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Today's presentation

- What is “resilience”?
- How do we build it in
- What “building science” is needed?

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Building Science

bil-ding sahy-uhns

1. cross-disciplinary collection of knowledge & experience required to understand and predict many aspects of the behaviour (performance) of buildings & their systems
2. Err, duh, ugh.



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Resilience

ri-zil-yuhns

1. the act of rebounding or springing back
2. the capacity to adapt to changing conditions and to maintain or regain functionality and vitality in the face of stress or disturbance.

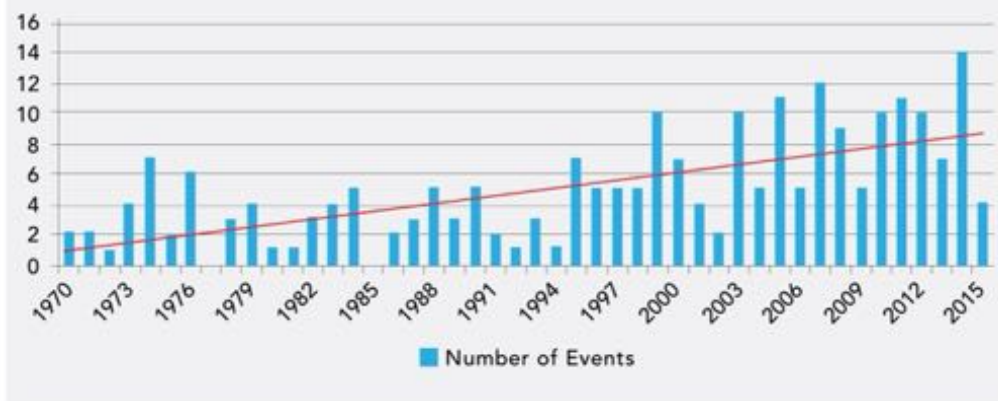


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“Natural” Disasters

- # of events requiring federal gov't assistance

Insurance Bureau of Canada, “property and casualty insurance payouts from extreme weather have more than **doubled every five to 10 years** since the 1980s”



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Source: Public Safety Canada. 2016-2017 Evaluation of the Disaster Financial Assistance Arrangements.

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Resilience

- Many aspects are about **flood** control!
 - Siting, basements, backed-up sewers
- Some are about temperature control
 - Human comfort (and freezing pipes)
 - Summer Overheating
 - Winter cooling

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Resilience Risks

- Power outages!
 - Overheating
 - Freezing
- Flood
- Wildfire
- other



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Less Resilient Customers

- Higher-density housing
- More expectations (comfort + convenience)
- Fewer skills (wood stove?)
- Fewer resources (water well + bucket)



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A Great Resource

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FLOODING



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Flooding

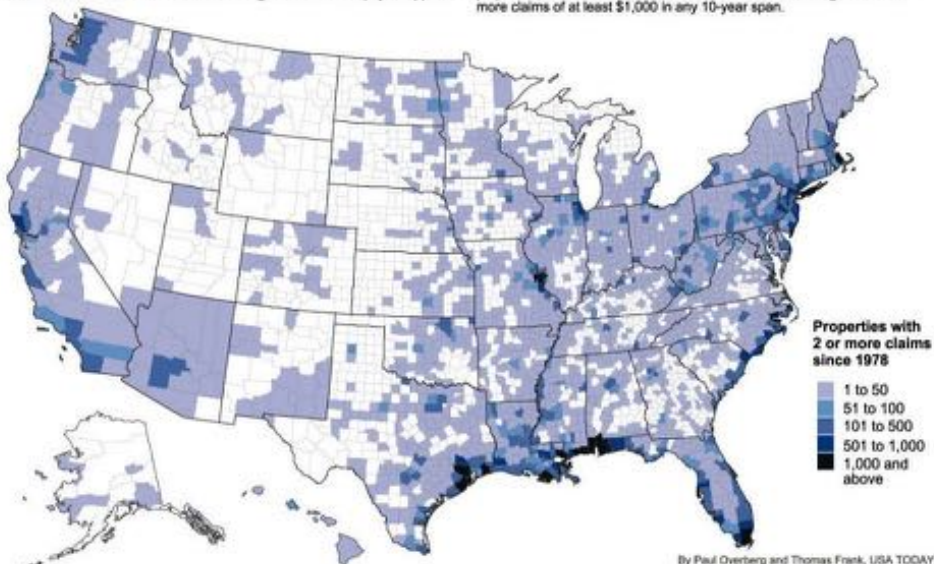
- Climate change is causing more intense storms, more extremes
- Infrastructure is aging / not maintained / overburdened
- River flooding, basements, waste and storm water systems



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Frequent flooding drains insurance fund

Repeatedly flooded properties have cost a federal insurance program \$11 billion in claims since 1978 and are a huge drain on the taxpayer-supported insurance fund. This map shows counties with the most "repetitive-loss properties," a FEMA term for a home or commercial building with two or more claims of at least \$1,000 in any 10-year span.



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Flood Zones

- Don't build there. But if you have too



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- Intense rains
- Poor infrastructure

Winnipeg homeowners grapple with damaged homes, ruined basements amid flooding from spring storm

The city says staff are working around the clock to help people deal with flooding

[Peggy Lam](#) · CBC News · Posted: Apr 24, 2022 7:56 PM CT | Last Updated: 6 hours ago

