Supplementary Materials

A review of bottom up studies on life cycle carbon emissions for rural dwellings

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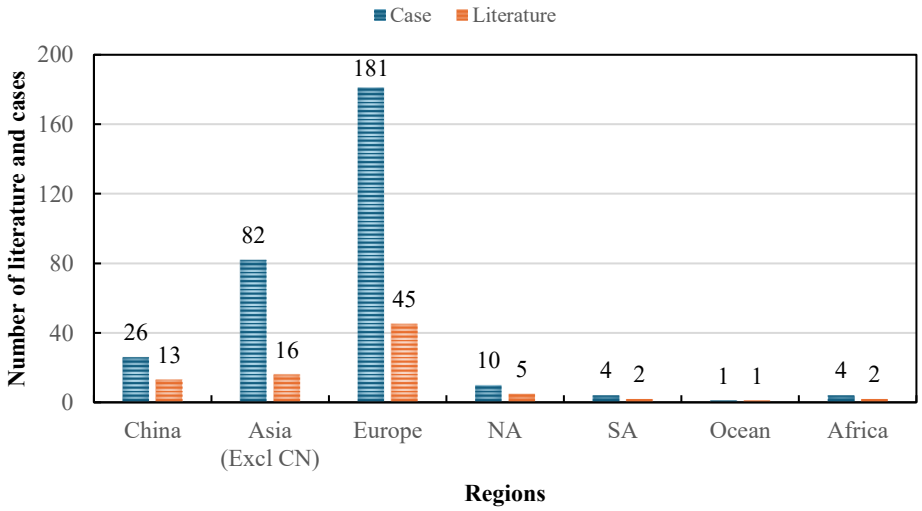
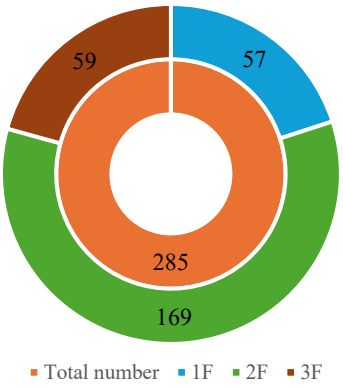
- *Geographical location.* The cases were from 36 countries, including 26 from China, 82 from other Asian countries, 181 from Europe, 10 from North America, 4 from South America, and 1 from Ocean. Statistics provided by the United Nations showed that the global urbanization rate in 2022 was 57.0%, consisting of 63.6%, 52.3%, 75.3%, 83.0%, and 81.7% for China, Asia, Europe, North America, and South America, respectively.

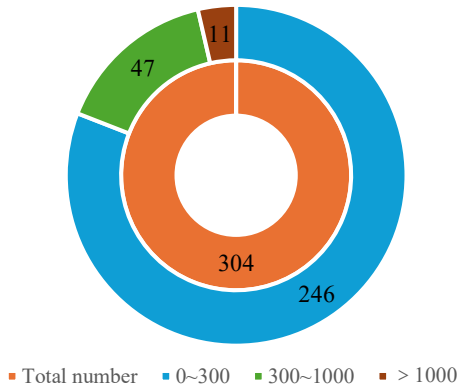


Appendix Fig. 1 Literature and cases (by region)

• *Number of floors.* There are 285 RCBs cases with specific building floors, including 57 one-storey, 169 two-storey and 59 three-storey buildings, accounting for 20.0%, 59.3% and 20.7% of the total, respectively (Appendix Fig. 2).



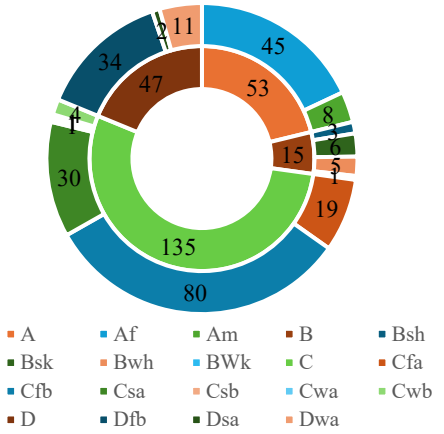
Appendix Fig. 2 The number of floors of building cases



