FROM RISK TO READINESS
MAY 17, 2022

Defining the existing building challenge

Every building needs a plan

Monte Paulsen
Passive House Specialist
RDH Building Science
mpaulsen@rdh.com

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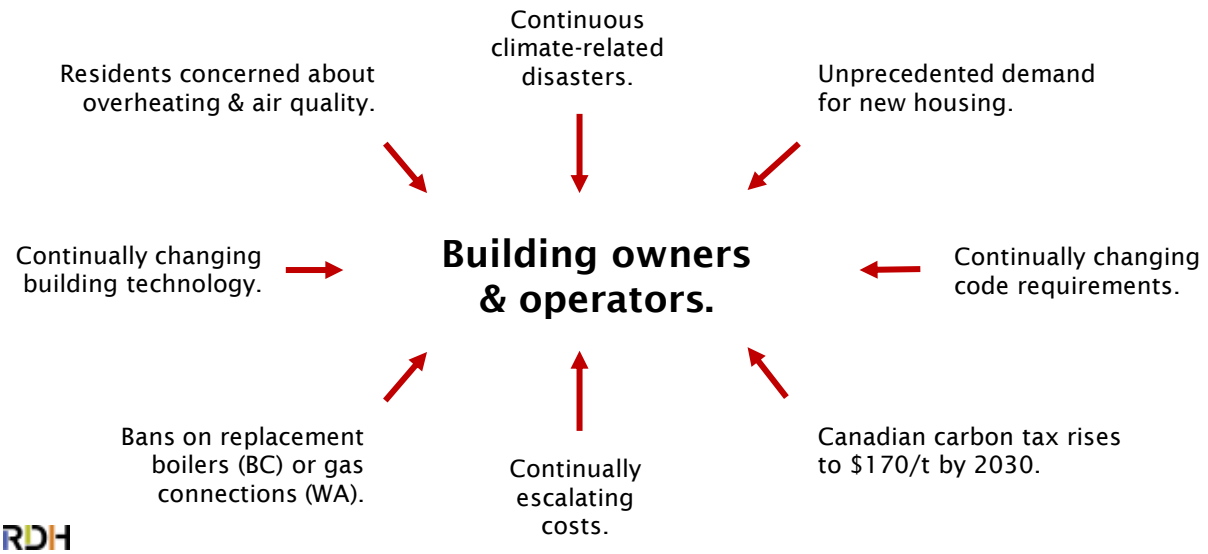
Lytton, B.C., July 9, 2021.
Photo by Darryl Dyck, The Canadian Press.

1

Are you facing a confusing array of new issues?



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Let's look at the context for today's symposium

- What climate disruption looks like at +1.1˚C.
- How buildings contribute to climate disruption.
- What will happen as we approach +3.2˚C of global heating?
- How will building **adapt** to a more hostile climate?
- How will buildings **mitigate** greenhouse gas emissions?
- How new **government requirements** will drive mitigation.
- Every building needs a plan.

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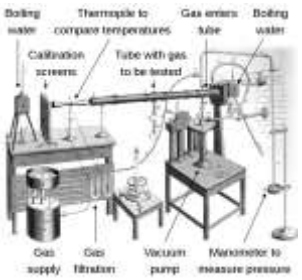
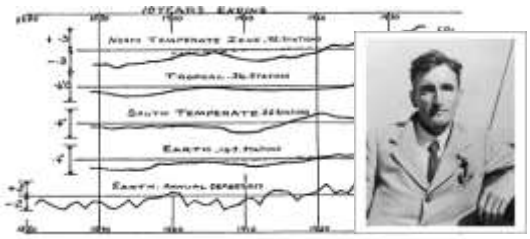
The science of climate change is not in doubt

- Scientists have been studying climate for more than 160 years.
- Scientists have reached extraordinary consensus: Human emissions are fueling global heating.
- The Intergovernmental Panel on Climate Change (IPCC) conducts peer review and summarizes consensus.
- Divergent public opinions are a result of decades-long disinformation campaigns led by fossil fuel industry.



John Tyndall, 1859.



Guy Callender, 1938.

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What climate disruption looks like at +1.1˚C

"Cascade effects" are magnifying risk to life and property.

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*That's 2˚F for those who speak American.

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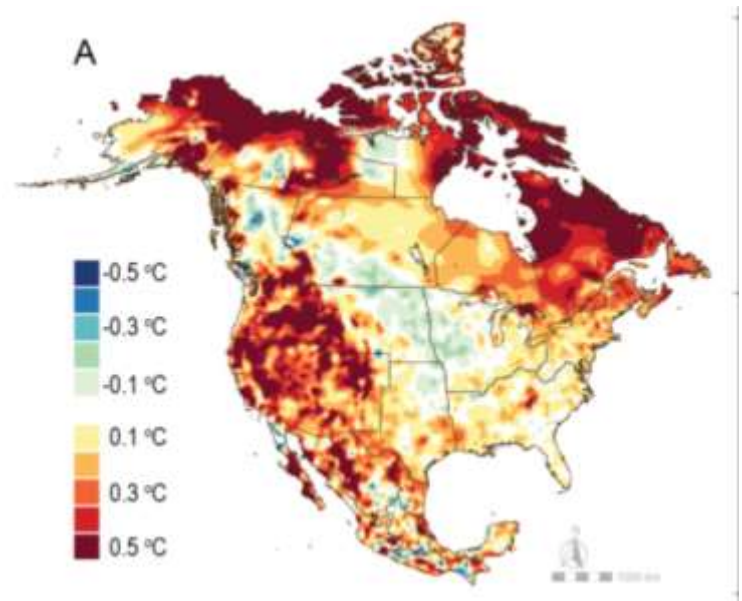
Global heating is not evenly distributed

→ The planet has warmed 1.1°C since the pre-industrial era.



Mean temperature trend from 1980 to 2015. Source: IPCC AR6 WG2 report, page 2511.

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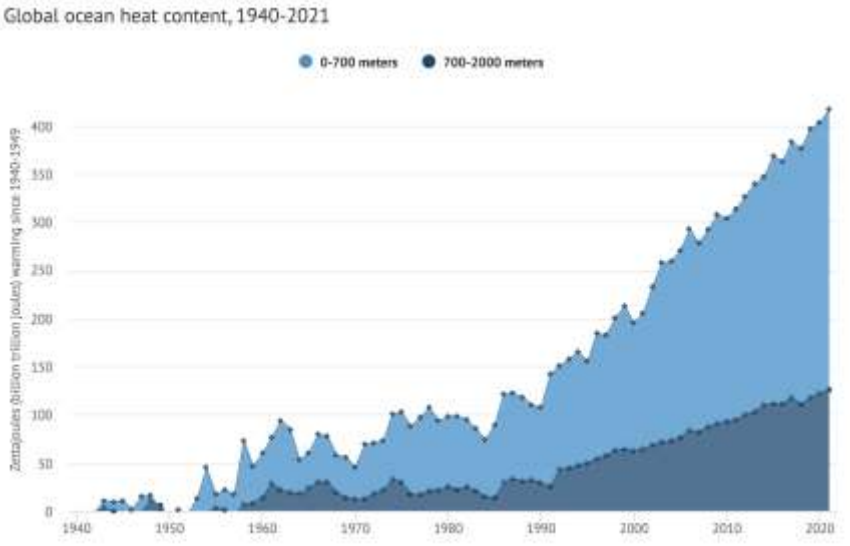
Oceans are absorbing 90% of the heat – for now



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Ocean Warming Continues through 2021 despite La Niña Conditions. *Adv. Atmos. Sci.* (2022).

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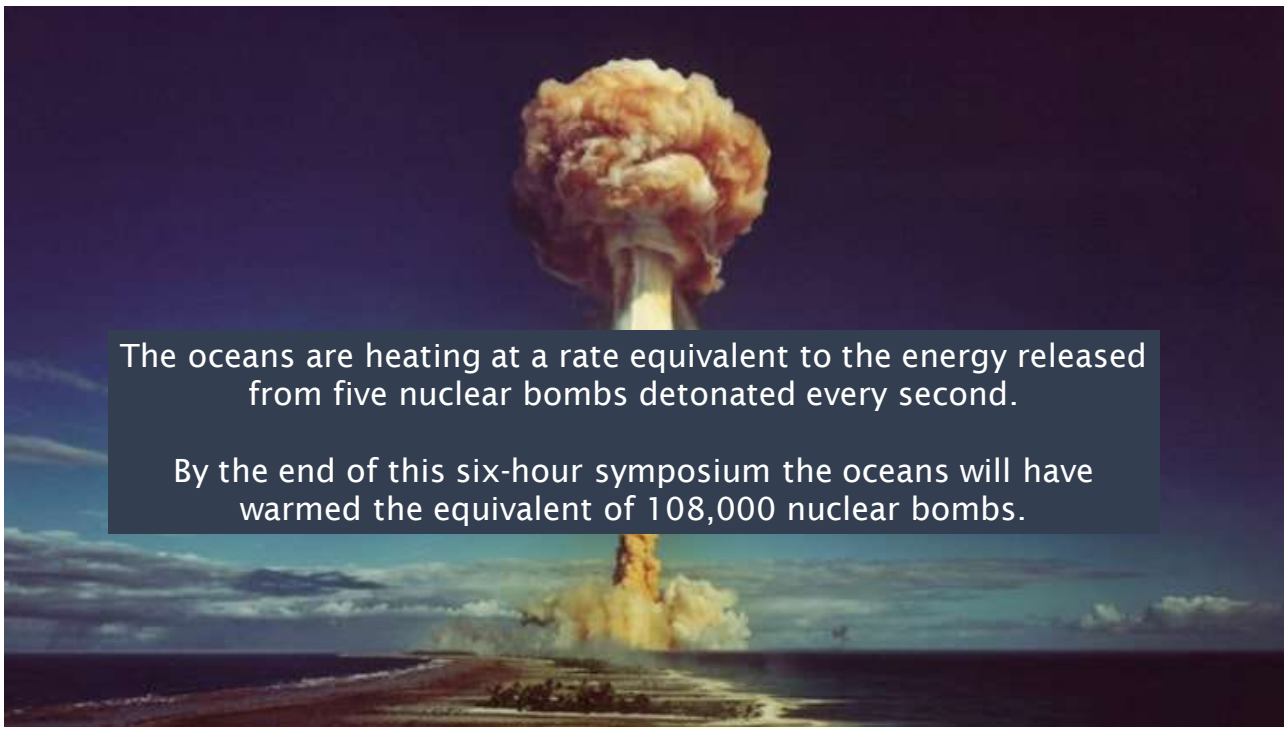

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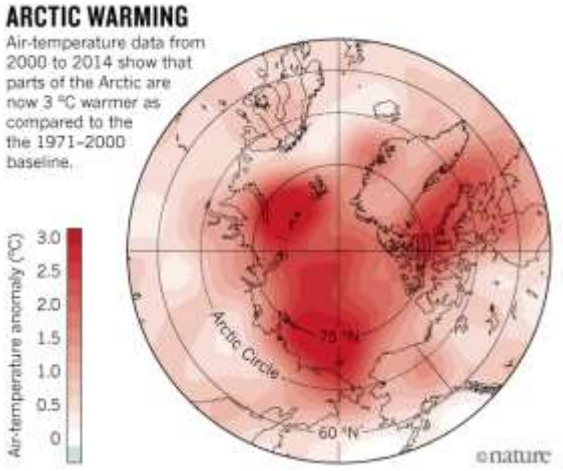
Arctic warming 3 times faster than the planet

→The Arctic's average annual temperature rose by 3.1ºC from 1971 to 2019.



