BUILDING RESILIENCY

It's not just a MECHANICAL issue

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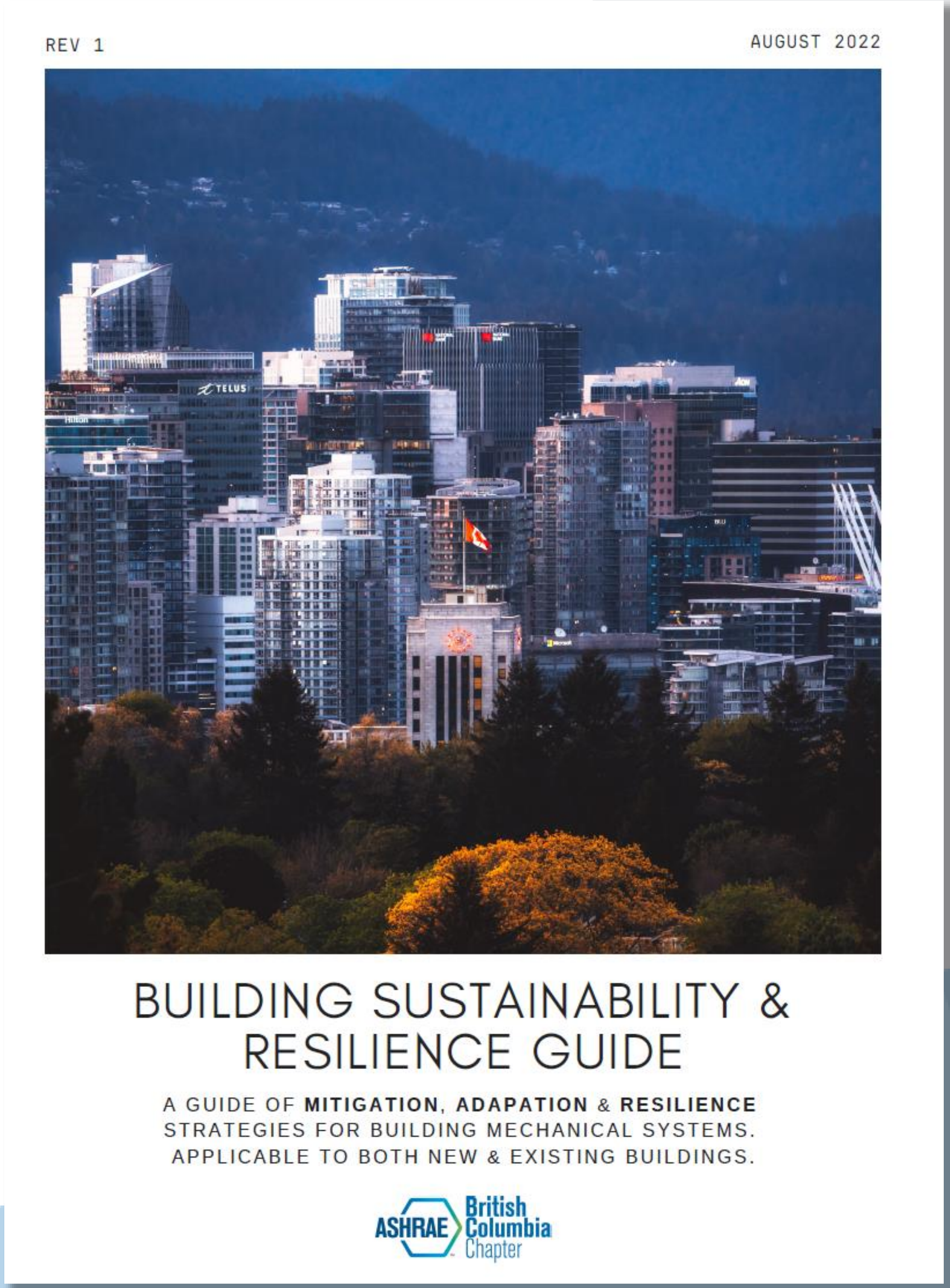
Agenda

- Resiliency and why it matters?
- Energy targets
- Mechanical Design Fundamentals
- Design for the Future

What is RESILIENCY?

Resiliency is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events, including:

- Increasing outdoor air temperatures
- Decreased outdoor air temperatures
- Ventilation and air quality
- Controls



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Key Metrics

TEDI = Thermal Energy Demand Index (heating load)

TEUI = Total Energy Use Index

Overheating Hours = 200 (or 20 for vulnerable groups) hours limit per year

GHGI = Greenhouse Gas Index

BC Building Code Targets

Performance Limits Step Code Step 3, Climate Zone 4		
Building Type	TEUI (kWh/m^2)	TEDI (kWh/m^2)
Residential	120	30
Office	100	20
Business / Mercantile	120	20

From BC Building Code 2018, Part 10

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Local Extreme Climate Events

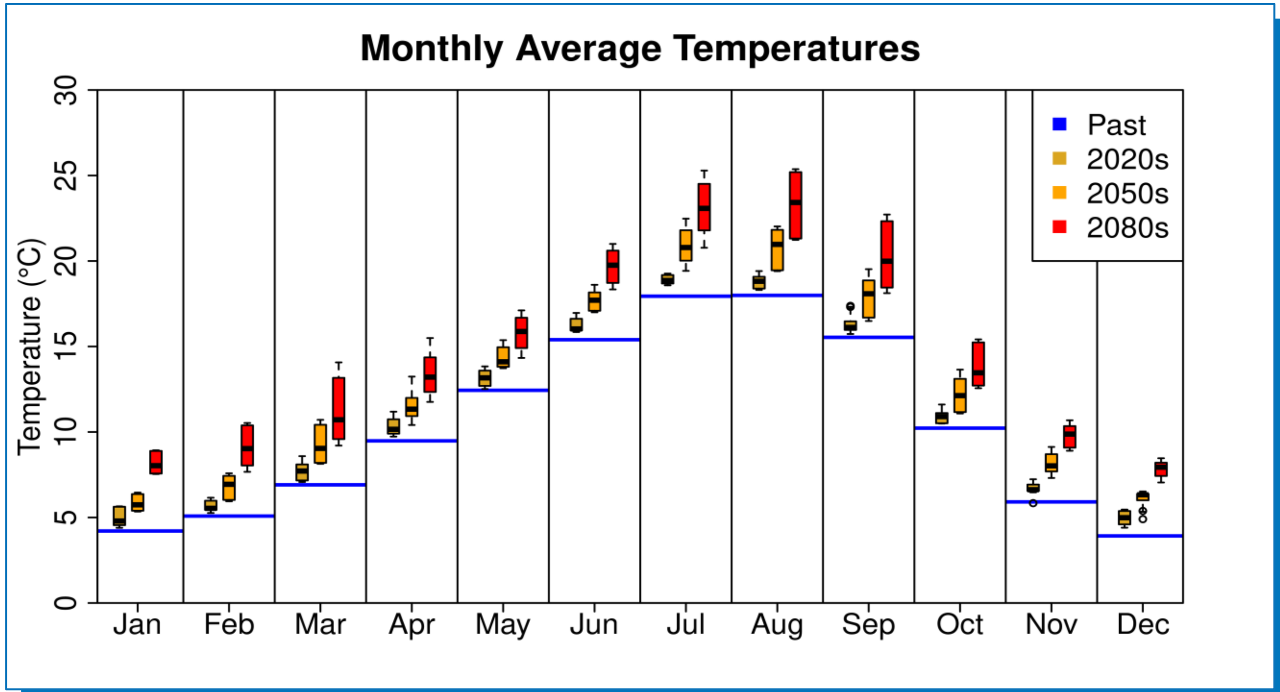
Lytton 49.5C – June 2021

Abbotsford 5411mm Rainfall – November 2021

Vancouver Tornado – November 2021

Vancouver worst air quality globally – August 2021

Future Weather Data



- Energy models currently use CWEC 2016 which is an average of the weather data 10 years prior. Future weather data available from PCIC
- Thermal comfort studies can be used for code compliance or expected future operating conditions
- Projected future weather data is well below the extreme temperatures experienced from June to August in 2021 and 2022

