ANNEX 80

EBC
Energy in Building and Communities Programme

International Energy Agency

Resilient Cooling of Buildings Key Performance Indicators Report (Annex 80)

Energy in Buildings and Communities Technology Collaboration Programme

May 2024

Technology Collaboration Programme
by iea

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May 2024

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Preface

The International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster international co-operation among the 30 IEA participating countries and to increase energy security through energy research, development and demonstration in the fields of technologies for energy efficiency and renewable energy sources.

The IEA Energy in Buildings and Communities Programme

The IEA co-ordinates international energy research and development (R&D) activities through a comprehensive portfolio of Technology Collaboration Programmes (TCPs). The mission of the IEA Energy in Buildings and Communities (IEA EBC) TCP is to support the acceleration of the transformation of the built environment towards more energy efficient and sustainable buildings and communities, by the development and dissemination of knowledge, technologies and processes and other solutions through international collaborative research and open innovation. (Until 2013, the IEA EBC Programme was known as the IEA Energy Conservation in Buildings and Community Systems Programme, ECBCS.)

The high priority research themes in the EBC Strategic Plan 2019-2024 are based on research drivers, national programmes within the EBC participating countries, the Future Buildings Forum (FBF) Think Tank Workshop held in Singapore in October 2017 and a Strategy Planning Workshop held at the EBC Executive Committee Meeting in November 2017. The research themes represent a collective input of the Executive Committee members and Operating Agents to exploit technological and other opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy technologies, systems and processes. Future EBC collaborative research and innovation work should have its focus on these themes.

At the Strategy Planning Workshop in 2017, some 40 research themes were developed. From those 40 themes, 10 themes of special high priority have been extracted, taking into consideration a score that was given to each theme at the workshop. The 10 high priority themes can be separated in two types namely 'Objectives' and 'Means'. These two groups are distinguished for a better understanding of the different themes.

Objectives - The strategic objectives of the EBC TCP are as follows:

– reinforcing the technical and economic basis for refurbishment of existing buildings, including financing, engagement of stakeholders and promotion of co-benefits;
– improvement of planning, construction and management processes to reduce the performance gap between design stage assessments and real-world operation;
– the creation of 'low tech', robust and affordable technologies;
– the further development of energy efficient cooling in hot and humid, or dry climates, avoiding mechanical cooling if possible;
– the creation of holistic solution sets for district level systems taking into account energy grids, overall performance, business models, engagement of stakeholders, and transport energy system implications.

Means - The strategic objectives of the EBC TCP will be achieved by the means listed below:

– the creation of tools for supporting design and construction through to operations and maintenance, including building energy standards and life cycle analysis (LCA);
– benefitting from 'living labs' to provide experience of and overcome barriers to adoption of energy efficiency measures;
– improving smart control of building services technical installations, including occupant and operator interfaces;
– addressing data issues in buildings, including non-intrusive and secure data collection;
– the development of building information modelling (BIM) as a game changer, from design and construction through to operations and maintenance.

The themes in both groups can be the subject for new Annexes, but what distinguishes them is that the 'objectives' themes are final goals or solutions (or part of) for an energy efficient built environment, while the 'means' themes are instruments or enablers to reach such a goal. These themes are explained in more detail in the EBC Strategic Plan 2019-2024.

The Executive Committee

Overall control of the IEA EBC Programme is maintained by an Executive Committee, which not only monitors existing projects, but also identifies new strategic areas in which collaborative efforts may be beneficial. As the Programme is based on a contract with the IEA, the projects are legally established as Annexes to the IEA EBC Implementing Agreement. At the present time, the following projects have been initiated by the IEA EBC Executive Committee, with completed projects identified by (*) and joint projects with the IEA Solar Heating and Cooling Technology Collaboration Programme by (☼):