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2021 results from Arctic Monitoring and Assessment Programme (AMAP)

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Let's look at how these factors are causing "cascade effects" in British Columbia

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At 0.7˚C: warming: Pine Beetles surviving winter

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Mountain Pine Beetle, image via NRCan.

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By 1.0˚C: Big wildfires part of every summer

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At 1.1˚C: Atmospheric rivers carried 2x the water

A given volume of air at 20˚C (68˚F) can hold twice the amount of water vapor than at 10˚C (50˚F).

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At 1.1˚C: Heavy rain turned clear-cut forests to mud

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At 1.1˚C: Vancouver cut off from Canada by road

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At 1.1˚C: Fraser Valley flooded 3x in three weeks

17


At 1.1˚C: More than 640,000 farm animals died

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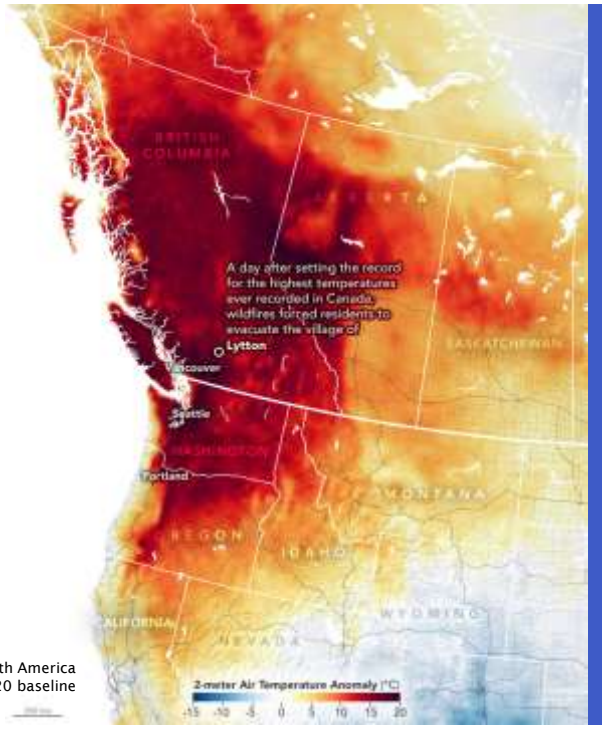
595 British Columbians died in 2021 Heat Dome

- Plus about 600 more deaths in Washington and Oregon.
- Record high of 49.6˚C on June 29 in Lytton.
- Record high “nighttime lows” made sleep difficult for many.



Map: Air temperature anomalies across North America on June 29, 2021, compared to 2014–2020 baseline

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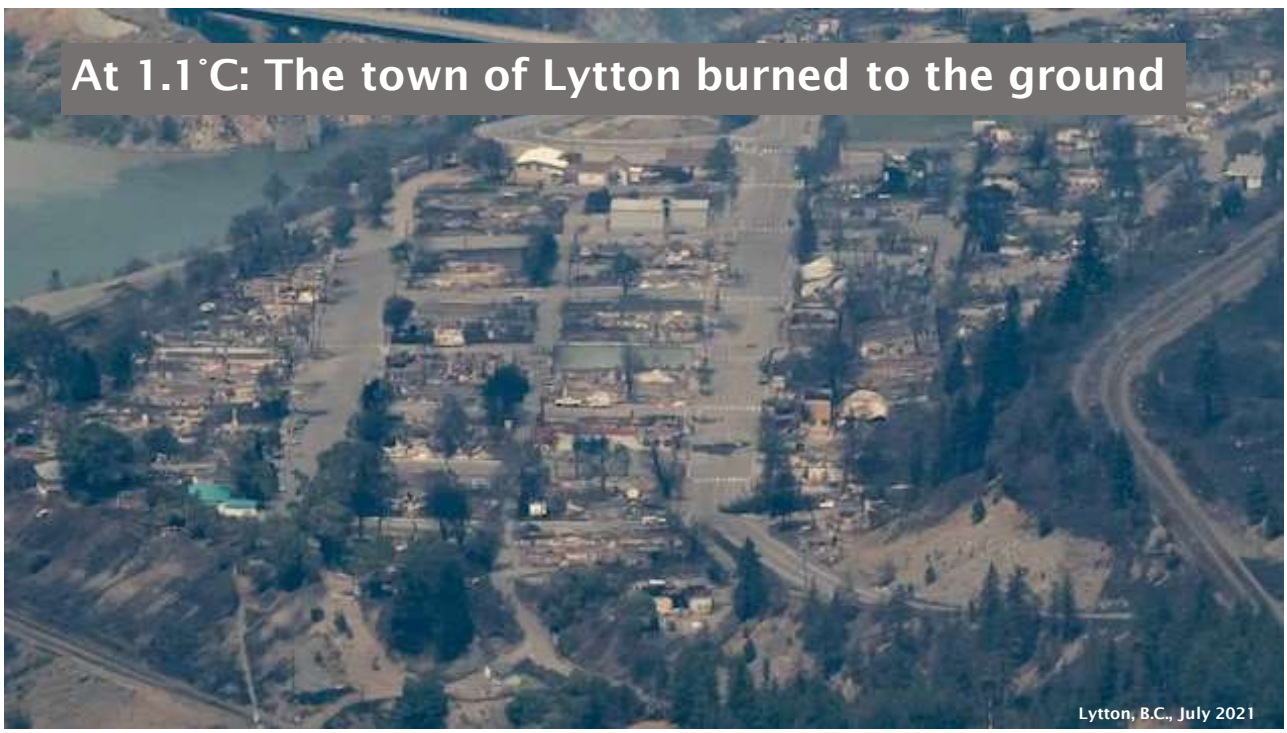

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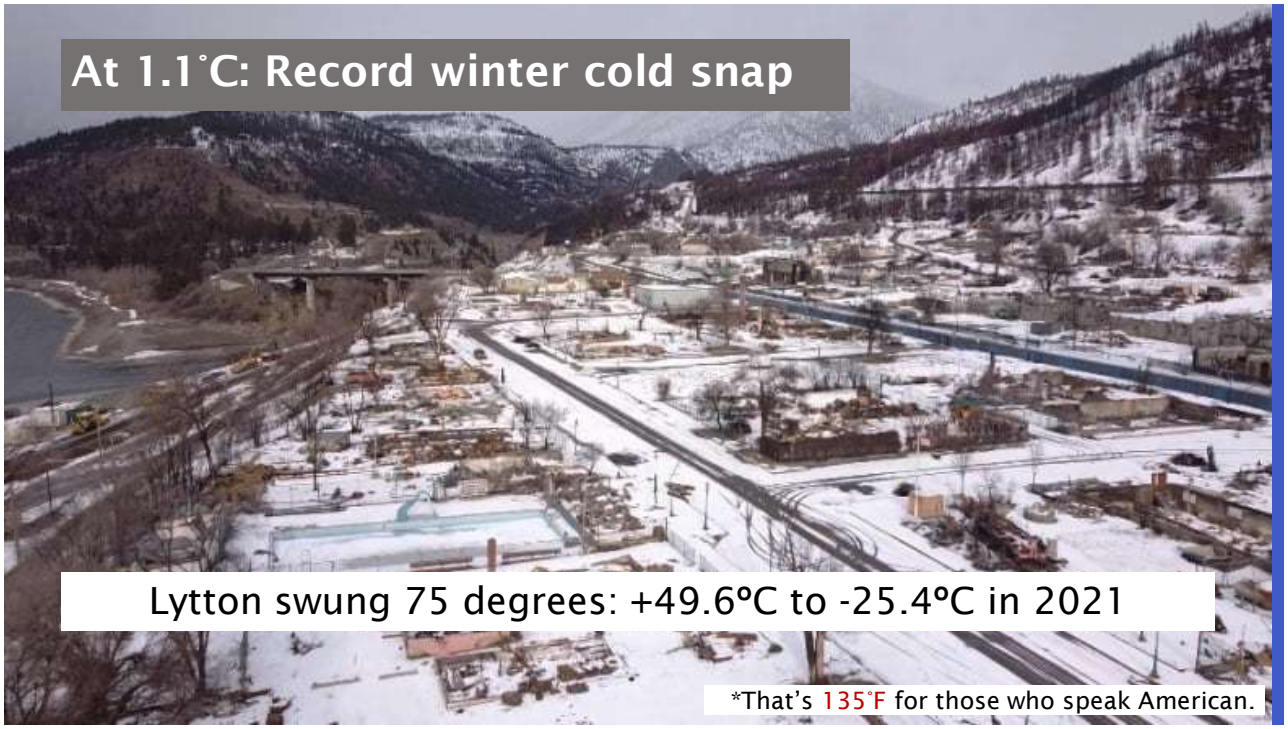

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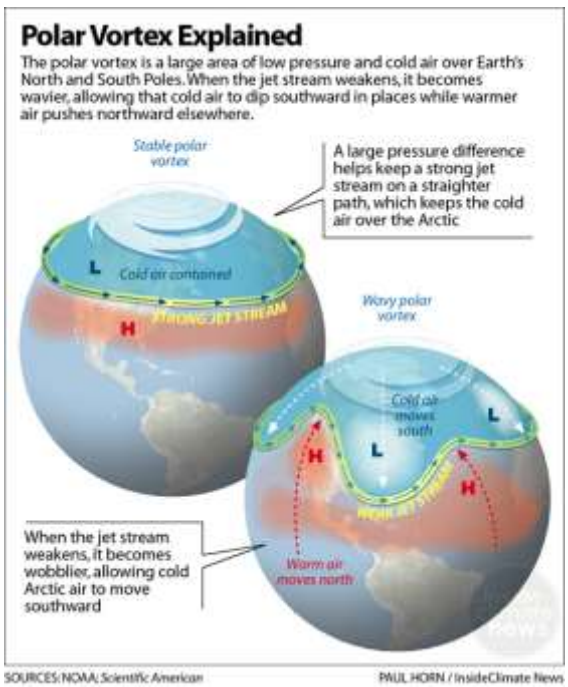
Warmer Arctic = "Wobbly" Jet Stream

- The Jet Stream is a river of air races from west to east.
- It draws power from the temperature differential.
- As the Arctic warms, the Jet Stream becomes weaker.
- A weak Jet Stream leads to both Heat Domes and Arctic Blasts.