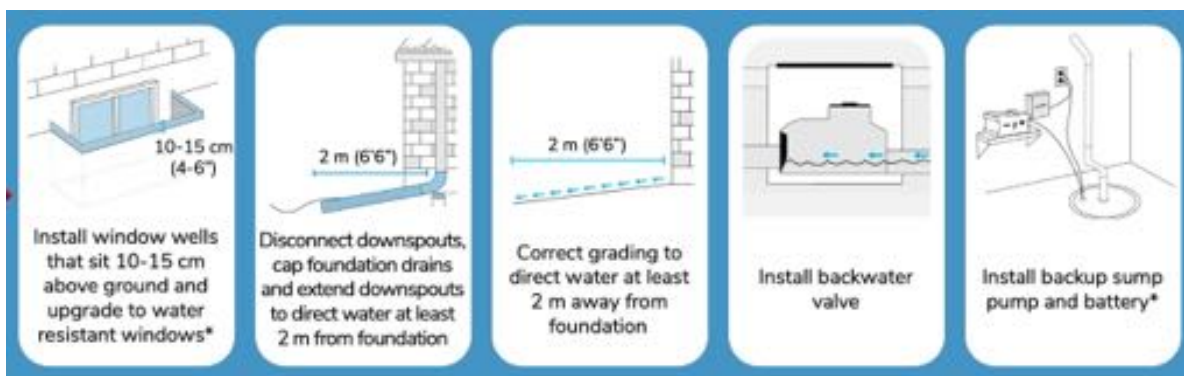


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Manage Flood Risk

- Design choices

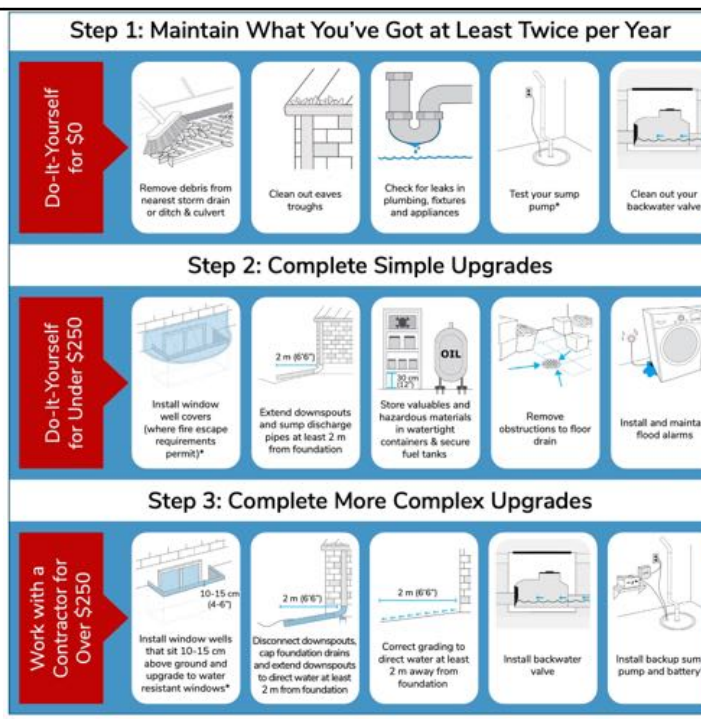


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Flood Mitigation

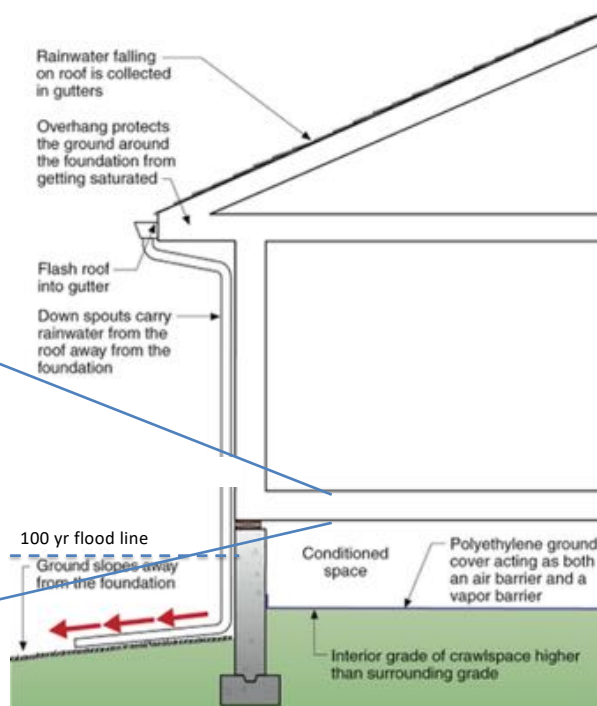
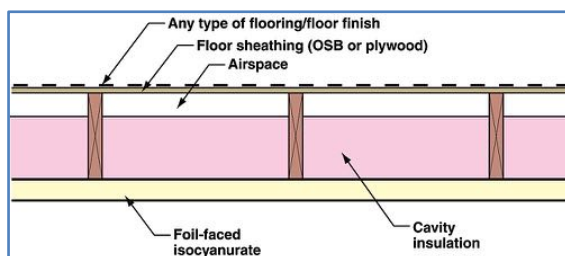
- Simple steps once built



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Crawlspaces?

- Prepare for drying and drainage



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Guidance for New Communities



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POWER OUTAGES ... and the resulting mayhem

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Texas Power Outage

CNN
US
 Crime + Justice
 Energy + Environment
 More

Millions without power as US braces for another winter storm

By Meg Wagner, Judson Jones and Mike Hayes, CNN
Updated 7:58 p.m. ET, February 16, 2021

More than 250,000 without power as deadly winter storm brings icy hazards

Nearly 4,000 flights within, into and out of the U.S. were canceled for Friday due to the storm, which also appeared to cause a deadly tornado in Alabama.

Texas faces power outages, freezing temperatures during winter storm

WINTER STORM POWER OUTAGES IN TEXAS BRING UP MEMORIES OF LAST YEAR'S STORM CRISIS

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Power Outages

- High performance houses use less energy
- BUT, may be more dependent on supply
- Electricity is becoming more unreliable
 - Not just a climate thing



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Backup generators



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Photovoltaic Generators?

- *Most grid-tie inverters shut down when power fails,*
 - eg PV no longer generates when grid fails
- Must use “special” inverter and batteries for PV to work
 - The next frontier?



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Low Energy Buildings & Power loss

- Low-energy buildings *can* be very resilient
- Will stay warm for days, remain above freezing temperatures
- Require very little backup heat
 - E.g., Small wood stove
- But can be more susceptible to overheating



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Power Outages

- Design to survive 24?-96? hr power outage
 - Pumps for below grade
 - Overheating
 - Avoid freezing pipes?
- Active measures
 - Generators, batteries



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Resilience: Passive Survivability

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Environmental Building News
THE LEADING SOURCE FOR ENVIRONMENTALLY RESPONSIBLE DESIGN & CONSTRUCTION

Passive Survivability: A New Design Criterion for Buildings

In December 2005 an editorial in EBN introduced the concept of “passive survivability,” or a building’s ability to maintain critical life-support conditions if services such as power, heating fuel, or water are lost, and suggested that it should become a standard design criterion for houses, apartment buildings, schools, and certain other building types (EBN Vol. 14, No. 12). Since then, the term has begun creeping into the lexicon of green building, though we have a long way to go before the mainstream building industry takes notice.

