Impacts of Climate Change on Building Envelope Energy Efficiency

SPEAKERS

ENTUITIVE

Paul Carter Senior BE Specialist
Chris Van Dongen Senior BE Specialist

RWDI

Jeff Lundgren Technical Director | Principal

OUTLINE

- Introduction to Climate Futures
- Energy Modelling Exercise
- Unmet Cooling Hours
- Discussion/Next Steps

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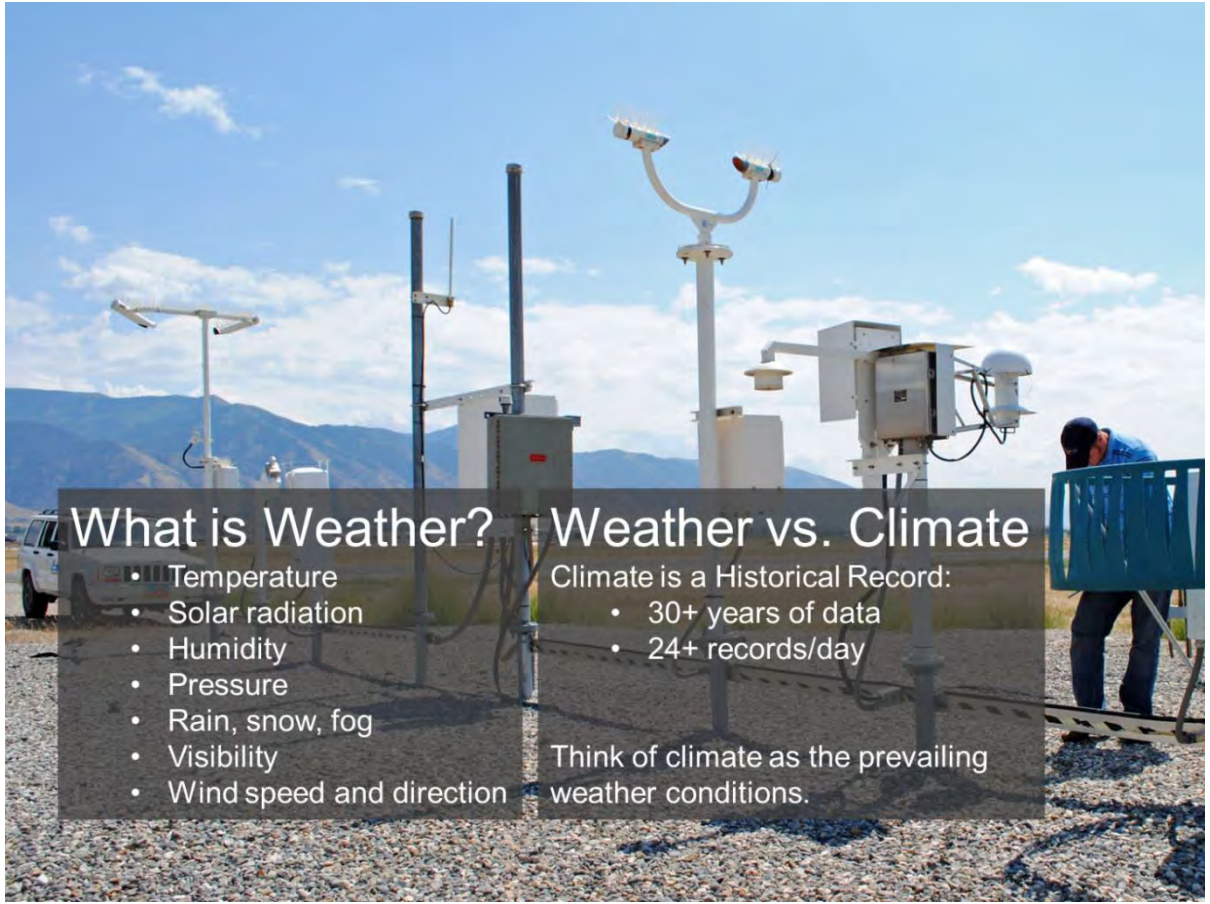
- **Introduction to Climate Futures**
- Energy Modelling Exercise
- Unmet Cooling Hours
- Discussion/Next Steps

Intro to Meteorology, Weather and Climate



What is Weather?

- Temperature
- Solar radiation
- Humidity
- Pressure
- Rain, snow, fog
- Visibility
- Wind speed and direction

Weather vs. Climate

Climate is a Historical Record:

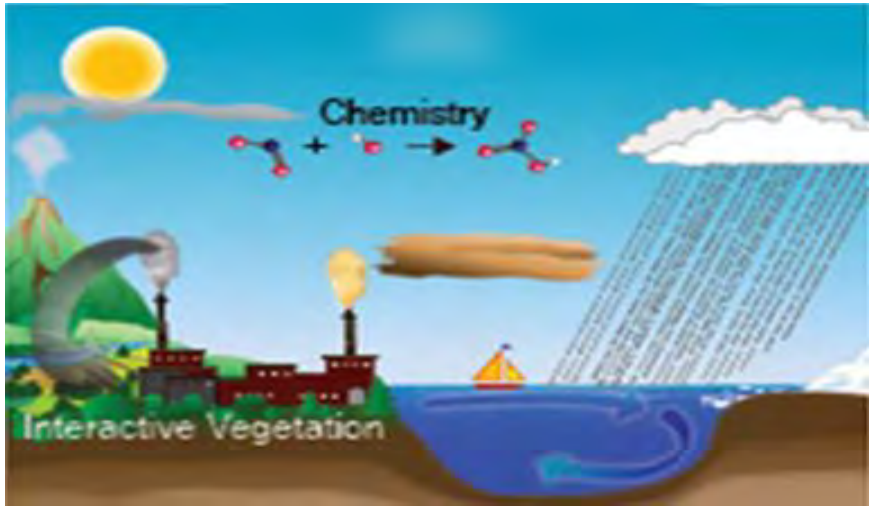
- 30+ years of data
- 24+ records/day

Think of climate as the prevailing weather conditions.