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This is how “cascade effects” magnify risk in B.C.


Species change, many die.


Forests evolve rapidly.


Year-round wildfires.


Warmer oceans, more rain.

What are the cascade effects in your region?

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How buildings contribute to climate disruption

Three gasses: carbon dioxide, methane, and refrigerants

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Greenhouse gasses make the Earth habitable

- A natural blanket of water vapor, carbon dioxide, and methane keeps the Earth about 30°C (54°F) warmer than it would be otherwise.
- Without this blanket, the Earth would be an uninhabitable ball of ice.
- By burning massive amounts of fossil fuel since the Industrial Revolution, we've wrapped an extra blanket around the planet.
- This extra blanket traps heat that would otherwise radiate to space.

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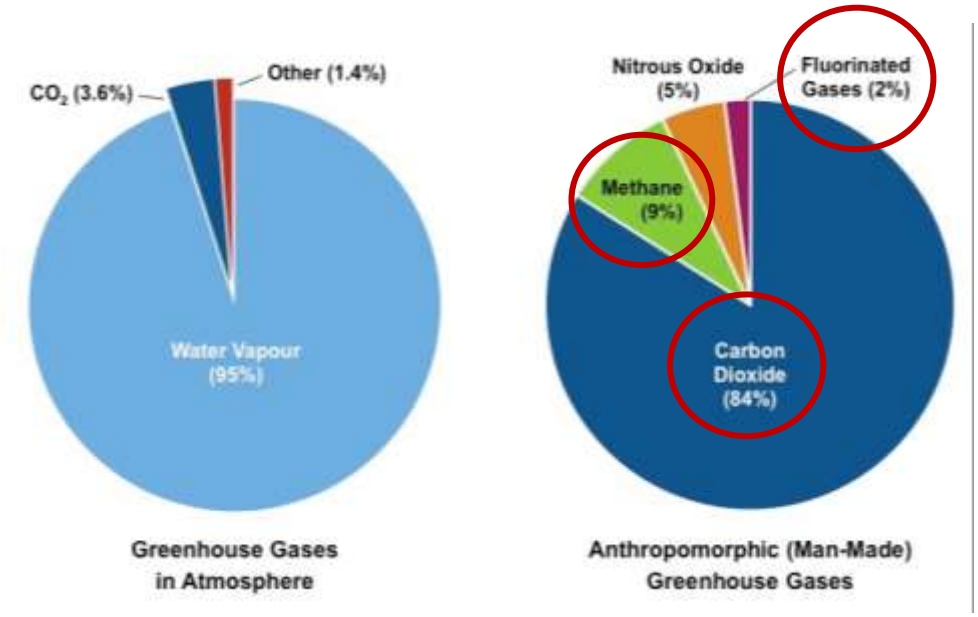

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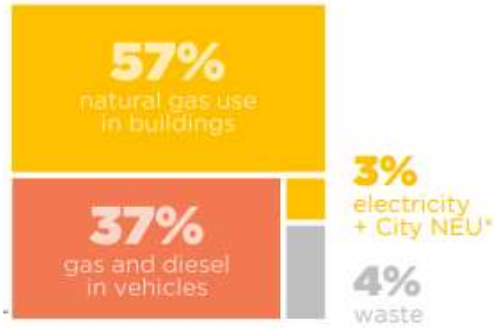
Carbon Dioxide (CO_2)

- The combustion of fossil fuels to heat buildings is the leading source of greenhouse gas emissions in urban areas.
- In New York, for example, buildings contribute 70% of emissions.
- When calculating "Global Warming Potential" (GWP) of various gasses, carbon dioxide is the baseline.



Combustion of "Natural Gas" in buildings accounts for 57% of GHG emissions in Vancouver.

Chart by City of Vancouver

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CO_2 flows from furnaces, boilers, DHW heaters

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Methane (CH_4)

- “Natural Gas” is about 90% methane (+/-).
- Methane also comes from wetlands, livestock, and fossil fuel production.
- Methane (CH_4) warms **86 times faster** than CO_2 in first 20 years.
- Methane is responsible for 30% of temperature rise.

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Leaked methane more damaging than burned gas

- About 2.7% of gas leaks from pipelines & production facilities. to the atmosphere.
- Because the GWP of methane is 86X that of CO_2, the leaked methane does approximately twice as much climate damage as the burned gas.
- However, some govt inventories and most building-level accounting accounts for only the carbon dioxide, thereby undervaluing the contribution of methane.

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Refrigerants are fluorinated gasses

- Fluorinated gases have no natural sources.
- The most common refrigerant, HFC-134a, is about 1,300 times more damaging than CO_2.
- Industry estimates project that up to 35% of refrigerant leaks every year.

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Buildings emit 21% of GHGs

- Buildings contributed **21%** of global GHG emissions in 2019.
- Over the period 1990-2019, **global CO2 emissions from buildings increased by 50%.**
- (This IPCC calculation does not fully account for methane and refrigerant leakage.)

"Mitigation of Climate Change" IPCC Working Group Three, April 2022.

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Architecture "lagging behind all other sectors"

"The sector hasn't modernized at all since the second world war. And now, the data shows it's lagging behind all other sectors."

~ Dr. Yamina Saheb, co-author of IPCC Working Group Three report.

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"Architecture "lagging behind all other sectors" in climate change fight" DeZeen, 6 April 2022

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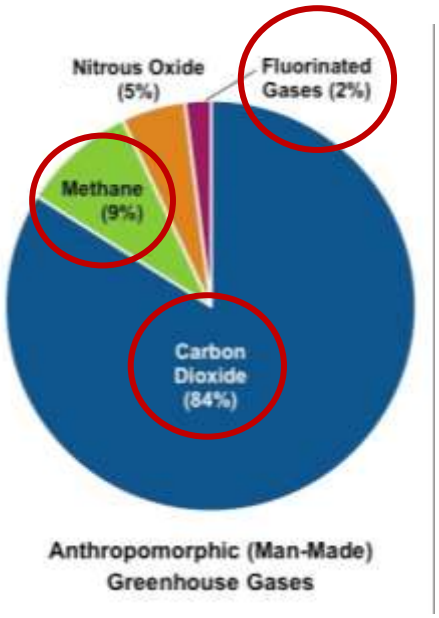
TAKEAWAYS: THREE GASSES

How much carbon dioxide, methane, and refrigerants are flowing through your buildings?

- Construction lagging behind other sectors.
- Architects & engineers may be professionally liable.
- (Politicians can say they didn't see it coming. But we can not.)



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What will happen as we approach 3.2˚C?

No human has ever lived on a planet like this.

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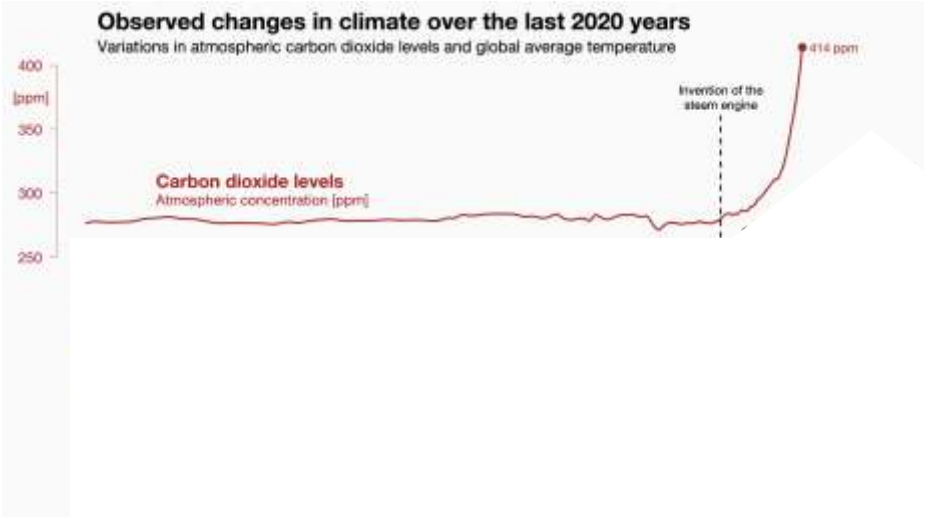
The accumulation of these GHGs is warming Earth



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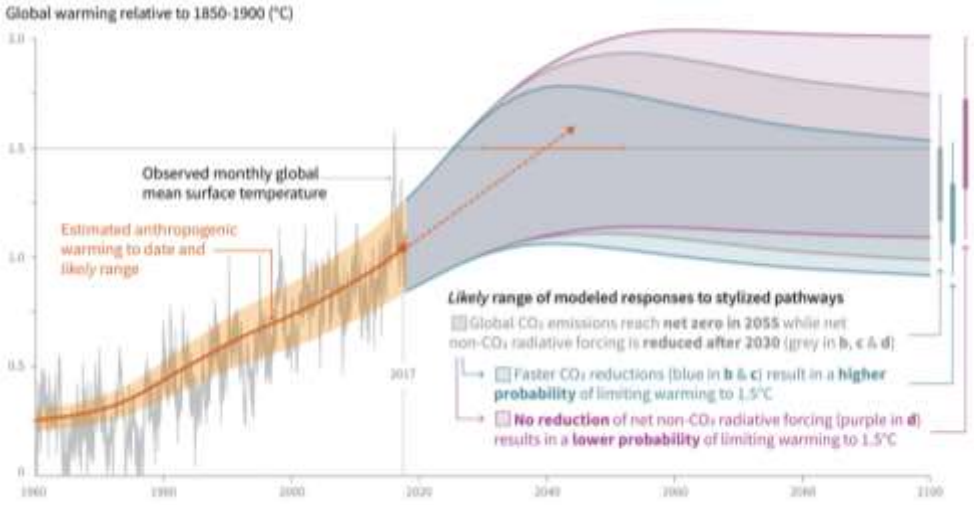
Scientists: Limit to 1.5˚C to avoid tipping points



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"Special Report on Impacts of Global Warming of 1.5˚C" by Intergovernmental Panel on Climate Change.