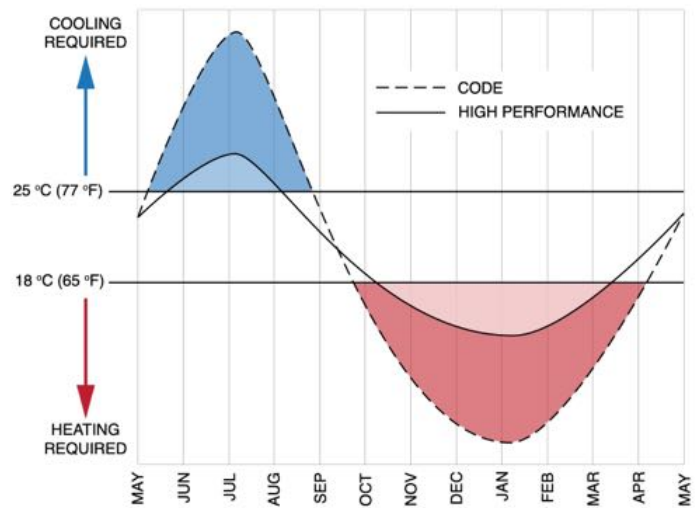
In this article we examine the concept of passive survivability in greater detail and address some specific strategies that can be employed in adopting this design criterion for buildings.



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Thermal autonomy

The fraction of time a building can passively maintain comfort conditions without active system energy inputs.



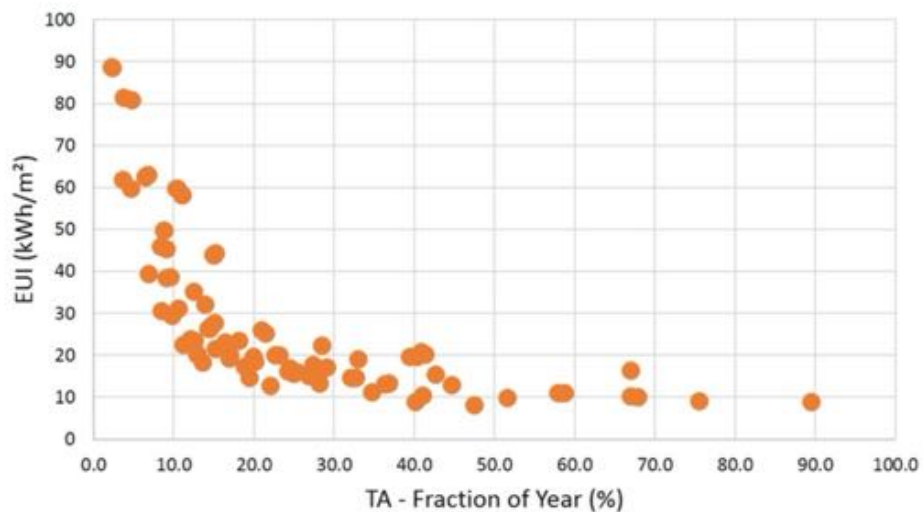
Kesik, T. et al. Thermal Resilience Design Guide, 2019.

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EUI vs Thermal Autonomy

- Strong trend: lower Energy Use, higher Thermal Autonomy



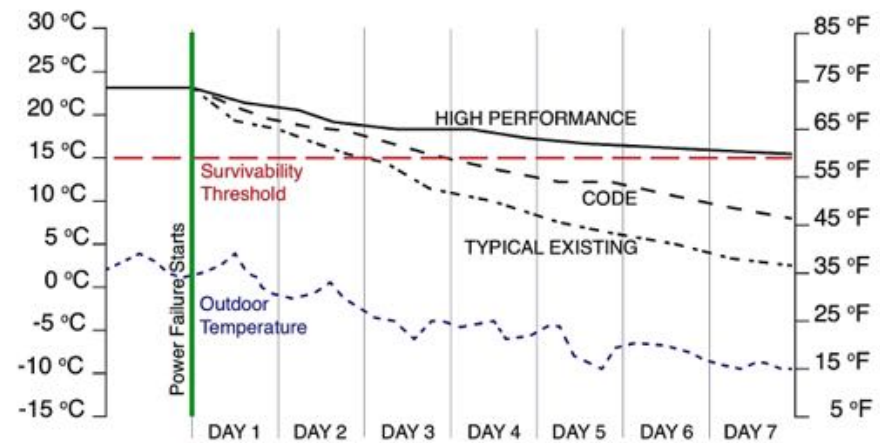
Aylin Ozkan et al, ICBEST 2018.

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Passive Survivability Cold Weather

- Critical with new all-electric homes
- How long before building cools down



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T. Kesik, Thermal Resilience Planning Guide

