Canadian Roofing Expo 2025

April 16, 2025

How reducing carbon emissions and climate change adaptation are shaping building practices

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Director, Climate Design Initiative

…shaping building practices?

Here’s the agenda for this morning:

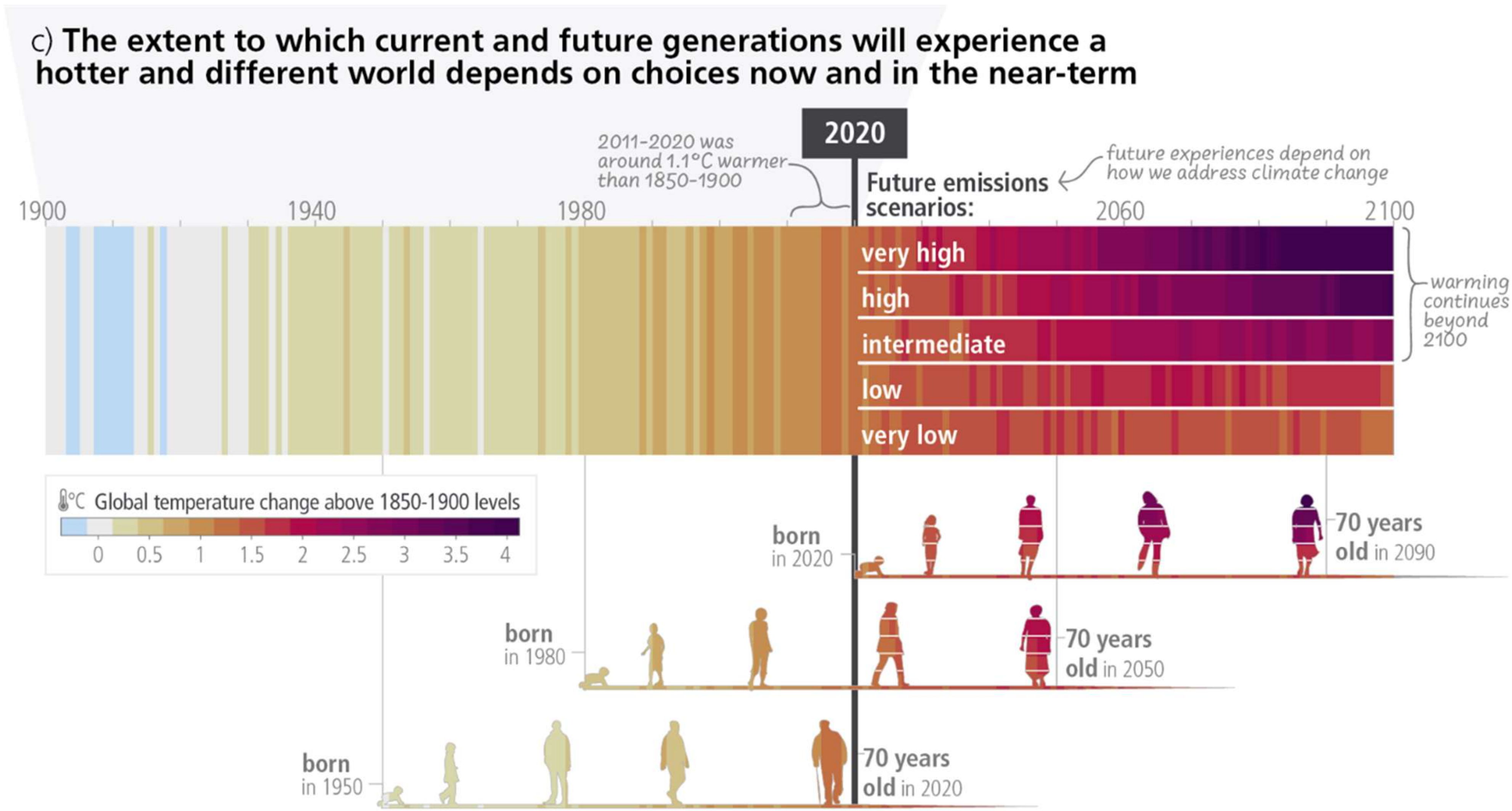
1. Understanding how the climate crisis is changing our building practice
    a. Operational and “embodied” carbon
    b. Full lifecycle planning
    c. Adaptation
2. What can you expect? 5 takeaways for roofs


Let’s discuss the climate crisis

“We are moving into uncharted territory with climate change.

The climate we’ve been living in, is not going to be the climate we are living in right now, nor over the next decades.”

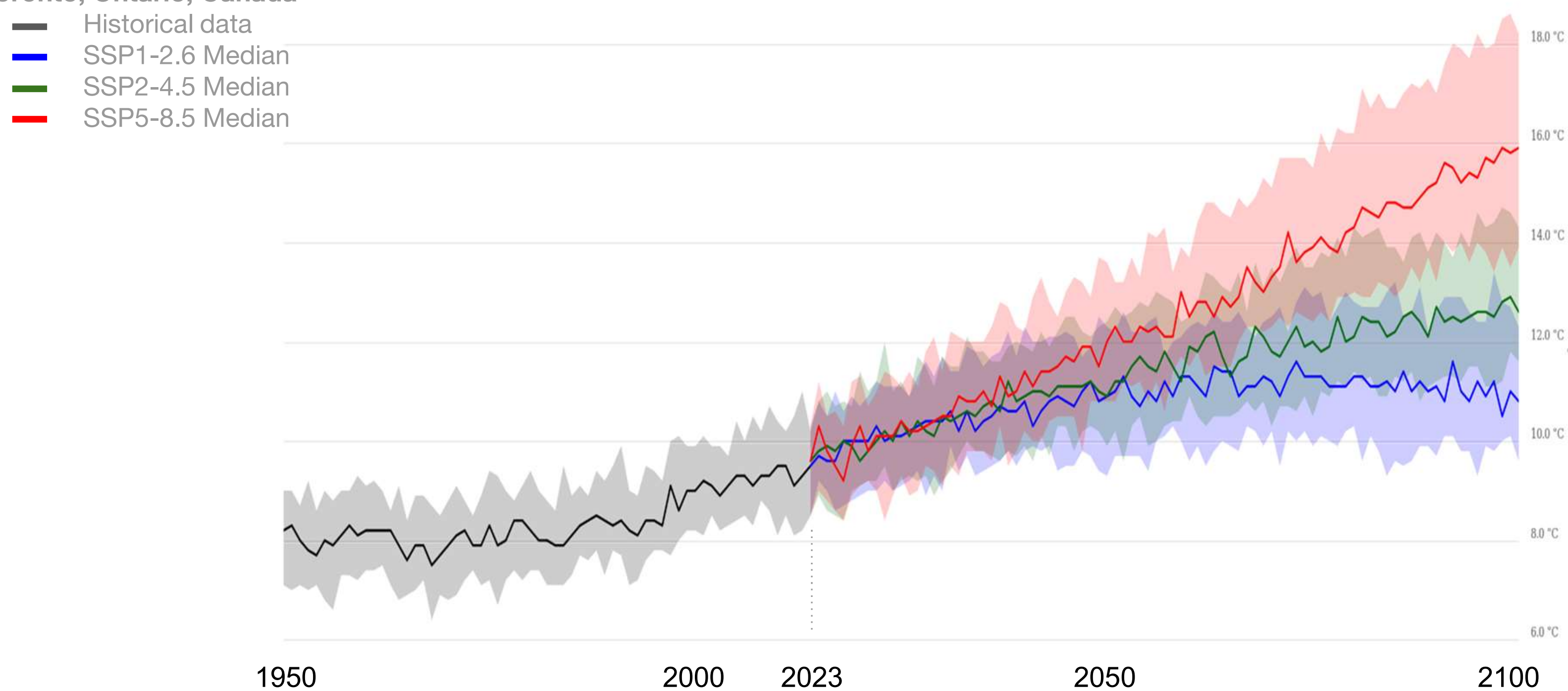
Kim Cobb, a lead author of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change



[image: SYNTHESIS REPORT OF THE IPCC SIXTH ASSESSMENT REPORT (AR6) - https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_SPM.pdf]

Adapting to a Dynamic Climate

Mean Temperature 1950 to 2100, Toronto, Ontario, Canada



[Data:Toronto, Ontario. climatedata.ca]

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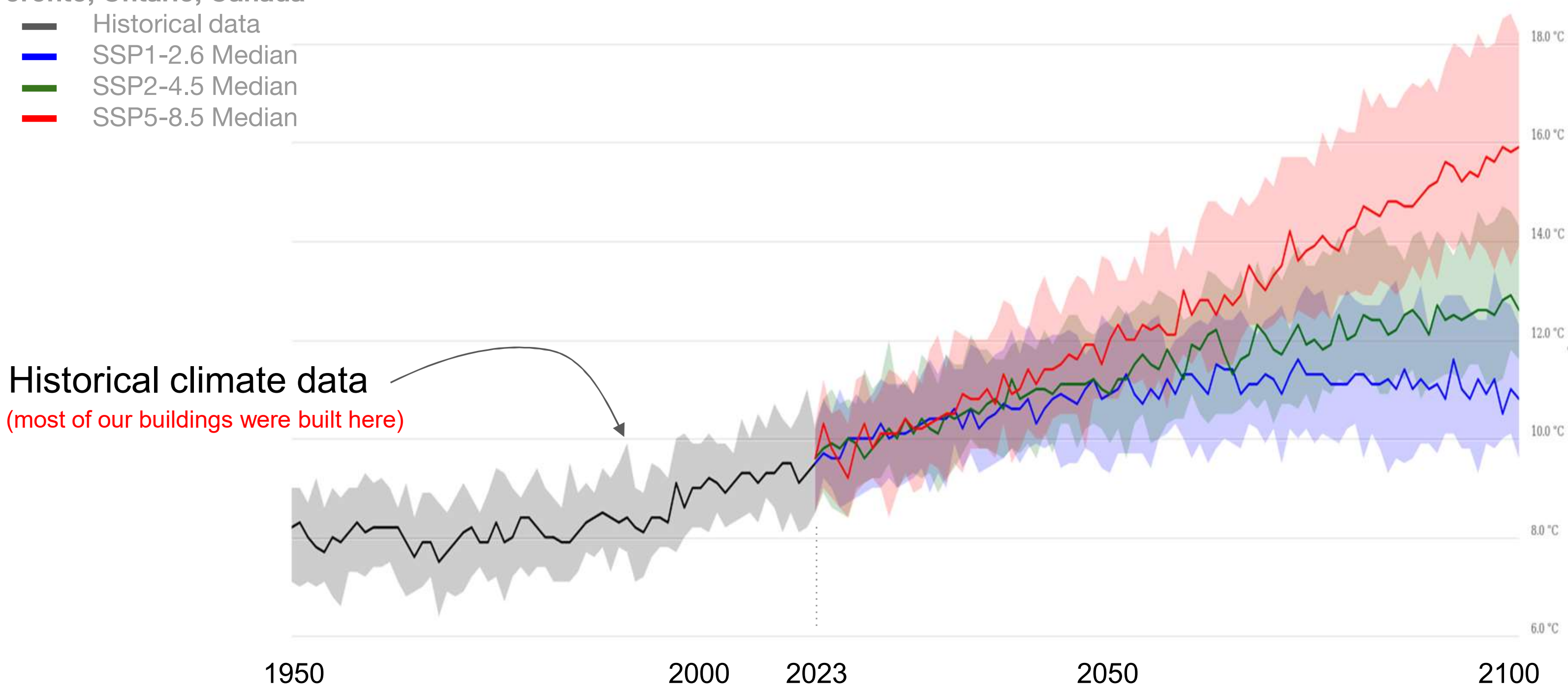

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Adapting to a Dynamic Climate

Mean Temperature 1950 to 2100,
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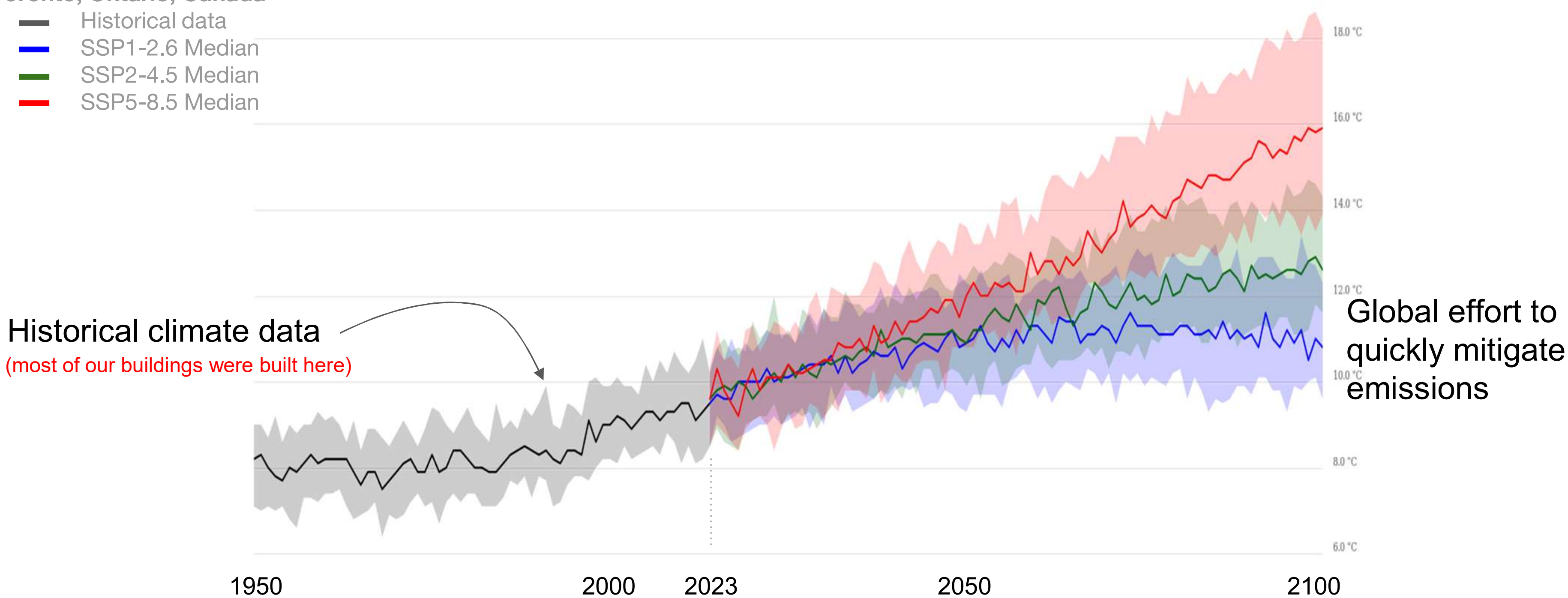

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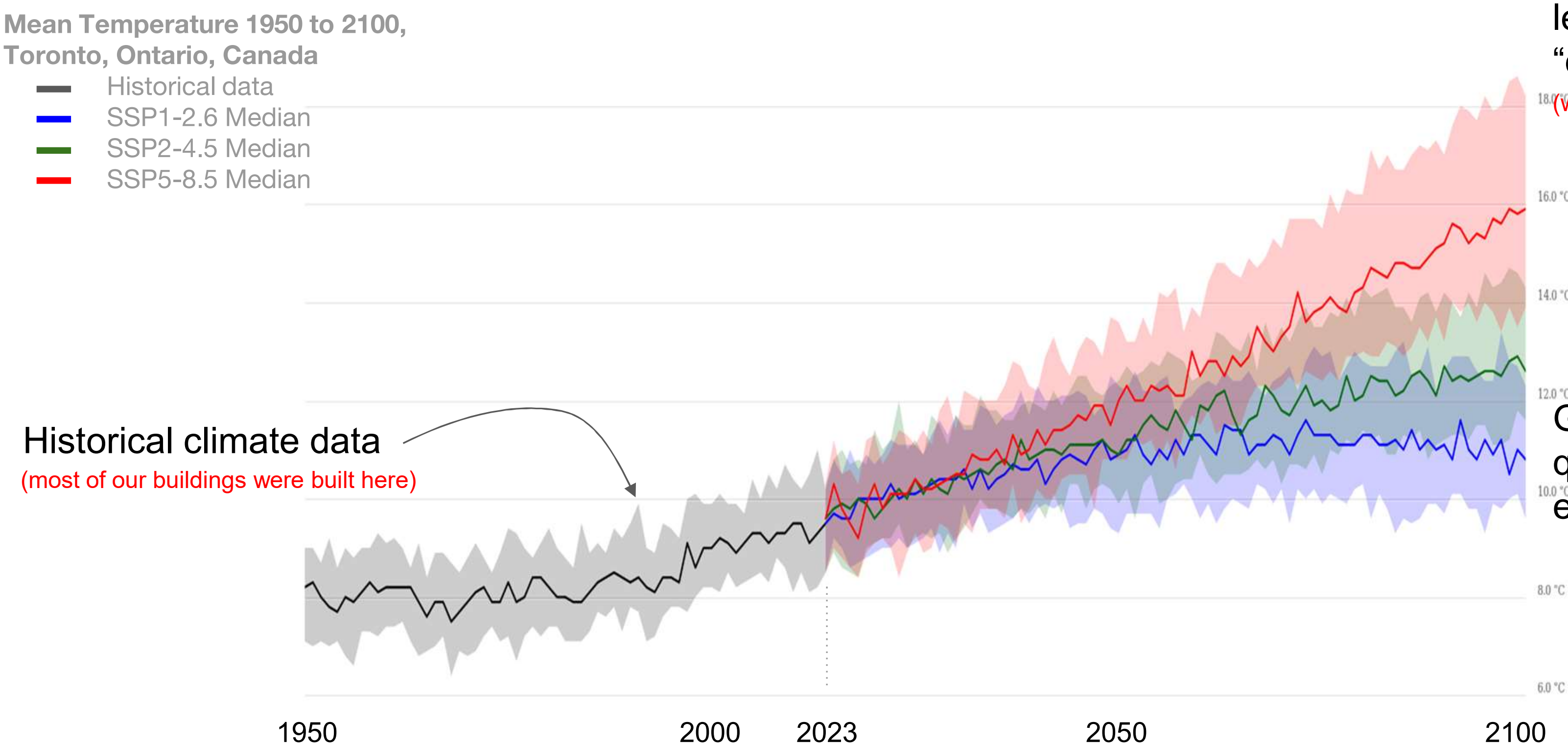
Adapting to a Dynamic Climate

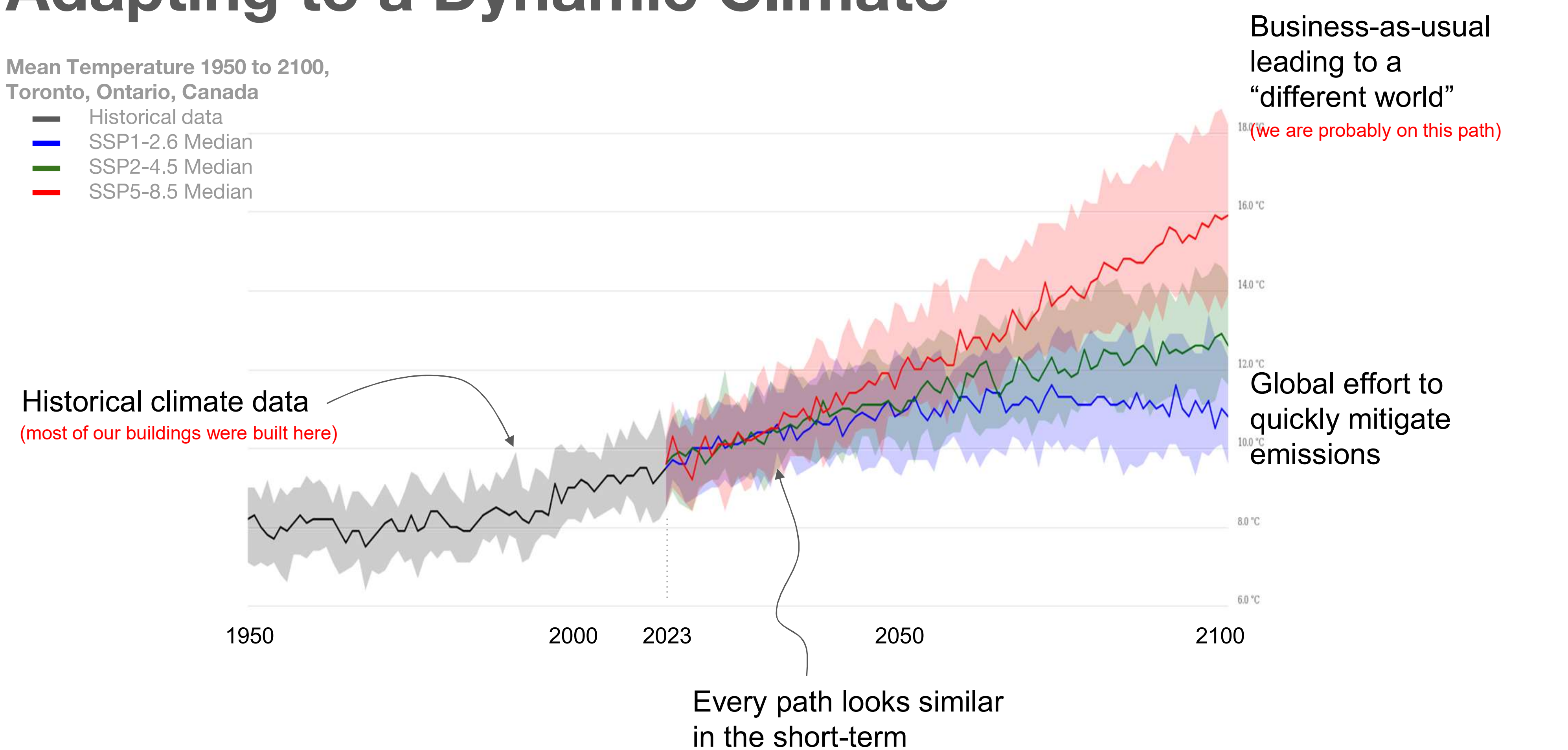


Business-as-usual leading to a “different world”
(we are probably on this path)