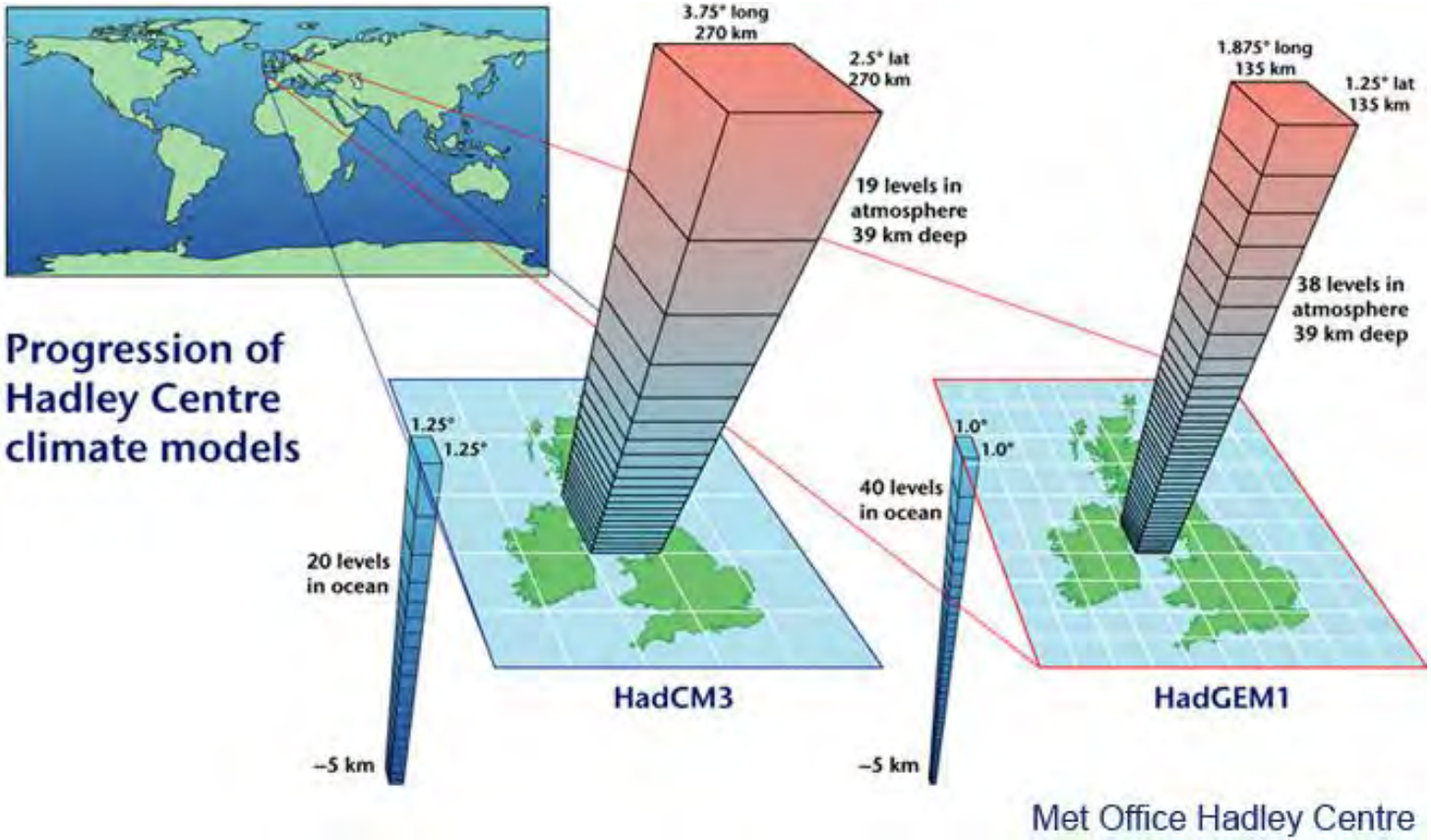
Intro to Climate Models

MID-1970'S

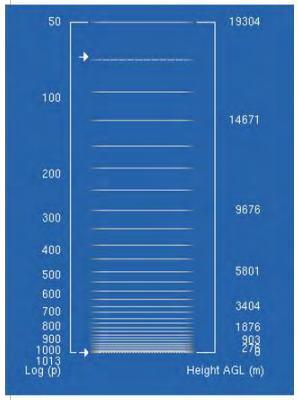
TODAY



Structure of Global Climate Models

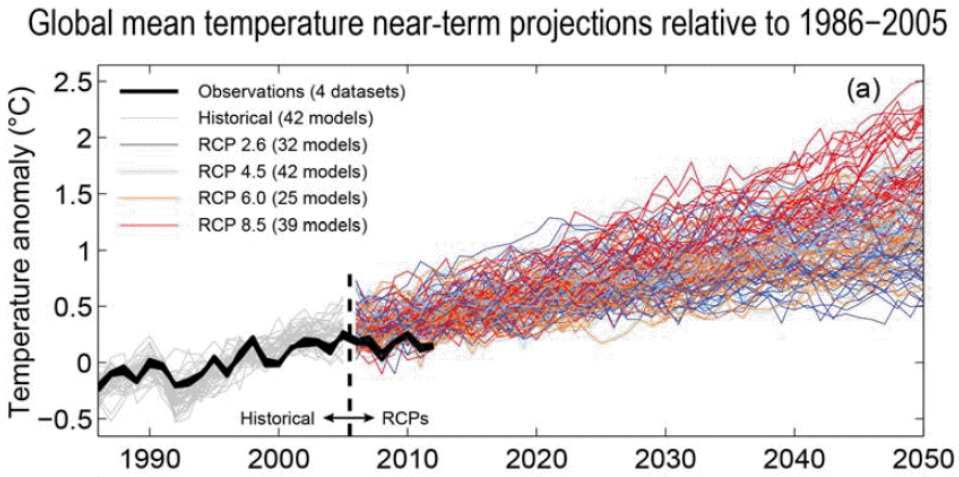


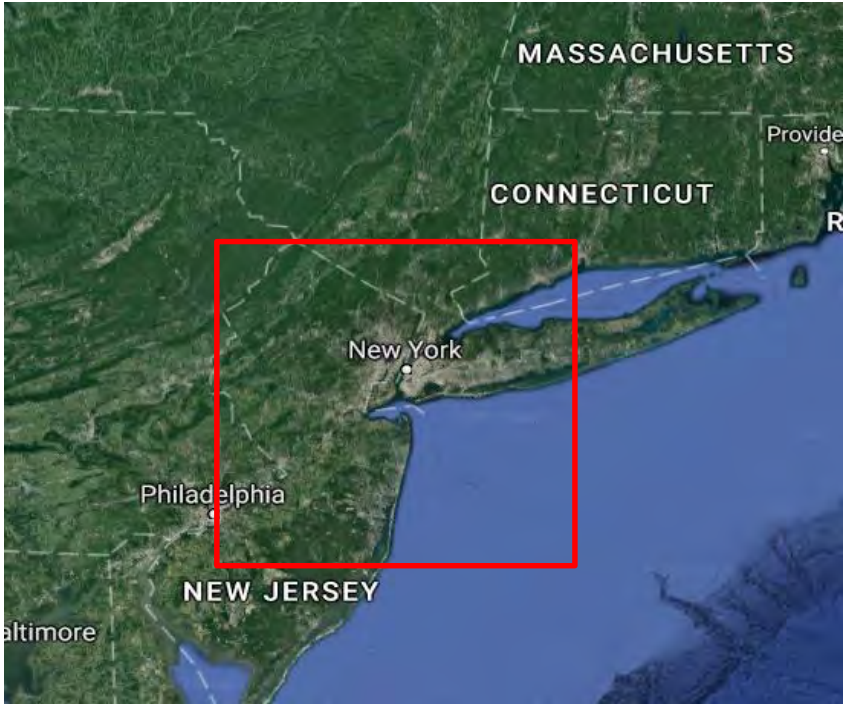
Regional Climate Downscaling



Vertical Cell Profile

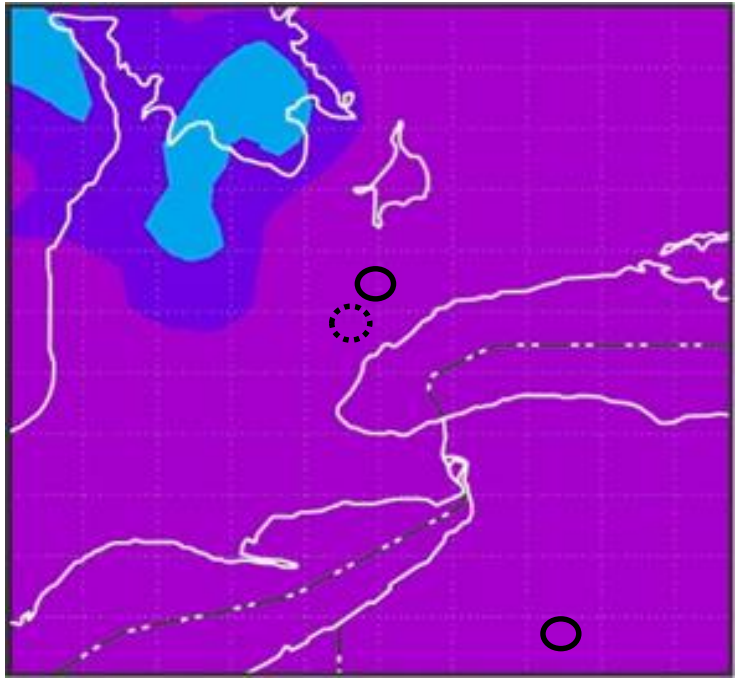
Parameters to ‘Be Careful With’…



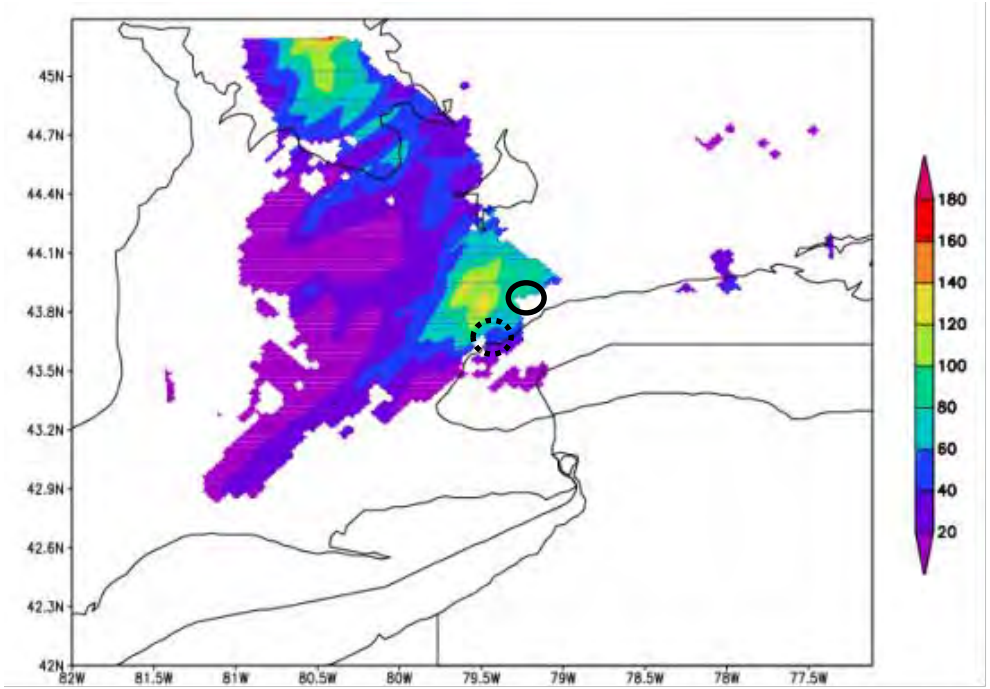


Precipitation Example

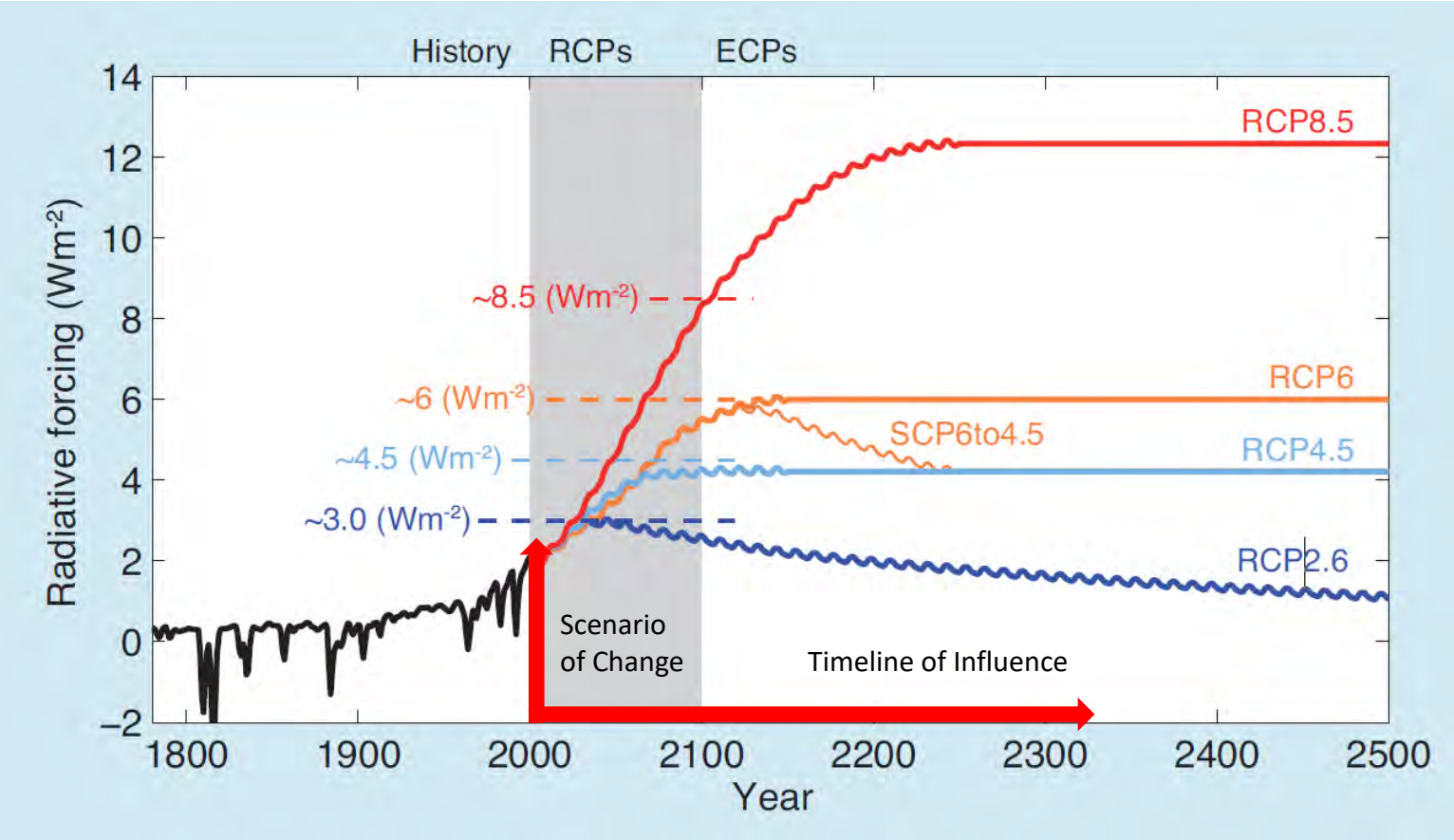
12x12 km grid simulation



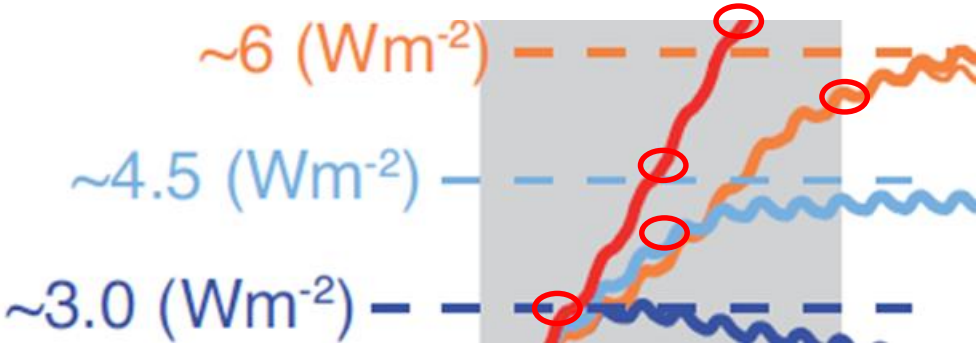
1x1 km grid simulation

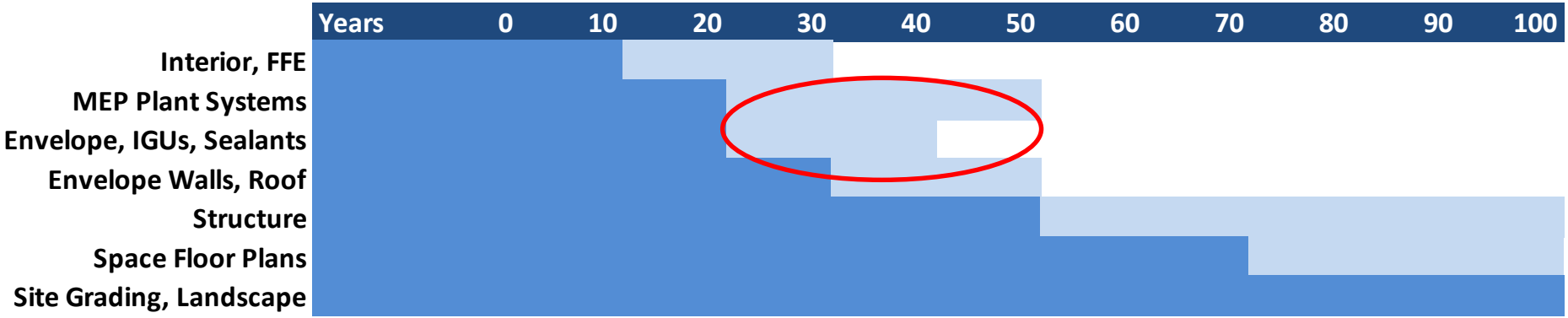


Climate Models Models – Time and RCP

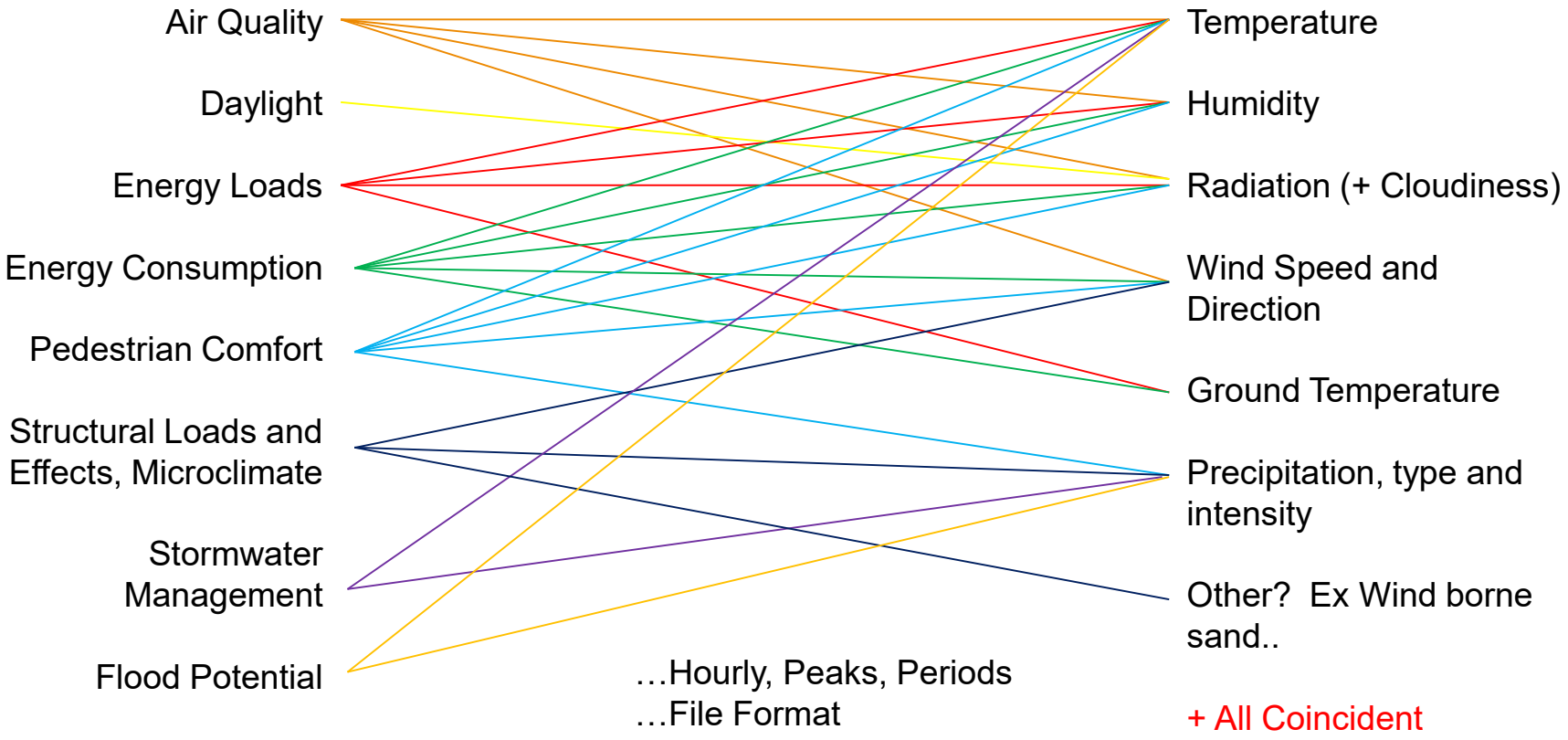


Typical Design Life Timelines





What Information is Needed



What Information is Needed

Air Quality

Daylight

Energy Loads

Energy Consumption

Pedestrian Comfort

Structural Loads and Effects, Microclimate

Stormwater Management

Flood Potential

Temperature