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Local Extreme Climate Events

Peak temperatures recorded during the 2021 heat dome:

- **Vancouver: 32.4°C**
- **Victoria: 39.4°C**
- **Calgary: 36.3°C**
- **Edmonton: 33.7°C**

Increasing temperatures overlap with wildfire season in BC and Alberta, and natural ventilation will not always be a viable option to cool spaces

Responses to Extreme Weather

Climate Emergency

Approximately 30 municipalities in BC have declared a climate emergency

https://raog.ca/climate-emergency-declarations-canada/

Vancouver Cooling Policy

City of Vancouver is proposing requirement for mechanical cooling for all residential buildings (taller than three stories or larger than 600 m2) by 2025

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Changing Code Targets

BC Building Code (BCBC), Proposed Jan 1, 2023:

Table 10.2.3.3.-H
Energy Performance Requirements for Other Residential Occupancies
Forming part of Sentences 10.2.3.3.(1) and (2)

Degree-Days Below 18ºC	Step	Equipment and Systems – Maximum Total Energy Use Intensity, kWh/(m²•year)	*Building* Envelope – Maximum Thermal Energy Demand Intensity, kWh/(m²•year)
Less than 3000	1	~~Conform to Part 8 of the NECB~~ Reserved	
	2	130	45
	3	120	30
	4	100	15
3000 to 3999	1	~~Conform to Part 8 of the NECB~~ Reserved	
	2	130	45
	3	120	35
	4	110	22
4000 to 4999	1	~~Conform to Part 8 of the NECB~~ Reserved	
	2	135	50
	3	120	35
	4	110	22
5000 to 5999	1	~~Conform to Part 8 of the NECB~~ Reserved	
	2	135	55
	3	120	40
	4	110	22
6000 to 6999	1	~~Conform to Part 8 of the NECB~~ Reserved	
	2	150	60
	3	140	50
	4	125	35
Greater than 6999	1	~~Conform to Part 8 of the NECB~~ Reserved	
	2	180	90
	3	160	75
	4	140	60

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https://www2.gov.bc.ca/gov/content/industry/construction-industry/building-codes-standards/bc-codes/public-review

MECHANICAL DESIGN

THE FUNDAMENTALS

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Building Performance Factors

TEDI

- Envelope assembly thermal performance (wall, window, roof)
- Building massing, shading, & window extent
- Airtightness
- HRV/ ERV recovery efficiency
- Mechanical outdoor airflow rates (ventilation)

TEUI

All the above, plus:

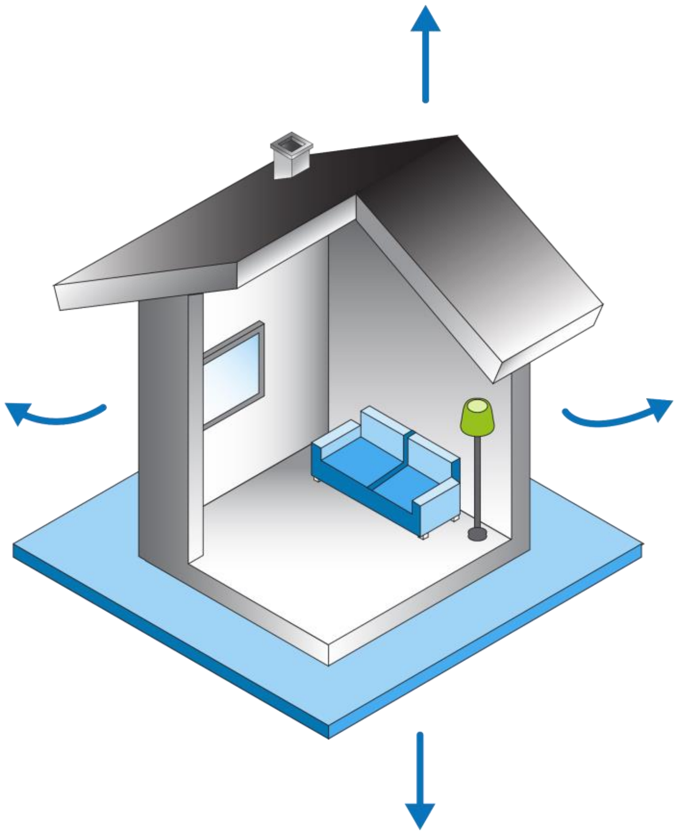
- Mechanical system efficiencies (fans, heating & cooling equipment, pumps)
- Lighting
- Plug loads & appliances

GHGI

All the above, plus:

- Fuel source emission factor
- Future: refrigerant

TEDI – Heating Loads

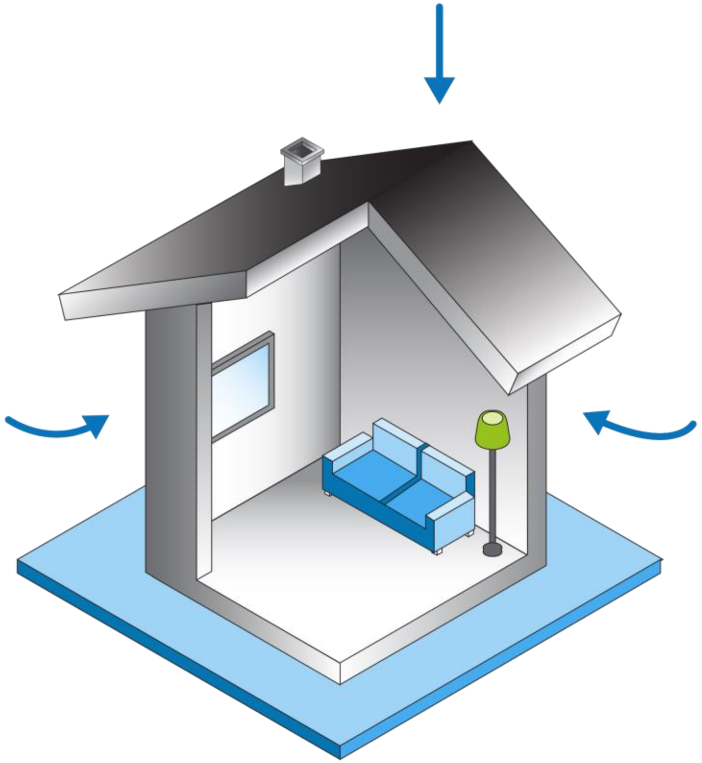


$$Q = U \times A \times (T1 - T2)$$

Q = Amount of heat required

U = envelope performance
A = surface area
T1 = outside temperature
T2 = desired inside temperature

