EBC

Energy in Buildings and Communities Programme

Next Generation Building Energy Codes

12 November 2025

Welcome and Introduction

Meli Stylianou
Natural Resources Canada
BECWG Co-Chair

Agenda

EBC
Energy in Buildings and Communities Programme

Session 1: Presentations and Q&A on *Modern Building Code Approaches to Resilience and Multi-Hazard Mitigation*

Three 15-minute presentations with Q&A after each. Moderated by Dr. Ellen Franconi.

- Ryan Colker on Advancing Resilience and Hazard Mitigation through Codes and Standards
- Dr. Shady Attia on Future-Proofing the EPBD: Multi-Hazard Resilience in Europe's Building Energy Codes
- Dr. Simona Bianchi on Multi-Hazard Risk and Resilience in Building Codes

Session 2: Panel Discussion on the *Potential of Artificial Intelligence (AI) for Building Energy Codes*

A 45-minute panel discussion with Dr. Nora Esram and Dr. Hanlong Wan. Moderated by Jean-Simon Venne

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Energy in Buildings and Communities Programme

Session I.

Modern Building Code Approaches to Resilience and Multi-Hazard Mitigation

Moderated by Dr. Ellen Franconi, Senior Research Engineer, PNNL

Advancing Resilience and Hazard Mitigation through Codes and Standards

Ryan Colker

Executive Director, Energy, Resilience & Innovation

International Code Council

Advancing Resilience and Hazard Mitigation through Codes and Standards

Ryan Colker, Executive Director, Energy, Resilience & Innovation

BECWG Symposium

November 12, 2025

The Family of Building & Community Solutions

- Codes and Standards
- Personnel Training and Certification
- Product Evaluation
- Accreditation Services
- Codification & Administration Services
- Engineering Support
- Community Resilience Benchmarks™
- Third-Party Evaluation Services

ICC INTERNATIONAL CODE COUNCIL®

International Initiatives & Action

- Buildings Breakthrough
  - Near-zero emission and resilient buildings as the new normal by 2030
    - Priority Action 1: Standards & Certifications; Priority Action 5: Capacity Building
- Declaration de Chaillot/Intergovernmental Council on Buildings & Climate
  - Developing policy recommendations, issuing common statements, and providing technical briefs to assist member states in advancing sustainable transformation in the building sector.
    - 6.1. Implementing long-term regulatory roadmaps and frameworks, mandatory building and energy codes for all buildings, or supporting the adoption of these at the subnational level; requiring integrated comprehensive design
- Market Transformation Action Agenda
  - The outcome is a co-created transformative action agenda guiding the path towards halving emissions by 2030 and reaching net zero by 2050.
    - Intervention 5: Standards Alignment
- Others: World Bank, OECD, UNDRR, IEA

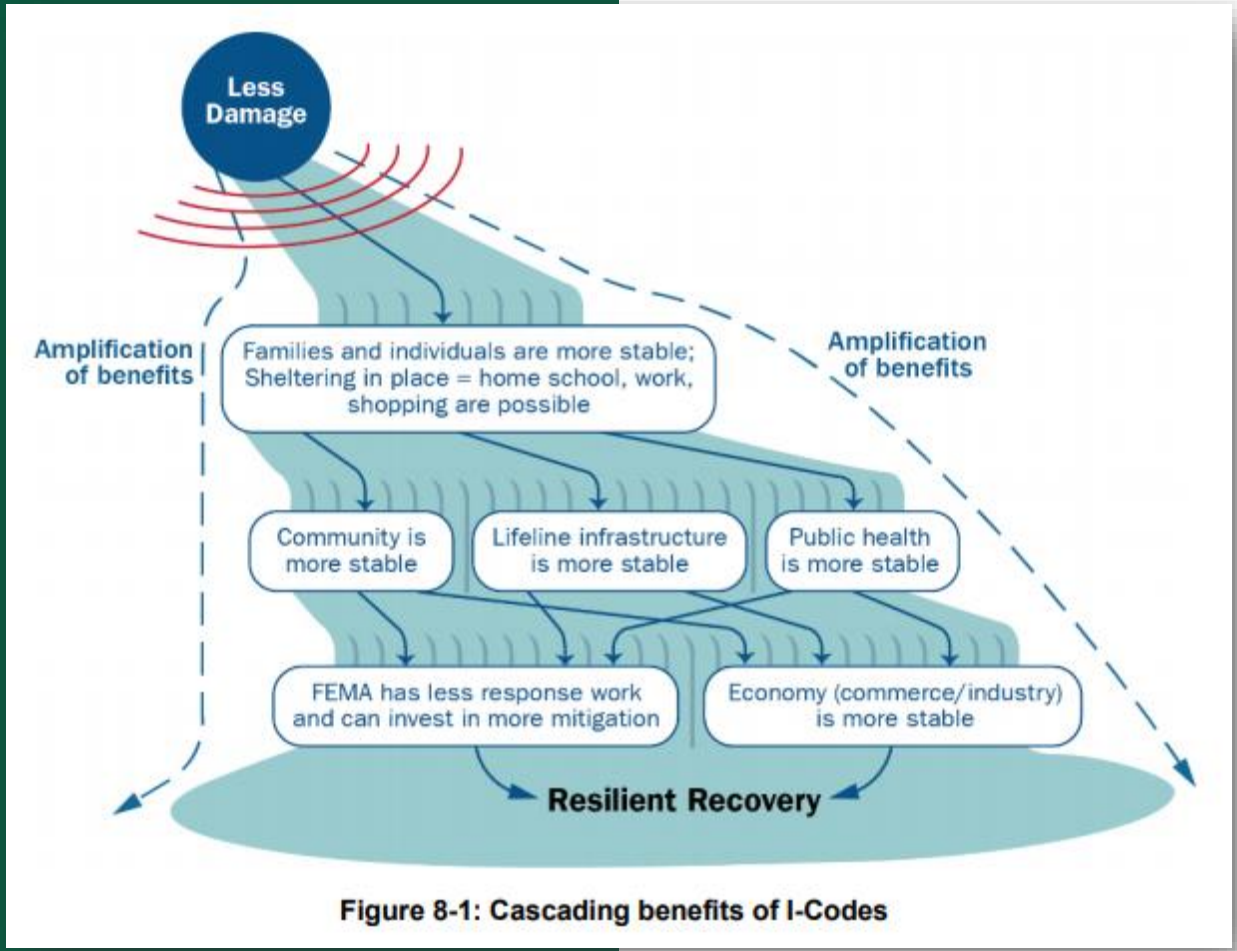
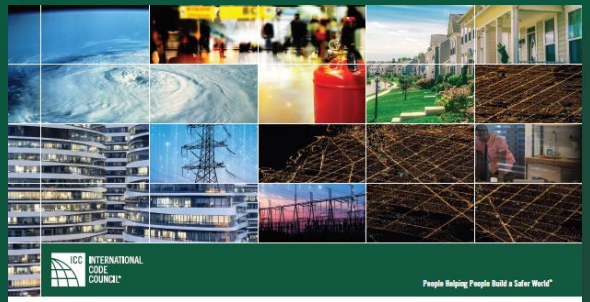


Figure 8-1: Cascading benefits of I-Codes

Energy Codes are a Resilience Strategy



The Important Role of Energy Codes in Achieving Resilience

Second in a series

https://www.iccsafe.org/wp-content/uploads/19-18078_GR_ANCR_IECC_Resilience_White_Paper_BRO_Final_midres.pdf

