Accentuate the Positive: Climate Responsive Design

PRESENTERS:
Terri Meyer Boake | University of Waterloo
Mike Williams | RWDI

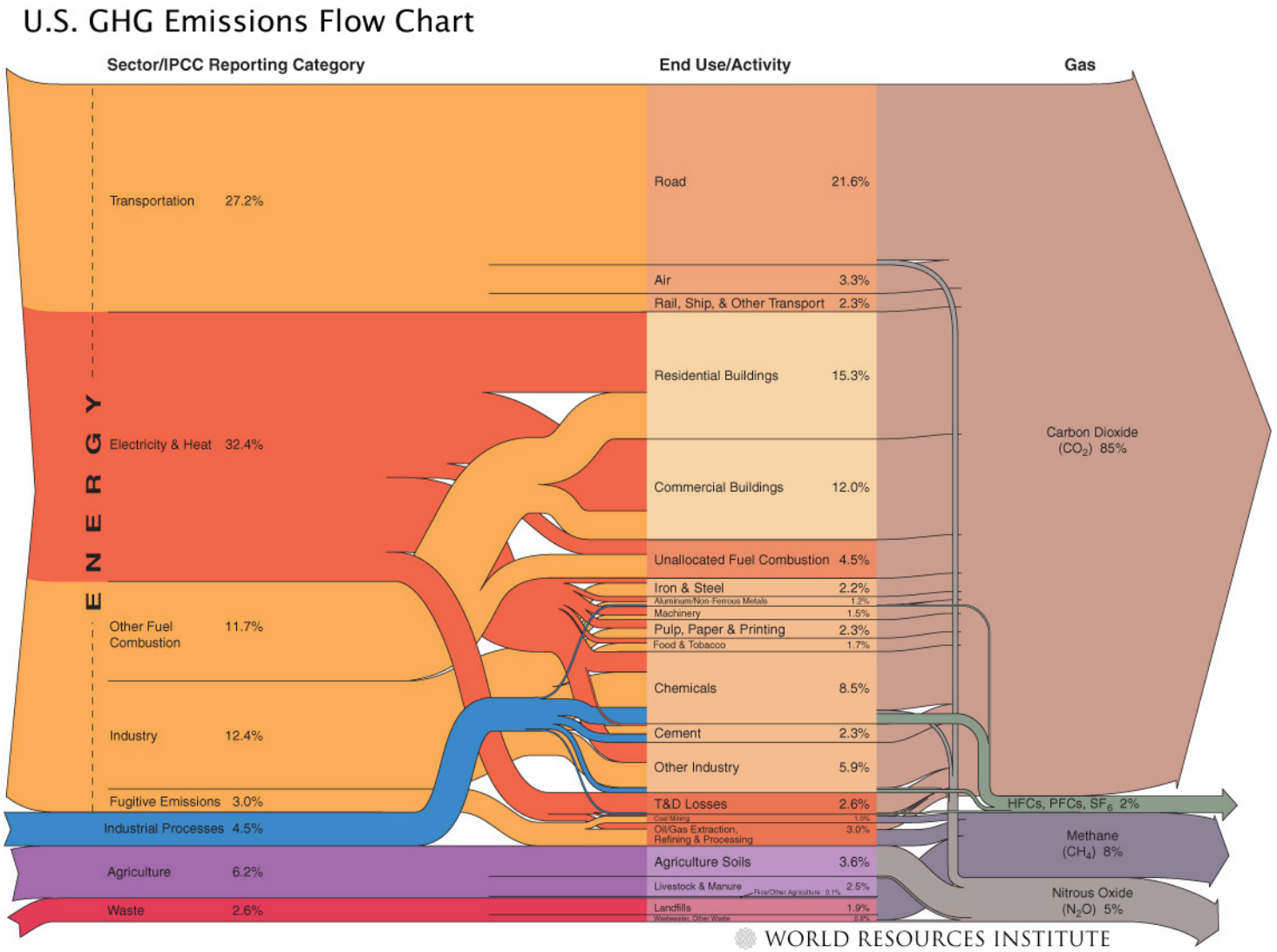
Produced By: OAA
Developed By: aia seattle
In partnership with: architecture 2030

The Global Warming Pie....

These values look at Secondary **Energy Use** by Sector in Canada (2006)

(*energy used by the final consumer i.e. operating energy*)

Emissions and their Sources



Technological advances have allowed us to build anything…

Photo:National Trust

The Glass House New Canaan Connecticut 1949, by architect Phillip Johnson who coined the term “International Style”

Conventional construction:
Boxes hooked up to life support

In Florida turn the dial one way,

in Maine turn it the other.

Think Building Green.com


CONNECTICUT


ARIZONA
04 20 2012


NEW MEXICO
3785


314
BCAR 2010
FLORIDA

Opportunities to Work With and Harvest Climate

Roughly….

The Sun = Free Heat, Light, Cooling & Ventilation

The Wind = Free Ventilation & Cooling

Rain & Snow = Free Water & Cooling

There is lots that can and must be done at the OUTSET of a project with respect to the Climate, Building Siting and Orientation that can HELP to reduce energy.

If not done you will spend a lot of time and energy working to correct these bad decisions.

Good decisions at the start can be built upon ….

Bad decisions at the start need to be corrected ….

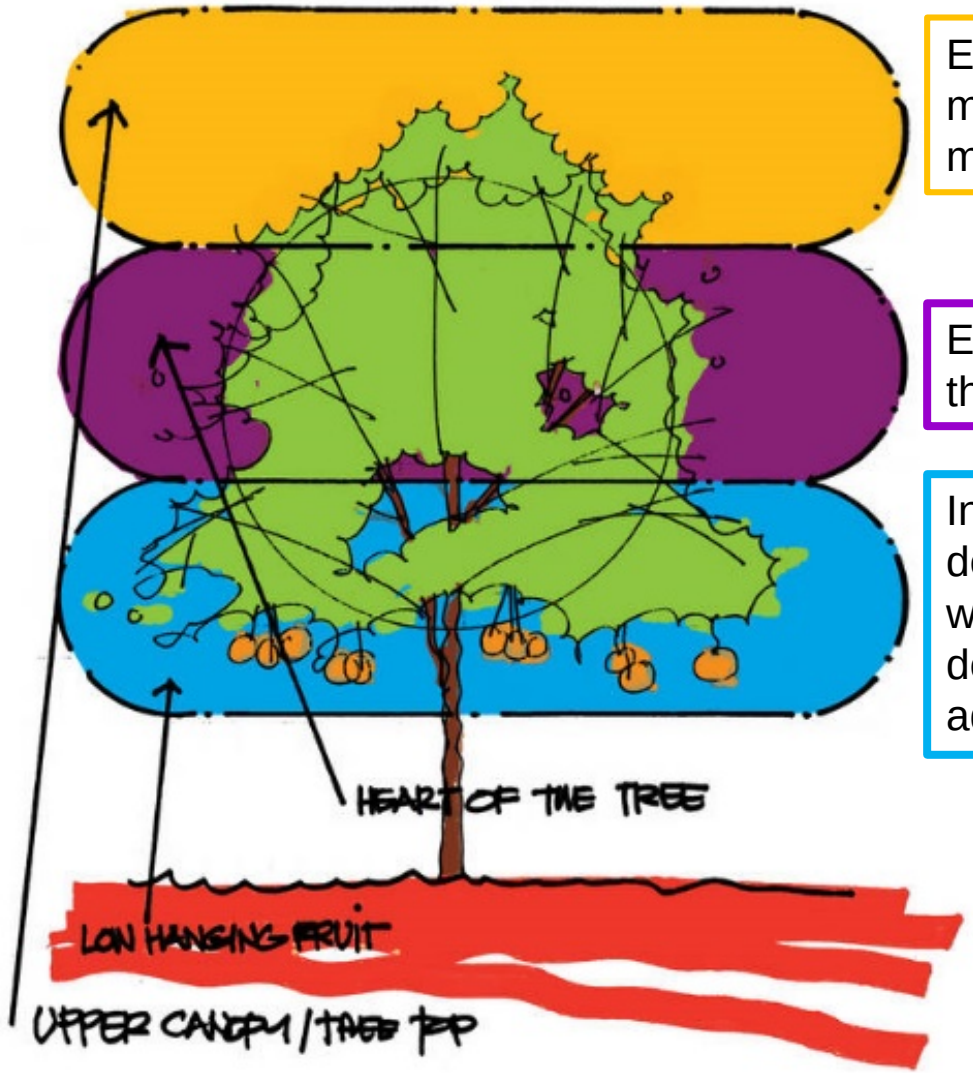
Must Understand What Climate Responsive Design can Impact

Climate responsive design means designing to work with the local climate.

This can mean shaping massing, materials, etc. to:

- **Reduce snow accumulations at entrances / exits**
- **Store coolth generated at night to the day**
- **Passive solar heating**
- **Wind driven natural ventilation**
- **Locations of windows, atria, skylights etc. to benefit daylighting**
  - **These also impact natural ventilation**
- **Locating pollutant/odour sources downwind from building intakes**
- **Providing adequate snow melt run-off capacity**
- **Burying the water pipes deep enough**
- **Using a ground exchange system to pre-heat / pre-cool intake air**

Low Hanging Fruit



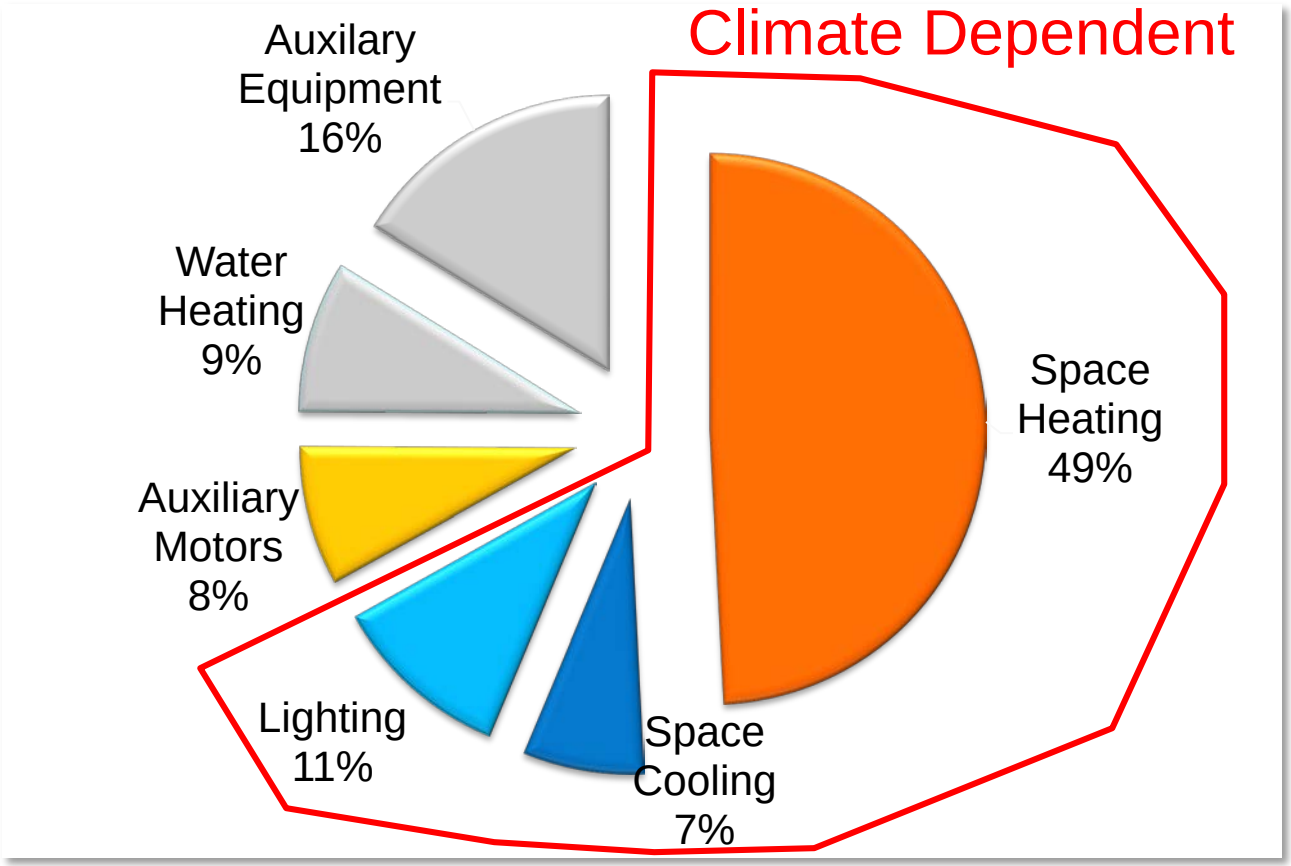
Expensive systems such as PV, micro wind turbines, various mechanical and electrical equipment

Extra insulation, better windows, thermal mass, shading devices.

Initial site and climate based design decisions that really cost nothing but will benefit the project: climate, defining comfort, orientation, adjacencies, massing, landscaping

Energy Use in Buildings: Operating Energy

Total Commercial/Institutional Secondary Energy Use by End Use in Canada (2006)



Source: Natural Resources Canada, 2006

Operating Energy of Building

80% of the problem!

Landscape + Site

Disturbance vs. sequestration

Embodied Carbon in Building Materials

People, “Use” + Transportation

Renewables + Site Generation

Counting Carbon costs….

+ purchased offsets

Operating Energy of Building

80% of the problem!

Building envelope performance directly impacts operating energy

Embodied Carbon in Building Materials

Building envelope material selection and sourcing directly impacts embodied energy

OPERATING ENERGY IS CLIMATE DEPENDENT

Three Key Steps – IN ORDER:

#1 - Reduce loads/demand first

(conservation, passive design, daylighting, shading, orientation, etc. with CLIMATE RESPONSIVE DESIGN)

#2 - **Meet loads efficiently and *effectively*** (energy efficient lighting, high-efficiency MEP equipment, controls, etc.) to reduce energy requirements, in order to

#3 - **Use renewables to meet energy needs** (doing the above steps *before* will result in the need for much smaller renewable energy systems, making carbon neutrality achievable.)