Annex 1: Load Energy Determination of Buildings (*)
Annex 2: Ekistics and Advanced Community Energy Systems (*)
Annex 3: Energy Conservation in Residential Buildings (*)
Annex 4: Glasgow Commercial Building Monitoring (*)
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities (*)
Annex 7: Local Government Energy Planning (*)
Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)
Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
Annex 15: Energy Efficiency in Schools (*)
Annex 16: BEMS 1- User Interfaces and System Integration (*)
Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18: Demand Controlled Ventilation Systems (*)
Annex 19: Low Slope Roof Systems (*)
Annex 20: Air Flow Patterns within Buildings (*)
Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
Annex 29: ☼ Daylight in Buildings (*)
Annex 30: Bringing Simulation to Application (*)
Annex 31: Energy-Related Environmental Impact of Buildings (*)
Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: ☼ Solar Sustainable Housing (*)
Annex 39: High Performance Insulation Systems (*)
Annex 40: Building Commissioning to Improve Energy Performance (*)
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG) (*)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM) (*)
Annex 43: ☼ Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings (*)
Annex 45: Energy Efficient Electric Lighting for Buildings (*)
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (*)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings (*)
Annex 48: Heat Pumping and Reversible Air Conditioning (*)
Annex 49: Low Exergy Systems for High Performance Buildings and Communities (*)
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings (*)
Annex 51: Energy Efficient Communities (*)
Annex 52: ☼ Towards Net Zero Energy Solar Buildings (*)
Annex 53: Total Energy Use in Buildings: Analysis and Evaluation Methods (*)
Annex 54: Integration of Micro-Generation and Related Energy Technologies in Buildings (*)
Annex 55: Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance and Cost (RAP-RETRO) (*)
Annex 56: Cost Effective Energy and CO2 Emissions Optimization in Building Renovation (*)
Annex 57: Evaluation of Embodied Energy and CO2 Equivalent Emissions for Building Construction (*)

Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements (*)
Annex 59: High Temperature Cooling and Low Temperature Heating in Buildings (*)
Annex 60: New Generation Computational Tools for Building and Community Energy Systems (*)
Annex 61: Business and Technical Concepts for Deep Energy Retrofit of Public Buildings (*)
Annex 62: Ventilative Cooling (*)
Annex 63: Implementation of Energy Strategies in Communities (*)
Annex 64: LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles (*)
Annex 65: Long-Term Performance of Super-Insulating Materials in Building Components and Systems (*)
Annex 66: Definition and Simulation of Occupant Behavior in Buildings (*)
Annex 67: Energy Flexible Buildings (*)
Annex 68: Indoor Air Quality Design and Control in Low Energy Residential Buildings (*)
Annex 69: Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings
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Annex 89: Ways to Implement Net-zero Whole Life Carbon Buildings
Annex 90: EBC Annex 90 / SHC Task 70 Low Carbon, High Comfort Integrated Lighting
Annex 91: Open BIM for Energy Efficient Buildings
Annex 92: Smart Materials for Energy-Efficient Heating, Cooling and IAQ Control in Residential Buildings

Working Group - Energy Efficiency in Educational Buildings (*)
Working Group - Indicators of Energy Efficiency in Cold Climate Buildings (*)
Working Group - Annex 36 Extension: The Energy Concept Adviser (*)
Working Group - HVAC Energy Calculation Methodologies for Non-residential Buildings (*)
Working Group - Cities and Communities
Working Group - Building Energy Codes

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Abbreviations

Abbreviations	Meaning
AWD	Ambient Warmness Degree
DH	Degree Hours
GHG	Greenhouse Gas
HE	Hours of Exceedance
HVAC	Heating, Ventilation, Air Conditioning
HI	Heat Index
IOD	Indoor Overheating Degree
KPI	Key Performance Indicator
OEF	Overheating Escalation Factor
PET	Physiological Equivalent Temperature
PHS	Predicted Heat Strain
PMV	Predicted Mean Vote
POR	Percentage Outside the Range
PPD	Predicted Percentage of Dissatisfied
RH	Relative Humidity
SET	Standard Effective Temperature
WBGT	Wet Bulb Globe Temperature
WHE	Weighted hours of exceedance
WMO	World Meteorological Organization

1. Objectives

Within Annex 80, there is a manifold need to use key performance indicators (KPI, i.e. performance metrics). This is relevant to all Subtasks. The “Task Group KPI” is established to coordinate and clarify the KPIs, used within Annex 80. The Task Group shall collect and coordinate KPIs, relevant to Resilient Cooling. It shall develop and constantly maintain a well-structured list of KPIs, including their definition and ranges of application within the Annex. This report documents all developed KPIs.

