LL97 and High-Rise Retrofit

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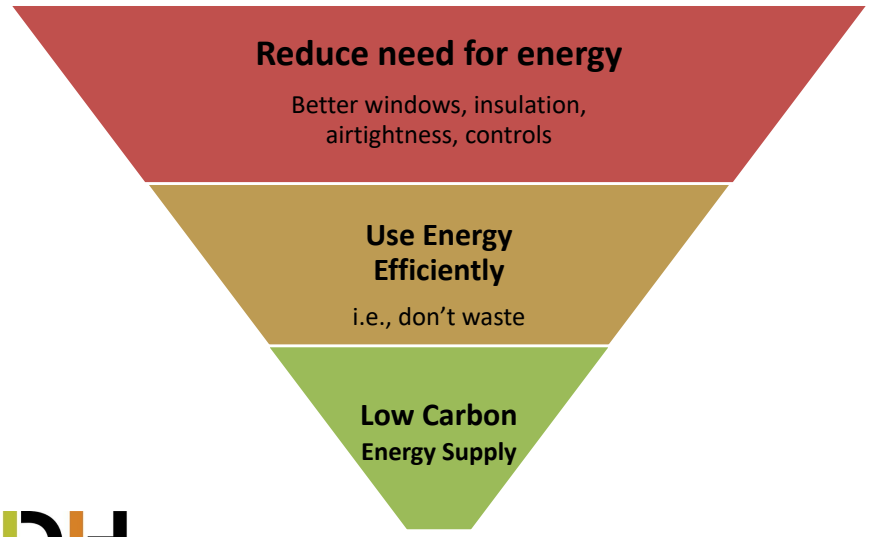
What Generates Carbon

- ~~Construction & Materials~~
- Space heating, cooling, ventilation
  - Enclosure (walls, roof, windows, basement, air leak)
  - Mechanical equipment (meets load from enclosure)
- Domestic hotwater
- Lights, elevators, appliances……

Reducing Carbon Emissions



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LL97: Energy → Carbon

- Electric 0.637 lb $C0_{2e}$ per kWh
- Natural gas 0.117 lb $C0_{2e}$ per kbtu
  - 1 kbtu = 0.293 kWh
- #2 Fuel oil 0.164 lb $C0_{2e}$ per kbtu
- District steam 0.099 lb $C0_{2e}$ per kbtu

- How will these change 2025, 2030?

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Fuel switching

- A good heat pump with COP=2.5
  - 0.075 lb CO_2 to deliver 1000 Btu heat
- A typical NG boiler with 82% efficiency
  - 0.142 lb CO_2 to deliver 1000 Btu heat
- Therefore switching NG to heatpump reduces carbon by a factor of 2
- Fuel oil @80% vs nat gas at 92%... Saves 40%

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LL97 Carbon limits → Energy

- Vary with Building type
- B Office: 18.75 lb CO_{2e} per square foot
  - 29.4 kWh/sf for all electric 315 kWh/m^2
- R-2 Residential: 14.87 lb CO_{2e} per square foot
  - 23.3 kWh/sf for all electric 250 kWh/m^2
- Using heat pumps, NG increases allowable energy use above these targets

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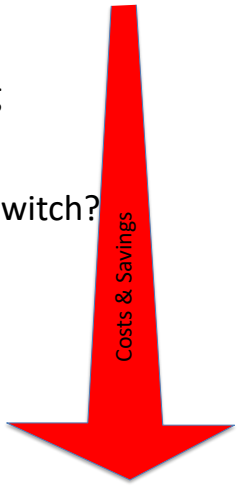
Retrofit Economics

- Tweaks & Repairs
  - Fix controls, replace weather stripping
- Upgrades & Improvements
  - Add controls, weather stripping, fuel switch?
- Retrofit & Renewal
  - Glazing/roof/façade replacement
  - Boiler/chiller
- Gut rehab



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Timing is everything

- Energy efficiency / carbon reduction best timed with major replacements / renewal
- Have a plan for each major equipment replacement ….
- And how that fits into long-term plan

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Planning

- All buildings will spend big $ on replacement
  - Boilers, windows, chillers, water heater
- But… When? And replaced with what?
- Too often replaced when if fails (panic) and with like-for-like

