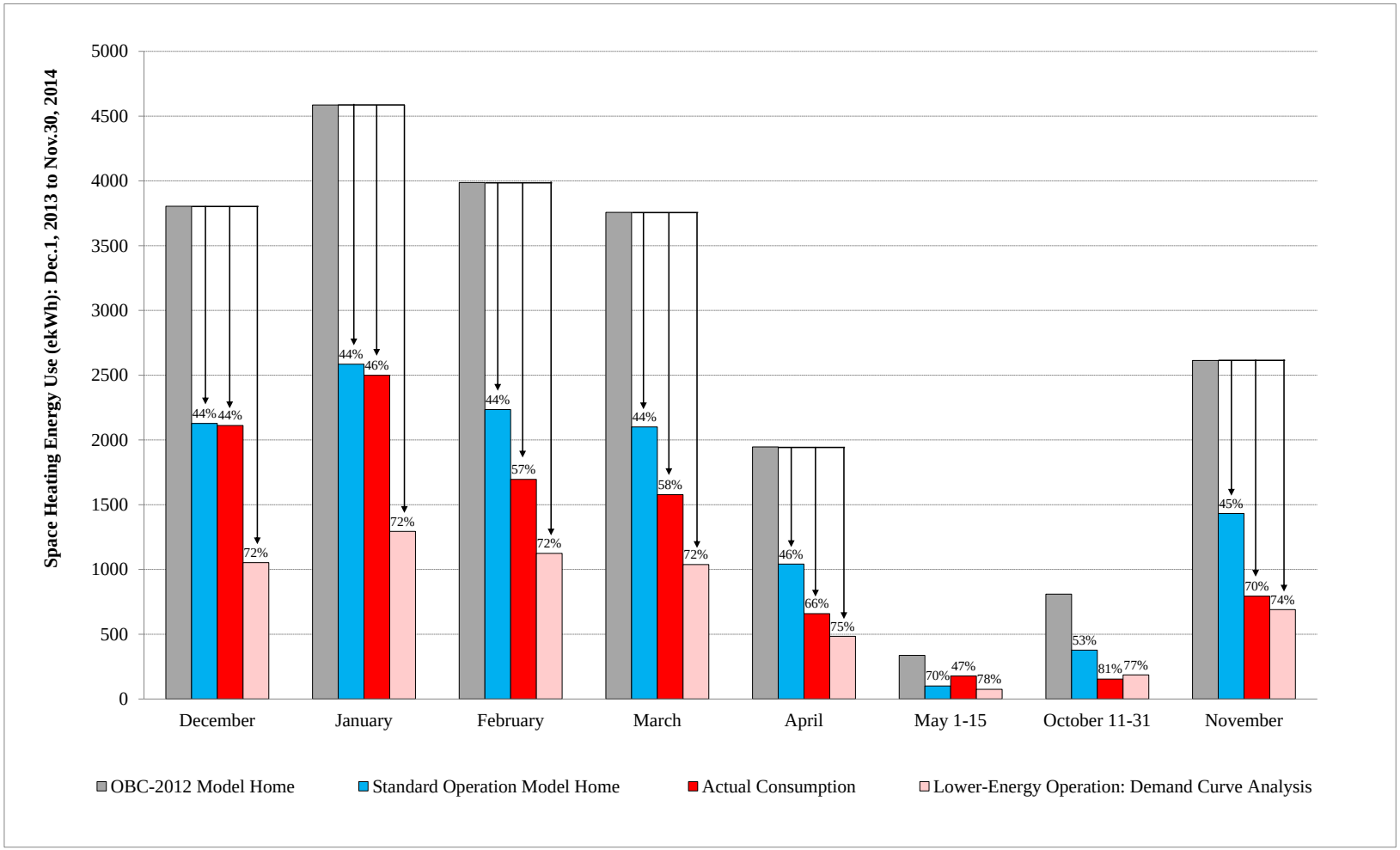
Heating Energy Use Compared to Original Building



Heating Energy Use Compared to a Modern Home



Heating Energy Use Comparison by Month



Savings compared to SB-12:

44% when Core and Perimeter areas are heated.

73% savings when Perimeter areas are turned off.

Occupant Comfort…

- Low energy homes: quieter and more comfortable.
- Air tightness measures mean no cold drafts
- Low thermal mass: perimeter rooms can be quickly heated.
- Highly insulated walls mean warmer surface temperatures, improved occupant comfort.

Occupant Comfort

- Radiant floor heating increases the mean radiant temperature.
- Fresh air is supplied from ERV's when and as needed.
- Core zone can serve as a shelter zone if outdoor air quality event occur

Benefits

- Significant space heating reductions
- Energy-efficiency option
- Improved occupant comfort
- Extended service life
- Applications to other types of buildings

Challenges

- Thermal and air control layer continuity
- Quality control during construction
- Constructors need specialized skills

Lessons Learned

- Nest Thermal Envelopes is a viable and can yield large energy savings;
- Constructible design details are required;
- Quality assurance is required during all phases of construction;
- A knowledgeable and informed constructor is needed;
- A ‘cost-plus contract’ is no assurance that the necessary quality will be achieved;
- Nested Thermal Envelope Design Should be delivered by a Construction Management.

Lessons Learned (cont'd)

- Achieving air tightness is the single biggest challenge in a thermal retrofit.
- Mechanical penetrations and leaky ERV supply and return contributed to a general lack of air tightness.
- The southern exposed perimeter space is a viable passive solar feature that could have been improved with a higher Solar Heat Gain Coefficient for the exterior windows.

Lessons Learned (cont'd)

- Further energy savings are possible if an inter-zonal heat pump is utilized.
- The vented masonry approach is an effective way of internally insulating historic masonry buildings.
- Retrofitting an historic masonry building is probably the most difficult and challenging building to retrofit!

Colour TV in the 1950's?

- The single largest impediment to the implementation of the NTED concept is inexpensive energy.
- If natural gas on a carbon basis cost the same as electricity, then natural gas would cost 5 times more in Toronto ON!
- With prices that reflect the cost of carbon, many low energy approaches including NTED would be economically viable

Onward and as always… Upward!

All the best!

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