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Overheating

- British study (2014)
- Widespread problem with well insulated homes

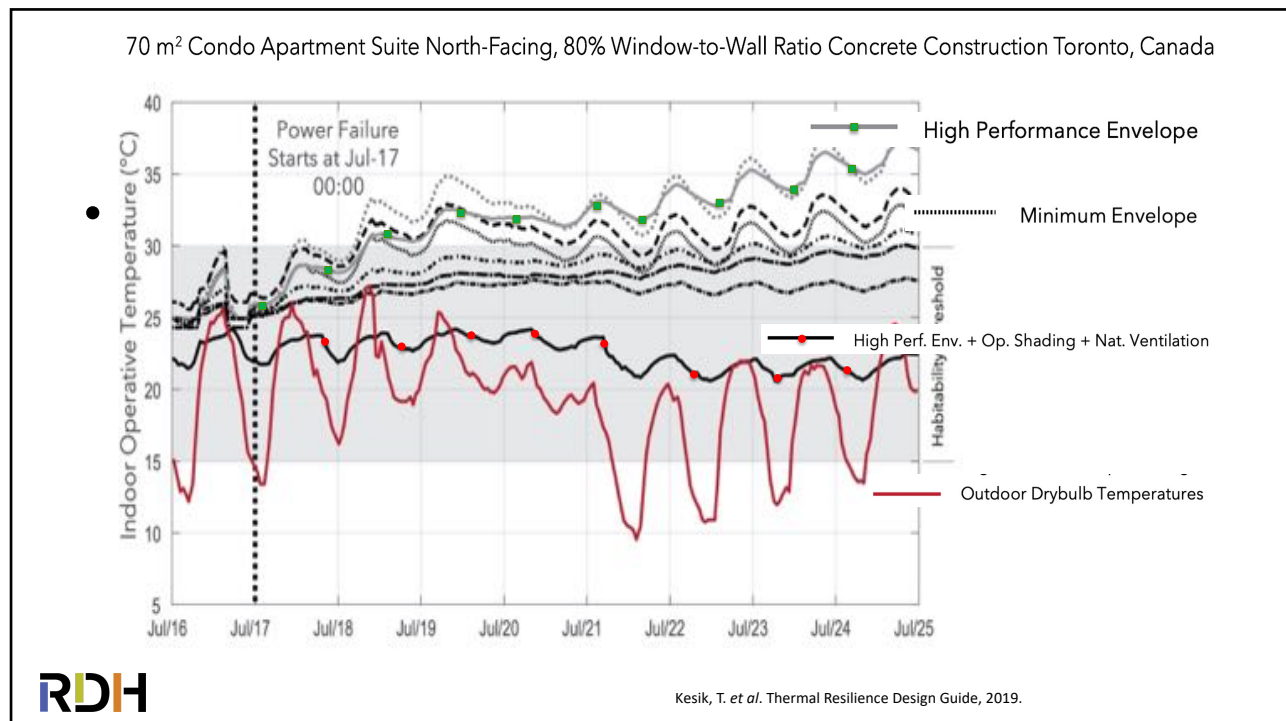


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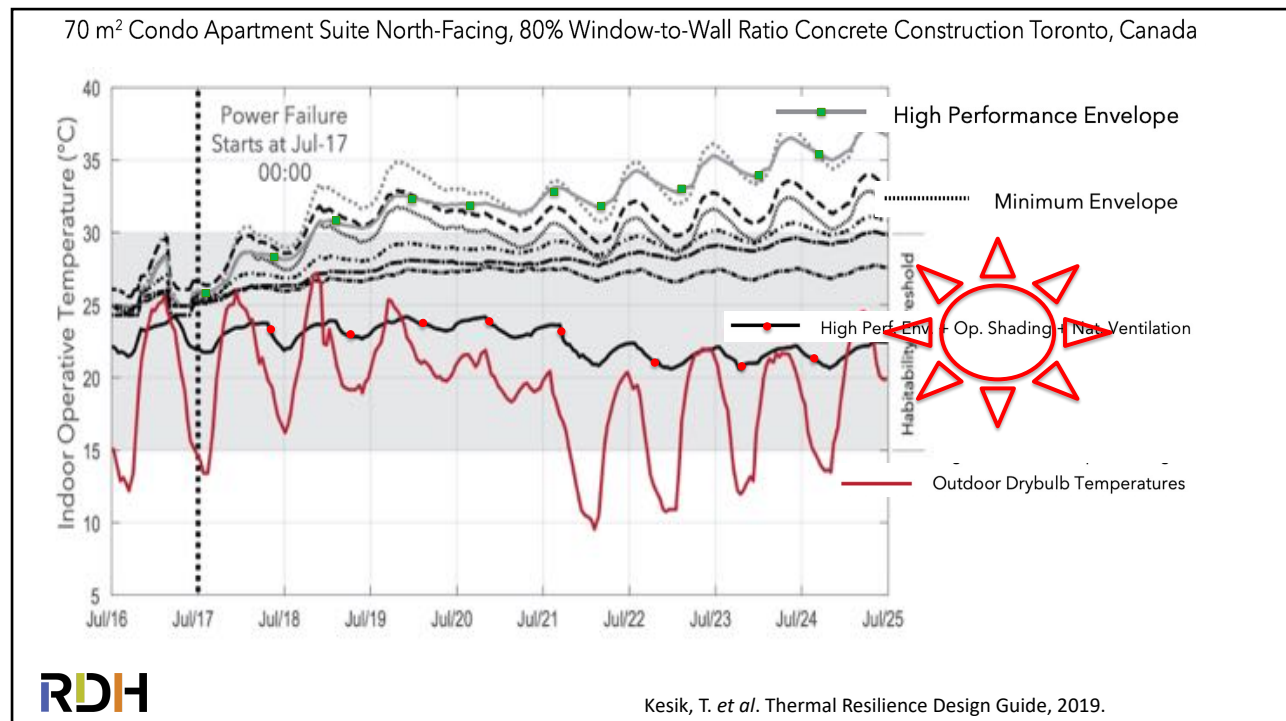
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High Solar Gain

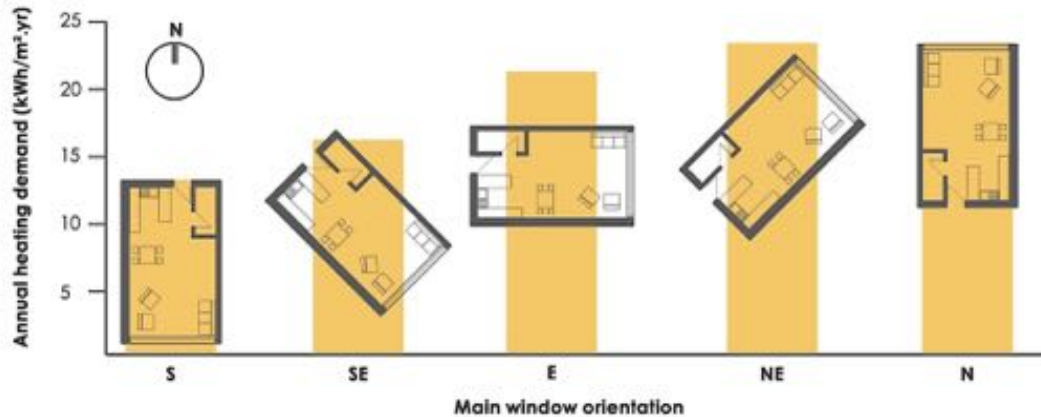
- High performance enclosures results in an building that is more sensitive to overheating
- High solar gain windows rarely a good idea
 - A hangover from the 1980's solar design?
 - Misguided implementation of Passive House?