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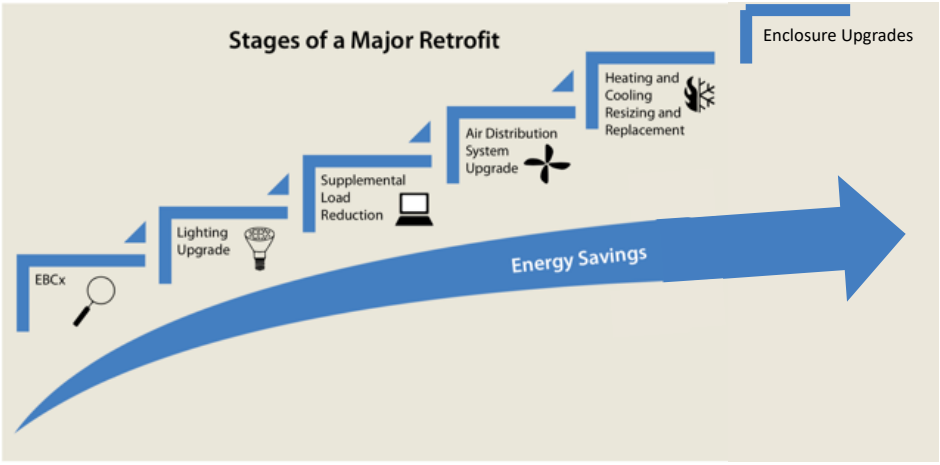
Levels of Intervention

- Well developed lower steps



Adapted from the U.S. EPA's Energy Performance Rating System.

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Deep Retrofits / Renewals

- For buildings with failing / end of life enclosures (windows / walls, curtainwall)
  - Opportunity for a major intervention

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The Empire State Building Retrofit

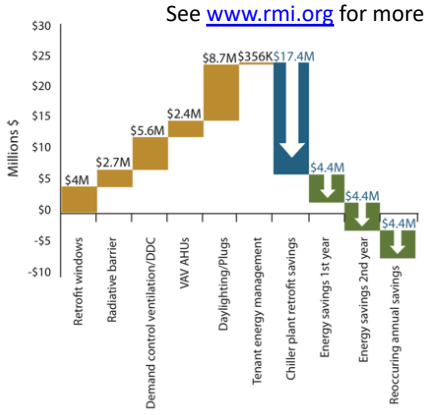
- A famous local example
- Part of a $550M overhaul
  - Around $200/sf overhaul
  - $106M energy-related

ESB Retrofit

- Rocky Mountain Institute Case Study
- Coherent plan
- Many components working together
- Priority made considering the costs and benefits

Tunneling Through the Cost Barrier

See www.rmi.org for more



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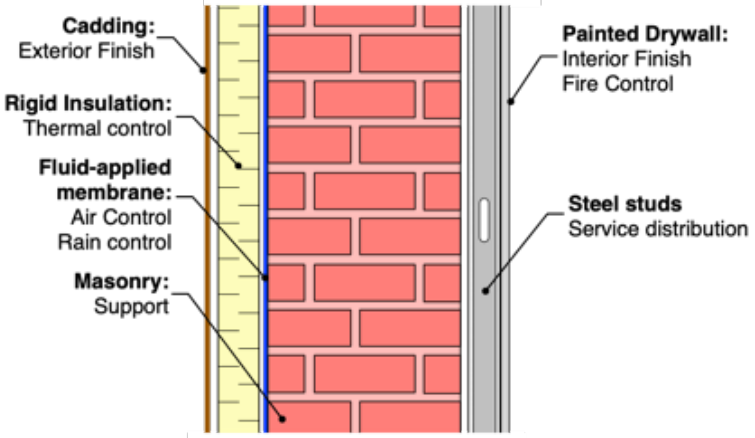
Thousands of buildings

Enclosure Retrofit Choices



Exterior retrofit always technically better!!

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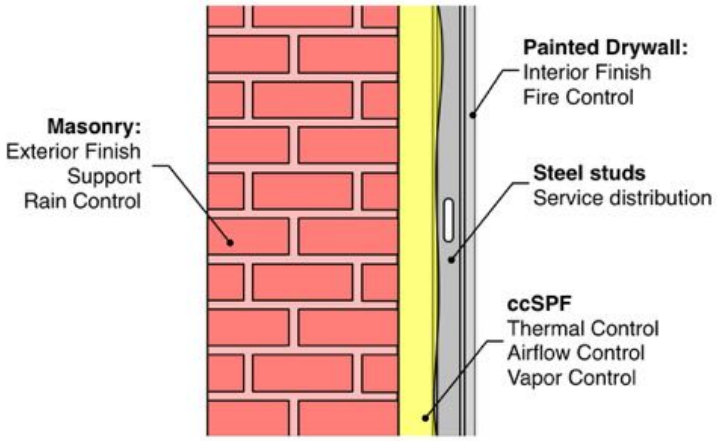
But, if we have to, can do interior



- beware floors, partitions, etc.
- Freeze-thaw, corrosion

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Exterior Retrofit

- Preferred Building Science solution
  Great for ugly buildings

Exterior Retrofit

- Controls rain, heat, *and* air
- Protects existing structure and cladding
- … while providing a new finish