Global effort to quickly mitigate emissions

[Data:Toronto, Ontario. climatedata.ca]

Adapting to a Dynamic Climate



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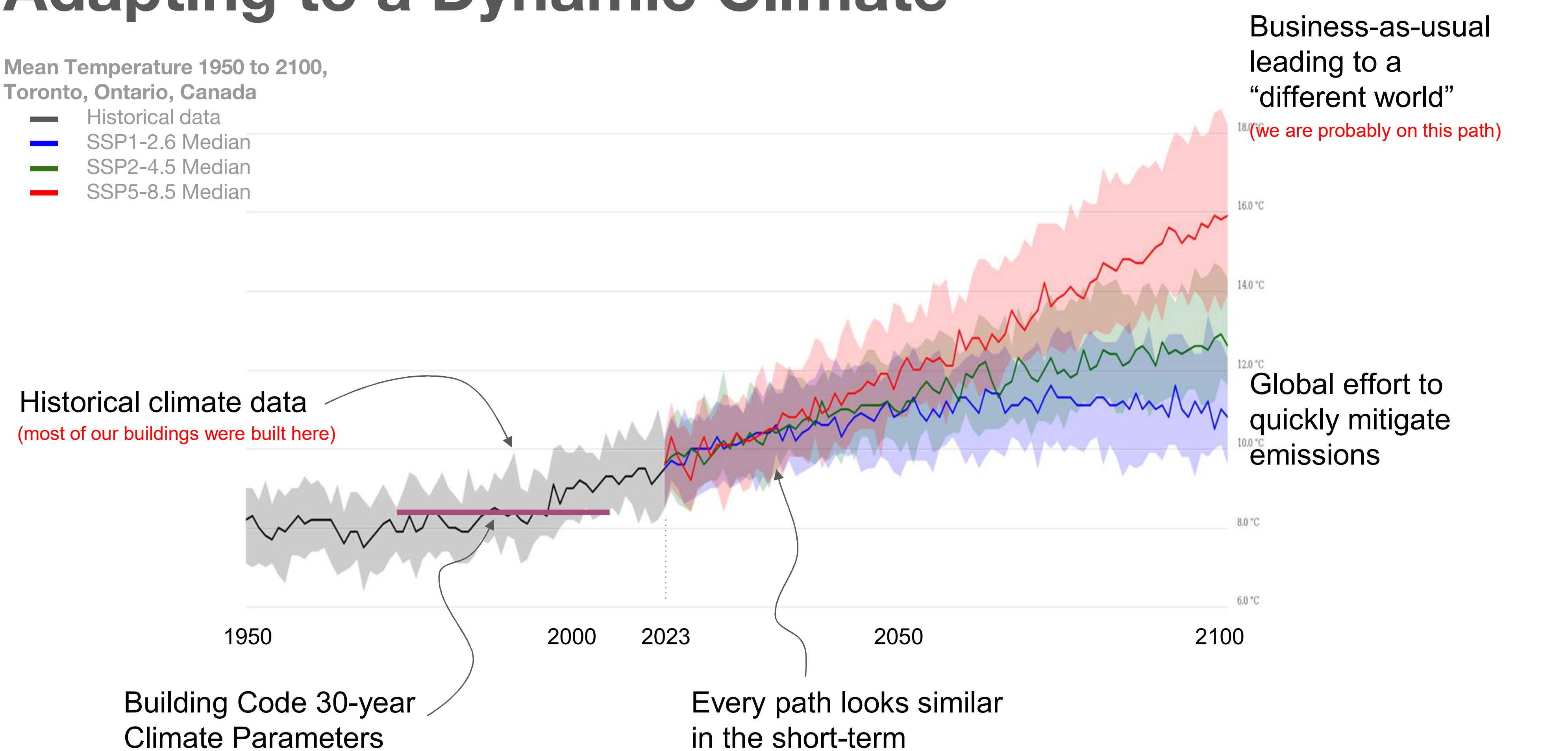
Adapting to a Dynamic Climate



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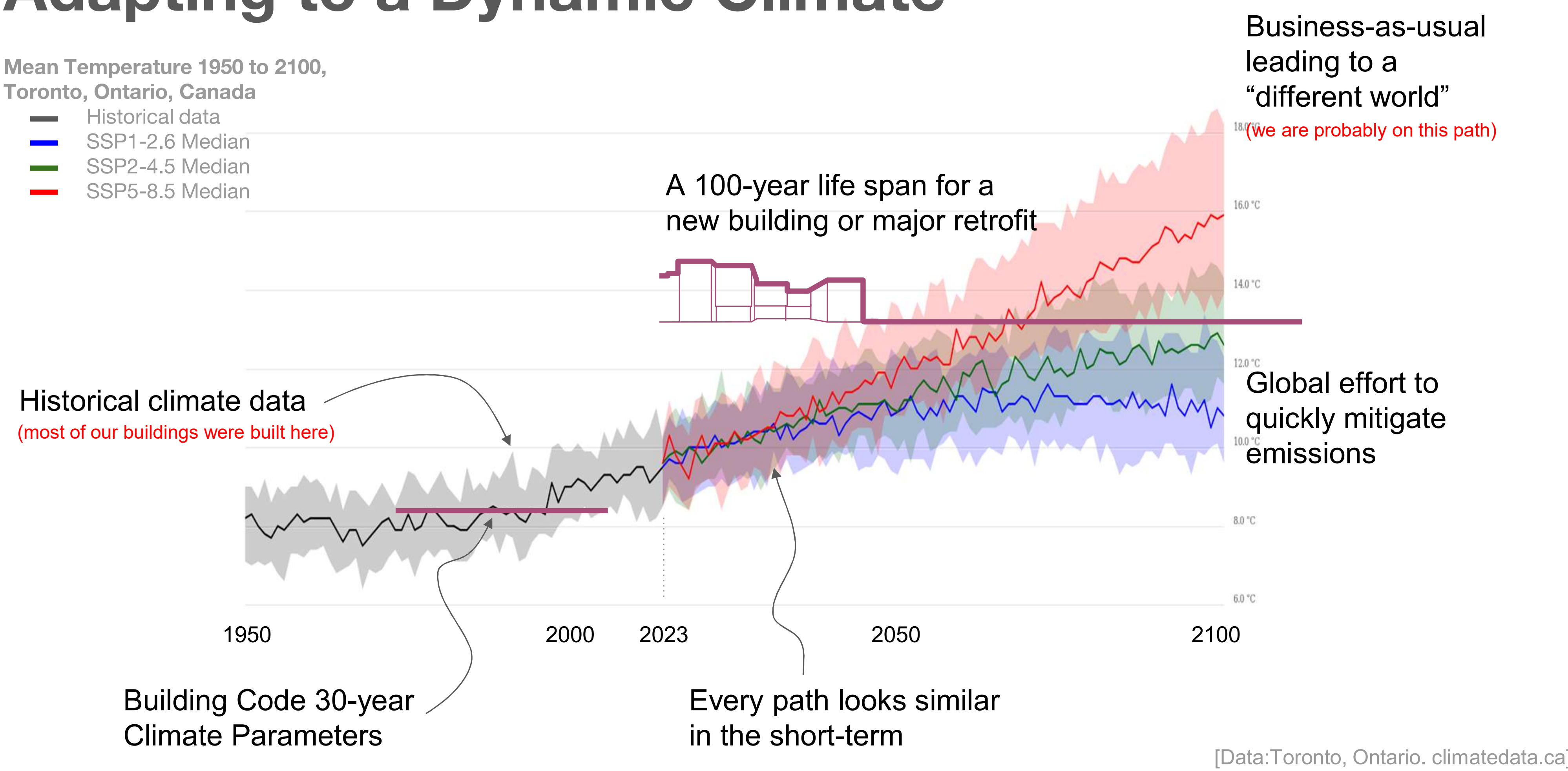
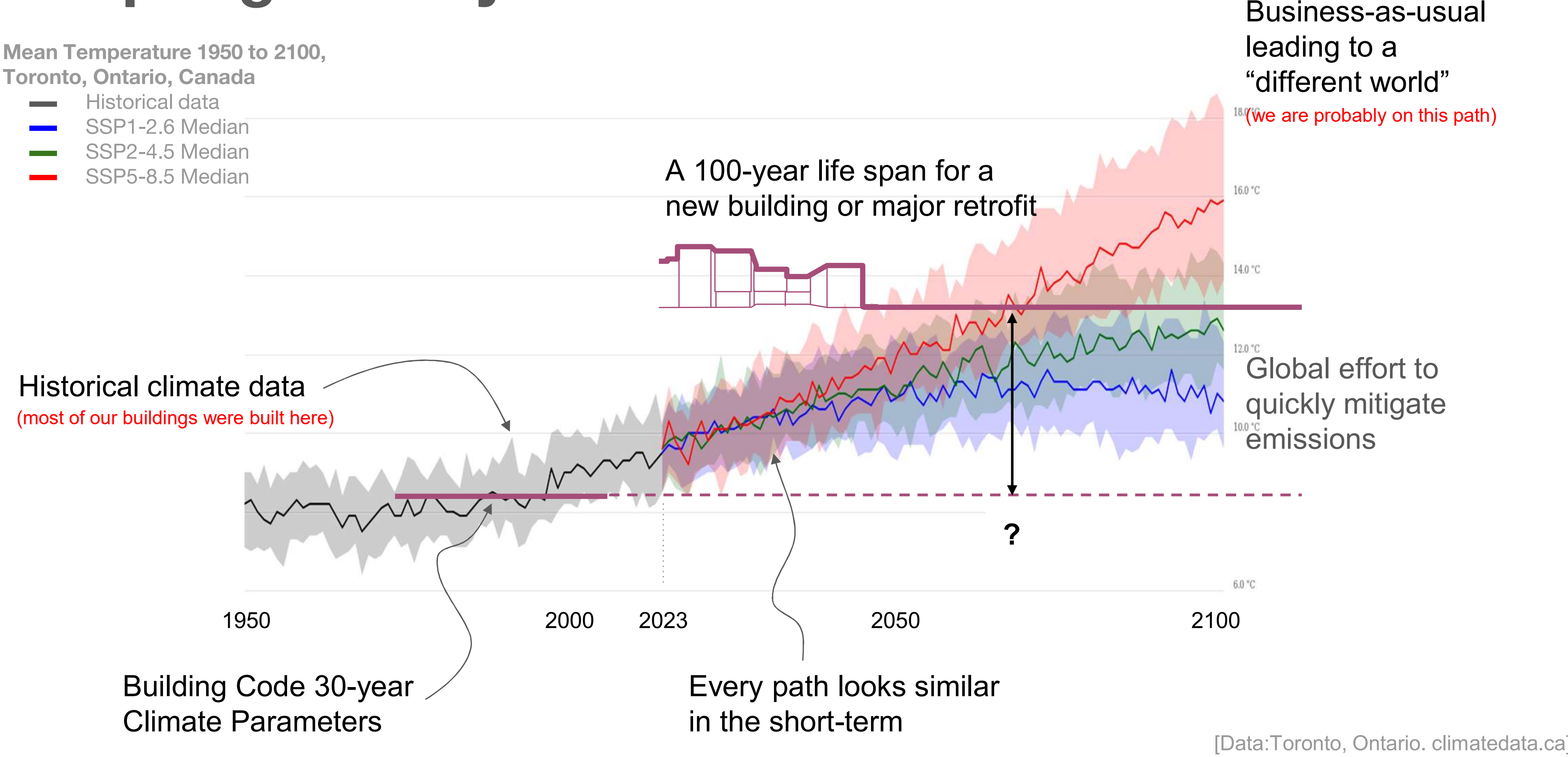
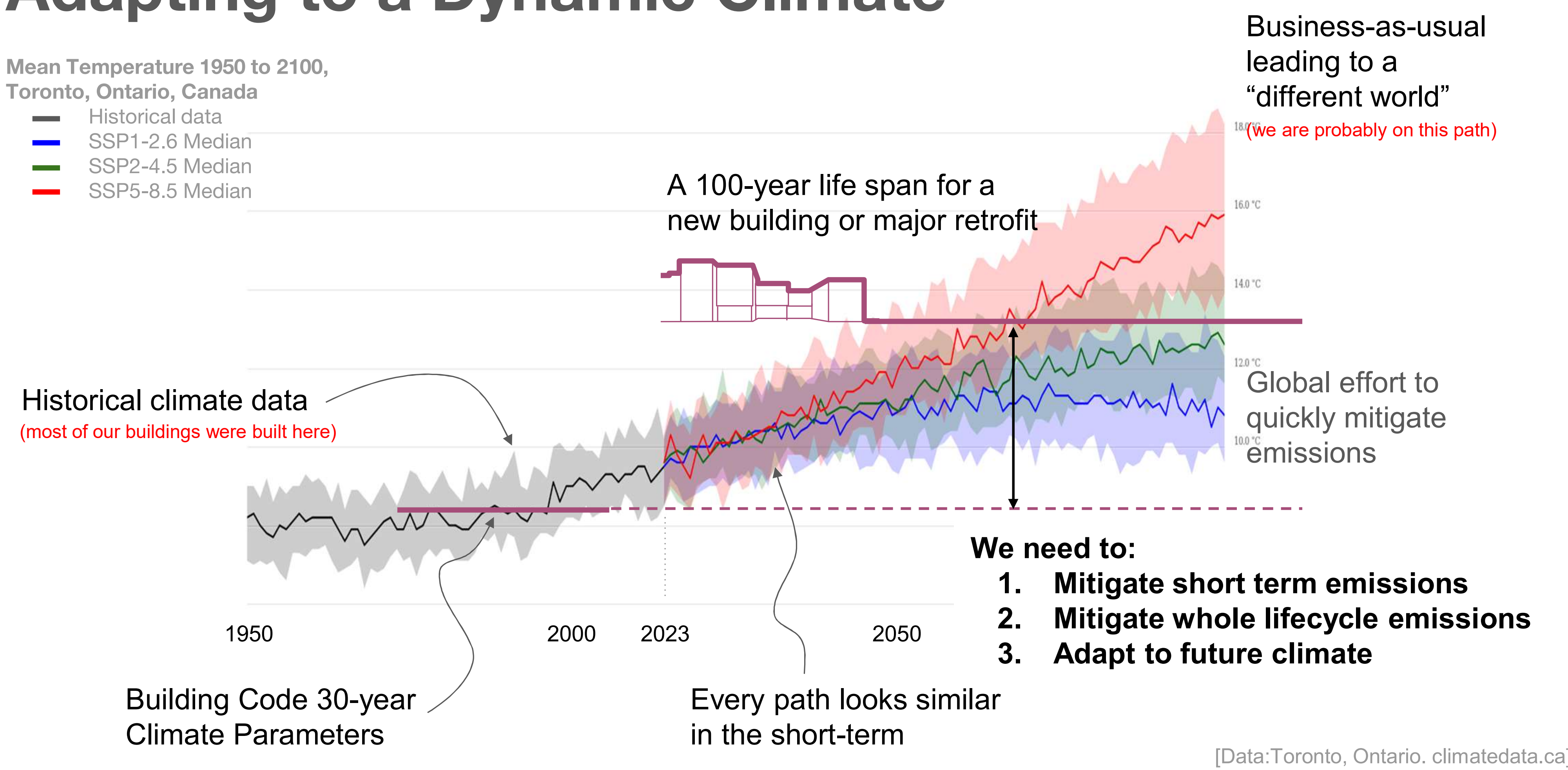
Adapting to a Dynamic Climate



Adapting to a Dynamic Climate



Adapting to a Dynamic Climate



1. Design to minimize emissions over the next two decades

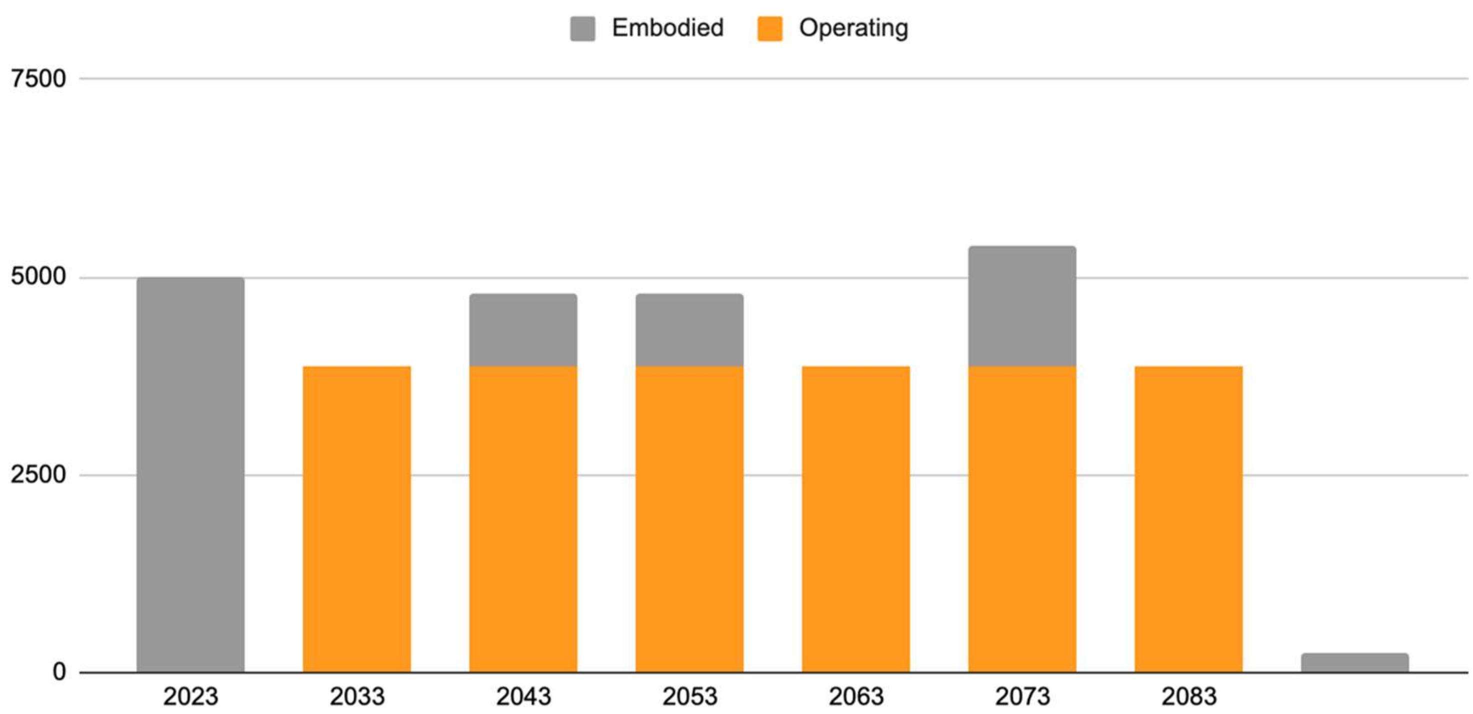
"Toronto Green Standard Version 4 (2022) . . . to be applied to new development applications under the Planning Act commencing May 1, 2022"

Toronto Green Standard v4	TIER	TEUI (kWh/m²-yr)	TEDI (kWh/m²-yr)	GHG (kg/m²)
Residential >6 Storeys	**T1** (2022)	135	50	15
	T2 (2026)	100	30	10
	T3 (2030)*	75	15	5
	+ Net Zero Emissions**			0

* Includes Passive House and CaGBC Zero Carbon Building compliance pathways
** Applies to City of Toronto-owned buildings