2. Methodology

This study employs a structured approach to evaluate Key Performance Indicators (KPIs) for assessing the resilience of buildings across various technologies. The methodology consists of the following steps.

All suggested KPIs pertinent to assessing building resilience were collected and listed comprehensively. This involved an extensive review of existing literature, standards, and expert opinions. The aim was to compile a comprehensive inventory of KPIs that encompass diverse aspects of building resilience.

Each identified KPI is systematically described to ensure clarity and understanding. This description includes:

> **Definition:** A clear and concise definition of the KPI to establish its scope and purpose.
> **Synonym** (optional): A different, commonly used, term addressing the same KPI
> **Unit** (if applicable): Specification of the unit of measurement associated with the KPI to facilitate quantitative analysis.
> **Source**: Identification of the source(s) from which data for the KPI can be obtained, ensuring reliability and validity.

3. Glossary of Terms

The glossary of terms collects terms and metrics which are relevant for the deliverables of the Annex. No benchmarks or target values of these terms are addressed within the glossary of terms.

3.1 Energy and Carbon

3.1.1 Energy Need for Heating, Cooling or Domestic Hot Water

Heat to be delivered to or extracted from a thermally conditioned space to maintain the intended space temperature conditions during a given period of time.
Synonym: useful energy
Units: kWh, kWh/a and corresponding
Source: ISO 52000-1:2017 [1]

3.1.2 Energy Need for Humidification or Dehumidification

Latent heat in the water vapour to be delivered to or extracted from a thermally conditioned space by a technical building system to maintain a specified minimum or maximum humidity within the space.
Synonym: useful energy
Units: kWh, kWh/a and corresponding
Source: ISO 52000-1:2017 [1]

3.1.3 Delivered Energy for Heating, Cooling or Domestic Hot Water

Energy, expressed per energy carrier, supplied to the technical building systems through the assessment boundary, to satisfy the uses taken into account (i.e. heating, cooling or domestic hot water).
Synonym: site energy
Units: kWh, kWh/a and corresponding
Source: ISO 52000-1:2017 [1]

3.1.4 Delivered Energy for Humidification or Dehumidification

Energy, expressed per energy carrier, supplied to the technical building systems through the assessment boundary, to satisfy the uses taken into account (i.e. humidification or dehumidification).
Synonym: site energy
Units: kWh, kWh/a and corresponding
Source: ISO 52000-1:2017 [1]

3.1.5 Delivered Energy for Ventilation

Electric energy input to a ventilation system for air transport and heat recovery.
Units: kWh, kWh/a and corresponding
Source: ISO 52000-1:2017 [1]

3.1.6 Auxiliary Energy

Electrical energy used by technical building systems to support energy transformation to satisfy energy needs. This includes energy for fans, pumps, electronics, etc. Electrical energy input to a ventilation system for air transport is not considered as auxiliary energy, but as energy use for ventilation. Auxiliary energy

can be counted as its own quantity or can be counted together with the delivered energy for the uses taken into account.
Units: kWh, kWh/a and corresponding
Source: ISO 52000-1:2017 [1]

3.1.7 Primary Energy

Energy that has not been subjected to any conversion or transformation process.
Synonym: source energy
Units: kWh, kWh/a and corresponding
Source: ISO 52000-1:2017 [1]

3.1.8 Carbon Emissions

Emissions of CO_2-equivalents from energy use, respectively cooling, expressed.
Synonym: Greenhouse Gas (GHG) Emissions
Units: kg_{CO2}, kg_{CO2}/a, $kg_{CO2}/(m^2_{GFA}.a)$
Source: ISO 52000-1:2017 [1]