- Historically, retrofit was a major reasons modern **EIFS** was developed post WW2
- Many different lightweight cladding products now available

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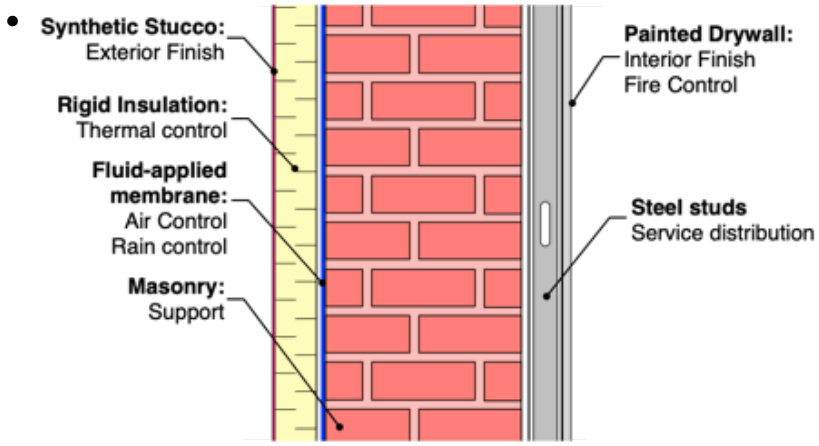
EIFS



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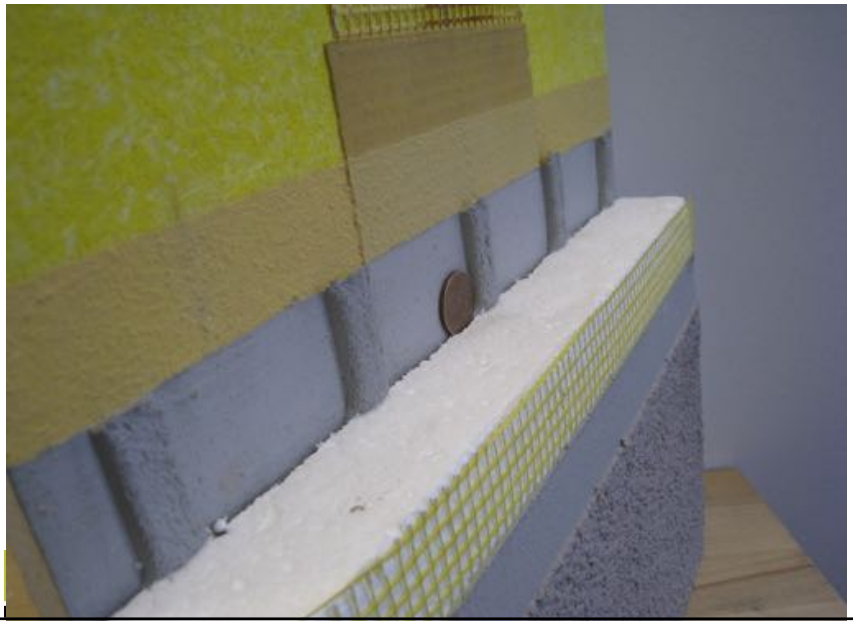
Drained EIFS: nice but not always needed



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EIFS Retrofit Advantages

- Best building science location for insulation, air and water barrier
- Lightweight = flexible
- Like-New looks

Modernization increases asset values, rents and payback periods

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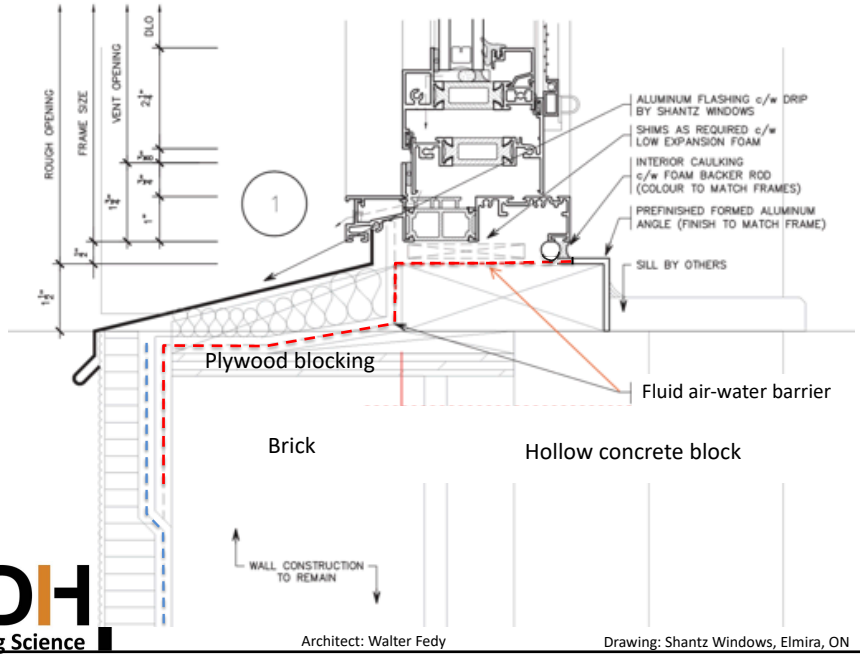
Not covering all of building… Phased approach?