TEDI - Infiltration

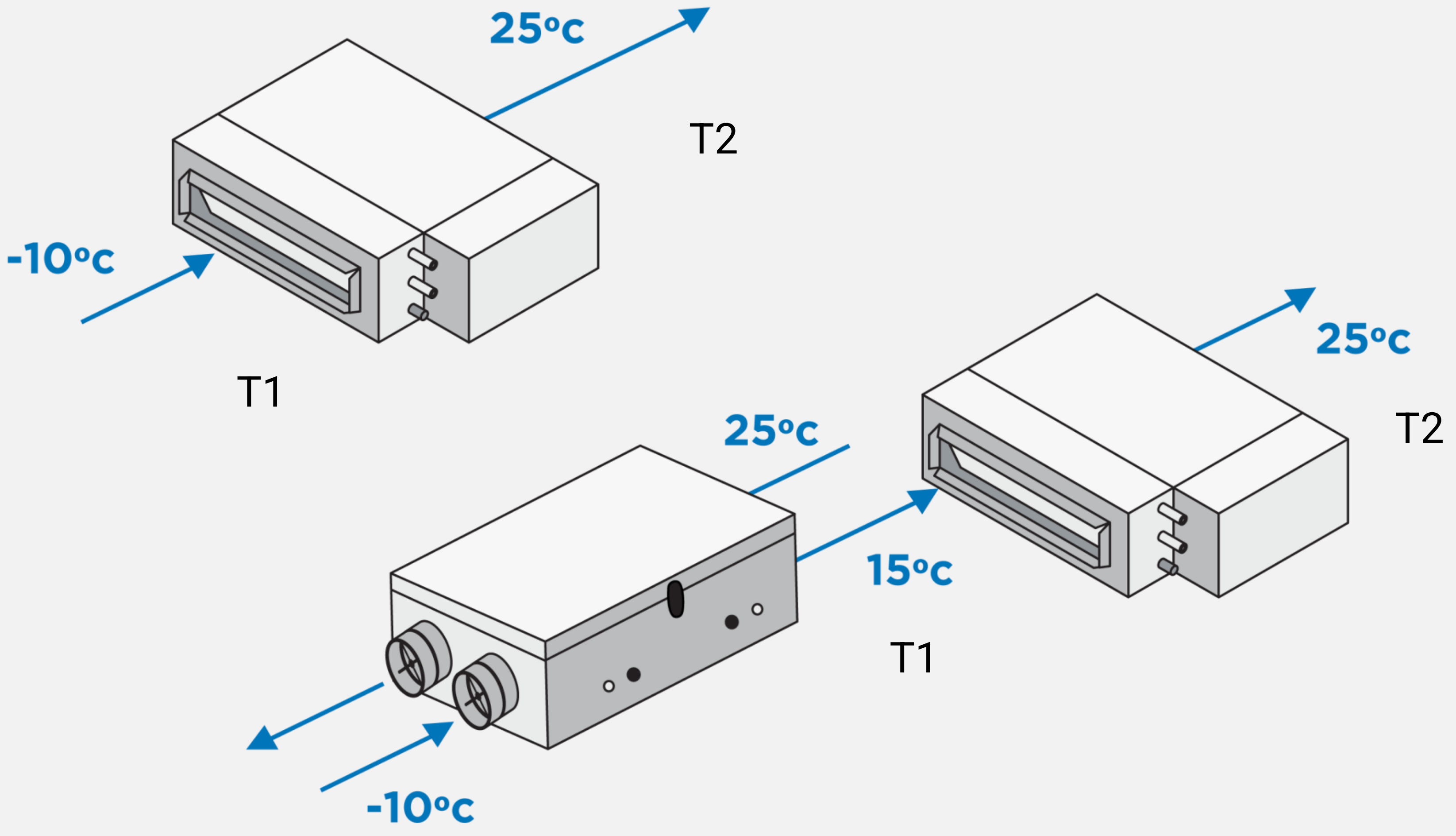


$$Q = 1.08 \times AIRFLOW \times (T1 - T2)$$

Q = Amount of heat required

AIRFLOW = air infiltration [CFM]
T1 = outside temperature
T2 = desired inside temperature

TEDI - Ventilation



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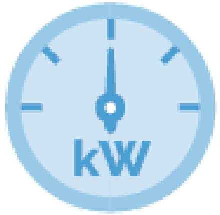
TEDI Summary

TEDI

- Envelope assembly thermal performance (wall, window, roof)
- Building massing, shading, & window extent
- Airtightness
- HRV/ ERV recovery efficiency
- Mechanical outdoor airflow rates (ventilation)

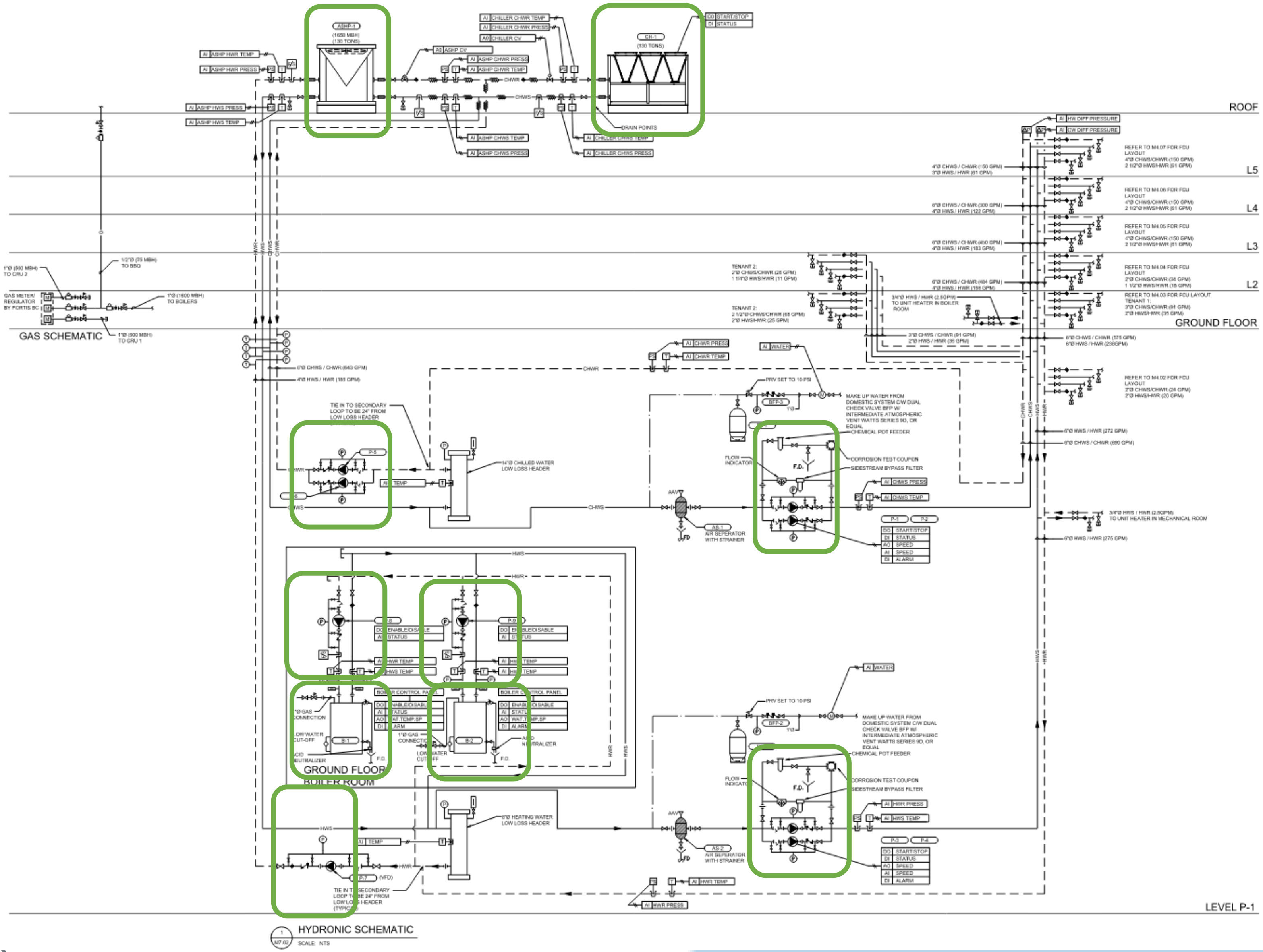
TEUI



TEUI

- Envelope assembly thermal performance (wall, window, roof)
- Building massing, shading, & window extent
- Airtightness
- HRV/ ERV recovery efficiency
- Mechanical outdoor airflow rates (ventilation)
- Mechanical system efficiencies (fans, heating & cooling equipment, pumps)
- Lighting
- Plug loads & appliances