Energy Codes are a Resilience Strategy

Selected Code Topic	Relevant Sections (2018 IECC)	Supported Resilience Strategy	Relevant Hazards
Insulation	C402.2, R402.2	▪ Passive survivability ▪ Reduced energy burden ▪ Reduced grid impact ▪ Reduced ice-dams ▪ Reduced condensation, limiting mold and mildew	▪ Extreme heat ▪ Extreme cold ▪ Snow storms ▪ Social resilience ▪ Secondary impacts to all hazards
Walk-In Coolers and Freezers	C403.10	▪ Food safety/preservation	▪ Extreme heat ▪ Secondary impacts to all hazards
Daylighting	C402.4.1	▪ Passive survivability ▪ Reduced grid impact	▪ Extreme heat ▪ Secondary impacts to all hazards
Window-to-Wall Ratios	C402.4.1, R402.3	▪ Passive survivability ▪ Impact vulnerabilities	▪ Extreme heat ▪ Extreme cold ▪ Hurricanes ▪ Tornadoes
Solar Heat Gain Coefficient	C402.4.3, R402.3.2	▪ Passive survivability ▪ Reduced grid impacts	▪ Extreme heat ▪ Secondary impacts to all hazards
Solar Reflectance of Roof	C402.3	▪ Urban heat island ▪ Passive survivability	▪ Extreme heat ▪ Secondary impacts to all hazards
Air Leakage	C402.5, R402.4	▪ Contaminants (secondary to wild-fire, earthquake, etc.) ▪ Mold and mildew (secondary to flooding, hurricane, extreme cold, etc.)	▪ Secondary impacts to all hazards
Pipe Insulation	C404.4, R403.4	▪ Passive survivability ▪ Reduced energy burden	▪ Extreme cold ▪ Drought ▪ Social resilience
On-Site Renewable Energy	C406.5, Appendix CA, Appendix RA	▪ Contribute to distributed generation ▪ Facilitates islandability	▪ Secondary impacts to all hazards

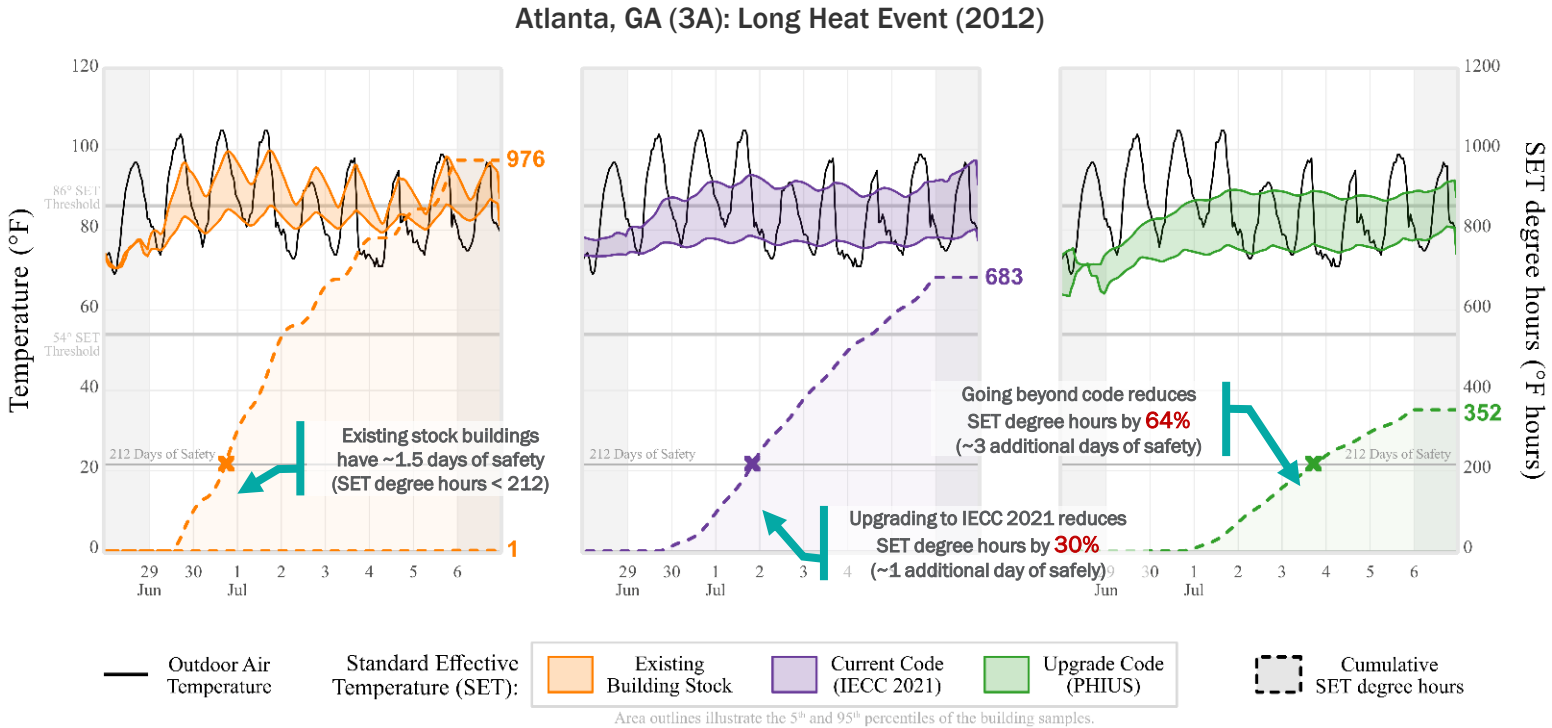
Table 1. Select Energy Code Provisions Contributing to Resilience

ICC INTERNATIONAL CODE COUNCIL®

Benefit type	Energy efficiency outcome	Resilience benefit
Emergency response and recovery	Reduced electric demand	Increased reliability during times of stress on electric system and increased ability to respond to system emergencies
	Backup power supply from combined heat and power (CHP) and microgrids	Ability to maintain energy supply during emergency or disruption
	Efficient buildings that maintain temperatures	Residents can shelter in place as long as buildings' structural integrity is maintained.
	Multiple modes of transportation and efficient vehicles	Several travel options that can be used during evacuations and disruptions
Social and economic	Local economic resources may stay in the community	Stronger local economy that is less susceptible to hazards and disruptions
	Reduced exposure to energy price volatility	Economy is better positioned to manage energy price increases, and households and businesses are better able to plan for future.
	Reduced spending on energy	Ability to spend income on other needs, increasing disposable income (especially important for low-income families)
	Improved indoor air quality and emission of fewer local pollutants	Fewer public health stressors
Climate mitigation and adaptation	Reduced greenhouse gas emissions from power sector	Mitigation of climate change
	Cost-effective efficiency investments	More leeway to maximize investment in resilient redundancy measures, including adaptation measures