Drained EIFS, Window Detail

Window Details are usually the most crucial & difficult



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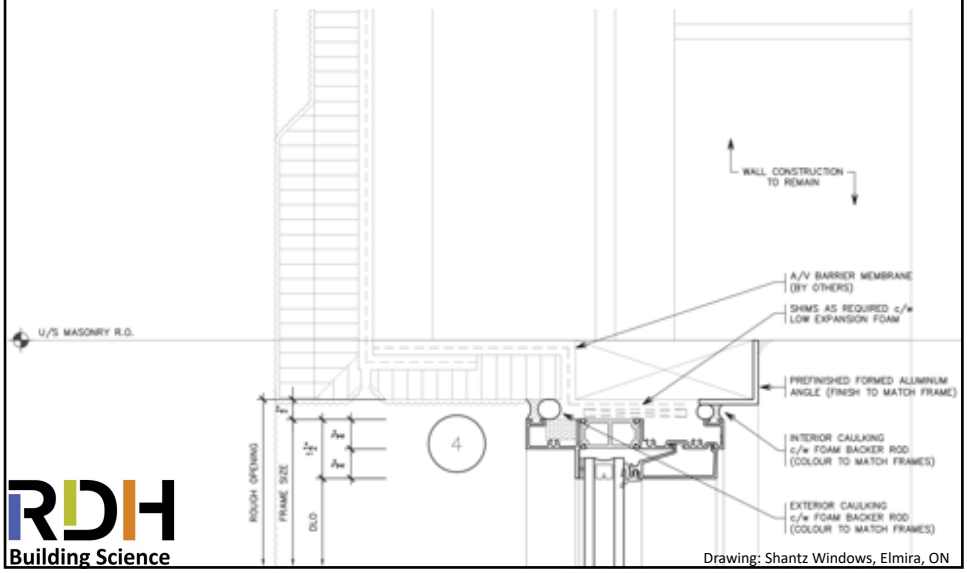
Architect: Walter Fedy

Drawing: Shantz Windows, Elmira, ON

Window Head: Note EIFS Drain opening



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Drawing: Shantz Windows, Elmira, ON

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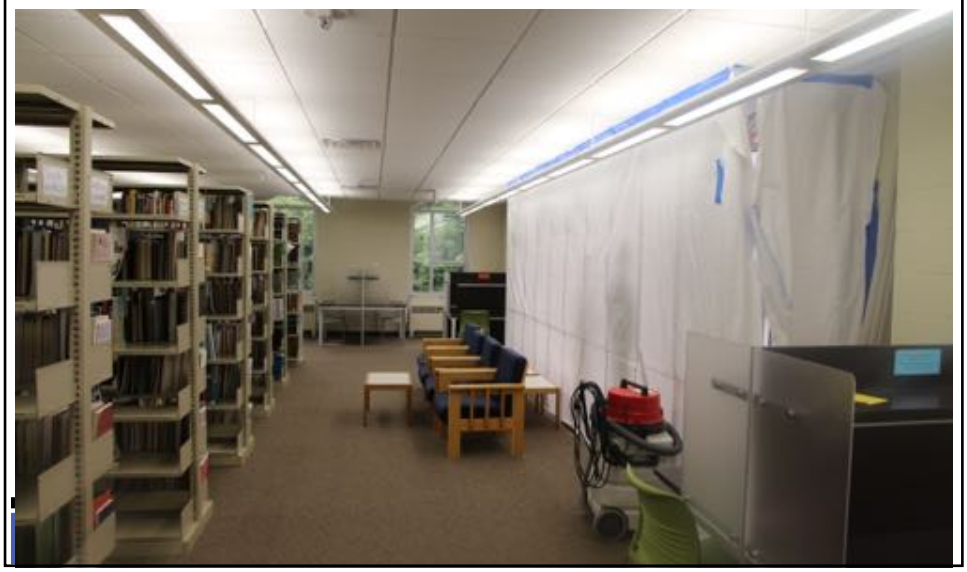
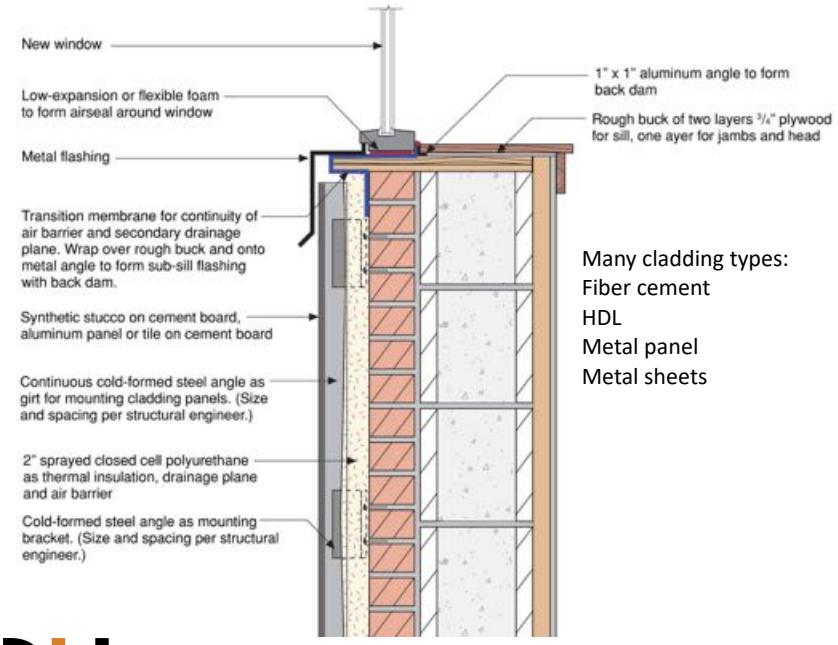
1970's University Admin / Library building