Humidity

Radiation (+ Cloudiness)

Wind Speed and Direction

Ground Temperature

Precipitation, type and intensity

Other? Ex Wind borne sand..

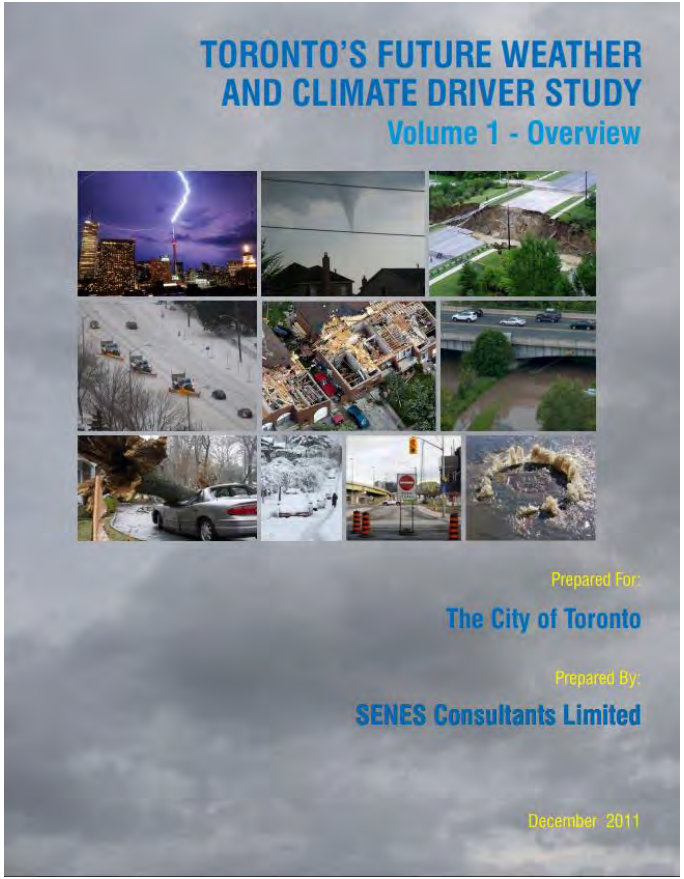
+ All Coincident

…Hourly, Peaks, Periods
…File Format

Approaches for Developing Weather Files

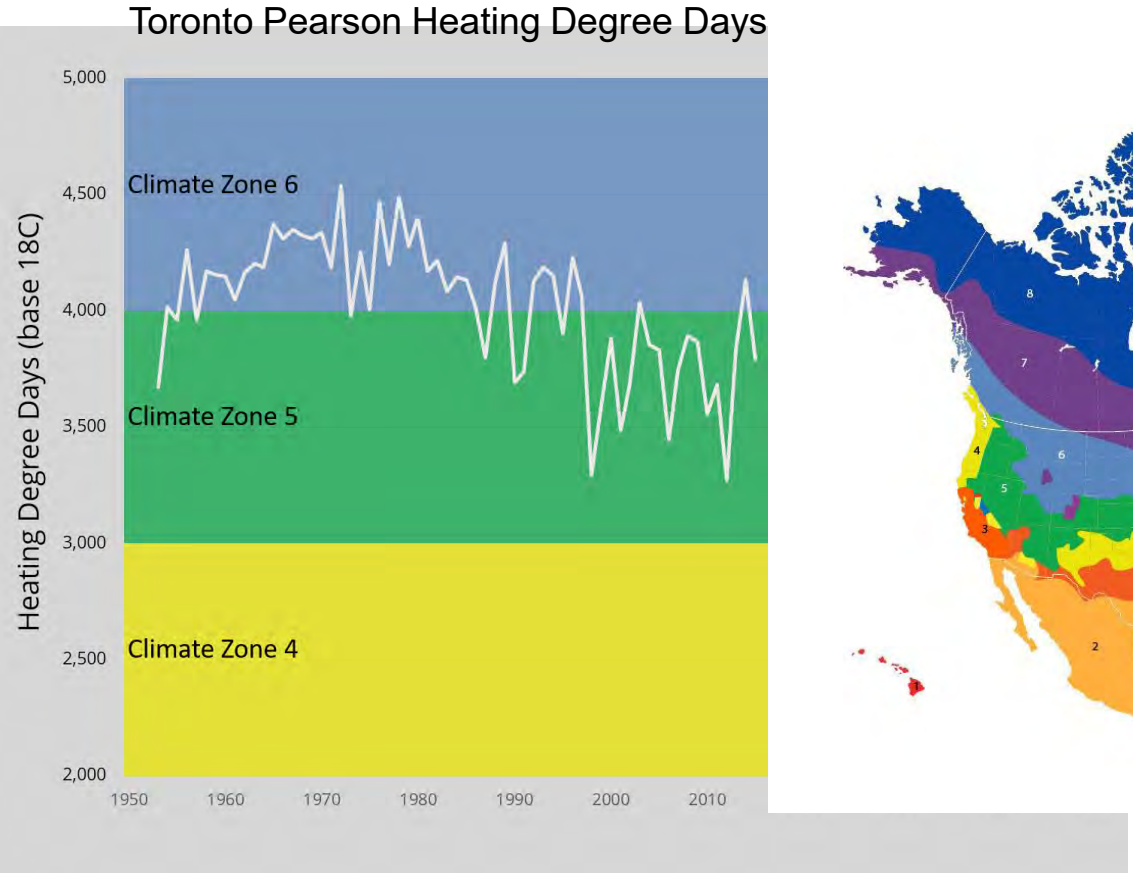
- Current - Baseline Weather File (TMY Based on 1976-2005)
- Statistically ‘Shifted’ Future Weather File , TMY basis – 2050’s – BASIC
- Statistically ‘Shifted’ Future Weather File, TMY basis – 2050’s – ADVANCED
- Statistically Downscaled Future Weather File – 2050’s - COMPLEX
- Dynamically Downscaled Future Weather File – 2050’s – VERY COMPLEX

Toronto's Future Weather and Climate Driver Study



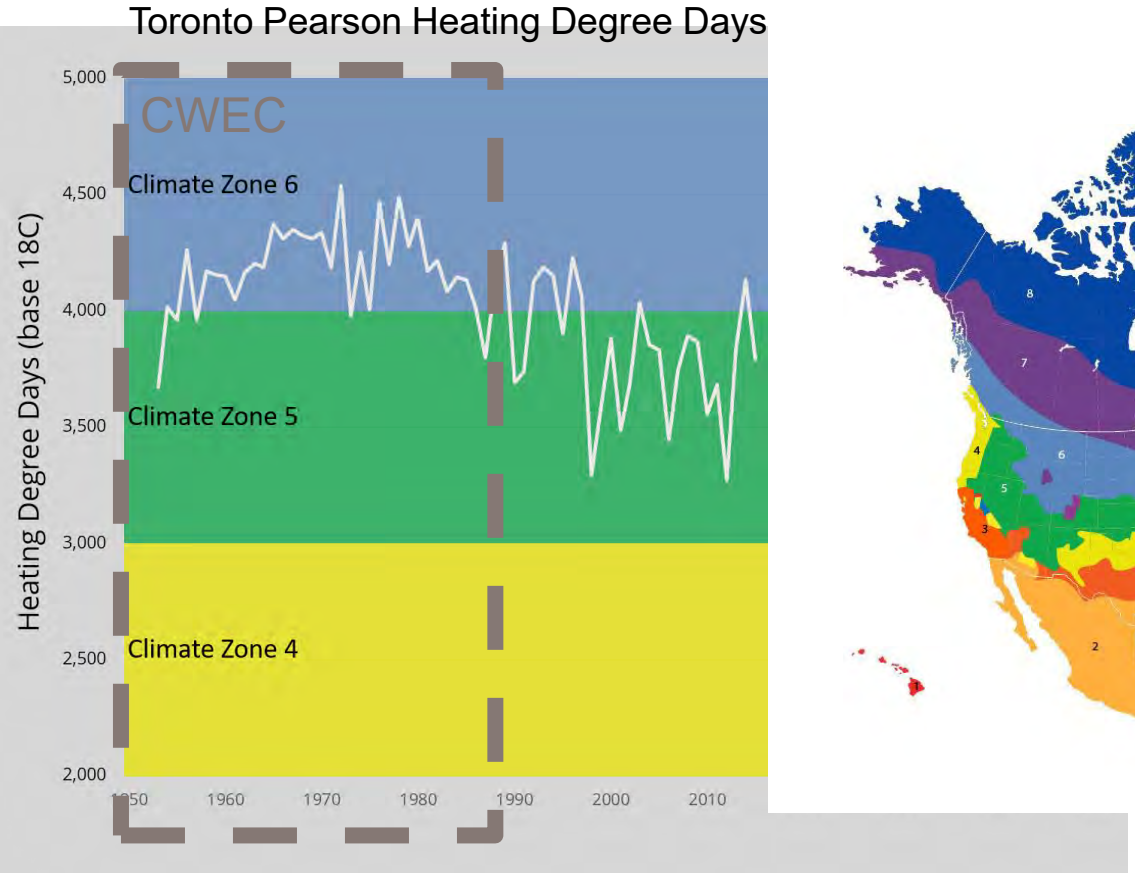
https://www1.toronto.ca/city_of_toronto/environment_and_energy/key_priorities/files/pdf/tfwcds-executive-summary.pdf

Climate Change



ASHRAE Climate Zones

Typical Metrological Years (TMY)