Carbon Reduction: The Tier Approach

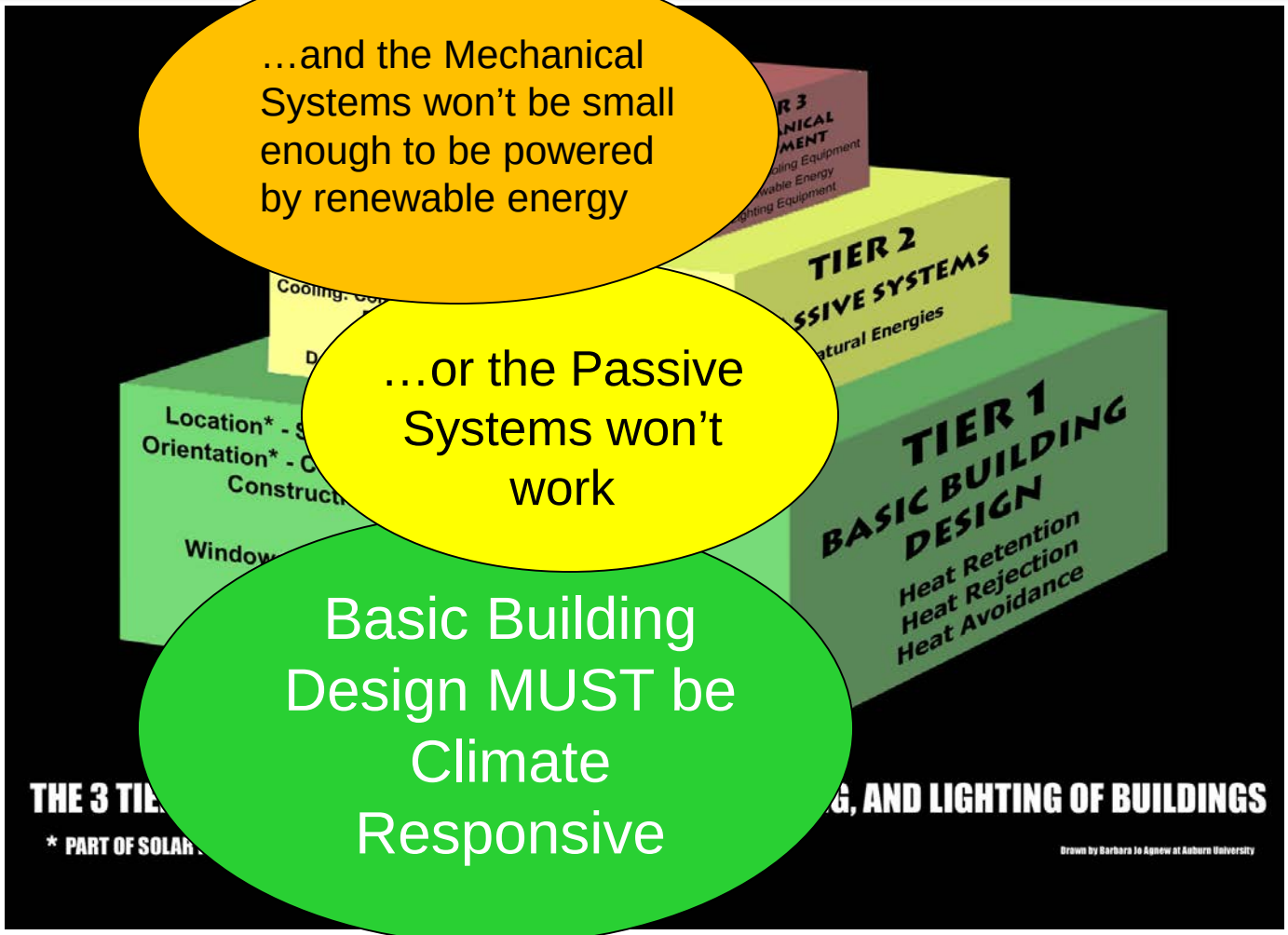
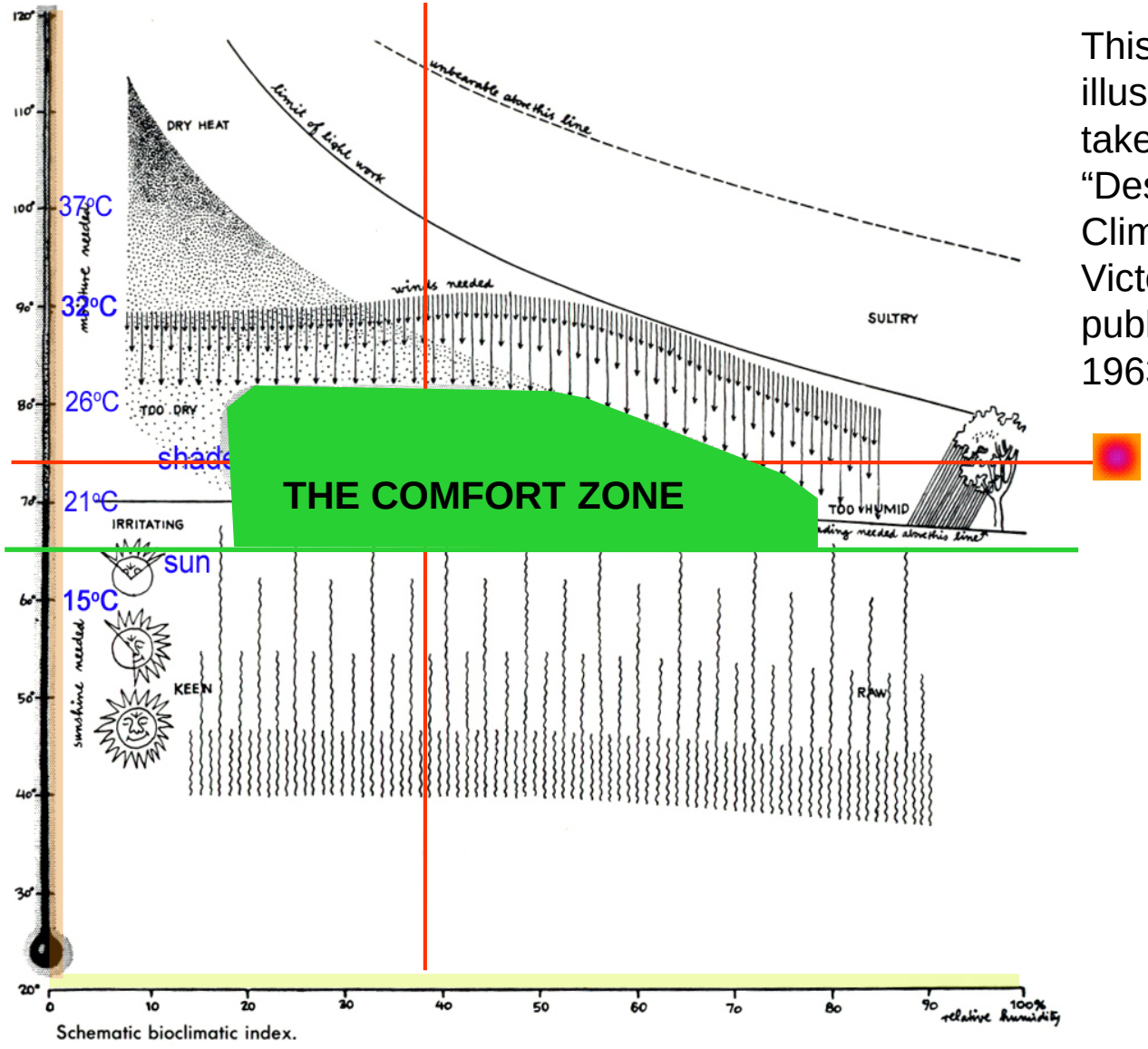


Image: Norbert Lechner, "Heating, Cooling, Lighting"

Climate as the Starting Point for a Climate Responsive Design

Designing to the **Comfort Zone** vs. Comfort Point:

REDUCING OPERATING ENERGY



Schematic bioclimatic index.

This famous illustration is taken from “Design with Climate”, by Victor Olgyay, published in 1963.

Passive Bio-climatic Design: **COMFORT ZONE**

IDEALLY comfort expectations may have to be reassessed to allow for the wider “zone” that is characteristic of buildings that are not exclusively controlled via mechanical systems.

Creation of new **“buffer spaces”** to make a hierarchy of comfort levels within buildings.

Require **higher occupant involvement** to adjust the building to modify the temperature and air flow.

North American Bio-climatic Design:

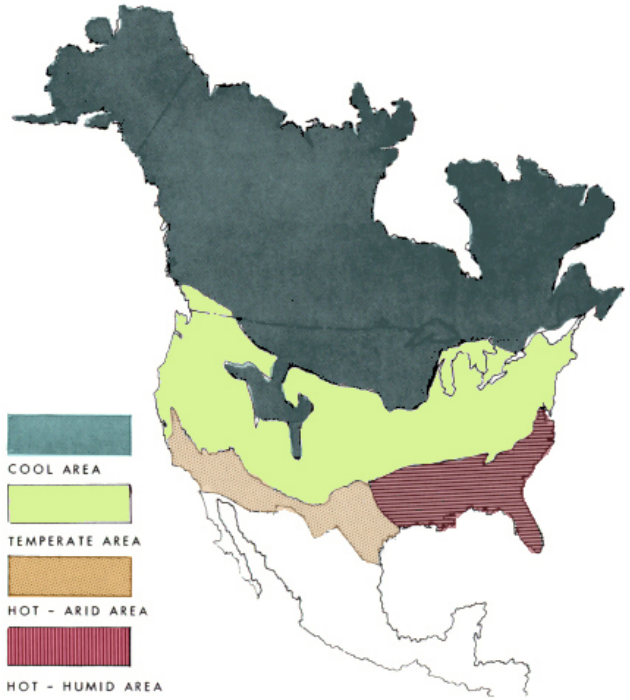
Design must first acknowledge regional, local and microclimate impacts on the building and site.