Better window airsealing at inorganic shims required

Retrofit while in use





Many cladding types:
Fiber cement
HDL
Metal panel
Metal sheets

Panel Cladding Retrofit

Metal Overclad -- reshape

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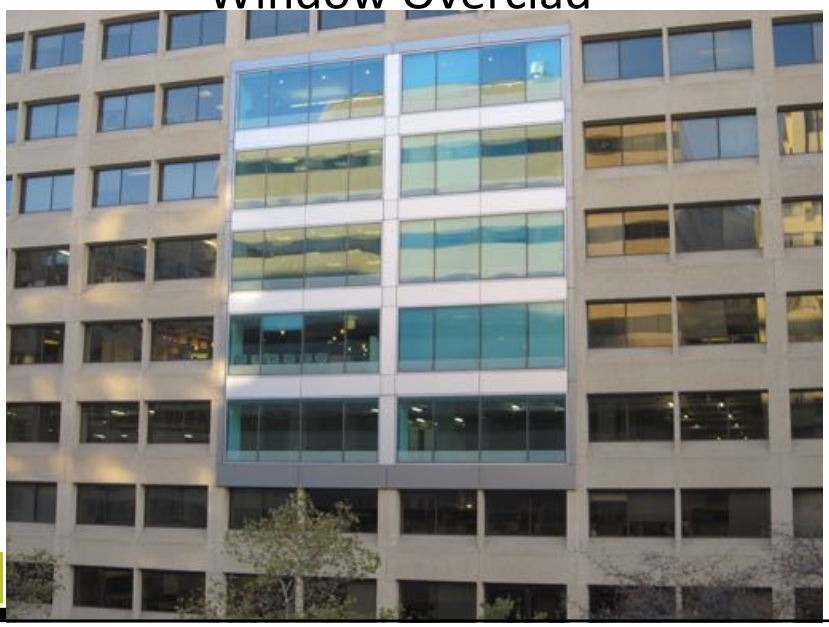
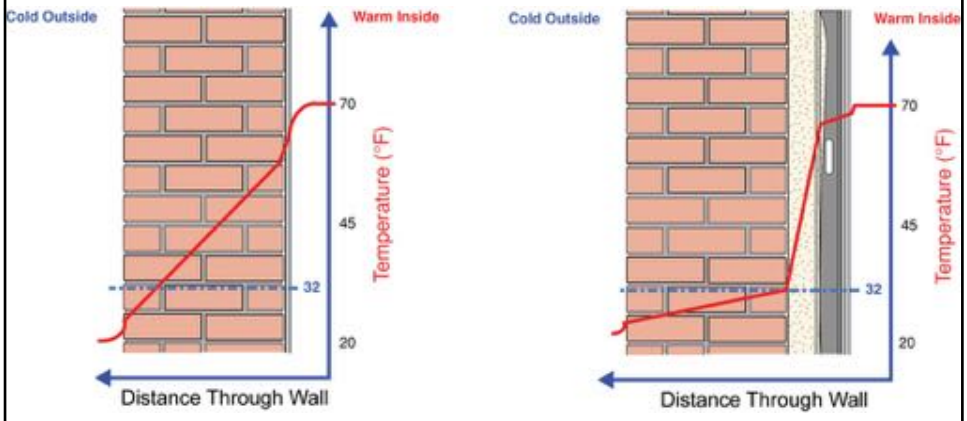
Window Overclad