ASHRAE Climate Zones

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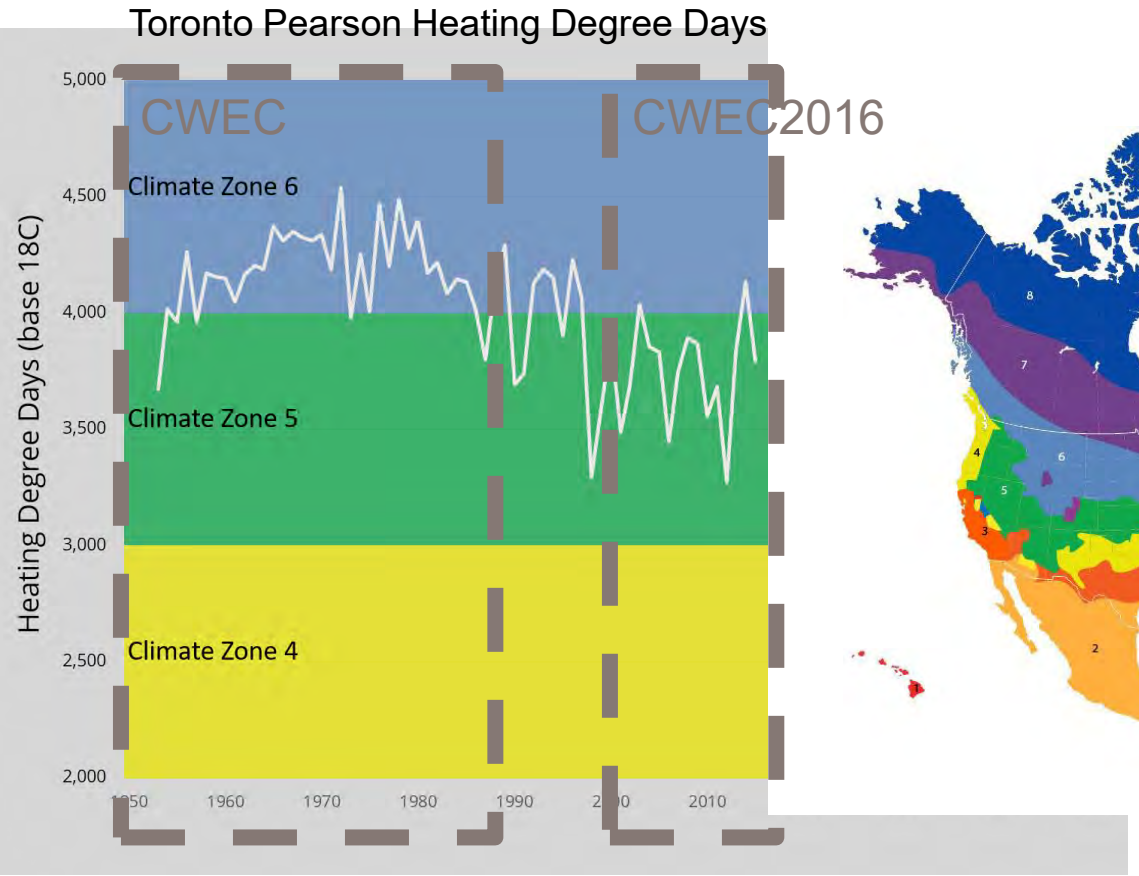
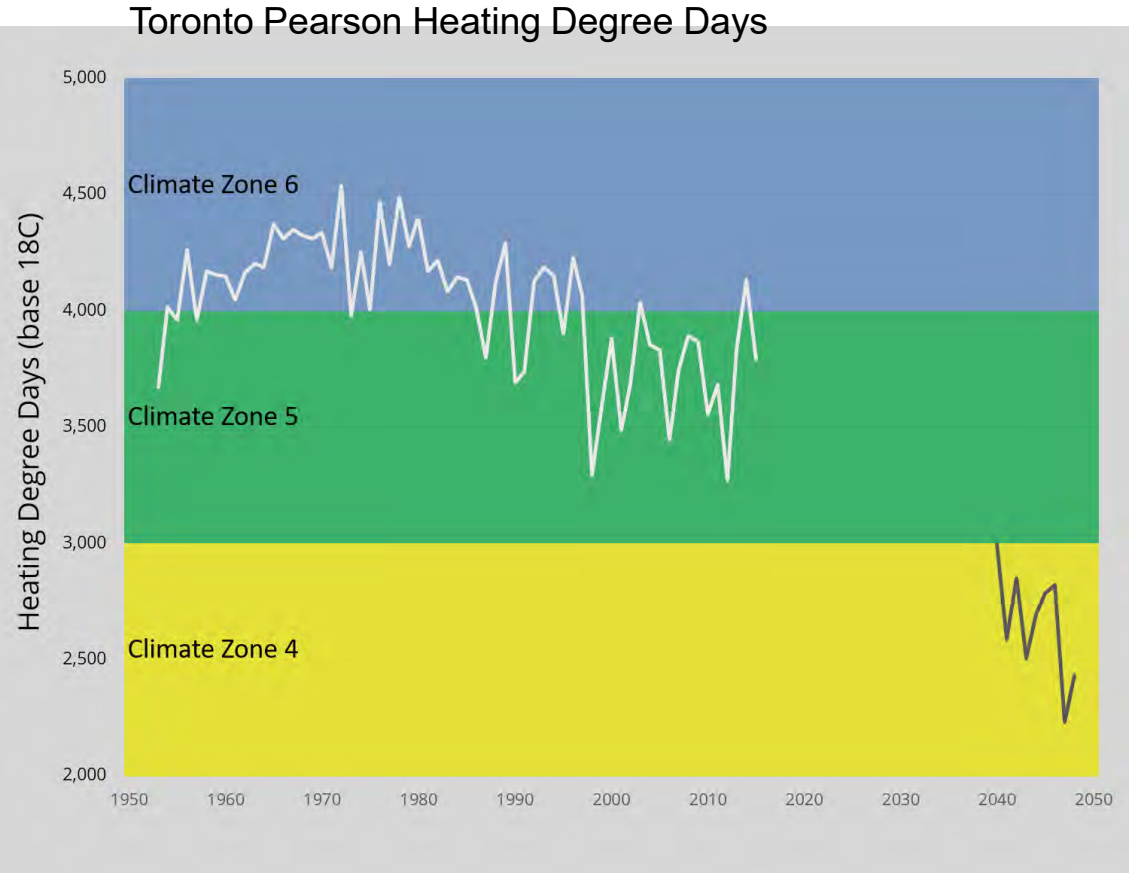


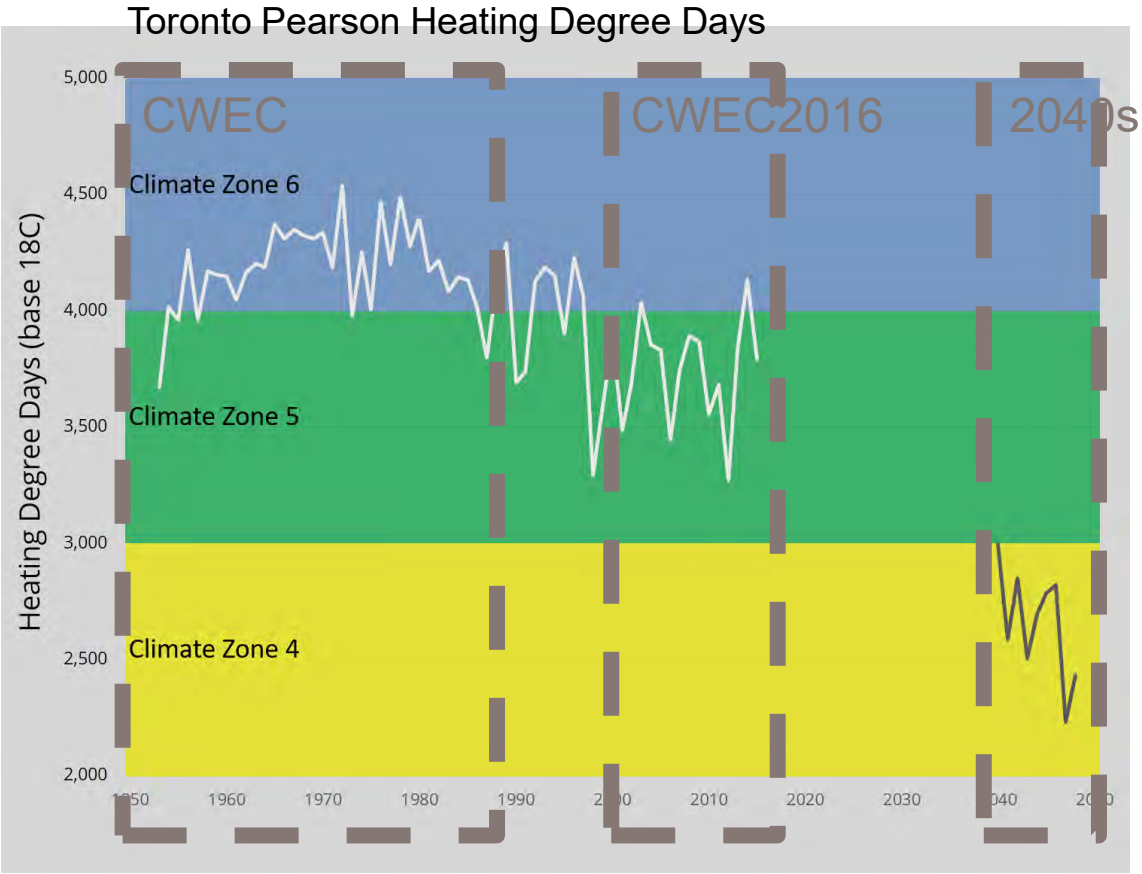
ASHRAE Climate Zones

Climate Futures



ASHRAE Climate Zones

Weather Files



ASHRAE Climate Zones

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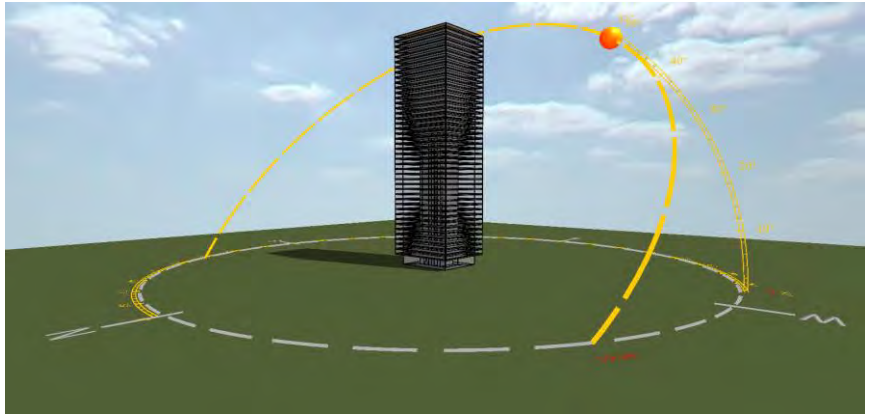
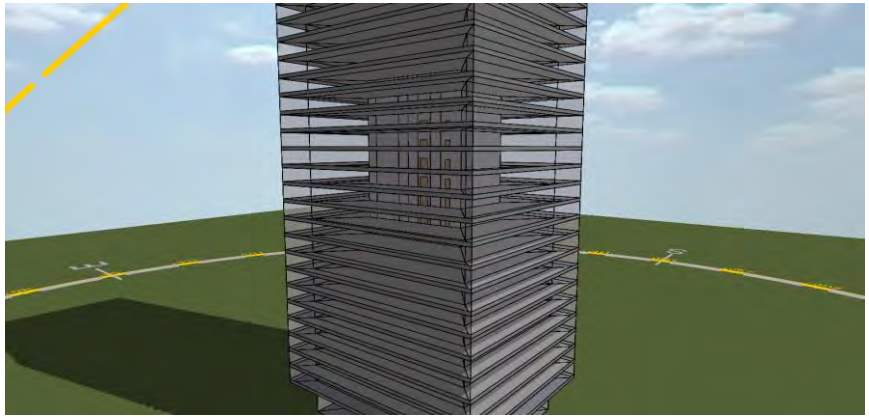
- **Energy Modelling Exercise**
- Unmet Cooling Hours
- Discussion/Next Steps

Energy Modeling Exercise





Modeling Software: IES-VE

Model Building:

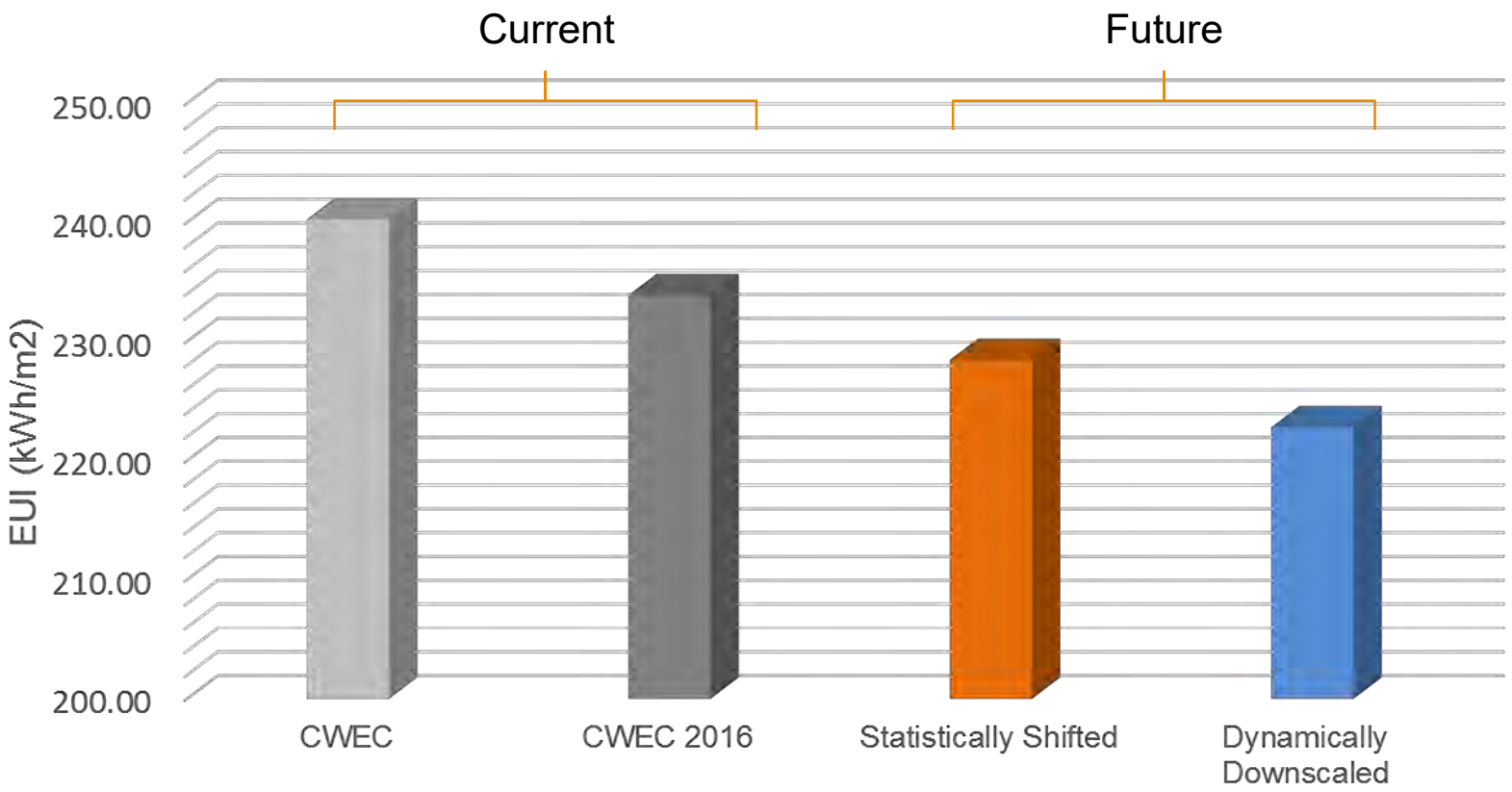
- Located in Toronto
- Typical Commercial Office Tower
- 44 Stories
- Fully-glazed (Curtain Wall) Façade

Energy Modeling Exercise

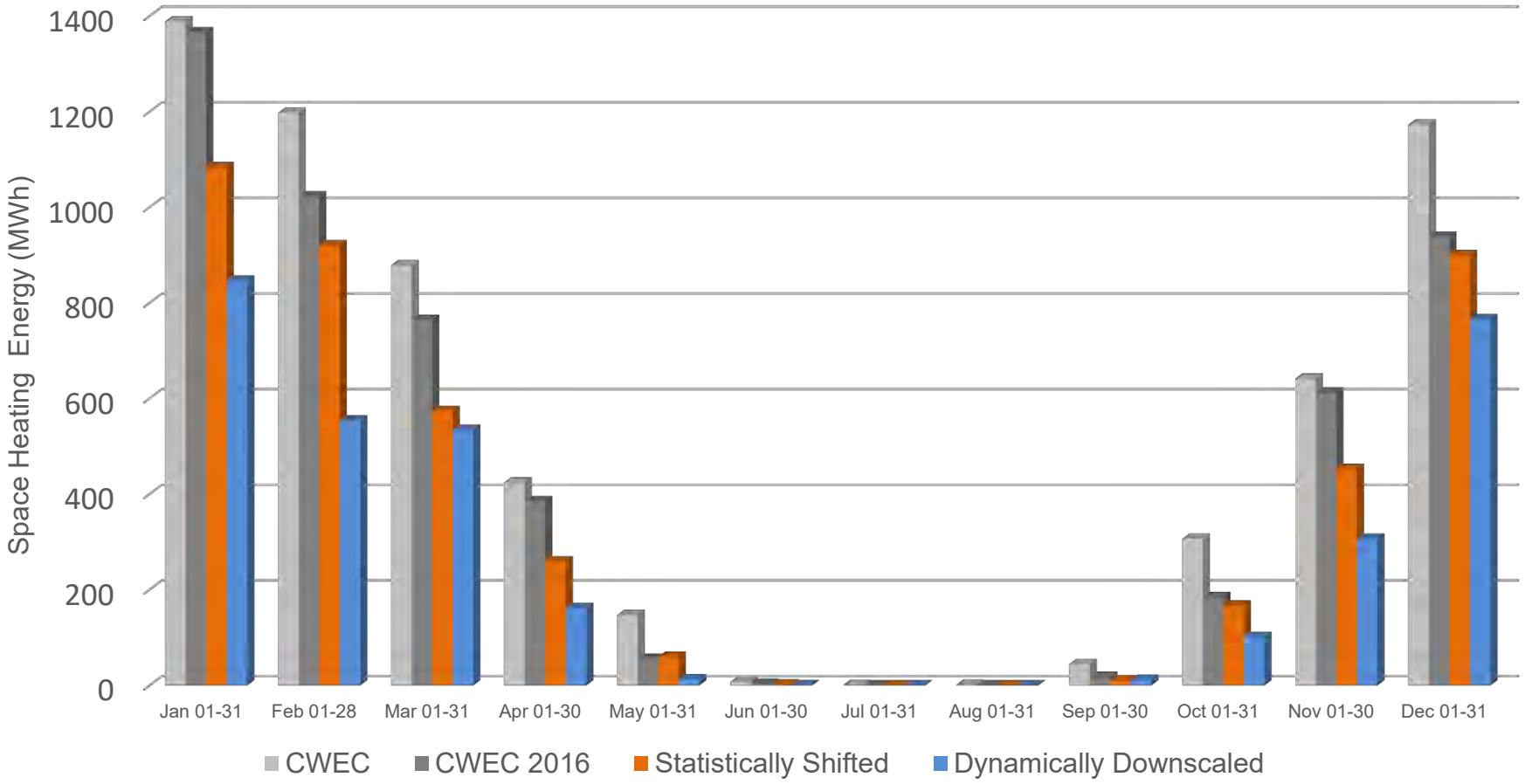
Review of Climate or Weather Files:

- CWEC – (Baseline)
- CWEC 2016 - (Updated Baseline)
- Statistically Shifted – 2031 - 2050
- Dynamically Downscaled – 2040 - 2050