TEUI - Equipment



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THERMAL BRIDGING & MECHANICAL

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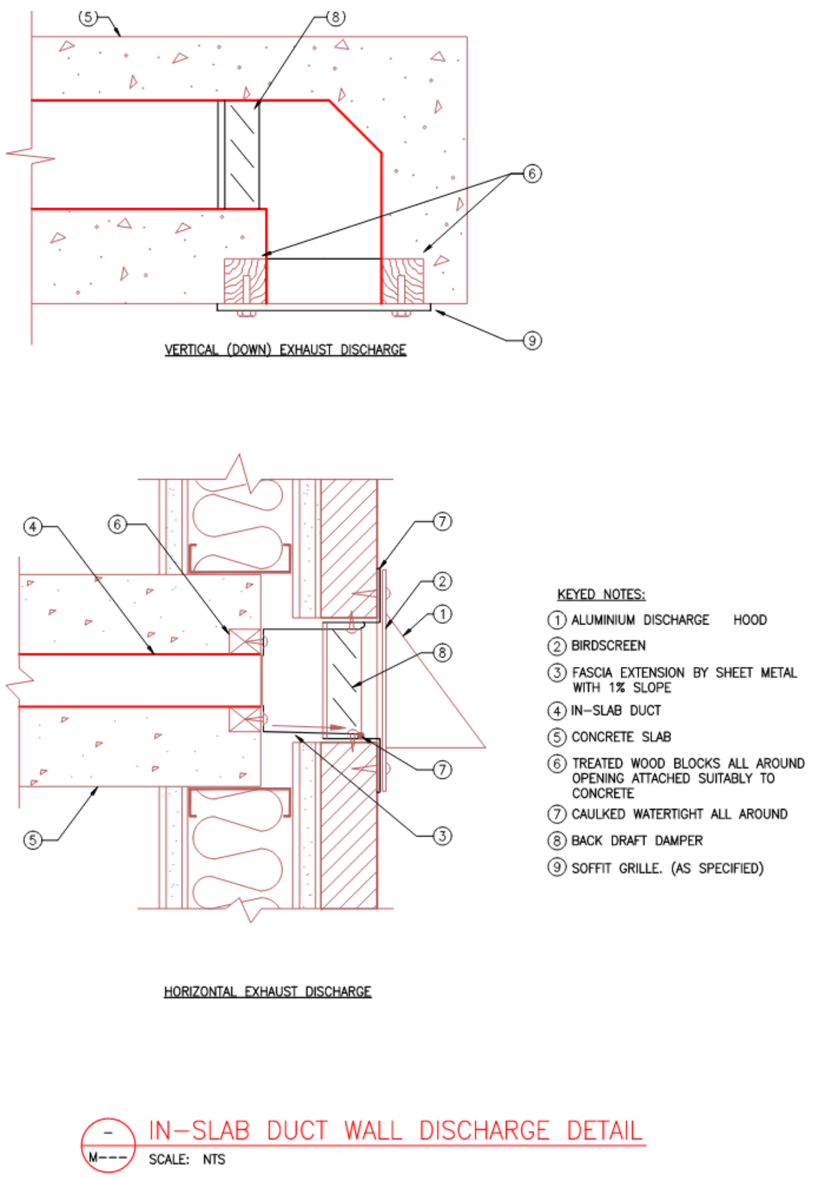
Details



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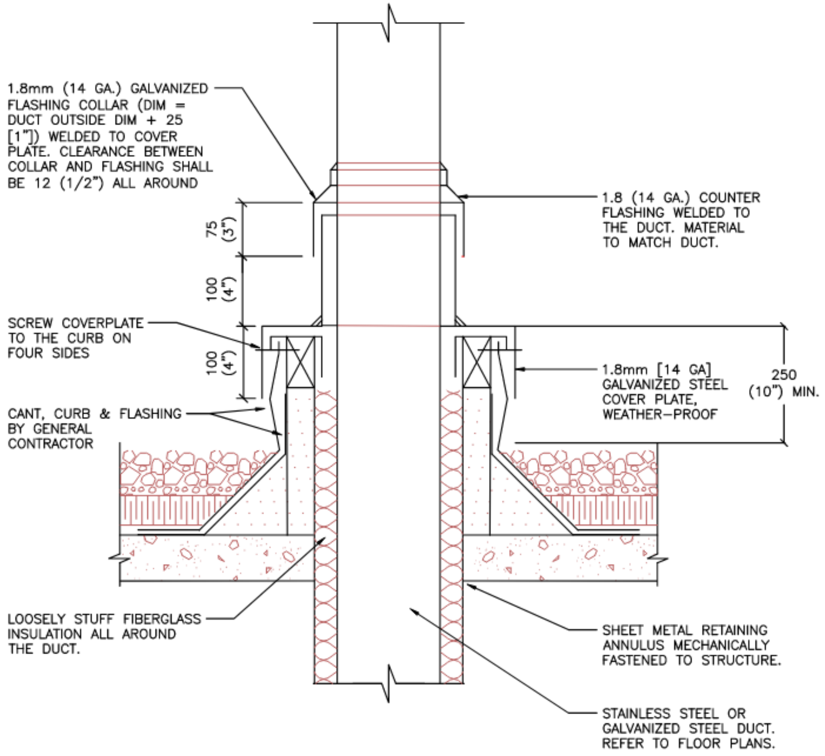

DETAIL NOTES
1. REFER TO SPECIFICATION FOR DUCT INSULATION REQUIREMENTS.
2. PRIME AND PAINT ALL WELDED AREAS FOR GALVANIZED STEEL DUCTS.
3. ALL WORK BY DIVISION 15, UNLESS OTHERWISE NOTED.

– M---
DUCT PENETRATION THRU ROOF
SCALE: NTS

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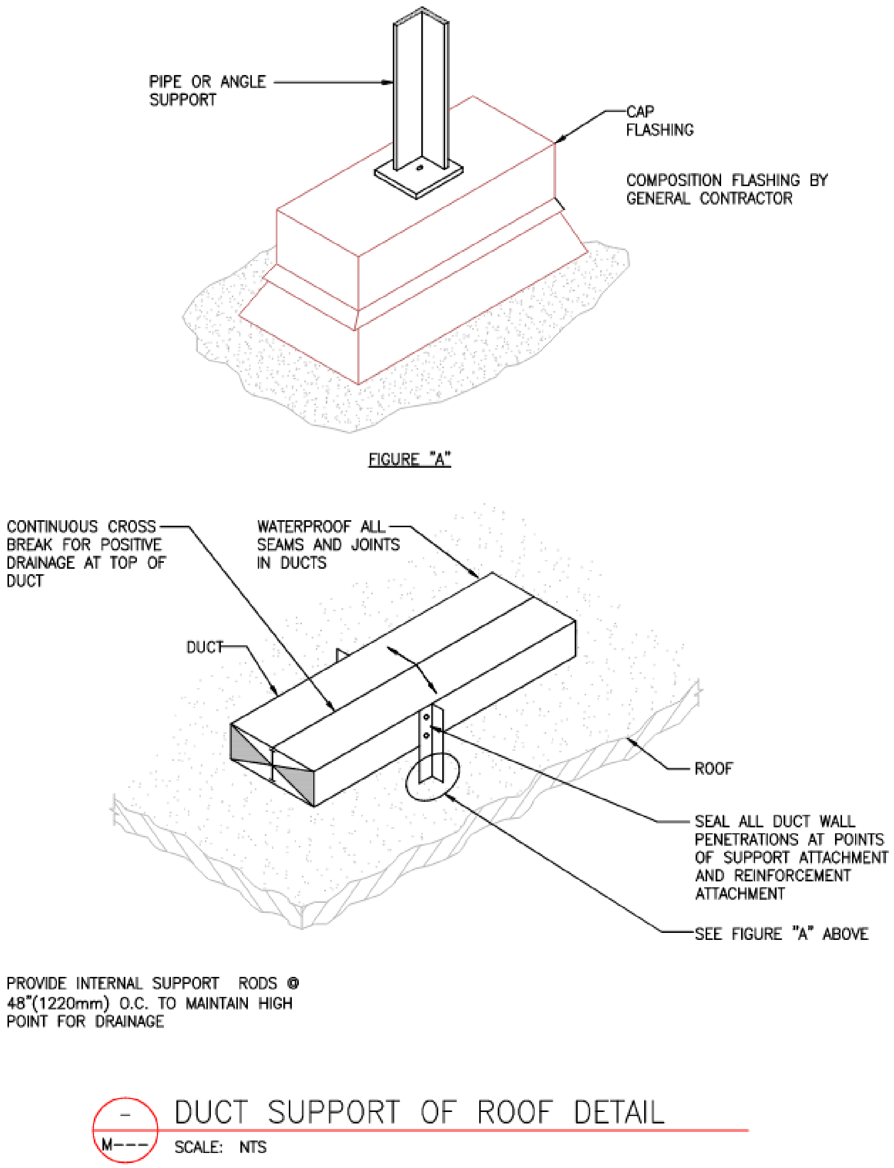
Details