3.2 Loads

3.2.1 Sensible Heating or Cooling Load

Hourly mean value of the heating or cooling heat flow rate supplied to or extracted from the internal environment to maintain the intended space temperature conditions.
Synonym: source energy
Units: W, kW and corresponding
Source: ISO 52000-1:2017 [1]

3.2.2 Latent Heating or Cooling Load

Hourly mean value of the latent heat in the water vapour to be supplied to or extracted from the internal environment to maintain the intended space air moisture conditions.
Synonym: source energy
Units: W, kW and corresponding
Source: ISO 52000-1:2017 [1]

3.3 Temperatures

3.3.1 Operative Temperature

The average of the air temperature and the mean radiant temperature weighted, respectively, by the convective heat transfer coefficient and the linearized radiant heat transfer coefficient for the occupant.
Units: °C
Sources: ASHRAE 55-2020 [2] and ISO 7726 [3]

- Within Annex 80 it is agreed to use operative temperature prior to air temperature.
- Within Annex 80 the adaptive comfort model with its variable operative temperature to buildings without mechanical cooling is applied.

3.3.2 Dry Bulb Air Temperature

The temperature of air measured by a thermometer freely exposed to the air, but shielded from radiation.
Units: °C
Source: ISO 7726:2001 (2021) [4]

3.4 Thermal Comfort Metrics

3.4.1 PMV Thermal Sensation Vote

An index that predicts the mean value of the votes of a large group of persons on the seven-point thermal sensation scale.
Unit: dimensionless number
Sources: ASHRAE 55-2020 [2], ISO 7730 2005 [5], ISO 17772-1 2017 [6]

- Within Annex 80 the comfort model of PMV/PPD to mechanically cooled buildings is applied.
- Within the Annex 80 - Dynamic simulation guideline comfort limits of PMV/PPD according to category II are used, defining the limit of thermal comfort with a PMV lower than 1.

3.4.2 Physiological Equivalent Temperature (PET)

PET is defined as the equivalent air temperature at which, in a standard indoor setting (without wind and solar radiation), the heat budget of a person in light activity (1.5 met) and wearing typical summer clothing with 0.9 clo is balanced with the same core and skin temperature as under the complex outdoor conditions to be assessed.
Unit: °C
Source: Höppe P. (1999) [7]

3.5 Heatwave Definitions

3.5.1 Meteorological Heatwave Definition

This is an exclusively meteorologically based definition, dependent from the ambient temperature of the local climate.

According to this method, a heatwave is a period of days with abnormally high daily mean ambient temperatures, occurring at least during three consecutive days, defined by three specific thresholds of the daily mean ambient temperature of a historical multi-year period:

Spic: the 99.5 percentile, *Sdeb*: the 97.5 percentile, *Sint*: the 95.0 percentile

The beginning of the heatwave is the first day whose daily mean temperature exceeds the *Sdeb* threshold. The end of the heatwave can be determined by two conditions: Either the temperature falls below *Sint* or the temperature falls below *Sdeb* for at least three consecutive days.

According to this method, each heatwave can be characterized by its duration, severity, and intensity:

Duration: Number of consecutive days fulfilling the heatwave definition criteria. Unit: days
Severity: Cumulative exceedance of the daily mean ambient temperatures, during the heatwave, above the threshold of *Sdeb*. Unit: Degree Celsius days, °C.d
Intensity: Maximum daily mean ambient temperature reached during the heatwave. Unit: °C

– Within Annex 80, this heatwave definition has been used to identify heatwaves within future weather datasets for adaptation and resilience studies linked to climate change [8].

Source: This heatwave definition is based upon the method proposed by Ouzeau et al. [9].

3.5.2 Physiological Heatwave Definition

This is a physiologically based definition, independent from the local climate.

According to this method, a heatwave is a period of days with warm ambient temperatures that result in heat stress (or thermal discomfort) to people who are directly exposed to such heat events under sunshade (no beam sunlight) over at least one day.