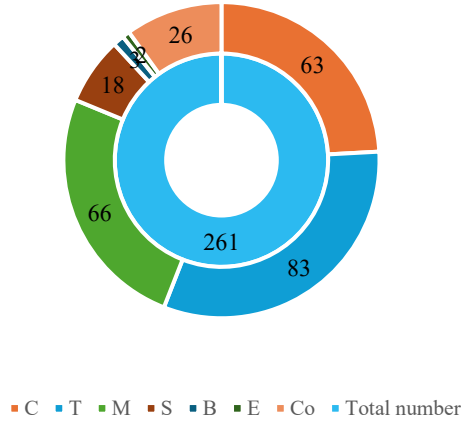
Appendix Fig. 3 Building floor area of building cases
(Unit: m^2)

• *Building floor area*. A total of 304 cases provided data on the building floor area, including 246 cases with floor areas of 0-300 m^2, 47 cases with floor areas of 300-1000 m^2, and 11 cases with floor areas of over 1000 m^2 (Appendix Fig. 3).

• *Climate condition*. A total of 250 cases provided sufficient information to help track the climate zone in which they were located according to the Köppen climate classification method. The numbers of cases in climate zones A, B, C, and D were 53, 15, 135, and 47, respectively at the primary zoning level. The majority of cases were in secondary climate zone Af, Cfa, Cfb, Csa, and Dfb, with 45, 19, 80, 30, and 34 cases, respectively (Appendix Fig. 4).

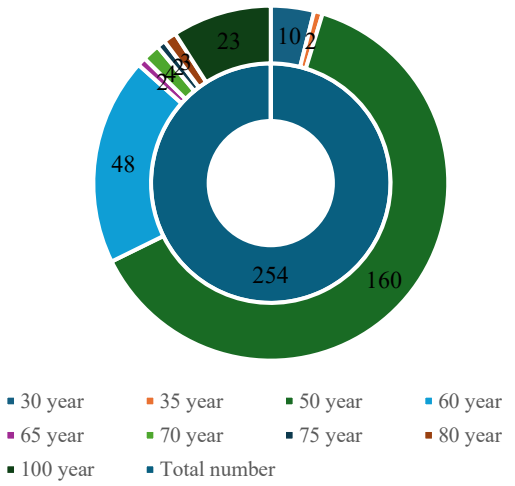


Appendix Fig. 4 Climate distribution of building cases



Appendix Fig. 5 Structure type of building cases

- *Building structure*. A total of 261 cases provided information on building structures. There were 66, 63, 18, and 83 masonry, concrete, steel, and timber structures, respectively. In addition, 26 cases were composite structures, 3 cases were bio-based structure, and 2 cases were rammed earth structure (Appendix Fig. 5).
- *Calculation period*. A total of 254 cases provided the expected service life of a building during the CE calculation period, of which 160 (63.0%) had a calculation period of 50 years. In addition, 10, 48, and 23 cases were set to 30, 60, and 100 years, respectively, and the remaining 13 cases were set to other values between 30 and 100 years (Appendix Fig. 6).



Appendix Fig. 6 Calculation period of building cases. Note: China M., China

mainland; BE+PT+SE, Belgium+Portugal+Sweden; DE+AT, Germany+Austria; DE+SI+ES, Germany+Slovenia+Spain; CO+ES, Colombia+Spain; USA+CH, USA+Switzerland; CN+Fin, China+Finland

Appendix Table 1. OCE calculation methods and items.

Literature	Location	Main methods	Content
Zhang et al.[16] 2021	China	Energy simulation (DeST)	H, C, L
Gong et al.[17] 2012	China	Energy simulation (DeST)	Electricity, Natural gas
Yang et al.[18] 2021	China	Energy-efficient building design	H, C, V, L, DHW
Zhang et al.[21] 2023	China	Energy simulation (Design Builder)	H, C,
Cai et al.[22] 2023	China	Calculation	Electricity, Natural gas, Coke
Liu et al.[23] 2023	China	Calculation	H, C, L
Yan et al.[24] 2024	China	Energy simulation (Design Builder)	H, C, L, DHW
Huang et al.[26] 2024	China	Monitored energy consumption	Electricity, Coal gas
Song et al.[27] 2025	China	PKPM-CES	H, V, A, C, L, DHW
Shi et al.[104] 2023	China	Calculation	Electricity, H, Natural gas, LPG
Gerilla et al.[29] 2007	Japan	/	Electricity, Gas, Kerosene
Atmaca et al.[39] 2015	Turkey	Energy records	Electricity, Natural gas, Coal
Kayaçetin et al.[40] 2024	Turkey	BEP-TR	H, C