Interior Insulation

- Creates cold exterior surfaces



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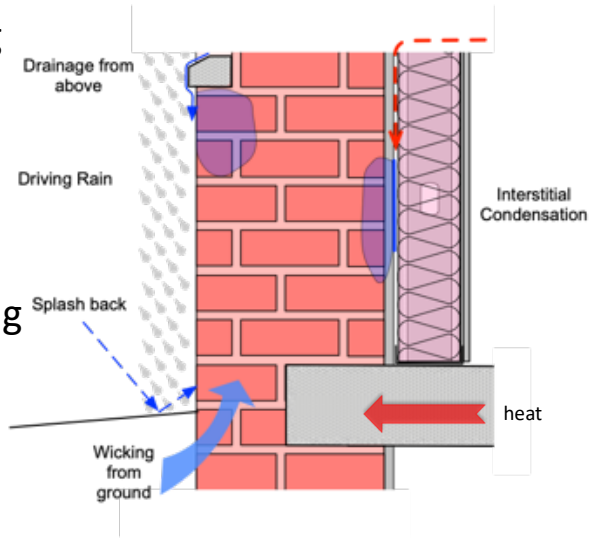
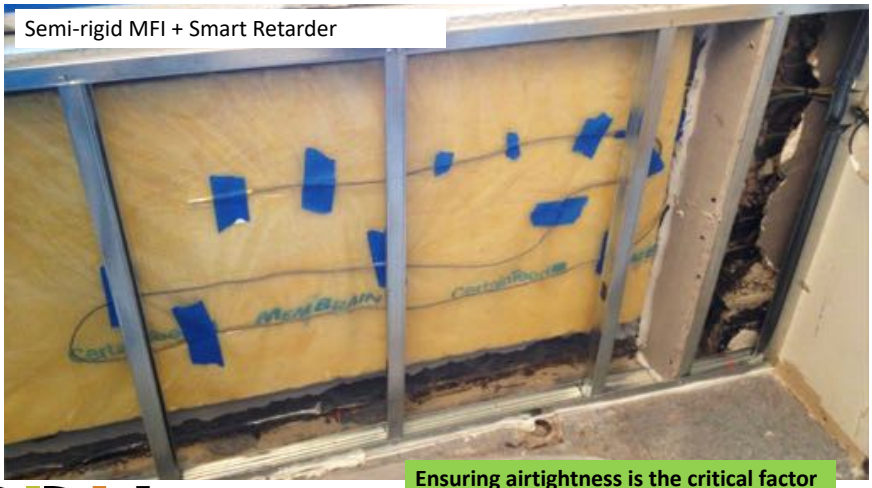
Interior Insulation

- Reduced drying = risks
- Reduced effectiveness thermal bridging



ccSPF on interior

Non-foam solutions



Ensuring airtightness is the critical factor for durability, and hard to do!

Cavity walls

- Interior insulation does not solve many of the problems!
- Often need repairs
  - Leaks because of failed flashing
  - Cracked bricks
- Economics– exterior is often better… if improved air and water tightness matters

Expensive, Difficult, error prone

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Federal Building
Cleveland, OH
Celebrezze

Energy Bills were high
Quality of space was low
Much of the glass & stainless was still in good shape
Limited blast resistance