COLD

TEMPERATE

HOT-ARID

HOT-HUMID

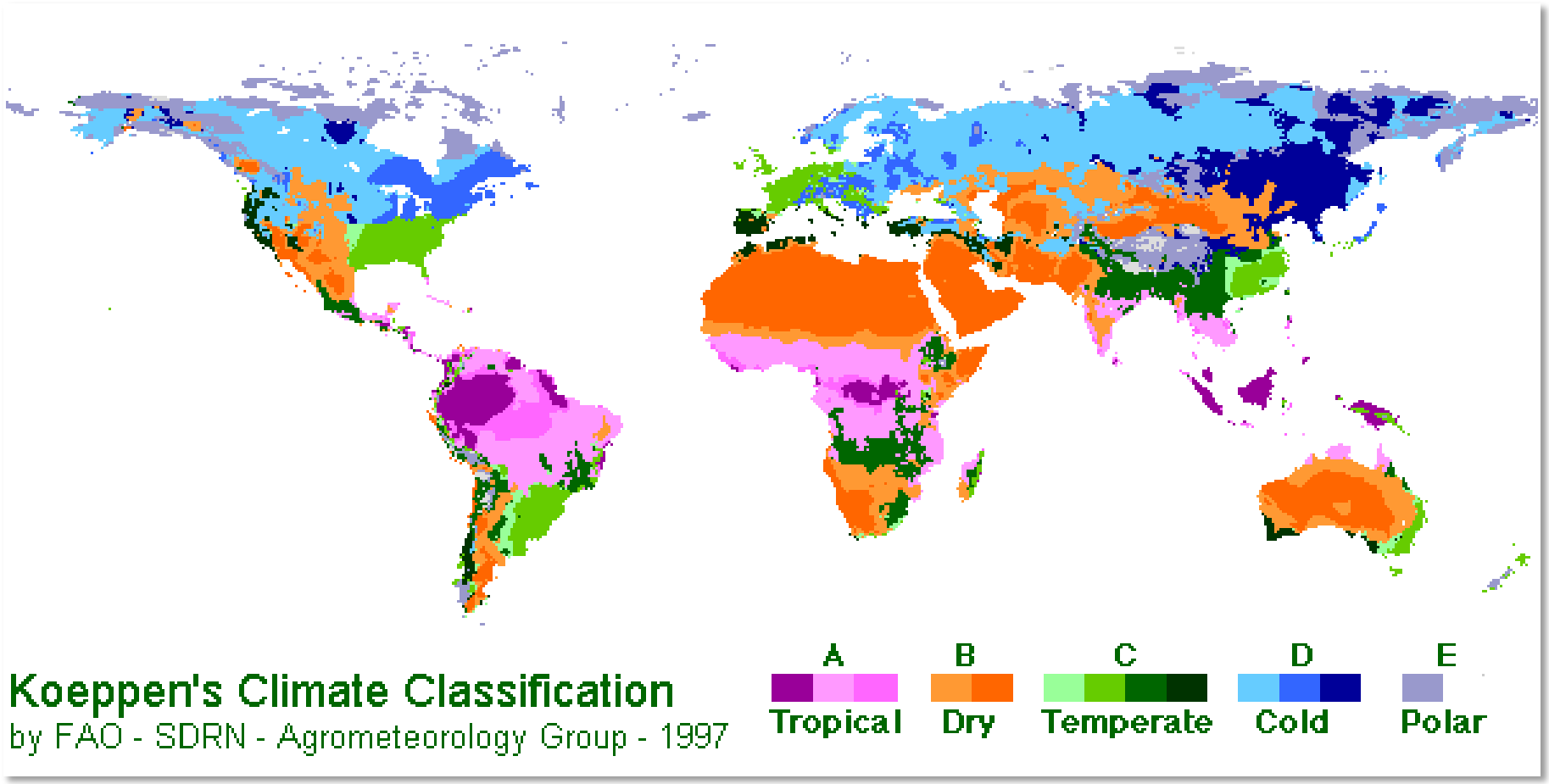


11. Regional climate zones of the North American continent.

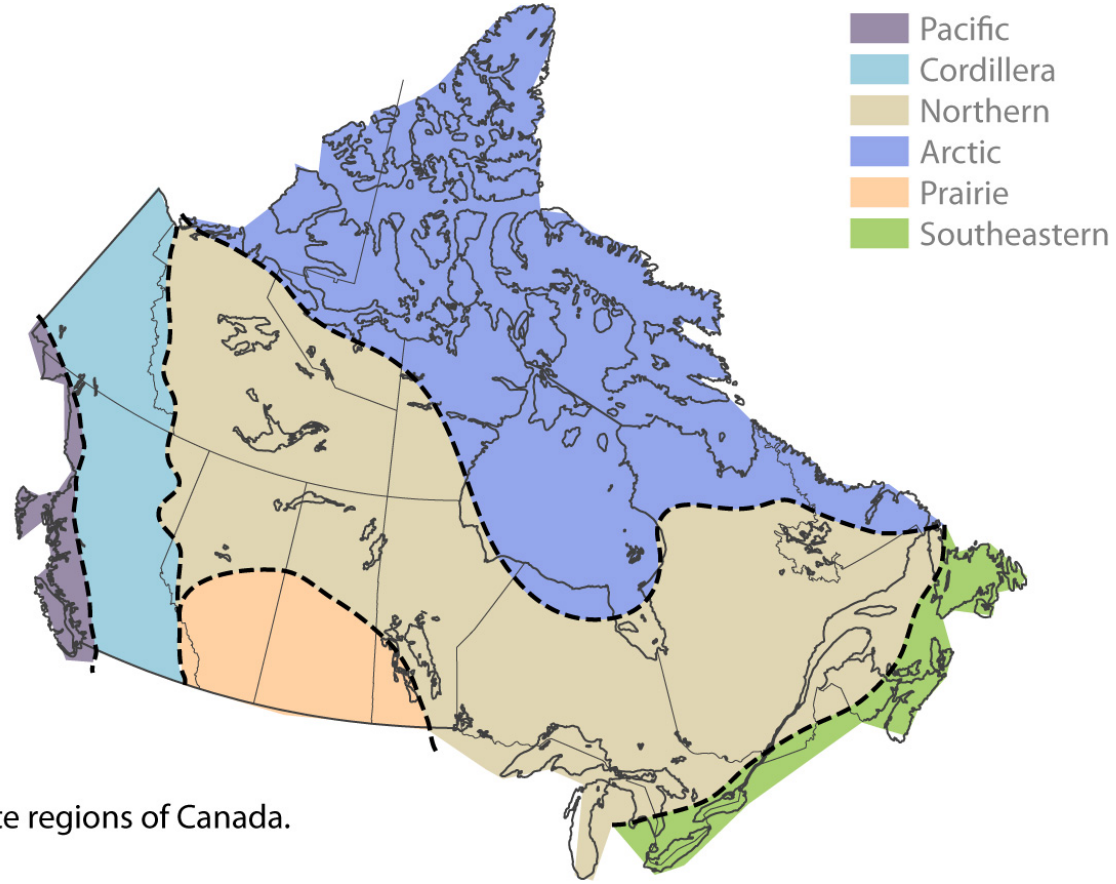
Image: 1963 "Design With Climate", Victor Olgyay.

Global Bio-climatic Design:

Design must first acknowledge regional, local and microclimate impacts on the building and site.



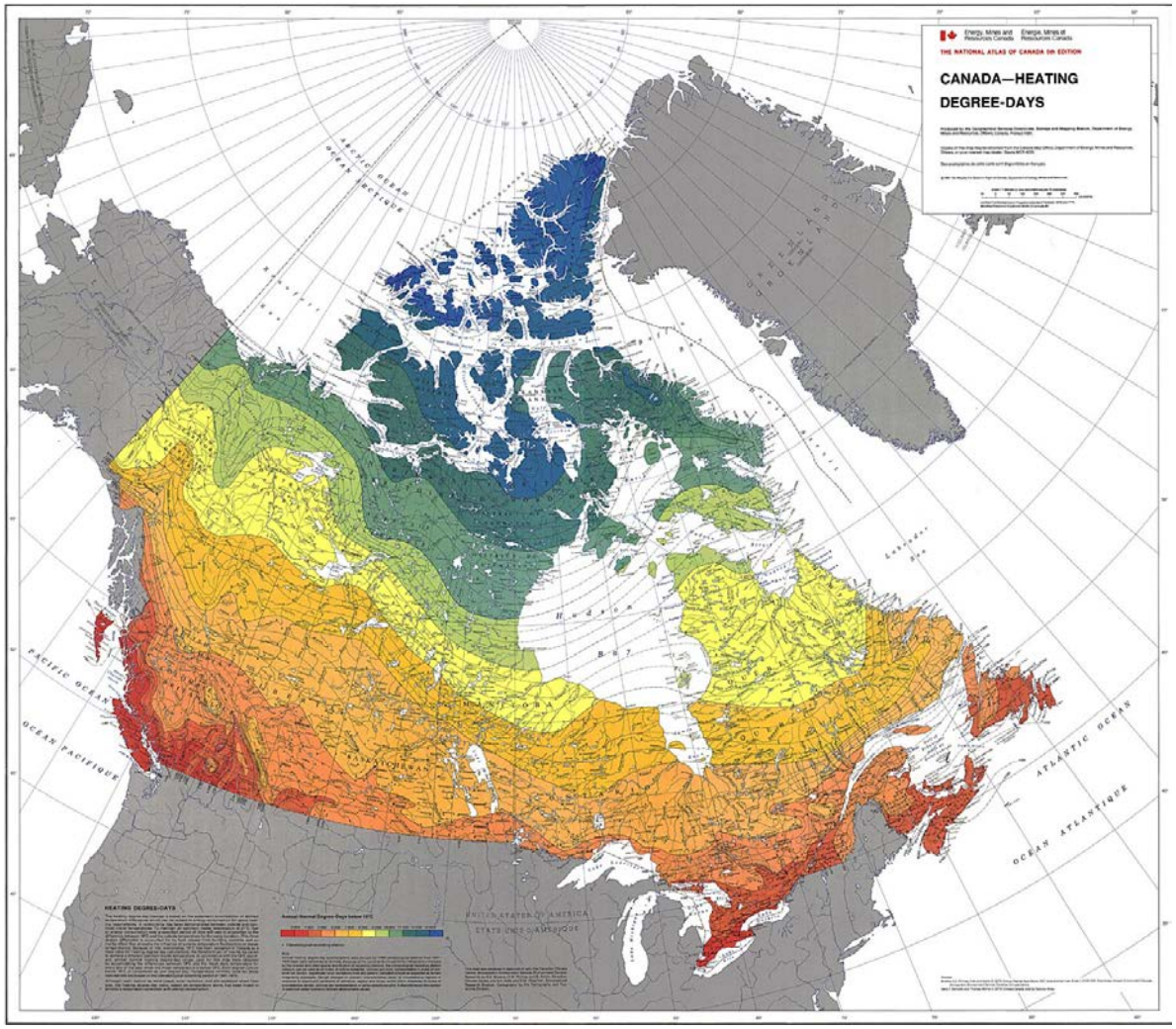
The climate regions of Canada



Climate regions of Canada.

Even within Canada, there exist variations in climate, enough to require very different envelope design practices and regulations. This mostly concerns insulation and water penetration, as well as humidity concerns.

Heating and Cooling Degree Days

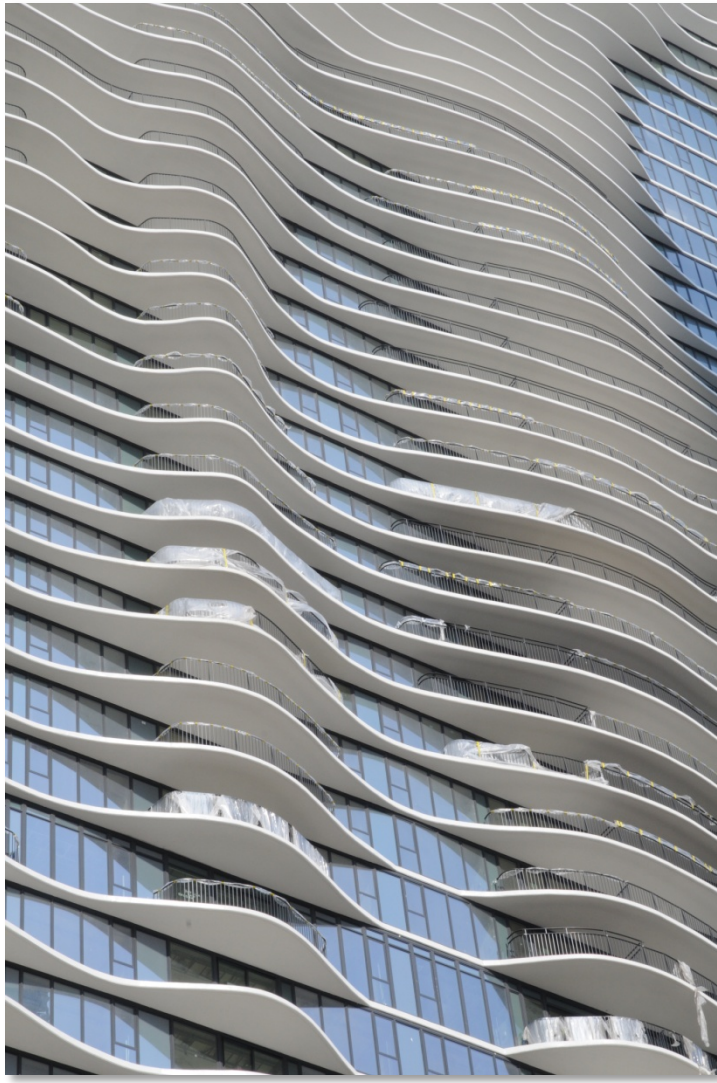


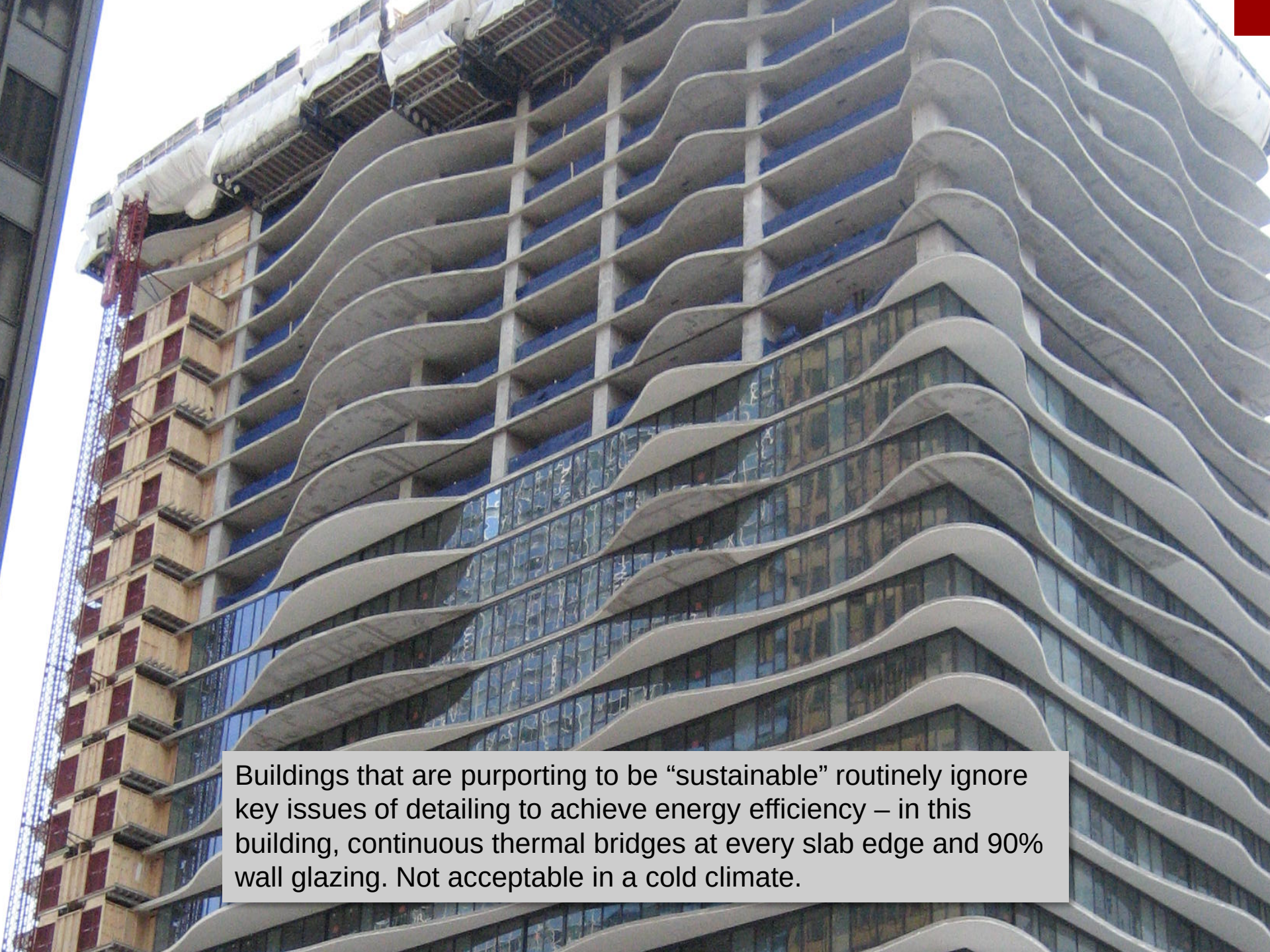
This map shows the annual sum of heating degree days (an indicator of building heating needs). Data for period 1941 to 1970.

Determine if the climate is *heating* or *cooling* dominated …this will set out your **primary strategy**.