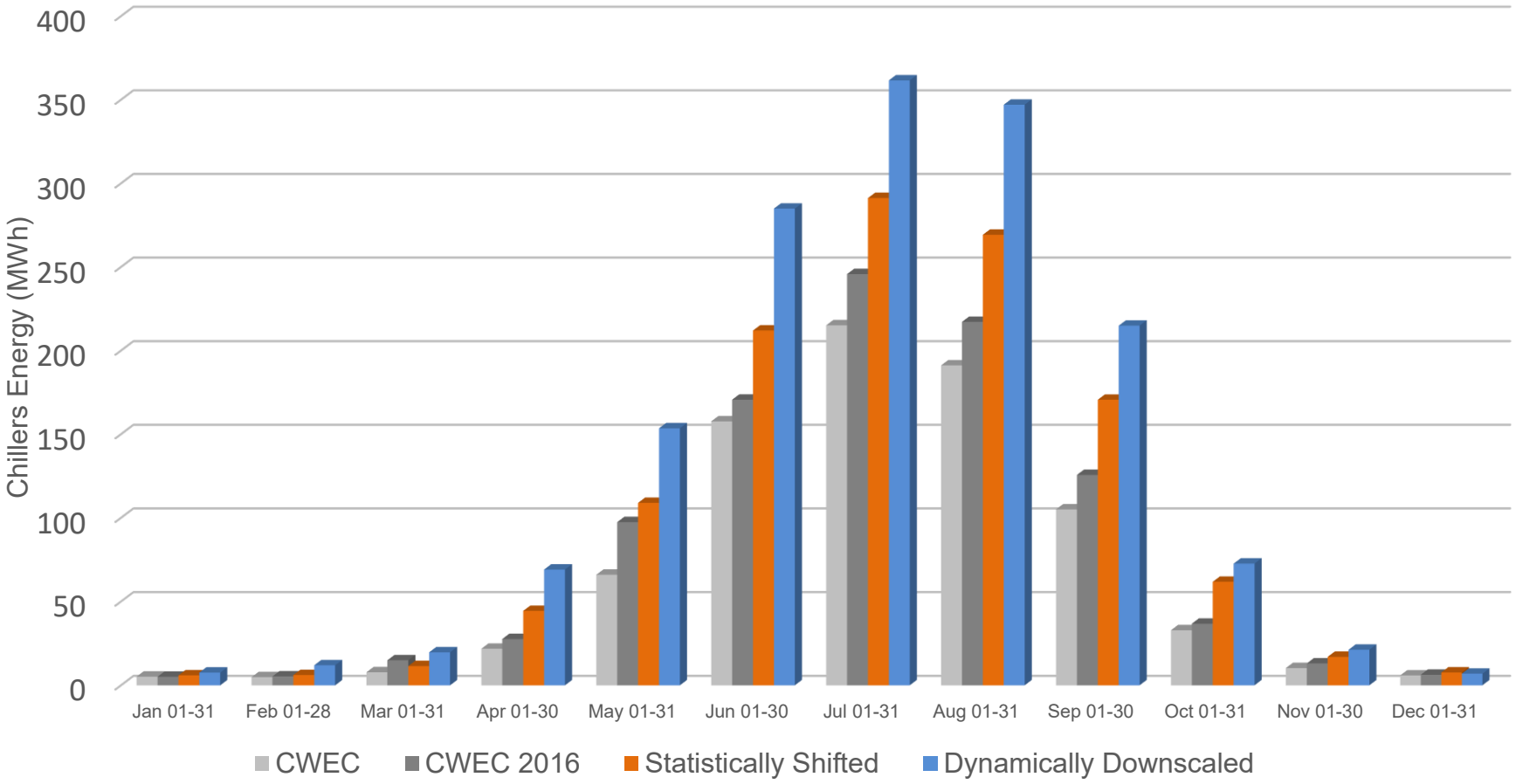
Energy Use Intensity



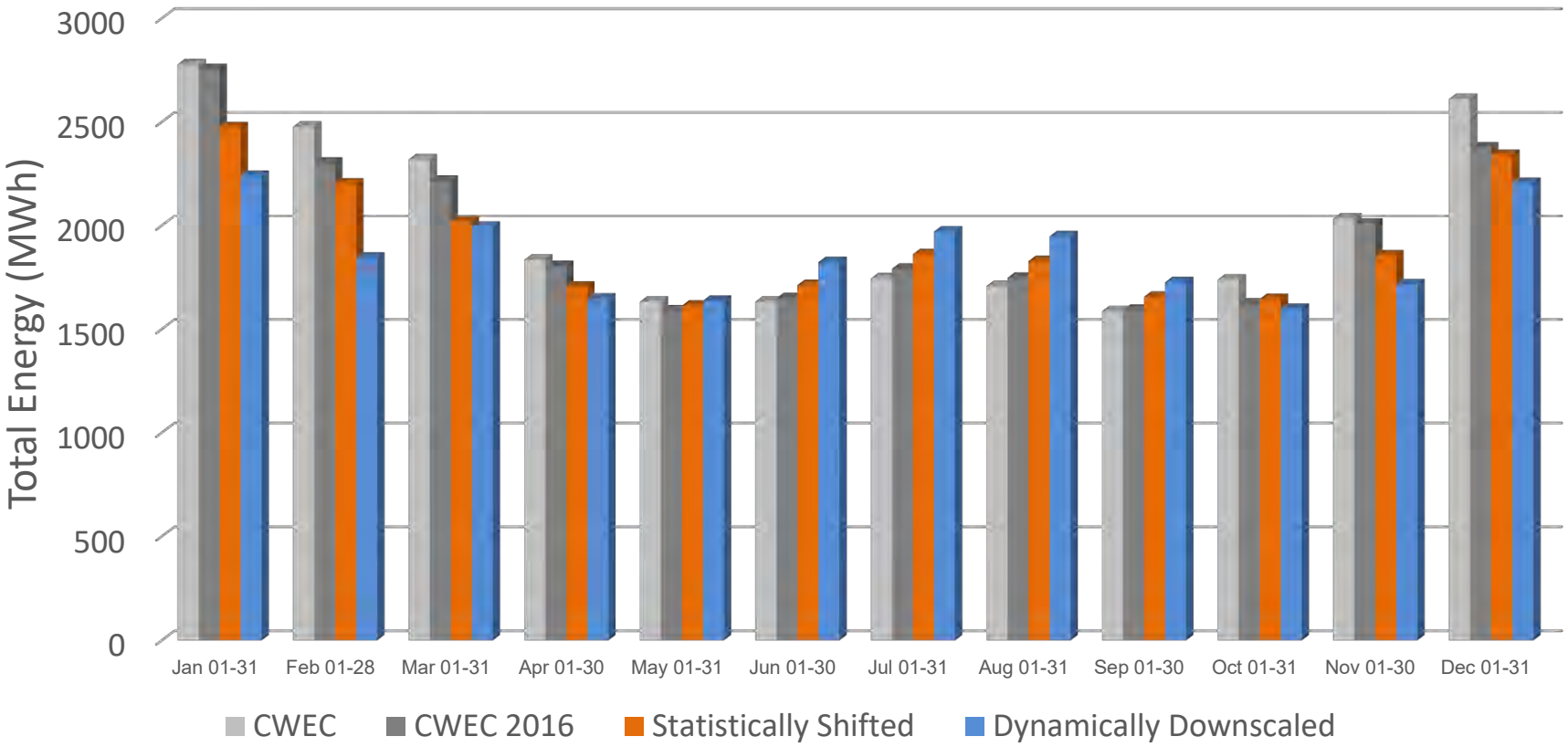
Heating Energy



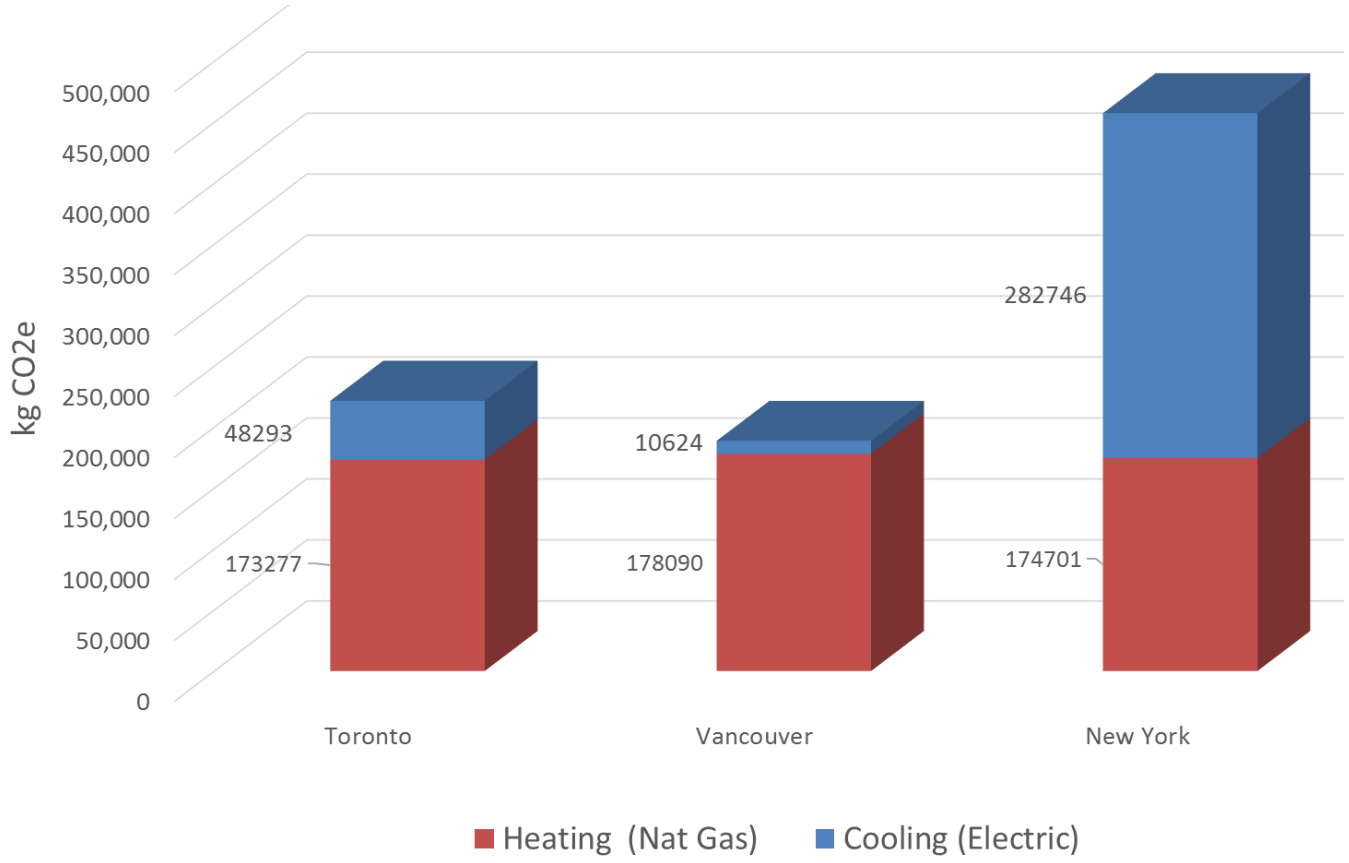
Cooling Energy



Total Energy



GHG Emissions by Location – CWEC 2016



Building Envelope Parameter Sensitivity Analysis

Window to Wall Ratio (WWR)

