IEA EBC Annex 80

EBC
Energy in Buildings and Communities Programme

Part 2: Definitions of Resilient Cooling of Buildings & Overview of Indicators to assess Resilience

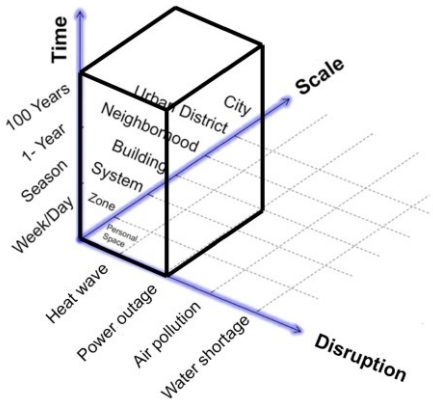
Wendy Miller et al, Developing an understanding of resilient cooling: a socio-technical approa City and Environment Interactions, City and Environment, 2021

Attia et al, Resilient cooling of buildings to protect against heat waves and power outages: Ke concepts and definition, Energy Buildings, 2021

Identifying the Boundaries

We limited the definition to:

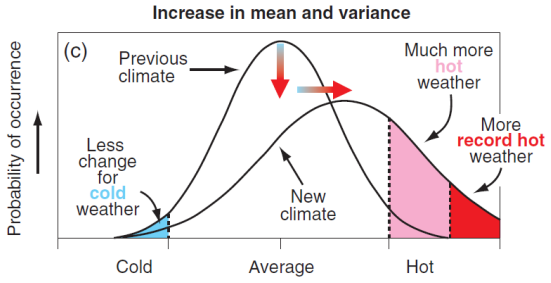
- **building scale**
- **heat waves**
- **power outages**



Source: Attia et al, Resilient cooling of buildings to protect against heat waves and power outages: Key concepts and definition, Energy Buildings, 2021

Background

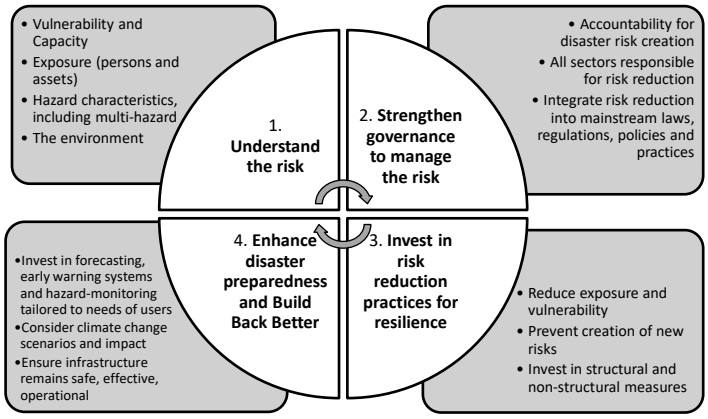
Why Resilience?



- **longer and more intense heatwaves**
- **risk of power outages**

Source: (IPCC). Climate Change 2001: The scientific basis. Contribution of Working Group I

Sendai Framework for Disaster Risk Reduction



Process for "temperature hazard" management based on Sendai Framework for Disaster Risk Reduction

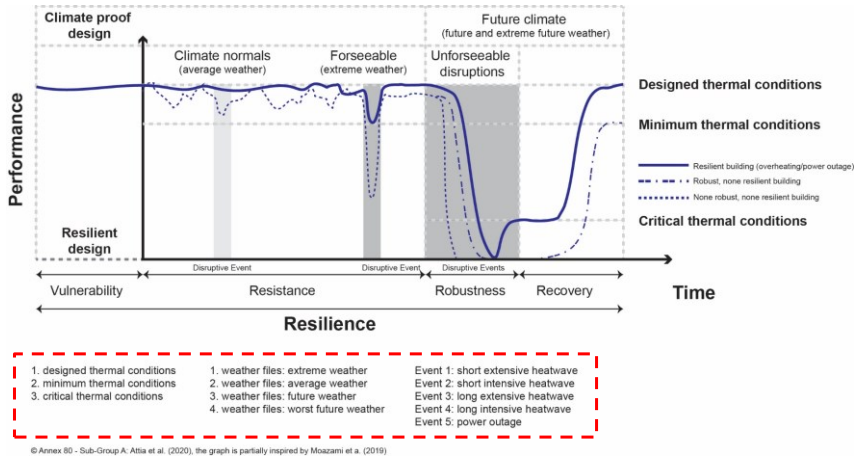
Source: United Nations. Sendai Framework for Disaster Risk Reduction 2015-2030. Geneva 2015

Definition of Resilient Cooling Characteristics and Risk Factors

Resiliency Characteristics	Vulnerability	Resistance	Robustness	Recoverability
Resilient Cooling Characteristics	Overheating Exposure Risk	Overheating Exposure Severity	Overheating Exposure Adjustment	Overheating Exposure Recovery
Risk Factors	Climate Change Scenarios Heat wave events Power Outages Urban Heat Island Load Change (occupancy, solar or other thermal loads)	Building Design (glazed area, thermal mass, …) Cooling Technology Characteristics Level of Energy Autonomy	Occupant Adaptability Potential Occupant/System Interaction Potential Building Adaptability Potential (thermal safety zones,…) Smart Readiness Level (System Adaptation) Emergency Control Possibility Energy System Back-Up Availability	Building Design Cooling Technology Characteristics Learning Ability of Building, Systems and Occupants