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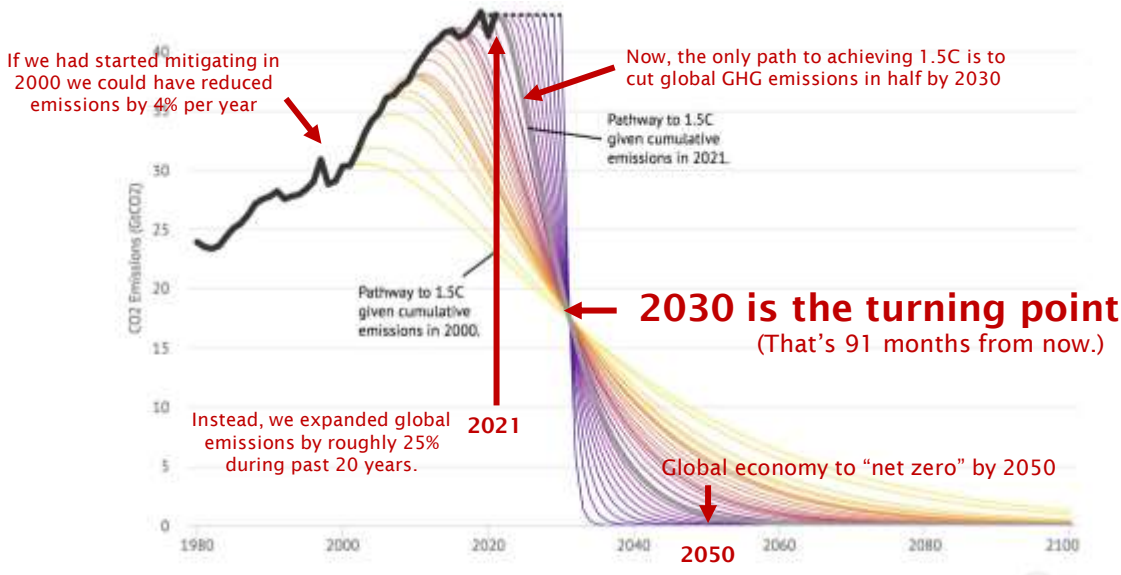

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Graphic: Carbon Brief

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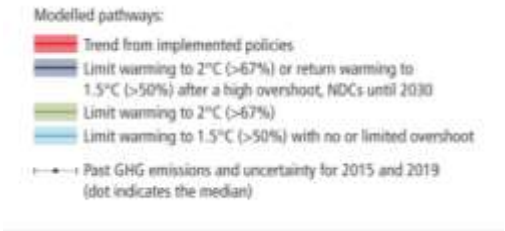
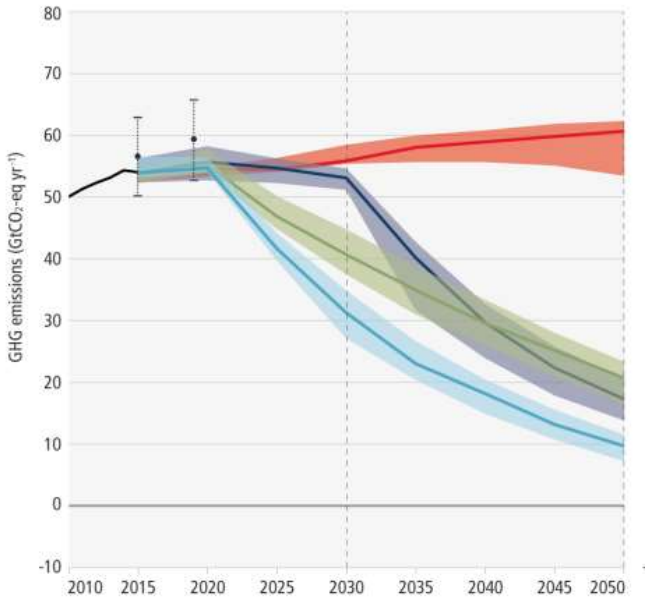
Projected emissions are likely to exceed 1.5° C by 2030





"Mitigation of Climate Change" IPCC Working Group Three, April 2022.

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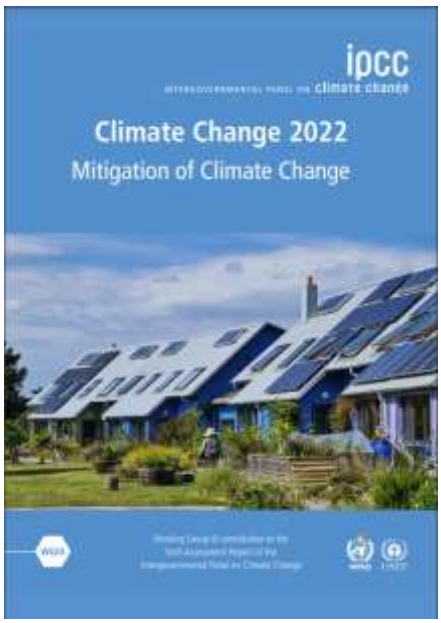
IPCC Working Group Three report released April 4

www.ipcc.ch



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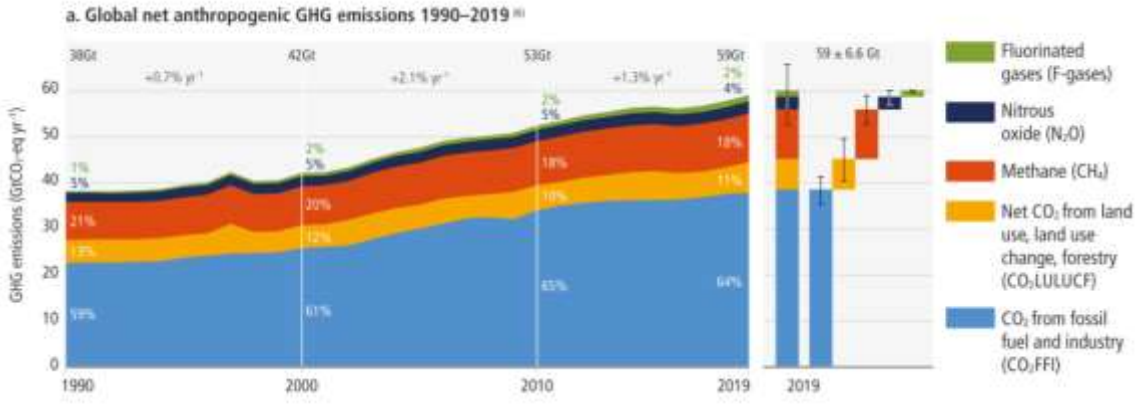
GHG emissions still rising



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"Mitigation of Climate Change" IPCC Working Group Three, April 2022.

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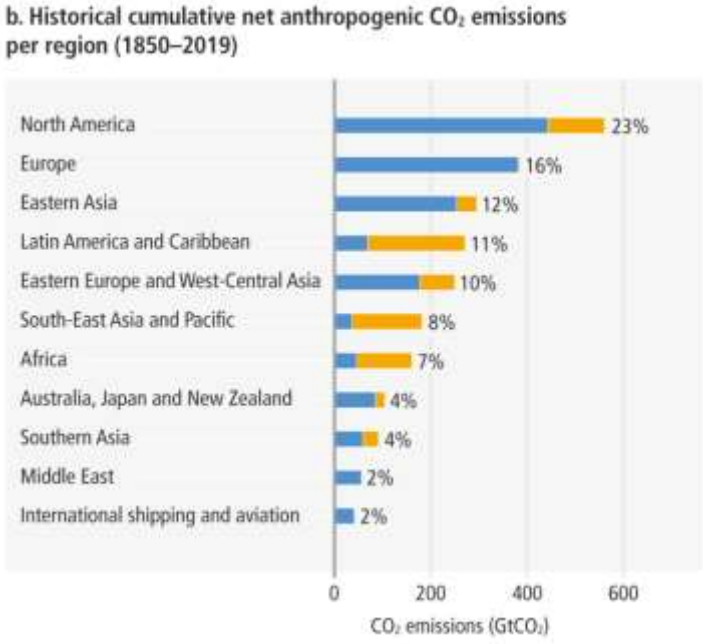
Canada and the US have emitted far more GHGs than any other region



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"Mitigation of Climate Change" IPCC Working Group Three, April 2022.

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IPCC now predicts 3.2° C global heating by 2100

"Without a strengthening of policies beyond those that are implemented by the end of 2020, GHG emissions are projected to rise beyond 2025, leading to a median global warming of 3.2˚C by 2100. [2.2 to 3.5]"

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"Mitigation of Climate Change" IPCC Working Group Three, April 2022.

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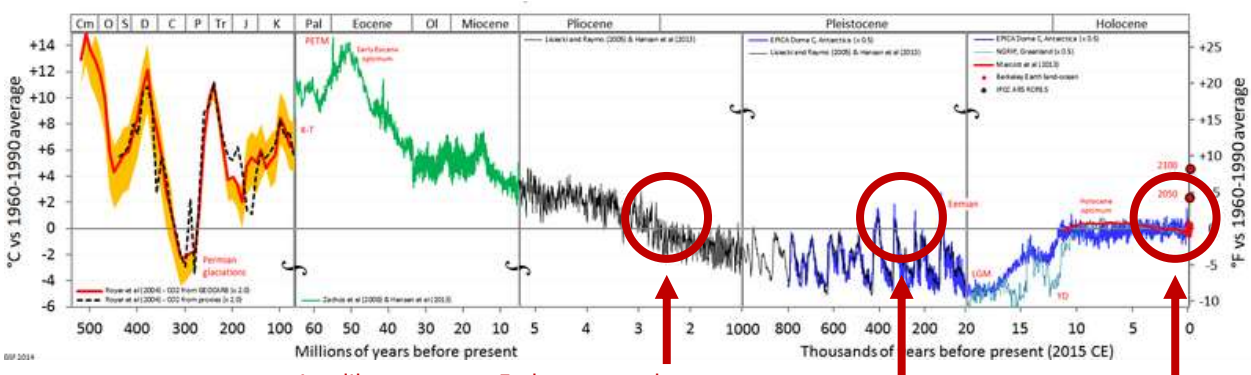
Let's put +3.2˚C in historical context…



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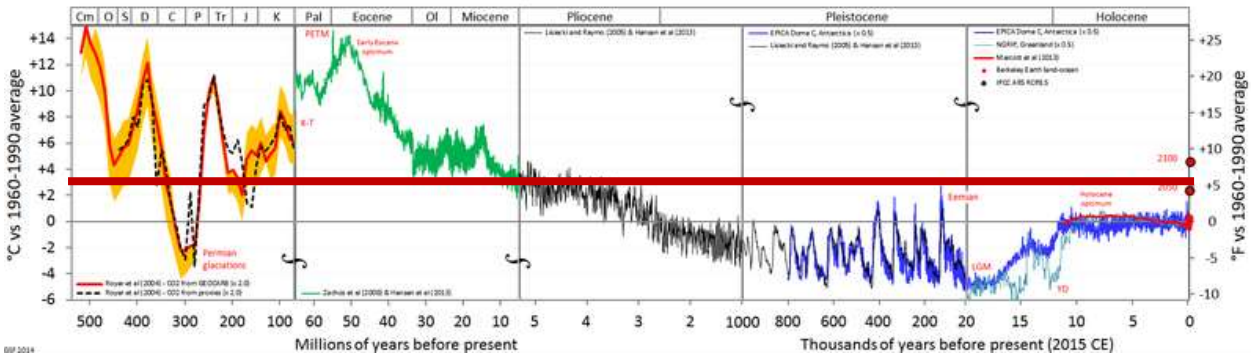
No human has ever lived on a +3.2˚C planet



We will require incredibly resilient buildings in order to survive.