Low: 80%, Med: 60%, High: 40%

Glazing U-Value

Low: 2.38, Med: 1.87, High: 1.41

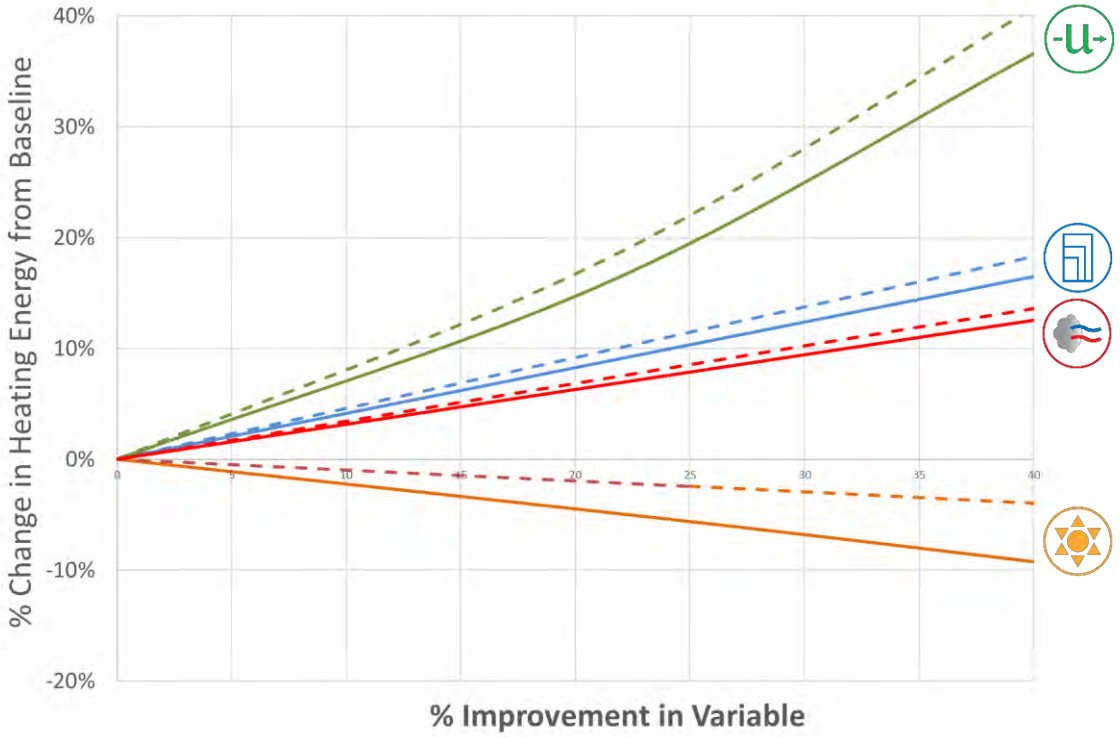
SHGC

Low: 0.4; Med: 0.3; High: 0.23

Air Infiltration

Low: 0.35, Med: 0.23, High: 0.1

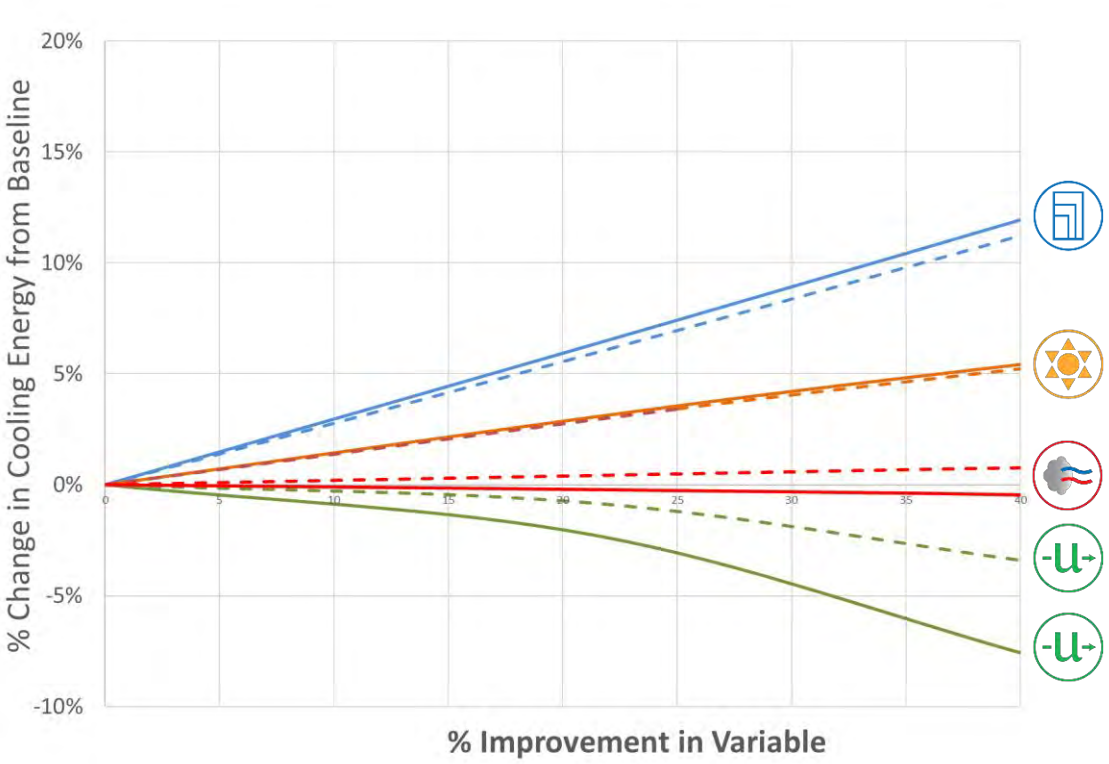
Relative Change in Total Heating Energy



Current

Future

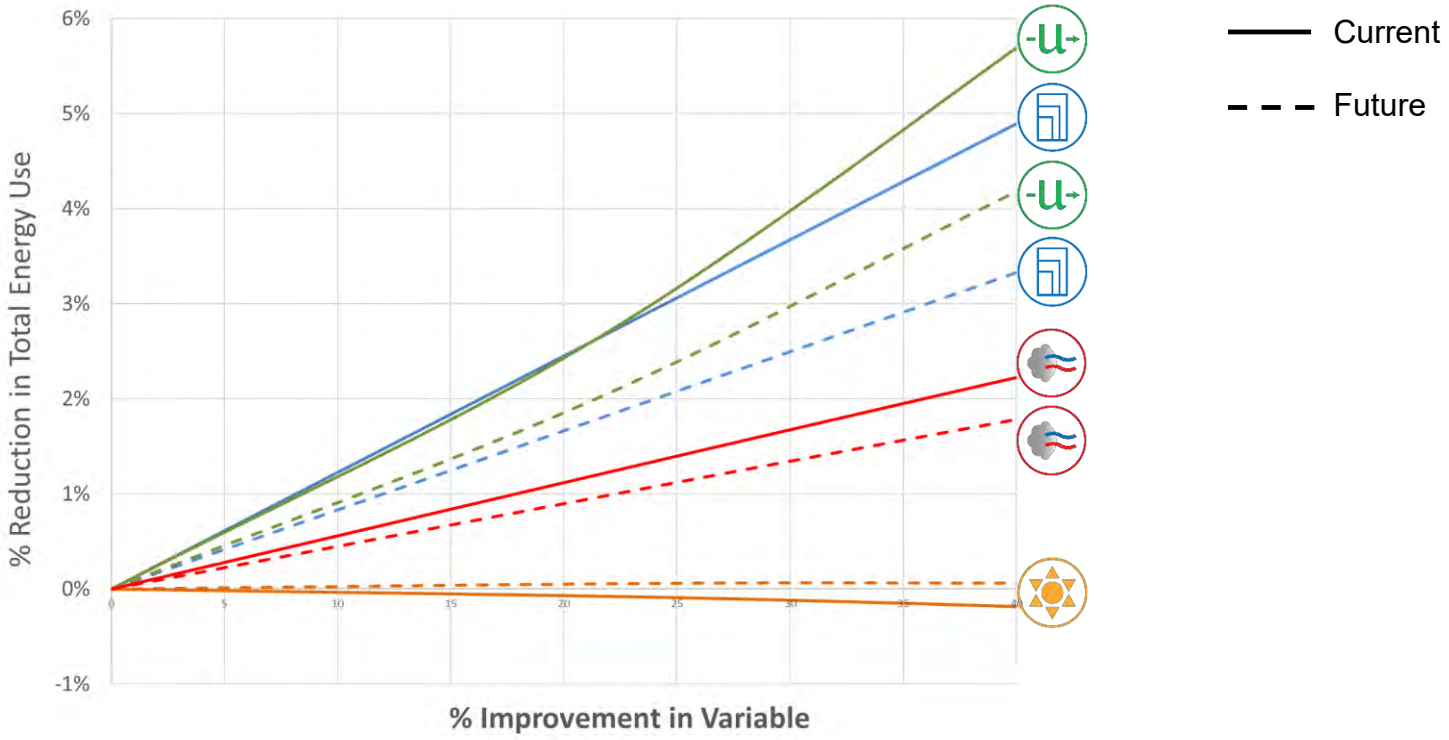
Relative Change in Total Cooling Energy



Current

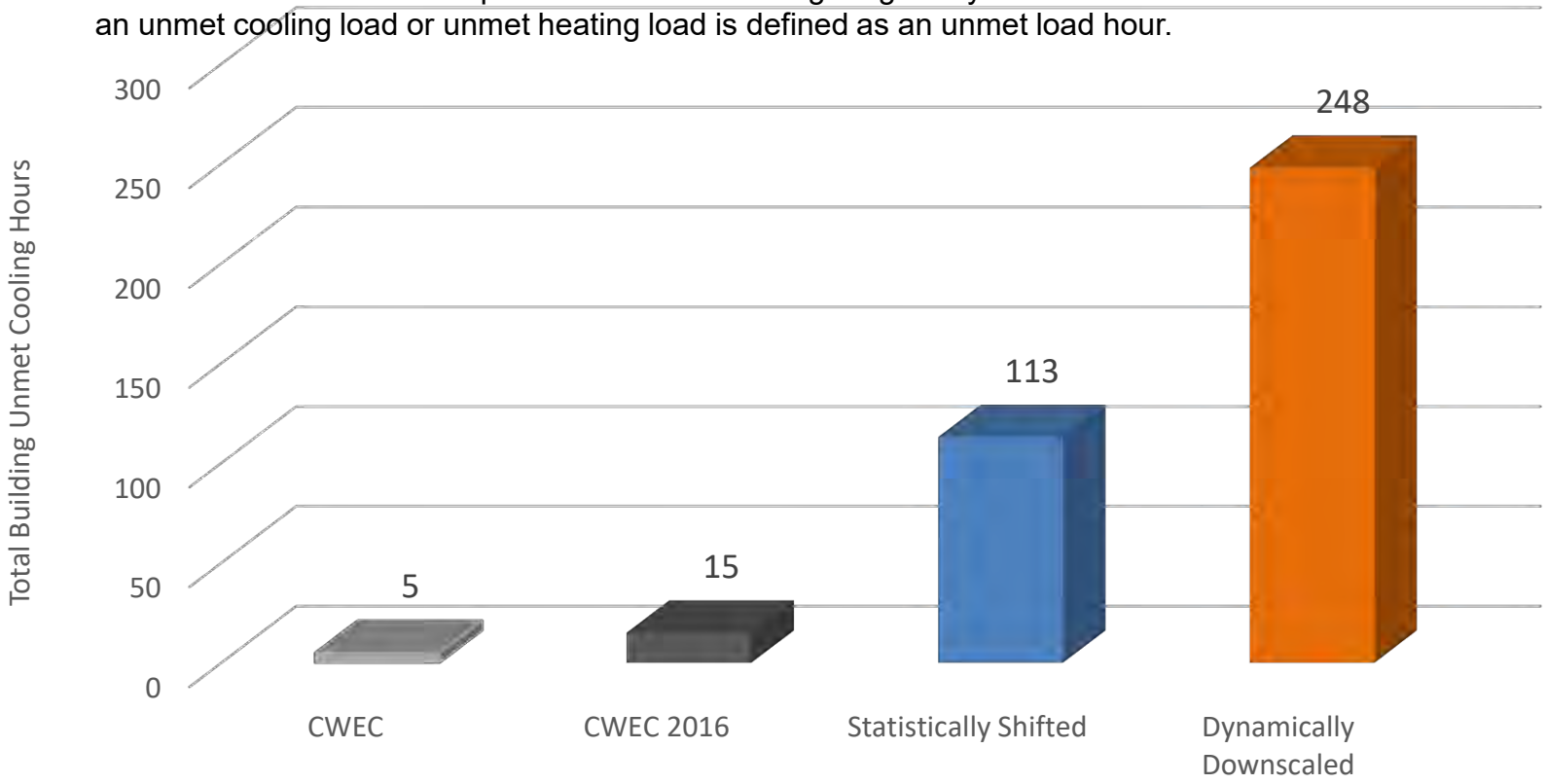
Future

Relative Change in Total Building Energy



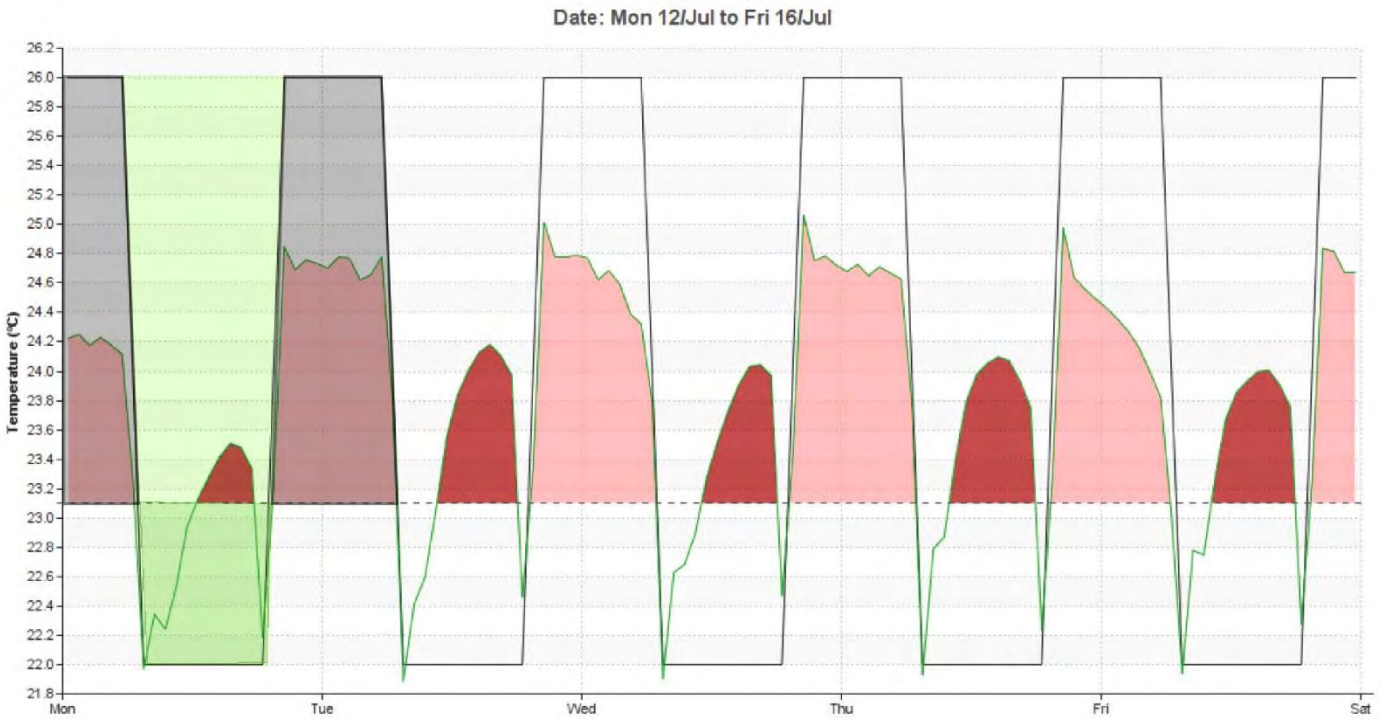
Unmet Cooling Hours by Future Weather Scenario

Unmet Load Hour: An hour in which one or more zones is out-side of the thermostat setpoint plus or minus one half of the temperature control throttling range. Any hour with one or more zones with an unmet cooling load or unmet heating load is defined as an unmet load hour.



Current Climate CWEC 2016

Future Climate Dynamically Downscaled



Unmet Cooling Hours
(OCCUPIED hours!)

Cooling Setpoint + 1.1°C

Cooling Setpoint (22°C)

UNOCCUPIED
(NIGHT SETBACK)

TIME OF OCCUPANCY
(DAY)