The Controversial “Cover” of Greensource Magazine

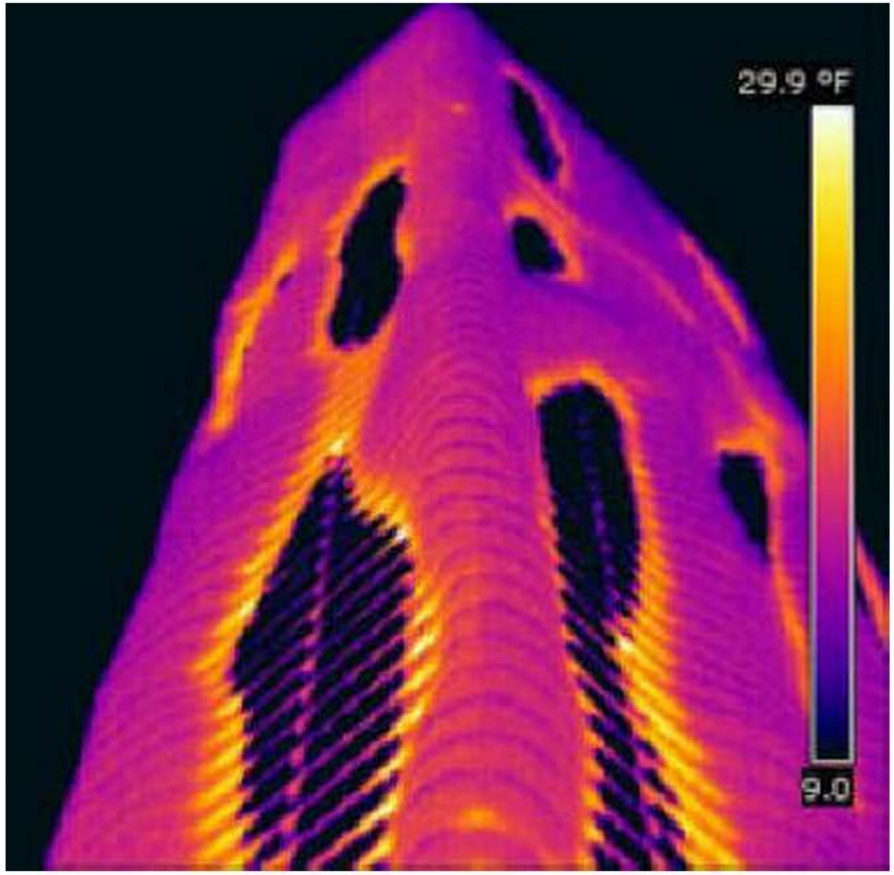
A “sustainable” Chicago residential skyscraper – going for LEED





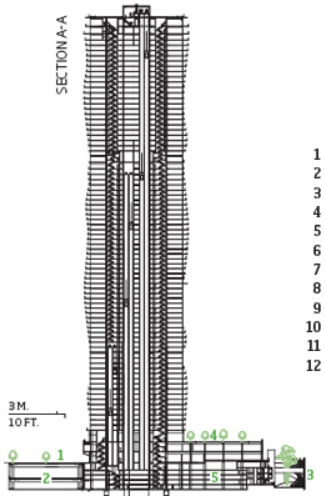
Buildings that are purporting to be “sustainable” routinely ignore key issues of detailing to achieve energy efficiency – in this building, continuous thermal bridges at every slab edge and 90% wall glazing. Not acceptable in a cold climate.

The Controversial “Cover” of Greensource Magazine



http://www.healthyheating.com/Definitions/Mean%20Radiant_pg4.htm#.VQ8iKo7F8Zs

Chicago Climate Data



1 Upper Columbus Drive
2 Lower Columbus Drive
3 Stair to Harbor Park
4 Roof garden
5 Parking
6 Living/dining room
7 Den
8 Kitchen
9 Bedroom
10 Master bedroom
11 Great room
12 Dining room

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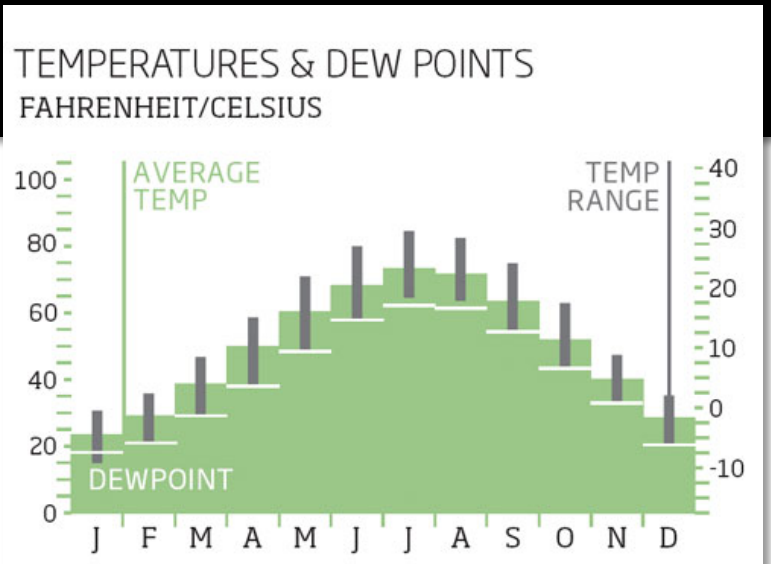
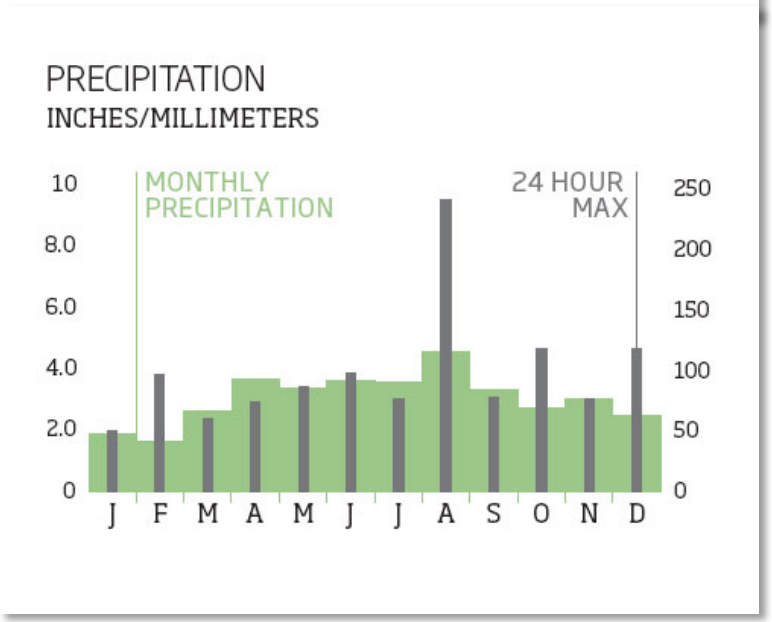
10 Master bedroom
11 Great room
12 Dining room

Heating degree days 6,479 F (3,582 C)
Cooling degree days 782F (417 C)





Solving the thermal bridge

The “classic” bad balcony detail results in heat loss as well as moisture and mold problems.

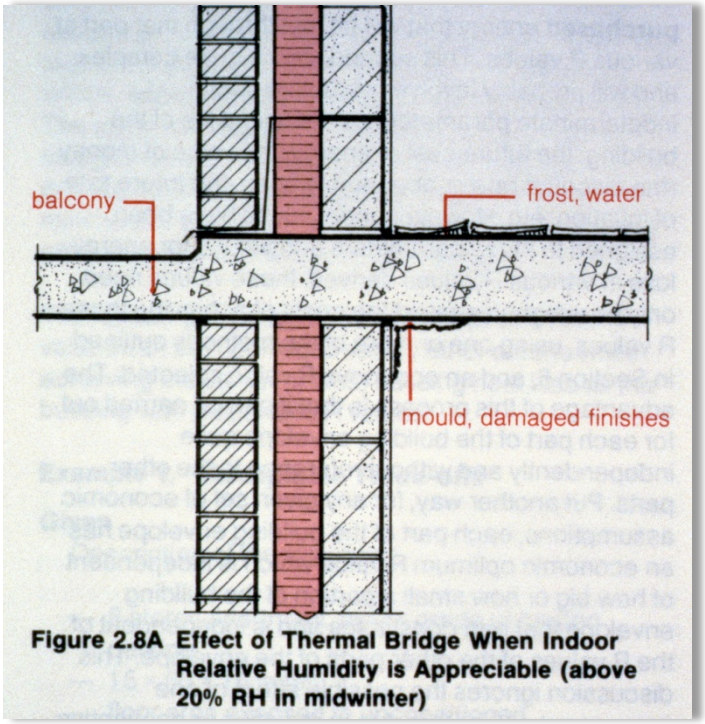
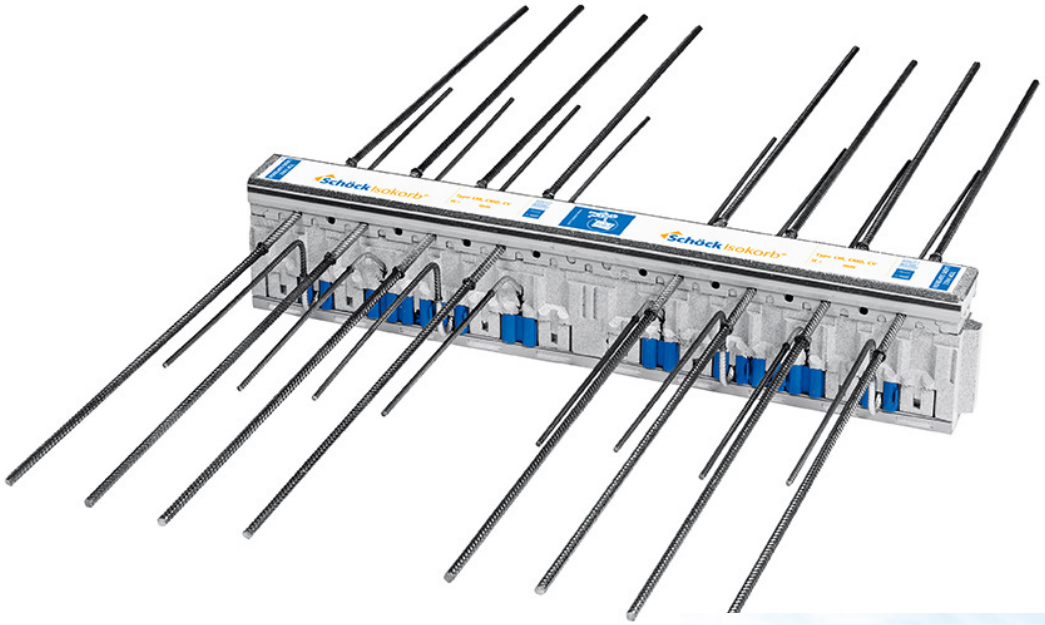


Figure 2.8A Effect of Thermal Bridge When Indoor Relative Humidity is Appreciable (above 20% RH in midwinter)

Off the Shelf Thermal Break Products



Can work if they are not “value engineered” out of the project.

Schock Isokorb

Climate - It all starts here…

In the built environment, meteorology is the start of all design …

Structural design / response

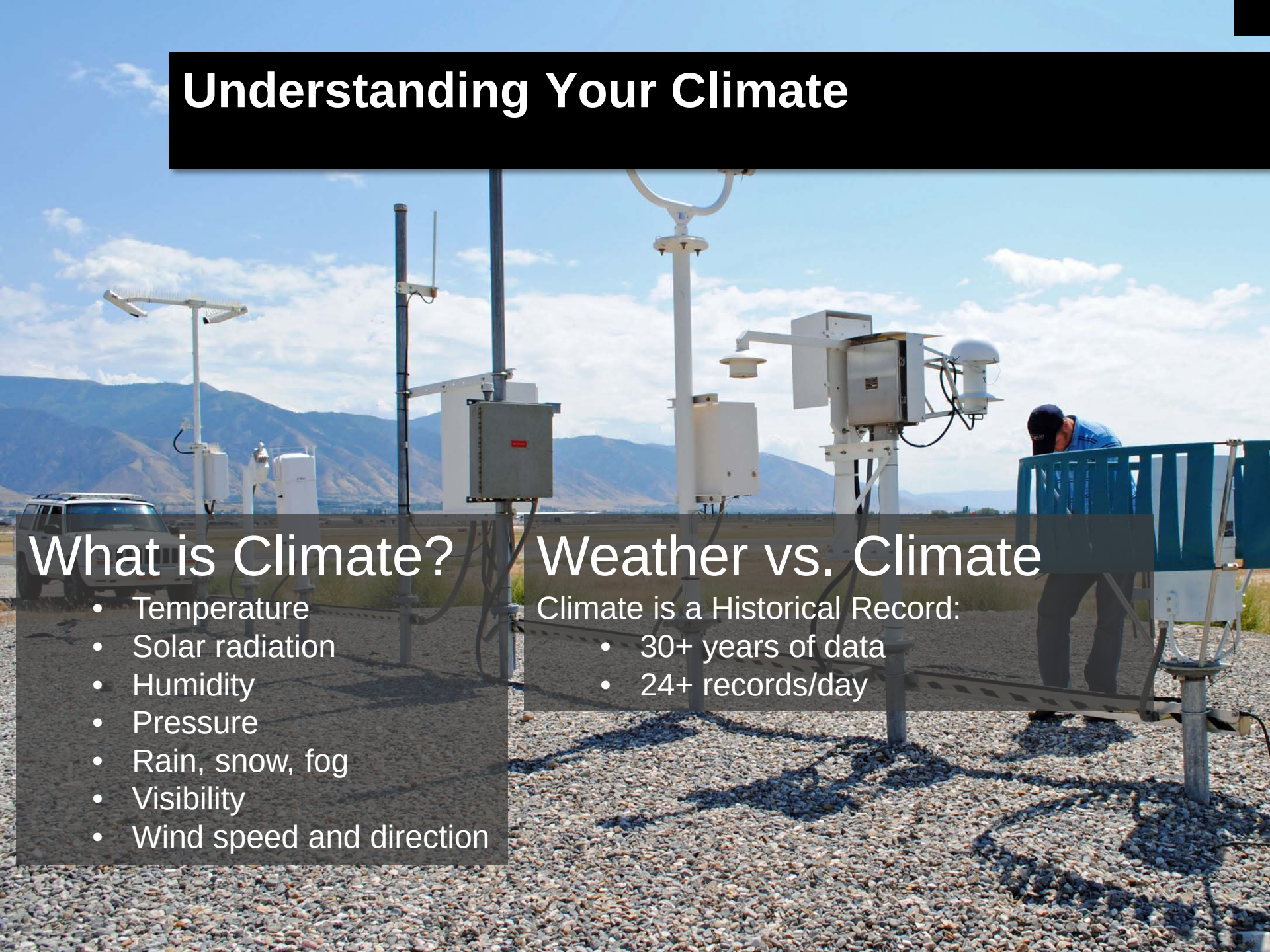
Pedestrian comfort

Air quality / plume dispersion

Energy demand / heating and cooling loads

etc.

Understanding Your Climate



What is Climate?

- 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

Climate Consultant

http://www.energy-design-tools.aud.ucla.edu/

Climate Consultant 5 is a free tool available from the above address.

You will need to download .epw climate data for your city from this website

http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm

Choose Comfort Model

- Buildings are designed for their use, occupancy or occupants
- Normally it is the people that need to be comfortable in doing their tasks, not the building
- Some uses can accommodate a much higher range of temperatures than others
- Decide if using a fully automated heating AND cooling system
- Can the building **eliminate an A/C system** due to climate?
- Can the building **use passive solar to heat** the building?
- Can the building **use passive ventilation** to cool the building?
- Can the building **take advantage of daylight** to light the building?