Life-cycle GHG Emissions by Decade

- office building, conventional design



Life-cycle GHG Emissions by Decade

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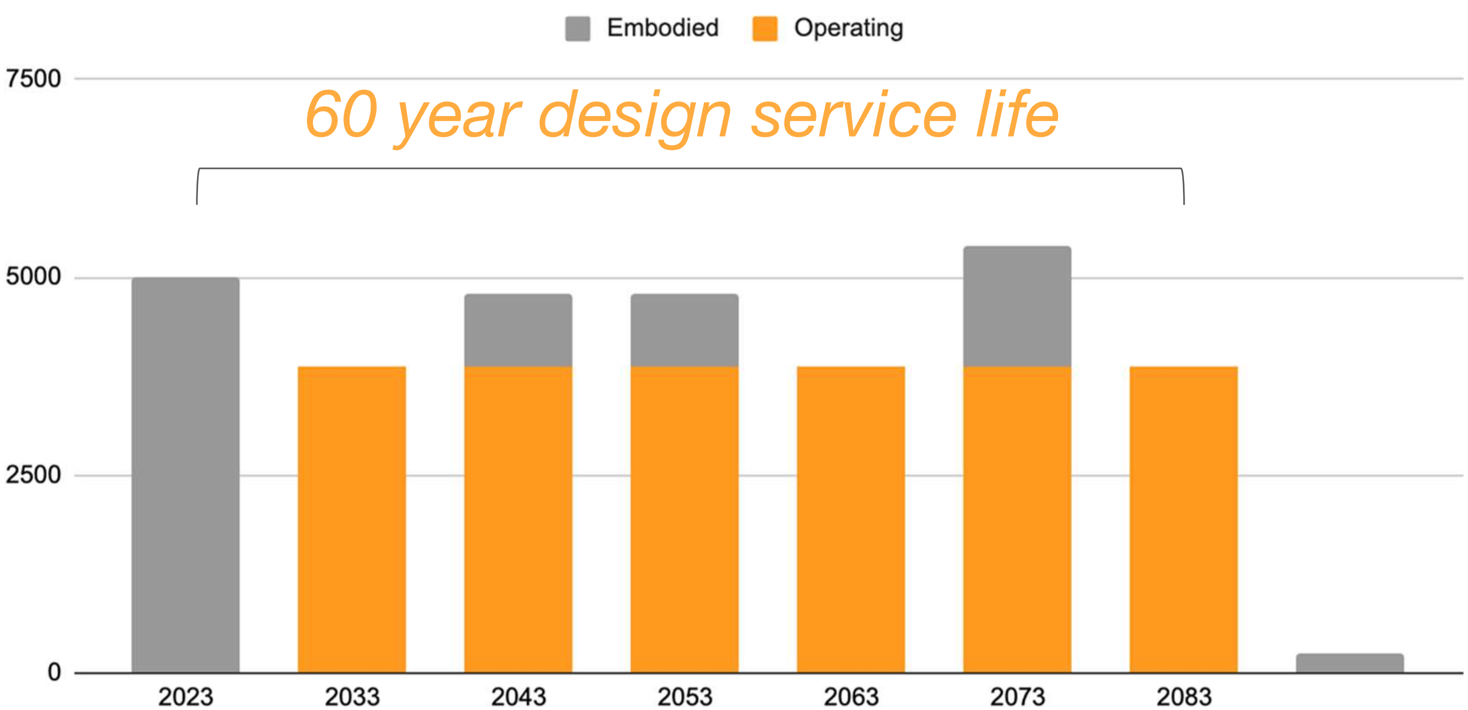

Life-cycle GHG Emissions by Decade

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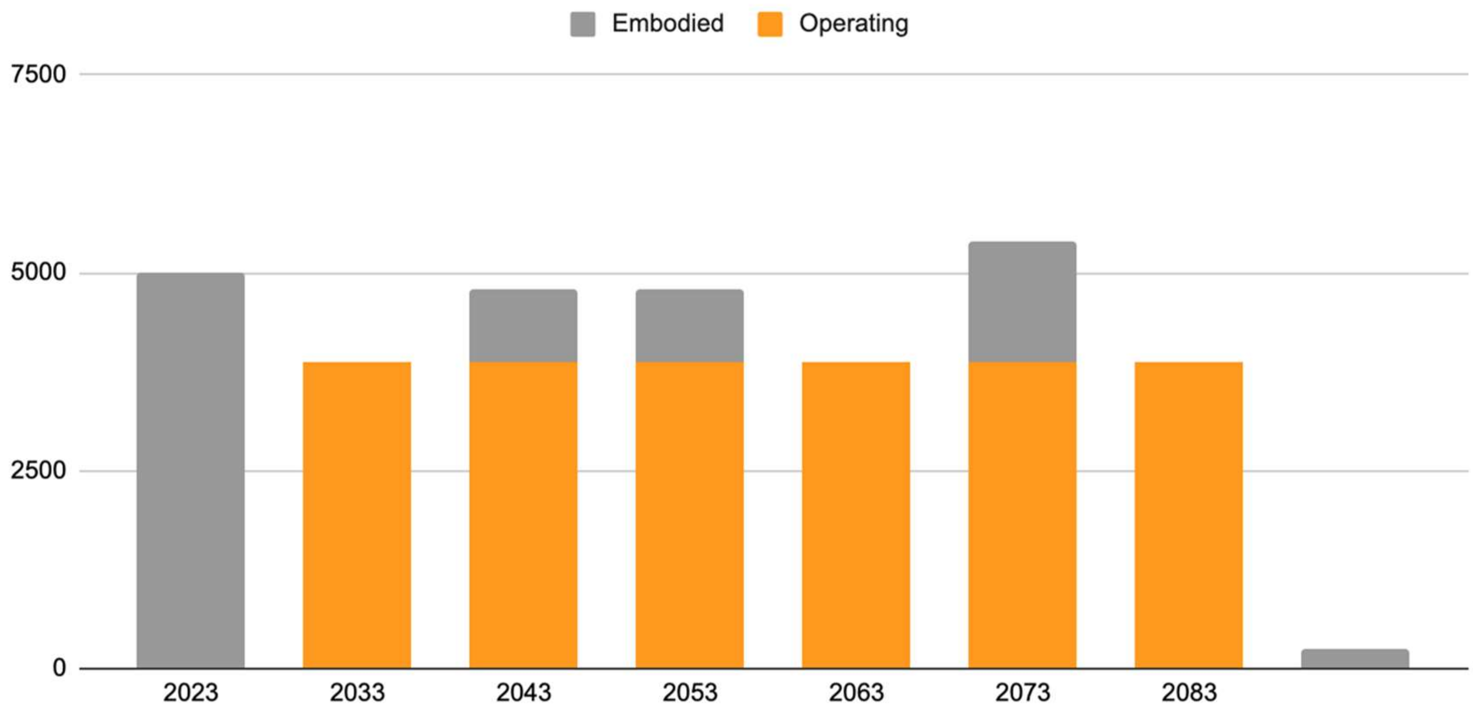
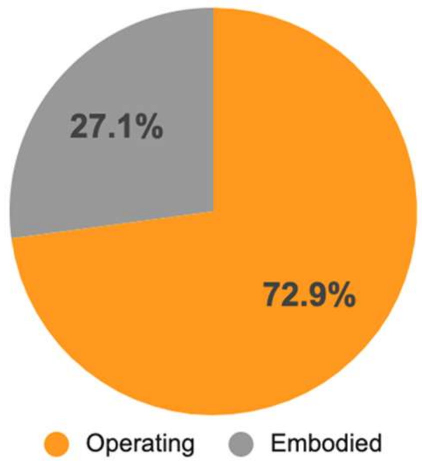
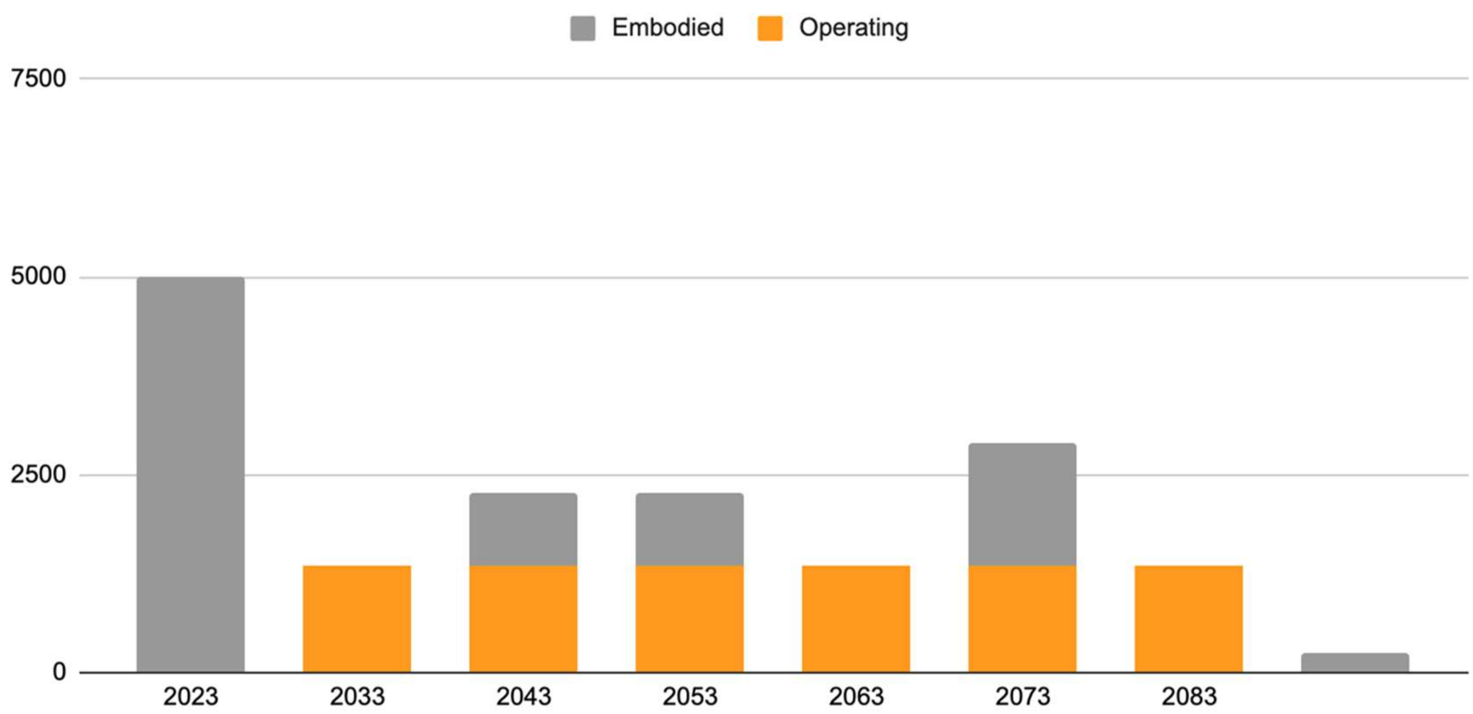
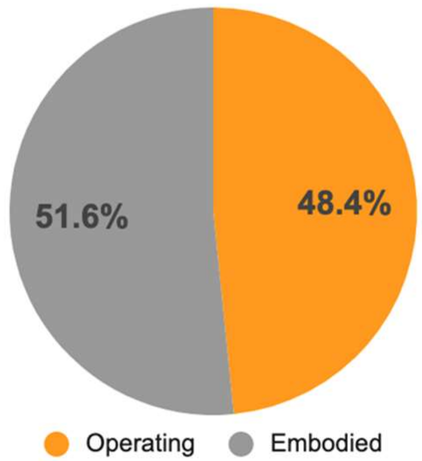




Life-cycle GHG Emissions by Decade

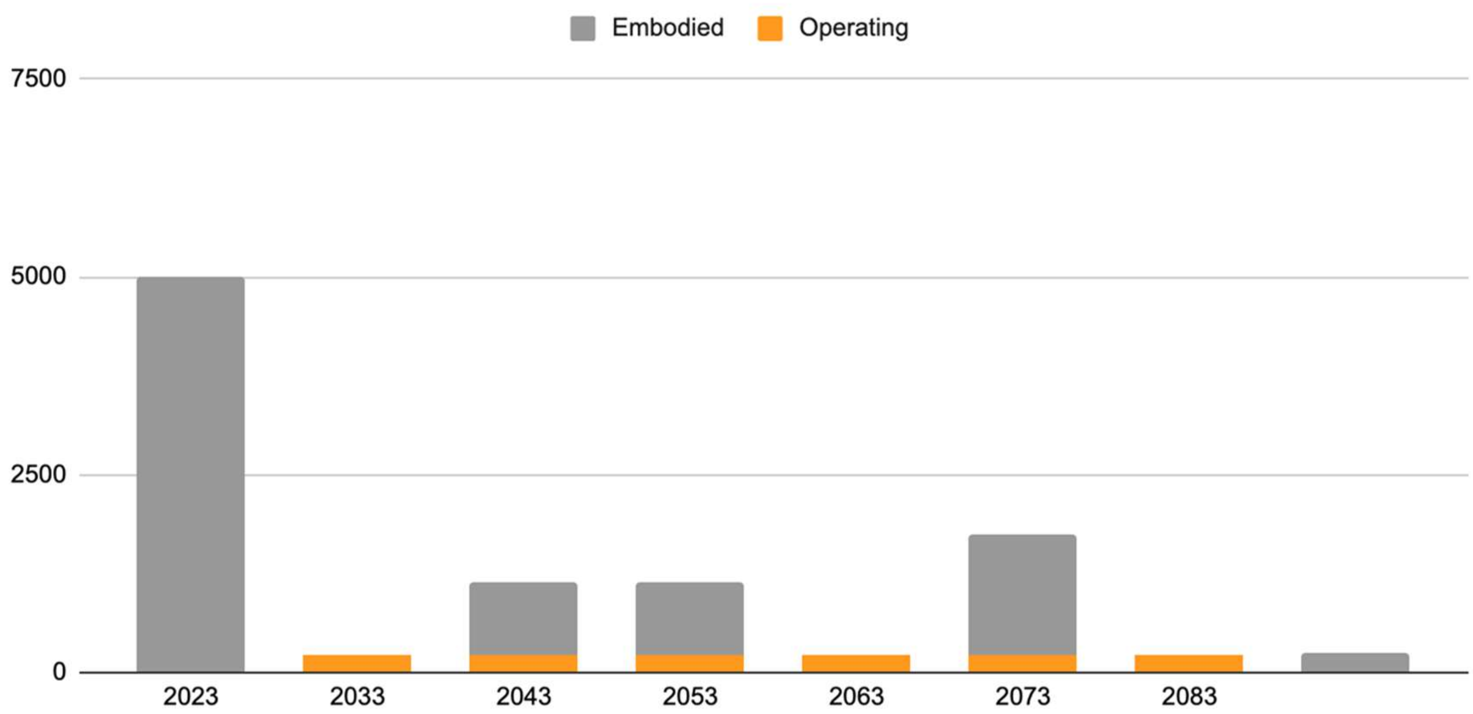
- office building, *energy efficient design*

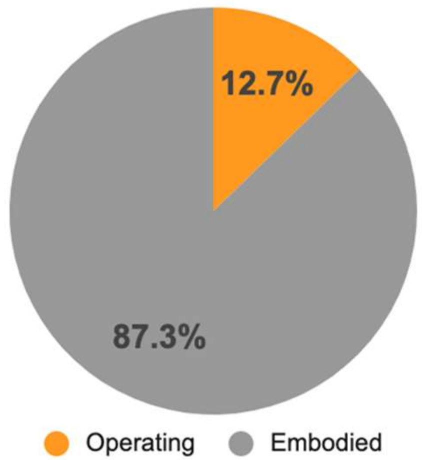




Life-cycle GHG Emissions by Decade

- office building, *energy efficient + all low carbon electricity*





Life-cycle

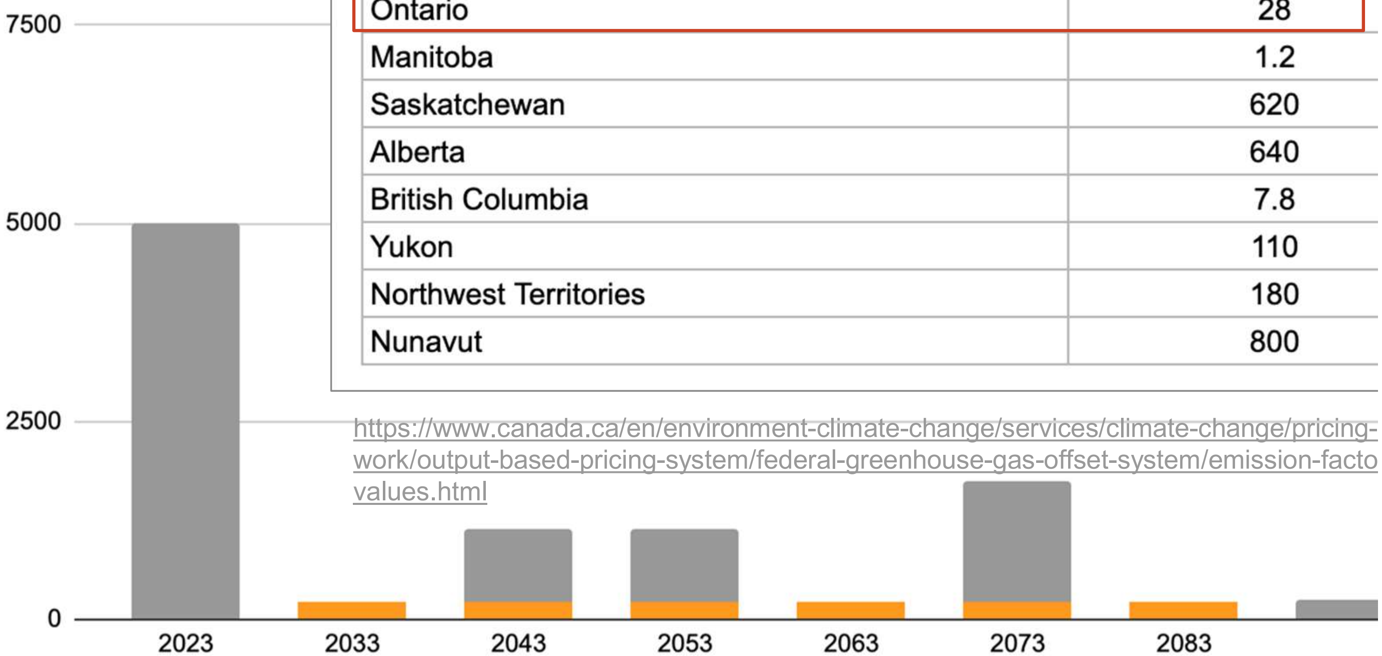
- office b

source

Electricity consumption intensity values (g CO2e/kWh electricity consumed)

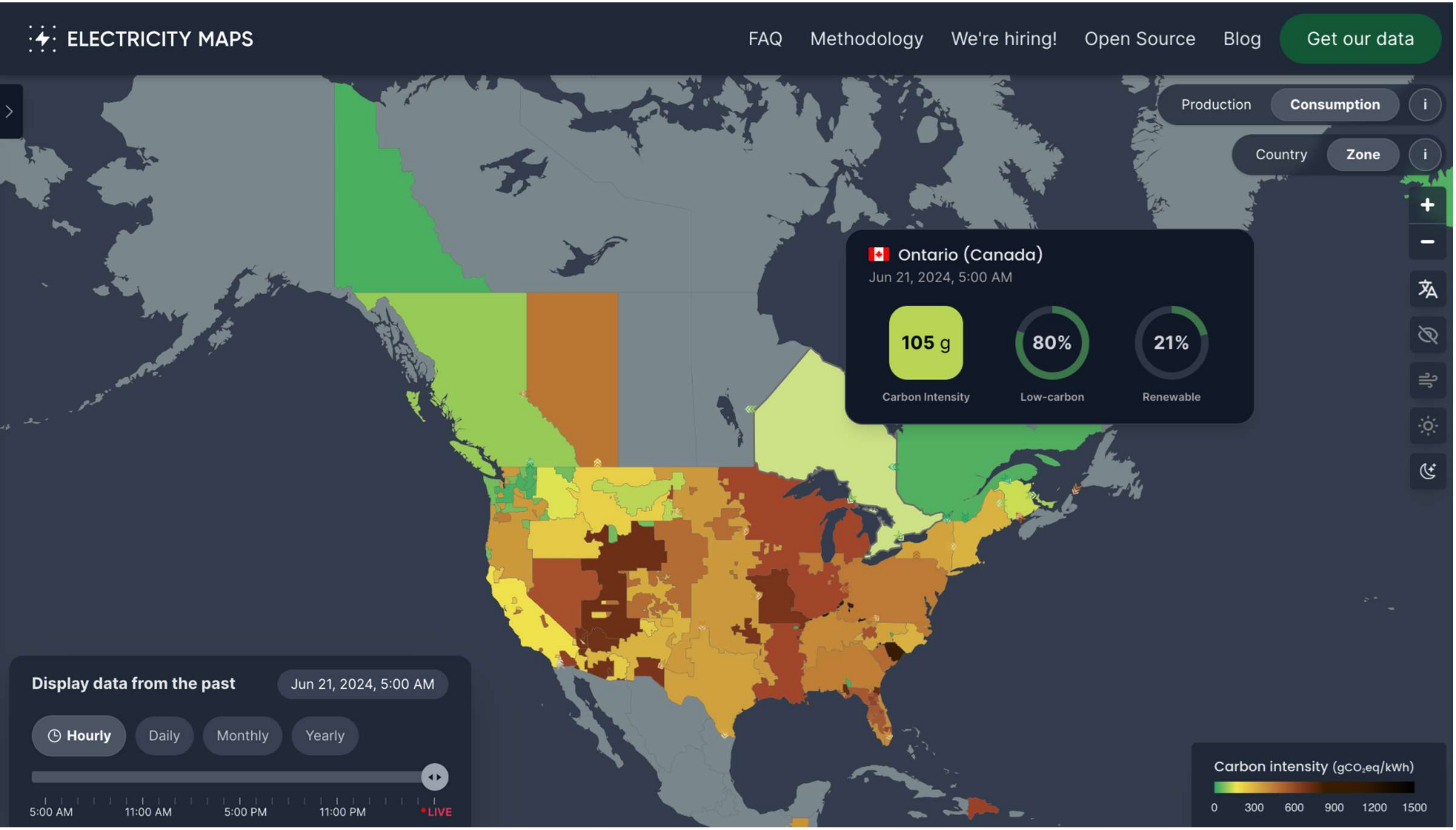
Province	Consumption intensity
Newfoundland and Labrador	25
Prince Edward Island	300
Nova Scotia	680
New Brunswick	300
Quebec	1.9
Ontario	28
Manitoba	1.2
Saskatchewan	620
Alberta	640
British Columbia	7.8
Yukon	110
Northwest Territories	180
Nunavut	800

https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-work/output-based-pricing-system/federal-greenhouse-gas-offset-system/emission-facto values.html