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*That's just below six degrees Fahrenheit.

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What the 2040s could look like on current path

- Global heating surpasses 2˚C.
- Heatwaves that used to occur once per 10 years now occur 6x every 10 years.
- In drought-prone regions, drought is about 2.4x as severe.
- By the end of the decade, sea-level rise may surpass 0.5 meters.
- Over 99% of coral reefs have been degraded or lost.
- Air quality has worsened, and morbidity and mortality from air pollution have increased.
- Parts of the Middle East become too hot for human survival.
- **Adaptation to climate impacts in general becomes "increasingly unfeasible."**
- The estimates are *before* cascade effects are fully considered.

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Probabilities for SSP5 (RCP 8.5) scenarios extracted from IAR6 reports.

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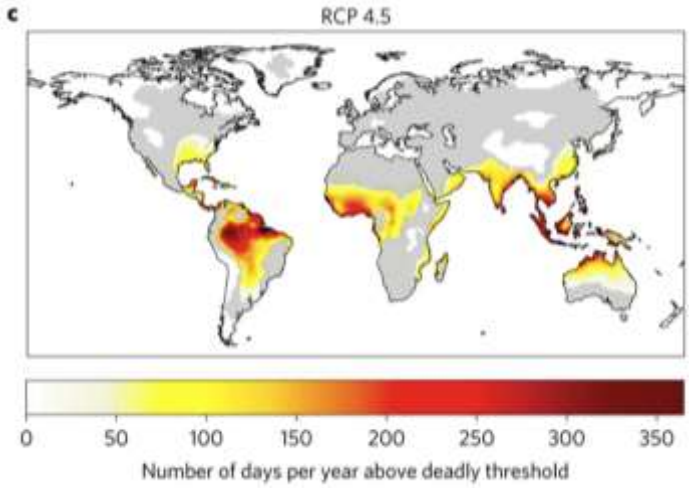
Distribution of most deadly disruption not even



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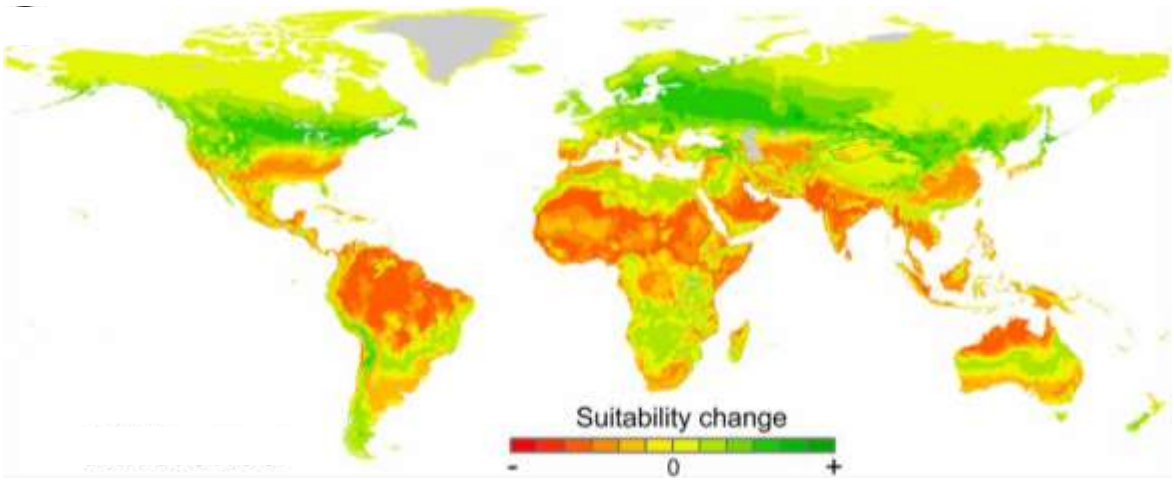
At 3.2˚C: Three billion climate refugees



Visualization of the potential source (orange) and sink (green) areas for the coming decades if humans relocate in a way that would maintain historic distribution with respect to average annual temperature.

Source: "Future of the human climate niche," by Chi Xu, Timothy Kohler, et al. Proceedings of the National Academy of Sciences, May 4, 2020.

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Buildings must both adapt and mitigate

ADAPTATION tackles the effects of climate disruption.

→Adaptation involves adjusting to actual or expected future climate. The goal is to reduce our vulnerability.

MITIGATION tackles the causes of climate change.

→Mitigation involves reducing the flow of heat-trapping greenhouse gases into the atmosphere.

We missed the opportunity to merely mitigate back in the 1990s.
Now we must tackle two large tasks simultaneously.

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Definitions from NASA

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How will buildings adapt to a hostile climate?

Overheating, flooding, indoor air quality.

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$10 million awarded to overheating condo owners

- San Francisco condo association won a $10 million settlement after claiming it's residents were being "cooked" in their homes.
- Two-thirds of 100 units affected.
- Building located in Hayes Valley neighbourhood. (Settlement bars naming property or developer.)
- The risk of non-action is rising.

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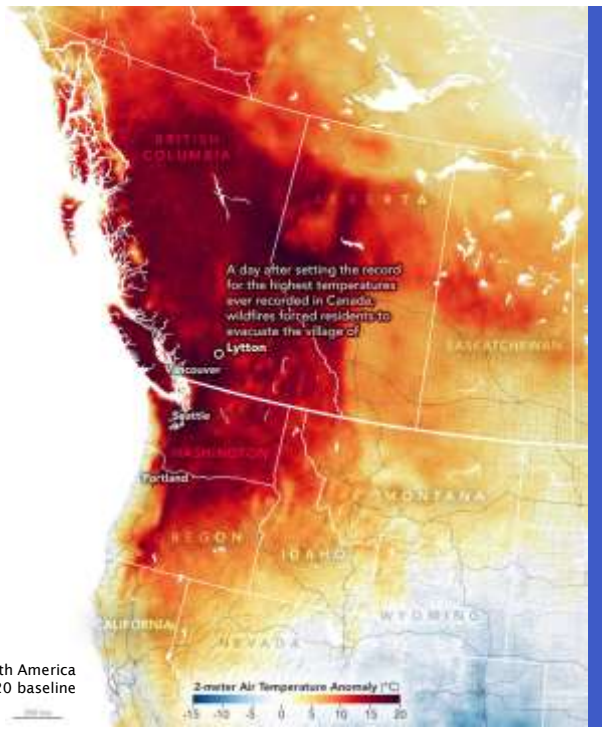
1,200 dead in Pacific Northwest during 2021 Heat Dome

- Nearly all died in their homes.
- The vast majority were seniors.
- The risk of non-action is rising.



Map: Air temperature anomalies across North America on June 29, 2021, compared to 2014–2020 baseline

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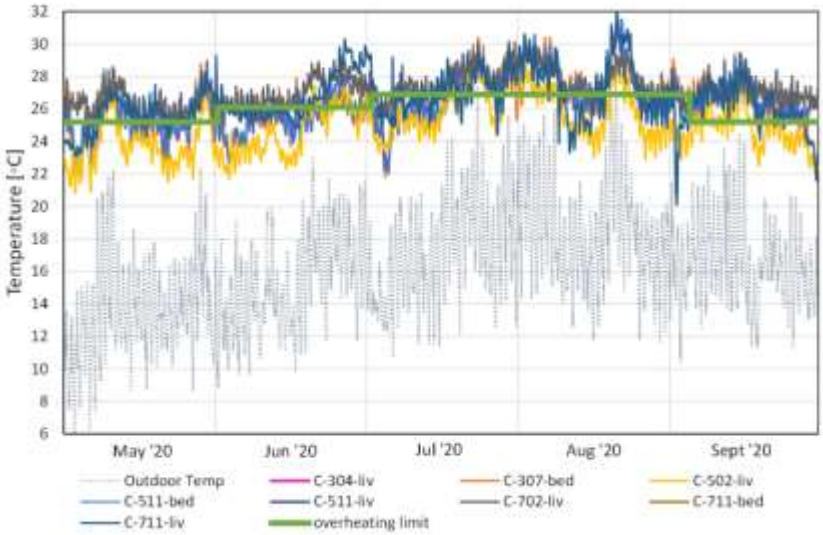
Rental housing overheating 21% of summer in B.C.



"Indoor Environmental Quality of Social Housing Buildings in British Columbia" BC Housing Research Centre

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Climate change is *not* the only cause of overheating

OUTSIDE *the* BUILDING

SOLAR GAIN
Shading, SHGC, glazing area.

TEMPERATURE
Model for 2050 & 2080, not 1985.

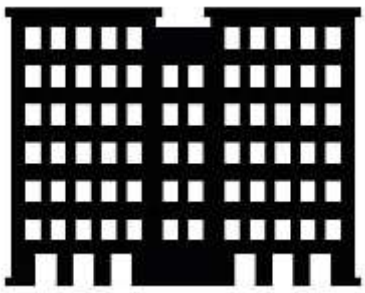
URBAN HEAT ISLAND
Most multiunit on infill sites.
Effects greater than climate change.

INSIDE *the* BUILDING

OCCUPANT DENSITY
Small units produce higher IHG/m2 than large units.

MECHANICAL HEAT LOSS
Don't put DHW in same room as HRV. Shorten DHW runs.

LIFESTYLE VARIATION
How residents live and play affects IHGs significantly.



Understand *why* a building is overheating before implementing solutions.

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Assume cooling will be required in all multiunit buildings unless detailed modelling proves otherwise

- Understand why a building is overheating before implementing solutions.
- Demand your comfort modelers consider all factors inside and outside building.

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AIBC: Code "may not be not sufficient"

- **"Current code minimums may not be sufficient for dealing with poor ambient air quality and high temperatures."**
- "When designing buildings of all types, architects should consider building envelope performance in conjunction with HVAC systems that respond to significant social and climatic issues."