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ENVELOPE THERMAL PERFORMANCE

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Envelope Thermal Performance

- NECB 2015
  (3.1.1.7) Include repetitive structural members
  Can exclude assemblies if cross section area <2%

- Step Code / VBBL
  Follow Building Envelope Thermal Bridging Guide method, and can exclude thermal bridges if cumulative impact on transmittance is < 10%

- NECB 2020
  (3.1.1.7) Include major structural members through the envelope, and junctions between assemblies such as at windows

- Passive House
  Very careful, conservative accounting of heat losses. Can exclude small losses if "thermal bridge free"

$$\Psi \leq 0.01 \quad W/(mK)$$

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DESIGN FOR FUTURE WEATHER

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City of Vancouver Rezoning Policy Study

CITY OF VANCOUVER
2021 REZONING POLICY

PROJECT NO.: 127B-069-20
VANCOUVER, BC

PREPARED FOR:
City of Vancouver
City Hall, 453 West 12th Ave,
Vancouver, BC, V5Y 1V4

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https://vancouver.ca/files/cov/zero-emissions-building-options-costing-study.pdf

Climate Resilience
Overheating and Future Weather

Using PCIC 2050 weather data, looking at occupant comfort in shock events for a building that has electrical HVAC equipment:

- Smoke Events
  Modelled with:
  Windows closed

- High Internal Heat Gains
  Modelled with:
  50% increase in lighting and plug loads
  100% increase in occupancy

- Loss of Power
  Modelled with:
  No lights, plug loads, mechanical ventilation or cooling

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Climate Resilience
Overheating and Future Weather

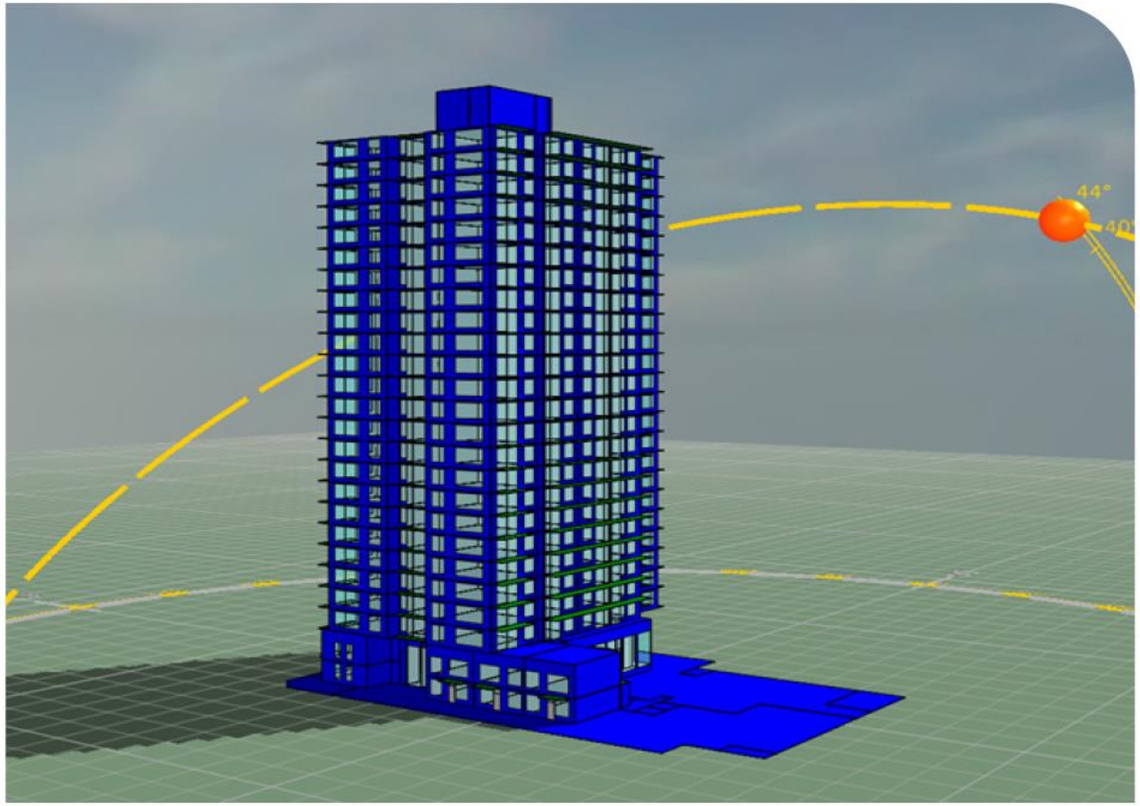
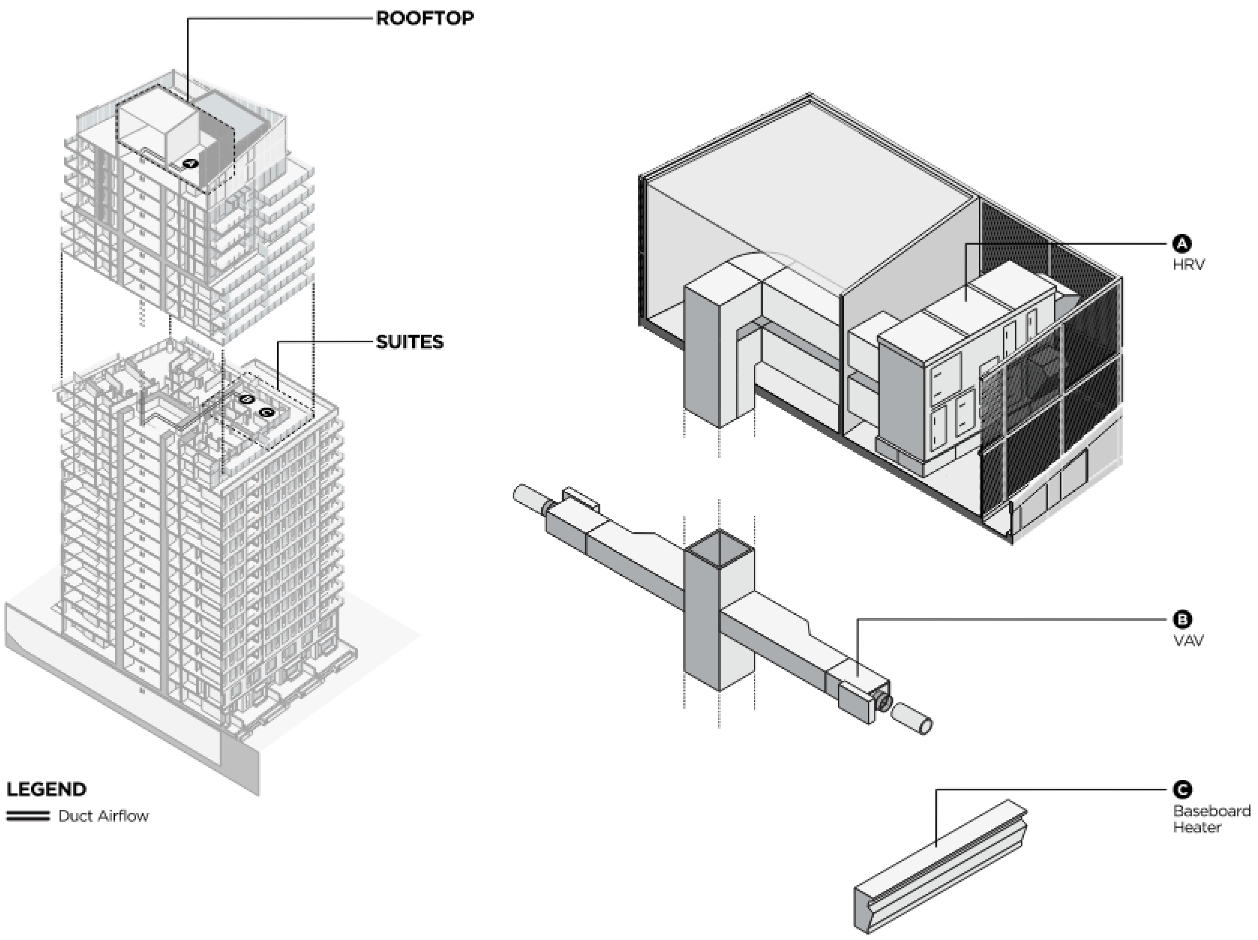