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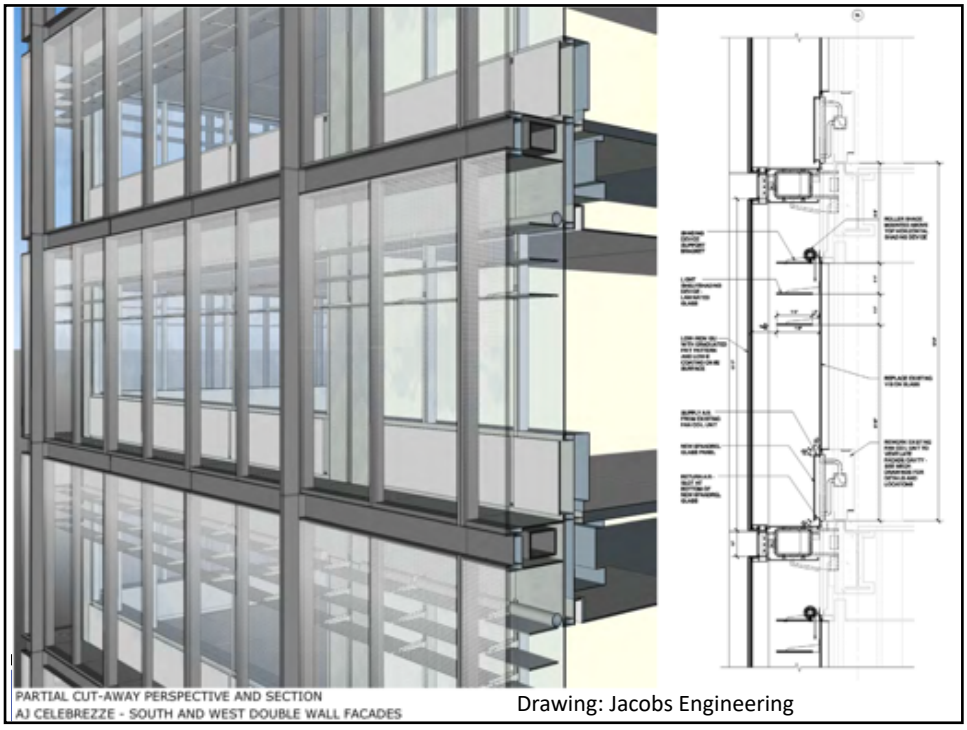

PARTIAL CUT-AWAY PERSPECTIVE AND SECTION
AJ CELEBREZZE - SOUTH AND WEST DOUBLE WALL FACADES

Drawing: Jacobs Engineering

Expensive, but it works

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Case Study: One Wall Center

Failure Mechanisms and Re-Glazing of an all Glass Tower

Thanks to Brian Hubbs, P.Eng
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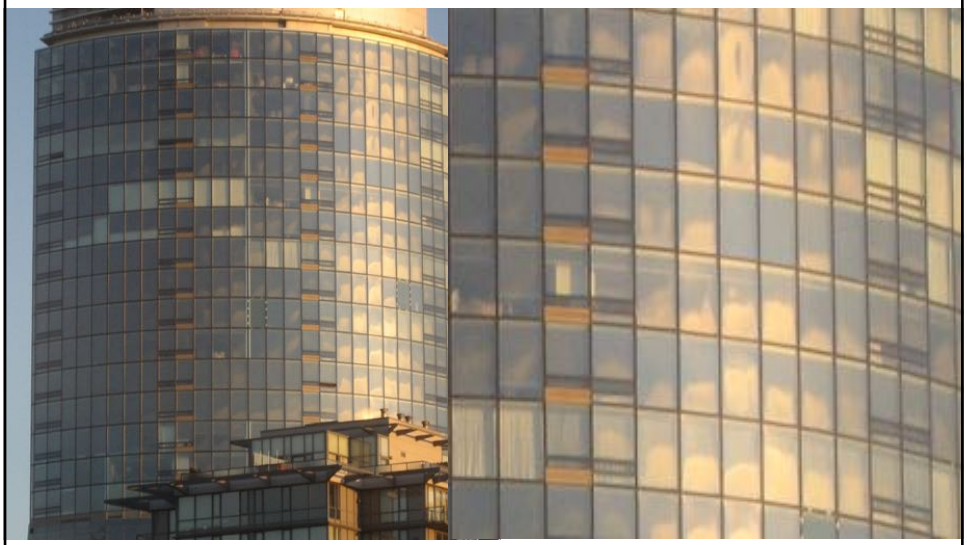
Fogged & Corroded Glazing Units

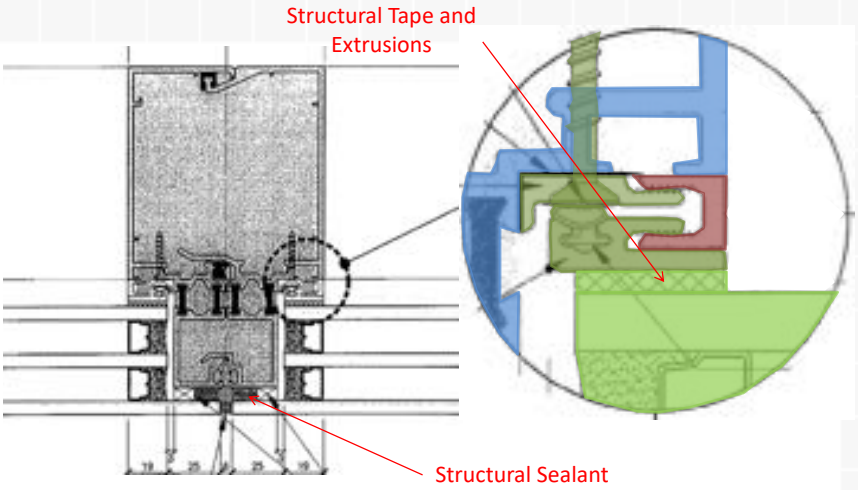
Condensation – Hot sunny day ?