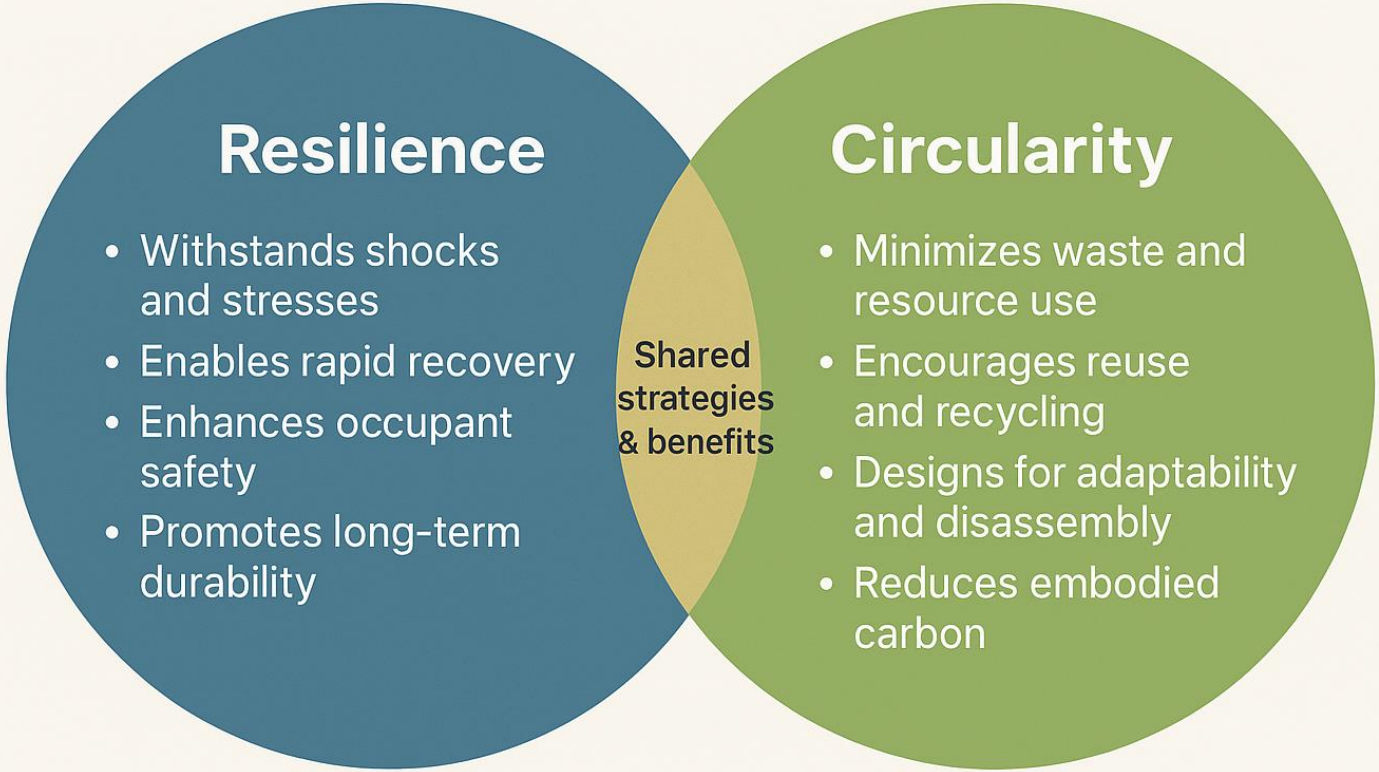
https://www.aceee.org/research-report/u1508

Energy codes improve resilience



As building envelope improves via better codes, building occupants can remain safe for longer

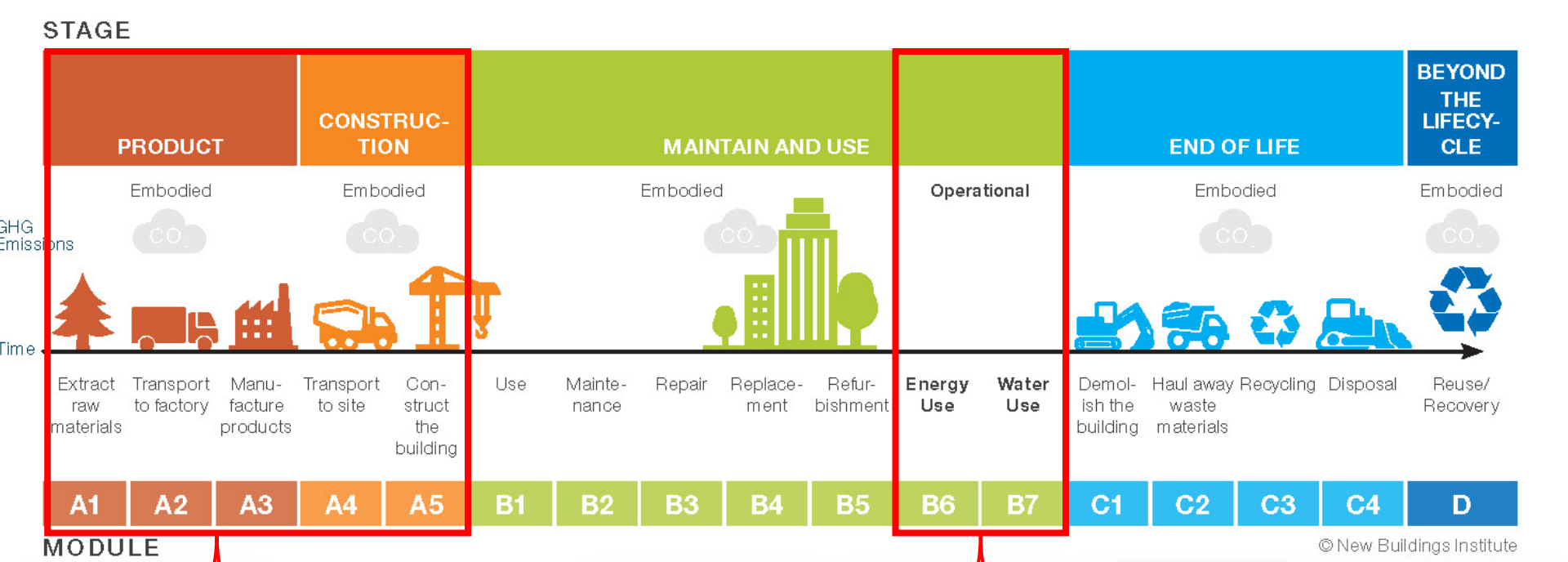
Source: Franconi, E, E Hotchkiss, T Hong, M Reiner et al. 2023. Enhancing Resilience in Buildings through Energy Efficiency. Richland, WA: Pacific Northwest National Laboratory. PNNL-32737, Rev 1



- Adaptable design
- Durable materials
- Efficient Recovery
- Integrated Standards

Emerging Sustainability & Resilience Opportunities

- Off-Site Construction
- Extreme Heat
- Energy Storage Systems
- Grid Interactivity
- Electrification
- Embodied Emissions



Building Life-Cycle GHG Impacts

ASHRAE/ICC Standard 240 - Quantification of Life Cycle Greenhouse Gas Emissions of Buildings

https://www.iccsafe.org/about/periodicals-and-newsroom/the-international-code-council-and-ashrae-seek-public-comments-on-proposed-standard-on-greenhouse-gas-emissions-evaluation/

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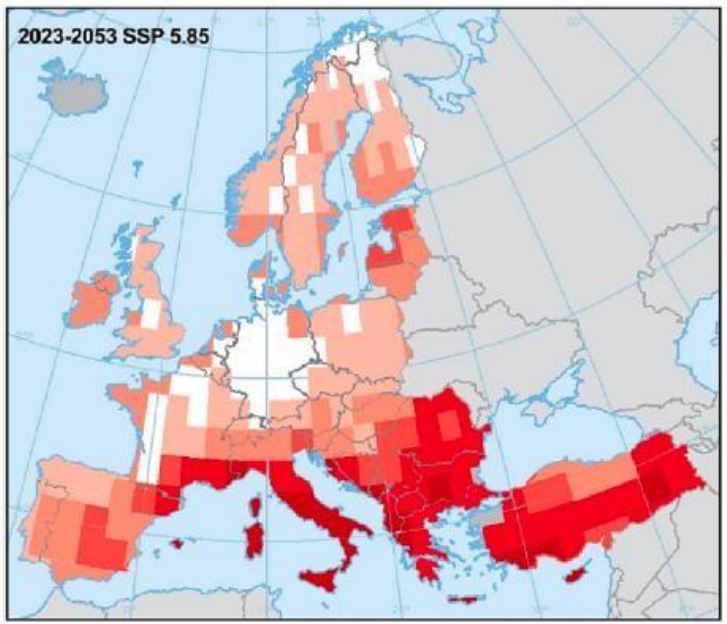
Future-Proofing the EPBD: Multi-Hazard Resilience in Europe's Building Energy Codes