Figure 1.1: High-Rise Residential Building Energy Model Geometry and Orientation

A design option was developed that achieved <20 hour overheating in 2050 weather:

- Fixed exterior shades
- Operable windows, 20% operable
- 30% WWR
- Walls R-5
- Windows U-0.30, SHGC 0.32
- Infiltration 0.20 l/s/m^2 façade

Climate Resilience
Overheating and Future Weather



Model inputs continued:

- Cooling through central ventilation air
- Ventilation increase of 10% in summer
- Electric baseboards
- 85% HRV, without bypass

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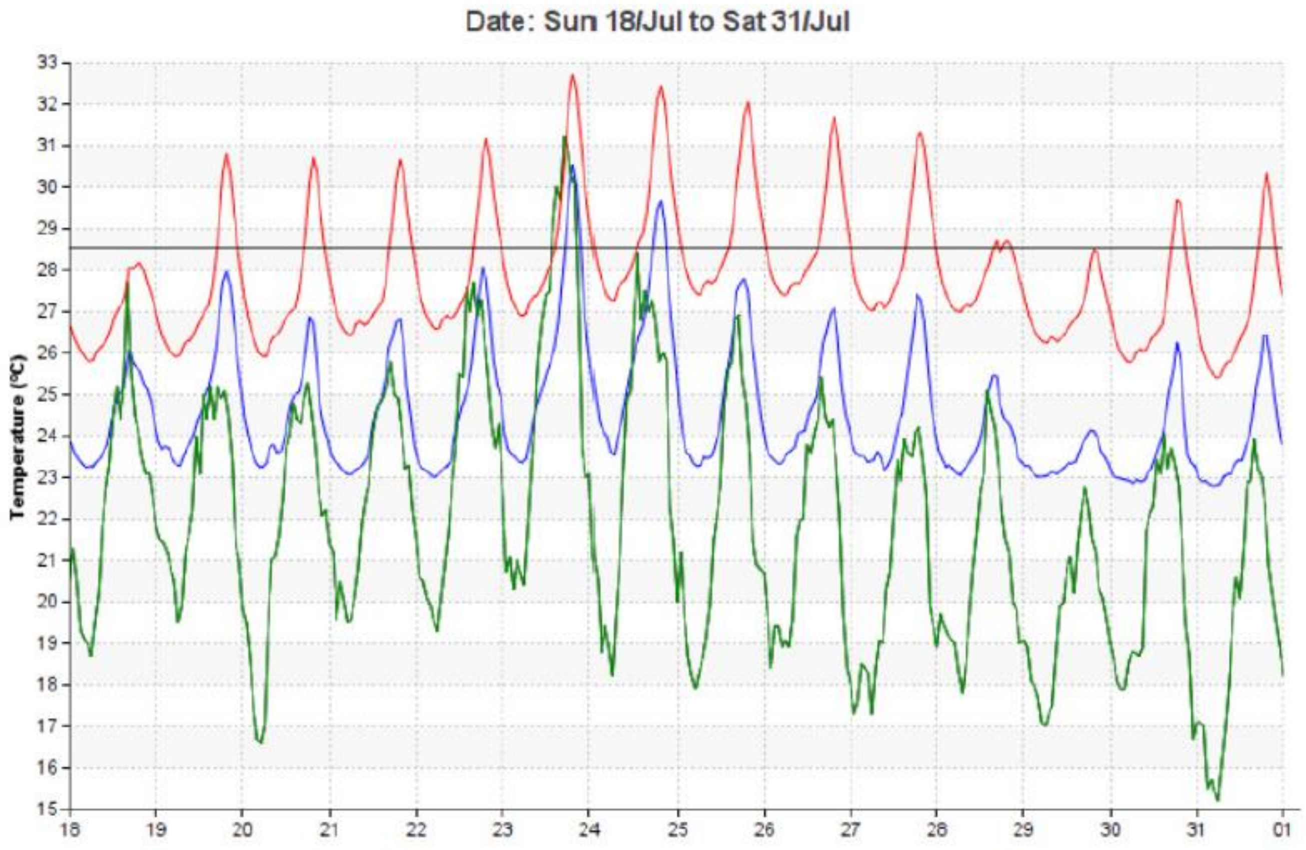
Climate Resilience
Overheating and Future Weather

Smoke Events



Comparing windows closed and open (blue and red lines), it is challenging with passive measures to achieve comfort in 2050

- Indoor Air Temperature – Windows Closed
- Outside Air – Dry Bulb Temperature
- Indoor Air Temperature – Windows Open
- 80% acceptability upper limit in July