Ajay et al.[42] 2025	Myanmar	Monitored energy consumption	LPG, Electricity, H, C
Passer et al.[44] 2012	Austria	Calculation	H, C, V, L
Krasny et al.[45] 2017	BiH	BIM Energy Analysis	H
Pal et al.[46] 2017	Finland	Energy simulation (IDA ICE)	H, C, V, L, A, DHW
Thiers et al.[47] 2012	France	Calculation	H, V, L, A, DHW
Thiers et al.[48] 2008	France	Thermal simulation (ALCYONE)	H, A, DHW
Houlihan et al.[49] 2014	Norway	Calculation	H, L, A, DHW, PV system
Kristjansdottir et al.[50] 2017	Norway	Energy simulation (IDA-ICE)	H, V, L, A, DHW, Pumps, PV system
Moran et al.[52] 2017	Ireland	Energy calculation (DEAP)	H, V, L, DHW
Asdrubali et al.[53] 2013	Italy	Energy simulation	H, C, L, A, DHW, Cooking
Blengini et al.[54] 2010	Italy	Statistical data, calculation with software EDILCLIMA EC501	H, V, L, A, DHW, Cooking, Washing
Vitale et al.[56] 2018	Italy	Energy balance calculation (Epix7©)	H, C, DHW
Proietti et al.[57] 2013	Italy	Monitored energy consumption	H, L, DHW, Cooking, Washing
Monteiro et al.[61] 2012	Portugal	Energy calculation (RCCTE)	H, C
Zabalza et al.[62] 2009	Spain	Energy consumption (Building Certification Software)	H, C, L, DHW

Ortiz et al.[63] 2009	Spain	Energy simulation (DesignBuilder)	H, V, L, A, DHW, Cooking
Davis et al.[65] 2025	Spain	Calculation	/
Petrovic et al.[67] 2023	Swden	Calculation	H, V
Gustavsson et al.[68] 2010 Gustavsson et al.[69] 2010	Sweden	Energy simulation (ENSYST)	H, V, L, A, DHW
Karami et al.[71] 2015	Sweden	Energy simulation	Primary fuels, Secondary fuels
Petrovic et al.[72] 2019	Sweden	Energy simulation (TMF Energy)	Electricity, Heat pump, PV system
Peñaloza et al.[73] 2016	Sweden	/	Electricity, Heat
Citherlet et al.[75] 2007	Switzerland	Energy simulation (Lesosais, Polysuns, Pvsysts)	H, V, L, A, DHW
Aurora et al.[76] 2025	Belgium	Energy simulation (DesignBuilder)	H, V, A, C, DHW, L
Norouzi et al.[77] 2025	UK	Calculation	H, V, A, L, DHW
Haniyeh et al.[79] 2023	UK	Energy modelling (PHPP)	Electricity
Norouzi et al.[80] 2023	UK	Energy simulation (DesignBuilder)	Electricity, H, C
Newberry et al.[81] 2023	UK	Energy simulation (IES VE)	H, Electricity
Cuéllar-Franca et al.[82] 2012	UK	Calculation	H, L, A, DHW, Cooking
Iddon et al.[86]	UK	Calculation	H, V, L, DHW

2013			
Hacker et al.[87] 2008	UK	Energy modelling (ENERGY)	H, C, L, A, DHW
Essaghouri et al.[88] 2023	Morocco	Energy simulation (BINAYATE)	H, C
Rossi et al.[90] 2012 Rossi et al.[91] 2012	Belgium, Portugal, Sweden	Calculation	H, C, V, L, DHW, Building automation
Quintana-Gallardo et al.[93] 2021	Germany, Slovenia, Spain	Energy simulation (DesignBuilder)	H, C, L, A, DHW
Moghayedi et al.[94] 2025	South Africa	Energy simulation (EDGE)	Electricity, LPG
Salazar et al.[96] 2009	Canada	Energy simulation (HOT2000)	H, C
Zhang et al.[97] 2014	Canada	Calculation	H, C, V, L, A, DHW
Keoleian et al.[98] 2001	USA	/	H, C, L, A
Arvizu-Piña et al.[99] 2023	Mexico	Energy simulation (TRNSYS)	L, A, C
Ortiz et al.[100] 2010	Colombia, Spain	Energy simulation (DesignBuilder)	H, C, V, L, A DHW, Cooking
Mosteiro-Romero et al.[103] 2014	USA, Switzerland	Energy simulation (e REM/DesignTM)	H, C, V, L, DHW

Note: H, heating; C, cooling; V, ventilation; L, lighting; A, electrical appliances; DHW, domestic hot water.