Different metrics for heat stress or thermal discomfort may be used within this method. Within Annex 80 the metric of SET (standard effective temperature) is used, with two alternative thresholds, which are 30 °C for heat un-acclimatized people and 31.2 °C for heat acclimatized people. The outdoor SET takes into account the outdoor weather variables of temperature, relative humidity (RH), wind speed and radiative heat from diffuse sunlight.

According to this method, a heatwave starts, when the severity of a daily heat event exceeds a minimum value of 4 °C*h and ends, when it falls below it. The minimum value of severity is chosen to minimise body dehydration below 1 % for continuous exposure to heat of up to 4 hours.

Each heatwave can be characterized by its duration, severity, and intensity:

Duration: Number of consecutive days fulfilling the heatwave definition criteria. Unit: days
Severity: Cumulative exceedance of the hourly outdoor SET, during the heatwave, above the fixed threshold of SET. Unit: Degree Celsius hours, °C.h., Synonym: magnitude,
Intensity: Severity, divided by the duration of the heatwave, divided by the factor of 24.

Source: This heatwave definition is based upon the National Building Code of Canada method [10].

4. Key Performance Indicators

The KPI collection contains indicators which are relevant for the Annex 80 deliverables. Their application may be more precisely defined in the guidelines of specific task groups or Subtasks of Annex 80, e.g. in the simulation guideline or in the case study document.

4.1 Thermal Comfort KPIs

4.1.1 Hours of Exceedance (HE)

The number of hours within a given period, when the room's air temperature or others exceed a zonal comfort criterion.
Synonyms: unmet hours, percentage outside the range (POR)
Units: hours within a given period (e.g. one year or one day), percentage of hours of exceedance per hours of the period, leading to h/a, h/d, %
Sources: CEN/TR 16798-2: 2019 [11] and ASHRAE 55-2020 [2].

- Hours of Exceedance may also be applied using weighing factors, either according to the degree hours criteria or according to PPD weighted criteria. (See CEN/TR 16798-2: 2019, Annex D). In Annex 80 it is agreed to use Hours of Exceedance (HE) usually without weighing factors. Exceptions are possible in specific cases.
- Hours of Exceedance can be calculated per year, per month, per week or per day. In Annex 80 it is agreed to choose the time periods of year and of day. Years shall be chosen for performance evaluations under test reference year conditions. Days shall be chosen for performance evaluations under short term heatwave conditions. If calculated as percentage of hours of exceedance per hours of the period, it is agreed to count only hours of occupation.
- Hours of Exceedance can be applied to a wide range of comfort criteria, such as operative temperature, PMV, PPD, SET and others. The comfort criteria itself may be static or dynamic. In Annex 80 Hours of Exceedance (a) are applied to the criterion of operative temperature (Top) in case of buildings without heating or cooling and (b) to the criterion of PMV/PPD in case of buildings with heating or cooling.
- When applying hours of exceedance to short time heat waves, the question occurs how to deal with weekends that randomly might fall into the days of the heatwave. In Annex 80 it is decided to perform the heatwave analysis for constant usage of operation of the building without changes for weekends, even ignoring holidays or similar interruptions of use during heatwaves.

4.1.2 Thermal Autonomy

The fraction of time a building can passively maintain comfort conditions without active systems.
Unit: % of the occupied hours.
Source: Attia et al. (2021) [12].

4.1.3 Indoor Overheating Degree (IOD)

The overheating of an indoor space. Hourly summation over the summertime period of the positive values of the difference between the operative temperature of the occupied building thermal zones and the zonal thermal comfort limit temperature, divided by the sum of the zonal occupied hours.
Unit: Kelvin

Source: Hamdy et al (2017) [13]

– Note: IOD corresponds with the weighted unmet hours criteria, defined in CEN/TR 16798-2: 2019 [11] and with the weighted exceedance hours criterion, defined in ASHRAE 55-2020 [2].