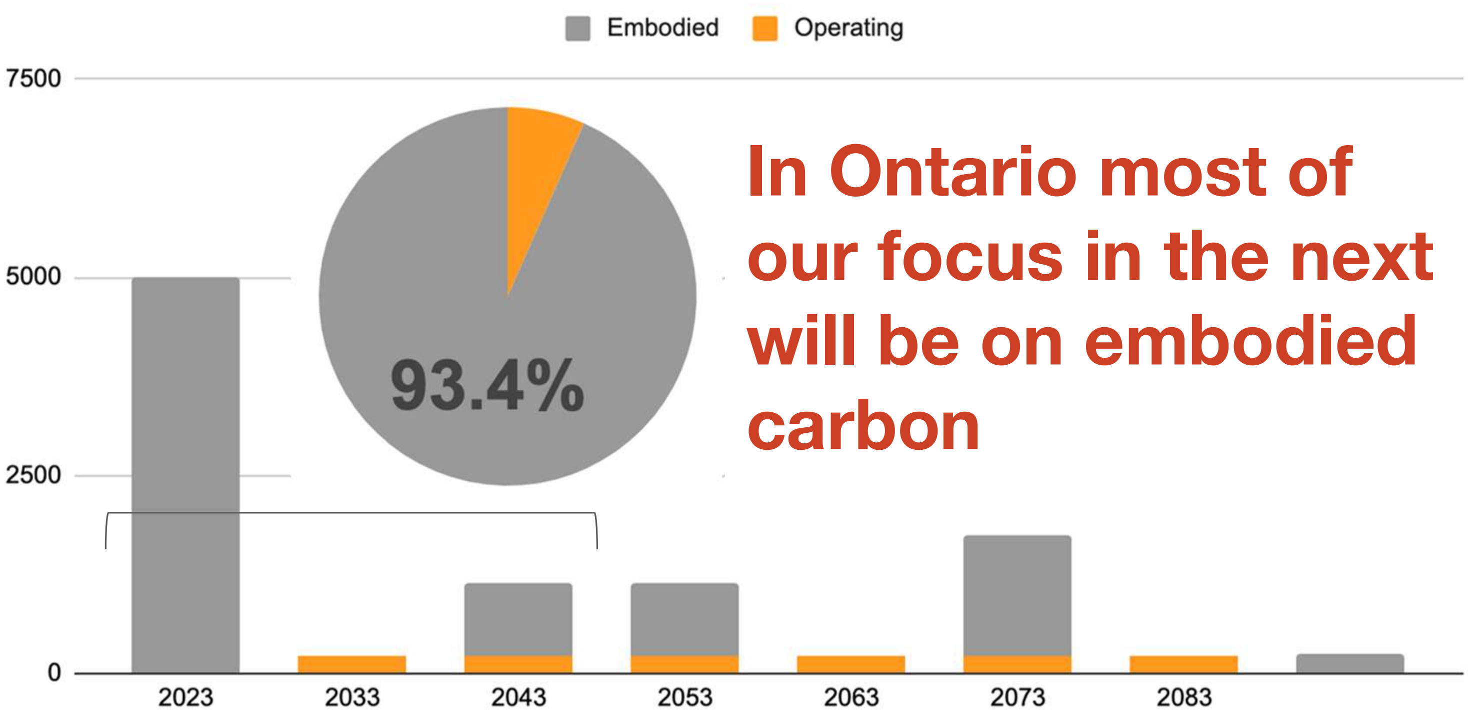
Ontario's grid is pretty clean! (currently)

All electric makes sense for Ontario buildings. (other regions this might not make as much sense)

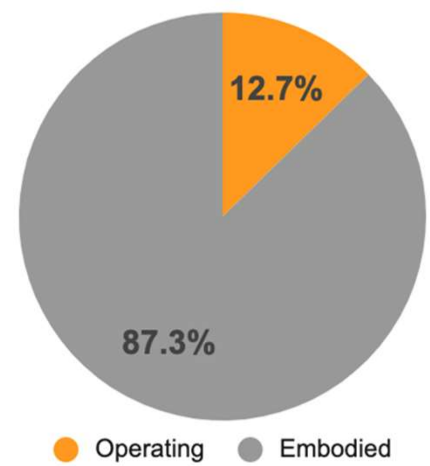

ELECTRICITY MAPS
FAQ
Methodology
We're hiring!
Open Source
Blog
Get our data
Production
Consumption
Country
Zone
Ontario (Canada)
Jun 21, 2024, 5:00 AM
105 g
Carbon Intensity
80%
Low-carbon
21%
Renewable
Display data from the past
Jun 21, 2024, 5:00 AM
Hourly
Daily
Monthly
Yearly
5:00 AM
11:00 AM
5:00 PM
11:00 PM
LIVE
Carbon intensity (gCO₂eq/kWh)
0
300
600
900
1200
1500

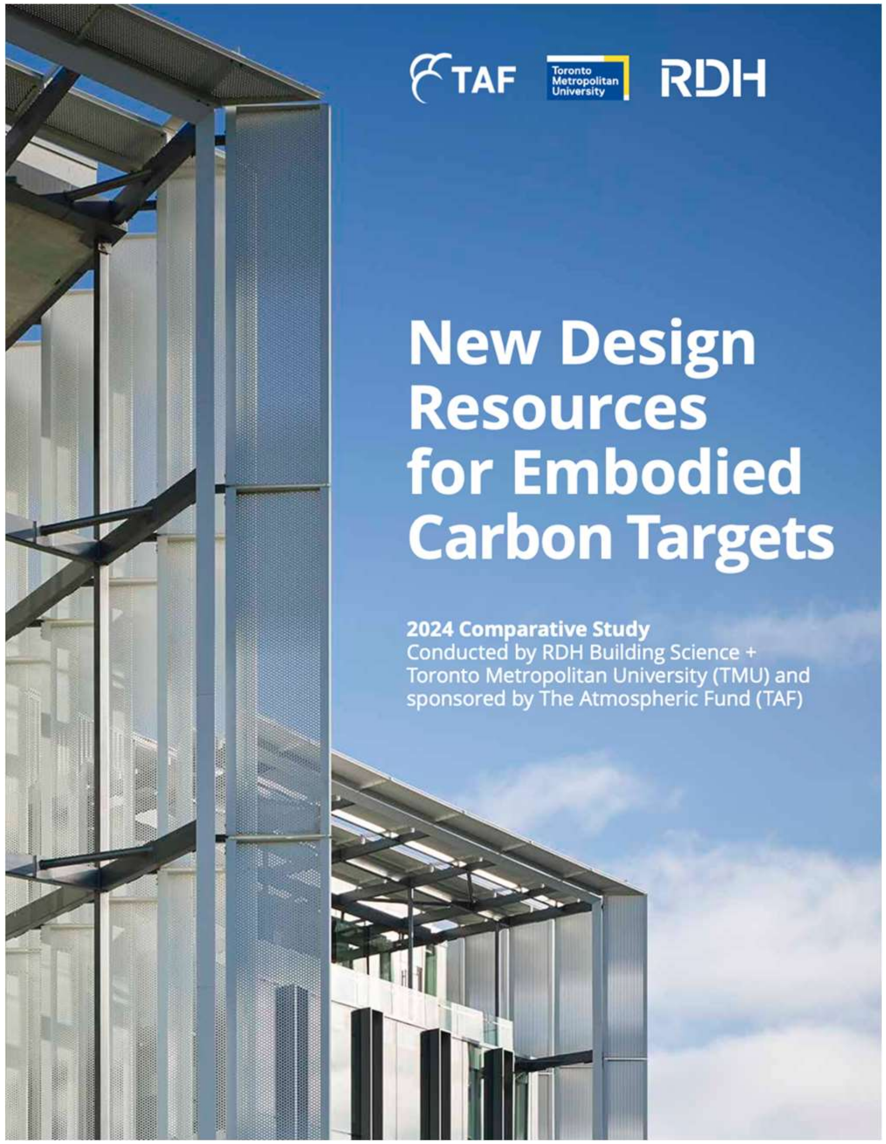
Life-cycle GHG Emissions by Decade

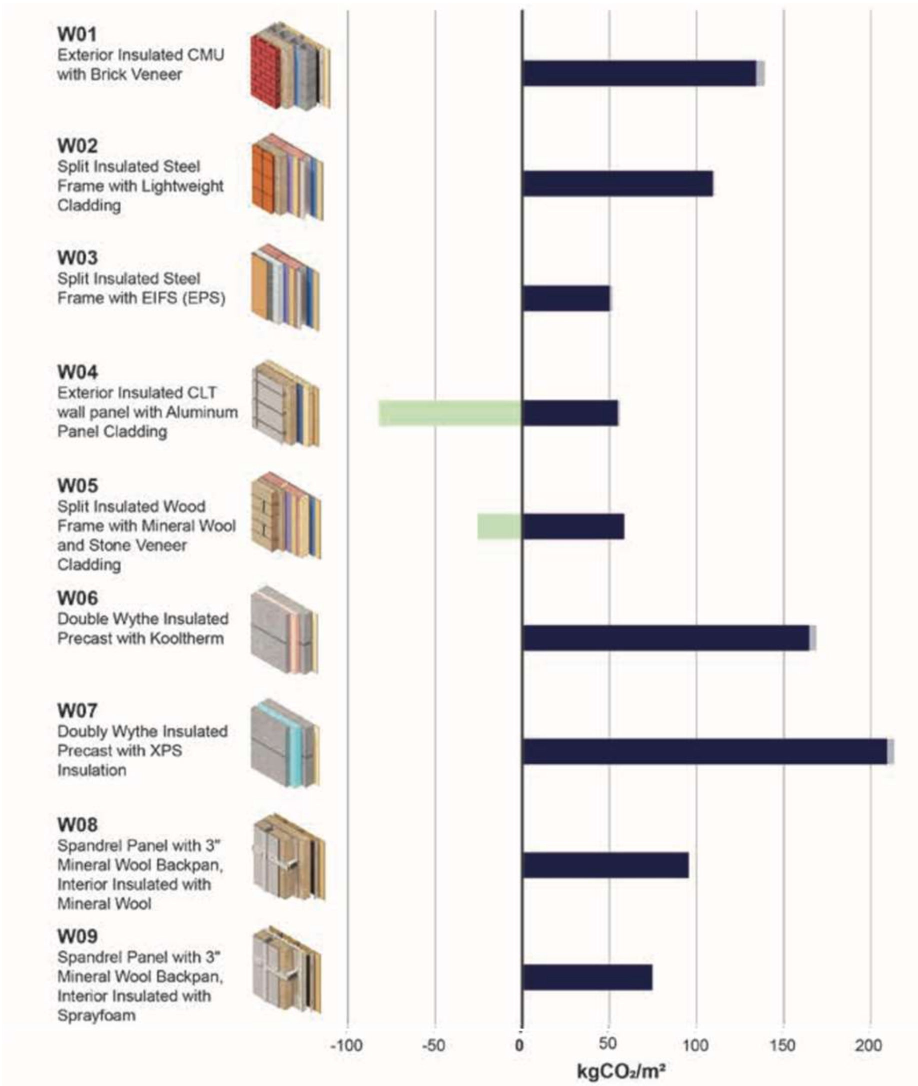
- office building, *energy efficient with low carbon energy source*

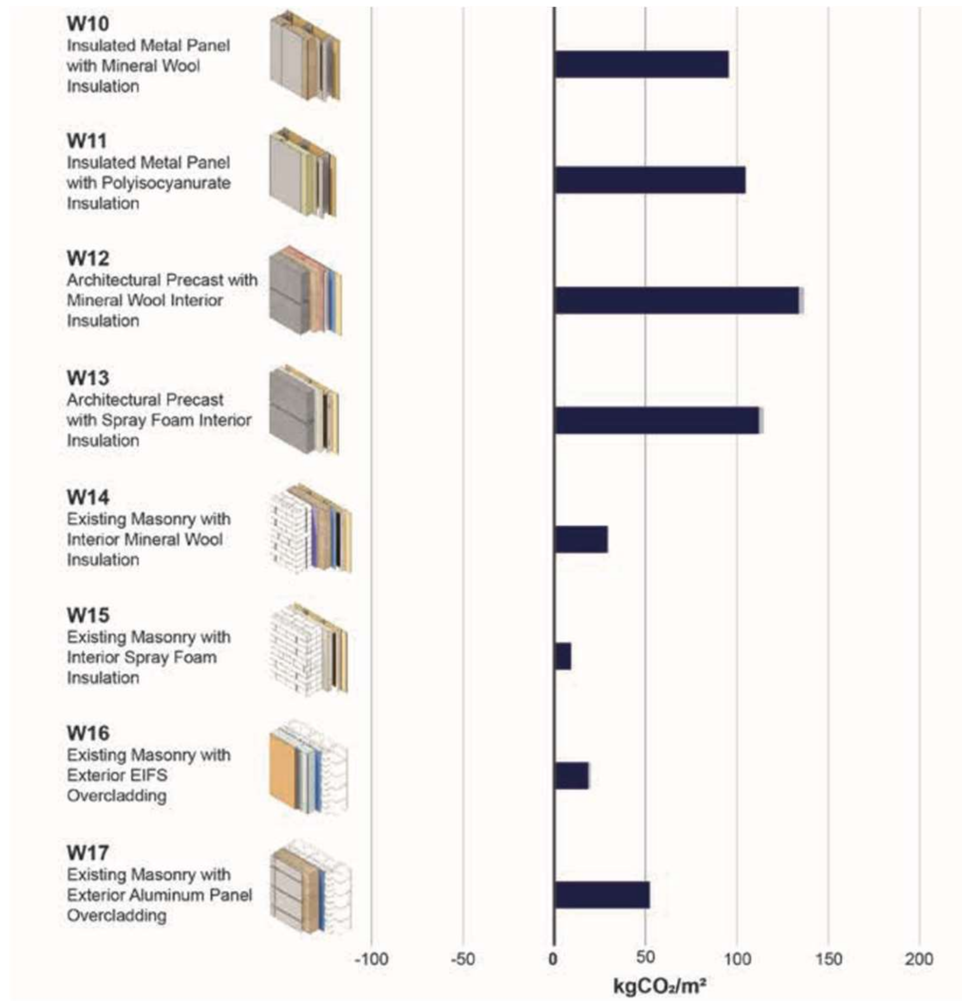


In Ontario most of our focus in the next will be on embodied carbon

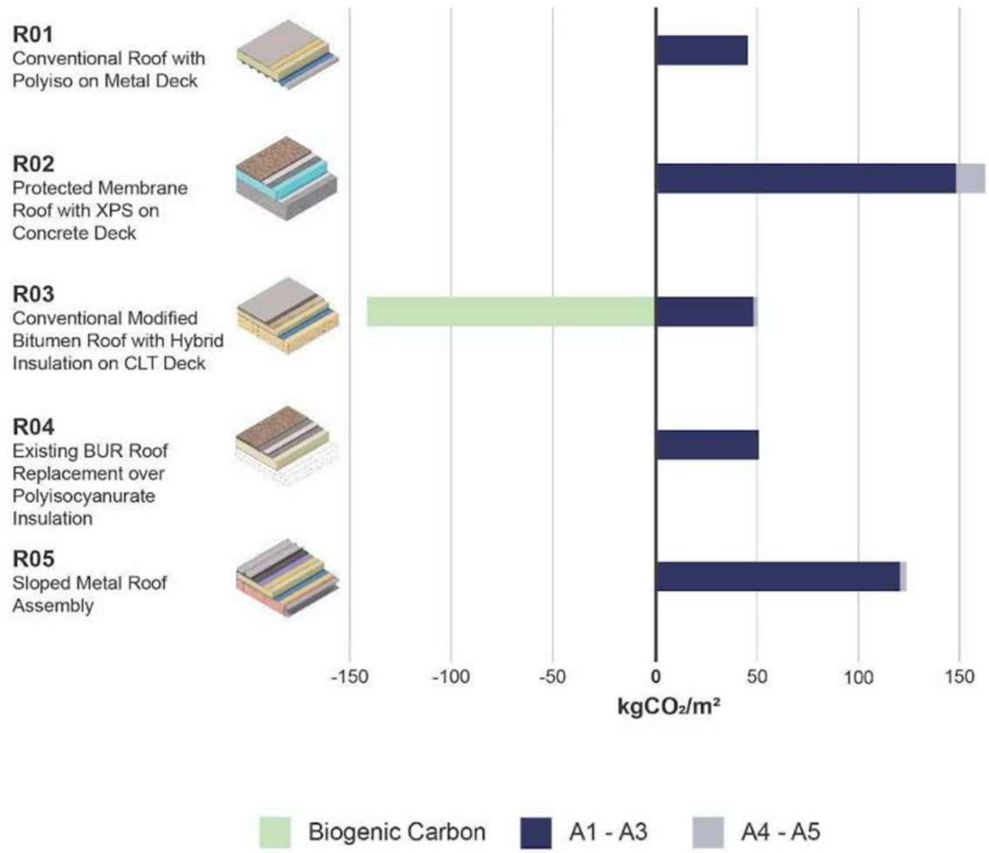



TAF
Toronto Metropolitan University
RDH
New Design Resources for Embodied Carbon Targets
2024 Comparative Study
Conducted by RDH Building Science +
Toronto Metropolitan University (TMU) and
sponsored by The Atmospheric Fund (TAF)





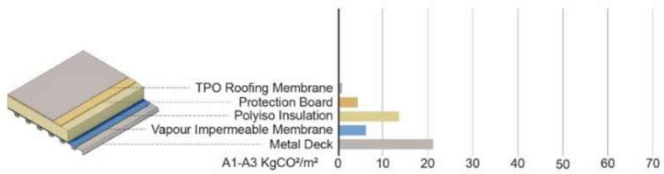
Biogenic Carbon A1 - A3 A4 - A5

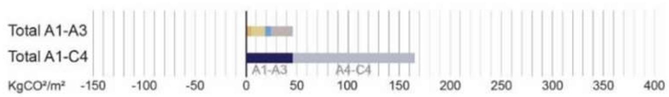

R01
Conventional Roof with Polyiso on Metal Deck
R02
Protected Membrane Roof with XPS on Concrete Deck
R03
Conventional Modified Bitumen Roof with Hybrid Insulation on CLT Deck
R04
Existing BUR Roof Replacement over Polyisocyanurate Insulation
R05
Sloped Metal Roof Assembly
-150
-100
-50
0
50
100
150
kgCO₂/m²
Biogenic Carbon
A1 - A3
A4 - A5

APPENDIX A **ROOF ASSEMBLY 01**

R01: Results Summary

Metrics	Results
Description	**Conventional Roof with Polyiso on Metal Deck**
Effective R-value	RSI-5.2 m²K/W | R-29.6 ft²·°F·h/BTU
Embodied Carbon per m² of Enclosure (A1-A3)	46.3 $kgCO_2/m^2$
Biogenic Carbon per m² of Enclosure	0 $kgCO_2/m^2$





R01: Assembly Effective R-value Calculation

Description	t_{SI}	t_{IP}	k	C (USI)	$RSI_{effective}$	$R_{effective}$	$R_{nominal}$
Units	mm	in	W/mK	W/m²K	m²K/W	ft²·°F·h/BTU	ft²·°F·h/BTU
Interior air film					0.11	0.61	
Corrugated metal roof deck	1.20	0.05	50.00	41530	0.00	0.00	
Self-adhered sheet-applied air barrier and vapour-impermeable membrane	0.80	0.03	-	-	-	-	
Rigid polyisocyanurate insulation, fully adhered (polyurethane adhesive)	127.00	5.00	0.003	0.26	4.93	28.00	28.00
Asphalt protection board, fully adhered (polyurethane adhesive)	4.80	0.19	-	-	0.14	0.79	
Waterproof roof membrane system	2.20	0.09	-	-	-	-	
Exterior air film					0.03	0.17	
TOTALS	**136.0**	**5.40**			**5.20**	**29.60**	**28.00**