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Beware “free” solar heat

- Focus on mid-winter conditions risks overheating in summer



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Exterior shade

- FAR (5-10x) more effective if exterior
- New requirement for high performance
 - Did not need it as much
 - Powerful resilience tool for AC buildings
- Combine with fire / wind shutters?

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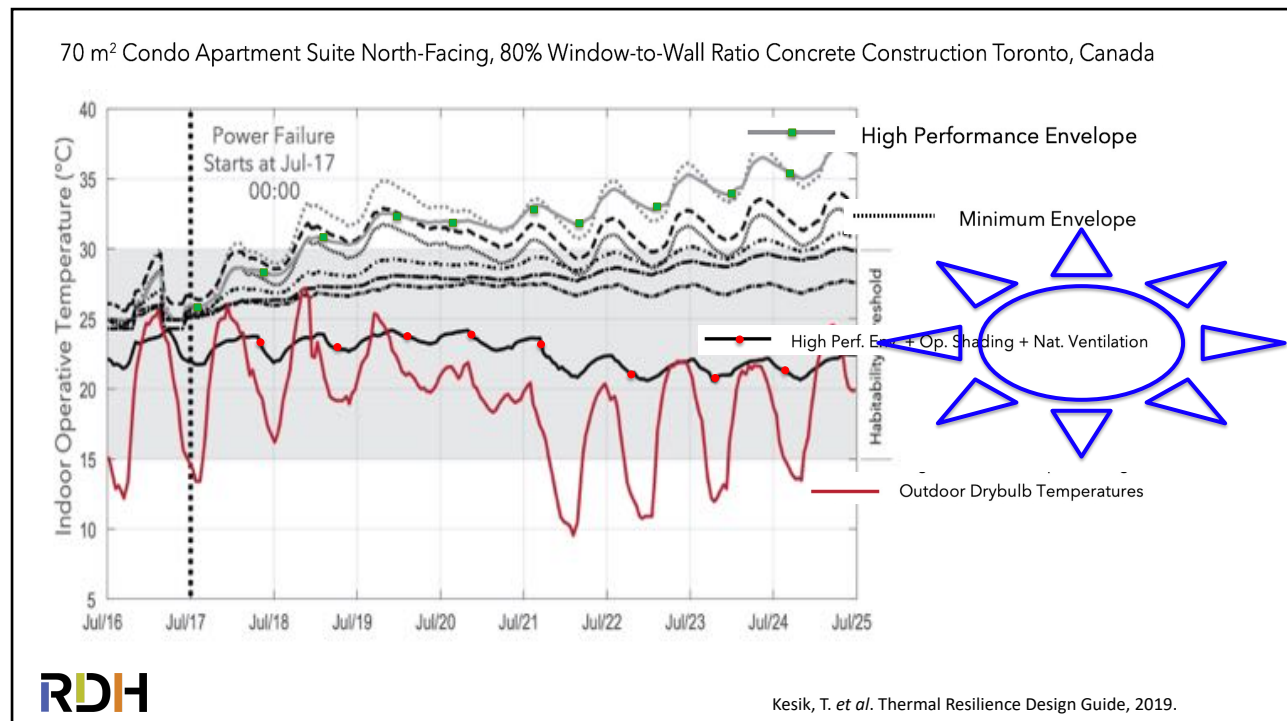


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Ventilation Cooling

- Exchanging indoor air with outdoor provides cooling IF, and ONLY IF, it is cooler outside
- Critical period occurs when outside is hot, and sunny increases heat indoors

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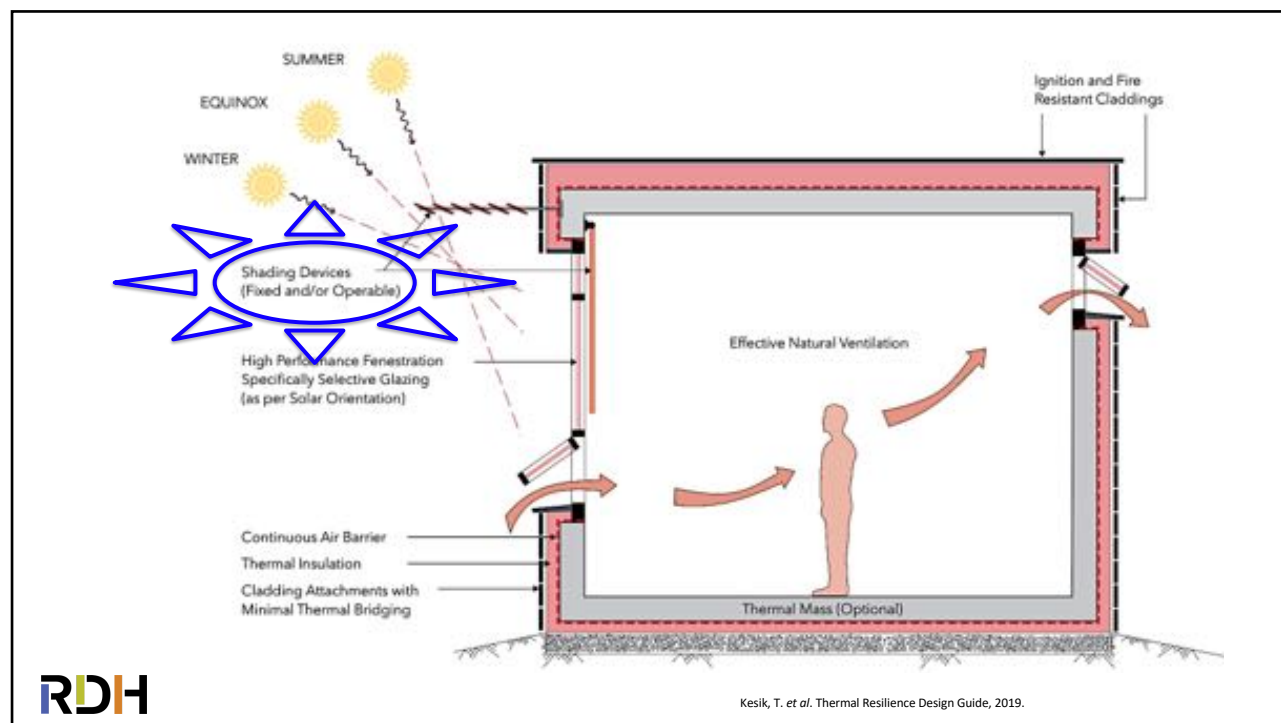
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Ventilation Fresh Air

- Only requires operable windows with small areas
- Cross-ventilation (two sides of a room) is vastly preferred
 - Difficult to design in to most multi-unit housing



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TGS Resilience check-list: thermal only



Checklist - Toronto Green Standards Version 3.0

Resilience Planning New Construction

What measures have been taken to reduce the impacts of heat waves?