Choose Comfort Model

California Energy Code Comfort Model (Default)

For the purpose of sizing residential heating and cooling systems the indoor Dry Bulb Design Conditions should be between 68°F (20°C) to 75°F (23.9°C).

No Humidity limits are specified in the Code, so 80% Relative Humidity and 66°F (18.9°C) Wet Bulb is used for the upper limit and 27°F (-2.8°C) Dew Point is used for the lower limit (but these can be changed on the Criteria screen).

YOU LIKELY WANT TO SWITCH AWAY FROM THIS DEFAULT IN A COLD CLIMATE.

Choose Comfort Model

ASHRAE Handbook of Comfort Fundamentals 2005

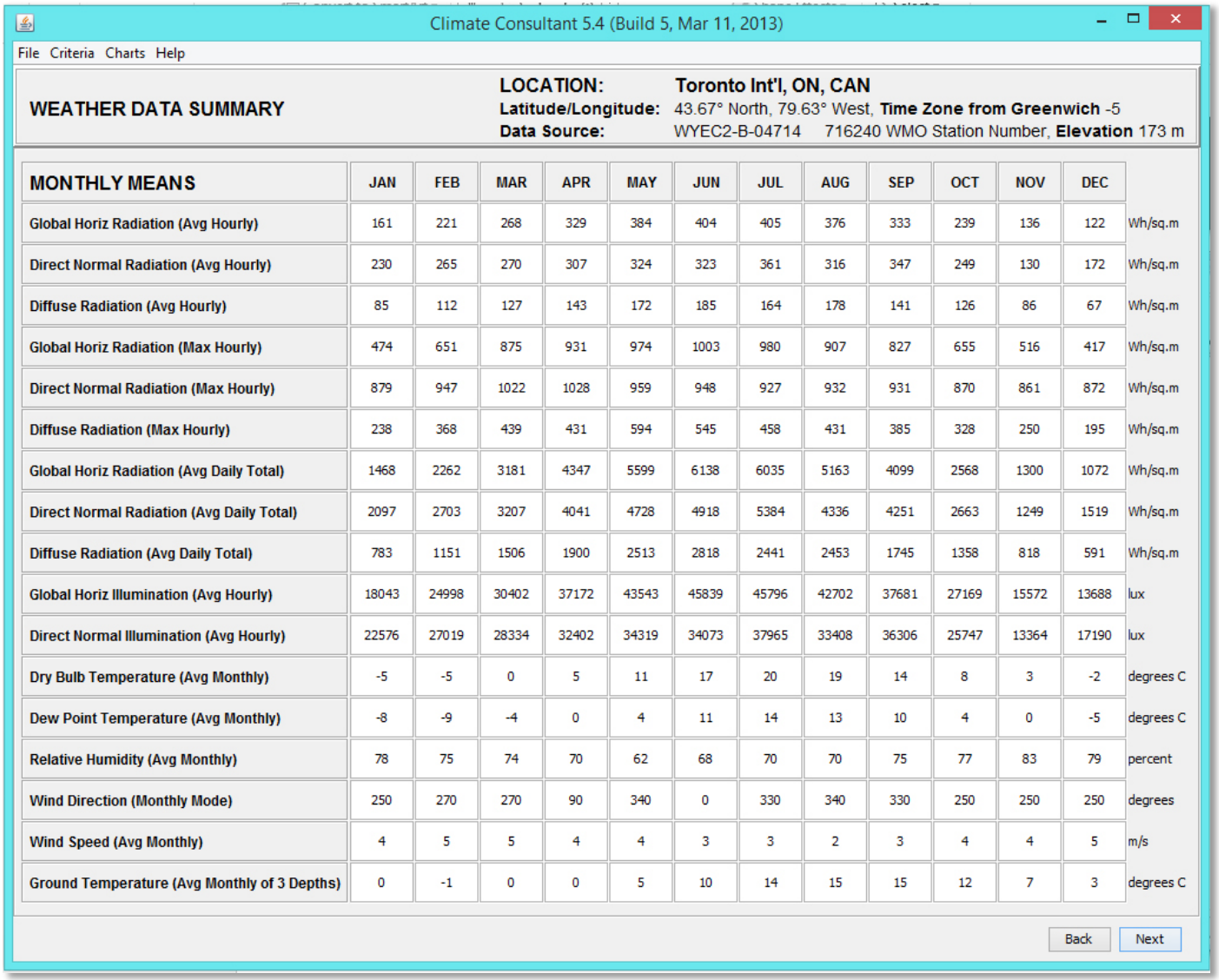
For people dressed in normal winter clothes,

Effective Temperatures of 68°F (20°C) to 74°F (23.3°C) (measured at 50% relative humidity), which means the temperatures decrease slightly as humidity rises.

The upper humidity limit is 64°F (17.8°C) Wet Bulb and a lower Dew Point of 36F (2.2°C).

If people are dressed in light weight summer clothes then this comfort zone shifts 5°F (2.8°C) warmer.

EPW Weather Data for 1000s of Locations



Climate Consultant 5.4 (Build 5, Mar 11, 2013)

File Criteria Charts Help

WEATHER DATA SUMMARY

LOCATION: **Toronto Int'l, ON, CAN**
Latitude/Longitude: 43.67° North, 79.63° West, **Time Zone from Greenwich** -5
Data Source: WYEC2-B-04714 716240 WMO Station Number, **Elevation** 173 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	161	221	268	329	384	404	405	376	333	239	136	122	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	230	265	270	307	324	323	361	316	347	249	130	172	Wh/sq.m
Diffuse Radiation (Avg Hourly)	85	112	127	143	172	185	164	178	141	126	86	67	Wh/sq.m
Global Horiz Radiation (Max Hourly)	474	651	875	931	974	1003	980	907	827	655	516	417	Wh/sq.m
Direct Normal Radiation (Max Hourly)	879	947	1022	1028	959	948	927	932	931	870	861	872	Wh/sq.m
Diffuse Radiation (Max Hourly)	238	368	439	431	594	545	458	431	385	328	250	195	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	1468	2262	3181	4347	5599	6138	6035	5163	4099	2568	1300	1072	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	2097	2703	3207	4041	4728	4918	5384	4336	4251	2663	1249	1519	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	783	1151	1506	1900	2513	2818	2441	2453	1745	1358	818	591	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	18043	24998	30402	37172	43543	45839	45796	42702	37681	27169	15572	13688	lux
Direct Normal Illumination (Avg Hourly)	22576	27019	28334	32402	34319	34073	37965	33408	36306	25747	13364	17190	lux
Dry Bulb Temperature (Avg Monthly)	-5	-5	0	5	11	17	20	19	14	8	3	-2	degrees C
Dew Point Temperature (Avg Monthly)	-8	-9	-4	0	4	11	14	13	10	4	0	-5	degrees C
Relative Humidity (Avg Monthly)	78	75	74	70	62	68	70	70	75	77	83	79	percent
Wind Direction (Monthly Mode)	250	270	270	90	340	0	330	340	330	250	250	250	degrees
Wind Speed (Avg Monthly)	4	5	5	4	4	3	3	2	3	4	4	5	m/s
Ground Temperature (Avg Monthly of 3 Depths)	0	-1	0	0	5	10	14	15	15	12	7	3	degrees C

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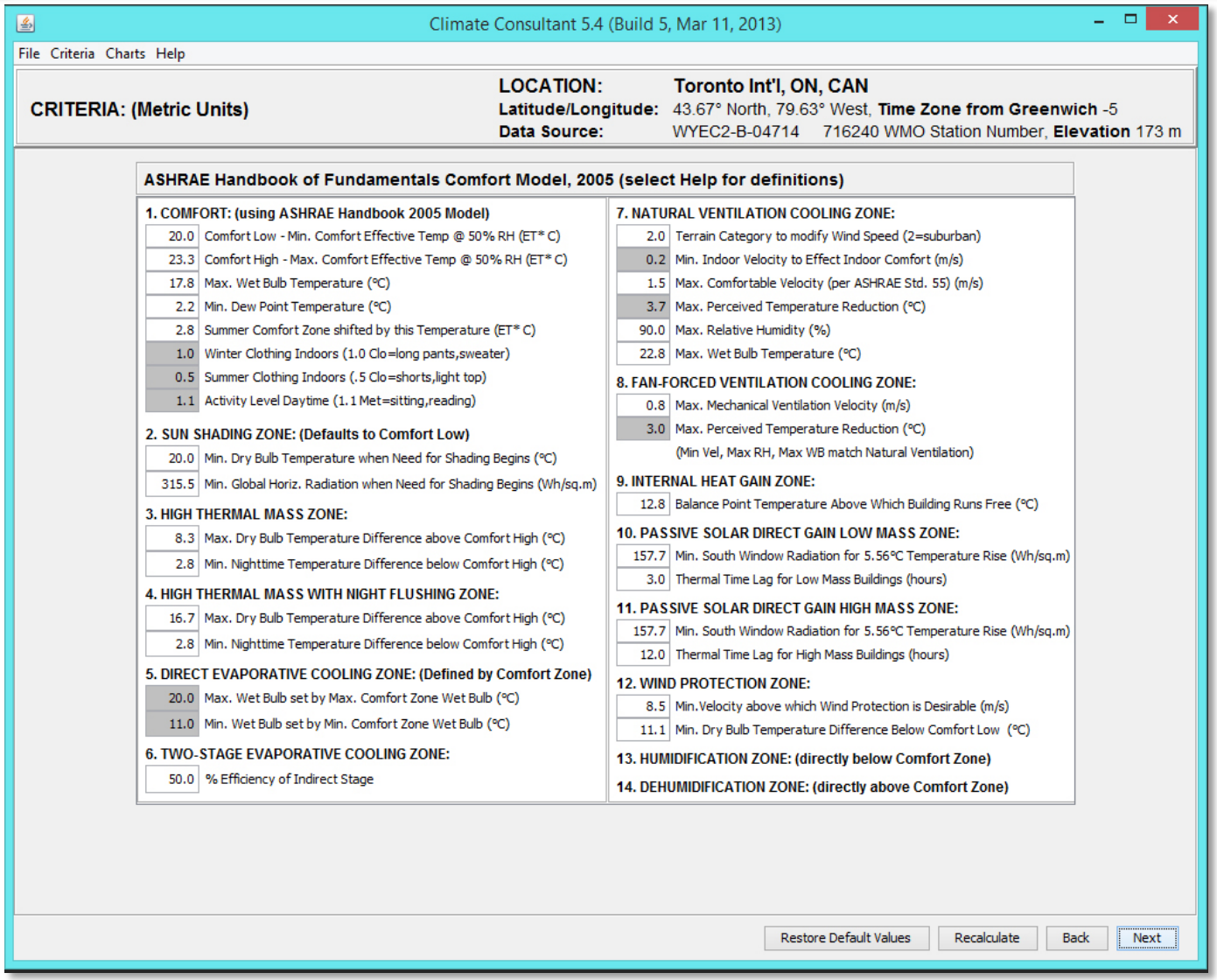
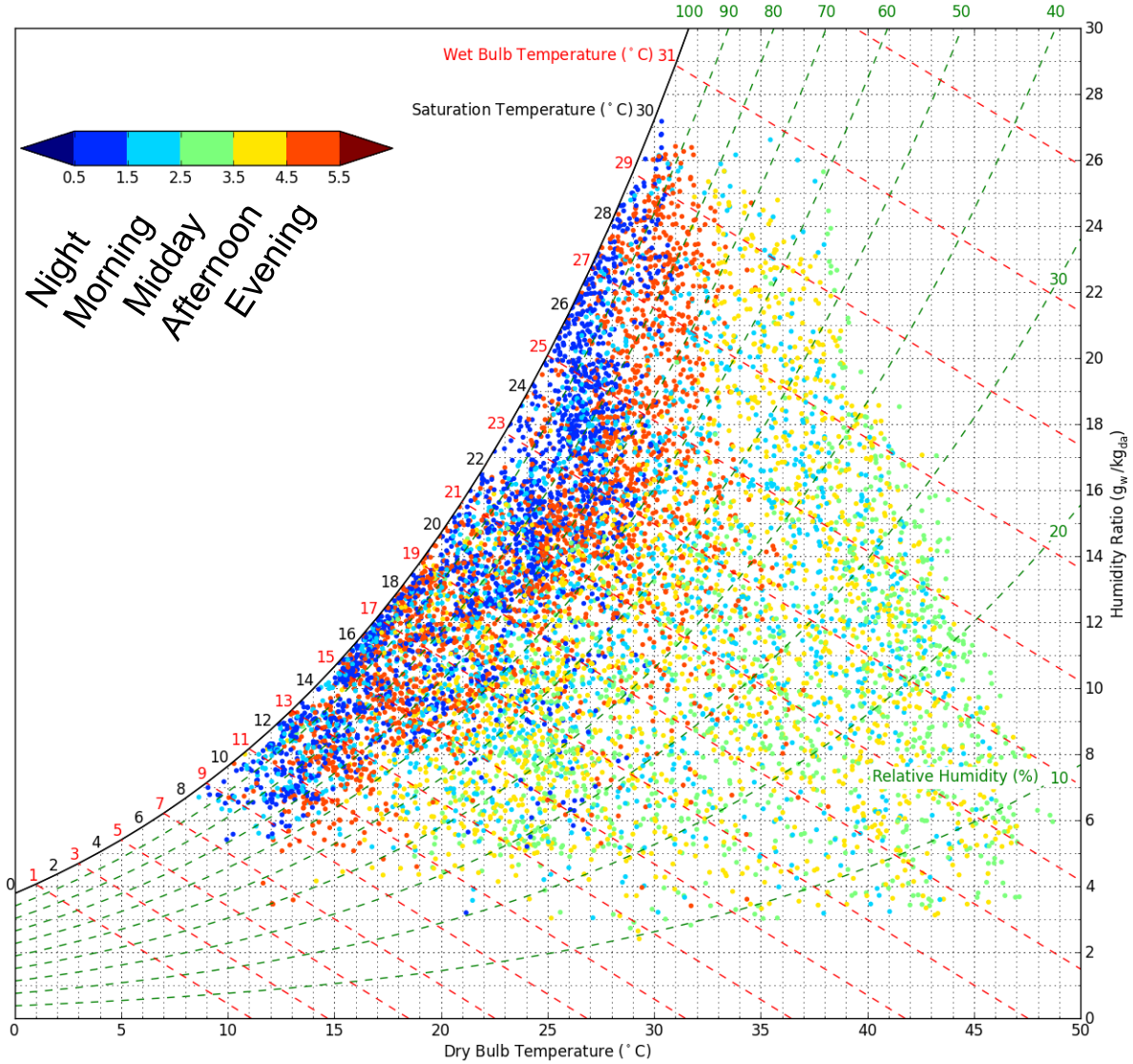
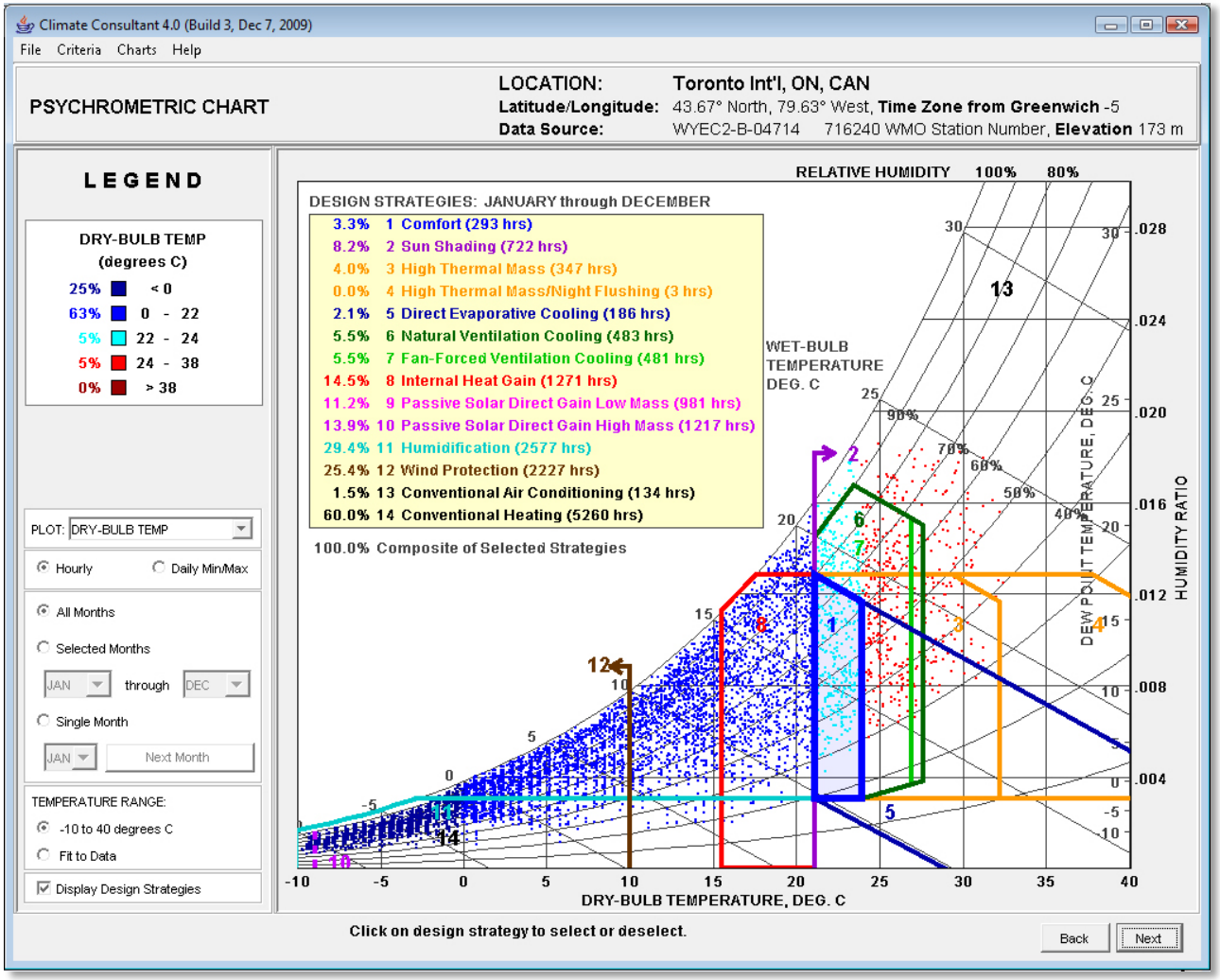
Setting the Project Criteria