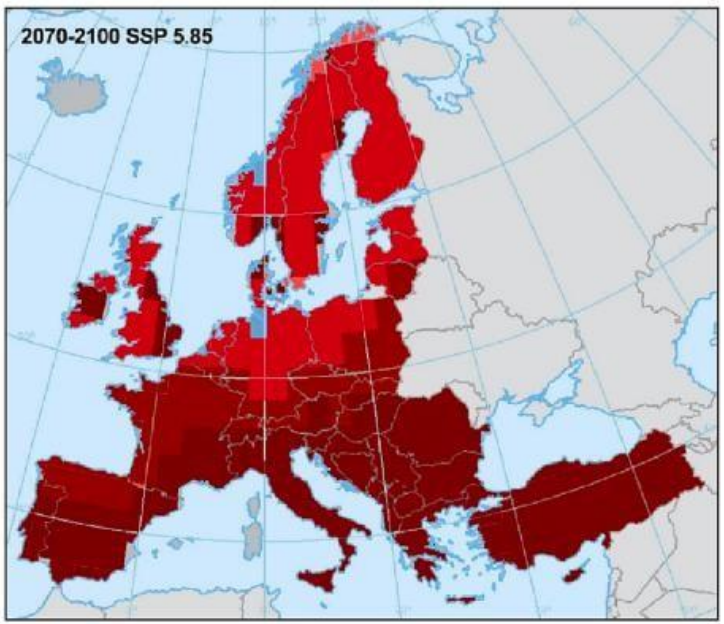
Dr. Shady Attia

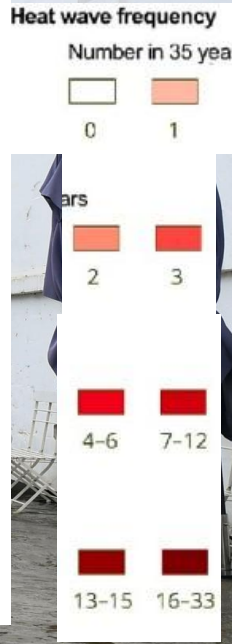
Full Professor of Sustainable Architecture and Building Science,
University of Liège, Belgium

Future-Proofing the EPBD:

Multi-Hazard Resilience in Europe's Building Energy Codes







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Context

7th Annual Symposium on Building Energy Codes – hosted by the Building Energy Codes Work Group (BECWG) under the IEA Energy in Buildings and Communities Programme (EBC), organized by the Pacific Northwest National Laboratory (PNNL), held during the week of **November 10, 2025.**

Avec le soutien de la Wallonie

Consortiums OCCuPANt & Surchauffe

ISO/AWI 52016-3

ISO/TC 163/SC2/WG 15

International Energy Agency

IEA Annex 80

Resilient Cooling (2019-2023) Advanced Solar Control

EBC Energy in Buildings and Communities Programme

EUROPEAN SOLAR-SHADING ORGANIZATION

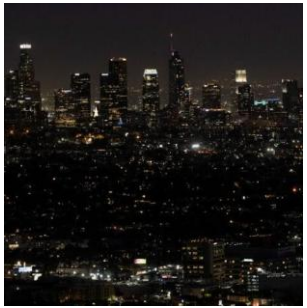
Multi-Hazard Resilience

Drought

Floods

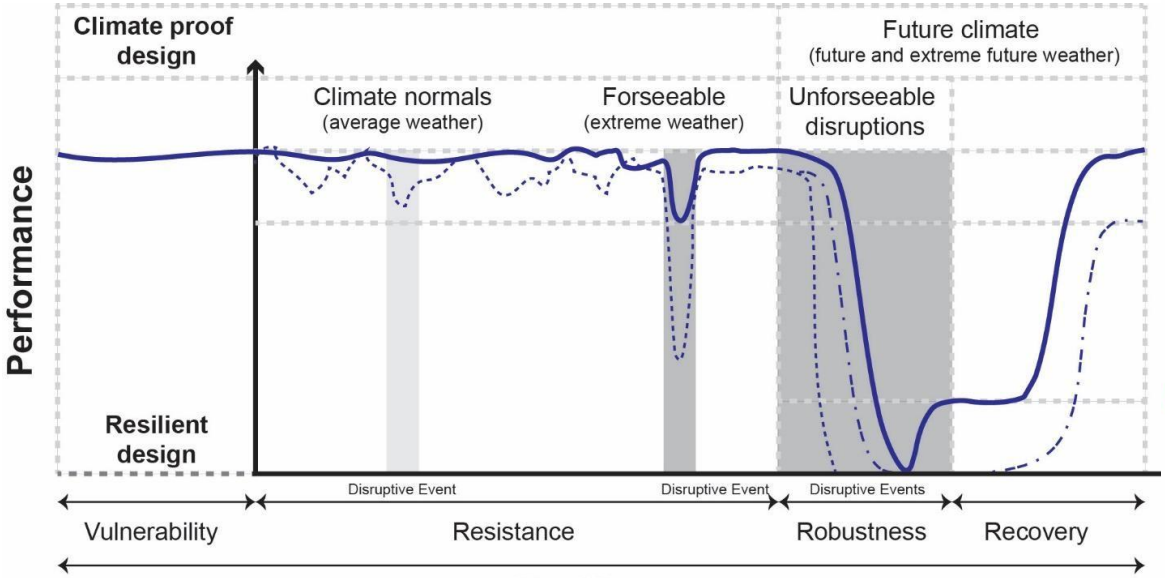
Heatwaves

Fires



Blackout

Definition: Resilience vs. Shock = FAILURE

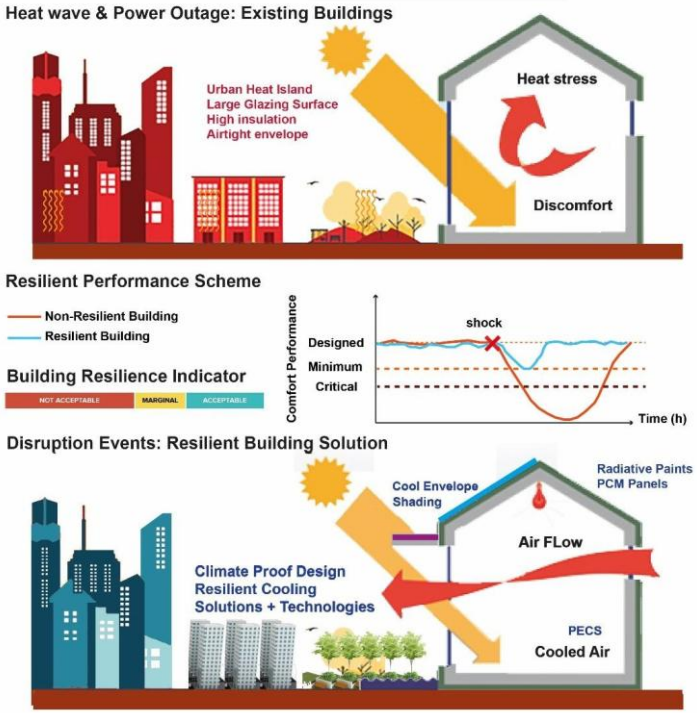


1. designed thermal conditions
2. minimum thermal conditions
3. critical thermal conditions

1. weather files: extreme weather
2. weather files: average weather
3. weather files: future weather
4. weather files: worst future weather

Event 1: short extensive heatwave
Event 2: short intensive heatwave
Event 3: long extensive heatwave
Event 4: long intensive heatwave
Event 5: power outage

doi.org/10.1016/j.egypro.2016.06.218



Non-Resilient and Resilient Performance Curve during heat waves and power outage events.

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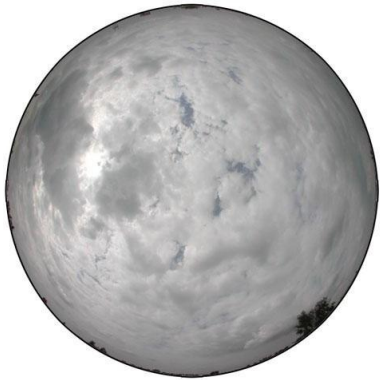
Relevance to Europe

CIE Standardized Skies in Europe

Mediterranean overheating and Northern cold-snap risks; EPBD focus on efficiency only.



overcast sky

intermediate sky

clear sky

clear turbid / turbulent

climate trends and EPBD recast objectives. Show that EU codes still emphasize energy efficiency but rarely account for resilience.

Source: Wyard, C (2018). Global radiative flux and cloudiness variability for the Period 1959–2010 in Belgium: a comparison between reanalyses and the regional climate model MAR. Atmosphere, 9(7), 262.