Building - passive

<input type="checkbox"/> Higher roof R values ←	<input type="checkbox"/> Higher envelope R values ←
<input type="checkbox"/> Operable Windows ←	<input type="checkbox"/> Window films
<input type="checkbox"/> Cool/green roof ?	<input type="checkbox"/> High albedo envelope materials
<input type="checkbox"/> External window shading devices ←	<input type="checkbox"/> Triple glazed windows ←
<input type="checkbox"/> Tenant emergency preparedness guides	
<input type="checkbox"/> Other passive ventilation strategies	

Building - active

<input type="checkbox"/> Indoor refuge area with cooling ←	<input type="checkbox"/> Centralized air conditioning ?
<input type="checkbox"/> Ceiling fans ←	

The # chosen really matters



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WILDFIRES



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Residents grab what they can before escaping wildfire near Lytton, B.C.

People were fleeing and structures burned before evacuation order was issued

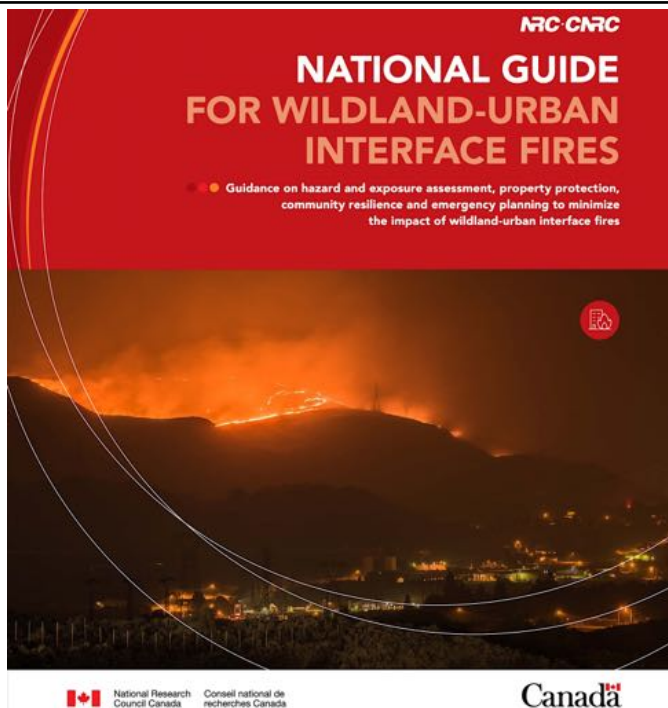
The Canadian Press · Posted: Jul 01, 2021 3:18 AM PT | Last Updated: July 1, 2021



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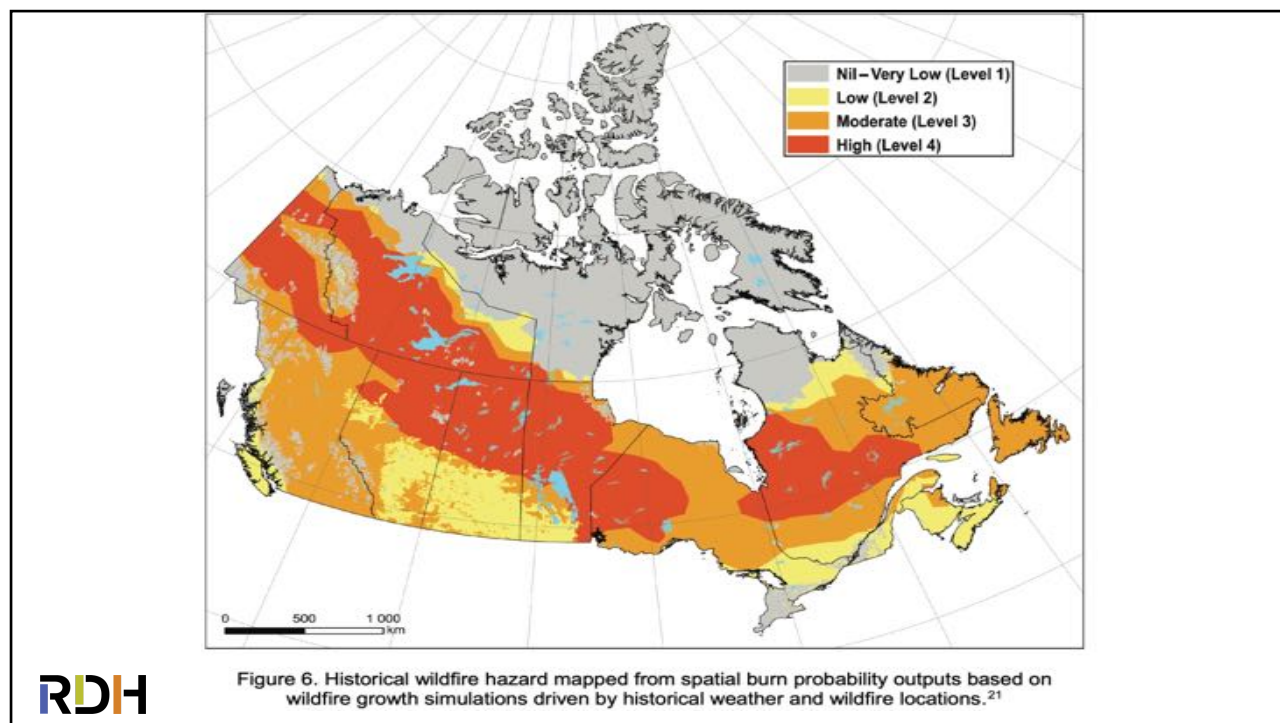
Video captured by a Lytton resident fleeing the B.C. community on June 30, 2021 shows numerous structures on fire. (2 Rivers Remix Society/Vimeo)