Source: Attia et al, Resilient cooling of buildings to protect against heat waves and power outages: Key concepts and definition, Energy Buildings, 2021

Definition of Resilient Cooling of Buildings



Important Parameters for Resilience Assessment

1. **Thermal Conditions**: designed, minimum, critical
2. **Weather**: average, extreme, future, extreme future
3. **Disruptive Events**: heat wave, power outage

1. Thermal Conditions

- **ISO 17772 P1-2** (PPD, PMV and adaptive Model)
- Limitation of the thermal comfort model
  -> ASHRAE 55
  -> EN 15251

Table 3.3 Acceptability classes in ASHRAE 55

ASHRAE 55 class	Scope	PPD (%)	Fanger PMV	Adaptive ΔT_{op} (K)
90%	To be used when a higher standard of thermal comfort is desired	≤10	$-0.5 \leq PMV \leq +0.5$	±2.5
80%	To be used for typical applications and when other information is not available	≤20	$-0.85 \leq PMV \leq +0.85$	±3.5

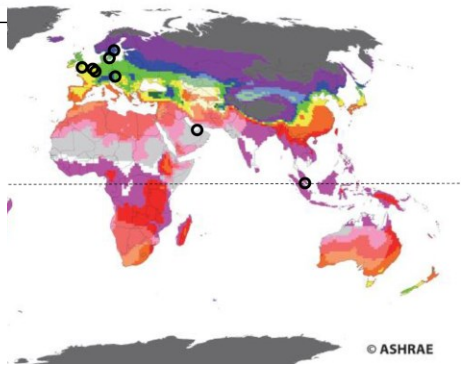
Table 3.4 Thermal comfort categories and acceptability ranges according to EN 15251

EN 15251 category	Description	Fanger		Adaptive
		PPD (%)	PMV	ΔT_{op} (K)
I	High level of expectation and is recommended for spaces occupied by very sensitive and fragile people with special requirements like handicapped, sick, very young children and elderly persons	≤6	$-0.2 \leq PMV \leq +0.2$	±2
II	Normal level of expectation and should be used for new buildings and renovations	≤10	$-0.5 \leq PMV \leq +0.5$	±3
III	An acceptable, moderate level of expectation and may be used for existing buildings	≤15	$-0.7 \leq PMV \leq +0.7$	±4
IV	Values outside the criteria for the above categories. This category should only be accepted for a limited part of the year	>15	PMV<−0.7 and PMV > 0.7	

2. Future Weather

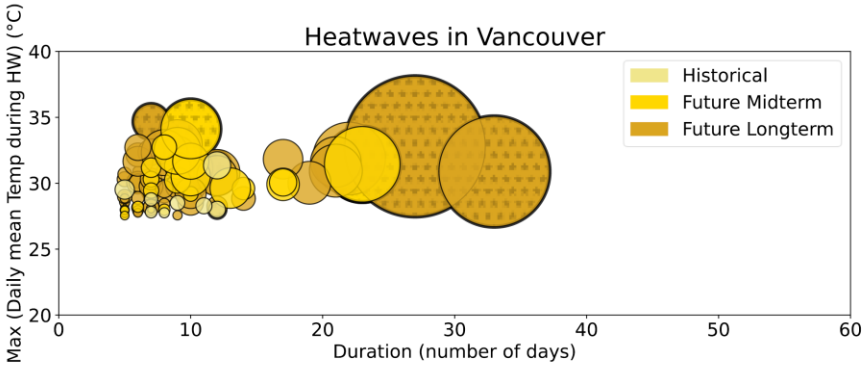
1. At least **one city for climate zones** considering the ASHRAE classification
2. Cities with **high population and growth**
3. Cities in **different continents** with preference for **cities of the Annex 80 participants**

CLIMATE ZONE	City	Country	Continent
0A	Singapore	Singapore	Asia
0B	Abu Dhabi	UAE	Asia
1A	Guayaquil	Ecuador	South America
2A	Rome	Italy	Europe
2A	Sao Paulo	Brazil	South America
2B	Cairo	Egypt	Africa
3A	Buenos Aires		South America
3B	Teheran	Iran	Asia
3B	Los Angeles	California	North America
4A	Paris	France	Europe
4A	London	UK	Europe
4A	Gent	Belgium	Europe
4A	Brussels	Belgium	Europe
4B	Xian	China	Asia
4C	Vancouver	Canada	North America
5A	Toronto	Canada	North America
5A	Copenhaguen	Denmark	Europe
5A	Vienna	Austria	Europe
6A	Montreal	Canada	North America
6A	Stockholm	Sweden	Europe



➢ **Webinar 2 of this series**

3. Heatwaves



Categories of KPIs

a. IEQ / Thermal Comfort Metrics
   - comfort, thermal safety, indoor overheating degree …

b. Energy Metrics
   - energy use, power demand, carbon emissions, …

c. HVAC and Grid Metrics
   - SEER, SCOP, recovery time…

d. Specific KPIs, relevant to specific cooling technologies

Conclusions

- Any definition of resilience must be based on the **identification of a specific shock or disruption.**
- Designer must specify and distinguish, the **resistance and robustness conditions against heat waves and power outage events**.
- Resilient cooling design is an **urgent requirement for future proof buildings**.
- **Building operation systems and building management systems will play a significant role** in applying the adaptation strategies and risk mitigation plans in collaboration with buildings users.
- **Resilience is a process**, and its criteria should be addressed **integrating user experience during shocks is essential to increase the emergency learnability and feed the preparedness loop.**

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