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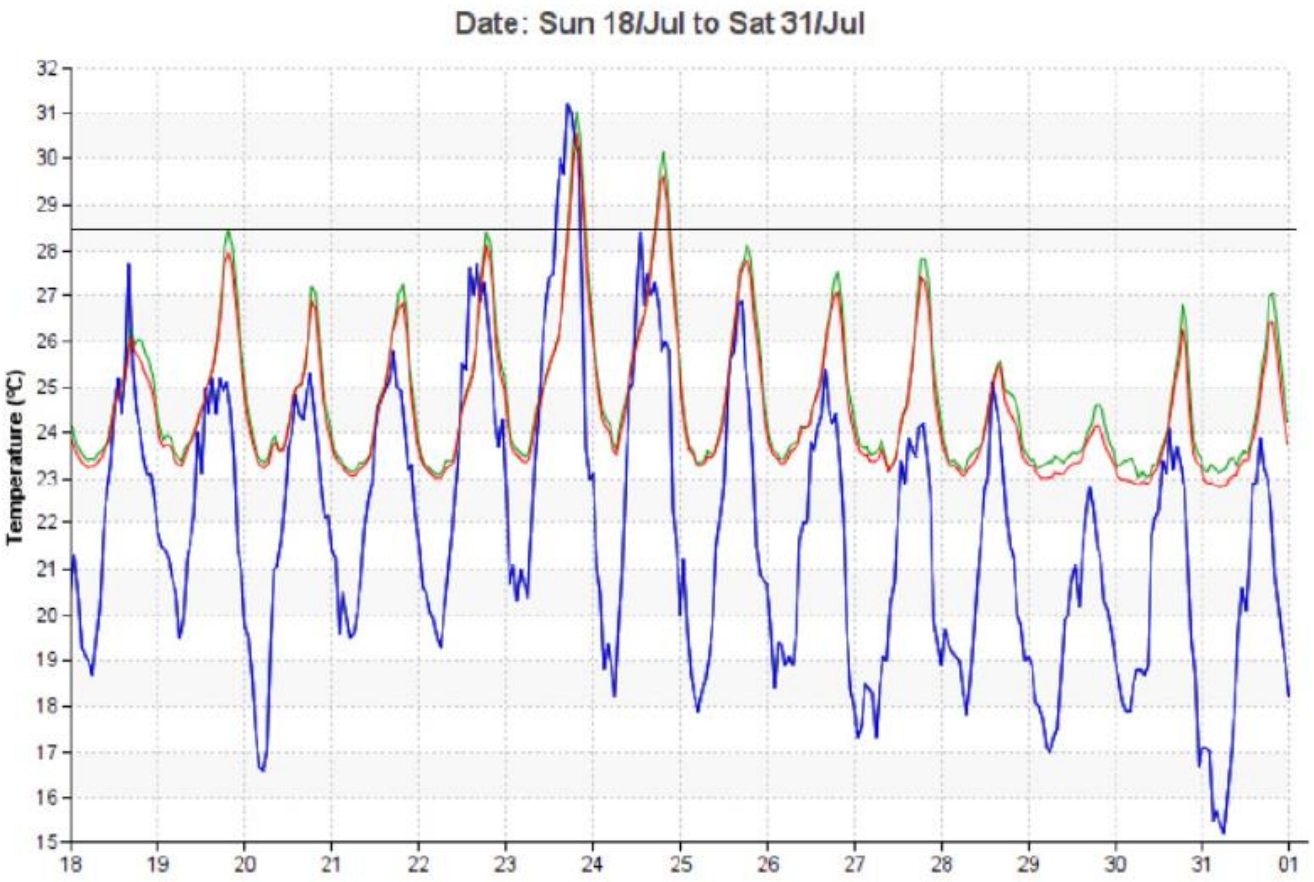
Climate Resilience
Overheating and Future Weather

High Internal Heat Gains



Operable windows and passive measures can be reasonably effective in accommodating higher internal gains (red and green lines) .

- Indoor Air Temperature – High Internal Gains
- Outside Air – Dry Bulb Temperature
- Indoor Air Temperature – Standard Internal Gains
- 80% acceptability upper limit in July

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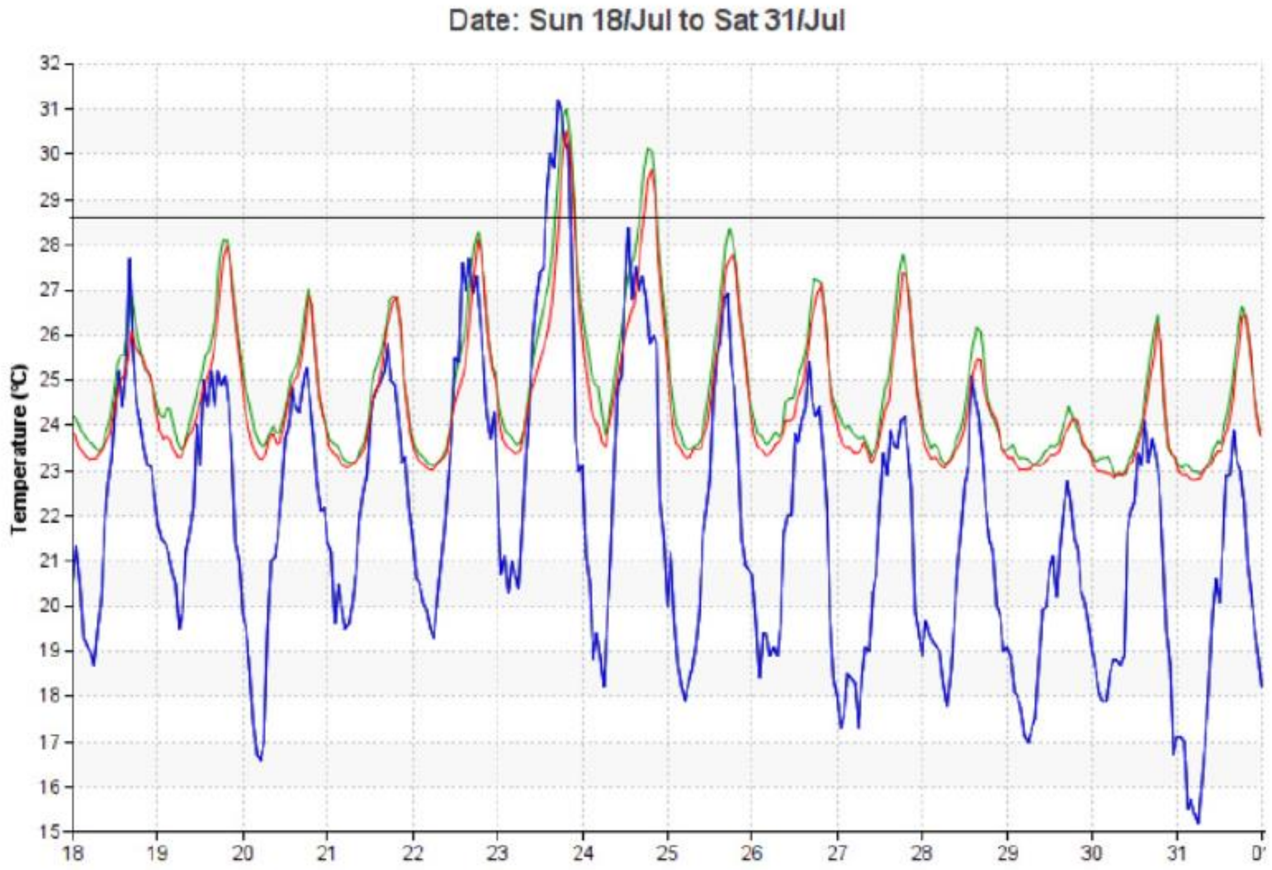
Climate Resilience
Overheating and Future Weather

Loss of Power



Operable windows and passive measures can be reasonably effective during power outages (red and green lines)

- Indoor Air Temperature – Loss of Power Scenario
- Outside Air – Dry Bulb Temperature
- Indoor Air Temperature – Standard Scenario
- 80% acceptability upper limit in July