4.1.4 Ambient Warmness Degree (AWD)

The heat stress of an outdoor environment. Hourly summation over the summertime period of the positive values of the difference between the outdoor air temperature and a fixed base temperature. The value of this base temperature must be defined and declared.
Unit: Kelvin
Source: Hamdy et al (2017) [13]

– Note: AWD corresponds in content with the weighted unmet hours criteria, defined in CEN/TR 16798-2: 2019 [11] and with the weighted exceedance hours criterion, defined in ASHRAE 55-2020 [2].

4.1.5 Overheating Escalation Factor (OEF)

The ratio of IOD to AWD.
Unit: dimensionless number
Source: Hamdy et al (2017) [13]

4.2 Heat stress KPIs

4.2.1 Standard Effective Temperature (SET)

The equivalent dry bulb air temperature of an isothermal environment at 50 % relative humidity, and still air, in which an imaginary subject, while wearing clothing standardized for activity concerned, would have the same heat stress (skin temperature) and thermoregulatory strain (skin wettedness) as in the actual test environment. For the calculation method of SET see ASHRAE 55-2020 Appendix D [2] or CBE Thermal Comfort Tool: https://comfort.cbe.berkeley.edu/ [14].
Unit: °C
Source: ASHRAE 55-2020 [2], Parsons. K. Human Thermal Comfort 2020 [15]

4.2.2 Wet Bulb Globe Temperature (WBGT)

The sum of linear weighting of air, black globe and naturally ventilated web bulb temperatures

Unit: °C

Sources: ASHRAE 55-2020 [2] and ISO 7726 [3]

– Note: WBGT is suggested by U.S. Green Building Council as one out of two suitable metrics to prove compliance with passive survivability (thermal safety). See LEED BD+C: New Constructionv4 - LEED v4 [16].

4.2.3 Heat Index (HI)

Heat Index describes how the temperature feels like to the human body when relative humidity is combined with the air temperature.

Synonym: apparent temperature [17].

Unit: dimensionless number

Sources: U.S. National Oceanic and Atmospheric Administration [17] and U. S. Occupational Safety and Health Administration Heat Advisory Levels [18].

- Note: HI is suggested by U.S. Green Building Council as one out of two suitable metrics to prove compliance with passive survivability (thermal safety). See LEED BD+C: New Constructionv4 - LEED v4 [16].
- Note: U.S. National Oceanic and Atmospheric Administration presents benchmarks of HI to avoid health risk:
  - A HI above between 80 F (26,7 °C) and 90 F (32,2 °C) is classified with “caution”: Fatigue possible with prolonged exposure and/or physical activity.
  - A HI between 90 F (32,2 °C) and 103 F (39,4 °C) is classified with “Extreme Caution”: Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity.
  - A HI 103 F (39,4 °C) and 124 F (51,1 °C) is classified with “Danger”: Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity.
  - A HI of 125 F (51,7 °C) and beyond is classified with “Extreme Danger”: Heat stroke highly likely”.

4.2.4 Predicted Heat Strain (PHS)

Calculates the thermal balance of the body influenced by the parameters of the thermal environment (air temperature, mean radiant temperature, partial vapor pressure, air velocity) and the mean characteristics of the subjects exposed to the working situation (metabolic rate and clothing insulation).

Unit: dimensionless number

Source: ISO 7933:2023 [19]

4.2.5 Passive Survivability

The ability to maintain safe indoor thermal conditions in the absence of active cooling, respectively Air Conditioning. Given in yes/no within a chosen timestep.

Unit: yes/no within a chosen time step

Source: U.S. Green Building Council, 2020. LEED BD+C: New Constructionv4 - LEED v4 [16].

4.3 Energy Performance KPIs

4.3.1 Annual Cooling Demand per Conditioned Floor Area

The annual amount of heat to be extracted from a building space with the aim of reaching and maintaining a given maximum space temperature. This amount of energy is represented specified over the conditioned floor area.

Unit: $kWh/m^2 \cdot a$

Source: ISO 52000-1:2017 [1]

4.3.2 Annual Heating Demand per Conditioned Floor Area

The annual amount of heat supplied to a building space with the aim of reaching and maintaining a given minimum space temperature. This amount of energy is represented specified over the conditioned floor area.