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Regulatory Review | Implementing Approaches for Better Indoor Air Quality (Part 1) (aibc.ca)

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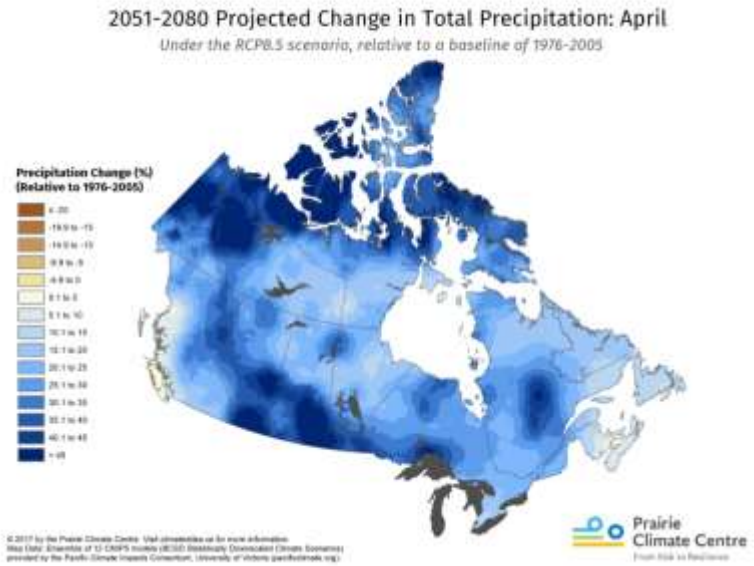
Precipitation is not evenly distributed

In most regions, rainfall will come in greater quantities delivered by more intense storms, with longer dry periods between storms.



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IPCC AR6 WG2 report, page 2511

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Expect 26% more flooding by 2050

→ "Current flood risk mapping, relying on historical observations, fails to account for increasing threat under climate change."

→ 26.4% increase in flood risk by 2050


ARTICLES

nature climate change

OPEN

Inequitable patterns of US flood risk in the Anthropocene

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"Inequitable patterns of US flood risk in the Anthropocene," Oliver Wing et al, Nature Climate Change, January 2022

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Nuisance flooding can cost more than large floods

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Nuisance flooding costs more in coastal cities

- "In response to sea level rise, nuisance flooding could generate property value exposure comparable to, or larger than, extreme events."
- Also, nuisance flooding can be a warning sign of more severe floods to come.


AGU PUBLICATIONS

Earth's Future

RESEARCH ARTICLE

Cumulative hazard: The case of nuisance flooding

"Cumulative hazard: The case of nuisance flooding" Hame Moftakhari, et al. AGU Publications. Jan 2017

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Outdoor air is not always healthier than indoor air

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Sources of indoor air pollution

→ Cooking, cleaning, and candles are the leading sources of indoor air pollutants in non-smoking homes.

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Sources of indoor air pollution

→ Cooking, cleaning, and candles are the leading sources of indoor air pollutants in non-smoking homes.

→ Gas stoves emit harmful chemicals.

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Gas stoves emit nitrogen dioxide and formaldehyde inside the home

Measured NO_2 Emissions from Gas Stoves	Peak (ppb)
Baking cake in oven	230
Roasting meat in oven	296
Frying bacon	104
Boiling water	184
Gas cooktop - no food	82–300
Gas oven - no food	130–546

Outdoor Standards for NO_2	1-hr average (ppb)
US National Standard (EPA)	100
Canadian National Standard	60
California State Standard	180
Indoor Guidelines for NO_2	**1-hr average (ppb)**
Canada	90
World Health Organization	106

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Source: "Health Effects from Gas Stove Pollution," Rocky Mountain Institute, May 2020

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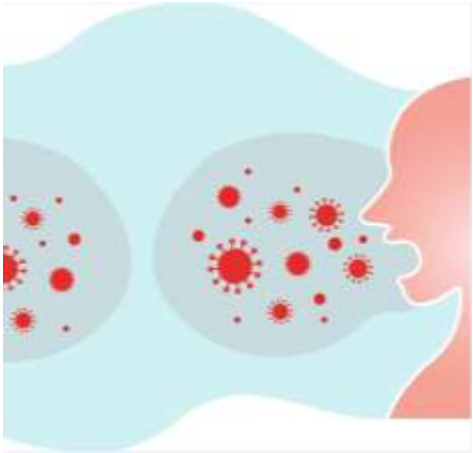
Sources of indoor air pollution

- Cooking, cleaning, and candles are the leading sources of indoor air pollutants in non-smoking homes.
- Gas stoves emit harmful chemicals.
- Airborne viruses such as COVID-19.



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Sources of indoor air pollution

- Cooking, cleaning, and candles are the leading sources of indoor air pollutants in non-smoking homes.
- Gas stoves emit harmful chemicals.
- Airborne viruses such as COVID.
- Vehicle emissions and tire particles lower air quality near busy streets.

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Sources of indoor air pollution

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- Gas stoves emit harmful chemicals.
- Airborne viruses such as COVID.
- Vehicle emissions and tire particles lower air quality near busy streets.
- Seasonal wildfire smoke.

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Sources of indoor air pollution

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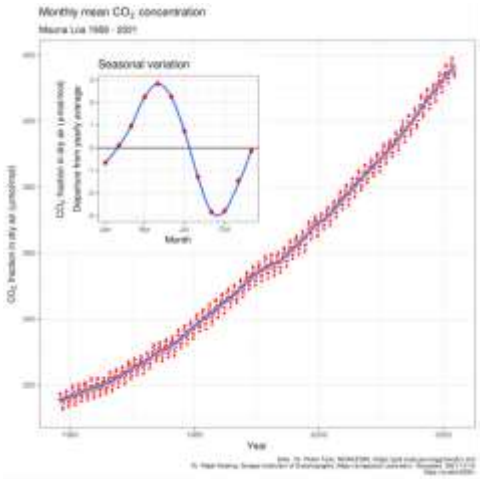
- Gas stoves emit harmful chemicals.
- Airborne viruses such as COVID.
- Vehicle emissions and tire particles lower air quality near busy streets.
- Seasonal wildfire smoke.
- Rising levels of C02 inside buildins.



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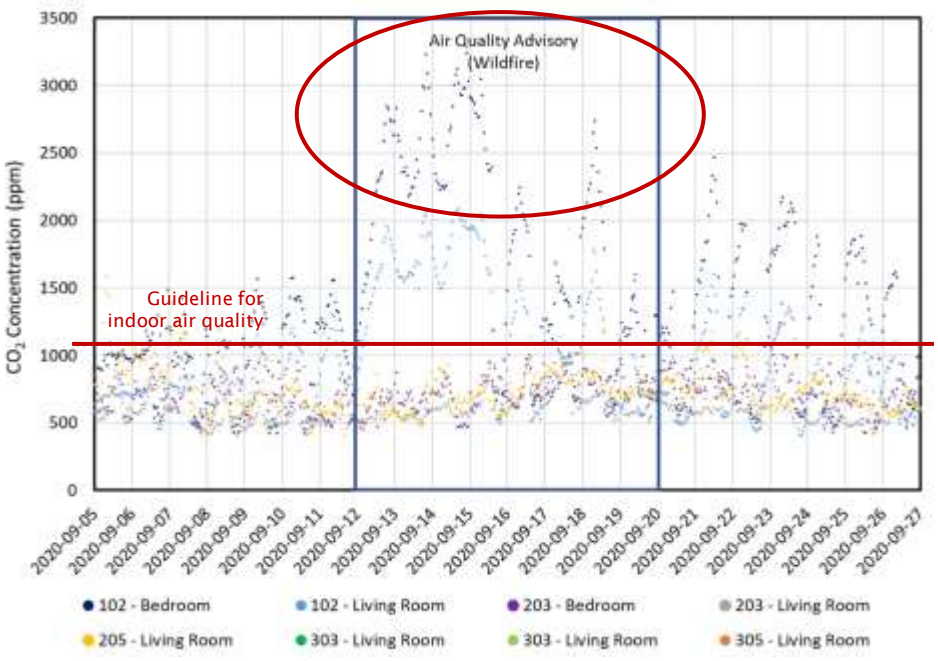
C02 levels in rental housing before, during, after wildfire



"Indoor Environmental Quality of Social Housing Buildings in British Columbia" BC Housing Research Centre

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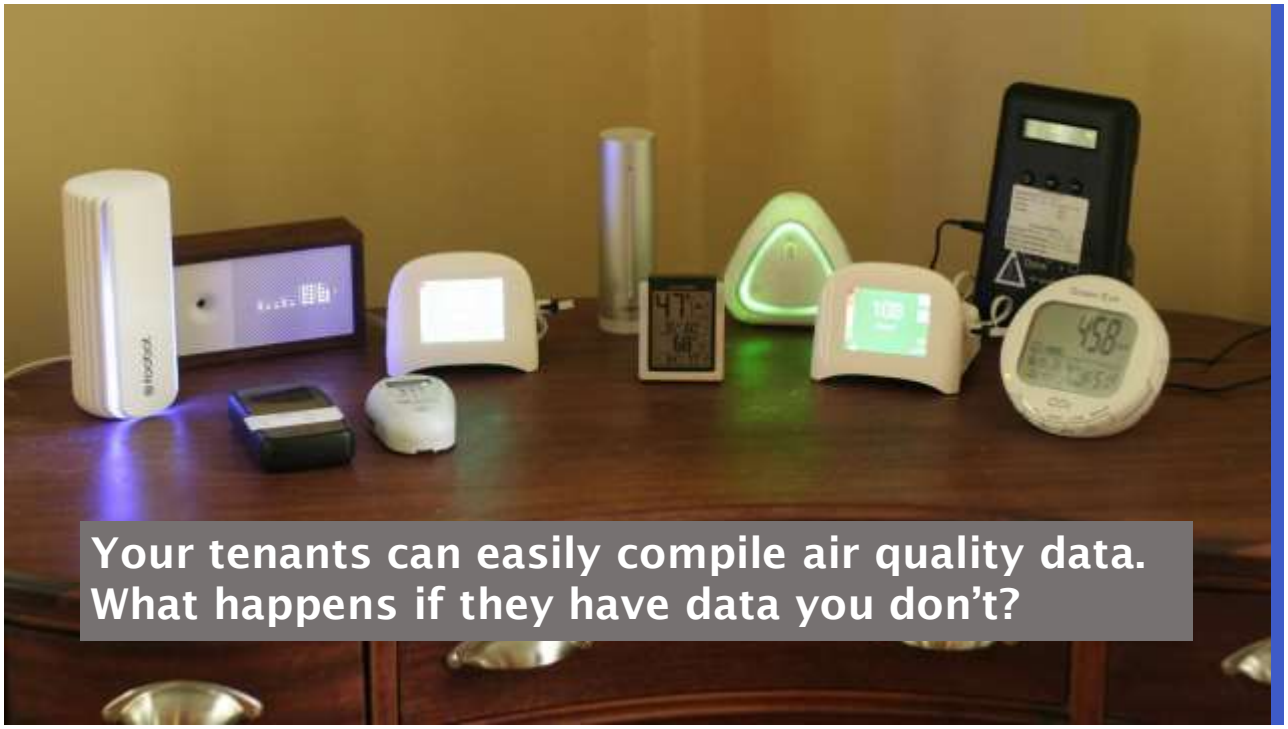

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TAKEAWAYS: ADAPTATION

Plan to install cooling & filtered ventilation

- Cooling likely necessary in all multi-unit residential buildings.
- Investigate causes & effects of nuisance flooding. Be aware that most flood maps are woefully out of date.
- Indoor Air Quality is getting worse as outdoor conditions deteriorate.
- Consider potential liability.