R01: Embodied Carbon Emissions (A1 to A3 Life Stages) for 9m² Assembly Area

Category	Material	Description (from EPD)	Thickness	Material Volume	Carbon Emissions (A1-A3)	% of total
Units			mm	m³	kgCO2e	%
Structure	Metal Deck	Steel roof and floor deck, 22-16 gauge (Steel Deck Institute) deck	1.204 (0.05")	0.010836	190	46.50%
Exterior Membrane	Vapour impermeable membrane	SBS polymer-modified bitumen membrane roofing, self-adhered, 6.69 kg/m2 (Certain Teed, Henry, IKO, Malarkey Roofing Products, Siplast, Soprema)	-	*	61	14.7%
Exterior Insulation	Polyiso	Polyisocyanurate (PIR) roof insulation boards, glass fiber reinforced cellulosic faced (GRF), boards	127 (5")	1.3716	120	28%
Insulation Protection	Protection Board	Roof cover board, fiberglass facing, 6.1 kg/m2, EVERBOARD™ - ¼ fiberglass faced (Continuous Materials, plant Philadelphia)	-	*	36	9%
Exterior Membrane	TPO Roofing Membrane	TPO Single ply waterproofing roof membrane (mechanically fastened) (Generic)	2.2 (0.1")	0.0198	10	3%
				TOTAL	**417**	100.10%

**Software auto-calculates the impact based on the area provided.*

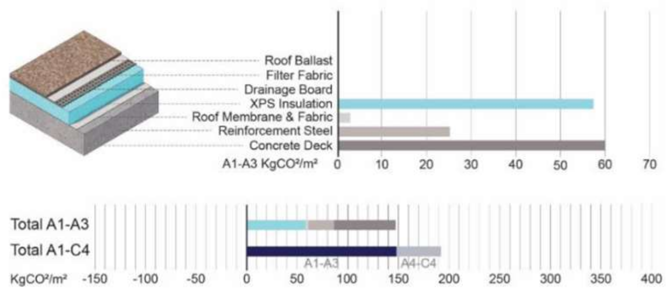
R01: Environmental Emissions (A1 to C4 Life Stages) for 9m² Assembly Area

Lifecycle Stage		**A1 to C4**	A1-A3	A4-A5	B1-B5	C1-C4	A1-A3 Contribution to total
Category	Units	**Total**	Construction Materials	Transport to Site & Construction	Material Replacement & Refurbishment	Deconstruction	%
Global Warming	kg CO2e	**1500.44**	417.57	3.9	328.75	750.22	27.83%
Acidification	kg SO	**5.79E-05**	1.63E-05	1.03E-06	1.16E-05	2.89E-05	28.17%
Eutrophication	kg Ne	**5.6006**	1.908	0.0223	0.87	2.8003	34.07%
Ozone Depletion	kg CFC11e	**1.1659**	0.36179	0.00316	0.218	0.58295	31.03%
Formation of Tropospheric Ozone	kg O3e	**77.622**	25.63	0.631	12.55	38.811	33.02%
Fossil Fuel Primary Energy	MJ	**8260.22**	3262.53	111.16	756.42	4130.11	39.50%
Biogenic Carbon Storage	kg CO2e	**0**	0				

APPENDIX A **ROOF ASSEMBLY 02**

R02: Results Summary

Metrics	Results
Description	**Protected Membrane Rood with XPS on Concrete Deck**
Effective R-value	RSI-5.6 m²K/W | R-31.7 ft²·°F·h/BTU
Embodied Carbon per m² of Enclosure (A1-A3)	148.4 $kgCO_2/m^2$
Biogenic Carbon per m² of Enclosure	0 $kgCO_2/m^2$



R02: Assembly Effective R-value Calculation

Description	t_{SI}	t_{IP}	k	C (USI)	$RSI_{effective}$	$R_{effective}$	$R_{nominal}$
Units	mm	in	W/mK	W/m²K	m²K/W	ft²·°F·h/BTU	ft²·°F·h/BTU
Interior air film					0.11	0.61	
Concrete roof structure	254.00	10.00	1.60	6.30	0.16	0.90	
Hot-applied rubberized asphalt waterproofing membrane	2.30	0.09	-	-	-	-	
Reinforcing fabric	0.26	0.01	-	-	-	-	
Hot-applied rubberized asphalt waterproofing membrane	3.20	0.13	-	-	-	-	
Drainage mat	10.00	0.39	-	-	-	-	
Extruded polystyrene (XPS) rigid board insulation, fully adhered (polyurethane adhesive)	152.40	6.00	0.03	0.19	5.28	29.98	29.98
Filter fabric	-	-	-	-	-	-	
Aggregate ballast	-	-	-	-	-	-	
Exterior air film					0.03	0.17	
TOTALS	**422.20**	**16.60**			**5.60**	**31.70**	**30.00**

R02: Embodied Carbon Emissions (A1 to A3 Life Stages) for 9m² Assembly Area

Category	Material	Description (from EPD)	Thickness	Material Volume	Carbon Emissions (A1-A3)	% of total
Units			mm	m³	kgCO2e	%
Structural Deck	Concrete Deck	Ready-mix concrete, Ontario industry average, 35 MPa concrete with air entrainment GU 50 SL	254 (10")	2.263	540	40.3%
	Reinforcement bar	Reinforcement steel (rebar), generic, 60% recycled content, A615	-	0.02286	240	18.0%
Exterior Membrane	Hot Rubber roof membrane and Reinforcing Fabric	Hot-applied rubberized asphalt membrane, waterproofing, 5.56 mm (219 mils), 6.39 kg/m2 (1.3 lb/ft2), Monolithic Membrane 6125 (MM6125) (Hydrotech Membrane Corp)	5.5 (0.22")	0.0495	28	2.1%
Exterior Insulation	XPS	XPS insulation (extruded polystyrene)	152.4 (6")	1.3716	520	39%
Drainage	Drainage Board	Drainage mat and moisture barrier, 2.15 kg/m2, DrainScreen (Sto)	-	*	2.5	0.2%
Drainage	Filter Fabric	Geotextile, generic, 312 g/m2 (1.02 oz/ft2), Composition: PP net, non-woven PE felt, generic	-	*	2.3	0.2%
Exterior Finish	Roof Ballast	Rock to be used for erosion control, Granite, product specific	-	*	2.7	0.2%
				TOTAL	1336	

**Software auto-calculates the impact based on the area provided.*

R02: Environmental Emissions (A1 to C4 Life Stages) for 9m² Assembly Area

Lifecycle Stage		A1 to C4	A1-A3	A4-A5	B1-B5	C1-C4	A1-A3 Contribution to total
Category	Units	**Total**	Construction Materials	Transport to Site & Construction	Material Replacement & Refurbishment	Deconstruction	%
Global Warming	kg CO2e	**1729.623**	1338.95	135.884	109.49	145.299	77.41%
Acidification	kg SO	**0.00093718**	0.000838	3.07E-05	5.97E-05	8.78E-06	89.42%
Eutrophication	kg Ne	**6.97305**	4.5046	0.21699	0.506	1.74546	64.60%
Ozone Depletion	kg CFC11e	**2.055435**	1.82279	0.094207	0.065	0.073438	88.68%
Formation of Tropospheric Ozone	kg O3e	**78.097398**	72.903	2.6225	1.3	1.271898	93.35%
Fossil Fuel Primary Energy	MJ	**13496.882**	6608.37	2025.96	4783.06	79.492	48.96%
Biogenic Carbon Storage	kg CO2e	**0**	0				

2. Design for the building’s full lifecycle

Over 15,000 “Big Box” stores have closed in North America since 2017. [Image from: Kunal Mehta | Shuttershock]

We cannot separate our material and energy flows from the environmental and social impacts at the location of production

Manitoba Hydro Place, Winnipeg [Image: KPMB Architects]

Bel Air bauxite mine in Guinea [Image: Alufer Mining]
https://www.mining-technology.com/projects/bel-air-bauxite-mine/]

3. Design for an anticipated future climate

How can we know
what this future will be like?

Location Variable Sector | Analyze Download Learn News Apps About Glossary HAVE A QUESTION? EN FR

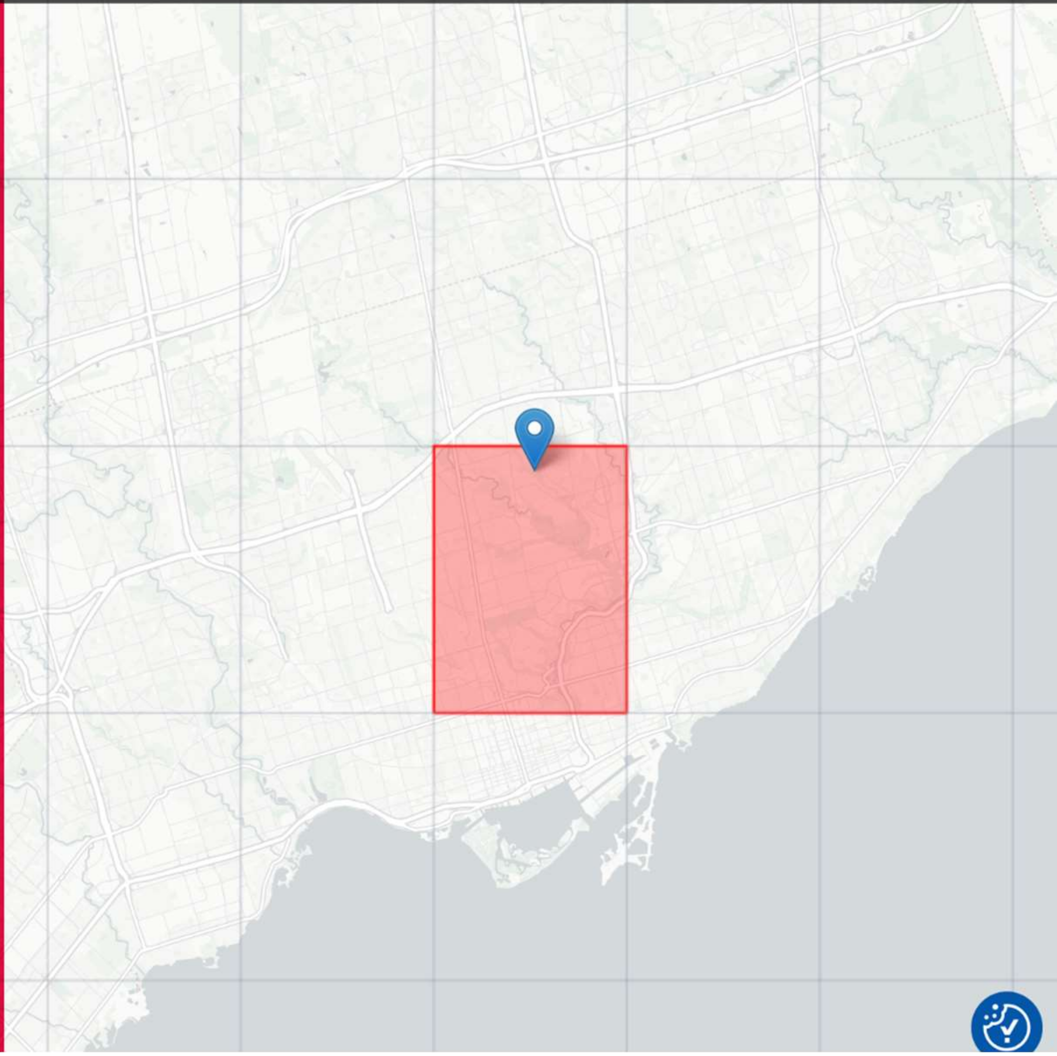
43.7417°N, 79.3733° W

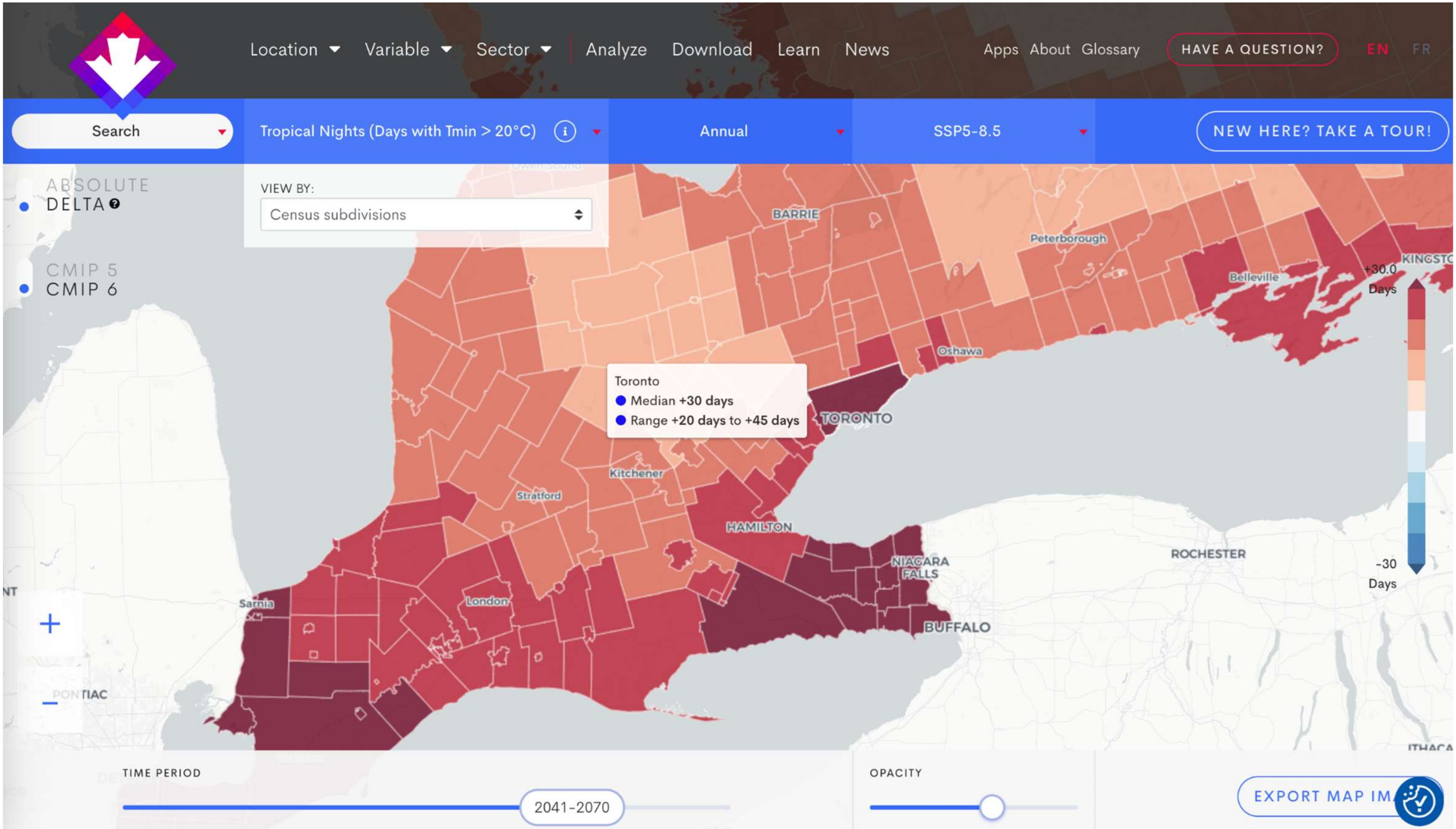
Toronto, ON

For the 1971–2000 period, the annual average temperature was **8.3** °C. Under a high emissions scenario, annual average temperatures are projected to be **10.8** °C for the 2021–2050 period, **13.0** °C for the 2051–2080 period and **14.7** °C for the last 30 years of this century.

Average annual precipitation for the 1971–2000 period was **811** mm. Under a high emissions scenario, this is projected to be **13**% higher for the 2051–2080 period and **19**% higher for the last 30 years of this century.

Seasonal and monthly changes in precipitation may be quite different from these annual average values.





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Range +20 days to +45 days
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Kitchener
Stratford
HAMILTON
NIAGARA FALLS
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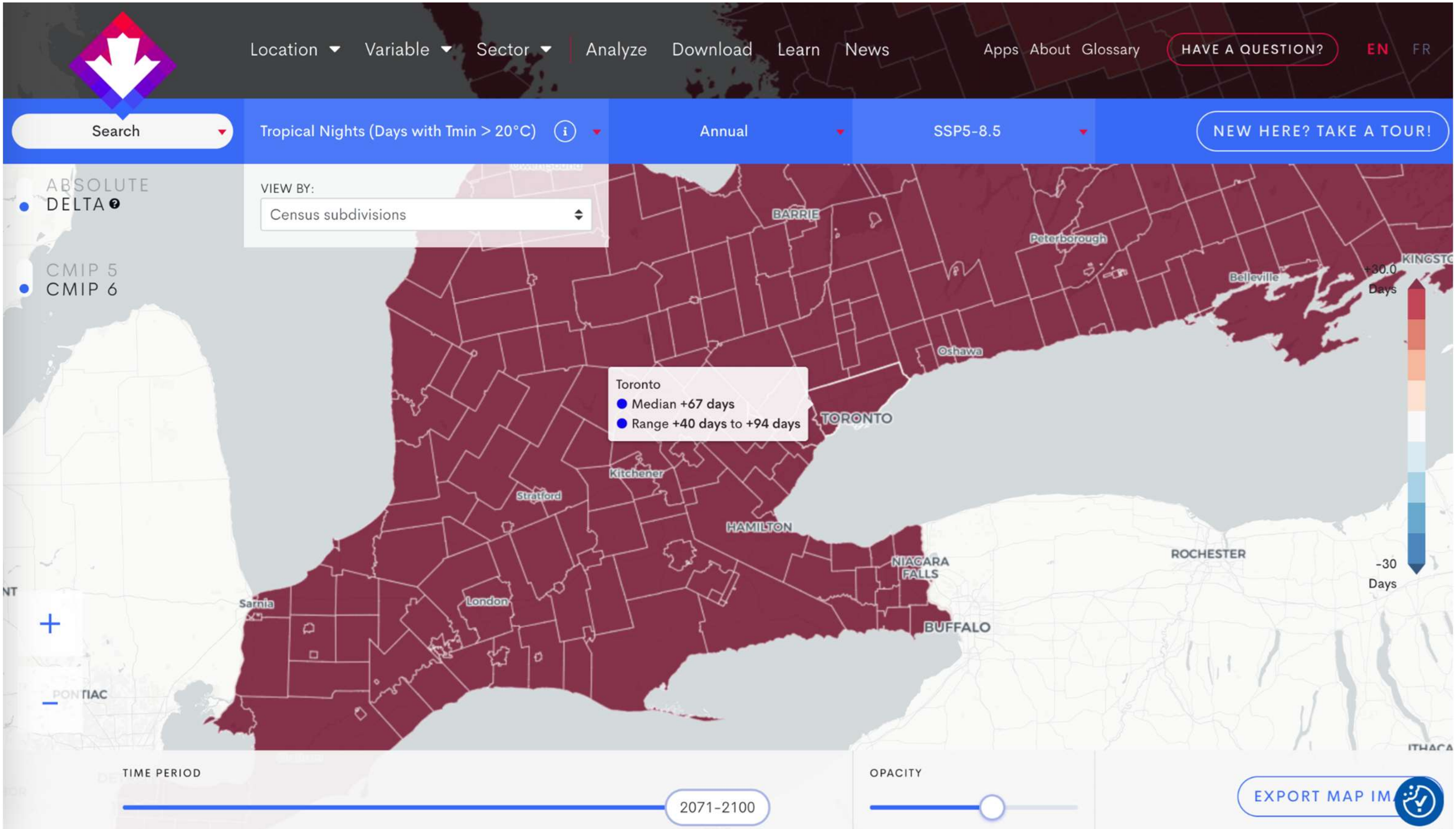

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CMIP 5
CMIP 6
Toronto
Median +67 days
Range +40 days to +94 days
BARRIE
Peterborough
Belleville
Oshawa
TORONTO
Kitchener
Stratford
HAMILTON
NIAGARA FALLS
BUFFALO
ROCHESTER
Sarnia
London
+30.0 Days
-30 Days
TIME PERIOD
2071-2100
OPACITY
EXPORT MAP IM

Future Building Design Value Summaries

The *Future Building Design Value Summaries* are location-based summaries of the building design values developed by Environment and Climate Change Canada as part of the Climate-Resilient Buildings and Core Public Infrastructure (CRBCPI) project.