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Wildfires

- Risk is very geography-specific
- E.g. Fort McMurray
- 2 400 homes destroyed
- 88 000 residents



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Site Design

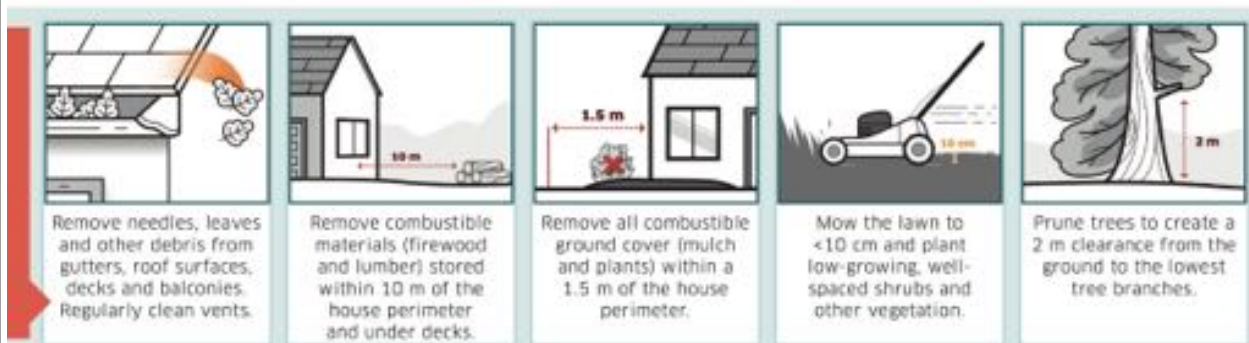
- *Critical* factor
 - Space from trees, shrubs, undergrowth
- Remove trees, trim trees, cut lawn
- Maintenance of growth required



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Maintenance... semi-annual

STEP 1: MAINTAIN WHAT YOU'VE GOT AT LEAST TWICE PER YEAR



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Burning embers / firebrands are leading cause of ignition



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Figure 6: A destroyed home following fire spread from the Angora fire. Note the intact, unburned vegetation surrounding the structure. Murphy et al. notes that this house was ignited by wind-blown firebrands, not by surface fire spread or radiant heating (Murphy et al., 2007).

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Vents

- Wall vents, soffit vents, HVAC vents
- Need to be protected by metal screens
 - **burning embers** are highest risk



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www.frontlinewildfire.com

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New Construction Recommendations

Roofs

- Ensure roofing achieves Class A rating (e.g., Clay tiles, concrete slate)

Vents (wall and soffit) Louvers, Hoods

- Screened with wire mesh no larger than 1/8 inch (3mm).

Eaves and Soffits Overhang and Projections

- Use Non-combustible soffits and fascia, eg fiber cement or metal.

Cladding and Siding

- exterior cladding must be ignition- resistant. E.g. fiber cement, stucco, masonry, and manufactured stone.



FEMA Homebuilder's Guide to Construction in Wildfire Zones - Technical Fact Sheet Series, 2008.

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New Construction Recommendations

• Windows

- must be dual-pane with tempered glass. Solid wood, aluminum, pultruded fiberglass window frames perform better
- Consider simple fire shutters for high-risk sites

• Eavestroughs (gutters)

- keep clear of combustible materials -- gutter guards are recommended. Metal gutters with metal flashing

• Base of Building

- Select planting carefully. Min 8" from grade to siding.



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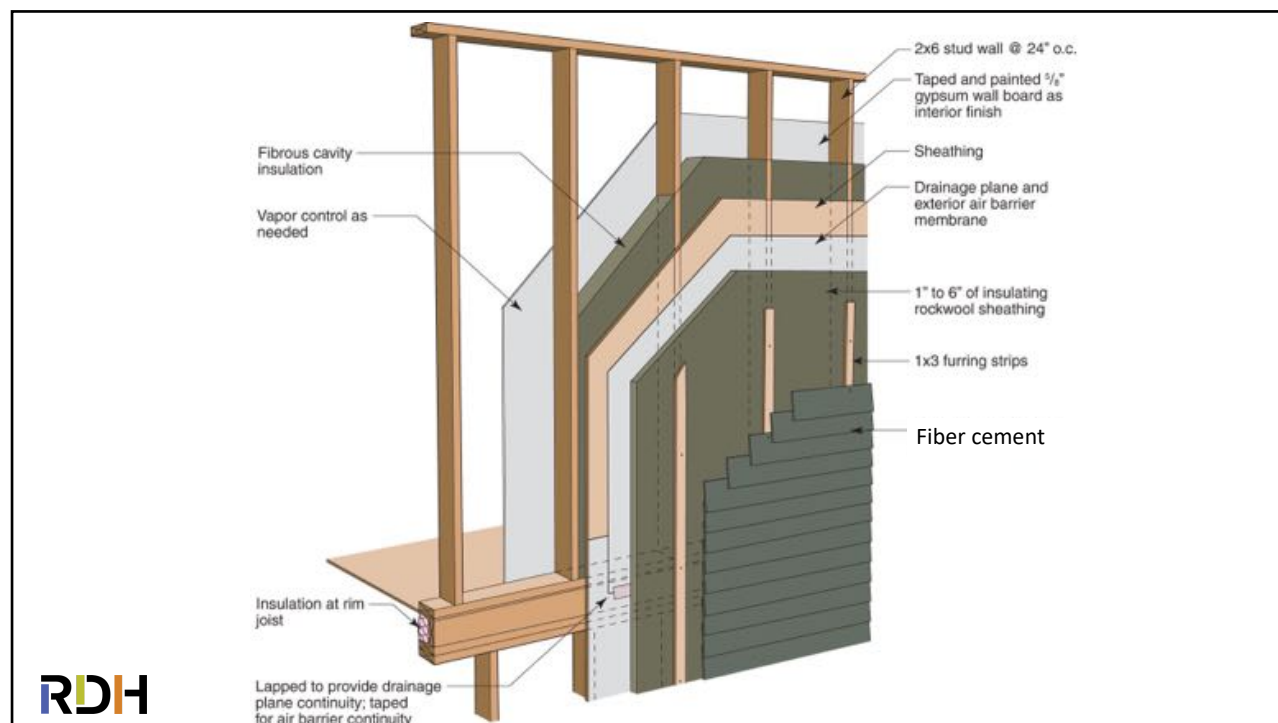
Simple New Construction Features