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How will buildings mitigate GHG emissions

Stop burning stuff in buildings.

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Mitigation: Replace furnaces, boilers, water heaters



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Heat pumps available for cooling, heating, DHW

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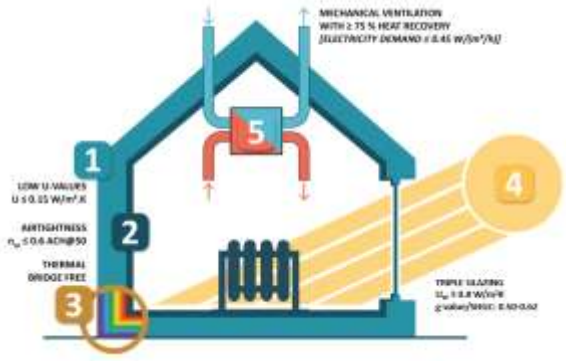
GHG reduction is not your sole concern

- Buildings must also adapt to climate disruption.
- Enclosure upgrades can lead to more resiliency, better indoor air quality, and improved health.
- Consider the needs of each building before choosing between electrification only and the "Enclosure-first" approach.



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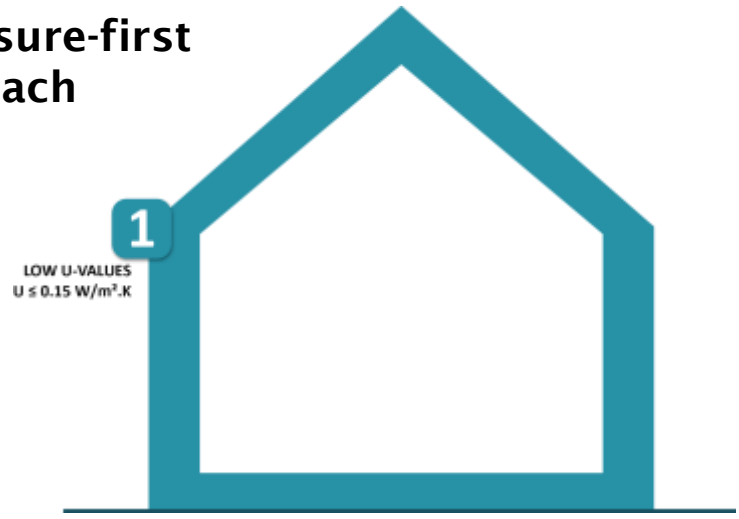
Enclosure-first approach



Graphic courtesy Passive House Canada.

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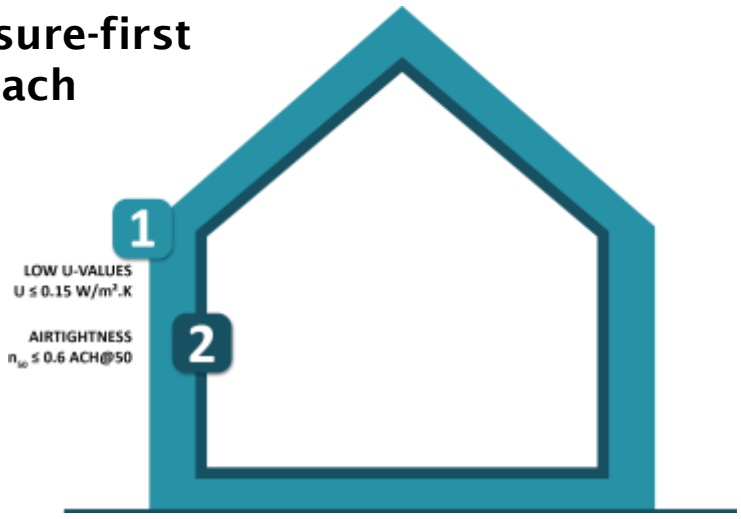
Enclosure-first approach



Graphic courtesy Passive House Canada.

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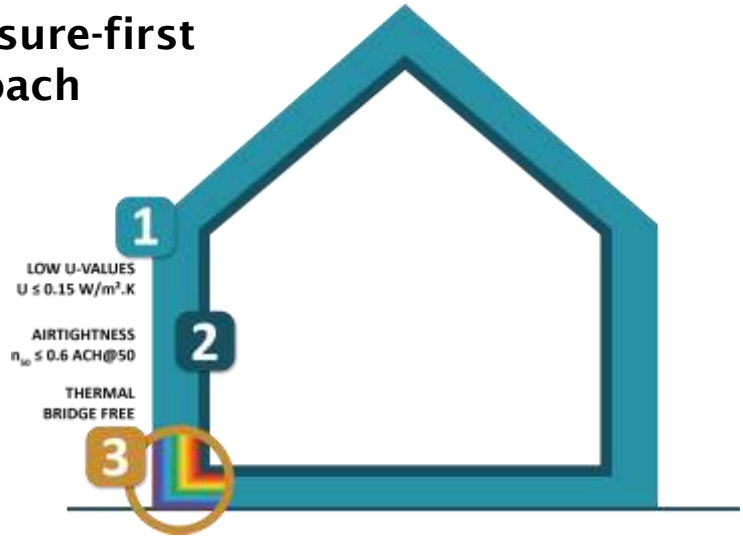
Enclosure-first approach



Graphic courtesy Passive House Canada.

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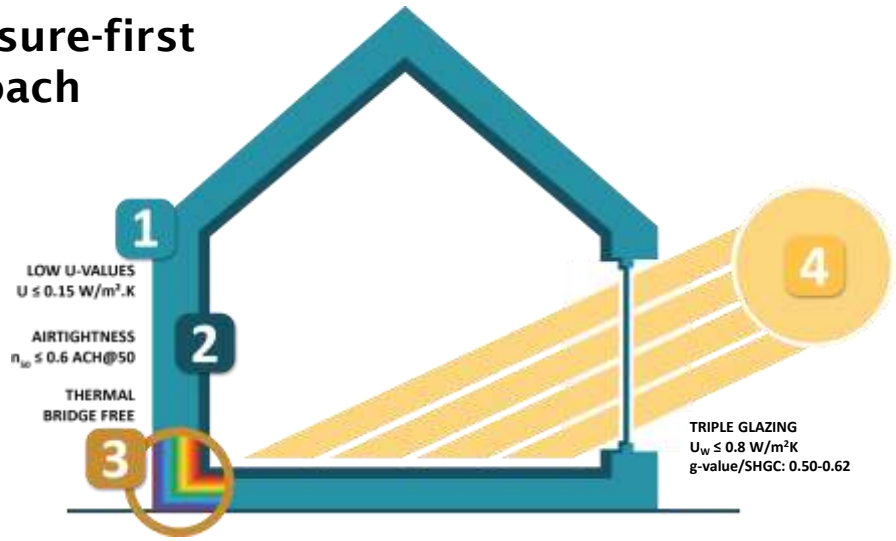
Enclosure-first approach



Graphic courtesy Passive House Canada.

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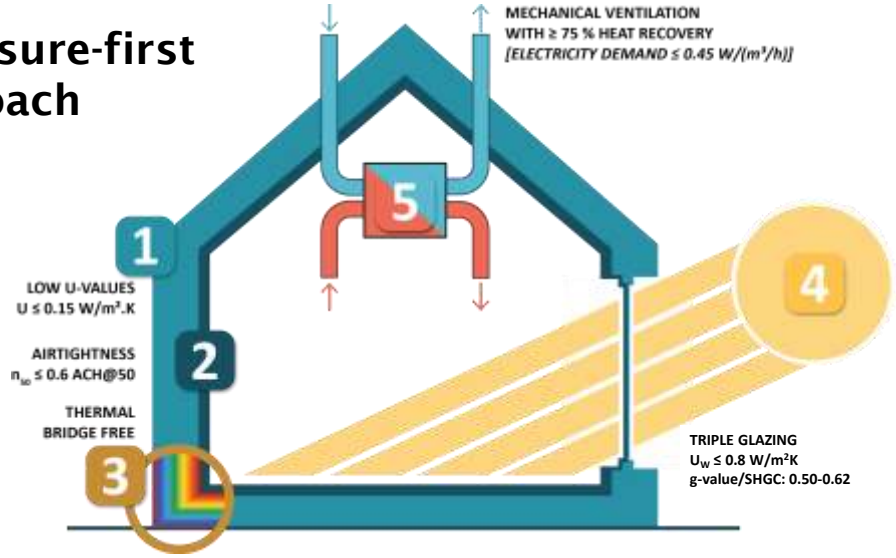
Enclosure-first approach



Graphic courtesy Passive House Canada.

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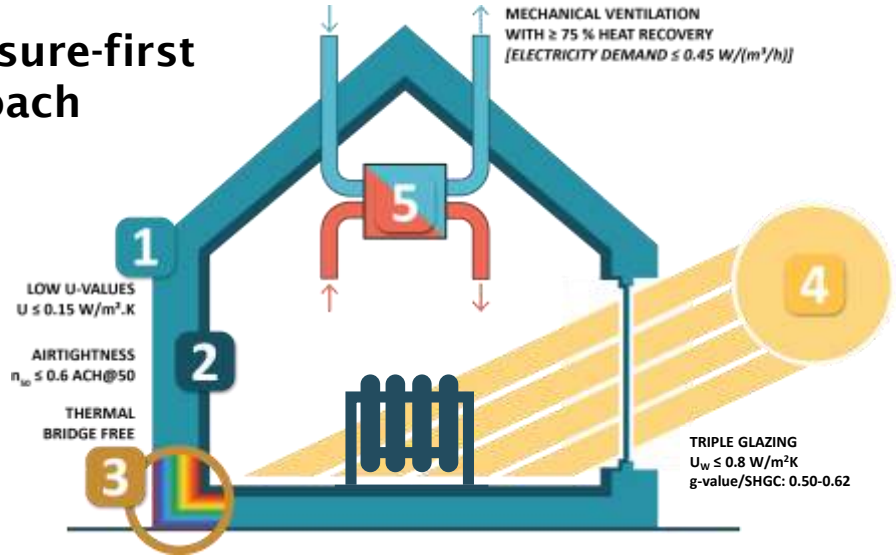
Enclosure-first approach



Graphic courtesy Passive House Canada.

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TAKEAWAYS: MITIGATION

Plan to electrify your buildings

- Weigh advantages of electrification & enclosure-first approach, look for a blend that suits your building.
- Understand emerging government requirements when thinking about timing.

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How are governments responding?

Connection bans, boiler bans, and other measures.

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U.S. & Canada have agreed to two targets

2030

40-45% below 2005

The entire global economy must reduce GHG emissions by 40-45%

2050

Net-Zero Emissions

The entire global economy either emits no greenhouse gas emission or offsets its emissions. 120+ nations.