The Psychrometric Chart

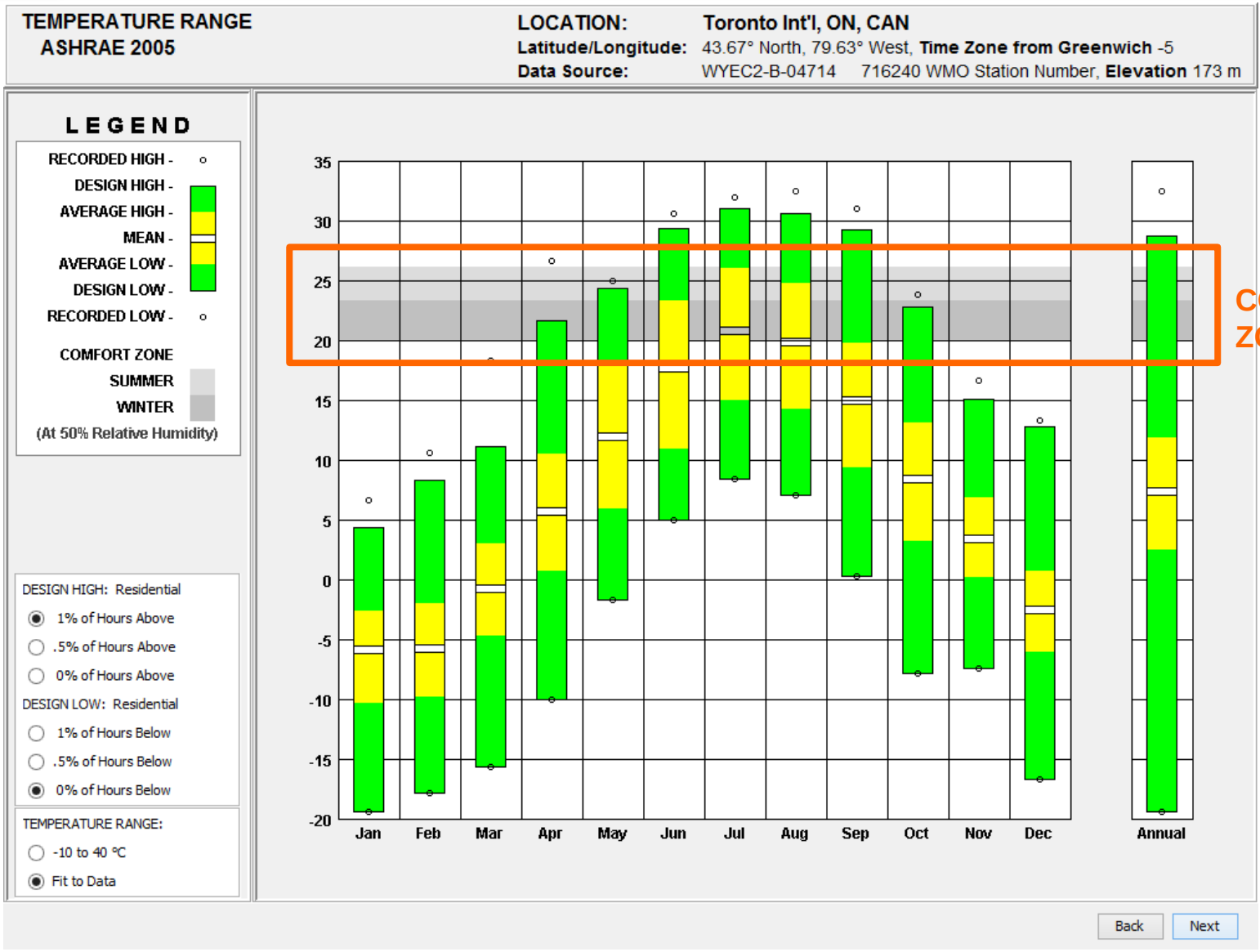


Psychrometric Chart

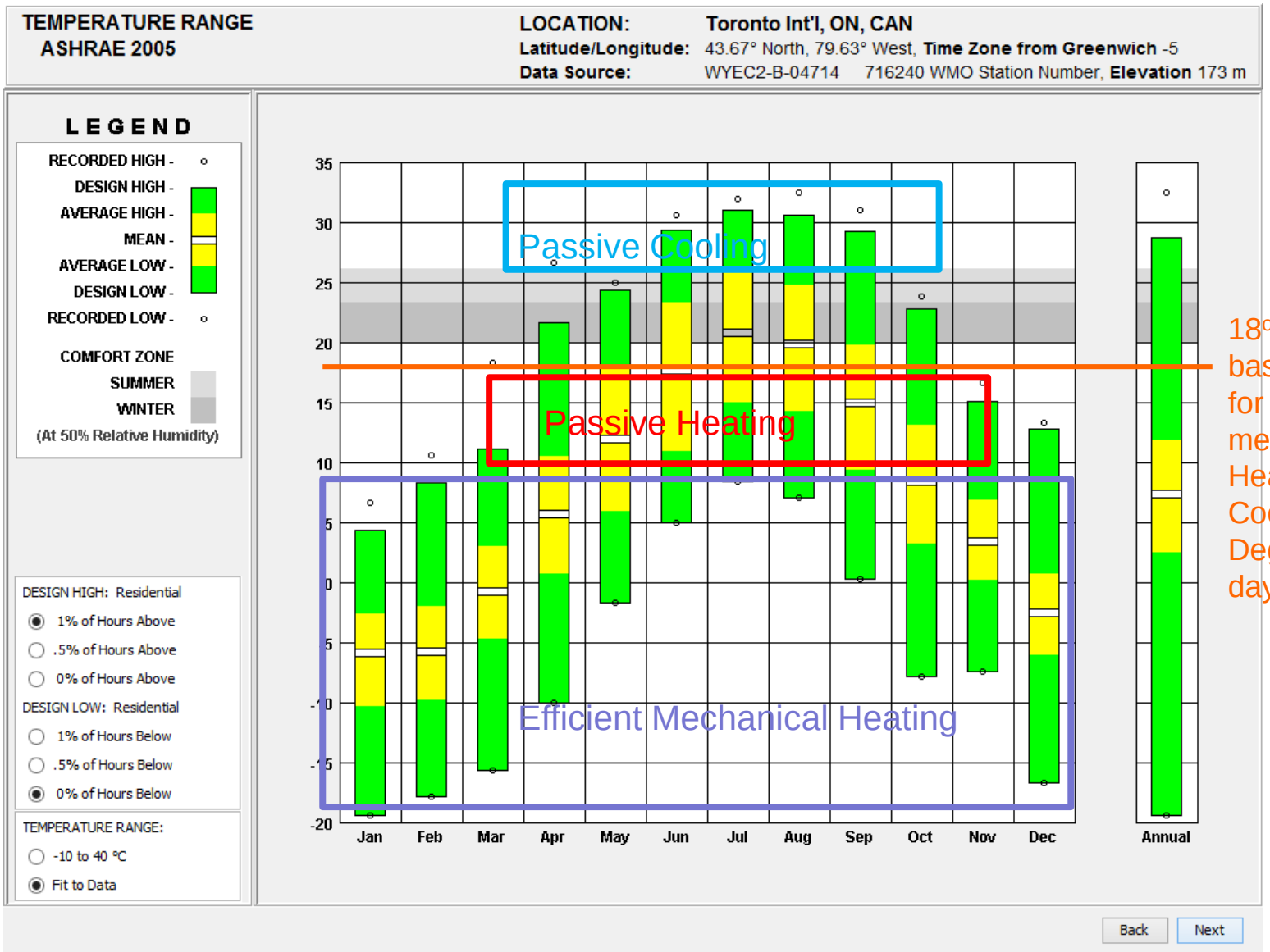


The chart helps to identify climate based strategies to achieve comfort.