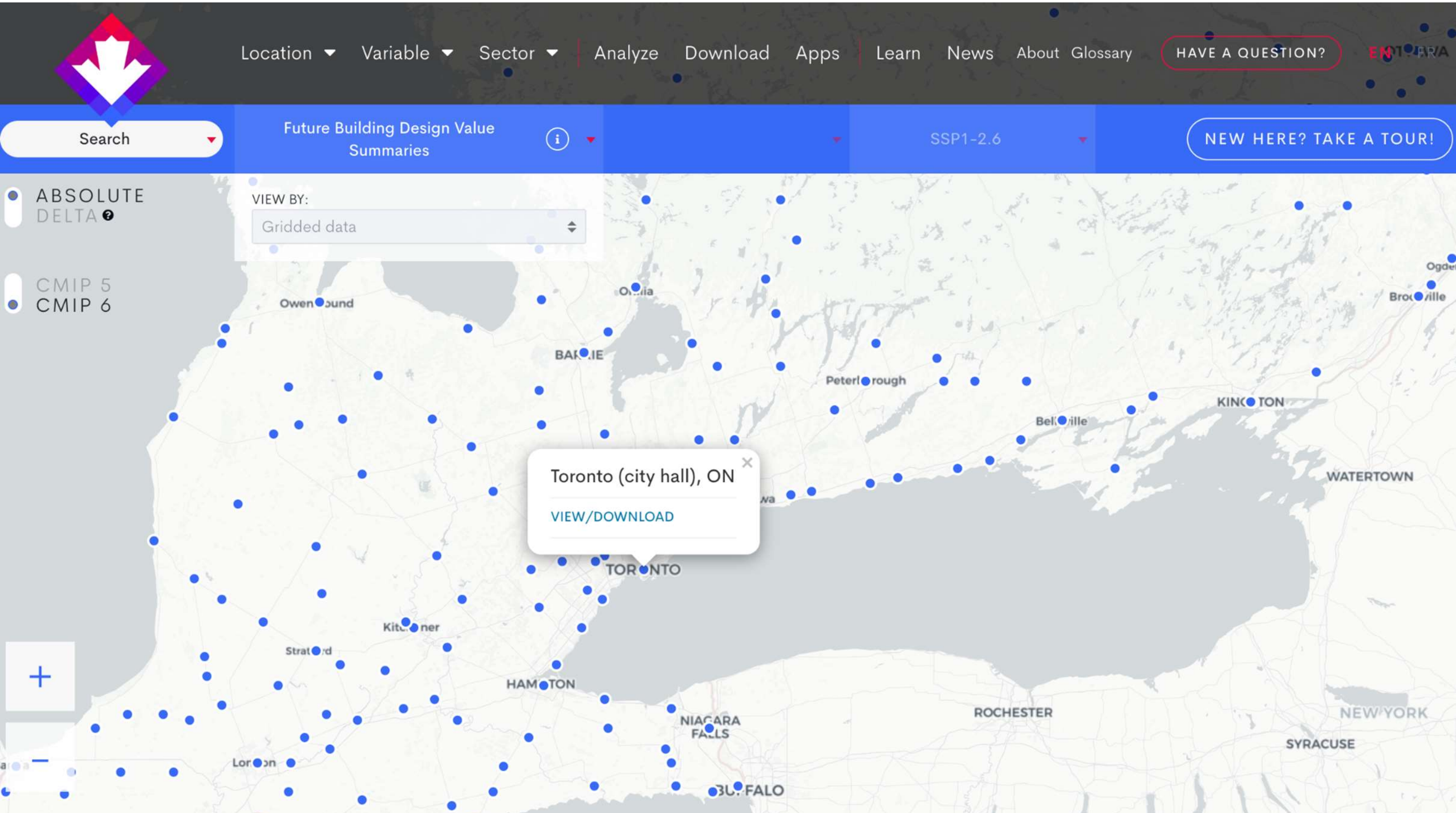
The values are obtained from the Pacific Climate Impacts Consortium (PCIC)'s Design Value Explorer and are summarized into a table alongside relevant supporting guidance and information for every location in the National Building Code of Canada (NBCC, 2015).

VARIABLE

Historical values are from the NBCC 2015, Table C-2* while the future values are derived from regional climate model simulations (CanESM2-CanRCM4) and are presented for two levels of global warming 1.5°C and 3°C above the 1986-2016 baseline period.

These summaries are tailored to users who would consult the NBCC as part of their work, for climate-related design and planning needs.

Read more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Life Cycle Table C-2 Design Values for - Toronto (city hall), ON

Archival Code: C2_2001_Version 1.0

24 / 06 / 14

The National Building Code of Canada states that "many buildings will need to be designed, maintained and operated to adequately withstand ever changing climatic loads". The design values and associated guidance presented here are intended to help designers meet the expectations to design for a changing climate.

The design values provided below are obtained from the Pacific Climate Impacts Consortium's Design Value Explorer (DVE), developed as part of the *Climate Resilient Buildings and Core Public Infrastructure* program.

	Design Temperature				Degree-Days Below 18°C	15 Min. Rain, mm	One Day Rain, 1/50, mm	Ann. Rain, mm	Ann. Tot. Ppn., mm	Driving Rain Wind Pressures, Pa, 1/5	Snow Load, kPa, 1/50		Hourly Wind Pressures, kPa	
	January		July 2.5%								Ss	Sr	1/10	1/50
	2.5%°C	1.0%°C	Dry °C	Wet °C										
NBCC 2015 / Historic	-18	-20	31	23	3,520	25	97	720	820	160	0.9	0.4	0.37	0.47
GWL_{2001}:1.5 / Mid-Century	-12	-14	33	25	2,960	29	113	780	860	170	0.7	0.3	0.38	0.48
GWL_{2001}:3.0 / End-Century	-8	-9	35	26	2,480	33	129	855	920	180	0.5	0.3	0.40	0.52

Note:

- The DVE uses a Global Warming Level (GWL) reference baseline period of 1986 to 2016, with a central year of 2001 (labelled here as GWL_{2001}). Note that this is not directly comparable with pre-industrial baselines such as 1850 to 1900 often used in Intergovernmental Panel on Climate Change (IPCC) Assessment Reports. Further, due to the specificity of this tool, designers should exercise caution in mixing this information with outputs from other sources of future projected climate data.
- The provided GWLs have estimated time horizons for exceedance. Most estimates of greenhouse gas emissions trajectories over the remainder of the century are consistent with exceedance of GWL_{2001}:1.5°C around mid-centruy, and GWL_{2001}:3.0°C towards the end of the century.

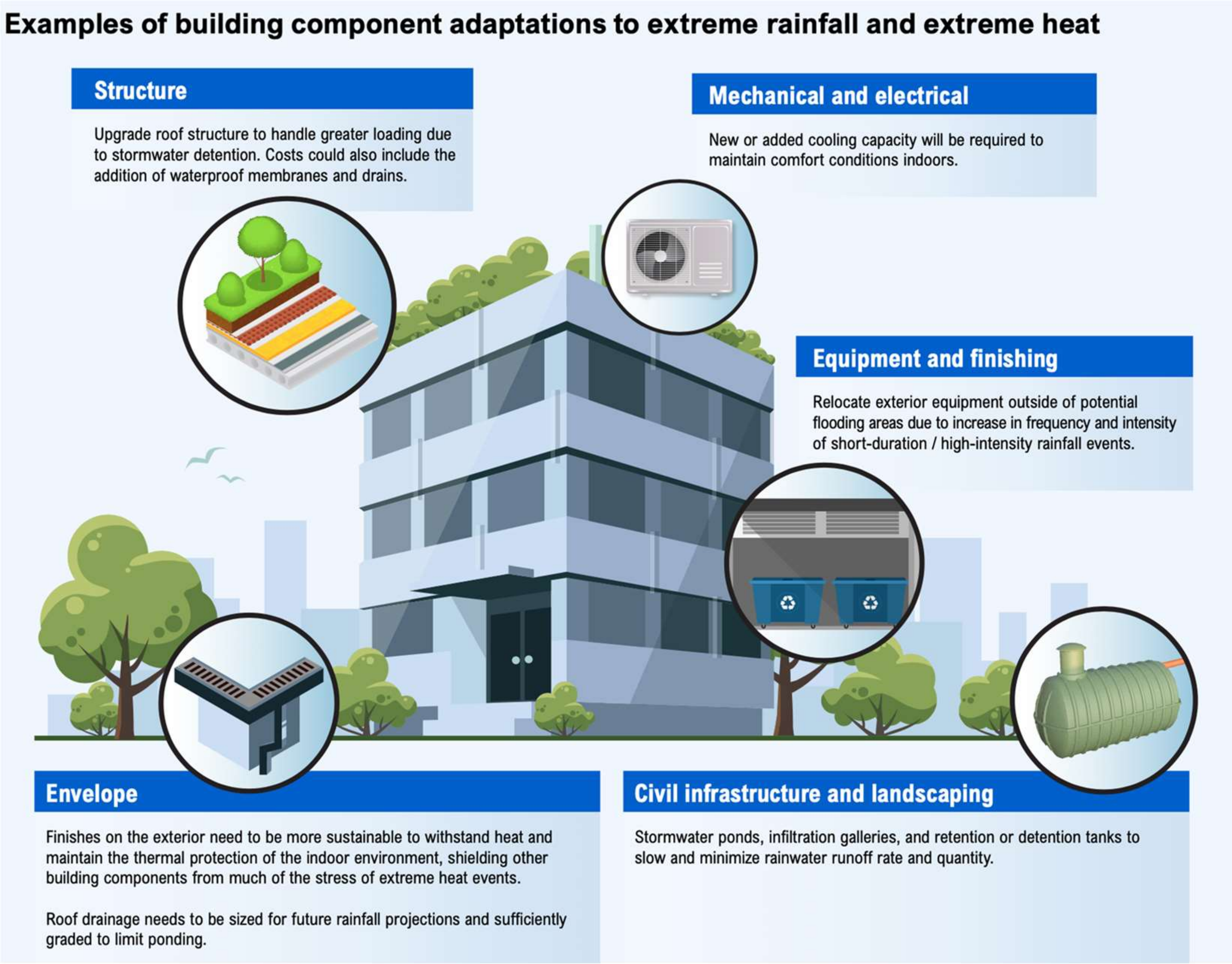
The guidance below is intended to assist with using future climate information for design and is intended to supplement the minimum requirements of the National Building Code of Canada and all other relevant codes in effect for the jurisdiction:

- Designers may consider using the most stringent value in their design of either the NBCC 2015 or the adjusted climate values at the end of the building or the building system's Design Service Life (DSL).
- The climatic design data provided here represent critical mid- and late-century thresholds:
  - GWL_{2001}:1.5°C is provided for the design of short to medium-term DSL components (e.g. 10 to 30 years, such as HVAC plants, fenestration).
  - GWL_{2001}:3.0°C is provided for the design of medium to long-term DSL components (e.g. 50+ years, such as primary structures or some HVAC systems).
- Additional GWLs may be considered to explore a range of building life-spans, emissions scenarios, and risk tolerances. They may be found in the CRBCPI report and accessed at the Design Value Explorer (DVE)[1]. More information about the relationship between GWLs and emissions scenarios is available in ClimateData.ca's Learning Zone.
- It is important that the variables selected for design and the associated GWL be prominently displayed on all relevant drawings and documents of record.
- Any questions about using and interpreting the data in this table can be directed to the Canadian Centre for Climate Services Support Desk or PCIC.

1. Note that the DVE contains two versions of historical data: one from the NBC (adopted for these tables) and one updated with more recent observations (up to 2018 for most variables).

How do we adapt?

How to adapt?

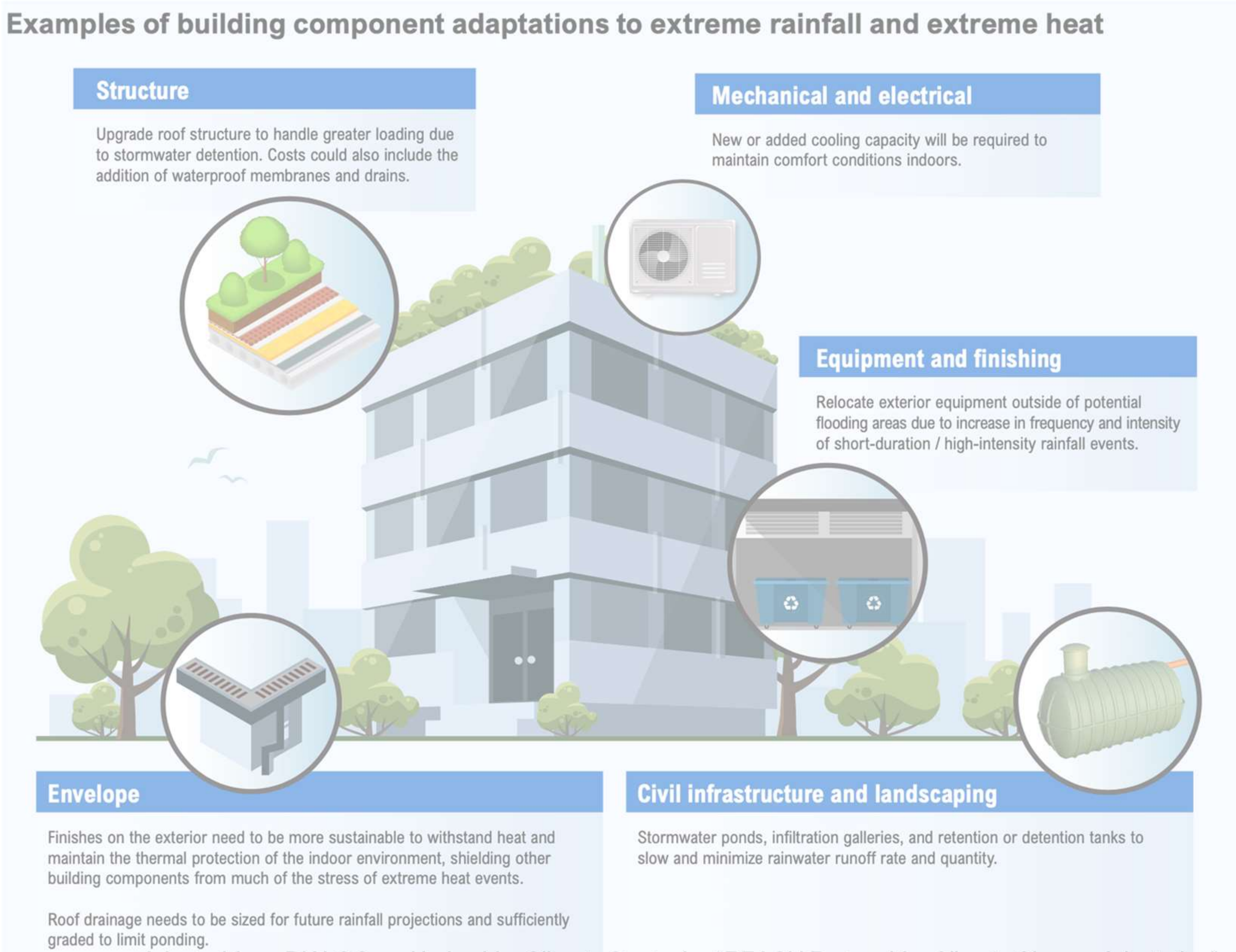

Examples of building component adaptations to extreme rainfall and extreme heat
Structure
Upgrade roof structure to handle greater loading due to stormwater detention. Costs could also include the addition of waterproof membranes and drains.
Mechanical and electrical
New or added cooling capacity will be required to maintain comfort conditions indoors.
Equipment and finishing
Relocate exterior equipment outside of potential flooding areas due to increase in frequency and intensity of short-duration / high-intensity rainfall events.
Envelope
Finishes on the exterior need to be more sustainable to withstand heat and maintain the thermal protection of the indoor environment, shielding other building components from much of the stress of extreme heat events.
Roof drainage needs to be sized for future rainfall projections and sufficiently graded to limit ponding.
Civil infrastructure and landscaping
Stormwater ponds, infiltration galleries, and retention or detention tanks to slow and minimize rainwater runoff rate and quantity.

Reactive Adaptation

Reactive adaptation responds to climate impacts **after they occur**.

This approach often leads to incurring **higher costs for recovery** and rebuilding post-disaster, as opposed to investing in upfront adaptation strategies.

While reactive adaptation may seem cost-effective initially, its long-term implications included: increased financial burden and reduced adaptive capacity.



Adapted from DIALOG and Lukachko Climate Strategies "REACH Protocol for Climate Change Adaptation"

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Proactive Adaptation

Proactive adaptation involves implementing measures **in anticipation** of future climate impacts to prevent or reduce their effects.

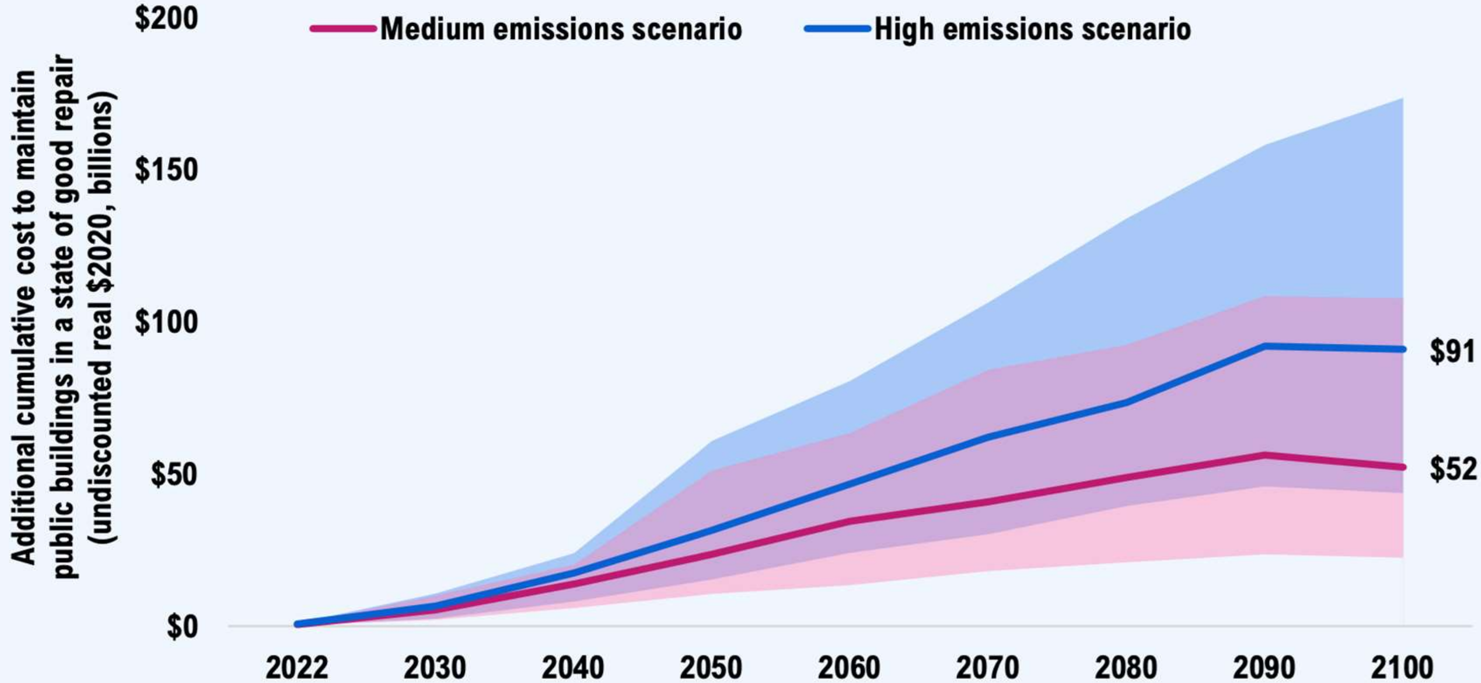
While proactive adaptation may involve upfront costs and the risk of perceived waste if events do not occur as expected, its potential for **long-term cost savings**, **resilience** building, and **risk reduction** underscores its importance in enhancing community preparedness and sustainability in the face of climate change impacts.