Conflicting & Complementary Measures

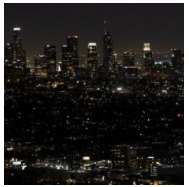
in Resilient Building Design


Drought


Floods


Heatwaves


Fires


Blackout

Conflicting Measures

Airtightness ↔ Ventilation during heatwaves

Full electrification ↔ Blackout vulnerability

Acoustic insulation ↔ Natural ventilation

PV dependency ↔ Power outage risk

Complementary Measures

Shading + Thermal mass: reduce overheating & heating demand

Cool roofs + Natural daylighting: less cooling & lighting energy

Permeable landscape + Passive airflow design: flood mitigation + microclimate cooling

Hybrid systems (PV + thermal storage): energy efficiency + backup resilience

Resilience and efficiency are not mutually exclusive: design intentions clash when multiple hazards are present.

IEA Annex 80: KPIs & Methods

Quantifying Thermal Resilience in Buildings

Aspect	Indicator (KPI)	Typical Threshold / Meaning
1. Overheating risk	Hours above 28 °C (adaptive comfort) → Overheating Hours (OH)	< 3 % annual hours → acceptable risk (EU EPBD benchmark)
2. Thermal autonomy	Number of hours indoor T remains within comfort limits after loss of power	≥ 48 h = high resilience (Annex 80 definition)
3. Recovery time	Time to restore comfortable range after blackout or peak event	≤ 6 h good ; > 12 h poor response
4. Adaptive comfort duration	Cumulative period in which indoor operative T follows adaptive comfort band	> 85 % hours = resilient occupant comfort
5. Hygrothermal stress index (optional)	Wet-bulb globe temperature (WBGT) and heat index	WBGT < 30 °C for safe occupancy periods

KPIs can be used to inform Life Cycle Impact Assessment (LCIA) by weighting resilience indicators (e.g., overheating hours, recovery time) according to event probability and duration.

Implementation Barriers

Europe needs resilience metrics that can guide renovation wave priorities.

1. **Misalignment Between Public Perception and Climate Reality**
2. **The EPBD's Legal Mandate Is Energy-Centric**
3. **Lack of harmonized link between resilience KPIs and life cycle impact assessment (LCIA) indicators.**
4. **Policy Saturation and Fatigue**
5. **Research–Policy Gap**

EPBD should evolve from efficiency-based to performance- and risk-based design.

Future-Proof EPBD Vision

From energy-only compliance to climate-proof performance

1. **Add “Resilience Performance Indicators” to EPBD annexes (and EPCs)**

2. **Couple Life Cycle Impact Assessment (LCIA) with risk-based design to capture both long-term efficiency and short-term hazard performance.** (mitigation + adaptation in one loop)

3. **Harmonize with standards & data (make it implementable)**

We can’t regulate what we don’t measure.

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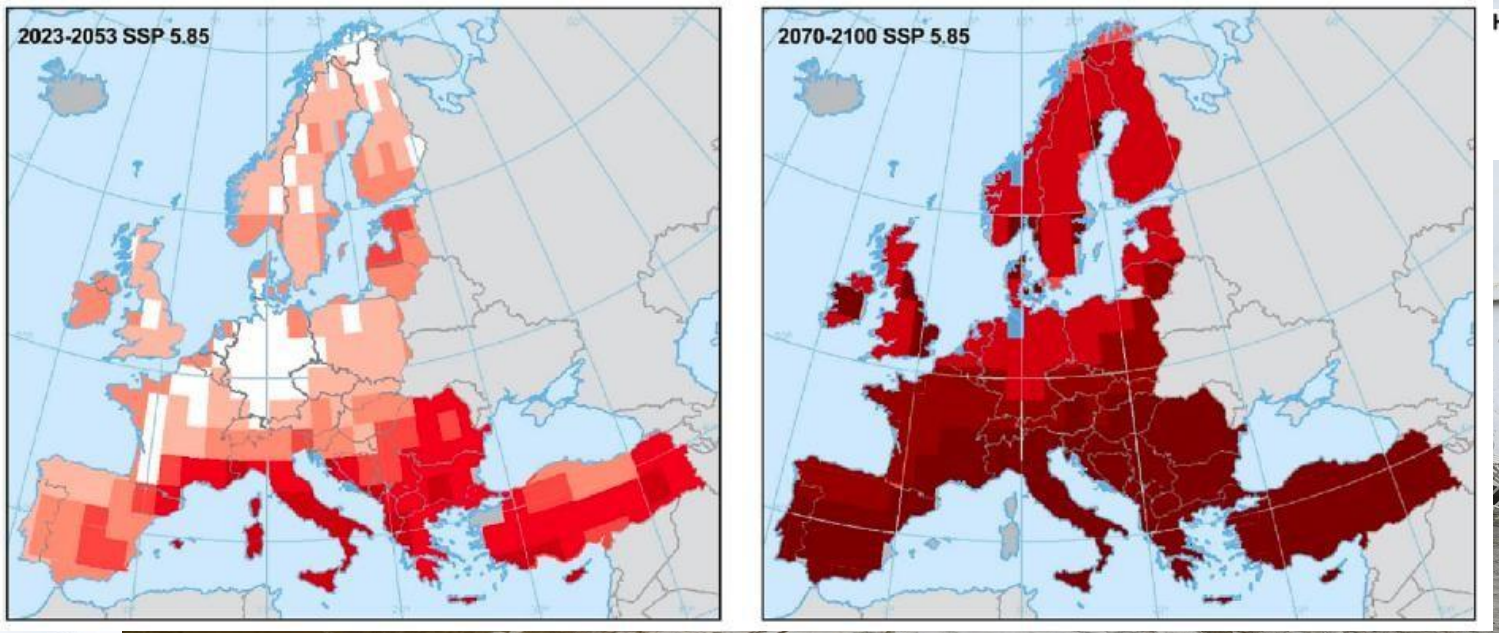
Future-Proofing the EPBD:

Multi-Hazard Resilience in Europe's Building Energy Codes



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Multi-Hazard Risk and Resilience in Building Codes

Dr. Simona Bianchi

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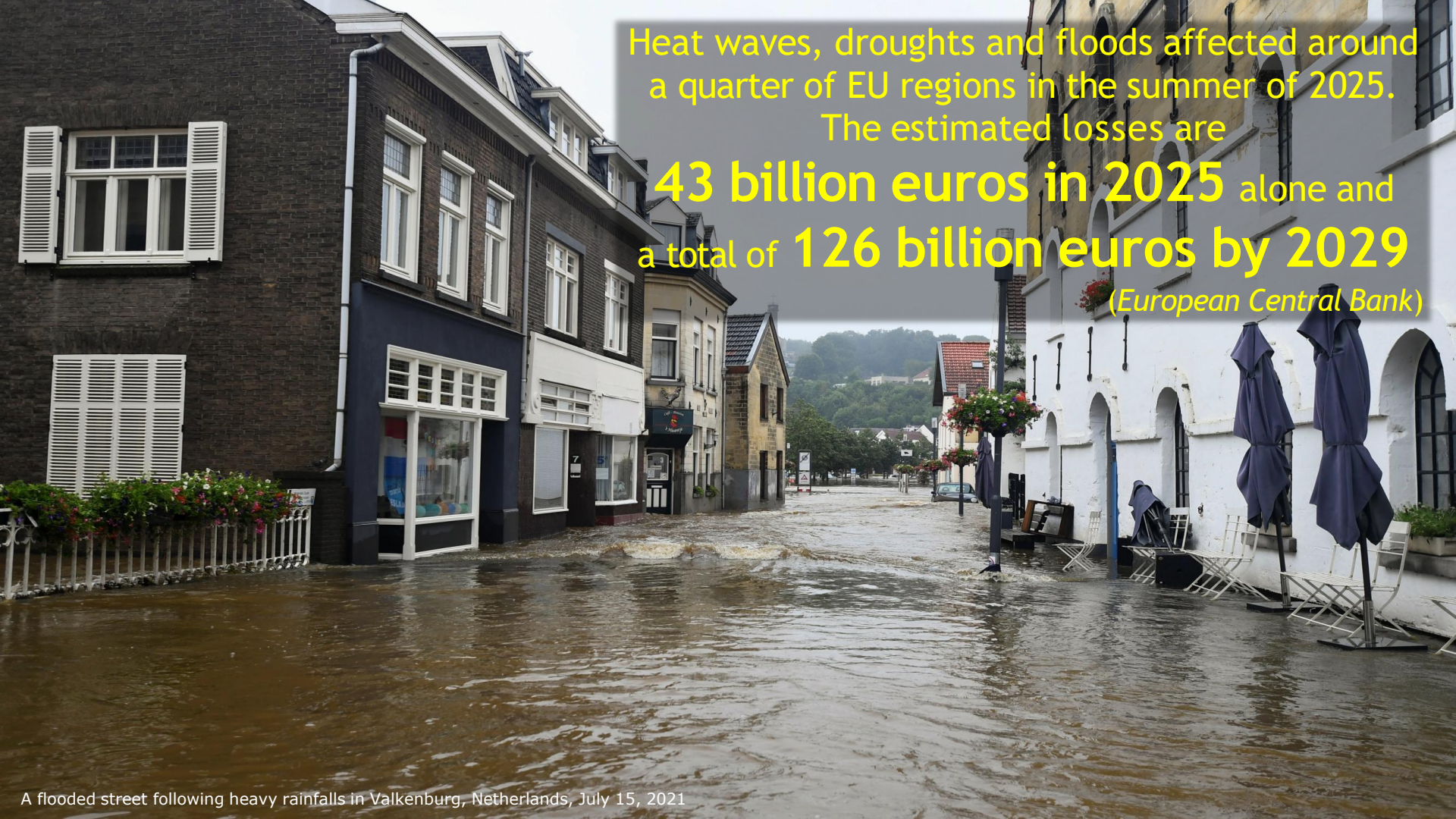
Multi-Hazard Risk and Resilience in Building Codes