Unit: $kWh/m^2 \cdot a$

Source: ISO 52000-1:2017 [1]

4.3.3 Annual Cooling Site Energy Use per Conditioned Floor Area

The annual amount of energy, expressed per energy carrier, supplied to the technical building systems through the assessment boundary, to satisfy the annual cooling demand taken into account or to produce the exported energy. This amount of energy is represented specified over the conditioned floor area.

Unit: $kWh/m^2 \cdot a$

Source: ISO 52000-1:2017 [1]

4.3.4 Annual Heating Site Energy Use per Conditioned Floor Area

The annual amount of energy, expressed per energy carrier, supplied to the technical building systems through the assessment boundary, to satisfy the annual heating demand taken into account or to produce the exported energy. This amount of energy is represented specified over the conditioned floor area.

Unit: $kWh/m^2 \cdot a$

Source: ISO 52000-1:2017 [1]

4.3.5 Annual CO_2 Emission per Conditioned Floor Area

Annual CO_2 emission is defined as the product of CO_2 emission coefficient, corresponding to energy carrier, and the annual amount of delivered energy. Due to the national dependency of CO_2 emission coefficients, the annual CO_2 emissions per conditioned floor area must additionally be indicated with the national carbon emission coefficients applied.

Unit: $gCO_2/m^2 \cdot a$

Source: ISO 52000-1:2017 [1]

4.3.6 Annual HVAC System Total Primary Energy Use per Conditioned Floor Area

Annual HVAC energy which has not been subjected to any conversion or transformation process. Primary energy includes non-renewable energy and renewable energy. If both are taken into account, it is called total primary energy.

Unit: $kWh/m^2 \cdot a$

Source: ISO 52000-1:2017 [1]

4.3.7 Degree Hours

Degree Hours or Degree Days are measures of how cold or warm a location is. A degree day is defined as a unit of measurement that compares the mean (or average) of the high and low outdoor temperatures recorded for a given location to a standard temperature. A high degree-day count is indicative of elevated energy use for space heating or cooling.

Unit: d or h

Source: U.S. Energy Information Administration [20]

4.4 HVAC and grid KPIs

4.4.1 Seasonal Energy Efficiency Ratio (SEER)

The Energy Efficiency Ratio (EER) is the ratio between useful cooling output and power input, at a given state of operation. The Seasonal Energy Efficiency Ratio (SEER) is the same ratio over a full cooling period. EER can be applied not only to active cooling technologies but also to automated passive ones. In this case, the power input is limited to auxiliary energy inputs, such as fans, circulation pumps, actuators, or controls.

Unit: dimensionless number

Source: EN 14825:2022 [21]

4.4.2 Seasonal Coefficient of Performance (SCOP)

The coefficient of performance (COP) is the ratio between useful heating output and power input, at a given state of operation. The Seasonal Coefficient of Performance (SCOP) is the same ratio over a full heating period.

Unit: dimensionless number

Source: EN 14825:2022 [21]

4.4.3 Reduction in Peak Site Power Demand Intensity

The (annual) reduction of site peak power demand that can be achieved by a specific (resilient) cooling measure, against a conventional cooling solution without this specific (resilient) cooling measure.

Unit: W/m^2

4.4.4 Ozone Depletion Potential (ODP)

The relative strength of a substance's (for example of a refrigerant) ability to destroy ozone. It is defined as the ratio of the change in global ozone for a given mass emission of the substance to the change in global ozone for the same mass emission of CFC-11 ($CFCl_3$).

Unit: kg CFC-11 equivalent

Source: World Meteorological Organization (WMO) [22]

4.4.5 Global Warming Potential (GWP)

An index measuring the radiative forcing following an emission of a unit mass of a given substance, accumulated over a chosen time horizon, relative to that of the reference substance, carbon dioxide (CO_2). The GWP thus represents the combined effect of the differing times these substances remain in the atmosphere and their effectiveness in causing radiative forcing.

Unit: kg CO_2 equivalent

Source: Intergovernmental Panel on Climate Change (IPCC) [23]

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