Adapted from DIALOG and Lukachko Climate Strategies “REACH Protocol for Climate Change Adaptation”

“Climate change will have a significant impact on the cost of maintaining public buildings in the absence of adaptation”

Financial Accountability Office of Ontario. “CIPI: Buildings – Assessing the financial impacts of extreme rainfall, extreme heat and freeze-thaw cycles on public buildings in Ontario” 2021

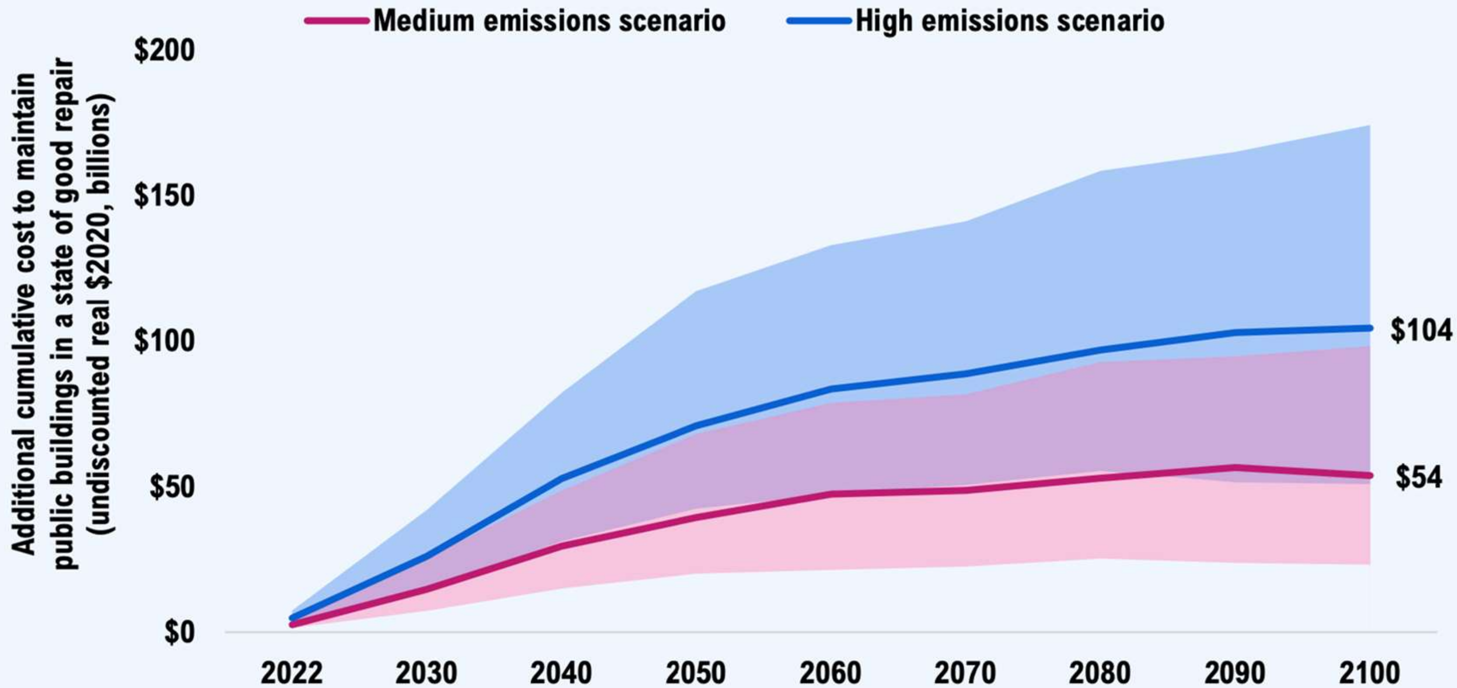
The *reactive adaptation* strategy will see gradual rise in costs throughout the 21st century



Notes: The solid line is the median (or 50th percentile) projection. The coloured bands represent the range of possible outcomes in each emissions scenario. The costs presented in this chart are in addition to the projected baseline costs over the same period.
Source: FAO.

[source FAO of Ontario. “CIPI: Buildings – Assessing the financial impacts of extreme rainfall, extreme heat and freeze-thaw cycles on public buildings in Ontario” 2021]

Proactively adapting all public buildings would require significant near-term investment



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Source: FAO.

[source FAO of Ontario. "CIPI: Buildings – Assessing the financial impacts of extreme rainfall, extreme heat and freeze-thaw cycles on public buildings in Ontario" 2021]

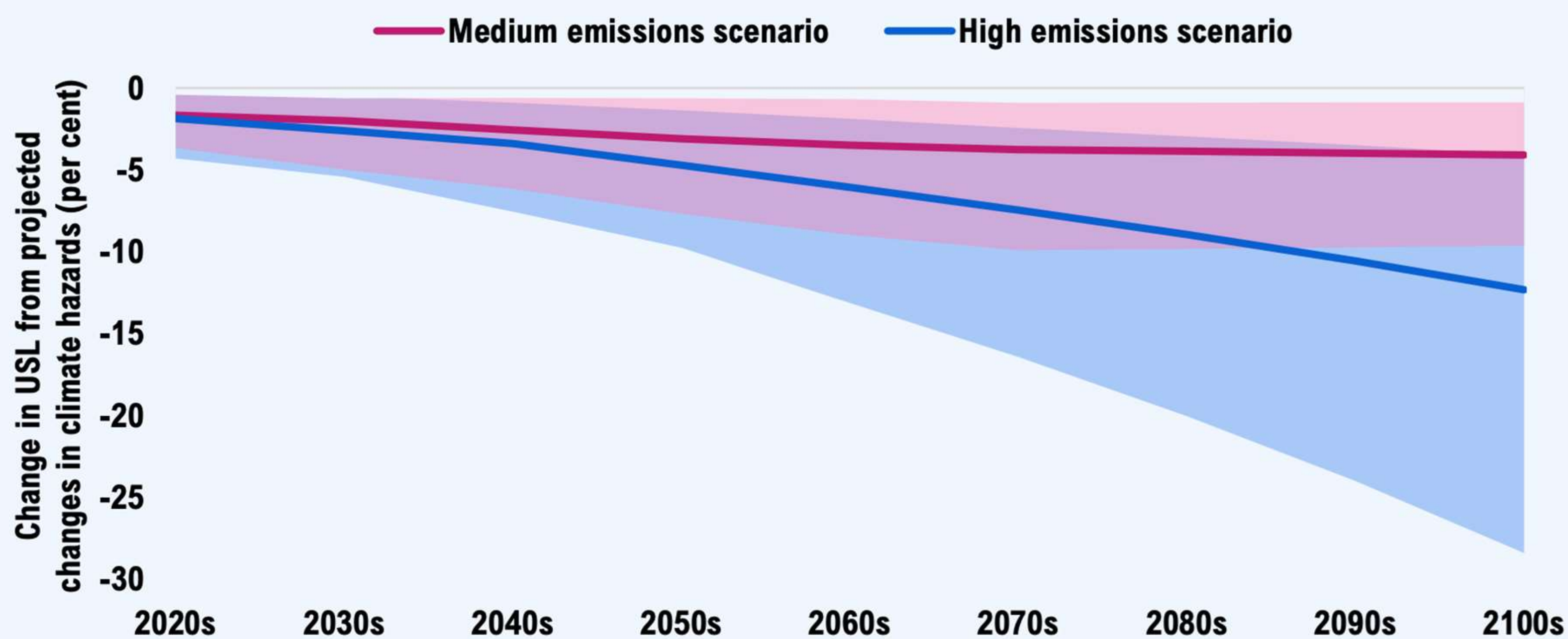
What can you expect? 5 takeaways

1. The climate is going to be very hard on roofs.

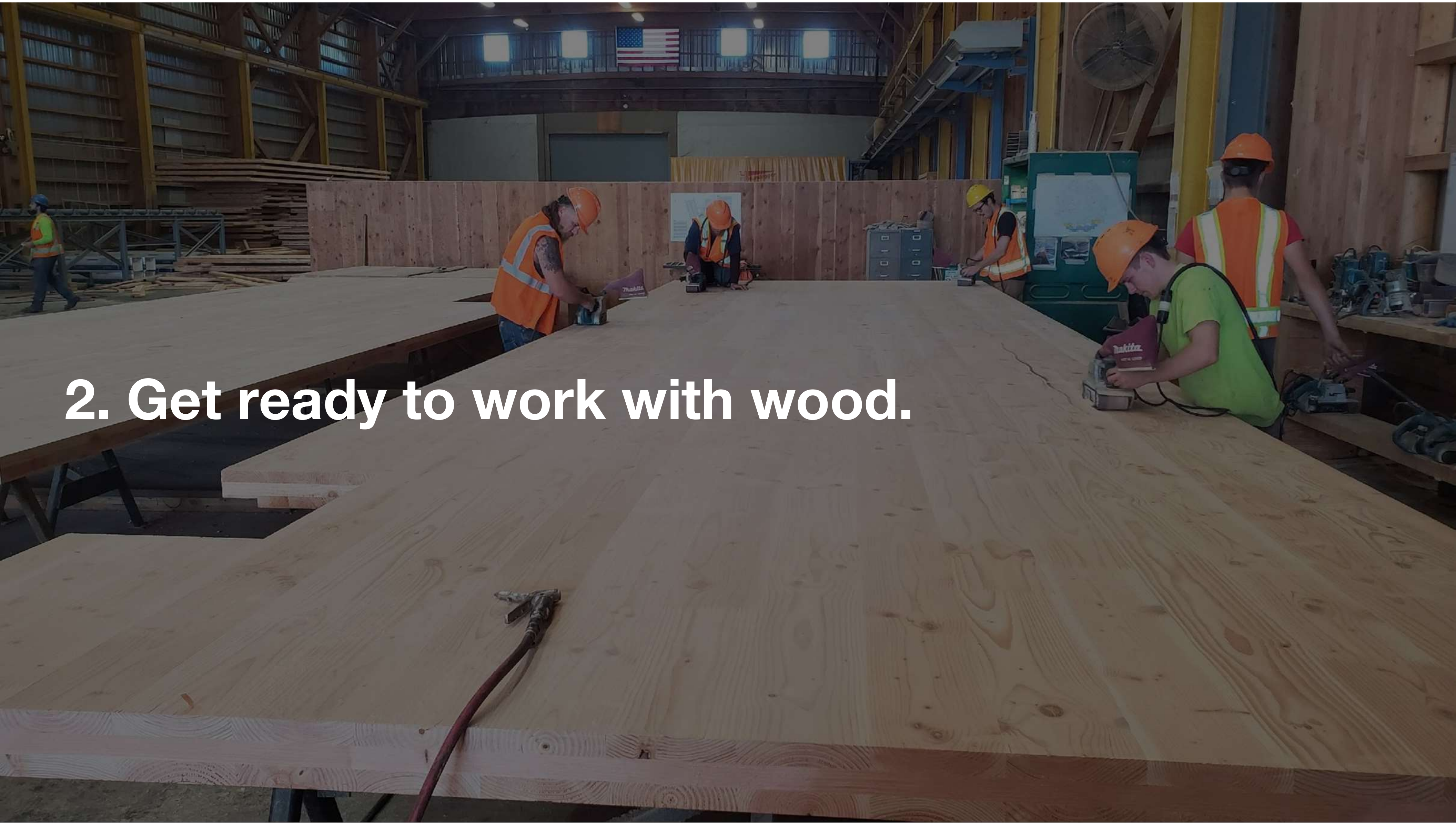
1. The climate is going to be very hard on roofs.

- roof assemblies already carry a big load
- more rain, more wind, more heat, less snow, more freeze-thaw
- better thermal control - in particular thermal bridging details
- roof assemblies are not expected to last as long

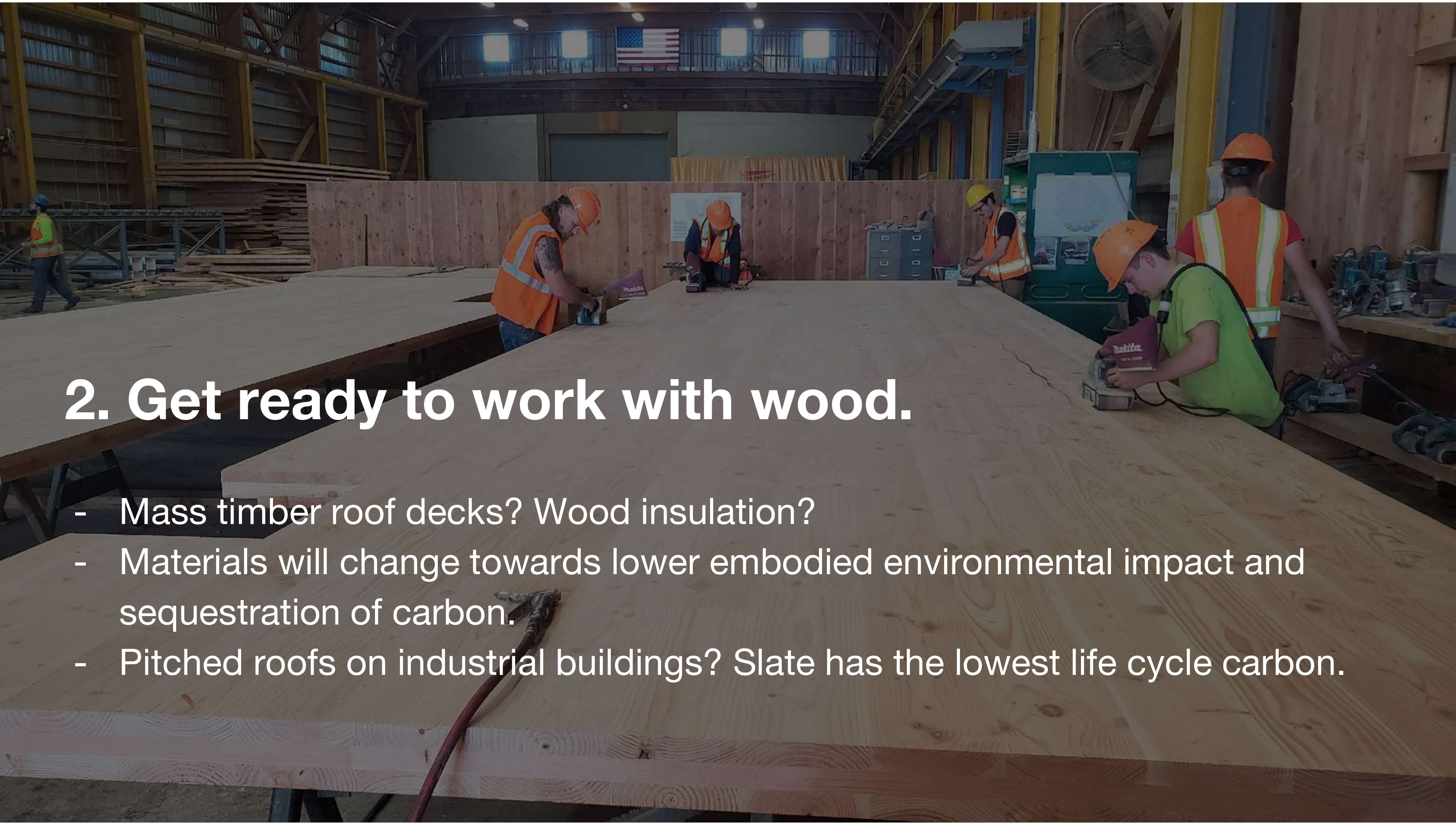
The useful service life of public buildings will decline due to projected changes in extreme heat, extreme rainfall and freeze-thaw cycles in the absence of adaptation actions



Note: The solid line is the median (or 50th percentile) climate projection using "most likely" engineering outcomes. The coloured bands represent the range of possible outcomes in each emissions scenario given climate and engineering uncertainty.
Source: WSP and FAO.



2. Get ready to work with wood.

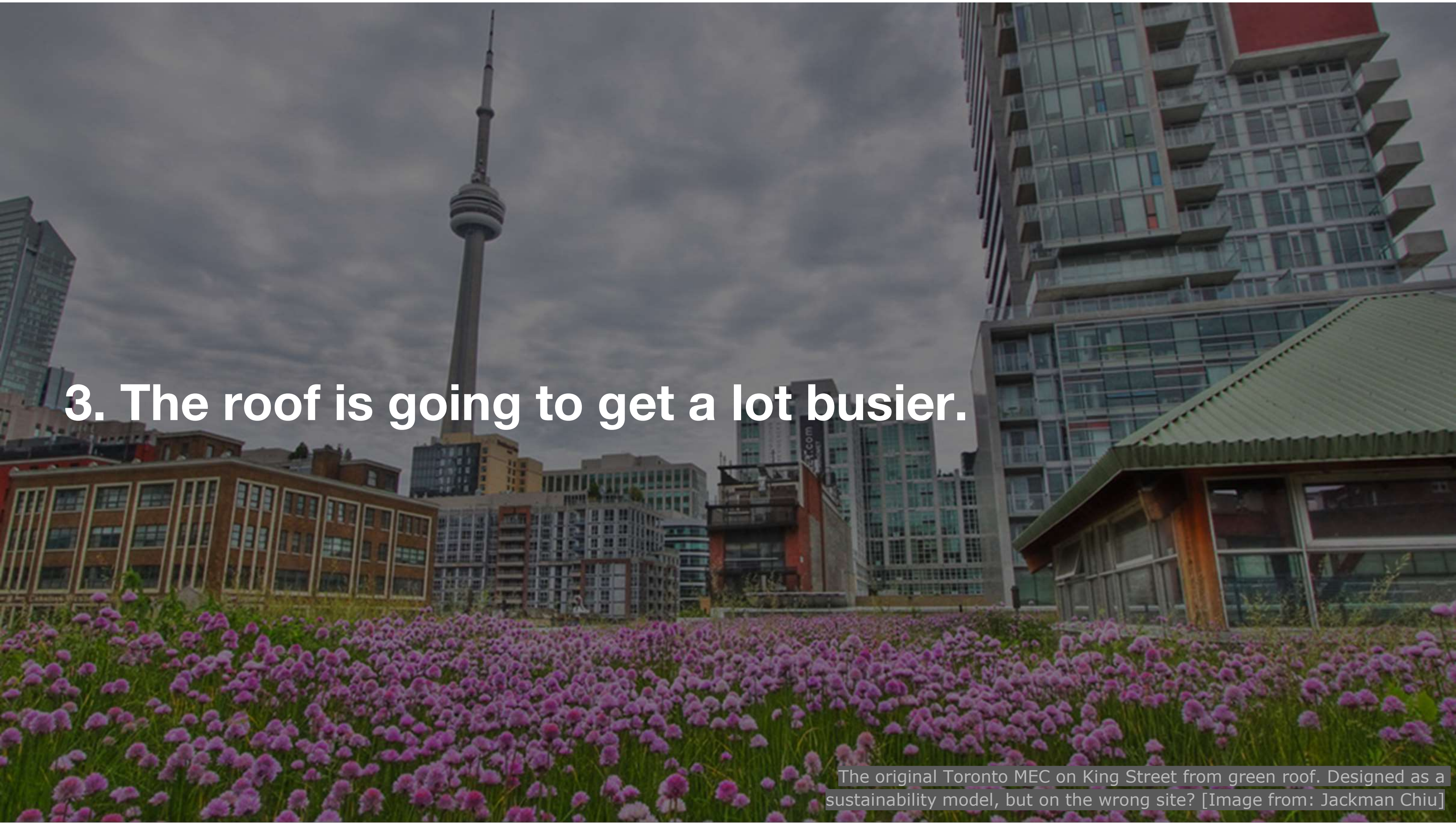


2. Get ready to work with wood.

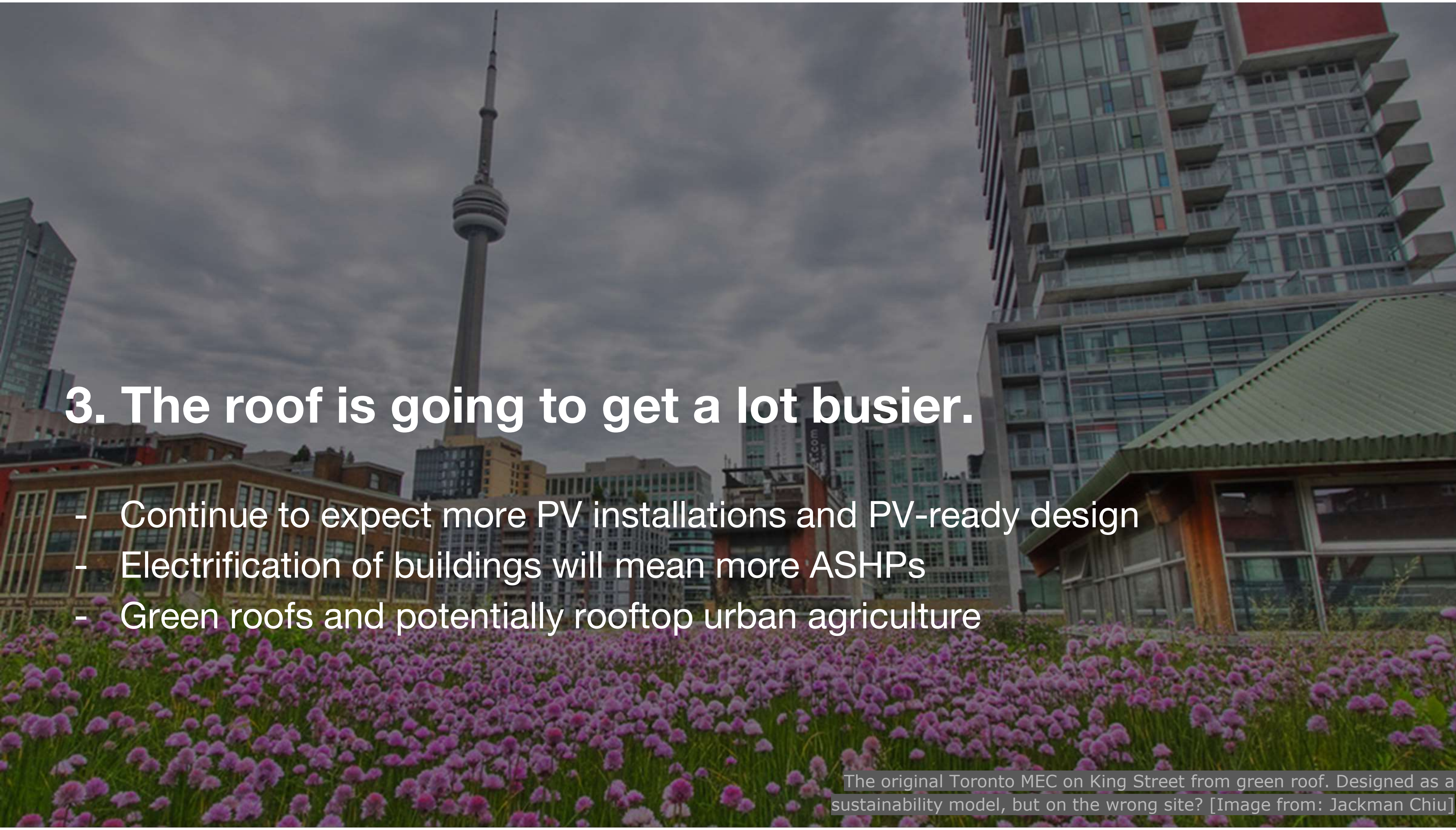
- Mass timber roof decks? Wood insulation?
- Materials will change towards lower embodied environmental impact and sequestration of carbon.
- Pitched roofs on industrial buildings? Slate has the lowest life cycle carbon.