Dr. Simona Bianchi
Delft University of Technology

7th BECWG Symposium, 12 November 2025



Heat waves, droughts and floods affected around a quarter of EU regions in the summer of 2025.
The estimated losses are
43 billion euros in 2025 alone and
a total of **126 billion euros by 2029**
(*European Central Bank*)

A flooded street following heavy rainfalls in Valkenburg, Netherlands, July 15, 2021

Climate Risks: The Netherlands

Heat Wave

Heavy Precipitation

Strong Wind

Coastal Flooding & Storm Surge

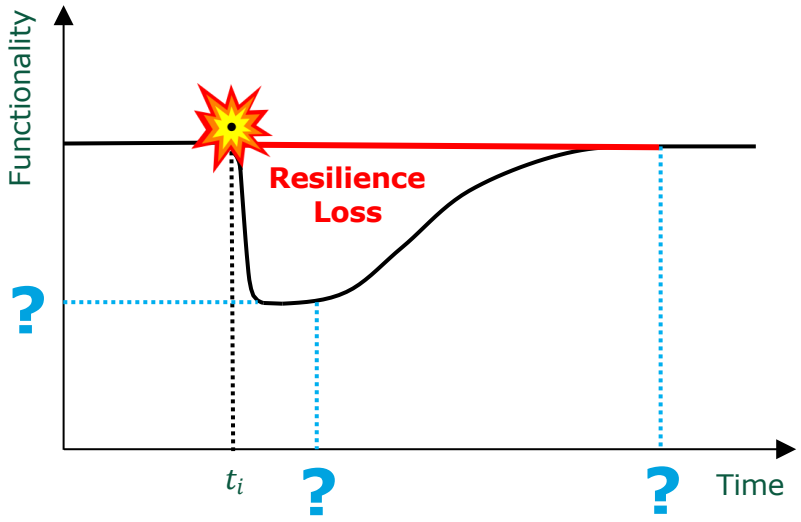
River Flooding

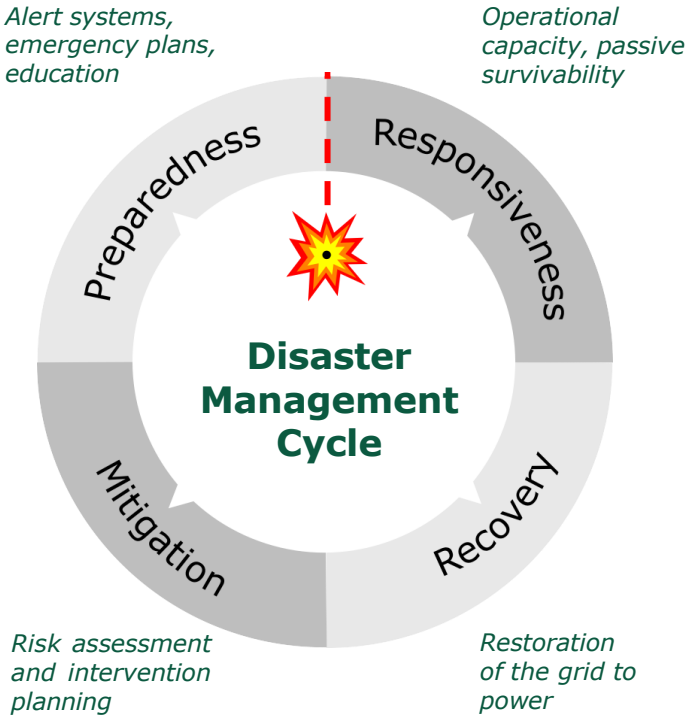
Hail

Drought

(KNMI, 2023)

Resilience concept





Resilience in Building Codes: The Netherlands

Energy efficiency
1) Outdoor climate - NEN 5060: 2018
2) BENG (Bijna Energie Neutraal Gebouw) - Bouwbesluit 2012, NTA 8800:2020
3) Energy Label - EPBD Directive

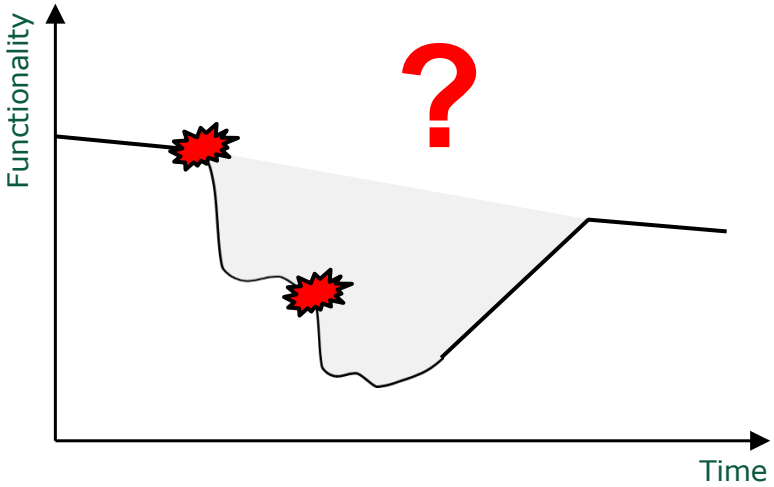
Thermal resilience
1) TO-July (Temperature Exceedance in July)
2) Heat Label - 2021 NKWK project *Heat in the Home*
3) Frailty index

➔ Build knowledge about cooling needs
➔ Effectiveness of possible measures
➔ Policy instruments for cooling

Label	GTO uren <=	T_{nacht} <= 26°C uren <=	Ta_max °C <=
A	450	6	28
B	450	24	32
C	900	200	35
D	1800	500	38
E	groter	groter	groter

(NKWK, 2021)