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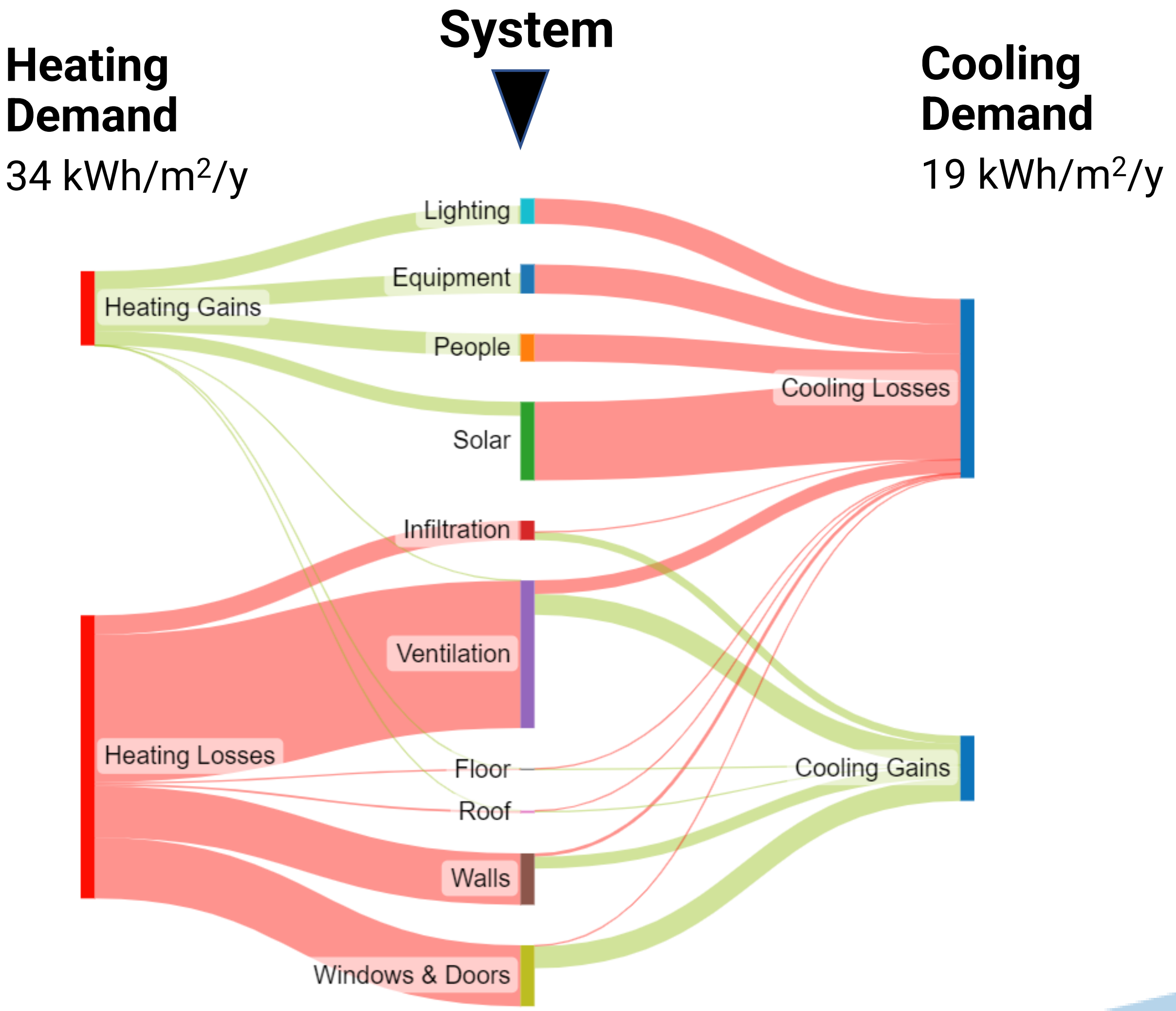
Annual Heat Losses and Gains – CWEC 2016 Weather



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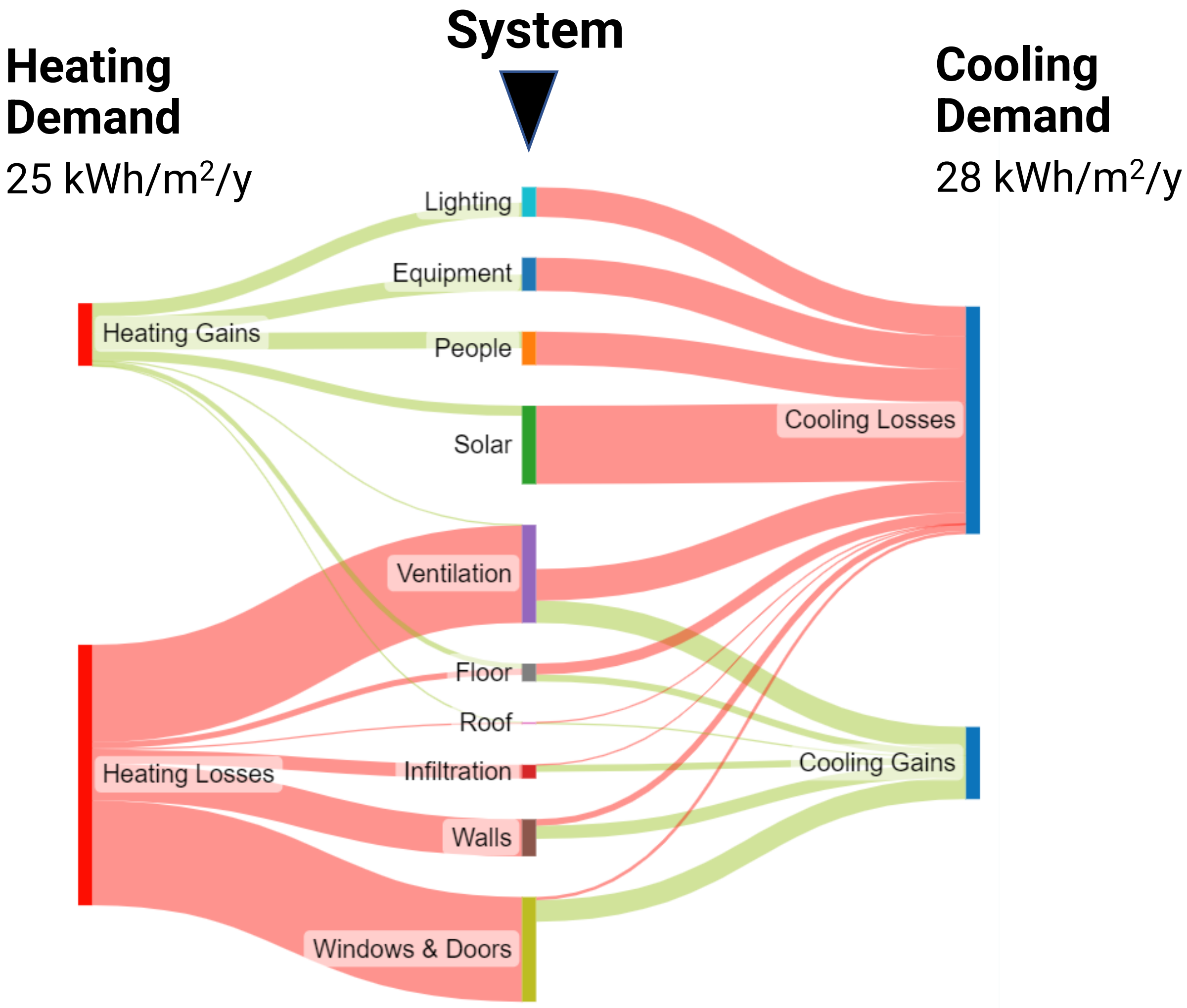
Note: Step code corridor pressurization adjustment not included in heating demand

Annual Heat Losses and Gains – PCIC 2050 Weather



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Note: Step code corridor pressurization adjustment not included in heating demand

Climate Resilience: Overheating and Future Weather

Study Considerations:

- Cooling and heating are both important for future resilience
- Steps to reduce cooling load:
  - Solar Shading / Solar Gains Controls
  - Envelope thermal performance
  - Airflow delivery / partial cooling
  - Natural ventilation

CONCLUSIONS

Conclusions

- Resilient buildings – not just a mechanical issue
- Coordination:
  - Solar gain control
  - Natural ventilation
  - Well insulated assemblies
  - Airtightness
  - Clean air intake

THANK YOU!

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