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(A note on the term “net zero”)

Net-Zero Energy

→ Describes a building or campus at which renewables (such as photovoltaic) generates as much **energy** as the facility consumes in a year.

→ Appropriate metric for buildings.

Net-Zero Emissions

→ Describes a nation in which GHG mitigation systems (such as forests or seas) absorb as much GHG gas as the nation emits in a year.

→ Appropriate metric for nations, not workable for buildings.

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Washington State: No gas in new buildings

- 2023: New commercial and multifamily buildings will no longer be allowed to use natural gas or other fossil fuels for space heating and some water heating.
- More than 50 municipalities in California, New York, and Massachusetts pursuing similar paths.

Washington Governor Jay Inslee

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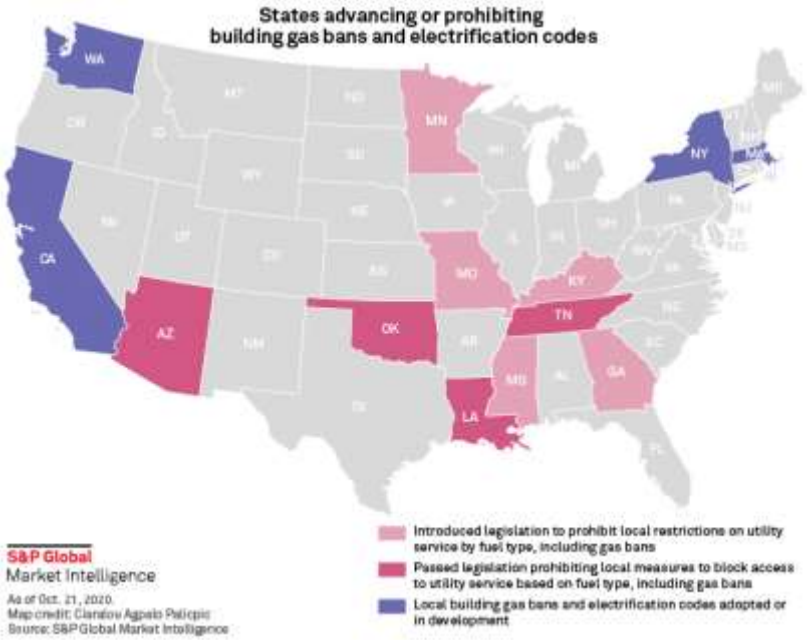
Lacking federal leadership, US states pursuing divergent paths



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Montreal: Buildings to zero emissions by 2040

- 2023: Building owners must declare all heating appliances using gas or oil.
- 2024: New buildings less than 2,000 square meters must be zero emissions.
- 2025: All new buildings must be zero emissions.
- 2040: All existing buildings must be retrofitted to zero emissions.

Montreal Mayor Valérie Plante

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British Columbia: 100% efficiency by 2030

Gas Boiler

c. 80% efficient

C02 (R744) Electric Heat Pump

COP of 4.11 = 411% efficient

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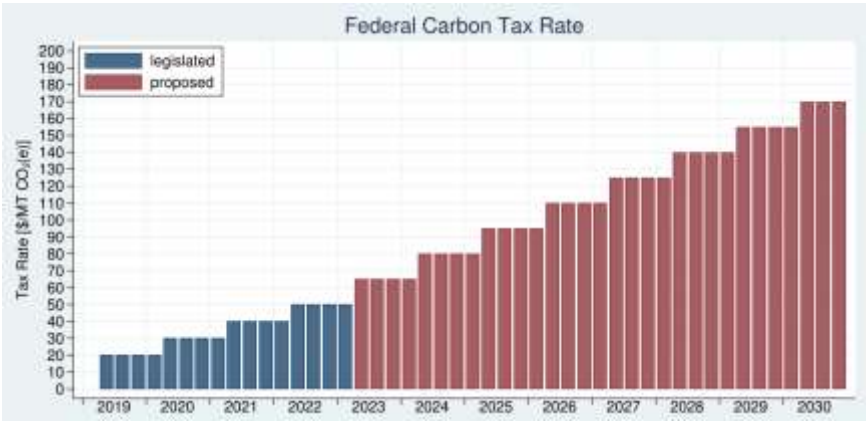
Canada's federal carbon tax: $9 GJ by 2030



Average Canadian house burns 92 GJ of methane gas per year. That's $828/yr by 2030.

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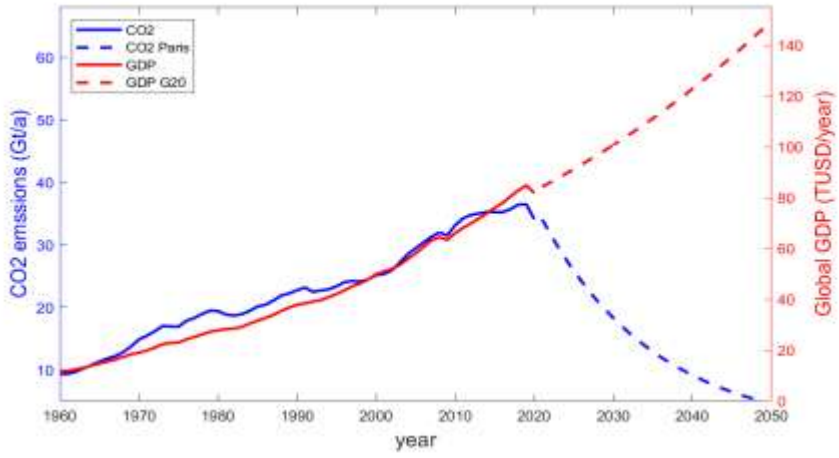
TAKEAWAYS: HOW ARE GOVERNMENTS RESPONDING?



Every serious government on Earth is working to decouple its economy from GHG emissions as swiftly as possible.

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Every building needs a plan.

Develop a zero emissions plan, then a step by step strategy.

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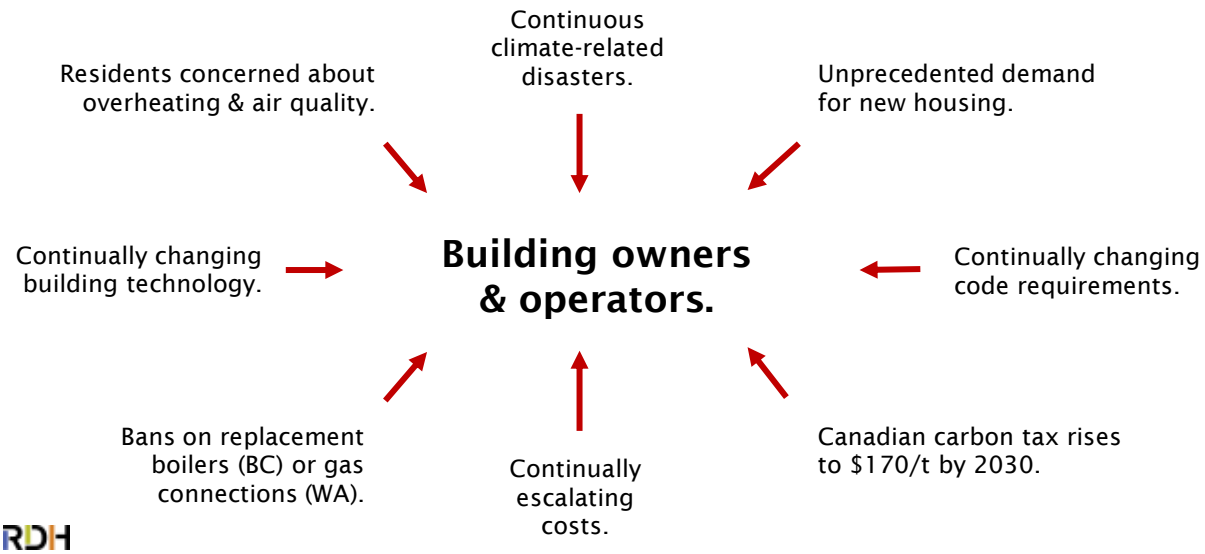
We will continue exploring solutions all day



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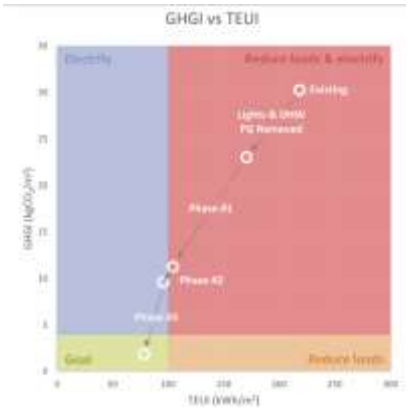
Every building needs a plan…

- Determine what to be renewed, by when.
- Consider climate risks.
- Assess options for windows & insulation.
- Assess options for replacing boilers with heat pumps that also provide cooling.
- Weigh coming legal mandates.
- Weigh costs and benefits.



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…a plan that can be broken into affordable steps

By developing a "master plan" first, you will avoid "painting yourself into a corner" through short-term thinking, and you will be prepared to respond to grants or loans that may become available in coming years.

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Every company needs a plan

- Google and many other firms are preparing to reach zero GHG emissions by 2030.
- What is your company or organization's climate plan?
- Are you monitoring your GHG emissions?
- Don't be like Kodak…

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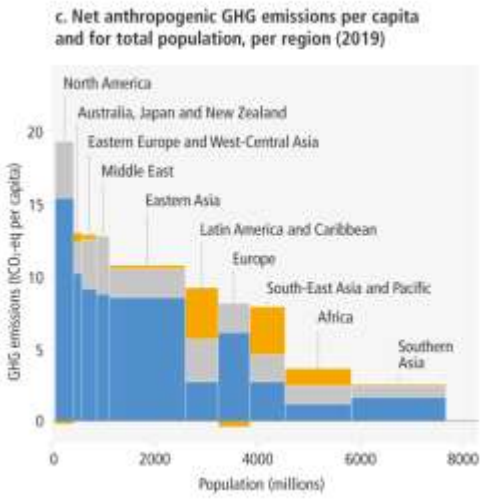
Every person needs a plan

- North Americans emit about 19 tons of GHG per person. Europeans emit about half as much.
- A typical house emits about 7.5 tons of CO_2/yr. Can we electrify our homes?
- A typical vehicle emits about 4.6 tons CO_2/yr. Can we drive less? Cycle more?
- A typical flight emits about ¼ ton of CO_2/hour. Can we fly less?
- The production of meat is a major emitter of methane. Can we eat less meat?
- No one is demanding abstinence. We begin by recognizing our role, and using a bit less.



"Mitigation of Climate Change" IPCC Working Group Three, April 2022.

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Discussion

Monte Paulsen
Passive House Specialist
mpaulsen@rdh.com

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