Climate Data for Toronto

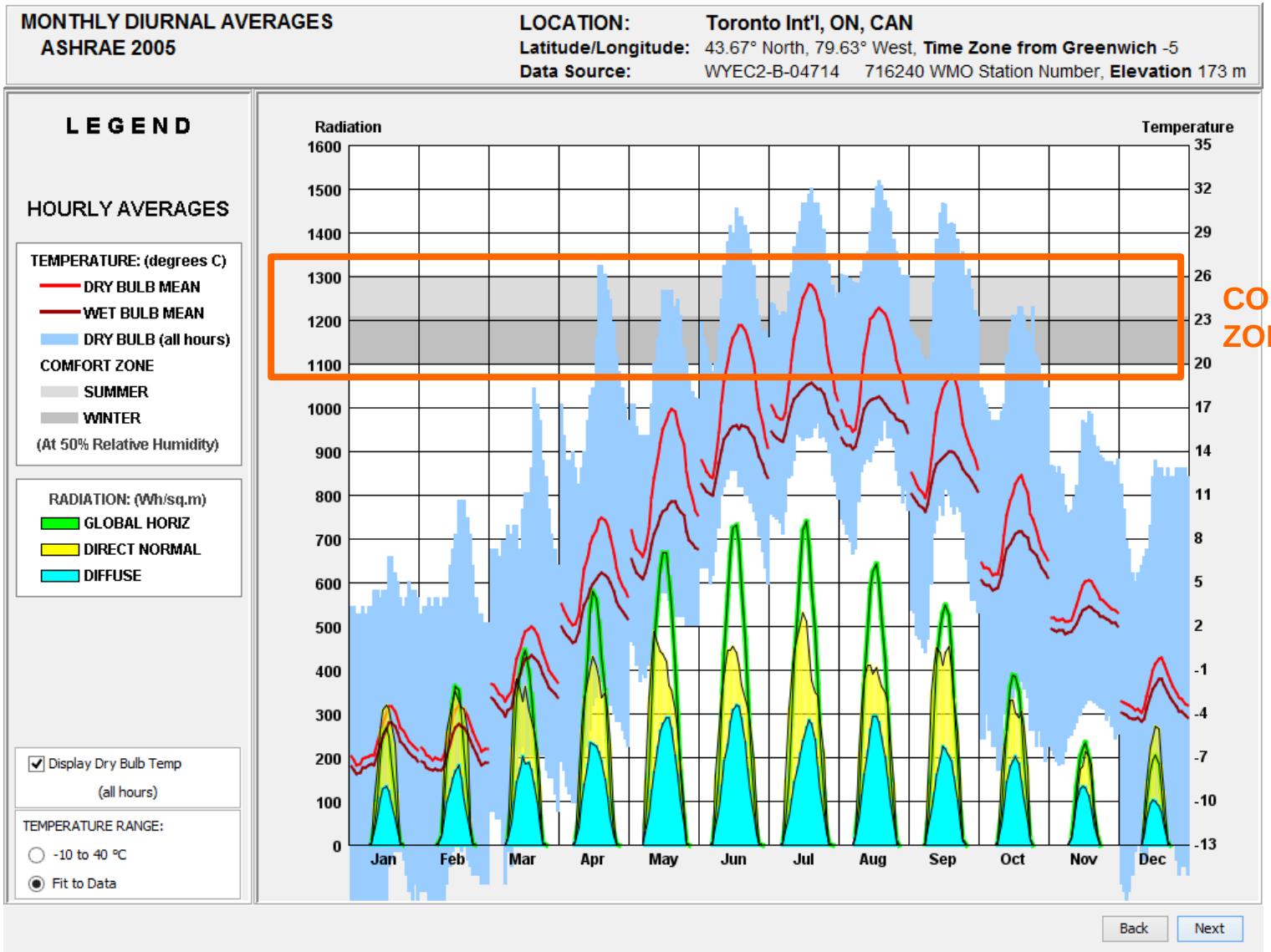


Climate Data for Toronto



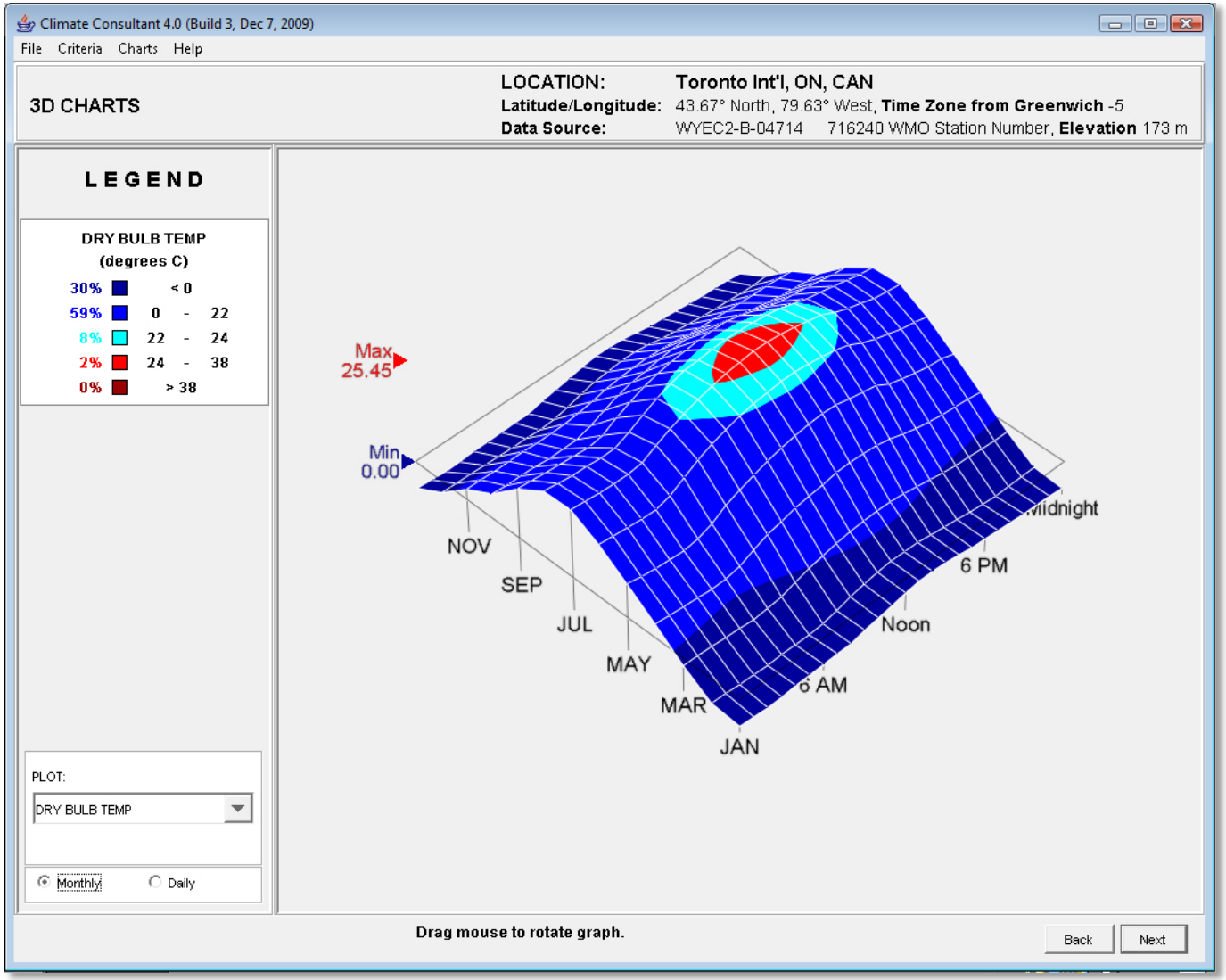
18°C is the base point for measuring Heating vs Cooling Degree days