https://www.architectural-review.com/buildings/sundby-school-in-nykobing-falster-denmark-by-henning-larsen

3. The roof is going to get a lot busier.



The original Toronto MEC on King Street from green roof. Designed as a sustainability model, but on the wrong site? [Image from: Jackman Chiu]

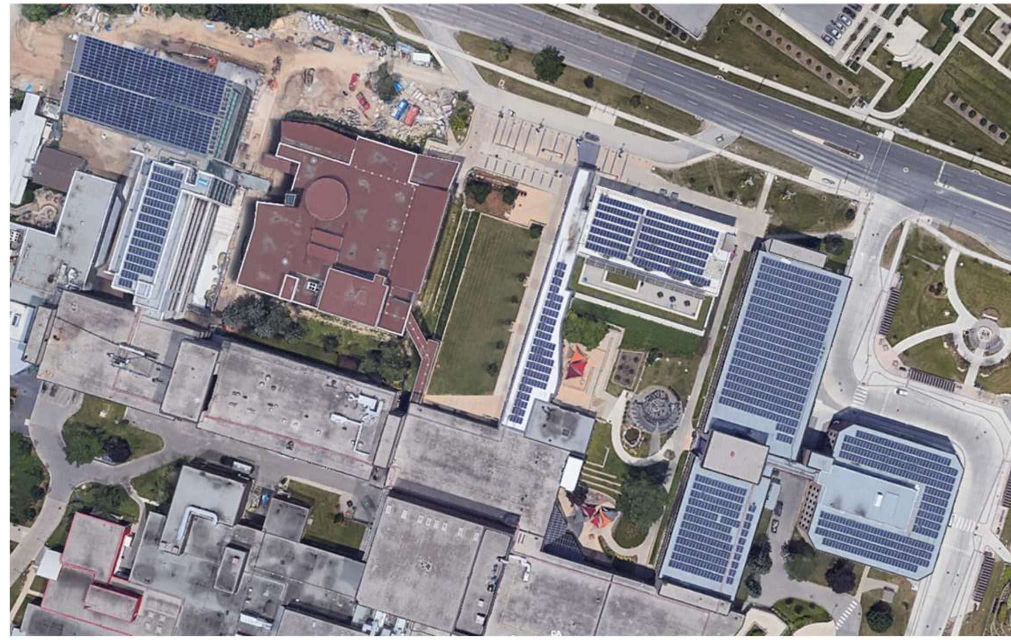


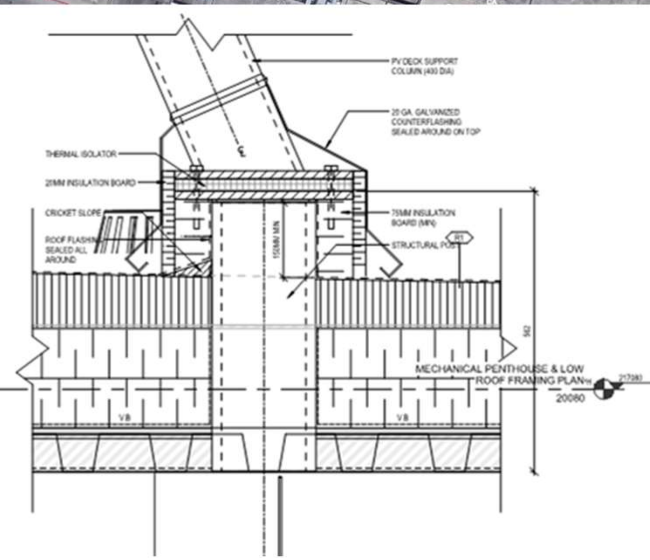
3. The roof is going to get a lot busier.

- Continue to expect more PV installations and PV-ready design
- Electrification of buildings will mean more ASHPs
- Green roofs and potentially rooftop urban agriculture

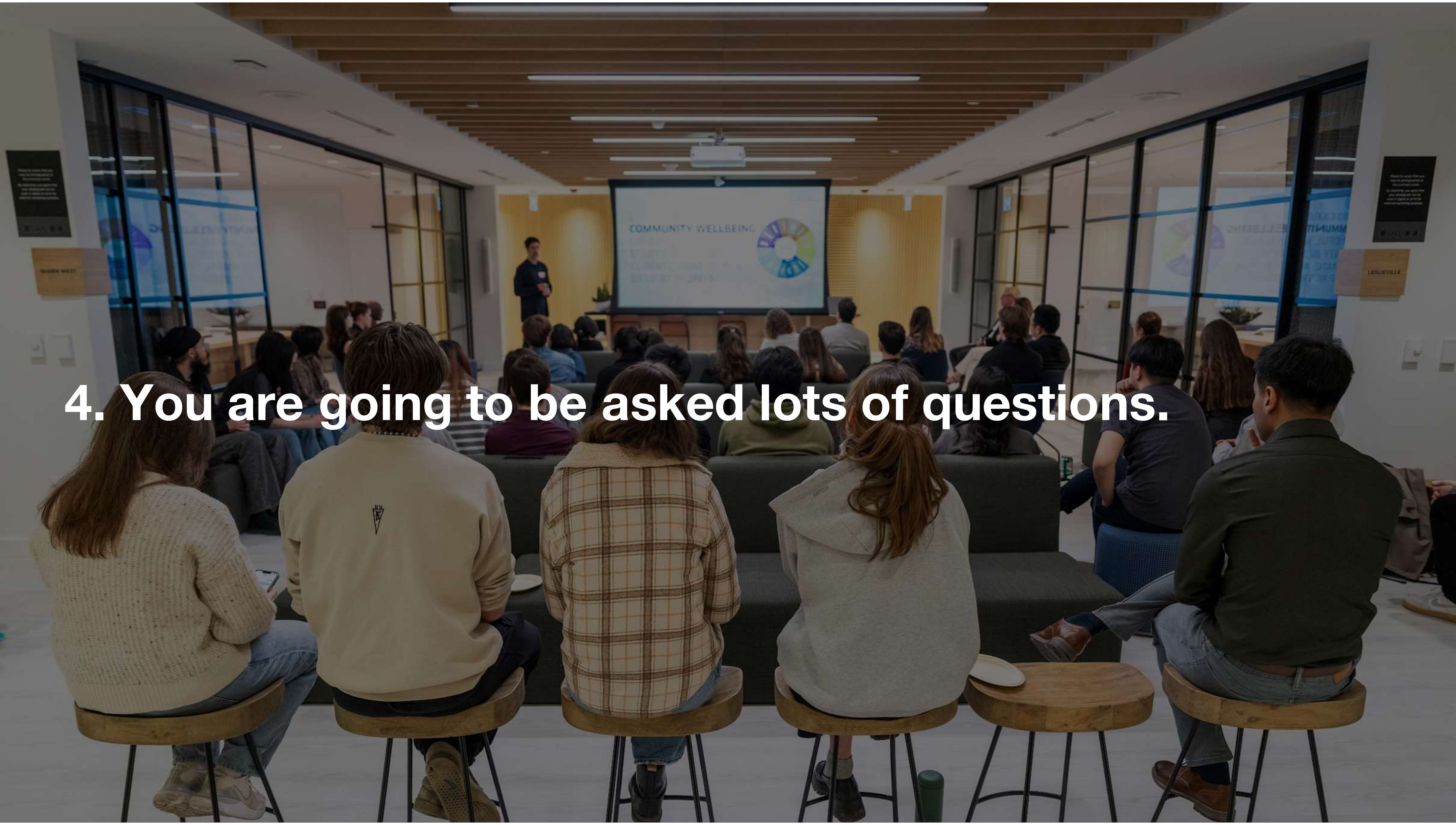
The original Toronto MEC on King Street from green roof. Designed as a sustainability model, but on the wrong site? [Image from: Jackman Chiu]

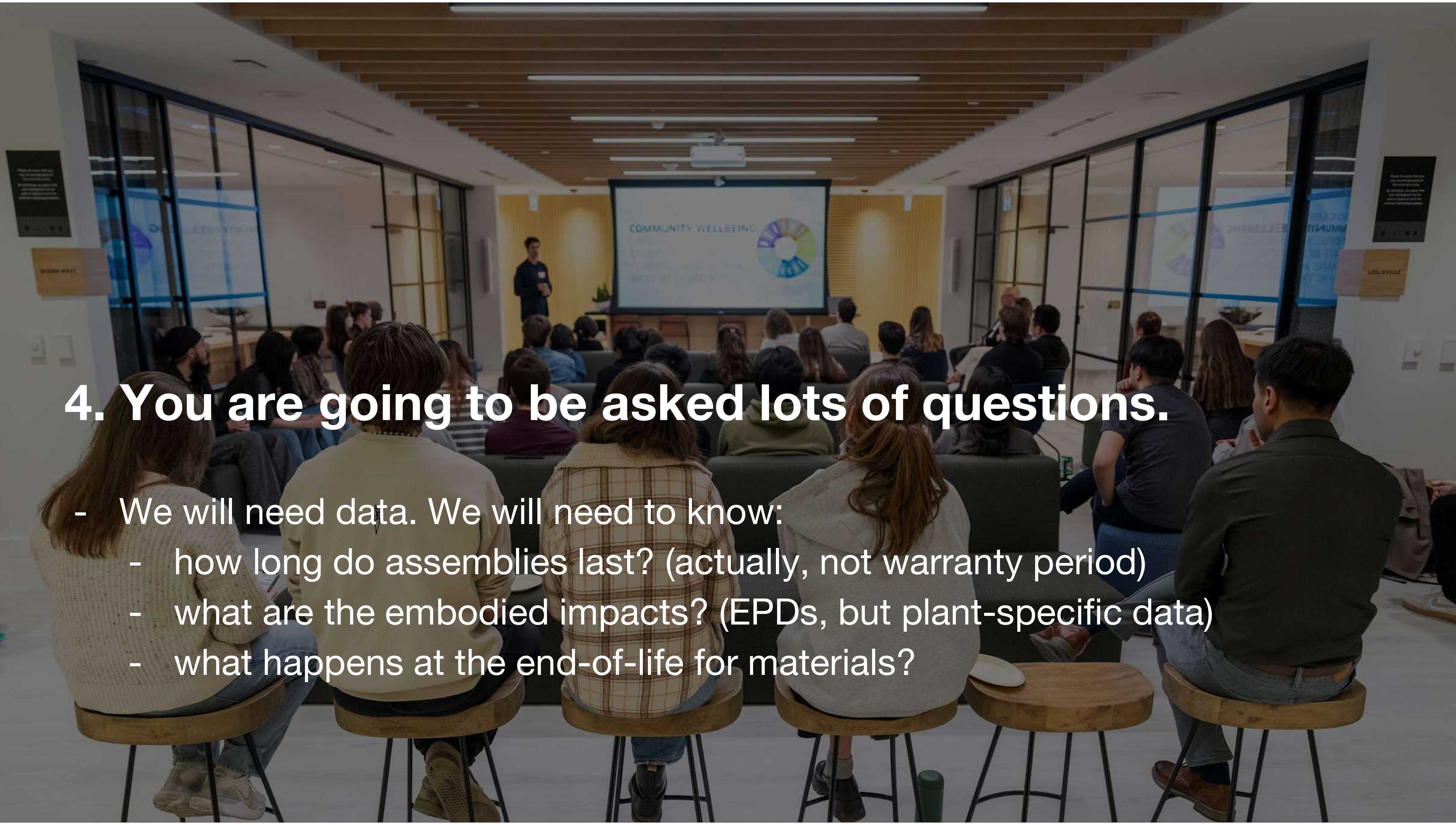
[Image from: Kevin Stelzer]





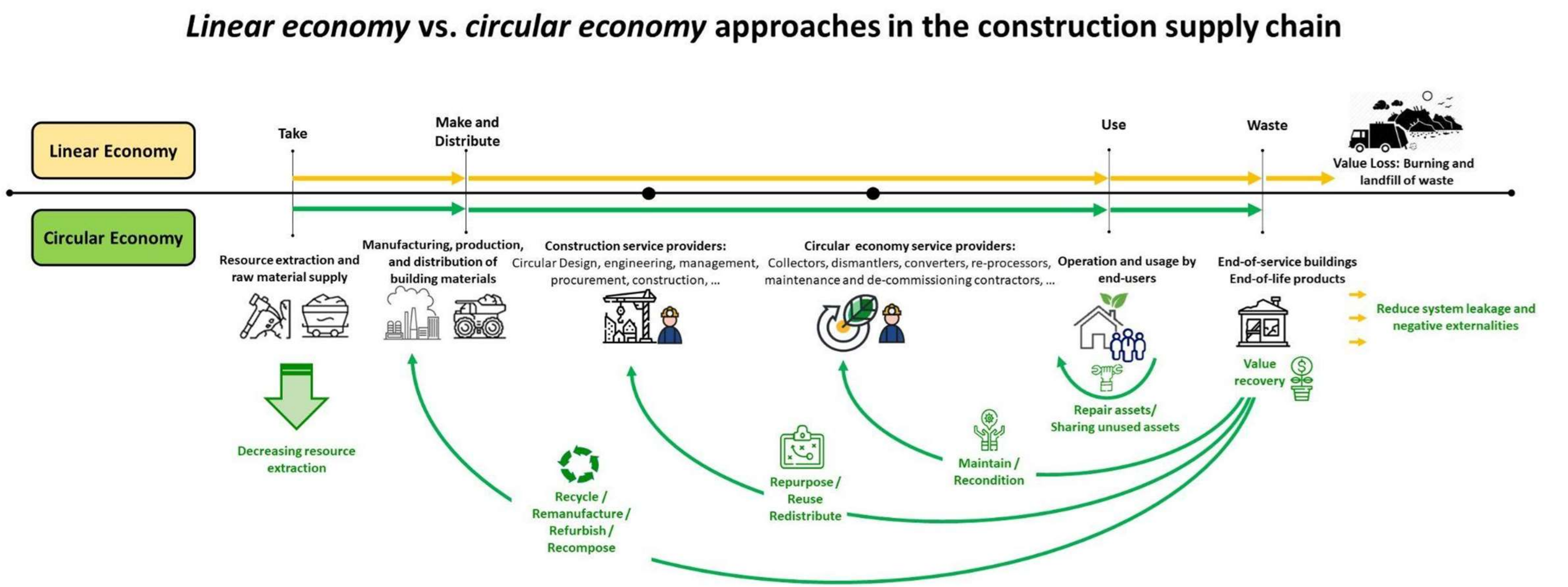
4. You are going to be asked lots of questions.





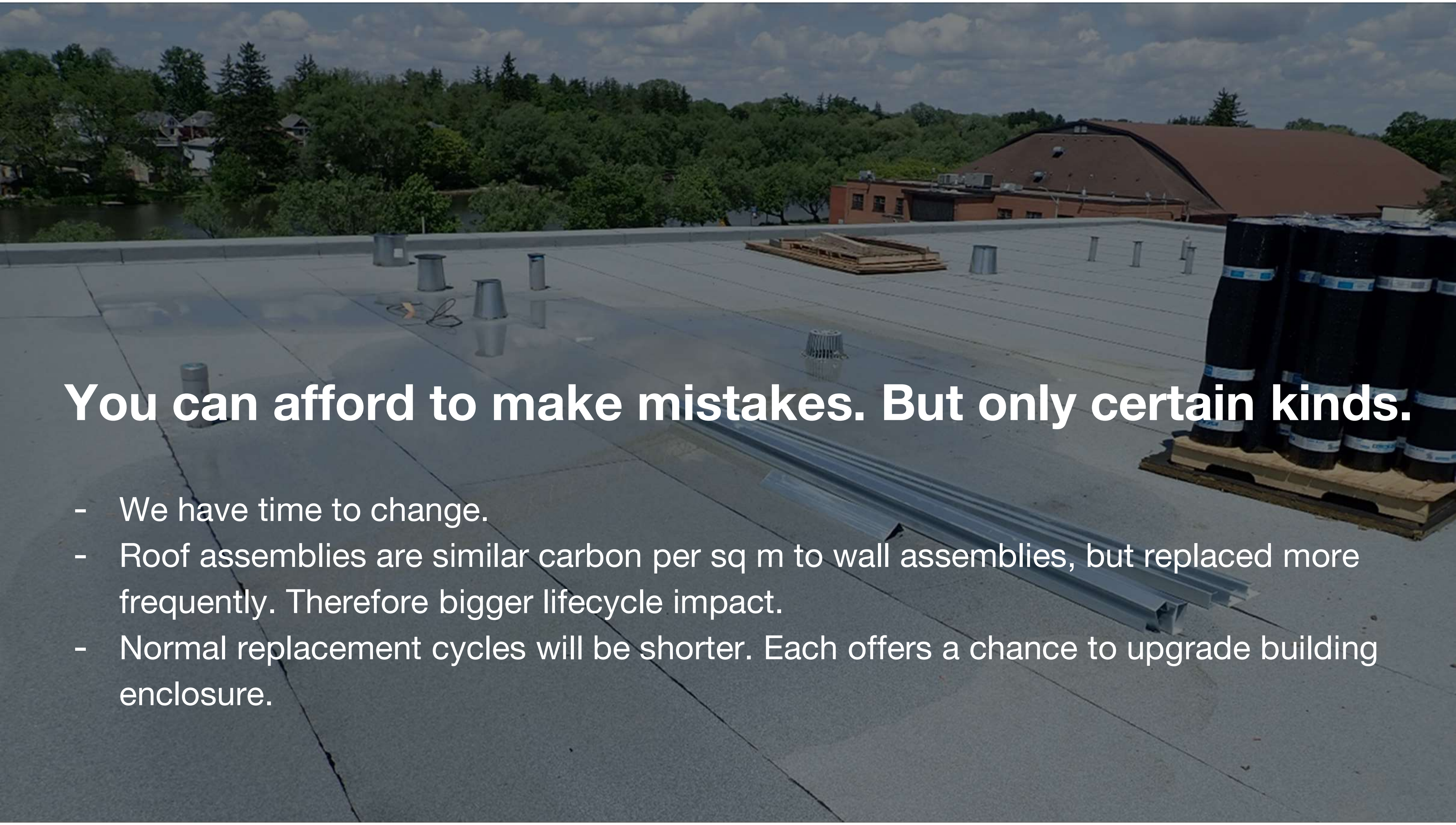
4. You are going to be asked lots of questions.

- We will need data. We will need to know:
  - how long do assemblies last? (actually, not warranty period)
  - what are the embodied impacts? (EPDs, but plant-specific data)
  - what happens at the end-of-life for materials?



Linear economy vs. *circular economy* approaches in the construction supply chain
Linear Economy
Circular Economy
Take
Make and Distribute
Use
Waste
Value Loss: Burning and landfill of waste
Resource extraction and raw material supply
Manufacturing, production, and distribution of building materials
Construction service providers: Circular Design, engineering, management, procurement, construction, ...
Circular economy service providers: Collectors, dismantlers, converters, re-processors, maintenance and de-commissioning contractors, ...
Operation and usage by end-users
End-of-service buildings End-of-life products
Reduce system leakage and negative externalities
Decreasing resource extraction
Value recovery
Repair assets/ Sharing unused assets
Maintain / Recondition
Repurpose / Reuse Redistribute
Recycle / Remanufacture / Refurbish / Recompose


You can afford to make mistakes. But only certain kinds.



You can afford to make mistakes. But only certain kinds.

- We have time to change.
- Roof assemblies are similar carbon per sq m to wall assemblies, but replaced more frequently. Therefore bigger lifecycle impact.
- Normal replacement cycles will be shorter. Each offers a chance to upgrade building enclosure.

Summary

Roofing is important now, and it’s going to be much more important in the future.

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- You can directly contribution to reducing operational and embodied emissions
- We must help with adaptation to future climate

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Five takeaways?

1. The climate is going to be very hard on roofs.
2. Get ready to work with wood.
3. The roof is going to get a lot busier.
4. You are going to be asked lots of questions.
5. You can afford to make mistakes. But only certain kinds.

Want to keep talking?

Contact me at alex.lukachko@daniels.utoronto.ca