Multi-Hazard Resilience concept



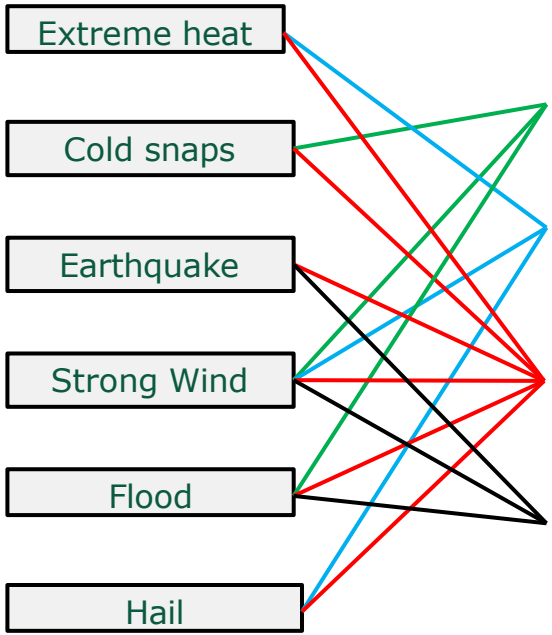
➔ Type of interaction
- Independent
- Cascading
- Change condition
- Compound
- Mutual exclusion

➔ Probable multi-hazard event set

➔ Spatial and temporal evolution

Multi-Hazard Resilience in Building Codes

- **Complementary measures**



Airtight envelope

- Retains heat, reduces indoor heat loss
- Reduces uncontrolled drafts and infiltration
- Prevent water ingress

Glazing design

- Reduces solar heat gain
- Strong glazing resists wind pressure
- Can resist damage from hailstones

Backup power capacity

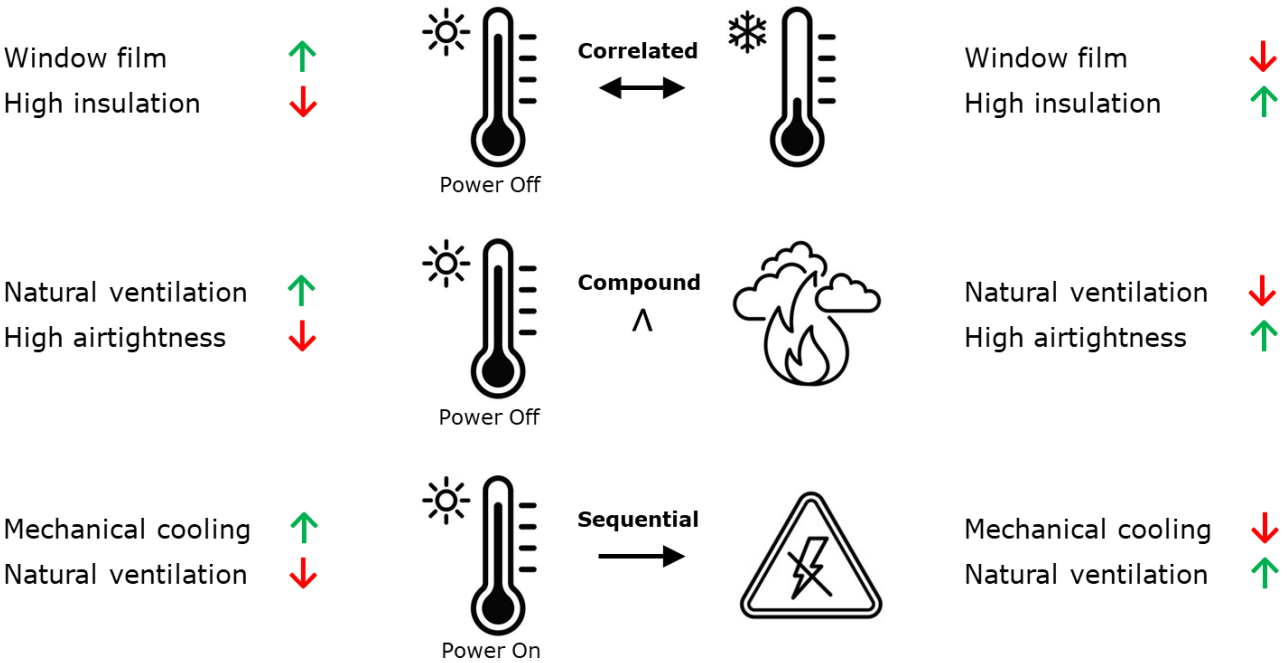
- Powers cooling / heating systems
- Can supply emergency systems if grid fails
- Can power critical systems if grid fails

Joint detailing

- Allows differential movement
- Prevent façade or window failure
- Prevent water ingress

Multi-Hazard Resilience in Building Codes

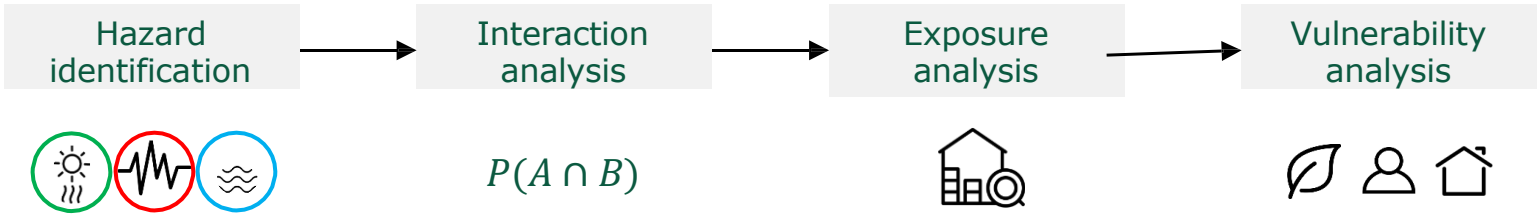
➢ Conflicting considerations



Integrating Multi-Hazard Risk and Resilience

1) Definition of multi-hazard events and consequences

- Type of interaction
- Impact assessment

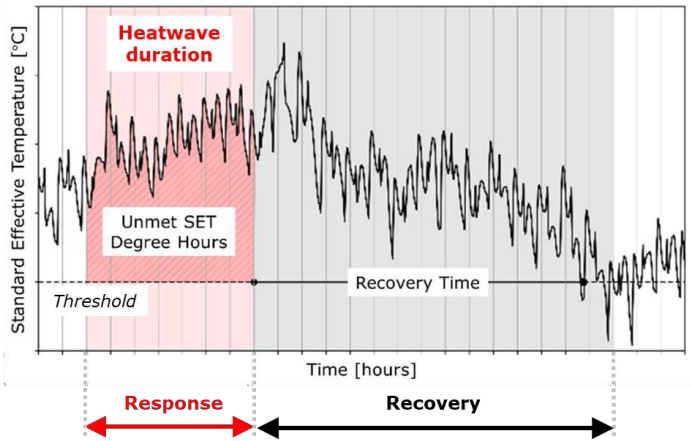


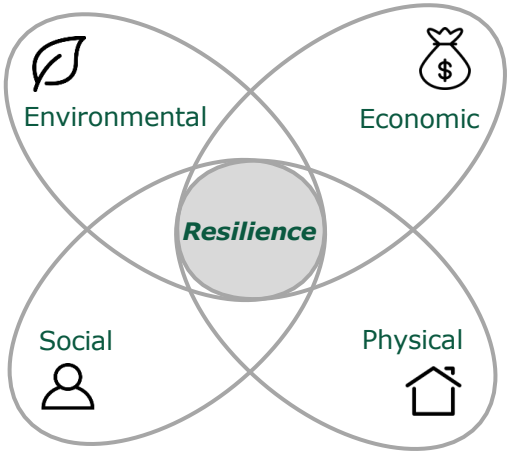
Bianchi et al. (2024) Resource-efficient climate-resilient buildings by multi-hazard risk modelling & resilience-oriented decision-making. Veni AES 2023, no. 21129.