Climate Data for Toronto

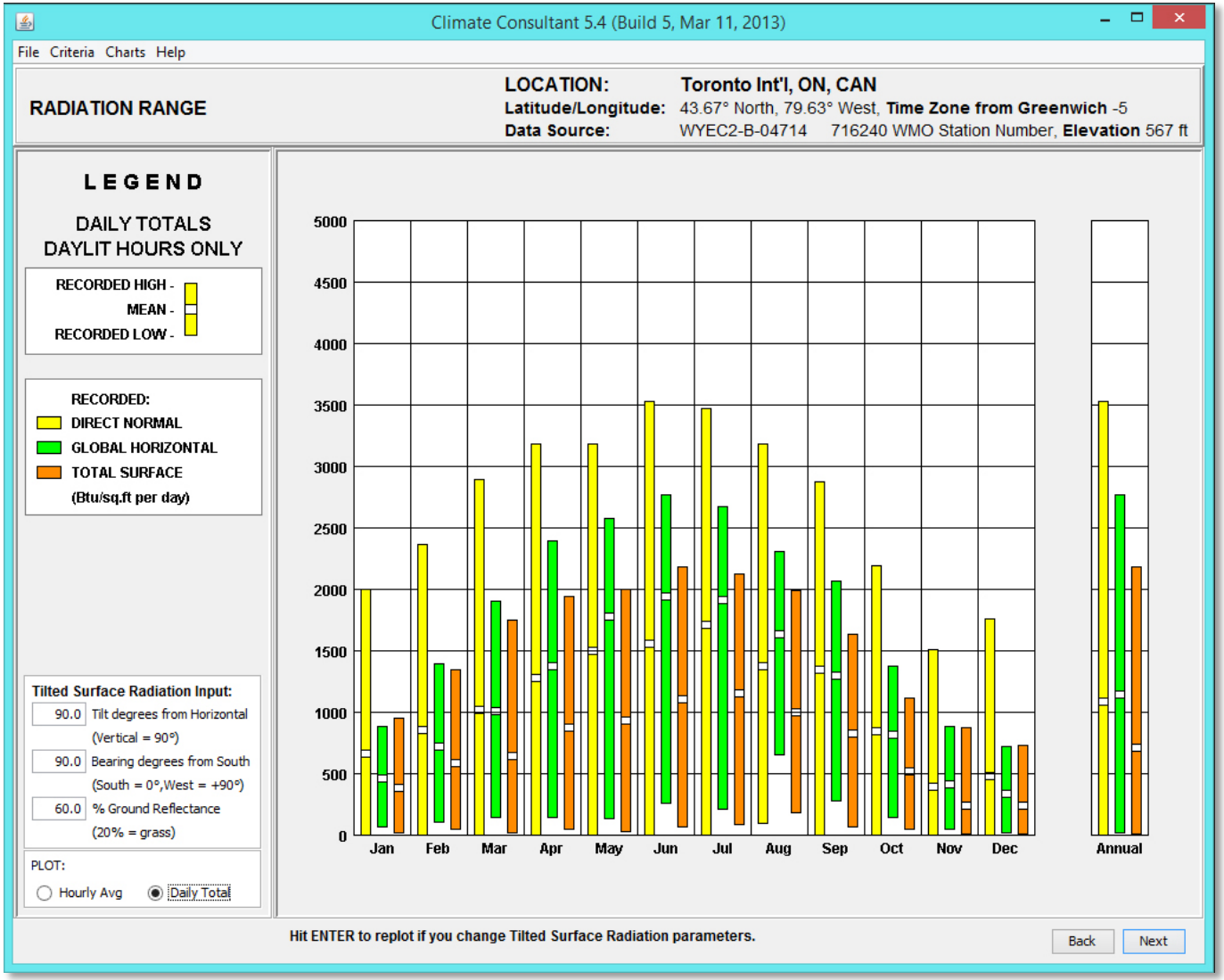


COMFORT ZONE

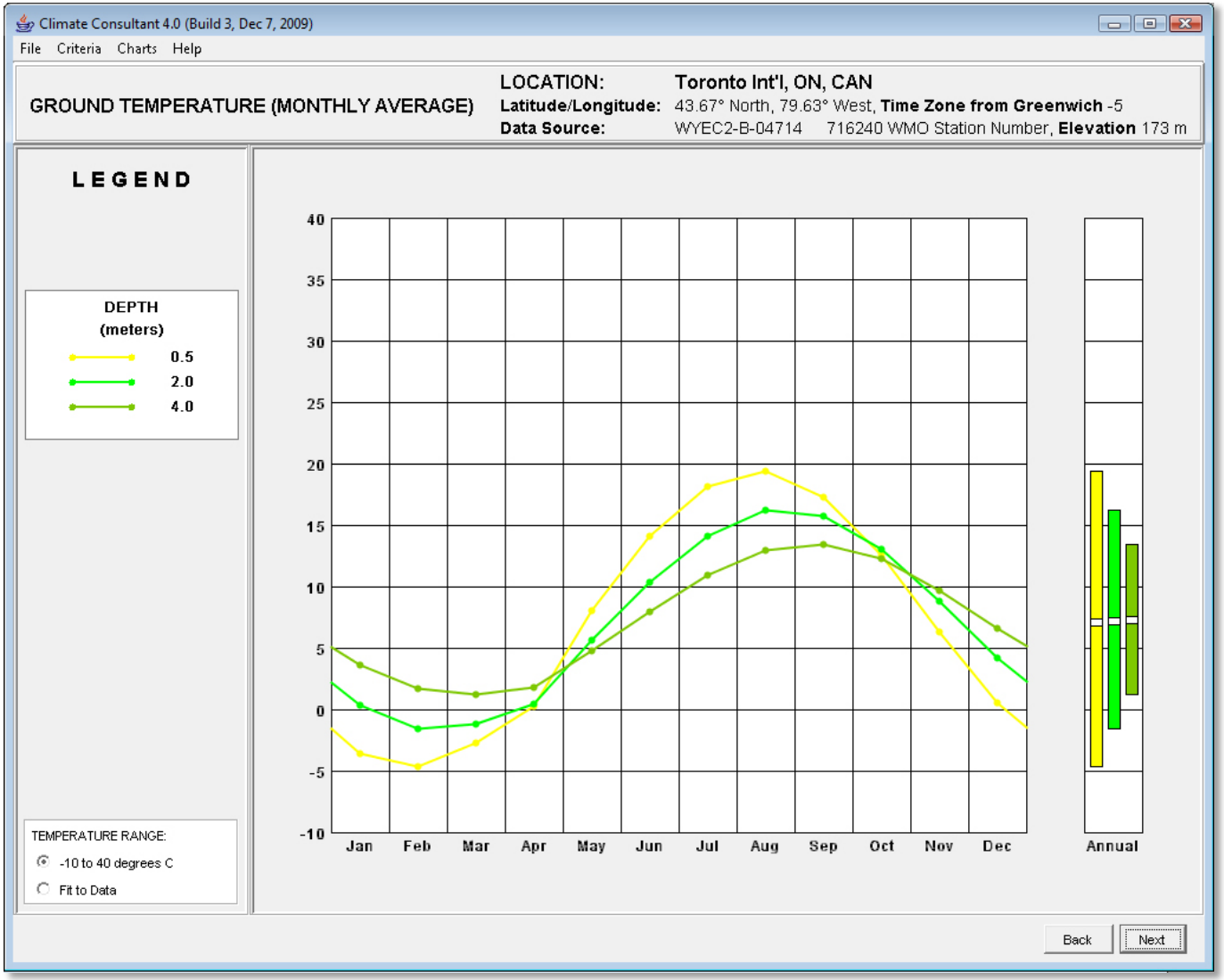
Temperature Range for Toronto



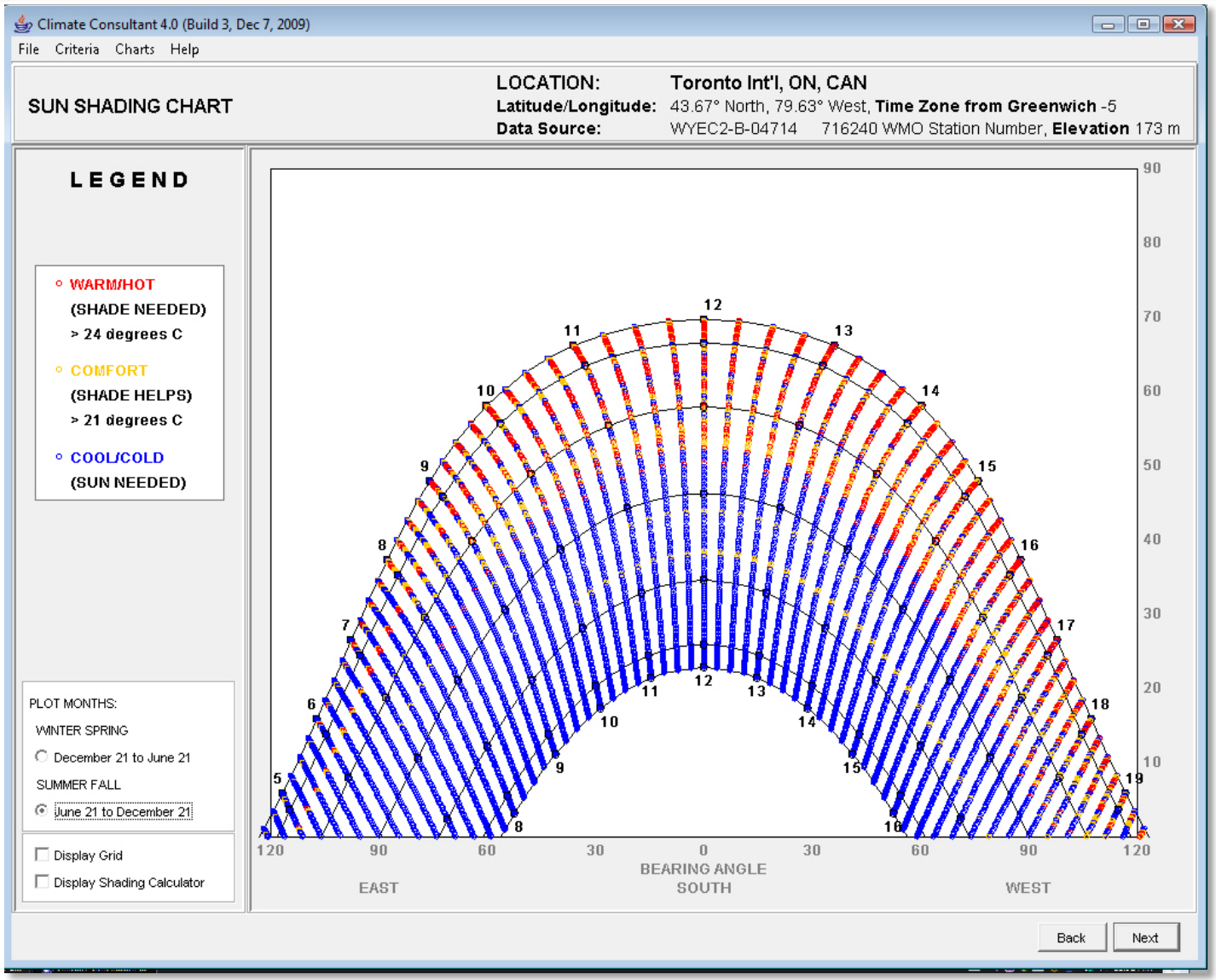
Toronto Solar Radiation Range



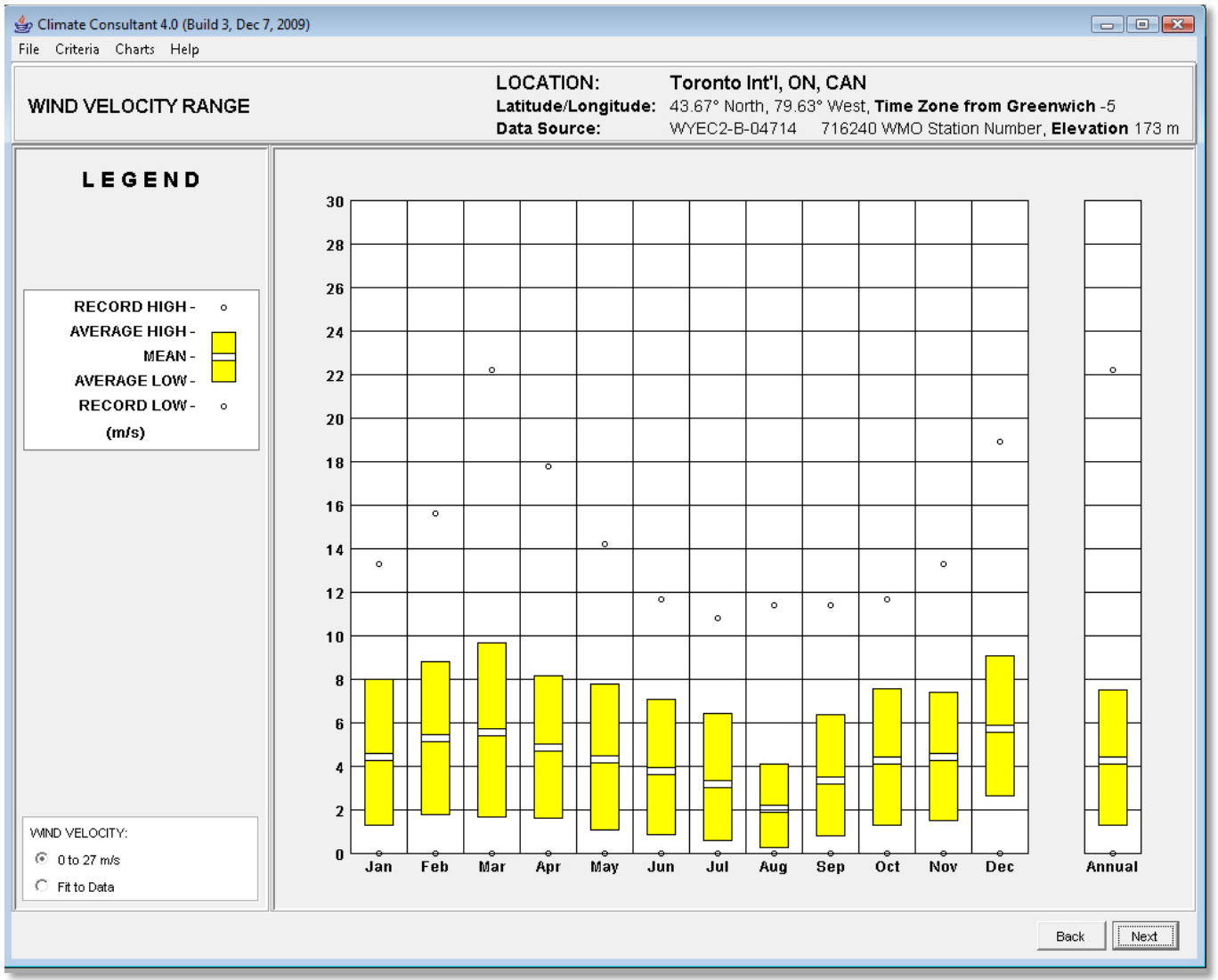
Ground Temperature for Toronto



Sun Shading Chart



Wind Speed


Climate Consultant 4.0 (Build 3, Dec 7, 2009)
File Criteria Charts Help
WIND VELOCITY RANGE
LOCATION: Toronto Int'l, ON, CAN
Latitude/Longitude: 43.67° North, 79.63° West, Time Zone from Greenwich -5
Data Source: WYEC2-B-04714 716240 WMO Station Number, Elevation 173 m
LEGEND
RECORD HIGH -
AVERAGE HIGH -
MEAN -
AVERAGE LOW -
RECORD LOW -
(m/s)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Annual
WIND VELOCITY:
0 to 27 m/s
Fit to Data
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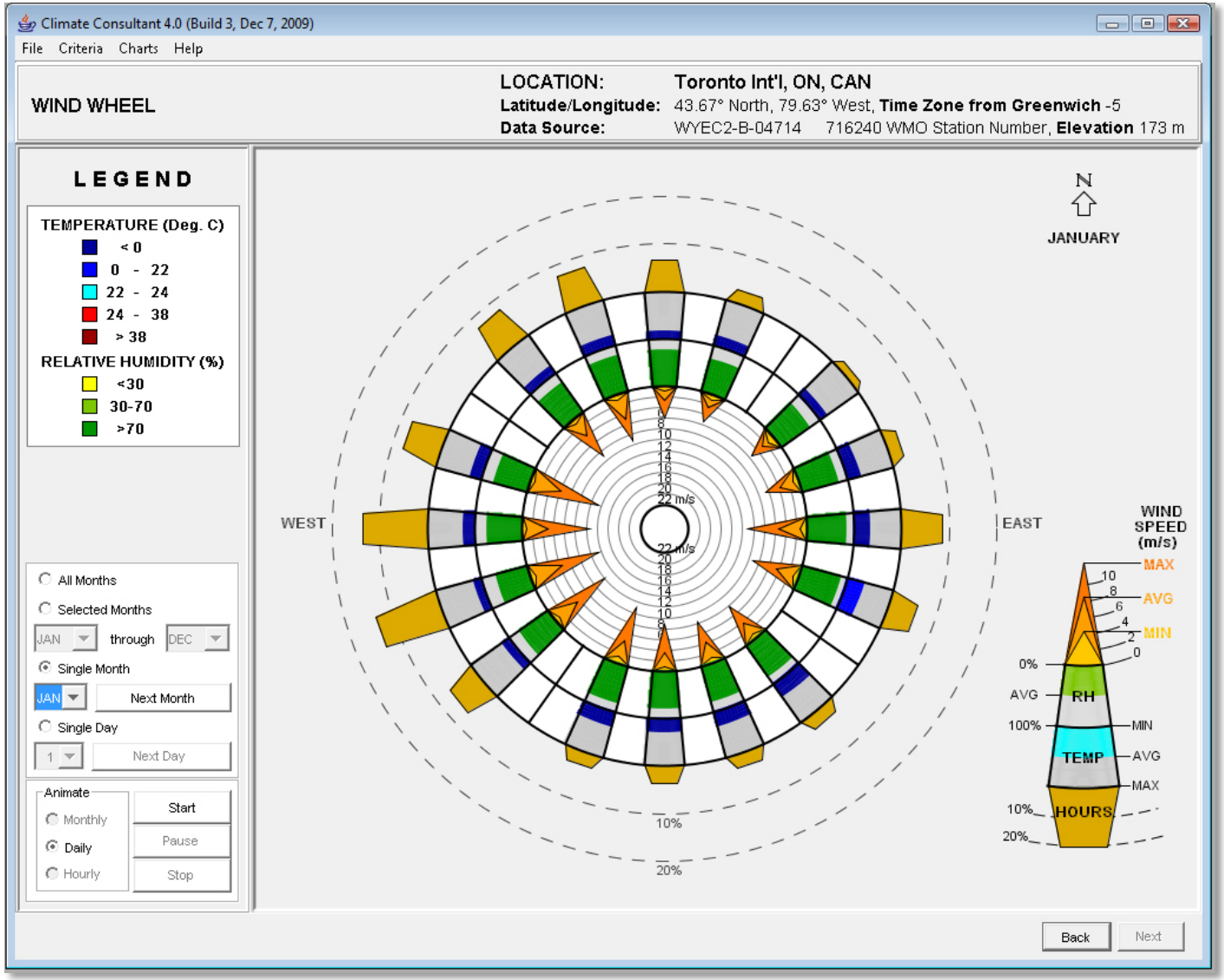
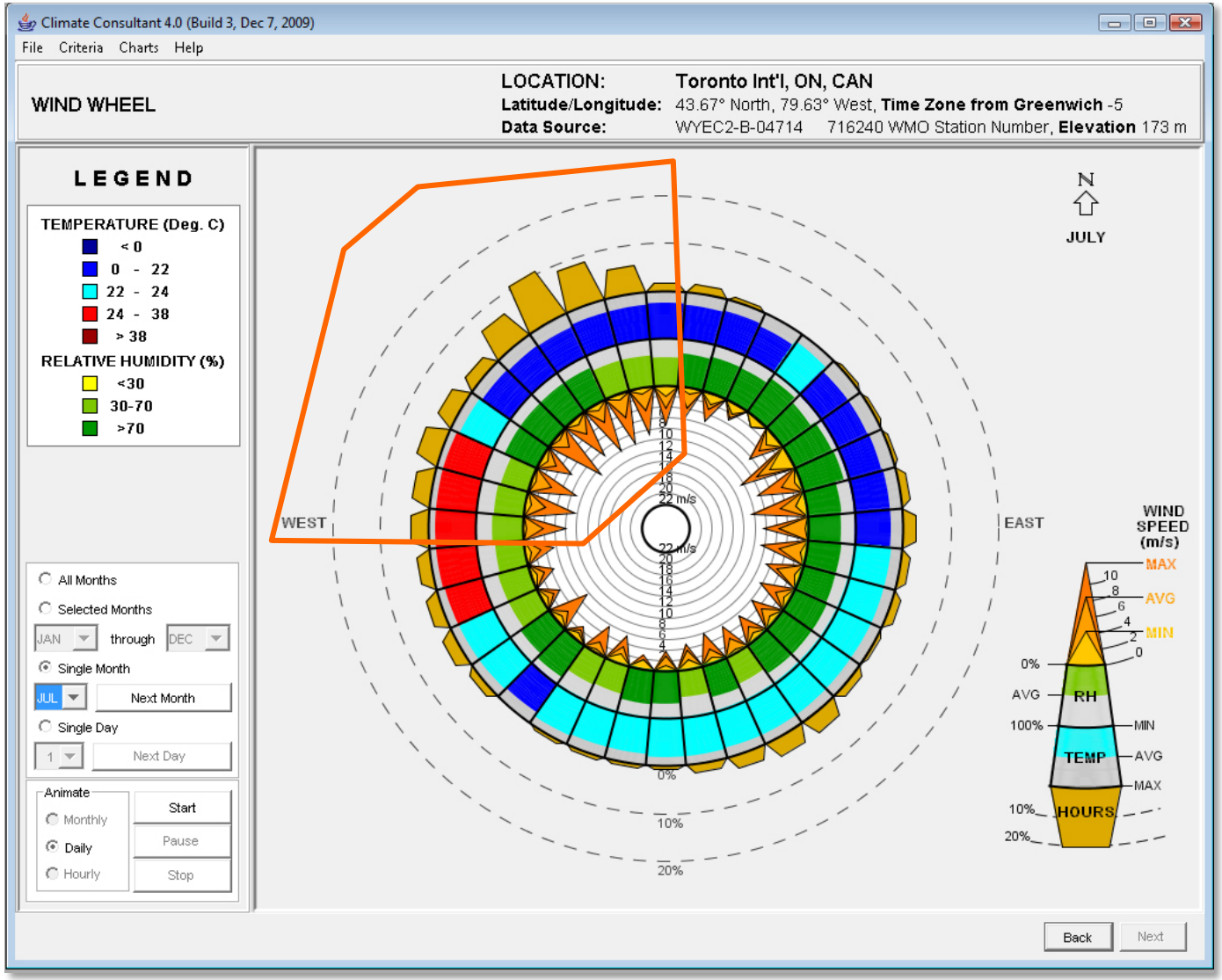
January Wind Wheel/Rose for Toronto



July Wind Wheel/Rose for Toronto



September Wind Wheel/Rose for Toronto