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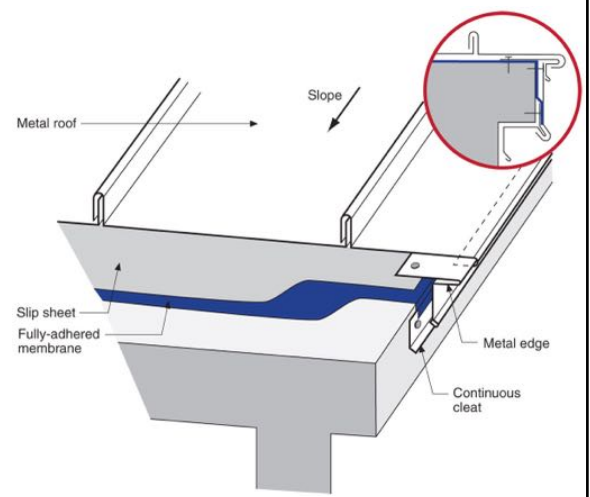
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Vented w/screen vs Unvented



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OTHER RESILIENCE CHALLENGES



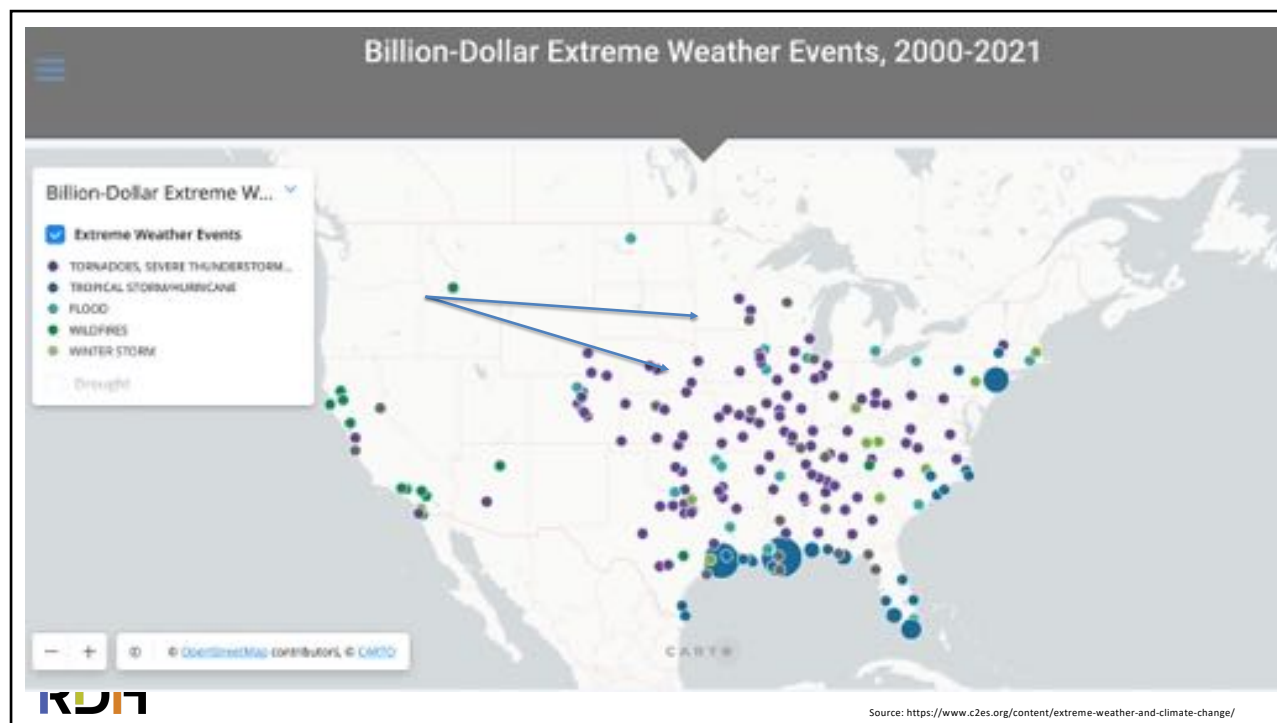
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Wind Storms

- Increase in high winds? Possible.
- Increase in Tornadoes... very likely



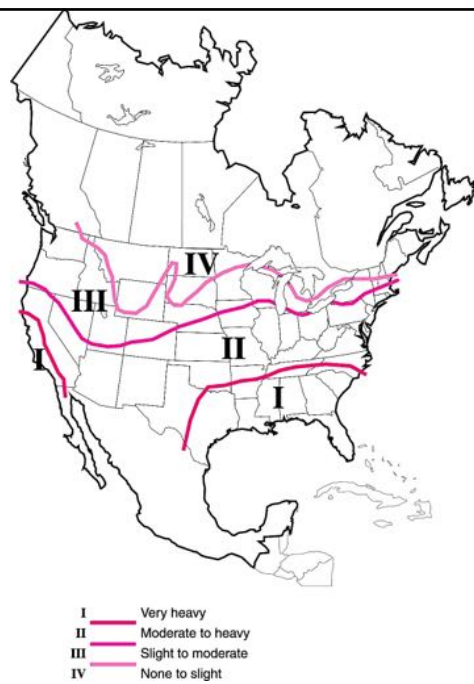
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Bugs: Termites

- Warming climate means expanded habitat for bugs
- Termite threat has been growing slowly for decades
- Very regional in Ontario



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Resilience and Building Science

- Are there special building science rules for resilience?
- **NO.** Resilience considerations mean
 - New challenges to solve, new customers
 - Changing climatic conditions
 - Different materials and methods of construction
 - Apply same “physics” to these new problems
- But, basic building science is still uncommon




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Conclusions

- There are numerous resilience challenges
- Many resources and common sense solutions to help improve buildings'
- More detailed site-specific risk profiles (flood, wind, wild fire) would be helpful





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Discussion + Questions

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