Design – Selecting Glass and Coatings

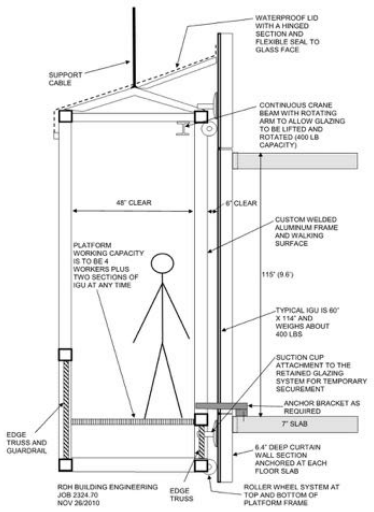
- Glass options were approved by the City and ultimately chosen by the developer
- Triple glazed 6 mm clear tempered with Viracon VY-30 coating on surface #2, and Sunguard Light Blue 63 on surface #5, Argon filled

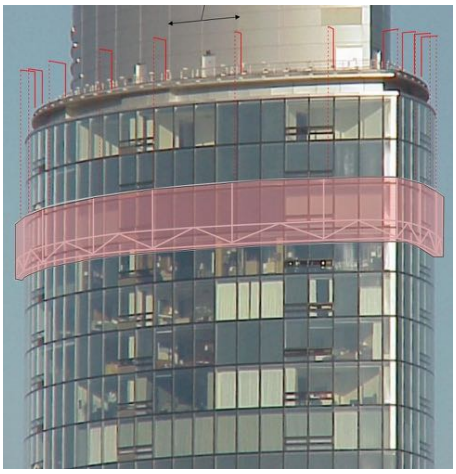
Design – Final Structural Silicone/Tape Detail



Final Design for re-glazing and Installation
2 redundant structural adhesive joints (1 in factory, 1 on site)

All Weather Work Platform (60km/hr wind)





Custom Suspended Scaffolding

Custom Suspended Scaffolding

All work is completed from the suspended stage or from the interior. Anchors through vent openings pinned to the structure keep the stage secure

→ 5-6 IGUs per crew day

Windows

- A major issue in retrofits!
- Usually leak heat, air and water
  - Must address at some time
- Leaving leaky windows in good retrofit wall limits performance
  …. Could cause problems!

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Air sealing

- New technology available for retrofitting
  - Sealing ducts
  - Sealing enclosures

→ Aerobarrier

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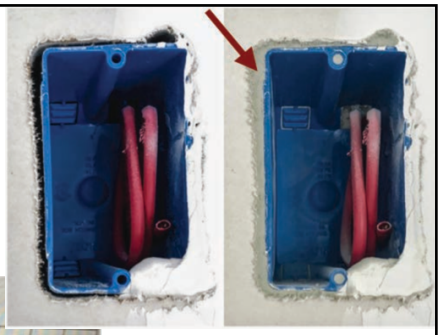

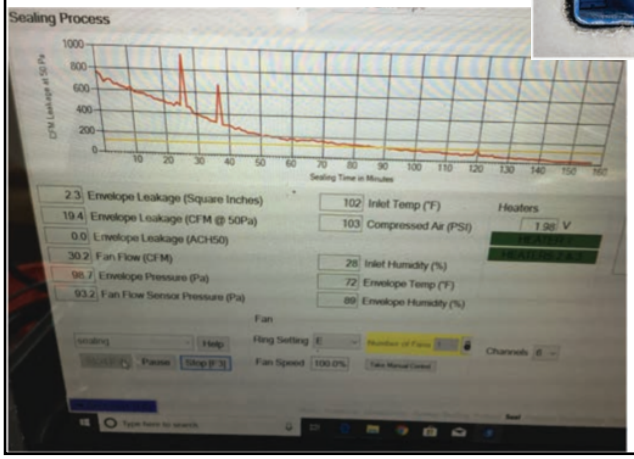

Planning as a System

- Many opportunities lost without planning
- Change boilers, windows, walls, roof
  - What order?
- System thinking
  - Easy to add PV, condensing boilers require a system design

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Conclusions

- Enclosure/Equipment Energy retrofits rarely pay for themselves w/savings
- Controls and equipment have limited impact, and just comfort and energy
- Enclosure upgrades affect durability, comfort, energy and re-sale / rent values
- Plan ahead, co-ordinate with required renewals

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