Integrating Multi-Hazard Risk and Resilience

2) Holistic assessment methods

- Multi-domain approach
- Time-dependent behaviour



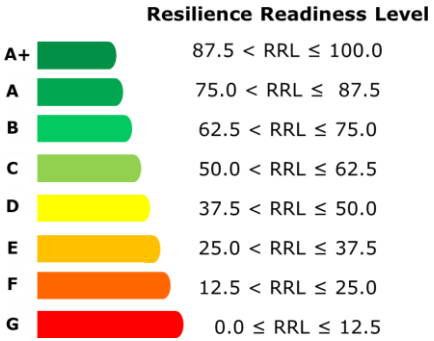


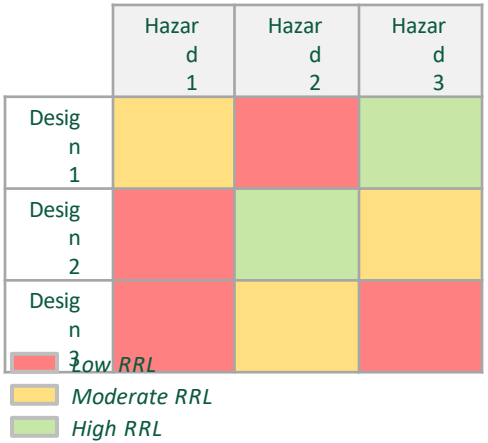
Bianchi et al. (2025) Resilience Readiness Levels for Buildings: Establishing Multi-Hazard Resilience Metrics and Rating Systems. International Journal of Disaster Risk Reduction, 128.

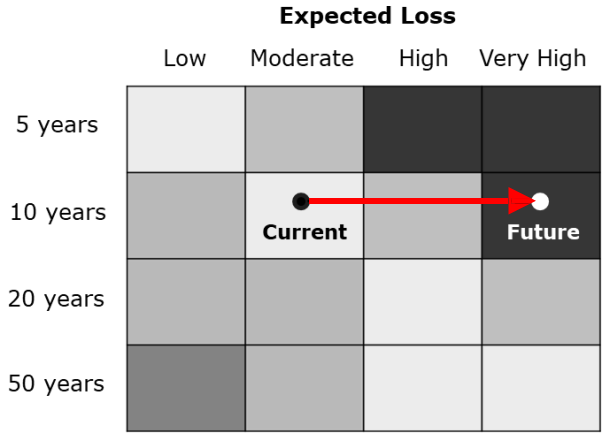
Integrating Multi-Hazard Risk and Resilience

3) Multi-performance design requirements

- Resilience levels
- Risk targets







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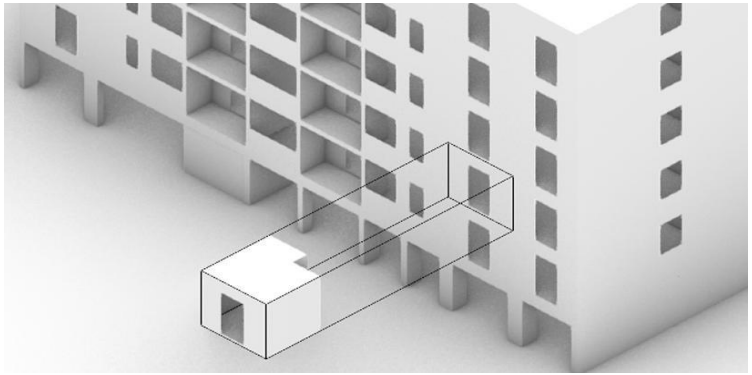
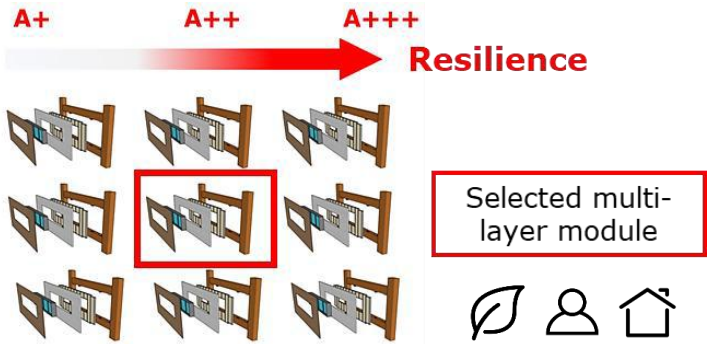
Integrating Multi-Hazard Risk and Resilience

4) Multi-scale mitigation strategies

- Occupant-Building
- Component-Building
- Building-Grid

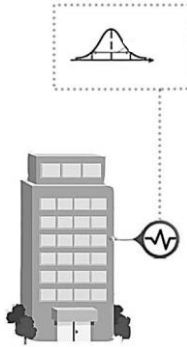


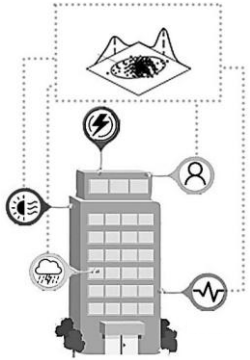


Bianchi, Overend et al. (2023) Multi-hazard low-carbon resilient technologies and multi-scale digital services for a future-proof, sustainable user-centred built environment. Horizon Europe project, GA no. 101123467.

Advancing Energy Building Codes

Single Hazard Resilience





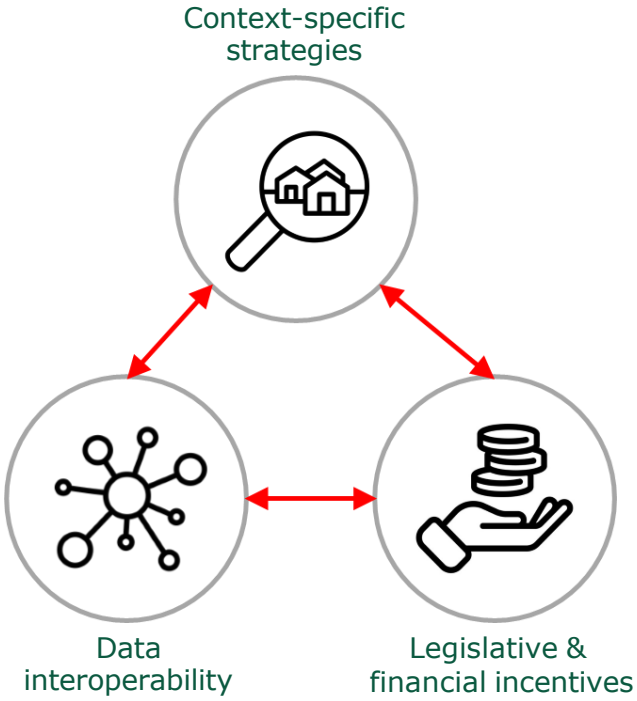
Multi Hazard Resilience

1) Extreme and future hazards
2) Standardized approach for resilience quantification
3) Resilience design criteria and targets
4) Integrated energy efficient and resilient technologies

1) Definition of multi-hazard events and consequences
2) Holistic assessment methods
3) Multi-performance design criteria and targets
4) Multi-scale mitigation strategies and benefits

Knowledge Gaps and Challenges

- **Data availability** on behaviour under failure modes
- Advancing **current practice** through training programmes
- Lack of resilience design, assessment and decision support **digital tools**



MULTICARE

MULTI-hazard low-**Ca**rbon **RE**silient technologies and multi-scale digital services for a future-proof, sustainable user-centred built environment

Bianchi S., Overend M., et al.

European Commission

Horizon Europe Research & Innovation Programme (GA no. 101123467)

RECLIMATE

Resource-efficient climate-resilient buildings by multi-hazard risk modelling & resilience-oriented decision-making

Bianchi S., et al.

NWO

Talent Programme Veni AES 2023 (no. 21129)

Multi-Hazard Risk and Resilience in Building Codes

Dr. Simona Bianchi
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7th BECWG Symposium, 12 November 2025

EBC

Energy in Buildings and Communities Programme

Session II.

The Potential of Artificial Intelligence (AI) for Building Energy Codes

Moderated by Jean-Simon Venne, President, Founder and CTO of BrainBox AI

The Potential of Artificial Intelligence (AI) for Building Energy Codes

EBC
Energy in Buildings and Communities Programme

Dr. Nora Esram
CEO, New Buildings Institute

Dr. Hanlong Wan
Mechanical Engineer, PNNL

Concluding remarks

Meli Stylianou
Natural Resources Canada
BECWG Co-Chair

EBC

Energy in Buildings and Communities Programme

Thank you!