ZONE AIR TEMPERATURE

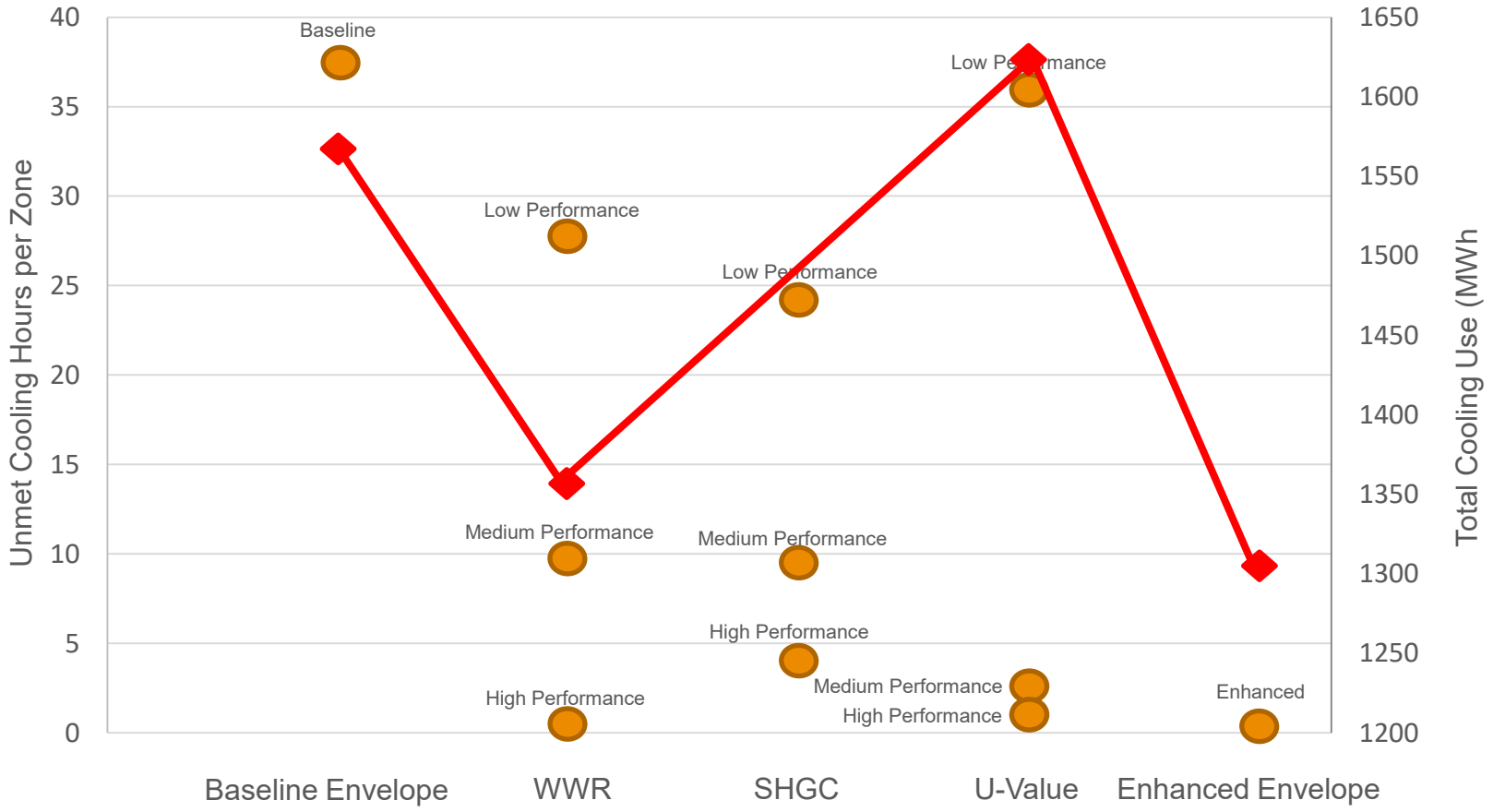
COOLING SETPOINT

Controlling Unmet Cooling Hours by Envelope Enhancements

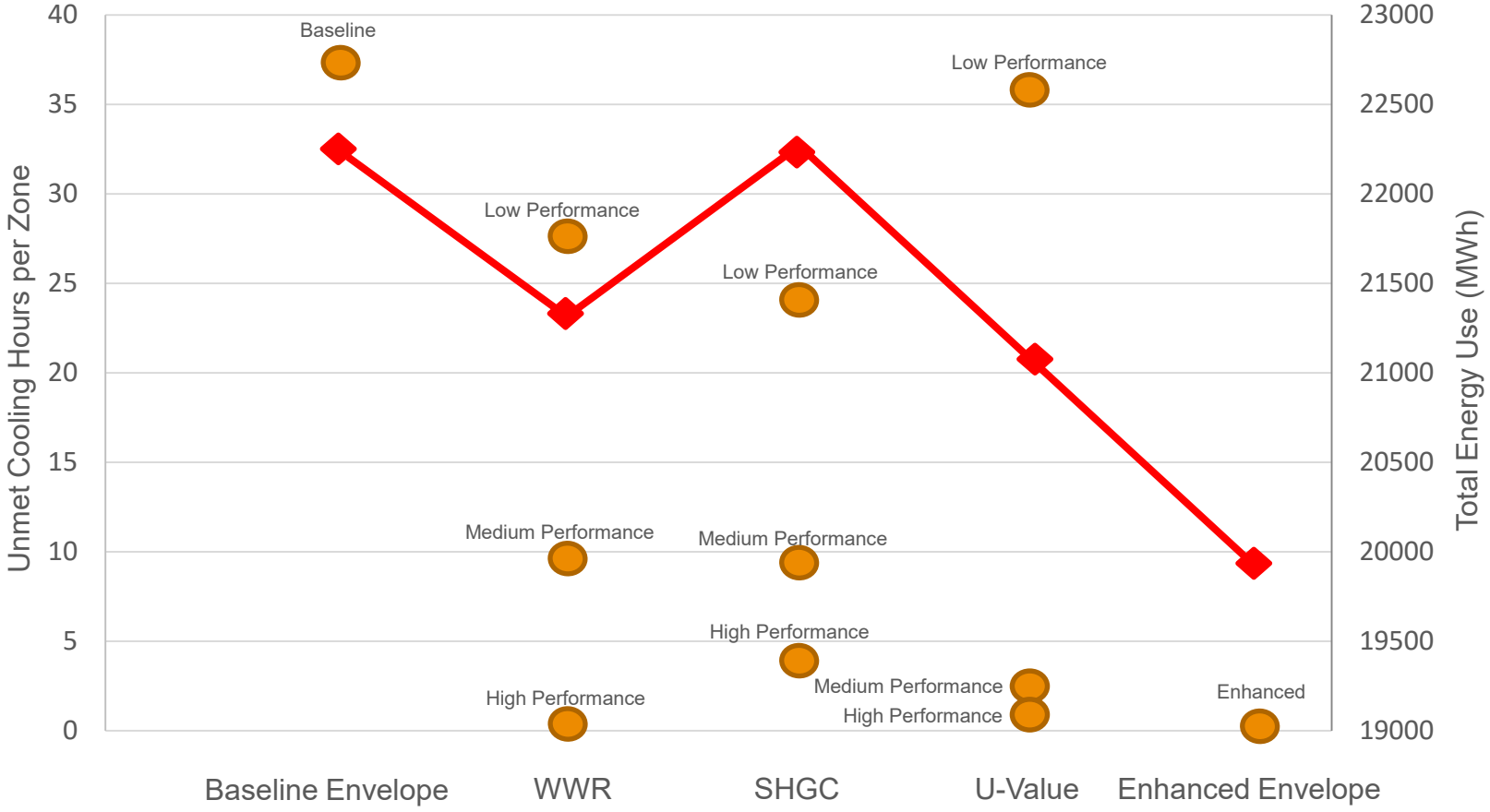
Performance	WWR	SHGC	U-Value (SI)
Low	80%	0.4	2.38
Medium	60%	0.3	1.87
High	40%	0.23	1.41
Enhanced Envelope	60%	0.23	1.41

Unmet Cooling Hours – Improvement Comparison

Unmet Cooling Hours & Total Cooling Energy – Improvement Comparison



Unmet Cooling Hours & Total Heating & Cooling Energy - Improvement Comparison



Conclusions

- Future climate needs to be considered during building design and the right data is important
- Some parameters may be impactful in both scenarios (WWR & U Value)
- Adaptation can be considered at both initial design phase and at component life cycle replacement when the effects of climate change are more certain
- Envelope optimization through modeling can be effective tool to limit the future climate change risk *and* maintain design flexibility

Effects of Climate Change on Building Envelope Energy Efficiency

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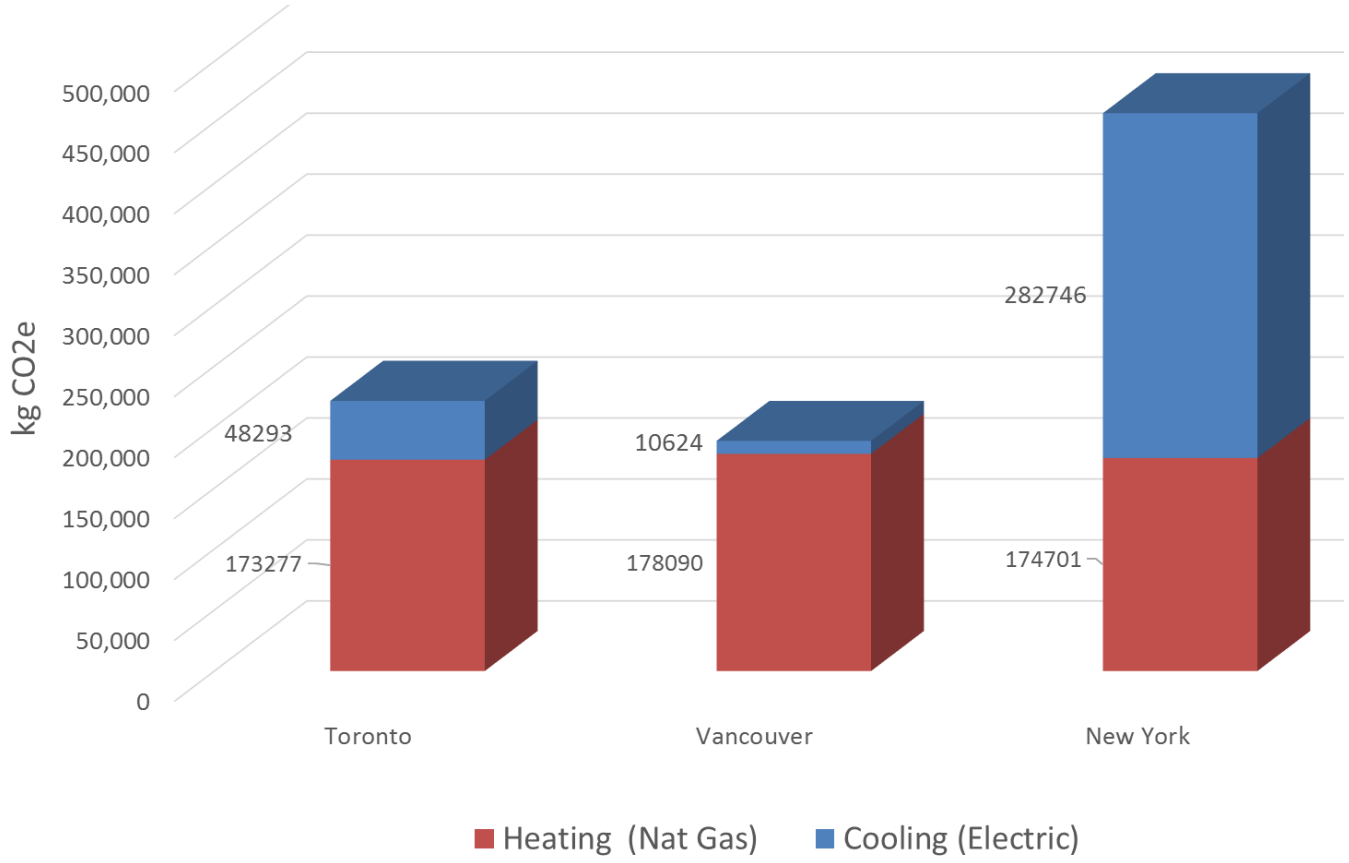
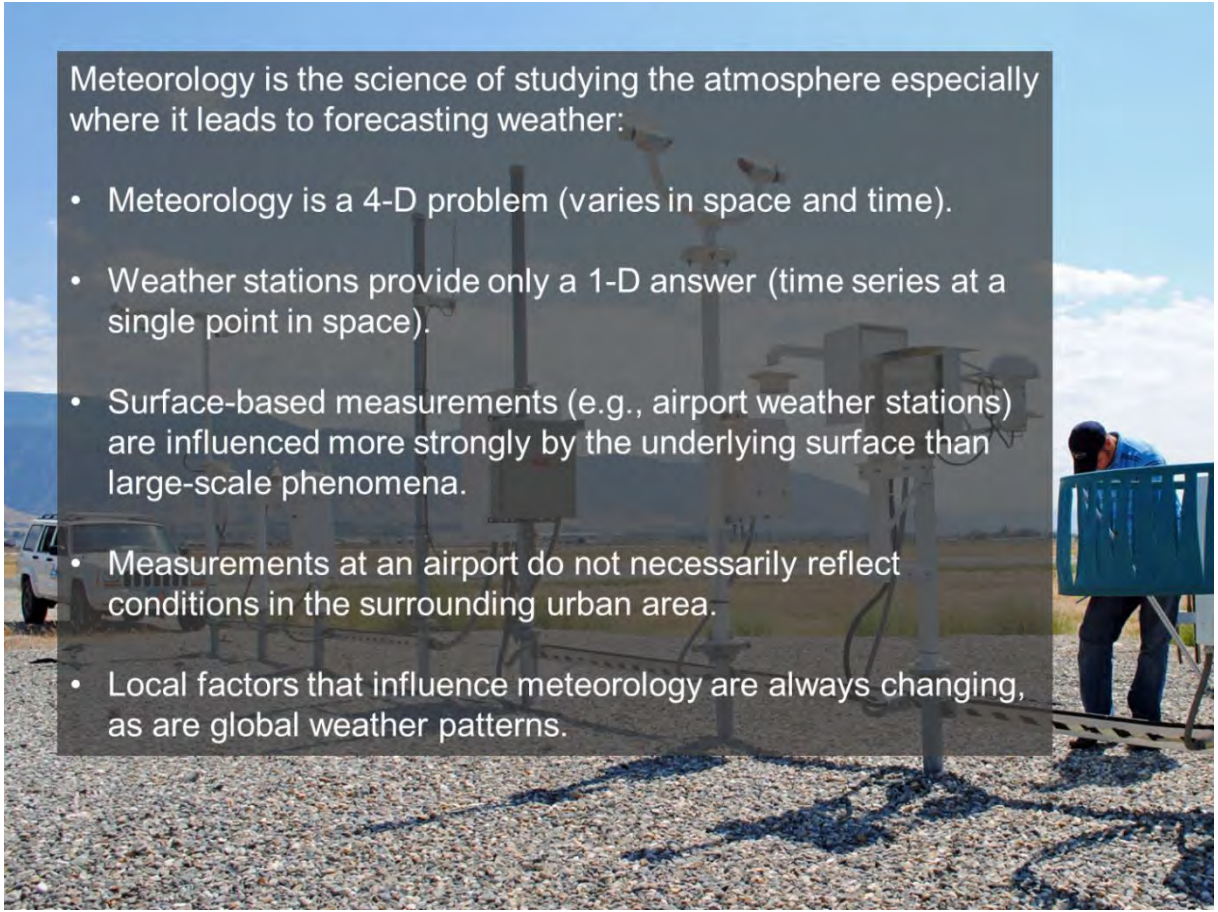
GHG Emission Factors by Location

	Natural Gas (kgCO2e/kWh)	Electricity (kgCO2e/kWh)
Toronto	0.180	0.050
Vancouver	0.185	0.011
New York	0.181	0.293

GHG Emissions by Location – CWEC 2016



More…



Meteorology is the science of studying the atmosphere especially where it leads to forecasting weather:

- Meteorology is a 4-D problem (varies in space and time).
- Weather stations provide only a 1-D answer (time series at a single point in space).
- Surface-based measurements (e.g., airport weather stations) are influenced more strongly by the underlying surface than large-scale phenomena.
- Measurements at an airport do not necessarily reflect conditions in the surrounding urban area.
- Local factors that influence meteorology are always changing, as are global weather patterns.